Supplementary Data: Historical documentary evidence of volcanism in 79, 536-37, 626-627, 939 CE						
Date	**Source Number**	**Author and/or source**	**Rank †**	**Translation**	**References**	**Notes**
Event 1, Consensus Date, 536-537, Age Marker						
536-537	1	*The Chronicle of Pseudo-Zachariah Rhetor*	A	The whole city was disturbed, and the earth with all that is upon it shook at the arrival of Agapetus [Pope Agapetus I arrived in Constantinople, March 536]. The sun began to become dark at daytime, and the moon by night, while the ocean was stormy with spray [alternatively: clouded by spray] from the 24th of the same month of this year [March, 536] until the 24th of June of the following [indiction] year fifteen [537] … The winter was [so] harsh that from the unusual amount of snow the winged creatures perished, and ... [from here there are lacunae in the manuscript] there was affliction ... that people in ... from awful things and ... not in each place that they were exposed to it.	*The Chronicle of Pseudo-Zachariah Rhetor*, Geoffrey Greatrex, ed., R.R. Phenix & C.B. Horn, trans., (Liverpool, 2011), p. 370.	
Uncertain: 534, 536 or 537	2	*Letter of Magnus Aurelius Cassiodorus Senator to Ambrosius, his Deputy*	B	How strange it is, I ask you, to see the principal star [the Sun], and not its usual brightness; to gaze on the moon, glory of the night, at its full, but shorn of its natural splendour? All of us are still observing, as it were, a blue-coloured sun; we marvel at bodies which cast no mid-day shadow, and at that strength of intensest heat reaching extreme and dull tepidity. And this has not happened in the momentary loss of an eclipse, but has assuredly been going on equally through almost the entire year… Hence it is that, for so long, the rays of the stars have been darkened with an unusual colour; that the harvester dreads the novel cold; that the fruits have hardened with the passage of time; that the grapes are bitter in their old age.	*Selected Variae of Magnus Aurelius Cassiodorus Senator*, S.J.B. Barnish, trans. (Liverpool, 1992), p. 180.	The descriptions of these phenomena are those of an eyewitness, but the letter was not dated and historians have variously estimated its date of composition to 534, 536, or 537.
536-537	3	Procopius, *Wars*	A	And it came about during this year that a most dread portent took place. For the sun gave forth its light without brightness, like the moon, during this whole year, and it seemed exceedingly like the sun in eclipse, for the beams it shed were not clear nor such as it is accustomed to shed. And from the time when this thing happened men were free neither from war nor pestilence nor any other thing leading to death. And it was the time when Justinian was in the tenth year of his reign [1 August 536 – 31 July 537].	Procopius, *History of the Wars*, H.B. Dewing, trans. (Harvard, 1916), 4.14.	

535-536	4	John Lydos, *On Portents*	A	If the sun becomes dim because the air is dense from rising moisture - as happened in the course of the recently passed fourteenth indiction [535/536] for nearly a whole year, when Belisarios held the consular office so that the produce was destroyed because of the bad time - it predicts heavy trouble in Europe. And this we have seen from the events themselves, when many wars broke out in the west and that tyranny was dissolved, while India, and the Persian realm, and whatever dry land lies toward the rising sun, were not troubled at all. And it was not even likely that those regions would be affected by the calamity because it was in Europe that the moisture in question evaporated and gathered into clouds dimming the light of the sun so that it did not come into our sight or pierce this dense substance.	Excerpt from John Lydos, *On Portents*, Antti Arjava trans., 'The Mystery Cloud of 536 CE in the Mediterranean Sources', *Dumbarton Oaks Papers*, 59 (2005), 73 – 94, here p. 80.	This source leaves open (but is not confirmation of) the possibility of volcanic atmospheric effects beginning in 535 CE.
536-537	5	Michael the Syrian	B	In the year 848 [536/537] there was a sign in the sun the like of which had never been seen and reported before in the world. If we had not found it recorded in the majority of proved and credible writings and confirmed by trustworthy people, we would not have recorded it; for it is difficult to conceive. So it is said that the sun became dark and its darkness lasted for one-and-a-half years, that is, eighteen months. Each day it shone for about four hours, and still this light was only a feeble shadow. Everyone declared that the sun would never recover its original light. The fruits did not ripen, and the wine tasted like sour grapes.	Michael the Syrian, *Chronicle*, J.B. Chabot, ed. and trans., 2 (Paris, 1899 – 1910), pp. 220 – 221.	Late twelfth century sources, but reliable transmitter of earlier lost texts.
536-537	6	Bar Hebraeus	B	And in the year eight hundred and forty-eight [AG = 536/537 CE] there was a sign in the sun the like of which had never before appeared. The sun became dark and his darkness lasted for eighteen months. Each day the middle of heaven shone faintly with a shadowy light, and every man decided that [the Sun] would never recover its full light. That year the fruits did not ripen and the wine tasted like urine.	*The Chronography of Bar Hebraeus*, E.A. Wallis Budge, trans., 1 (Oxford, 1932), pp. 74 –75.	Late thirteenth century, but broadly reliable transmitter of lost texts.

