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Does Astronomical and Geographical Information of Plutarch's *De Facie* Describe a Trip Beyond the North Atlantic Ocean?

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ABSTRACT

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In Plutarch's book *On the Apparent Face in the Orb of the Moon*, the interlocutors develop a dialogue about a trip to the "great continent" beyond the North Atlantic Ocean. By applying modern scientific data, the present reappraisal of the astronomical and geographical elements within this dialogue has produced a novel interpretation of the date and place of the meeting and a journey to the northern Atlantic Ocean. A described solar eclipse is dated to AD 75, making use of the National Aeronautics and Space Administration (NASA)/Espenak/Meeus list, as well as historical information. The described peculiar, recurrent trips take place every 30 years (when the planet Saturn reaches the Taurus constellation) from the Mediterranean Sea to the Cronian Open Sea, which is identified with northern Atlantic Ocean coasts. It has been suggested that the last mission had returned homeland in April AD 56. The information provided concerns, distances between coastal sites and islands, duration of sea paths in days, and the reported setting and size between the destination place and its gulf with regards to Azov (in Crimea) and the Caspian Sea. Implications of sea currents and the coastal geomorphology of those lands are given. Following strictly the Gulf Stream current, as well as other known sea currents in the northern Atlantic Ocean, and introducing estimated speed for the ship, the geographical location of destination of the Greek settlers is proposedly identified with St. Lawrence Gulf and Newfoundland island. Other unnamed islands mentioned in this dialogue are identified with Norway's islands, Azores, Iceland, Greenland, and Baffin islands. It has been shown that the journey is made with good knowledge of sea currents but by using bright stars and stellar configurations as astronomical nightscape markers that determine the exact orientation of the sailing toward the Iberian Peninsula and back to the eastern Mediterranean, making the current working hypothesis a plausible event.

ADDITIONAL INDEX WORDS: *Astronomy, coastal, constellation, dialogue, Greece, Mediterranean Sea, Plutarch, Roman, Moon, Saturn, Gulf Stream, sailing, solar eclipse*.

INTRODUCTION

Plutarch is a significant historian, biographer, and philosopher who lived in AD 45–50 to 120. He was born in Chaeronia, Greece, from a wealthy family, studied in the Academy of Athens (AD 67–68), and traveled a lot in the eastern Mediterranean, mainly in Rome, Egypt, Sicily, *etc*. It is claimed that Plutarch made several trips to Rome during the reign of Vespasian and probably stayed in Rome twice between AD 89 and 92 (Stadter, 2014a, p. 8). In Rome, he met important personalities (*e.g.*, Minicius Fundanus [a Roman philosopher], Iunius Rusticus [a Roman senator], and Lucius Maestrius Florus [a Roman consul]) and others. Specifically, Lucius Maestrius took care to award Plutarch the title of Roman citizen. Maestrius also accompanied Plutarch in the first trip to Rome, while Plutarch still young, and in Lombardy, in Cremona, which was looted and destroyed in AD 69 after

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Table 1. *The proposed time of the dialogue based on the solar eclipse occurrence.*

Author	Chronology (AD)	Place
Ginzel, 1899	20 March 71	Chaeronia
Sandbach, 1929	5 January 75	Carthage, Rome
Sandbach, 1929	27 December 83	Alexandria
Cherniss and Helmbold, 1957	Later than 75	in or about Rome
Stephenson and Fatoohi, 1998	20 March 71	Greece
Hirzel, 1895	After the devastation of Delphi and before the restoration of the oracle.	
Adler, 1910	Before 84	
The current study	75	Rome

two battles against Vitelian, during emperor Vespasian time (Plutarch, 1926, pp. 14.1–15.4, 18.1–2).

After having acquired Roman citizenship, the name Plutarch was altered to Lucius Mestrius Plutarch (Lamberton, 2001). He was *Magistratus* of Chaeronia and had served as a "representative" of Chaeronia and Boeotia. During his last 30 years, he also served as *High Priest* in the oracular Temple of Apollo in Delphi (Plutarch, 1936, *Moralia* 792F), and he had the responsibility of the interpretation of the prophecies. Then, he stopped traveling and wrote his work *Parallel Lives*. Among the numerous books written by Plutarch, *On the Apparent Face in the Orb of the Moon* (or abbreviated to *De Facie*) is the epitome of his work, found in the title *Moralia* (Plutarch, 1936). In this book, he engaged with various opinions on the nature of the Moon and presents significant astronomical elements. Plutarch's *Moralia* is a miscellaneous collection of essays and treatises composed earlier than *Parallel Lives* (Goodwin, 1878).

As the dialogue now stands, the reader is thrust amid a corrupt text and without any prefatory *mise-en-scene* into the conversation itself, which in turn confronts the reader almost immediately (Plutarch, 1960, 920B) with an enigmatic reference to the matter being recapitulated. The reason that the circumstances are unspecified, as well as those of the conversation itself, is making the onset difficult to explain because the beginning of the *De Facie* is lost (Martin, 1974).

In *On the Apparent Face in the Orb of the Moon* (Plutarch, 1960), some close relatives of Plutarch discuss issues concerning the Moon while walking. Also, a dialogue about a trip to the "great continent" beyond the North Atlantic Ocean has taken place after the six interlocutors have finished their walk and are sitting on pedestals (Plutarch, 1960, 937 D 2). This meeting follows an earlier gathering (probably a symposium) meeting; according to the book (Plutarch, 1960, 937 C 9), they should now discuss for "those that have not fled the memory of what were said earlier." Cherniss (1951) reported that a previous discussion must have occurred in which the main speaker Lambrias and Lucius refer to "our friend" (Plutarch, 1960, 921 F 1), and possibly they imply Plutarch (see also Sandbach [1929]).

It is of value to refer to the participants of the debate, as they are related to place and time of this meeting. These participants are known persons from other books of Plutarch. Coordinator of the discussion is the Plutarch's brother, Lambrias, priest in the Oracle of Livadia (*De defectu oraculorum*, 431 C-D) and also *magistratus* in the Apollo Temple in Delphi (Dittenberger, S.I.G. ii, 868 C note 6). The geometer Apollonides, someone called Aristotle, Pharnaces, Theon the grammarian from Egypt a stoic philosopher (Theon Gramm, *Testimonia*, 1, 1) and the mathematician Menelaus (from Alexandria) quoted by Ptolemaeus (*Syntaxis mathematica* 1, 2, 30, 18), which also was a famous astronomer who made two astronomical observations in Rome, in January of the year AD 98. The next participant is Sulla (Sextius) from Carthage (Tunis), who offered the welcome dinner to Plutarch for his arrival in Rome after his long absence; this is recorded in the 8th book *Symposia* (*Quaestiones conivales*, *727B* and *De cohibenda ira* 453, C 9). Finally, Lucius the Tyrrhenian, a Pythagorean student of Moderatus who participated in this discussion, mentioned in the *Quaestiones conivales* (727B 5), is also present in the dinner in Rome (see also Prickard [1911]). All were experts of different disciplines from letters, astronomy, physical sciences, and natural philosophy that echo Stoics, Pythagoreans, Aristotle's Peripatetic school, and other schools of thought in ancient Greece.

Regarding the place and time of the gathering, various opinions have been offered (see Table 1). The exact time is not given, but this meeting came shortly after a solar eclipse, though it is not clear if this was visible only in some Roman provinces or in Rome itself (Plutarch, 1960, 931 D-E). This eclipse started shortly after noon, and stars were seen in the sky, while the atmosphere became much like that of morning twilight. This description is in accordance with the occurrence of a total solar eclipse (Littmann *et al.*, 2008).

At the end of the dialogue, the participants were invited to listen to Sulla regarding a narration of an unnamed stranger, whom he met in Carthage, describing a mysterious journey to the Isle of Cronus and an eschatological myth that the stranger heard from the chamberlains and servitors of the Temple of Cronus. The stranger, in fact, is related to this peculiar trip (Plutarch, 1960, 941 A-C) that takes place every 30 years (when the planet Saturn reaches the Taurus constellation) from the Mediterranean Sea toward the great continent at the Cronian Open Sea, which from the context is identified with northern Atlantic Ocean coasts.

An earlier approach regarding this trip is given by Mariolakos (2010). He maintains that prehistoric Greeks knew of the Atlantic Ocean and that they traveled there, and he presents his skepticism and hypothesis about this trip, identifying Ogygia with Iceland, and attributes the location of the arrival to the St. Lawrence Gulf, without, however, describing the details of this journey. The retrieved information of geographical significance of the entire book *On the Apparent Face in the Orb of the Moon* has been studied elsewhere and by much earlier scholars (see Coones [1983] and references therein).

In this paper, scientific evidence concerning issues regarding astronomical phenomena and the journey itinerary is given. The timing and place of this dialogue is determined based on the astronomical events provided in the ancient text and the historical elements. Then, following the outline of the text on these recurrent trips and the detailed description of the location of the named great continent, in which the ships arrive, the destination is pinpointed, and the route of these trips is determined.

Indeed, the dialogue challenges us to reconfirm this story. Thus, any questions posed here regarding the timing, location, identification, and the both ways of the journeys themselves may well be more instructive to us than a mere professional philological or philosophical treatise could be. Astronomy has, in its proper course of development, become extremely technical and mathematical, sharply distinguished from general physical enquiry in reading ancient literature, though recently the onset of archaeoastronomy as a discipline has contributed a lot in deciphering hidden knowledge or allegorically reported issues (Liritzis and Coucouzeli, 2007; Liritzis *et al*., 2017; Magli, 2016). Identification of bright stars and attribution of zoomorphic or anthropomorphic images to the constellations was an early practice in early Greece, Egypt, and elsewhere for navigation, agricultural activities, determination of time for rituals, and festivities (Castro Belen, 2015; Hannah, 2015). Therefore, via natural sciences and definition of each physical parameter, the reported elements stated in this dialogue are deciphered.

Even astronomer Hipparchus of Rhodes, "though he loved truth above everything" yet, was not versed in natural science and was content to explain the motions of the heavenly bodies by a hypothesis mathematically consistent, without care for its physical truth (see Dreyer [1906, p. 165] and the passages quoted from Theon of Alexandria and Ptolemy, in Tihon [1999]). Along this rationale, the environmental elements recorded in this dialogue are treated strictly on a natural sciences basis, interpreting, confirming, reconstructing, and synthesizing all information to a convergent point: to provide a sound basis of this dialogue taking into account any vague and inconsistent quote in the text.

It is worth mentioning the importance of Plutarch's book on the Moon that has inspired and has been well studied by several pre-20th century authors and some renowned renaissance scholars such as Kepler (Rosen, 2003) and Newton (Whewell, 1887).

Although extraordinary, it seems that discoveries from the past overthrow current opinions. Extraordinary or plausible is a matter of investigation, provided that the transmitted information follows logical and robust present evidence. It is the latter rationale that has been applied, and this information is being unfolded in a most reliable modern scientific interdisciplinary approach. Yet evidence is provided that uses tools as a capable and necessary condition to decipher ancient information and to test its validity.

Subsequently, a critically assessed interpretation is unfolded, first on the solar eclipse and the ceremonial journey to the great continent and the destination land of settlers/colonists using updated astronomical software and second, describing the itinerary of the journey going and returning based on astronomical data, geographical coordinates in relation to the described trip, and other oceanographic and coastal elements.

However, although the putative histories of the journey that are obtained from Plutarch reflect coordination with modern scientific knowledge, they are not fully supported by undoubted evidence; hence, the data must be interpreted cautiously. Historical interpretation is always a continuously working process until robust data are discovered. This is a challenge that is faced by all historians and is a key aspect of what it means to investigate historical accounts. Natural sciences assisting history and archaeology can be an asset in this endeavor.

This written historical report is tried and tested and is finally coined scientific and not mythical; it is based on narrated sources (geographical, environmental, astronomical) critically assessed, and accreditation is given to proven elements that validate the true against false information provided. The distances and time of journey is tried based on actual facts regarding speed of triremes and sea currents given in the scientific literature.

METHODOLOGY AND EARLIER ATTEMPTS

In this investigation concerning ancient night skies, the digital planetarium Starry Night Pro Plus 6 (Starry Night User's Guide, 2006) was used. This software provides accurate representations of the celestial sphere between 4713 BC and AD 10,000 from any location on Earth. Starry Night User's Guide (2006) algorithms take into account the axial precession of Earth (precession of the equinoxes) to correctly represent the celestial sphere of the past. According to the software's creators, the position of the eight major planets should be accurate to within 5 arcseconds for times within 3000 years of the present. The position of the Moon should be accurate to within 10 arcseconds for several thousand years in either direction. The calculations are based on the VSOP87 model.

For the solar eclipses, Xavier Jubier's web application "Five Millennium (–1999 to +3000) Canon of Solar Eclipses Database" (Xavier Jubier, 2017) was employed, which uses the data based on Espenak and Meeus (2006). This National Aeronautics and Space Administration (NASA)/Espenak/Meeus list is based on model VSOP87D for the calculation of the position of the Sun and on model ELP-2000/82 for the calculation of the position of the Moon (Espenak and Meeus, 2006, 2009).

Many of the earlier authors (Cherniss and Helmbold, 1957; Sandbach, 1929) suggested that the gathering was at Rome or close to Rome because the basic interlocutors are related to Rome; the authors connect this dialogue with the second visit of Plutarch to Rome (see Table 1), while other authors attribute the place somewhere in Greece or Alexandria (Ginzel, 1899; Sandbach, 1929; Stephenson and Fatoohi, 1998). The predominance of opinion, however, is with Rome. Finally, earlier attempts have proposed various chronologies about this philosophical gathering based on this reported solar eclipse (Table 1).