Event 2, Consensus Date, 626-627, Age Marker						
626-627	1	Theophilus of Edessa	B	There was an eclipse of the sun and it lasted from October [626] until June [627], that is, for nine months. Half of its disc was eclipsed and the other half not; only a little of its light was visible. There was an eclipse of the sun and stars were visible in the daytime.	*Theophilus of Edessa's Chronicle*, R. G. Hoyland, trans. (Liverpool, 2011), p. 73.	Lost eyewitness source, reconstructed from Agapius of Manbij, *Kitab al-'Unwaiv* [A. A. Vasiliev ed., 'Kitab al-'Unvan, histoire universelle ecrite par Agapius (Mahboub) de Menbidj', Part 2.2, *Patrologia Orientalis*, 8 (1912), 399 -547] and Michael the Syrian [Michael the Syrian, *Chronicle*, J. B. Chabot, ed. and trans., 2 (Paris, 1899 – 1910).] Note, the second sentence of this record likely refers to the solar eclipse of 21 April 627, visible as partial across much of the Middle East, whereas the phenomenon described in the first sentence is clearly too long to be an eclipse. Both phenomena are likely conflated in the source because of their thematic similarity [see Event 3 for similar].
627-628	2	Bar Hebraeus	C	And in the sixth year of the Arabs a portion of the hemisphere of the sun departed, and there was darkness from the month of the First Teshrin [October 627] till the month of Haziran [June 628]. [It lasted so long] that men used to say that the sphere of the sun would never become whole and perfect again. And the *zanta,* that is to say the sickness of the *shar'ata* tumour, broke out in Palestine, and tens of thousands of men died of the disease.	*The Chronography of Bar Hebraeus*, E.A. Wallis Budge, trans., 1 (Oxford, 1932), p. 90.	Late thirteenth century, but broadly reliable transmitter of lost texts. Clearly derived from Theophilus, Bar Hebraeus offers more detail, but a date that is one year in advance of Theophilus.
624	3	*Annales Cambriae A*	C	The sun was obscured.	*Annales Cambriae: a translation of Harleian 3859; PRO E.164/1; Cottonian Domitian, A 1; Exeter Cathedral Library MS. 3514 and MS Exchequer DB Neath, PRO E*, P. M. Remfry, trans. (Castle Studies Research and Publishing, 2007), p. 46.	Tenth-century Welsh source containing earlier material. The modern editor, P. M. Remfry, believes the date to be inaccurately transmitted, correcting the manuscript's 624 to 627.