THE DATING OF THE DIALOGUE BASED ON THE ASTRONOMICAL DATA OF THE TEXT

The scholiasts of this dialogue state that several interlocutors were present in the symposium to honor Plutarch on his return to Rome after a long absence, linking this dialogue to that

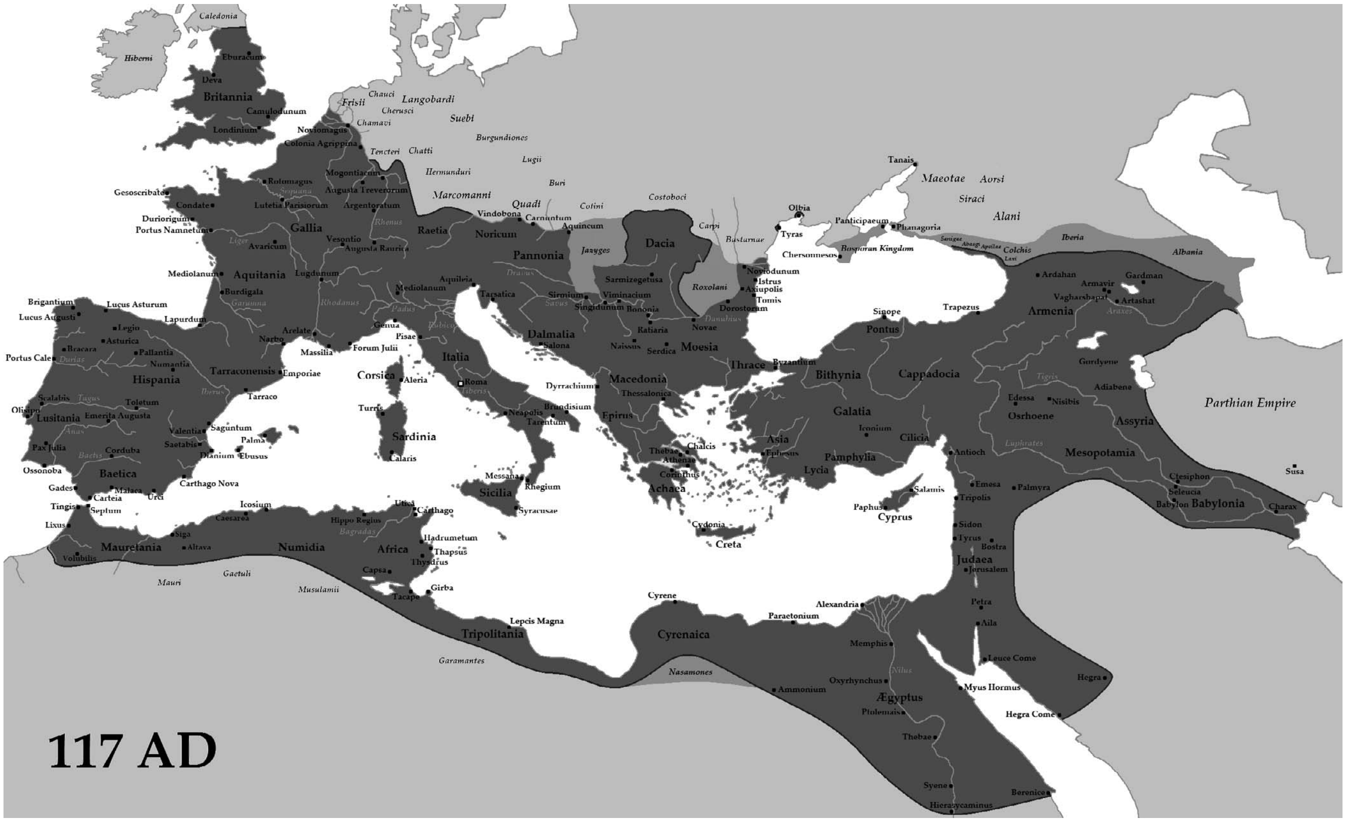

Figure 1. Map of Roman Empire (https://en.wikipedia.org/wiki/Trajan#/media/File:Roman_Empire_Trajan_117AD.png; under the Creative Commons Attribution-ShareAlike License).

gathering in Rome. Hence, the scholiasts do not imply of present meeting being Plutarch's first visit to Rome. Indeed, the circle of respondents with coordinator Plutarch's brother Lambrias shows an earlier acquaintance of each other. It is worth noting that the specific debate seems that another discussion-meeting referred to in the text ensued and that it indicated a person involved in that meeting that, although not named, the scholiasts suggest was Plutarch himself. Thus, after that meeting, the friendly circle continues the conversation while walking (Plutarch, 1960, 921 F, 937 C-D).

The Solar Eclipse

The time of this conversation is unknown, but according to Plutarch's text, this dialogue came shortly after a total solar eclipse (Plutarch, 1960, 931 D-E), though it is not clear whether this was visible in some Roman provinces or in Rome itself (Figure 1).

In fact, it is worth noting that (1) this "recent" eclipse started shortly after noon, and (2) the eclipse's description matches with a total and not a partial solar eclipse. However, based on NASA (2017) software, no total solar eclipse was visible in Rome during the first century AD. Therefore, the quoted solar eclipse in the dialogue was seen from another place of the Roman Empire (Table 2, Figure 1).

Indeed, 71 total solar eclipses are found, and 29 hybrid solar eclipses that occurred during AD 1–120; nine of them could be visible from the various regions of the Roman Empire, which was extended from the Iberian Peninsula to the Persian Gulf and from Egypt and northern Africa to Britain, as seen in Table 2 and Figure 1. A hybrid eclipse (also called an annular/total eclipse) shifts between a total and annular eclipse. At certain points on the surface of Earth, it appears as a total eclipse, whereas at other points it appears as annular. In Table 2, except for the path of totality, the maximum eclipse location, the time of maximum phase in this location, the maximum obscuration from Rome, and the starting time of the event in Rome is given for a comparison. The path of totality is the path run by the eclipse shadow (umbra) and is the only part of the Earth's surface in which the eclipse is observed as a total eclipse. Maximun obscuration is the maximum coverage percentage of the solar disc (from the moon) during a solar eclipse. Maximum eclipse location is the location in which the total eclipse has its maximum time duration.

However, knowing Plutarch's lifetime (AD 45–120), the solar eclipses of AD 17, 21, and 24 should be excluded. Similarly, the solar eclipse of AD 59 is excluded because Plutarch was a 14-year-old boy. Also, the last two solar eclipses of AD 113 and 118 are excluded because they started very early in the morning and *not shortly after noon*. Additionally, according to historians, Plutarch did not travel in the last 30 years of his life, *i.e.* after about AD 90. Moreover, the solar eclipse of AD 71 is also

Table 2. *Total solar eclipses observable from the Roman Empire (AD 1–120).*

Date (AD)	Eclipse (Type)	Path of Totality	Max Obscuration from Rome	Start Time in Rome UT (LT)	Max Eclipse Location	Max Time in this Location (UT)
15 Feb 17	Hybrid	Tripolitania (Libya), Greece, Moesia, Thrace	79%	0824 (0924)	Libya	0938
19 Jun 21	Total	Britania, Gallia	76%	0948 (1048)	Czech Rep.	1111
24 Nov 24	Total	Dacia, Asia Minor	73%	0704 (0804)	Qatar	0924
30 Apr 59	Total	Africa (Tunisia), Aegean Sea, Cyprus, Asia Minor (Syria)	76%	1148 (1248)	Morocco	1218
20 Mar 71	Hybrid	Tripolitania (Libya), Greece, Thrace	72%	0802 (0902)	Mediterranean Sea	0914
5 Jan 75	Total	Africa (Tunisia), Sicilia, Italia, Illyria, Dacia	89%	1314 (1414)	Cape Verde	1313
27 Dec 83	Total	Egypt, Palestine (Judaea), Mesopotamia	63%	1049 (1149)	Algeria	1158
1 Jun 113	Total	Hispania, Aquitania, Gallia	76%	0753 (0853)	Belarus	0947
3 Sep 118	Total	Britania, Gallia, Dacia, Black Sea-Caspia	73%	0706 (0806)	Azerbaijan	0925

excluded because the start time was ~0802 UT (or ~0902 LT) in Rome as well in Libya, *i.e*. early in the morning and *not shortly after noon*.

Therefore, among the solar eclipses of Table 2, only two remain as possible candidates: those of AD 75 and 83 (Figure 2a,b). Note that Lucius, who mentioned the solar eclipse, comes from Tyrrhenian, between Carthage and Egypt, which are regions where these total solar eclipses were observed. The start time of the total solar eclipse of AD 83 in Rome was ~1049 UT (~1149 LT), *i.e*. exactly at noon. If, however, the referred start time in the text concerns the position of the total solar eclipse, indeed this event started in Egypt immediately after noon (~1249 LT). Therefore, the solar eclipse of AD 75 is left and is favored, according to the following rationale.

The AD 75 Total Solar Eclipse: The 30 Years' Recurrent Trip to the Great Continent Related to the Planet Saturn's Position in the Sky

According to the text, Sulla met a stranger in Carthage and conveys to his interlocutors the conversation he has had with him. This stranger had returned of a trip from the distant great continent (Plutarch, 1960, 942 B), which is in the Cronian Sea. The following is according to Sulla's narration, which is itemized to ease the sequence of events.

A trip of settlers was taken place in that great continent every 30 years, when the planet Saturn (star of the Titan Cronus named *Fainon or Nyctouros* in the text) reaches the Taurus constellation (Plutarch, 1960, 941 C 9–941 D 5). The arrival to planet Saturn–Kronus in the Taurus constellation means that Saturn's orbit in the Ecliptic (zodiac circle) starts to project onto the sky in a region that houses the Taurus constellation. It is known that the time orbit of Saturn around the Sun is 29.4571 years, so this position of the planet is observed about every 30 years.

Once this happens, multiple preparations start for sending ships with colonizers to the great continent, which lasts a long time (Plutarch, 1960, 941 A 10–C 10).

The journey is deemed dangerous and lasts a long time (Plutarch, 1960, 941 B).

When the mission gets to the distant country, the settlers of the previous mission may return again back to their homeland.

Making use of astronomical ephimerides and a Starry Night software astronomical program (Starry Night User's Guide, 2006), the time periods that Saturn projected to the Taurus constellation was defined as during the first century AD (Table 3).

According to Lucian's remark about a recent solar eclipse, the return trip of the stranger to his homeland and his visit to Carthage, where he met and spoke with Sulla, should have been preceded from a total solar eclipse, visible in the Roman Empire. Then, shortly after the quoted eclipse, the specific dialogue takes place. That is, the following successions of the reported events take place:

(1) Entrance of the planet Saturn to the Taurus constellation.
(2) Return of the stranger from the foreign distant country.
(3) Arrival of the stranger at Carthage, where he searches for some sacred parchments buried outside the city (Plutarch, 1960, 942 C), when the old town was destroyed (149–146 BC) in the Third Punic War.
(4) He stayed too long in Carthage looking for these parchments (Plutarch, 1960, 942 C).
(5) Then he meets Sulla and others and gave them more information (Plutarch, 1960, 942 C); later, Sulla passed some of this information on to his interlocutors.
(6) After some time, the total solar eclipse occurs, starting immediately after midday.
(7) A short time later, this meeting and dialogue takes place.

Consequently, the time of the dialogue is determined based on the above analysis in comparison with the results (see Tables 2 and 3). The first time period (AD 26–29) of Table 3 does not concern this study because Plutarch was born in AD 45–50. Additionally, in accordance to these recorded events and in compliance with the narrative above, the return of the stranger from the distant country could not have been made in AD 85–88 (see Table 3) because the two following total solar eclipses of the years AD 113 and 118 (see Table 2) do not start shortly after midday, but in the morning. Moreover, in this case, his arrival to Carthage should not have happened earlier than AD 90, but as historians say, Plutarch did not travel after AD 90 (Jones, 1971; moreover, the Philosophers were again expelled from Rome after the death of Rusticus in AD 92). Hence, the stranger has returned from the great continent, when the last mission of the years AD 56–58 arrived there (see Table 3 and Figure 3). Consequently, the stranger must have arrived on the great continent with the AD 26–29 mission. Specifically with the entrance of the planet Saturn to the Taurus constellation in April AD 56 (Figure 4a), according to the text the lengthy preparations of the mission that the stranger waited to get back home had started. The journey must have started in the spring of AD 57, and the mission had reached the great continent after

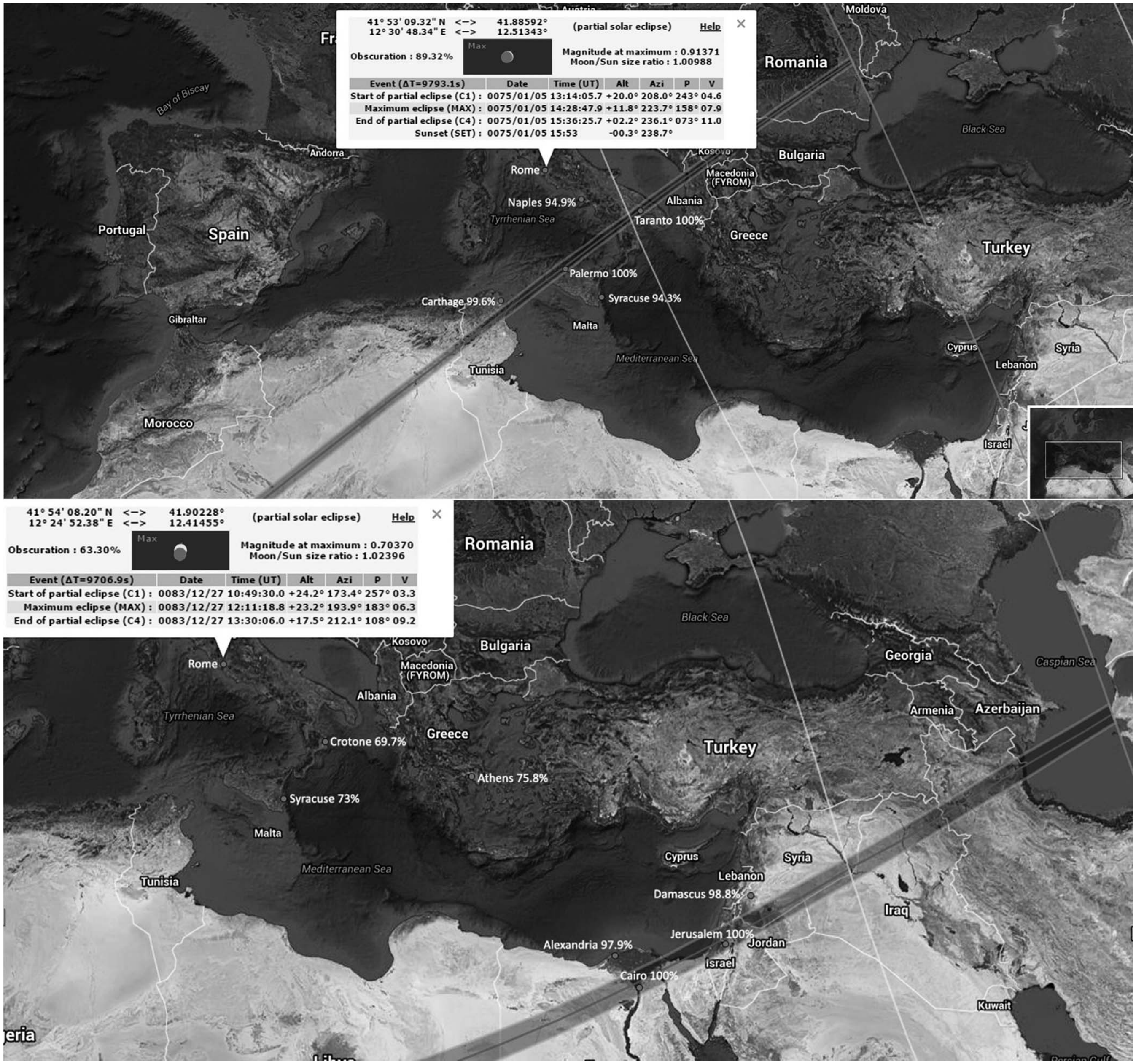

Figure 2. The zone of totality (two parallel lines crossing Africa, Italy, and the Balkans) for the solar eclipse of AD 75 (top) and the solar eclipse of AD 83 (bottom)(two parallel lines crossing Africa, and the Middle East). Data about the eclipse in Rome is given in the inset. The obscuration of the solar disk observed by various places is also given. The left oblique line defines the last external tangency of penumbral shadow cone with Earth's limb; the right oblique line defines areas in which the partial eclipse is seen, but the totality is seen here as the point that the total eclipse is fully developed.

some months. When the planet Saturn exits from the Taurus constellation in July AD 58 (Figure 4b), the similar lengthy preparations of the return journey followed, which brought him (and his companion) back to the homeland. It is reasonable to assume that this entire event lasted about 2–3 years. This means that the stranger must have returned to Greece approximately during AD 59–60.