623 (uncorrected AD/CE equivalent supplied by McCarthy (2005) - see Notes)	4	*Annals of Tigernach*	B	A dark year.	*The Annals of Tigernach*, trans. Gearóid Mac Niocaill (Cork, 2010). http://www.ucc.ie/celt/published/T100002A/index.html (Accessed 8 September 2014).	High-medieval Irish source that generally faithfully incorporates earlier eyewitness records, though with chronological errors in the seventh century. We follow Daniel McCarthy's systematic and independently verified corrections to the chronology of Irish annalistic texts, which place this event in 627 CE. [See Daniel McCarthy, 'Chronological synchronisation of the Irish Annals', 4th edition, (2005), www.cs.tcd.ie/misc/kronos/chronology/synchronisms/Edition_4/K_trad/K_synch.htm (accessed 8 September 2014).]
624 (uncorrected manuscript AD/CE year)	5	*Annals of Ulster*	B	A dark year.	*The Annals of Ulster to A.D. 1131*, ed. & trans. Sean Mac Airt and Gearóid Mac Niocaill (Dublin, 1983), p. 113.	Late-fifteenth to early-sixteenth-century Irish compilation of many early sources, including eyewitnesses. Known to be generally reliable in incorporating earlier sources, but with chronological errors for the seventh century. We follow McCarthy's corrections (ibid.) in placing this event in 627 CE.
626 (AD/CE equivalent date supplied by modern editor)	6	*Annals of Inisfallen*	D	Eclipse of the sun.	*The Annals of Inisfallen,* ed. & trans., Sean Mac Airt. (Dublin, 1944), p. 87.	High-medieval Irish source, with frequently unreliable chronology in earlier centuries. This source also often severely abbreviates and emends early material. In the present case, it is highly likely that the scribe has misunderstood the report of a dark year as found in earlier sources (and faithfully preserved in the *Annals of Tigernach* and *Annals of Ulster*), inferring that it describes a solar eclipse, though none was visible in Ireland in 626 or 627.

Event 3, Consensus Date, 939, Age Marker						
938 and/or 939	1	*Annales Casinates*	A	In the twelfth indiction [1 September 938 – 31 August 939], the thirteenth day from the end of July [19 July], day six [Friday], day 29 of the lunar month, the sun was eclipsed from the third hour all the way up to nearly the fifth hour. We observed the sun: it did not have any strength, brightness, nor heat. Indeed, we saw the sky and its colour changed, as if flushed. And others said that the sun was seen as if halved.	*Annales Casinates*, Monumenta Germaniae Historica, Scriptores, ed. G.H. Pertz 3 (Hannover, 1839), p. 172. Trans. for this paper by Conor Kostick.	This entry was mistakenly listed under 938 in the manuscript, but the cited indiction year (i.e. the 12th indiction) is correct for September 938 to August 939. The eclipse details as given in the first sentence are precise for the solar eclipse as visible from Monte Cassino, Italy, on 19 July 939. It is not certain whether the second sentence represents a continued description of the solar eclipse, or whether it is a different phenomenon that has been conflated because of its thematic similarity to the eclipse. It possesses many hallmarks of a volcanic dust-veil (e.g. the sun's lack of strength and heat, and a reddened sky). Alternatively, the colourful description may reflect the spectacle of a deep eclipse further enhanced by atmospheric volcanic aerosols.
939	2	*Chronicon Scotorum*	B	The sun was the colour of blood from the beginning of day to midday on the following day.	*Chronicon Scotorum*, William M. Hennessy & Gearóid Mac Niocaill, ed. & trans. (Cork, 2010). http://www.ucc.ie/celt/published/T100016/index.html (Accessed 8 September 2014)	Seventeenth-century Irish source, but with unique content from earlier and now-lost sources. This event, too extended to be a solar eclipse, has been widely considered an observation of Eldgjá's (Iceland) volcanic plume or dust-veil, and is reliably dated to 939. [See Francis Ludlow *et al.*, 'Medieval Irish chronicles reveal persistent volcanic forcing of severe winter cold events, 431-1649 CE', *Environmental Research Letters*, 8 (2013), doi:10.1088/1748-9326/8/2/024035, and references therein.]