Plutarch stresses that in this distant country, Greeks are living who speak Greek. Also, he notes that Greeks are

Table 3. *Saturn enters/exits Taurus constellation, first century AD.*

Saturn Enters Taurus	Saturn Exits Taurus
AD	AD
26 June 26	25 May 29
20 April 56	8 July 58
6 June 85	14 May 88

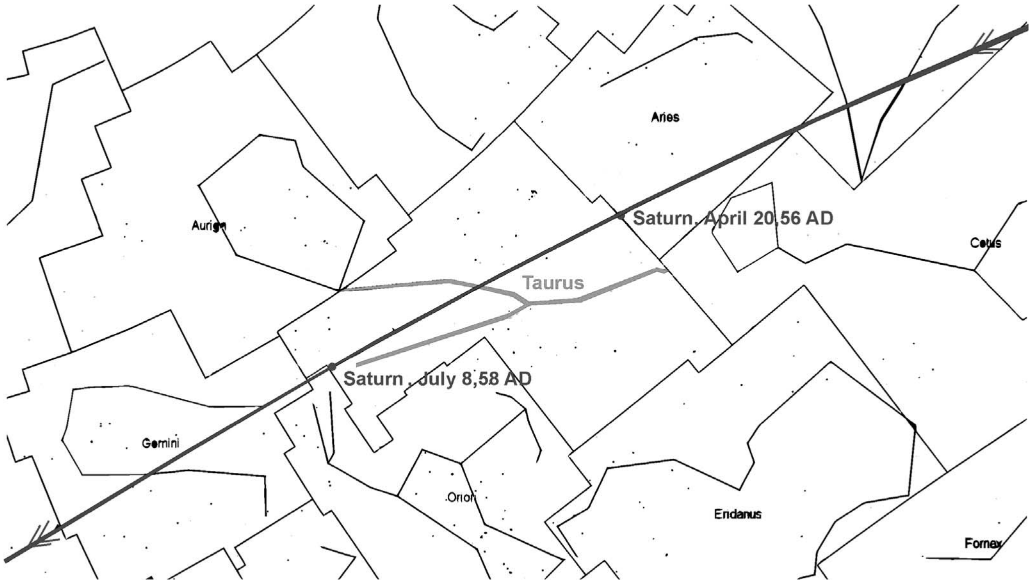

Figure 3. The planet Saturn's orbit (diagonal arrowed line) through the Taurus constellation (bifurcated image) during the period of AD 56–58.

transported in these trips since the time of legendary Hercules (Plutarch, 1960, 941C), rather a heroic figure that echoes heroic epics and myths back in Late Helladic times (13th–11th century BC). This means that the stranger, who was found in Carthage, was of Greek origin. He returned home, and after some time he got prepared and held the visit to Carthage. Thus, if indeed he returned in AD 59–60, he reached Carthage hypothetically at least 3–5 years later, as it took him enough preparation time for this new trip from his home to Carthage, knowing that he would remain long at Carthage. So, he reached Carthage approximately around AD 62–65. According to the narration of Sulla, the stranger stayed too long in Carthage to find what he wanted. This time that he stayed in Carthage is estimated at least 5–8 years before the meeting with Sulla, which was around AD 67–73.

Thereafter, the total solar eclipse of AD 75 (5 January) followed, which suits well with the events that took place before and after this. It started shortly after noon and was visible with 100% obscuration in Carthage and all over Magna Grecia (but in Rome too, with a significant obscuration of 89%). Sulla could well have seen it from Carthage with total obscuration, as well as Lucius from Tyrrhenian. After some months, in the spring of AD 75, it seems that Plutarch visits Rome, being around 30 years old, a Roman citizen and Principal (Magistratus) of Chaironea, and has become known to Roman social circles. If this was his second time visiting Rome, then indeed it had been a long time, for his first visit was made around AD 69. Sulla offers the dinner to honor him in the second visit to Rome. Many of the issues discussed there are described in the volume by Plutarch entitled *Quaestiones convivales* (Symposiaka). After the symposium, Plutarch's brother, Lambrias, Sulla, Lucius, and some others are walking and meditating as a continuation of the scientific dialogue preceding the symposium. The content of this discussion concerns the Moon, and it is recorded in this work of Plutarch. The later part of the dialogue about the journey is subsequently discussed.

THE LOCATION AND THE JOURNEY TO THE LARGE CONTINENT

A detailed description of the great journey up to northern Europe and the Atlantic is provided, giving information regarding islands, coastal sites, distances covered, alluvial deposits, and the itinerary that was followed. The mission of settlers that arrived near the islands was described to reanimate the Greek presence.

The Arrival Place in the Large Continent Beyond the Atlantic Ocean

Concerning the place of arrival of the settlers to the large continent, the information provided states (Plutarch, 1960, 941B, 941C):

> That sea-coast of the mainland Greeks are settled on, around a bay not smaller than the Maeotis, the entrance of which lies almost in a straight line opposite the entrance to the Caspian Sea. Those Greeks call and consider themselves continental people, but islanders all such as inhabit this land of ours, in as much as it is surrounded on all sides by the sea...

It is known that the north entrance (mouth) of the Caspian Sea, near the river Volga delta formation, has a latitude of 45°53′17.37″ N and a longitude of 48°42′50.30″ E (Figure 5a,b). Barely on the same parallel of about 45° in the American continent in the coasts of the North Atlantic Ocean, the entrance (mouth) of the Saint Lawrence Gulf occurs. In fact, the coordinates of the opening (half distance) between Nova Scotia islands and Newfoundland island is 45°48′46.84″ N and 60°0′28.24″ W. The difference of about 5′ in latitude between

Figure 4. (top) Planet Saturn's entrance to the Taurus constellation (marked with by bifurcated image) in 20 April 20 AD 56; (bottom) planet Saturn's exit of the Taurus constellation in 8 July 8 AD 58. The planet Saturn is the spot in the orbital trend.

the Caspian and Saint Lawrence mouths is within the error bar. Therefore, the place of arrival of the settlers to the great continent was the Saint Lawrence Gulf. The presented figures on the coordinates could not be measured with such accuracy then, but in the present work, modern values are presented on average location to ease elaboration of the obtained information. The same logic is applied to any quantified parameter, such as area, distance, and velocity, subsequently (see the "Discussion").

Plutarch's dialogue, however, provides additional information related with this place. It is a marine area that in fact is no smaller than Maeotis Lake, that is, the Azov Sea, in the northern part of the Black Sea (Figure 6). Indeed, the area of the Azov Sea is estimated as equal to 39,000 km^2 and that of Saint Lawrence Gulf is equal to 236,000 km^2, according to Google Maps (https://maps.google.com/) (see Figure 6 and Figure 5 [bottom] for a comparison).

Concerning the location of the great continent, i.e., America, "which is surrounded in circle by the great sea," the destination of the settlers, it is defined in relation to three islands of the Cronian archipelago and the Ogygia island (Plutarch, 1969, p. 941A-B), the latter also mentioned by Homer (1995, 6.172 and 7.244–254).

An isle, Ogygia, lies far out at sea, a run of five days off from Britain as you sail westward; and three other islands equally distant from it and from one another lie out from it in the general direction of the summer sunset. In one of these, according to the tale told by the natives, Cronus is confined by Zeus, and his son, holding watch and ward over those islands and the sea that they call the Cronian main, has been settled

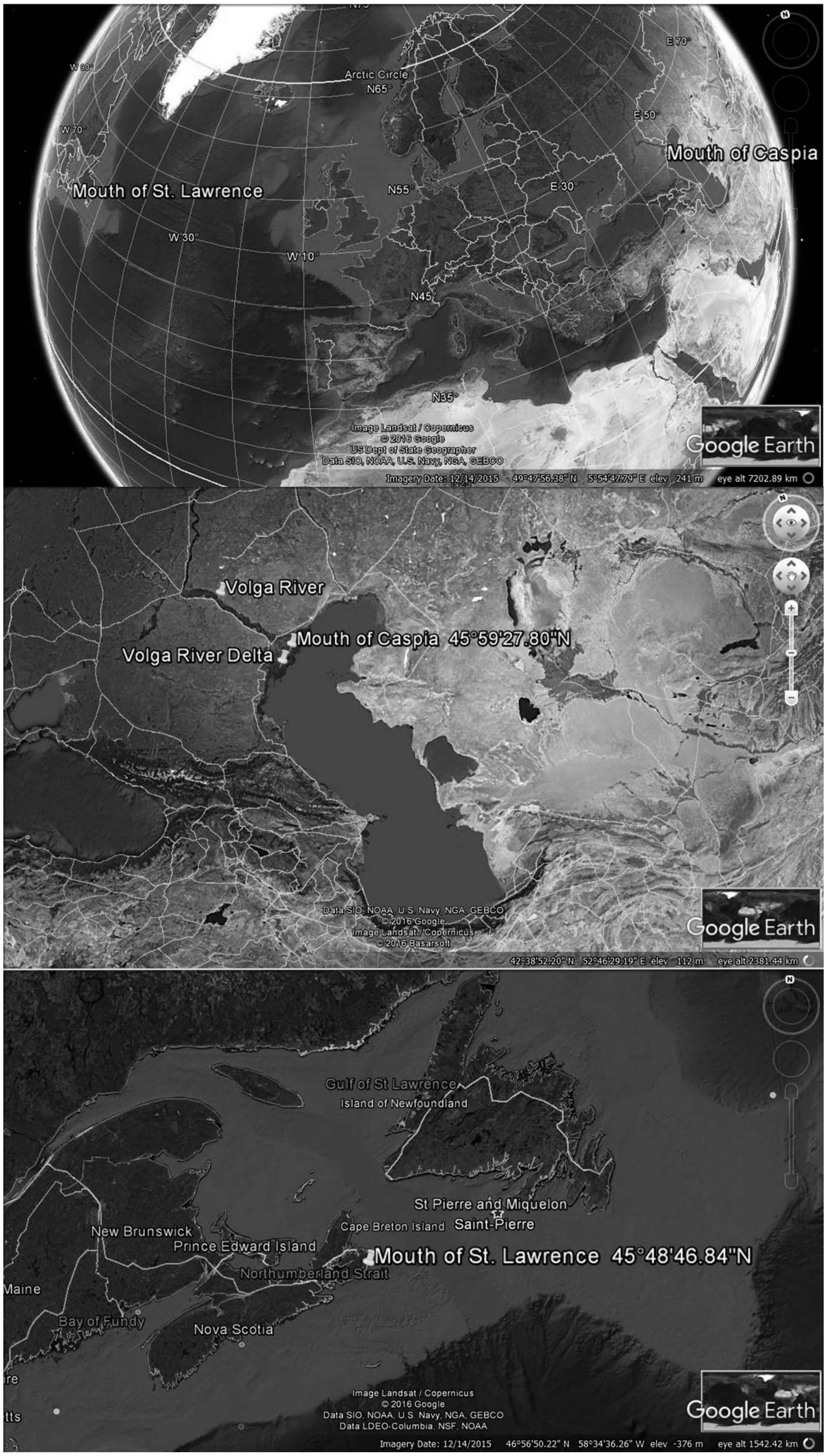

Figure 5. (top) The geographic latitude of the entrance (mouth) of the Caspian Sea, near the river Volga delta formation and the entrance (mouth) of Saint Lawrence Gulf between Nova Scotia islands and Newfoundland island, is almost the same. (middle) Map of the Caspian Sea; (bottom) Map of Saint Lawrence Gulf.

Figure 6. The map of the Black Sea and the Azov Sea (Maeotis Lake).

close beside him. The great mainland, by which the great ocean is encircled, while not so far from the other islands, is about five thousand stades from Ogygia, the voyage being made by oar….

In fact, Homeric Ogygia (Plutarch, 1960, 941A-B) is in a distance "a route of five days from Britain to the west." Unfortunately, it is not explained from which British port such a journey is made, but closer islands to Britain (apart of Ireland) are either NW or SW. Those are Iceland and Azores, respectively. Azores are 2200 km (11,880 stadiums) away from the southern edge of Britain (Celtic Sea). (Stade, or stadium, was an ancient Greek unit of length, based on the length of a typical sports stadium of the time. According to Herodotus, one stadium was equal to 600 Greek feet [*pous*] and varies between 160–185 m in city-states and local ancient games [Olympic, Pythian, Nemean, Isthmian]. The 185 m [Attic] is adopted here.) Supposing that a sailing ship covered this distance in 5 days, its anticipated average velocity would be about 18 km/h (9.7 knots). Also, Iceland is about 870 km (4700 stadiums) away from the northern edge of Britain (Hebrides islands), hence for a five days' journey an average velocity of 7 km/h (3.77 knots) is needed. (This Scottish land was known in ancient times. The Greek historian Diodorus Siculus [II, 47, 9] mentions in that place an island named Hyperborea [meaning "beyond the North Wind"]).

However, according to the text, the island of Ogygia should, at the same time, lie about 925 km (5000 stadiums) from the great continent. But this presumably does not hold for either Azores or for Iceland. Both places are much more distant from the American continent. The shortest distance of Iceland from America (*e.g.*, Newfoundland) is 2360 km (12,740 stadiums), and that of Azores (*e.g.*, Flores Island) is 2185 km (11,800 stadiums) from the southern edge of Newfoundland. In contrast, the Bermuda Islands lie at that distance from the American continent: east of the American coast, NE of Miami by 1770 km and about 1350 km south of Halifax in Nova Scotia of Canada. The nearest point of the land is the Hateras promontory in northern Carolina, W-NW, a distance of about 1030 km. Of course, Bermuda Islands are west of Britain but 5219 km away (28,188 stadiums); obviously a trip there should last much longer than 5 days (see, *e.g.*, a discussion on the grown speed of triremes, known since the early first millennium BC, in Krivec [2016] and relevant citations therein).

Either way, *there is no other island* in the Atlantic Ocean that can be traveled *for 5 days from Britain* but that is *only 925 km away from the American* coasts.

From all of the previous information, it is difficult to identify the Homeric Ogygia, but additional information in the text will help in determining this issue. The reference reports for *three islands* that remain in *equal distance from Ogygia* Island and in *equal distance between them*. These three islands are located to the point that the Sun sets during the summer, *i.e*. NW, in the Cronian Sea. (In one of these islands, the myth accounts that father god Zeus [Dias] has prisoned Cronus after the Titanomachia [the war between Titans and Gods], and for this reason the sea in which the issues take place, is known as Cronian Sea. The oldest reference about the Cronian Sea and its position in the North Atlantic Ocean is in the *Orphica Argonautica* [1078–1081]). The mission of the settlers of those islands was to reanimate the Greek presence there (Plutarch, 1960, 941 F).

At any rate, two possible interpretations exist about the three islands of the Cronian Sea, which are equidistant between them and are located NW in the North Atlantic Ocean.

First, if these three islands are equidistant, *i.e*. form an equal-sided triangle, then these are Greenland, Baffin Island, and Newfoundland (at the entrance of the Saint Lawrence Gulf). The distance between Greenland and Baffin Island is 1167 km, between Baffin Island and Newfoundland is 1218 km, and between Greenland and Newfoundland is 1166 km (*i.e*. round up to ~1200 km) (Figure 7, upper). In such case, Ogygia Island, which should be equidistant from these three islands, ought to be at the center of this triangle, but *no land* is around it.