933	3	*Mageoghagan's Book*, or *Annals of Clonmacnoise*	C	The sun for one day appeared like blood until noon the next day.	*The Annals of Clonmacnoise, being Annals of Ireland from the earliest period to A.D. 1408, translated into English A.D. 1627 by Conell Mageoghagan and now for the first time printed*, Dennis Murphy, ed. (Dublin, 1896).	Seventeenth-century Irish source that often amends and elaborates upon the content of earlier sources from which it draws. R. B. Stothers ['Far Reach of the Tenth Century Eldgjá Eruption, Iceland', *Climatic Change*, 39 (1998), 715 – 726] uses the 933 date from this source in support of an earlier eruption date for Eldgjá. However, the source has an unreliable chronology for the first millennium CE, and can be shown to have a systematic off-set of 6 years at this time [see Daniel McCarthy, 'Irish chronicles and their chronology', (2005). www.cs.tcd.ie/misc/kronos/chronology/synchronisms/annals-chron.htm (Accessed 8 September 2014).] Stothers does not note the later and reliable date of 939 (above) from the *Chronicon Scotorum*.

Uncertain: Before July 936, if read verbatim.	4	Widukind of Corvey, *The Deeds of the Saxons*	B	In this year, [941] certain portents appeared, namely comets. For they could be seen from the fifteenth Kalends of November [18 October] all the way up to the Kalends themselves [1 November]. Many people were terrified by these sights, they were dreading either a great pestilence or at any rate a change in royal power. For certain portents were revealed before the passing of King Henry [Henry I, the Fowler, 2 July 936], such as that while outside even though no cloudy tail covered it, the brilliance of the sun failed to appear but inside, that a red colour like blood poured through the windows of houses. The mount also, where the remains of the lord of things [Possibly Úlfljótr, the founder, lawgiver, and first lawspeaker of the united Icelandic Parliament, see R.B. Stothers, 'Far Reach of the Tenth Century Eldgjá Eruption, Iceland', *Climatic Change*, 39 (1998), 715 – 726, here p. 719] are buried, according to rumour, vomited many flames in that region. Furthermore, the left hand of a certain man having been cut off by the sword, almost a year later it was completely restored as he was sleeping, as a sign of this miracle a bloody line was noted at the place of the join. But there were comets and a great flood, and a cattle pestilence followed the flood.	Widukind of Corvey, *The Deeds of the Saxons*, Monumenta Germaniae Historica, Scriptores, ed. G.H. Pertz 3 (Hannover, 1839), II.32. Trans. for this paper by Conor Kostick.	R. B. Stothers [ibid.] argues that the dim sun occurs before 936, also drawing for support upon ice core dates that place an eruption in the early 930s. But doubt exists regarding Widukind's dating of this event, because it clearly suits his purpose to make a failing sun (and other ominous phenomena) act as a portent of the death of King Henry I.
Miscellaneous, 79 CE, Age Marker for GICC05 Chronology						
79	1	Cassius Dio, *Roman History*	B	An inconceivable quantity of ashes was blown out, which covered both sea and land and filled all the air. It wrought much injury of various kinds, as chance befell, to men and farms and cattle, and in particular it destroyed all fish and birds. Furthermore, it buried two entire cities, Herculaneum and Pompeii, the latter place while its populace was seated in the theatre. Indeed, the amount of dust, taken all together, was so great that some of it reached Africa and Syria and Egypt, and it also reached Rome, filling the air overhead and darkening the sun.	Greek text at Marie-Laure Freyburger-Galland, 'Les phénomènes volcaniques chez Dion Cassius' in Eric Foulon, ed. *Connaissance et représentations des volcans dans l'antiquité: actes du colloque de Clermont-Ferrand 2002* (Clermont-Ferrand, 2004), pp. 139 – 157, here p. 144. English translation at http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Cassius_Dio/66*.html (Accessed 25 August 2014).	This historical observation is cited as evidence of a significant southeasterly component in ash dispersal of the 79 CE eruption. [See also G. Rolandi *et al*., 'The 79 AD eruption of Somma: The relationship between the date of the eruption and the southeast tephra dispersion', *Journal of Volcanology and Geothermal Research*, 169 (2007), 87-98.] Note also: The relevant books of Cassius Dio, (66, 21, 1-24, 3) are only available through an epitome, that by the Byzantine monk Joannes Xiphilinus, Constantinople, c. 1075.