Second, if the three islands are equidistant on an isosceles triangle, then the islands are Iceland, Greenland, and Newfoundland (Figure 7, lower). The distance between the southern edges of Iceland to the southern edge of Greenland is ~1270 km. Respectively, the distance between the southern

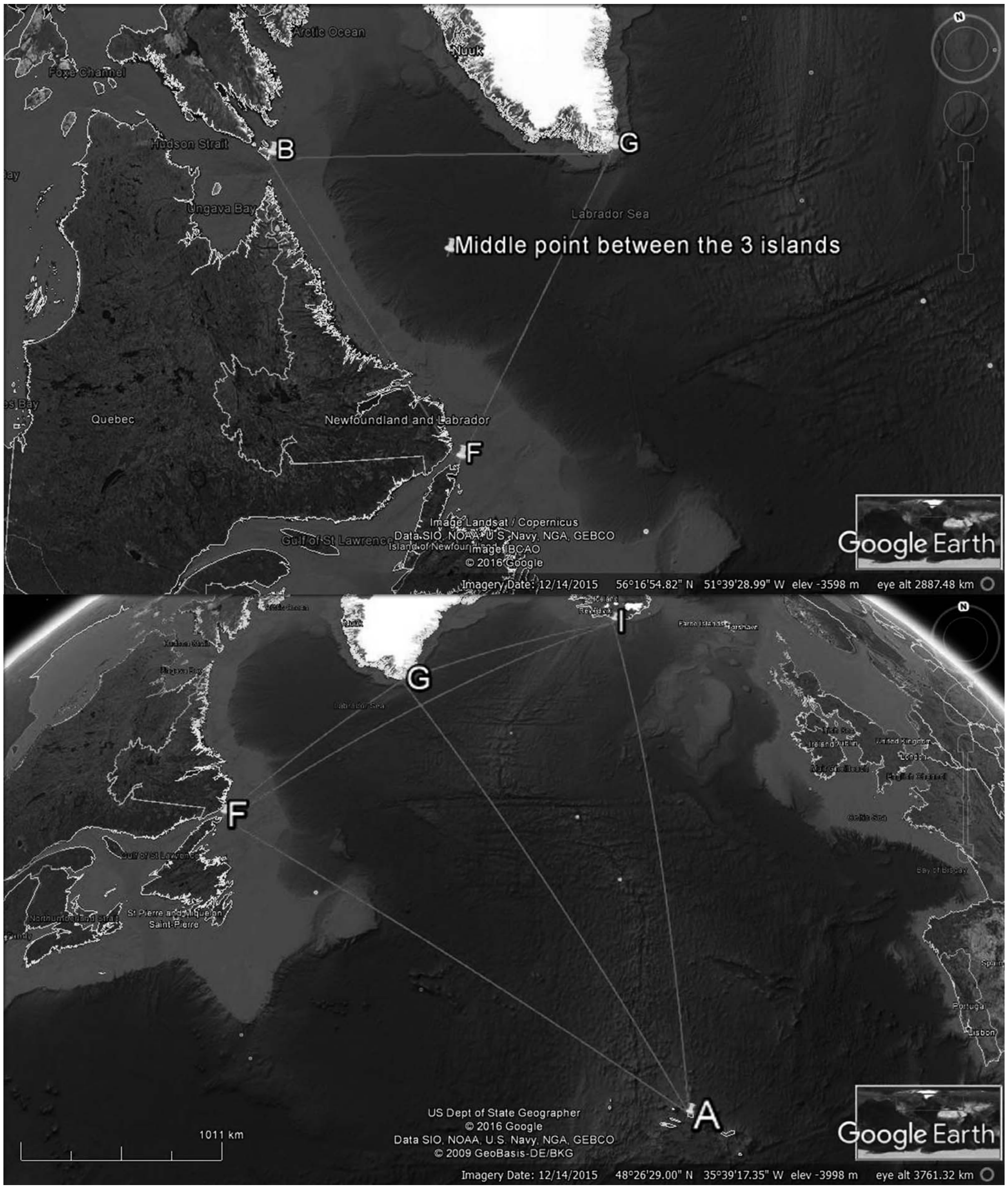

Figure 7. Upper: The three islands, Greenland (marked with G), Baffin Island (marked with B), and Newfoundland (marked with F), are equidistant, *i.e.* form an equal-sided triangle. The common distance between them is around ~1200 km. At the center of this triangle, no land exists. Lower: The three islands, Iceland (marked with I), Greenland (marked with G), and Newfoundland (marked with F), are equidistant on an isosceles triangle. The common distance between Iceland and Greenland, as well as between Greenland and Newfoundland, is approximately the same, around 1200–1300 km. The distance of the central island of Azores (Terceira) from any one of these three islands is around 2600–2700 km.

edges of Greenland to the northern edge of Newfoundland is ~1170 km. Thus, from all mentioned previously, Iceland to be identified as Ogygia is excluded, for the latter should be equidistant from these three islands of the Cronian Sea, including Iceland. Consequently, via incongruous deduction, Ogygia should lie in the islands of Azores.

Indeed, these three islands seem to be equidistant from Azores (Figure 7, lower). The distance of the central island of Azores (Terceira) from Iceland is 2750 km, from Greenland is 2590 km, and from Newfoundland is 2600 km, or all around 2600–2700 km. Also, the Saint Lawrence Gulf length is 1085 km, or ~5000 stadiums (from the *northern edge* of Newfoundland Island to the American continent, in the alluvial St. Lawrence River to Quebec). But, as referred to previously, the *southern edge* of Newfoundland Island determined geographically is at the same geographical latitude with the northern edge of Caspian Sea. Therefore, Newfoundland, which is the place of exile of mythical Cronus and is the final destination of

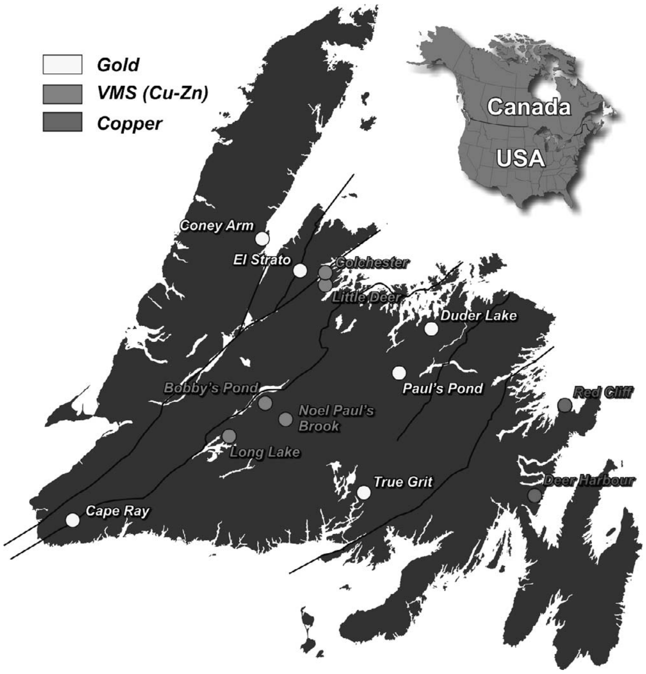

Figure 8. Mineral resources at the Island of Newfoundland pertaining to gold, Cu-Zn, and copper mines (Cornerstone Capital Resources, Inc., 2017) based upon the Geological Survey of Canada (2017).

those colonists, is just off the American coast about 1085 km, or 5000 stadiums. (In Greek mythology, Cronus, or Kronos was the leader and youngest of the first generation of Titans, the divine descendants of Uranus, the sky, and Gaia, the earth. He overthrew his father and ruled during the mythological Golden Age until he was overthrown by his own son Zeus and imprisoned in Tartarus [in Greek mythology, a horrible pit of torment in the afterlife, the darkest depths of the Underworld]).

Additional *nota bona* about Newfoundland as the place of the Greek colonists derives from the same text, metaphorically quoting a golden ore. According to the text, "Kronos is sleeping closed in a deep cave that looks like gold [. . ..] and even [. . ..] the foreigner who has returned from there carried several supplies in golden cups [. . .]" (Plutarch, 1960, 941F–942B). Indeed, even today there are many gold mines in this island (Figure 8).

Finally, the explanation as to why this trip is run slowly and with difficulty, with the use of rowing boats, is given. The text (Plutarch, 1960, 941B) refers clearly to the sea currents: "the open sea is travelled slowly, and it is sludge due to many currents. The sea currents that outflow through the large continent create aluvial deposits and the sea is dense, earthy, and considered coagulated."

It is clear that the sea currents imply the Gulf Stream (Figure 9), which starts from the Gulf of Mexico and bifurcated traverses through the northern Atlantic Ocean, reaching the coats of Scandinavia, and then returns back to Canada passing by the Gulf of St. Lawrence. Therefore, the sea currents of the Atlantic Ocean were well known.

Figure 9. The North Atlantic Ocean Sea Currents. Bold lines (mainly northward) indicate the thermal currents, and the light lines (mainly southward) indicate the cold currents (IFISC, 2017).

It ends up that the place of arrival of colonists was Newfoundland in the entrance to the St. Lawrence Gulf (Canada). There, according to the dialogue, Greeks were living since old times, and by that time the Greek presence was revived with the revisit by new colonists lead by Hercules (though a legendary mention but implies some ancient relevant traveling event). Since then, and every 30 years marked by the planet Saturn entering Taurus's constellation, a similar journey is made with new colonists. It makes one wonder why no other account is made on this trip every 30 years by any other historic source, apart of Plutarch; however, he is famous of being correct and not imaginative.

The Description of the Journey from the Mediterranean Sea to the Large Continent

Although the text provides many details about the trip preparation, the port of departure of the colonists is not mentioned. Nevertheless, speaking on the return of the stranger to his home, the text refers to the *big island* that he was nostalgic to see again, implying his homeland (Plutarch, 1960, 942 A 5). (Regarding this sentence, in a parenthesis, the view of "my own dwell" is puzzling. Europe is not an island, hence, a vacuity is met and unknown if Plutarch or the later copiers inserted this.) The five larger islands in the Mediterranean Sea are Sicily, Sardinia, Cyprus, Corsica, and Crete. Following Plutarch's multiple signaling that in the distant island of Cronus *only Greeks* were living who were transferred there by sea every 30 years, then the said stranger was Greek. Therefore, the named as great island—homeland of an ancient Greek—it could well be one of these three islands; Sicily, Cyprus, and Crete. The colonies of the Phoceans in Corsica and Sardinia are no longer there because of the conquest of Carchidonians.

Further the dialogue speaks about an offering to the gods and large preparations that were time consuming. The selection of the colonists/settlers and their transfer were made by draw. More than one ship was loaded with all of the necessary

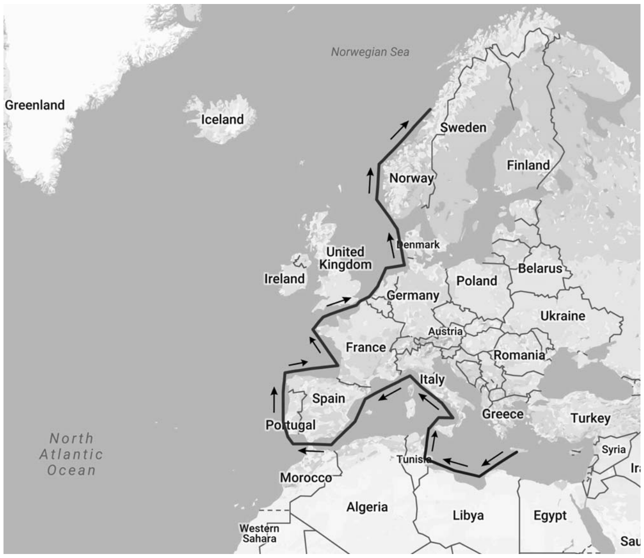

Figure 10. Proposed sea route of departure from southern Crete, following the coastal side along southern Europe that reaches Gibraltar and then up to Britain, Norway. The continuation of this trip is shown in Figure 17.

supplies for those people traveling by boat and rowing, for they should stay abroad for long. Though these are large rowing boats with heavy load, the speed should not be high.

The Trip: Departure and Arrival

The sea journey is not described, but it is apparent that they travel toward Gibraltar and then out to the Atlantic Ocean. In Figure 10, as a working hypothesis, the departure is set from southern Crete, between Cyprus and Sicily. The sea path follows the coastal side along southern Europe that reaches Gibraltar, covering thus a distance of 4120 km in 31 days nonstop, with an average speed of 3 knots (1 knot $\sim$1852 m/h). After a reasonable short stop at Tartessos, a large port in the straits of Gibraltar (the legend reports of Pillars of Hercules), the voyage continues to the north, profoundly near the Arctic Zone (Figure 10). (The phrase "Pillars of Hercules" was applied in Antiquity to the promontories that flank the entrance to the Strait of Gibraltar. According to Greek mythology, when Hercules had to perform 12 labours, one of them [the 10th] was to fetch the Cattle of Geryon of the far West and bring them to Eurystheus. See also Strabo [1887, III, 5, 5] and Herodotus [1932, IV, 8, 7]. Herodotus refers to Heracles's labour and specifically to the Cattle of Geryon that he brought back to Eurystheus, which marked the westward extent of his travels. Herodotus speaks about Erytheia Island near Gades/Gádeira that lied beyond the Pillars of Hercules in the limits of the Ocean [*'Ωκεανόν*]).

Now when they have put to sea the several voyagers meet with various fortunes as one might expect; but those who survive the voyage first put in at the islandic coasts nearby, which are inhabited by Greeks and see the sun passes out of sight for less than an hour over a period of thirty days, — and this is night, though it has a darkness that is slight and twilight glimmering from the west (Plutarch, 1960, 941 D).

These islandic coasts, according to the Liddell Scott dictionary (Liddell and Scott, 1940), are "islands lying across a coast," rather implying the European seaside. (Liddell–Scott Lemma *πρόκειμαι* = *lie*, I am lying in front of something. Moreover, infinitive κατισχεῖν [verb «καταμπ⌊χω» catching up] means enclose.) The "sun of the midnight" obviously refers to the longer daylight during *summer solstice* in the arctic region (Figure 11).

The geographical zones where the sun sets at about 1 hour in the summer solstice (of 21–22 June) for AD 100 (NASA, 2017) was confirmed (Solar Topo, 2017). This zone covers the region of archipelago Vega off the Norwegian coasts, which contains 6500 islands, the larger being Vega (Figures 12 and 13). In particular, in the northern part of this zone lies the town Eiden of Vega Island at longitude 65°31′41.60″ N and longitude 11°50′36.69″ E. Here, the day length during summer solstice's period is 23 hours and 10 minutes. Hence, it is certified, at least, that settlers had arrived at the area of the Vega archipelago islands.

Therefore, the mission after 8850 km passing Gibraltar reached the coasts of archipelagos Vega islands at around the summer solstice; hence for 30 days (from the beginning of June to first days of July) the sun sets for only 1 hour. Indeed, there lie many islands *close to the coast*. With a speed of 3 knots nonstop, the duration of this journey is estimated $\sim$66 days. Remember that this trip must have initiated in the spring of AD 57, 1 year after the entrance of planet Cronus to the constellation of Taurus due to time-consuming preparations. Taking into account the total duration of the trip estimated to be 3–4 months, the mission of settlers must have arrived at Vega archipelago during summer solstice.

Plutarch informed us that at that area Greeks were living, and the colonists stayed there for 90 days, accepting care offered by local Greek inhabitants who considered them as something "holy" (Plutarch, 1960, 941 D 10). This means that they stayed there the whole summer till September–October and that they departed from Norway near the autumn equinox, whereat, according to the text (Plutarch, 1960, 941 E), they traverse to the opposite side assisted by the winds. The waited for 3 months, which resulted in (1) melting of icebergs during the summer period for safe sail in the opposite coasts of America, and (2) waiting for the appropriate winds to pass quickly because the weather conditions in the Arctic Zone are hard. The crossing to the North Atlantic Ocean with ships was made via the aid of sea currents commencing from the Gulf Stream and reaching Norway coats (Figure 9). Here the Norwegian sea current grows coming from the west, whereas at these coasts it turns to the north reaching Svalbard islands (Figure 14). It is this current that is followed by migrated codfish from Mexico to Scandinavia, and the Vega Archipelago inhabitants are working with fishing codfish. This same current turns southward following the Greenland seaside (East Greenland current), passing by between Iceland and Greenland heading on to America.

However, the Norwegian current has seasonal variations (Lumpkin and Johnson, 2013) and in autumn, for example, has increased speed (improved measurements and modeling has not altered the trend of direction and intensity, though many surface currents are resolved to be narrower and

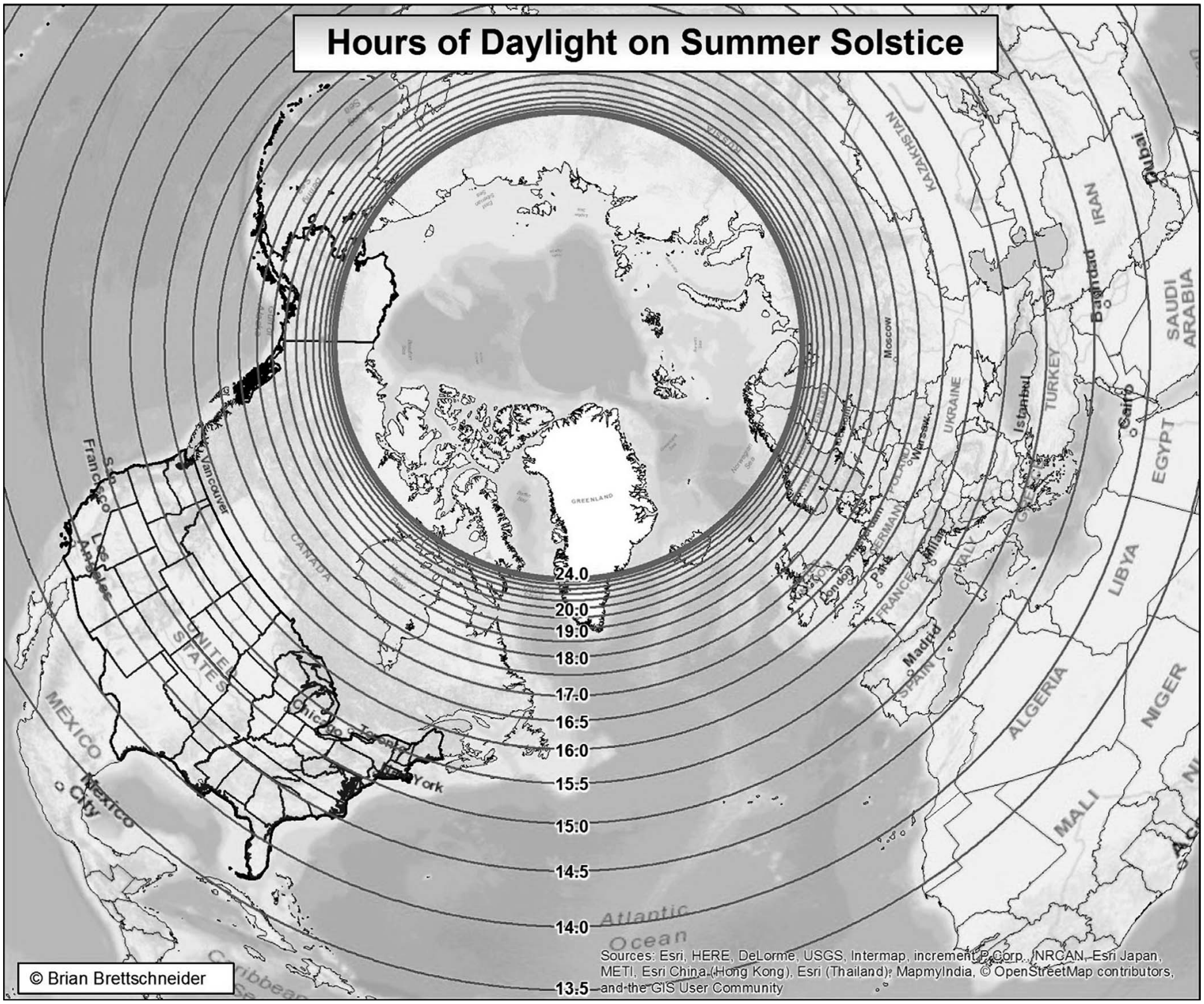

Figure 11. Concentric circles indicate places with hours of daylight on summer solstice (Brian B's Climate Blog, 2017).

stronger in the new climatology). In the Nordic Seas, pathways and features such as the Lofoten Vortex are definitely better resolved (*e.g.*, AOML NOAA, 2017; Laurindo, Mariano, and Lumpkin, 2017). The near surface velocities of the oceanic current, around a latitude of 65° and close to the archipelago Vega, increase during the transitional period of autumn to winter, in relation to the transitional period summer to autumn (see Figure 15). Obviously for this reason, the colonists waited until autumn to continue their journey faster, aided by these currents, in this difficult and cold region of the planet.

It should also be mentioned that during the season of the journey (summer to autumn), the sea-ice area is not expected to have changed considerably between 13th century BC and First century AD compared to modern era (see Figure 12 and Table 2 in Renssen *et al*. [2005]).

Ships from the northern coasts of Norway following the Spitsbergen current to the Svalbard Islands (Figure 16a) enter to the East Greenland current (Figure 16b). Sailing near the southern coasts of Greenland, they approach the stream of the Gulf of Labrador (Figure 16c), which leads them to the northern coasts of Newfoundland Island, the final destination of the colonists/settlers. The total interval from Norway to Newfoundland is 6430 km (Figure 17), a duration of 48 days taking in to account the velocity as 3 knots. But the favorable current velocity estimated on average to 30 cm/s (1080 m/h) adding to the ship's velocity, leads to shortening the trip to about 31 days.

It is worth mentioning that Vikings considered as the first Europeans colonists embarked in Newfoundland around AD 1000, established a settlement there currently called the Gulf of Meadows (L'Anse aux Meadows), and followed an almost

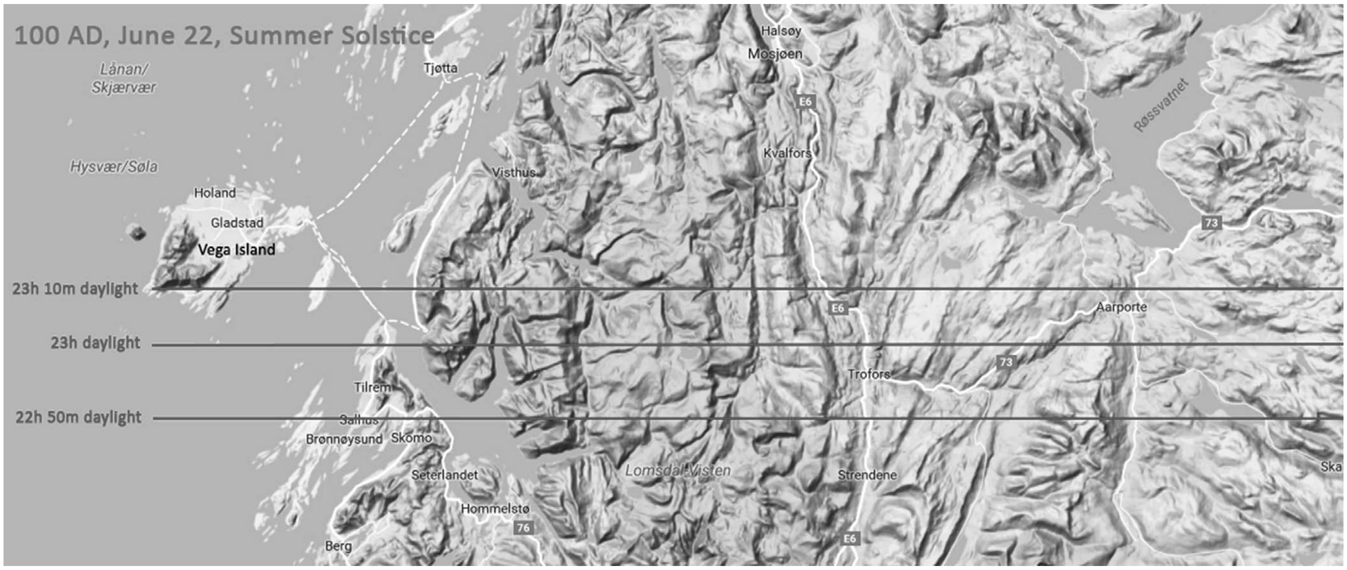

Figure 12. Archipelagos Vega off Norwegian coasts with daylight duration per latitude for AD 100 summer solstice. Dotted line indicates possible sea routes following the currents.

similar sea route coming from Norway, Iceland, and Greenland (see the Saga of Erik the Red [Sephton, 1880] and the Saga of the Greenlanders [Kunz, 2000]).

In conclusion, assuming that the preparations for this journey are signaled on AD 20 April 56, when Saturn (Cronus) enters the Taurus constellation, and lasted 1 year, this trip started in the spring of AD 57 and reached Norway in the summer solstice of the same year. They settled there until autumn and then following the sea-current path of the North Atlantic current arrived at the island of Newfoundland in the Gulf of St. Lawrence (Canada) in October–November of AD 57. Through the respective preparations for the return trip, the return journey started in the autumn of AD 58, after the date when Cronus pulls out of the Taurus constellation (AD 8 July 58).

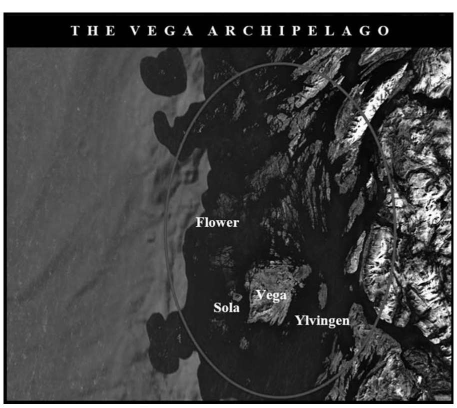

Figure 13. The Vega archipelago in Norway (Vega Archipelago, 2017).

The Return Trip

At any rate, the path of the return trip could not be similar with that one described earlier. The direction of the North Atlantic Ocean currents is opposed to the direction sailing from America to Europe, and hence an encumbrance on the returning trip with ships. Therefore, with the same rationale

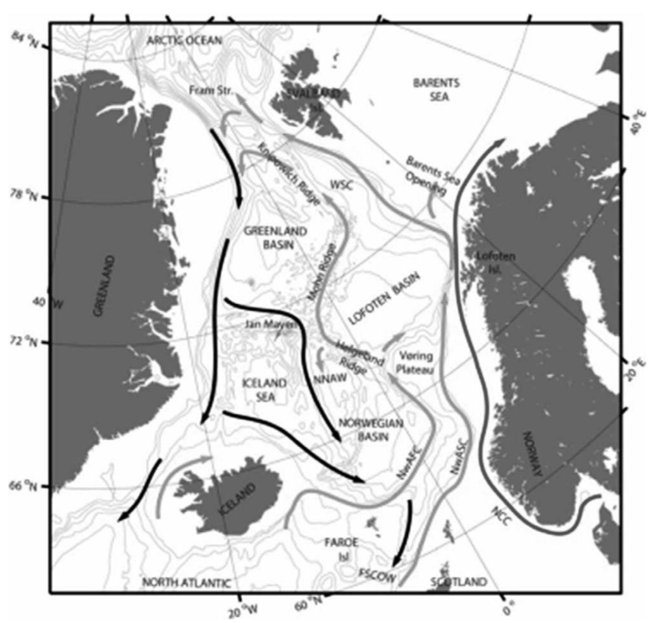

Figure 14. The major water pathways in the Nordic Seas. The warm inflowing Atlantic water (NWASC) is moving northward, while the cold and dense overflow waters are moving southward. The Norwegian Coastal Current (NCC) is represented by the northward arrow (Raj *et al.*, 2015).

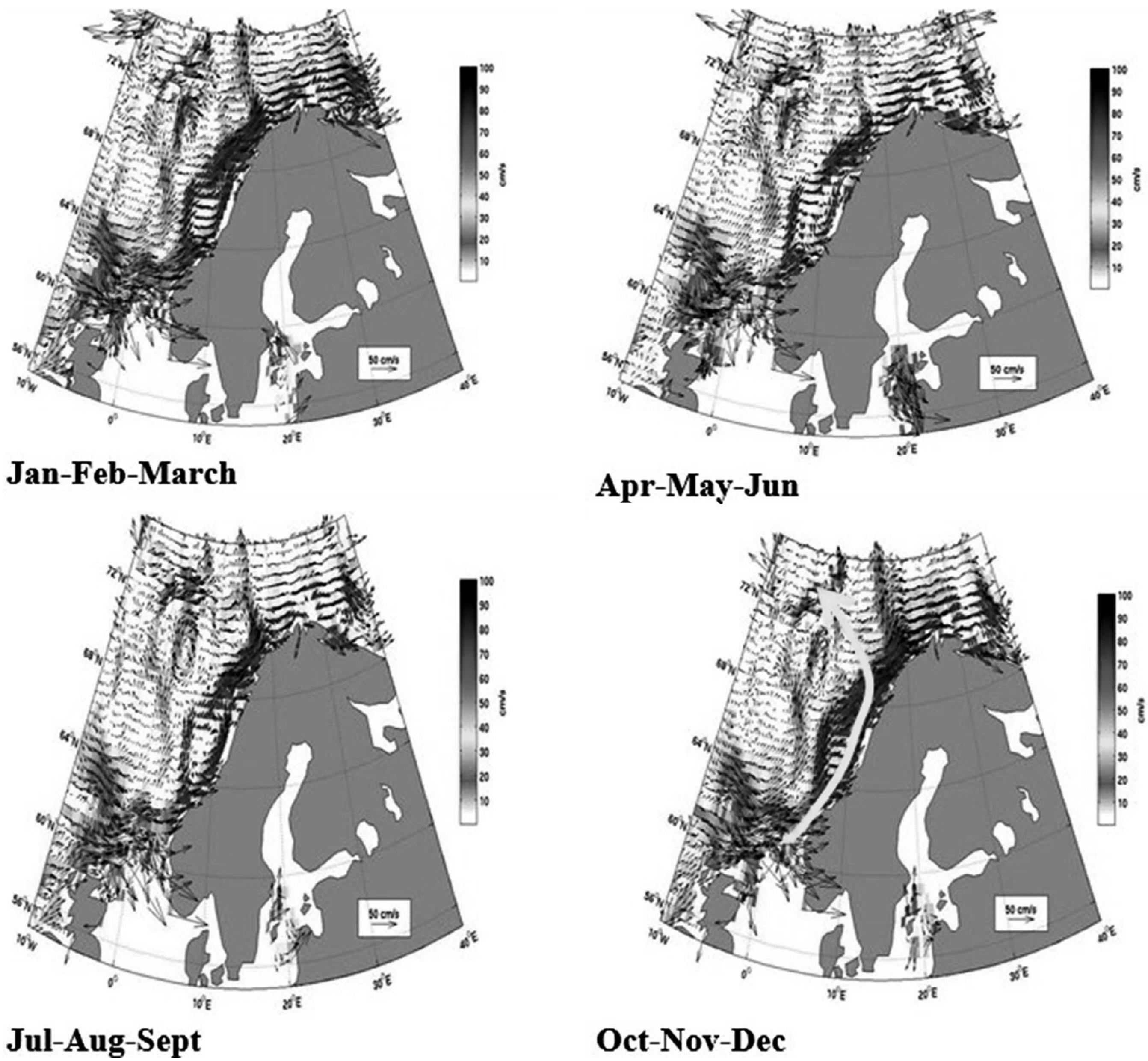

Figure 15. Seasonal variation of near-surface sea-current velocities in the area of the Norwegian coastal current (Laurindo, Mariano, and Lumpkin, 2017; Lumpkin and Johnson, 2013). The grayscale bar indicates the surface speed of currents (in cm/s). The highest speeds are shown with darker color. (AOML NOAA, 2017). We notice that the Norwegian current is faster in autumn (see darker colors). This current coming from the coasts of Norway is heading NW toward Svalbard Islands (see upward, light arrow; see also Figure 14).

of using sea currents and winds, following the favorable sea currents, the return trip from Newfoundland headed on southward in order to meet the Atlantic Gulf Stream (the Slope Jet current) that commences from the Mexican Gulf (Figure 18) and flows to the Atlantic Ocean.