† *Source reliability ranking*	*Rationale*
A	Eyewitness or contemporary with a reliable chronology.
B	Eyewitness or contemporary but with some chronological uncertainty. Or: Neither eyewitness nor contemporary but has a reliable chronology and/or accurately conveys the information from earlier works.
C	Eyewitness or contemporary but with evidence of errors or fabrications. Or: Neither eyewitness nor contemporary and with an unreliable chronology.
D	Neither eyewitness nor contemporary and with evidence of errors or fabrication.

Supplementary Data. Historical documentary evidence of volcanic dust veils, pre-536 CE

Date (BCE/CE)	*Summary*	*Rank*	*Sources and/or authors*	*Regions*	*References*
255 BCE	Disk of the sun resembles moon	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1989)
247	Disk of the sun resembles moon, also multiple incidence of haze and mist, and dense mist [1]	*Possible*	Astronomical dairies	Babylonia	Sachs & Hunger (1989)
231	Disk of the sun resembles moon, multiple observations	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1989)
221	Disk of the sun resembles moon	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1989)
217	Sun's disk contracted/diminished; additionally: the sun fights/struggles with the moon [2]	*Possible*	Livy 22.1.9-10	Mediterranean	Stothers (2002)
212	Sun's disk unusually red, like the color of blood	Probable	Livy 25.7.8	Mediterranean	Stothers (2002)
208	Stars fade/invisible for three months	Probable	*Table of dynastic records* (cf. Pang, 1991)	North China	Pang *et al.* (1987), Stothers (2002)
203	Disk of the sun resembles moon; also, mist and haze cover sky, and solar halo	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1989)
200	Sun's disk appears reddened	Probable	Livy 31.12.5	Mediterranean	Stothers (2002)
183	Disk of the sun resembles moon	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1989)
164	Disk of the sun resembles moon; also "billowing" solar and lunar halos, and multiple (non-billowing) solar halos	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1996)
161	Disk of the sun resembles moon	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1996)
147	Coloured rings surround sun	Probable	Obsequens	Mediterranean	Schlesinger (1959)
145 to 144	Recurring redness over eastern and western skies, September to October [145 BCE]; later, billowing halo (solar/lunar) and further solar and lunar halos [all in 145 BCE]. Reddened skies over Babylon, July to August [144 BCE]	Probable	Astronomical diaries	Babylonia	Stothers (2002), Sachs & Hunger (1996)
141	Disk of the sun resembles moon, multiple observations; also, multiple incidence of billowing solar and lunar halos	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1996)
137	Disk of the sun resembles moon, multiple observations; also, haze, multiple observations, and solar halo	Probable	Astronomical dairies	Babylonia	Sachs & Hunger (1996)
125 to 124	Billowing solar halo, also multiple billowing lunar halos, and lunar halo, dense haze and mist [3]	*Possible*	Astronomical dairies	Babylonia	Sachs & Hunger (1996)
121	A sky bow surrounds the Sun	*Possible* [4]	Pliny the Elder 2.29 [5]	Mediterranean	Stothers (2002)
90	A red ring surrounds the Sun	Probable	Pliny the Elder 2.29 [5]	Mediterranean	Stothers (2002)
84	Repeated incidence of dense haze & mist [6]	*Possible*	Astronomical dairies	Babylonia	Sachs & Hunger (1996)