They cover a distance of about 1184 km in order to meet the Slope Jet current and a distance of about 1236 km southward within the Slope Jet (Figure 18). During the autumn, the velocity of these currents is ~20 cm/s and 40 cm/s, respectively, that is, on average 30 cm/s (1080 m/h). For a ship velocity of 3 knots, this is augmented by the currents by about 1 km. Consequently, the total distance of 2420 km is covered in about 12 days.

Sailing with this current, they go ahead to the central Atlantic Ocean, where the Gulf Stream *is split* in 43° N, 45° W (see also Figure 9, Figure 16c, and Figure 18): one toward Ireland and Britain (North Atlantic Drift) and the other toward Portugal and Gibraltar (Azores current). It is imperative that *they must have known this* and chose the one toward Azores current, probably via some markers, most likely certain stars/ constellations.

Figure 19 shows that from the Slope Jet branch, following a southern direction, they meet Azores current in a distance of 245 km. This small distance is covered with a velocity of 3 knots in about 3 days. But the Azores current extant to about 3482 km in the Atlantic Ocean going from west to the east (Figure 19), and it has a high velocity about 70 cm/s (2520 m/h) in autumn. If the ship had a velocity of 3 knots and it is increased by about 2.5 km/h because of the current speed, this distance is made in about 11–12 days. Thus, the trip of 6147 km from Newfoundland to Gibraltar lasted 25–30 days. Subsequently, following the same path as in the departure in the Mediterranean Sea (duration about 30 days), they arrived at the *large island*, which was their return destination.

A critical phase in this return trip is the correct choice of the direction along the sea currents of the Atlantic Ocean to drive them toward Gibraltar but not Scandinavia. Specifically, the selection of the right branching path of the Slope Jet current at 43° N, 45° W drives them E-SE and not northward. Recalling from earlier literature (but later times, too) that the orientation of ancient sailors was based on the solar orbit during the day and bright stars and/or constellations during the night, it is of interest to inspect the autumnal night sky in the aforesaid geographical coordinates for AD 58 using the Starry Night program (Starry Night User's Guide, 2006). Arbitrarily 3 September is chosen, observing the sky night between the sunset and the next day sunrise. Along the passing of time (in hours), the following sky observations are made regarding *markers* comprising bright stars and constellations and other sky geometrical configurations.

At 2030 while the Sun is setting, the well-known summer triangle appears, comprising the three brightest stars of three constellations: Vega (Lyra), Deneb (Cygnus), and Altair (Aquila, Eagle). In the NE, the bright star named Capella of Auriga constellation rises.

At 2300 in the eastern sky, Aldebaran (of Taurus constellation) rises. Consequently, these two bright stars (Capella and Aldebaran) show the eastern direction, while the northern side is marked by the always visible polar star (Polaris) of Ursus Minor.

At 0100, the bright stars of the Orion constellation start rising from the east (*i.e*. Betelguese, Bellatrix, *etc*.) together with the bright stars Castor and Pollux of the Gemini constellation. At any rate, the summer triangle always predominates in the skyscape (Figure 20 for 3 September 00.00).

At 0200, more bright stars of the Orion constellation rise from the east, *e.g*., Rigel that appears above the SE horizon, and at the same time Procyon of the Canis Minor constellation, which is the forerunner of the brightest star, Sirius, which rises also.

At 0400, Sirius of the Canis Major constellation has risen at the low SE horizon while Vega starts to set, and Regulus of the Leo constellation rises in the E-NE. It becomes evident that the *correct* sea path should have direction toward Sirius and not Regulus (Figure 21 for 3 September 0400).

Therefore, making use of celestial bodies well known to Greeks since Mycenaean times, the Greek sailors could travel safely and explore distant lands. Such practice has been followed by latter generations; hence the previously described marine journey, together with associated oceanographic details in Plutarch's *De Facie* (1960), acquires a solid base and is proven correct.

DISCUSSION

Based on the working hypotheses, the assumptions are elaborated against a speculative attribution. Taking on literature and historical account and applying scientific tools encourages the possible "speculation" to be interpreted. Obviously, the plausibility must be grounded to scientific facts; albeit tangible evidence is missing, at any rate the supportive arguments derive from an interdisciplinary approach. Archaeoastronomy is scientific, but oceanography, spherical geometry, and astronomy are also scientific and support the narration. Albeit coincidental and too good to be true, it still provides a scientific, but not mainly speculative, vehicle to unfold and decipher some ancient literature.

The total solar eclipse referred to in the text has been much elaborated and attributed to AD 5 Jan 75. The archaeological evidence from the locations/places determined by the research and following Plutarch's dialogue on Norway and St. Lawrence is lacking, if any. It is worth noting, however, the reminiscent ancient cultural elements in northern Europe from Greece and the documented data regarding the possible trip from the late Bronze age down to Classical times and Hellenistic/Roman times, implying possible interactions via a long trade/exploration paths.

The Norwegian linguist scholar Kjell Aartun (1997) is one, according to whom mysterious letters and ship images of the period from 1800 to 1000 BC had been carved in granite in the Kongsberg region of Oslo. These letters, deciphered as Minoan stone carvings, (petroglyphs) are to be found on both sides of the Norwegian/Swedish border in the Norwegian county of Oestfold and the Swedish county of Bohuslan. Kristiansen and Larsson (2005) report the discovery of objects that could be classified as archaeological findings that in the Bronze Age an advanced culture had suddenly arisen in the southern Scandinavian countries with clear influence from the countries of the Aegean, first the Minoans, later also the Mycenaeans and the classical Greeks. The researchers concluded that it was most likely not only that the areas were visited by people from the south but also that the population had visited the southern countries over a period that lasted about 1000 years (northern landers called hyperboreans are often quoted by ancient literature).

Bioarchaeological research reported that the ancient Minoan DNA was most similar to populations from western and northern Europe. The population showed particular genetic affinities with Bronze Age populations from Sardinia and Iberia and Neolithic samples from Scandinavia and France. Hughey *et al*. (2013) produced evidence of sharing of Minoan haplotypes with modern and ancient populations. Genetic affinity was shown for modern Cretans and Minoans with Neolithic and modern European populations. The Minoan mtDNA haplotypes resembled those of the European popula-

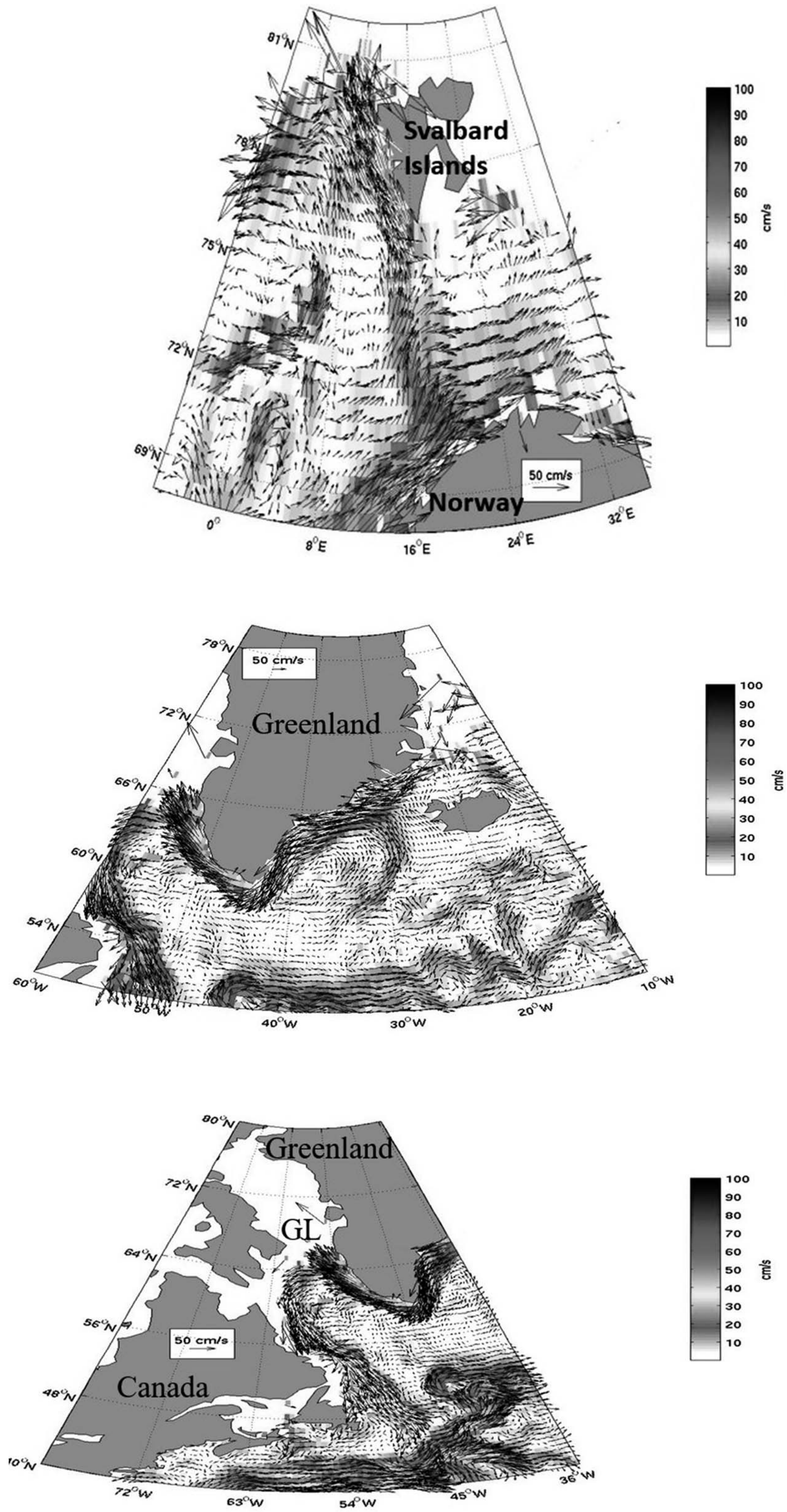

Figure 16. The surface speed of the North Atlantic currents in autumn. The grayscale bar indicates the surface speed of currents (in cm/s). The highest speeds are shown in with 60-100 cm/s in scale. (top) Spitsbergen current: Ships from the northern coasts of Norway following the Spitsbergen current (the direction of intense black arrows) are heading to the Svalbard Islands (74–81° N, 10–35° E). (middle) East and West Greenland currents: From Svalbard Islands, they enter to the

tions and considerably Scandinavians with four out of the top 10 nearest neighbours to the Minoans applying Principal Component Analysis. Indeed, enough Minoan genetic material was found in Southern Scandinavia to support the theories of *Rise of Bronze Age Society* by Kristiansen and Larsson (2005).

Trips to beyond the Hercules Pillars (Gibraltar) and north Atlantic ocean trips are mentioned by several ancient sources, especially about *Pytheas* (Diodorus Siculus [1933] of Sicily's history, Strabo [1887] *Geographica* Book II.4.1, II.4.2, Pliny's Natural History, Herodotus) (Pearson, 1954). In particular, *Pytheas Massiliensis* (fourth century BC) was a Greek geographer, astronomer, and explorer from the Greek colony of Massalia. He was the first Greek to visit and to describe the British Isles and the Atlantic coast of Europe. Though his principal work, *On the Ocean*, is lost, something is known of his ventures through the Greek historian *Polybius* (*c*. 200–*c*. 118 BC) (Encyclopædia Britannica, 2017). The descriptions of such trips beyond Gibraltar may seem extraordinary, but as Sarton (1993) quotes, Pytheas's fate was comparable to that of Marco Polo in later times; some of the things that they told were so extraordinary, so contrary to common experience, that wise and prudent men could not believe them and concluded that the descriptions were fables.

First millennium BC trips in the sense of sailing around have been reported by ancient Greek sources. For example, the *periplus* is a manuscript document that lists the ports and coastal landmarks (in order and with approximate intervening distances) that the captain of a vessel could expect to find along a shore (Kish, 1978). It served the same purpose as the later Roman *itinerarium o*f road stops; however, the Greek navigators added various notes, which if they were professional geographers (as many were) became part of their own additions to Greek geography. In that sense, the *periplus* was a type of log. The form of the *periplus* is at least as old as the earliest Greek historian, the Ionian *Hecataeus of Miletus* c. 550 BC–c. 476 BC (Herodotus, 1932, VI.137). The works of Herodotus and Thucydides contain passages that appear to have been based on *peripli* (Shahar, 2004).

Regarding the accuracies of estimated velocities in the previous text, uncertainties are incurred that depend on the conditions pertained (wind strength and direction, sea-current speed and eddies, rowing sessions and rowing system, number of complete/incomplete crew), and the speed could vary between 2–9 knots. Experimental trials on a Trireme evaluate maximum and sustained speed of 14 knots (25 km/h) and 7.5 knots (14 km/h), respectively (Cotterell and Kamminga, 1992, pp. 257–258). Sea trials of the experimental trireme *Olympias* demonstrated that 4–5 knots was normal in decent conditions (Hellenic Navy, 2017; Krivec, 2016, p. 1; Morrison, Coates, and Rankov, 2000, p. 263). When the information is taken as true, an average velocity is estimated and then compared to speed from ancient sources

Figure 17. The going and returning sea route of the colonists in the Atlantic Ocean starting from the shores of Norway, reaching Newfoundland Island, and then crossing again the Atlantic Ocean, reaching Gibraltar.

(Lipke, 2012, p. 14–15; Morrison *et al*., 2000, p. 263–264; Lipke, 1992; Shaw, 1993, p. 40; Taylor, 2012, p. 52; Tilley, 2012, p. 196).

Estimates may also be inferred from two historical sources. One is by Xenophon (*Anabasis* 6.4.2), who mentions a long day's voyage of 236 km (127 nautical miles) from Byzantium to Heraclea Pontica, which has been interpreted to mean two full-crew rowing sessions of about 8 hours each with a meal break (Morrison, Coates, and Rankov, 2000, p. 103; Wallinga, 2012, p. 152), yielding an average rowing speed of about 8 knots; however, if the long day were interpreted as closer to 24 hours, the speed estimate would be lower. The most frequently quoted account (Cotterell and Kamminga, 1992, p. 257; Pain, 2007) is from Thucydides' *History of the Peloponnesian War* (Crawley, 2004). It describes how during the Mytilene revolt of 427 BC, two triremes were dispatched from Athens to Mytilene, a distance of 345 km (185 nautical miles), on successive days. The first was sent with orders to quell harshly the rebellion (Crawley, 2004, 3.36.3) and with crew rowing slowly in light of the orders (3.49.4). The second was sent to countermand the orders and with crew rowing as fast as they could, without stopping, taking turns sleeping, and encouraged by incentives offered by Mytilenian representatives on board (Crawley, 2004, 3.49.3).

About accurate measurements of distance, surveying, and even more spherical (polar) triangles and latitude and longitude, the achievements of first millennium BC ancient Greek philosophers, mathematicians, and astronomers (Euclides, Hipparchus, Menelaus of Alexandria, Eratosthenes,

←
East Greenland current above Iceland and then to the West Greenland current (the direction of intense black arrows). These currents sail near the Greenland Island (64.17° N, 51.72° W) from east to west. (bottom) Gulf of Labrador current: Sailing near the southern coasts of Greenland Island, they approach the stream of the Gulf of Labrador (GL) (61° N, 56° W), which leads them (the direction of intense black arrows driving from north to south, near the Canadian coast) to the northern coasts of Newfoundland Island (49° N, 56° W) (Laurindo, Mariano, and Lumpkin, 2017; Lumpkin and Johnson, 2013; see also, AOML NOAA, 2017; http://oceancurrents.rsmas.miami.edu/atlantic/img_gosv_seasonal.php).

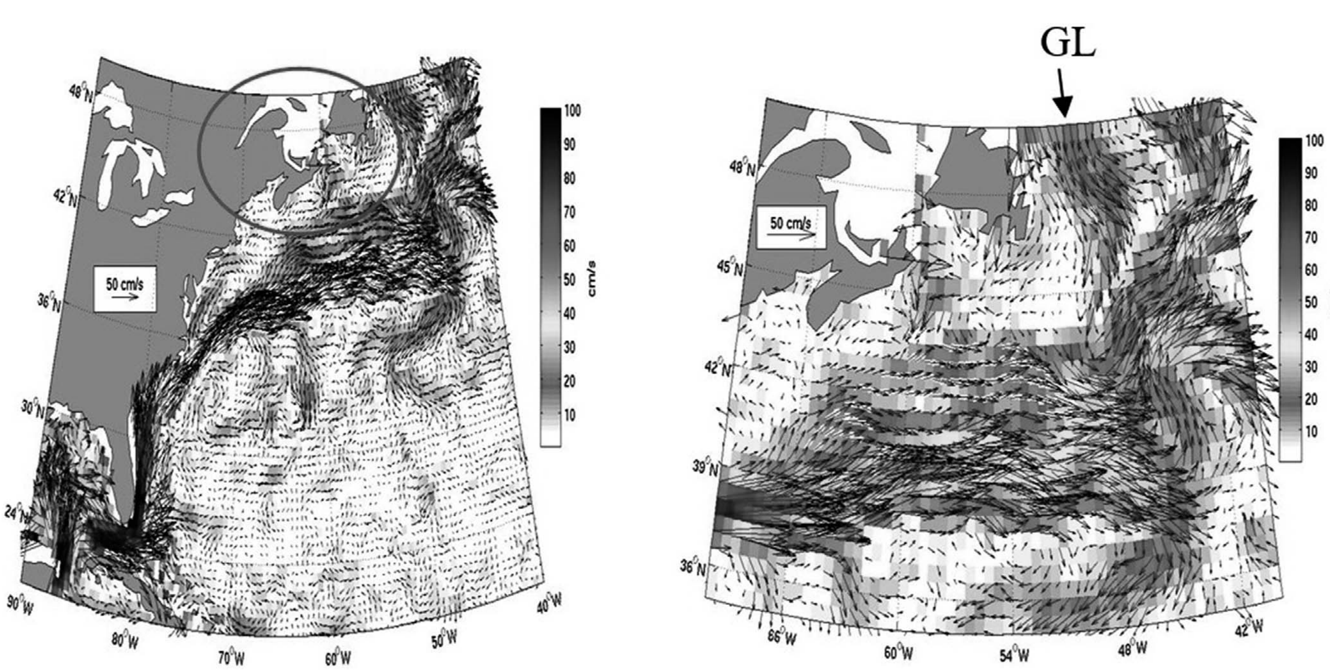

Figure 18. Left: The Atlantic Gulf Stream moves northern and passes south of Newfoundland Island (the direction of intense black arrows). Right: The zooming of the southern direction of the Stream of the Gulf of Labrador (GL) that encounters the Gulf Stream (the branch of Slope Jet). The color bar indicates the surface speed of currents (in cm/s). The highest speeds are shown in a darker shade (Laurindo, Mariano, and Lumpkin, 2017; Lumpkin and Johnson, 2013; see also, AOML NOAA, 2017; http://oceancurrents.rsmas.miami.edu/atlantic/img_gosv_seasonal.php). The ships from Newfoundland Island (49° N, 56° W) are heading south and entering in the Slope Jet current (the direction of intense wave of arrows in the right figure), which initially has a west-to-east direction. However, this current is branched out at 43° N, 45° W. One branch is heading NE, and the other branch is heading SE.

Ptolemy, to mention but a few) are well known, as well as relevant knowledge from ancient Egypt and Babylonia (Brummelen, 2013; Lewis, 2001). Eratosthenes (c. 276 BC–c. 195/194 BC) was best known for being the first person to calculate the circumference of the Earth, which he did by applying a measuring system using stadia, a standard unit of measure during that time period. His calculation was remarkably accurate. He, among others, was also the first to calculate the tilt of the Earth's axis (again with remarkable accuracy) and created the first map of the world, incorporating parallels and meridians based on the available geographic knowledge of his era (Roller, 2010).

Returning to the possibility and capacity of crossing open seas along coasts and nearer lands, it is known that the crossing of the north Atlantic has been made by Vikings much later *ca*. AD 1000 (Nydal, 1989) and before Columbus, in a favorable also climatic optimum during the Medieval warm period (AD 950–1250) (Mann, 2002). Prominent peak visibility from the Viking Path has been investigated by using Opentopomap and Freemaptool's Horizonfinder. Many prominent peaks are visible at great distances offshore all along the assumed trial trip and following coasts, perfectly suited for discovering new land. The longest unguided stretch is between the Faroe's island and Iceland and would take roughly 10 hours under favorable conditions (182 km at 10 knots). If the high probability of mirages in arctic waters and the fact that the longships had lengths comparable to triremes of c. 37 m and masts up to 16 m high (obtained from plethora of art images and later constructions) is taken into account, extending a visual range of 15 km in either direction, it is quite possible that they could see land through the entire journey with favorable conditions. The Greek

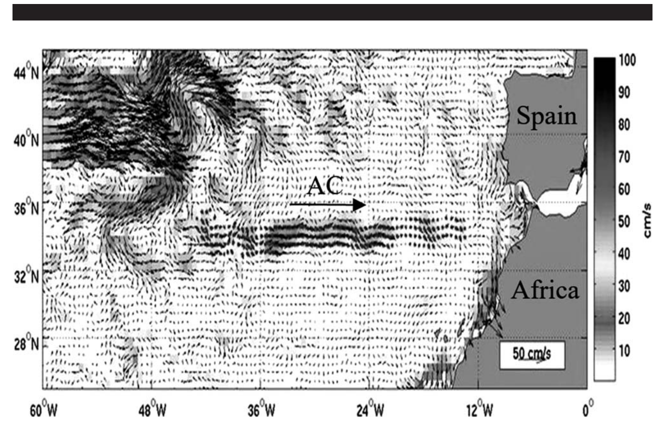

Figure 19. The surface speed of Azores current during the autumn. The color bar indicates the surface speed of currents (in cm/s). The highest speeds are in darker shades (Laurindo, Mariano, and Lumpkin, 2017; Lumpkin and Johnson, 2013; see also, AOML NOAA, 2017; http://oceancurrents.rsmas.miami.edu/atlantic/img_gosv_seasonal.php). The ships from the Slope Jet branch (see the direction of intense arrows in upper left corner) following a southern direction encounter Azores current (AC, the direction of intense dark arrows), which crosses the Atlantic Ocean from a west-to-east direction, approaching the Gibraltar.

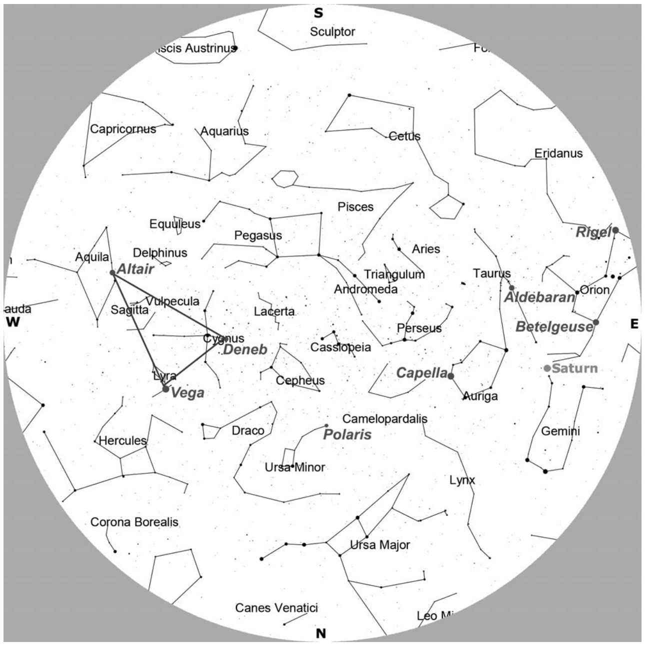

Figure 20. The sky map at 43° N, 45° W on 3 September AD 58 at 0000. The clearly observable bright stars are marked with a larger size lettering. The summer triangle between the bright stars Vega-Altair-Deneb is drawn to ease observation of the image.

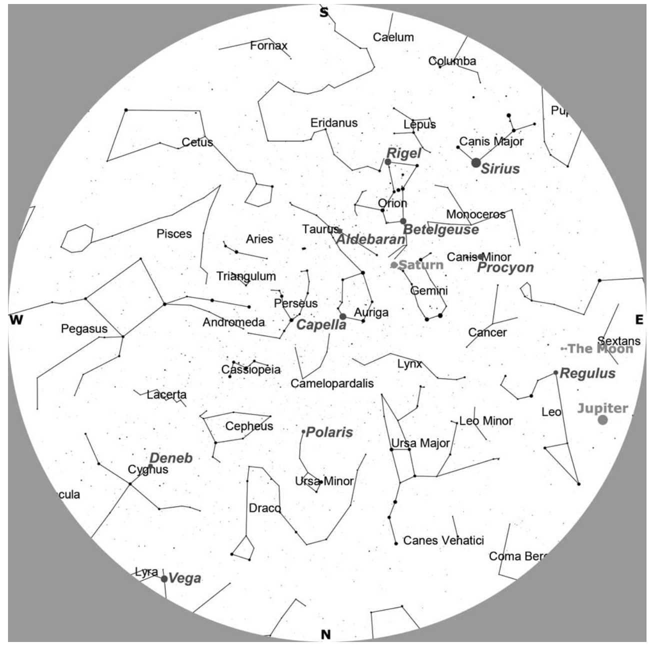

Figure 21. The sky map at 43° N, 45° W on 3 September of AD 58 at 0400. The clearly observable bright stars are marked with a larger size lettering. The appearance of the Moon (26 days, Waning Crescent, with –10.3 magnitude) does not prevent observation of the bright stars. The brightest star of the sky, Sirius, is well observable in the SE.

colony referred to in the text is provisionally accepted because the narration is supposedly followed (a working hypothesis).

The important point and aim of the present article is that when science is applied, it provides a plausible answer. Other opinions against the unfolded thesis are in favor of a skeptical view, but naive rejection and negation of any workable and elaborate treatment remain an option but overwhelmingly most theoretically unfounded and naturally speculative.

The surprising and extraordinary significant knowledge in the first millennium BC is in mathematics, engineering, and astronomy, but maritime advancement is a commonly accepted view by scholars, reinforcing the plausibility of exploration of distant oceans and lands by ancient Greeks at least during the first millennium BC; that is our thesis. The Greek maritime network in the Mediterranean and beyond is being discussed (Malkin, 2011), which illuminates the knowledge of the construction of seagoing vessels and the organization of maritime expeditions (Günsenin, 2012). Thus, the lack of tangible archaeological records precludes hitherto admitting knowledge about the making of a sea journey far distant, the scientific analysis of presented information by Plutarch may withstand, as highly possible.

Here this written historical report is tried and tested and finally coined scientific (and not mythical). It is based on narrated sources (geographical, environmental, astronomical) and is critically assessed; accreditation is given to proven elements that validate the true against false information provided. The distances and time of journey is tried based on facts regarding speed of triremes and sea currents, provided in the scientific literature.

In regard to questioning Plutach as a reliable source: Plutarch never claimed to be writing history, which he distinguished from biography (Kuiper, 2014). His aim was to delight and edify the reader, and he did not conceal his own sympathies, which were especially evident in his warm admiration for the words and deeds of Spartan kings and generals. Plutarch's perennial charm and popularity arise in part from his treatment of specific human problems in which he avoids raising disquieting solutions. Historians and biographers in the 16th and 17th centuries followed Plutarch in treating character on ethical principles.

In his *Parallel Lives*, the general scheme was to give the birth, youth, and character, achievements, and circumstances of death, interspersed with frequent ethical reflections; however, the details varied with both the subject and the available sources, which include anecdote mongers and writers of memoirs as well as historians. This provides a sense about Plutarch, and the fact is that international scholars cite Plutarch in historical themes also, especially during the Roman era (Scardigli, 1995).

Moreover, in Plutarch's other books, one may find adequate description of events and observations and does not miss referring to the past sources. Even in his description of the Moon's face and more, he is accurate and questions phenomena in a critical manner. For example, in his *obsolescence* of oracles, he speaks of the emanating gases under Pythia's tripod in *adyton* (confined room) and avoids the holy miracle of god

Apollo speaking through Pythia but promotes the common sense that the priestess was speaking herself. Via this vapor exhalation, the divinatory current aids prophetic faculty. At any rate, although French archaeologists who excavated Delphi refused to admit the existence of gases at the back of the Temple, scientists in late 1990s proved the existence of hydrocarbons emerging along with springs of ethene, ethylene, and methane coming from active seismic faults with imposing frenzy on Pythia (de Boer, Hale, and Chanton, 2001; Hale *et al.*, 2003). Thus, the priestesses of the oracle of Apollo at Delphi were intoxicated on emitted gaseous fumes as a result of geological processes. Hence, the historical/archaeological evidence on which any gaseous vent hypothesis must rest is re-examined.

That ancient Greeks made it to Scandinavia and the New World at present is not supported by archaeology yet, but the potentiality of such a hypothesis has been modeled by arguments and the reaffirmation of astronomical, geographical, and oceanographical factors.

CONCLUSION

Plutarch's dialogue about an ancient ceremonial trip to the northern Atlantic Ocean region every 30 years has been approached by astronomy, oceanography, and geography theories. It has been shown that the meeting of the colleagues and friends is chronologically determined, making use of a total solar eclipse that was identified to be AD 75 (5 January), among nine others during the first century AD, and the gathering occurred a few months later (specified in the dialogue), say, during the spring or summer. The stranger that told the story to Sulla had returned from the great continent of the mission, in which he had arrived there in AD 26 and returned in AD 56–58, specifically after the entrance of the planet Saturn to the Taurus constellation in April AD 56 (Plutarch, 1960).

Following the narration, the voyage to the arctic region was reconstructed, and the place where the mission settled for three summer months is hypothetically identified, somewhere in the Vega Archipelago islands off Norway or some Norwegian coastal site, where Greeks supposedly were living. There the reported "midnight sun" refers to the high latitude of Archipelago where night is less than 1 hour.

Following Norwegian Sea currents and the Gulf Stream, the mission reached the great continent identified with North America. Then, similar lengthy preparations made for the return journey that brought him (and his companion) back to the homeland approximately during AD 58–60 following the next 30-year trip of AD 56. According to the present investigation, he reached Carthage approximately around AD 62–65 and met with Sulla around AD 67–73.

The trip back home has been shown to follow the Gulf Stream, the Slope Jet current, the Azores sea current, and bright stars; the latter were well-known celestial objects since prehistoric times by Greek Myceneans and Minoans and well recorded and used in later times of Archaic, Classical, and Hellenistic/ Roman times. These sky markers take them to the E-SE direction that leads to Iberia and Gibraltar via the Azores sea current to finally enter the Mediterranean Sea.

According to the text, this stranger should have been Greek, and the colonists–settlers are also Greeks. The stranger served God Saturn and had been taught astronomy, geometry, and topics related to the study of nature. All information provided has been reconstructed and simulated via modern scientific tools.

Despite its eclectic mixture of rational inquiry and deliberate fantasy, the particular dialogue investigated here, which refers to the solar eclipse and details of the mysterious journey, possesses an intrinsic unity that is essential to the evolution and presentation of its scientific conclusion, mostly verified with current knowledge. Its inherent geographical and astronomical interest ultimately derives from the synthesis of this descriptive narration, and the dialogue contains rich detail and fertile ideas pertinent to geography, oceanography and archaeoastronomy.

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LITERATURE CITED

Aartun, K., 1997. *Die Minoische Schrift: Sprache und Texte*. Wiesbaden: Harassowitz, 893p.

Adler, M., 1910. Zwei Beiträge zum plutarchischen Dialog "De Facie in Orbe Lunae." *Jahresbericht des K. K. Staatsgymnasiums in Nikolsburg*, 1909–1910 Nikolsburg, 1910.

Atlantic Oceanographic and Meteorological Laboratory and National Oceanic and Atmospheric Administration (AOML NOAA). http://www.aoml.noaa.gov/phod/dac/dac_meanvel.php.

Brian B's Climate Blog. http://us-climate.blogspot.gr/.

Brummelen, G.V., 2013. *Heavenly Mathematics: The Forgotten Art of Spherical Trigonometry*. Princeton, NJ/Oxford: Princeton University Press, 208p.

Castro Belen, M., 2015. A historical review of the Egyptian calendars: The development of time measurement in ancient Egypt from Nabta Playa to the Ptolemies. *Scientific Culture*, 1(3), 15–27.

Cherniss, H., 1951. Notes on Plutarch's *Moralia. Classical Philology, Volume XLVI*. Cambridge, Massachusetts: Harvard University Press, pp. 137–158.

Cherniss, H. and Helmbold, W., 1957. *Plutarch's Moralia, Volume XII* (edited and translated in English). Cambridge, Massachusetts: Harvard University Press, 590p.

Coones, P., 1983. The geographical significance of Plutarch's dialogue, concerning the *Face Which Appears in the Orb of the Moon*. *Transactions of the Institute of British Geographers*, 8(3), 361–372.

Cornerstone Capital Resources, Inc. http://www.nafinance.com/Listed_Co/English/Cgp_e.htm.

Cotterell, B. and Kamminga, J., 1992. *Mechanics of Pre-industrial Technology—An Introduction to the Mechanics of Ancient and Traditional Material Culture*. Cambridge: Cambridge University Press, 344p.

Crawley, R., 2004. *Thucydides: History of the Peloponnesian War* (translation). Mineola, New York: Dover Publications, 432p.

de Boer, J.Z.; Hale, J.R., and Chanton, J.P., 2001. New evidence for the geological origins of the ancient Delphic oracle. *Geology*, 29, 707–710.

Diodorus Siculus, 1933. *Bibliotheca Historica,* edited by Vogel, F. and Fischer, K.T. Leipzig: Teubner, 560p.

Dittenberger, W. 1915–1924. *Sylloge inscriptionum graecorum*. 4 volumes. Leipzig, Germany: S. Hirzel, 780p.

Dreyer, J.L.E., 1906. *History of the Planetary Systems from Thales to Kepler*. Cambridge: Cambridge University Press, 454p.

Encyclopædia Britannica. *Pytheas*. https://www.britannica.com/biography/Pytheas.

Espenak, F. and Meeus, J., 2006. *Five Millennium Canon of Solar Eclipses: –1999 to +3000*. NASA Technical Publication TP-2006-214141.

Espenak, F. and Meeus, J., 2009. *Five Millennium Catalog of Solar Eclipses: –1999 to +3000*. NASA Technical Publication TP-2009-214174.

Ginzel, F.K., 1899. *Spezieller Kanon der Sonnen- und Mondfinsternisse für das Ländergebiet der klassischen Altertumswissenschaft*. Berlin: Mayer and Müller, 271p.

Geological Survey of Canada. *Mineral commodities of Newfoundland and Labrador zinc and lead*. http://www.nr.gov.nl.ca/nr/mines/investments/Zinc%20and%20Lead.pdf.

Goodwin, W.W. 1878. *Plutarch's Morals*. Boston: Little, Brown, and Co.

Günsenin, N. (ed.), 2012. Between continents. *Proceedings of the Twelfth Symposium on Boat and Ship Archaeology* (Istanbul 2009, Ege Yayinlari Istanbul), pp. 325–329.

Hale, J.R.; de Boer, J.Z.; Chanton, J.P., and Spiller, H.A., 2003. Questioning the Delphic oracle. *Scientific American*, 289(2), 66–73.

Hannah, R., 2015. The roles of observational astronomy in ancient Greece. *Scientific Culture*, 1(2), 47–56.

Hellenic Navy. 2017. *Trireme OLYMPIAS*. http://www.hellenicnavy.gr/en/history-tradition/ships-museum-exhibits/trireme-olympias.

Herodotus, 1932. *Historiae*, edited by Legrand, P.E. Paris: Les Belles Lettres.

Hirzel, R., 1895. *Der Dialog: Ein literarhistorischer Versuch*. Leipzig, Germany: S. Hirzel, 1086p.

Homer, 1995. *Odyssey*. Oxford: Harvard University Press, 448p.

Horizonfinder. https://www.freemaptools.com/find-horizon.htm.

Hughey, J.R.; Paschou, P.; Drineas, P.; Mastropaolo, D.; Lotakis, D.M.; Navas, P.A.; Michalodimitrakis, M.; Stamatoyannopoulos, J.A., and Stamatoyannopoulos, G., 2013. A European population in Minoan Bronze Age Crete. *Nature Communications*, 4, 1861.

IFISC. http://ifisc.uib-csic.es/LINCschool/Sources/2-THC/from-EPS131/2-RAPID/gulf_stream.php.html.

Jones, C.P., 1971. *Plutarch and Rome*. Oxford: Oxford University Press, 158p.

Kish, G., 1978. *A Source Book in Geography*. Cambridge: Harvard University Press, 21p.

Kristiansen, K. and Larsson, T., 2005. *The Rise of Bronze Age Society*. Cambridge: Cambridge University Press, 464p.

Krivec, R., 2016. Rowing times from Athens to Mytilene: Implications of misreading Thucydides for 5th-century Greek trireme speed. *The International Journal of Nautical Archaeology*, 45(1), 199–201.

Kuiper, K., ed., 2014. *Classical Authors 500BC to 1100CE*. New York : Britannica Educational Publications, 328p.

Kunz, K. 2000. The sagas of the Greenlanders and Erik the Red's saga. *In:* Smiley, J. (ed.), *The Sagas of the Icelanders*. London: Penguin, 759p.

Lamberton, R., 2001. *Plutarch*. New Haven: Yale University Press, 218p.

Laurindo, L.; Mariano, A., and Lumpkin, R., 2017. An improved near-surface velocity climatology for the global ocean from drifter observations. *Deep-Sea Research I*, 124, 73–92.

Lewis, M.J.T., 2001. *Surveying Instruments of Greece and Rome*. Cambridge, UK: Cambridge University Press, 389p.

Liddell, H.G. and Scott, R., 1940. *A Greek-English Lexicon. Revised and Augmented throughout by Sir Henry Stuart Jones*. With the assistance of Roderick McKenzie. Oxford: Clarendon. http://myria.math.aegean.gr/lds/web/index.php.

Lipke, P., 2012. Olympias 1992. Trials report. *In:* Rankov, B. (ed.), *Trireme Olympias: The Final Report*. Oxford: Oxbow, pp. 11–39.

Liritzis, I.; Bousoulegka, E.; Nyquist, A.; Belen, C.; Alotaibi, F.M., and Drivaliari, A., 2017. New evidence from archaeoastronomy on Apollo oracles and Apollo-Asclepius related cult. *Journal of Cultural Heritage* 26, 129–143.

Liritzis, I. and Coucouzeli, A., 2007. Ancient Greek heliocentric views hidden from prevailing beliefs? *Studies in History and Philosophy of Science*, 11(1), 39–49.

Littman, M.; Espenak, F., and Wilcox, K., 2008. *Totality: Eclipses of the Sun*. Oxford: Oxford University Press, pp. 18–19.

Lumpkin, R. and Johnson, G.C., 2013. Global ocean surface velocities from drifters: Mean, variance, El Niño-Southern Oscillation response, and seasonal cycle. *Journal of Geophysical Research: Oceans,* 118(6), 2992–3006.

Magli, G., 2016. *Archaeoastronomy. Introduction to the Science of Stars and Stones*. Cham, Switzerland: Springer, 260p.

Malkin, I., 2011. *A Small Greek World: Networks in the Ancient*. New York: Oxford University Press, 304p.

Mann, M.E., 2002. Medieval climatic optimum. *In:* MacCracken, M.C. and Perry, J.S. (eds.), *The Earth System: Physical and Chemical Dimensions of Global Environmental Change,* Volume 1. *In:* Munn, T. (ed.), *Encyclopedia of Global Environmental Change*. Chichester: John Wiley & Sons, pp. 514–516.

Mariolakos, I.D., 2010. The forgotten geographic and physical–oceanographic knowledge of the prehistoric Greeks. *Bulletin of the Geological Society of Greece, Proceedings of the 12th International Congress* (Patras), May 2010, pp. 92–104.

Martin, H., 1974. Plutarch's *De facie*: The recapitulations and the lost beginning. *GRBS*, 15(1), 73–88.

Morrison, J.S.; Coates, J.F., and Rankov, N.B., 2000. *The Athenian Trireme: The History and Reconstruction of an Ancient Greek Warship*, 2nd edition. Cambridge: Cambridge University Press, 348p.

National Aeronautics and Space Administration (NASA), 2017. *ModelE AR5 simulations: Past climate change and future climate predictions*. https://data.giss.nasa.gov/ar5/srvernal.html.

NASA. *NASA eclipse web site*. https://eclipse.gsfc.nasa.gov/SEcatmax/SEcatmax.html.

Nydal, R., 1989. A critical review of radiocarbon dating of a Norse settlement at L'Anse aux Meadows, Newfoundland, Canada. *Radiocarbon* 31, 976–985.

Pain, S., 2007. When men were gods. *New Scientist*, 193(2590), 46–47.

Pearson, L., 1954. Review of Hans Joachim Mette, *Pytheas von Massalia* (Berlin: Gruyter) 1952. *Classical Philology*, 49(3), 212–214.

Perseus Digital Library. http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A2008.01.0357#note7.

Plutarch, 1926. *Otho*. *In:* Perrin, B. (ed.), *Plutarch's Lives*, Volume 11. Cambridge, Massachusetts: Harvard University Press, 512p.

Plutarch, 1929. *De defectu oraculorum*. *In:* Sieveking, W. (ed.), *Plutarch Moralia*, Volume 3. Leipzig: Teubner, 602p.

Plutarch, 1936. *An seni respublica gerenda sit* (783b–797f). *In:* Fowler, H.N. (ed.), *Plutarch's Moralia*, Volume 10. Cambridge, Massachusetts: Harvard University Press, 512p.

Plutarch, 1960. *De facie in orbe lunae* (920b–945e) (0007: 126). *In:* Pohlenz, M. (ed.), *Plutarchi Moralia*, Volume 5.3, 2nd edition (translated by Bill Thayer). Leipzig: Teubner, 516p.

Prickard, A., 1911. *Plutarch on the Face which Appears on the Orb of the Moon. Translation and Notes, with Appendix*. Winchester: Warren and Son; London: Simpkin and Co, Stationers Hall Court, 92p.

Ptolemaeus, C., 1898. *Syntaxis mathematica*. *In:* Heiberg, J.L. (ed.), *Claudii Ptolemaei opera quae exstant omnia,* Volumes 1.1–1.2. Leipzig: Teubner, 549p.

Raj, R.P.; Leon Chafik, J.; Even, Ø.; Nilsen, J.; Eldevik, T., and Halo, I., 2015. The Lofoten vortex of the Nordic Seas. Deep-sea research part I. *Oceanographic Research Papers*, 96, 1–14.

Renssen, H.; Goosse, H.; Fichefet, T.; Brovkin, V.; Driesschaert, E., and Wolk, F., 2005. Simulating the Holocene climate evolution at northern high latitudes using a coupled atmosphere-sea ice-ocean-vegetation model. *Climate Dynamics*, 24(1), 23–43.

Roller, D.W., 2010. *Eratosthenes' Geography*. Princeton, New Jersey: Princeton University Press, 320p.

Rosen, E., 2003. *Kepler's Somnium. The Dream or Posthumous Work on Lunar Astronomy*. Mineola, New York: Dover, 288p.

Sandbach, F.H., 1929. The date of the eclipse in Plutarch's *De facie*. *The Classical Quarterly*, 23(1), 15–16.

Sarton, G., 1993. *Ancient Science through the Golden Age of Greece*. New York: Courier Dover, 646p.

Scardigli, B., 1995. *Essays in Plutarch's Lives*. Oxford: Clarendon, 403p.

Sephton, J, trans. *The Saga of Erik the Red*. http://sagadb.org/eiriks_saga_rauda.en.

Shahar, Y., 2004. *Josephus Geographicus: The Classical Context of Geography in Josephus. Mohr Siebeck*. Tubingen, Germany, 305p.

Shaw, T., 1993. The voyage and speed trials. *In:* Shaw, T. (ed.), *The Trireme Project, Operational Experience 1987–1990, Lessons Learnt*. Oxford: Oxford University Press, pp. 39–47.

Solar Topo. *Day Length, Sunrise and Sunset Calculator*. http://www.solartopo.com/daylength.htm.

Stadter, P.A., 2014a. Plutarch in context–Plutarch and Rome. *In:* Beck, M. (ed.), *A Companion to Plutarch*. Oxford: Blackwell, pp. 13–31.

Stadter, P.A., 2014b. *Plutarch and His Roman Readers*. Oxford, UK: Oxford University Press, 440p.

Starry Night User's Guide, 2006. Imaginova Corp., Toronto, Canada.

Stephenson, F.R. and Fatoohi, L.J., 1998. The total solar eclipse described by Plutarch. *Histos*, 2, 72–82.

Strabo, 1887. *Geographica*, edited by Meineke, A. Leipzig: Teubner, 531p.

Taylor, A., 2012. The slow trireme experience in Olympias in 1994 *Trireme Olympias:* The Final Report. Sea Trials 1992-4, Conference Papers 1998. Oxford: Oxbow, pp. 50–57.

Tihon, A., 1999. Theon of Alexandria and Ptolemy's handy tables. *In:* Swerdlow, N.M. (ed.), *Ancient Astronomy and Celestial Divination*. Cambridge, Massachusetts: MIT Press, 359p.

Tilley, A., 2012. Some recent publications on ancient warships. *International Journal of Nautical Archaeology*, 41.1, 194–197.

Theon Gramm., 1867. *Testimonia, De Theone grammatico eiusque reliquiis*, edited by Giese, K. Dresden: Diss.

Vega Archipelago. http://www.thesalmons.org/lynn/norscan10.jpg.

Wallinga, H., 2012. Xenophon on the speed of triremes. *In:* Rankov, B. (ed.), *Trireme Olympias: The Final Report*. Oxford: Oxbow, pp. 152–154.

Whewell, W., 1887. *History of Inductive Sciences,* 3rd edition. New York: N Appleton, 622p.

Xavier Jubier. *Five millennium (–1999 to +3000) canon of solar eclipses database*. http://xjubier.free.fr/en/site_pages/solar_eclipses/5MCSE/xSE_Five_Millennium_Canon.html.

Xenophon, 1904. *Anabasis*, edited by Marchant, E.C. Oxford: Clarendon, 272p.