44 to 42	Prolongued eclipse of the Sun, almost a year's continuous gloom (Mediterranean); Pale blue sun, casting no shadows (China)	Probable	Mediterranean summary from Pliny the Elder 2.30 [7]; Chinese summary from Han-Shu	Mediterranean, China	Forsyth (1988), Yau *et al.* (1988), Bicknell (1993), Stothers (2002), Oppenheimer (2011)
32	Orange sky, darkness in daytime	Probable	Han-Shu	China	Yau *et al.* (1988)
14 CE	Sun was completely eclipsed [8]	*Possible*	Cassius Dio 56.29.3 & others (see Stothers (2002))	Mediterranean	Stothers (2002)
188	Orange (reddish-yellow) solar disk	Probable	Hou-Han-Shu, Zhi	China	Yau *et al.* (1988)
300	Yellow fog covers the Sun [9]	*Possible*	Song Shu Wu Xing Zhi	China	Wittman & Xu (1987)
308	Sun concealed by dark yellow vapour	Probable	Jin-Shu, Zhi	China	Wittman & Xu (1987)
311	Sunlight discolored red and also anything it illuminates	Probable	Jin-Shu, Zhi	China	Yau *et al.* (1988)
352	Solar disk discolored red	Probable	Chin-Shu	China	Yau *et al.* (1988)
360	Dark mist obscures sky, sun disappears from dawn to noon [10]	*Possible*	Ammianus Marcellinus 20.3.1	Mediterranean or Middle East	McCormick *et al.* (2012)
416 and/or 417	Darkness during the day [11]	Probable	Marcellinus Comes	Mediterranean	Croke (1995), McCormick *et al.* (2012)
499	Sun dispossessed of light at dawn, disk like silver, without brilliance, can be gazed on without harm; phenomenon continues to eighth hour [12]	Probable	Summary from *Chronicle of Pseudo-Joshua Stylite*	Mediterranean	Witakowski (1996), Tombley & Watt (2000), McCormick *et al.* (2012)
501	Sun red and dim, or without brilliance	Probable	Wei-Shu	North China	Wittman & Xu (1987), Yau *et al.* (1988)

NOTES

[1] The relatively rare reports that characterize (in Babylonian astronomical diaries) the disk of the sun as resembling that of the moon, indicating diminished light and a discolored solar disk, are generally taken as probable indications of high-altitude dust or aerosol layers. In this year, 247 BCE, it is also reported that red sand fell from the sky. High-altitude non-volcanic dust may explain (or have additionally contributed to) the rare characterization of the sun this year. We thus rank a volcanic dust-veil this year as Possible, rather than Probable (see Methods).

[2] Uncertainty exists over whether this event can be explained by a partial solar eclipse on 11 February 217 BCE, visible widely in the Mediterranean region (Stothers, 2002). While Livy's description of the sun struggling with the moon is reminiscent of a solar eclipse, Livy in fact reports this separately to his description of a diminished sun (a point not noted by Stothers (2002)), and which is more reminiscent of a volcanic dust veil. Given that both events may well be distinct, we include the latter in our list, but assign it a rank of Possible, only.

[3] Solar halos are common in Babylonian astronomical diaries. While some may in fact be volcanic solar coronae (i.e. Bishop's Rings), their description in the diaries rarely allows discrimination. By contrast, solar haloes described as "billowing" are less common. With a notable confluence of additional halos, "dense" haze and mist this year, we consider this sufficient evidence for increased atmospheric turbidity consistent with volcanic atmospheric aerosol presence, meriting inclusion in our list with a rank of Possible, spanning 125 to 124 BCE.

[4] We rank this "sky bow" as Possible because the lack a reference to the colour of the bow leaves open the possibility that it may be a solar halo rather than corona.

[5] Stothers (2002) cites these observations (at 121 and 90 BCE) as found in Book 2, Chapter 98 of Pliny the Elder's *Historia Naturalis*. However, both are correctly found in Book 2, Chapter 29 (i.e. Pliny 2.29).

[6] Haze and mist are often reported in Babylonian astronomical diaries, which is expected given the frequent aridity of the region (present-day Iraq). Thus, such reports do not alone merit inclusion as a validation point. However, for this year (84 BCE) haze and mist (often specifically characterized as "dense") are exceptionally persistent. We take this as indicative of a dry fog or dust-veil, but rank it Possible only.

[7] An extensive literature is available on this dust veil, which is likely to have lasted from 44 to 42 BCE. See literature cited in References column, above.

[8] As Stothers (2002) notes, there is no total solar eclipse for 14 CE in the presumed Mediterranean region of recording that can explain this observation. However, as Stother's further notes, this event may be an allegorical omen of August Caesar's death this year. The event's fabrication cannot be proven, however, and should not be simply assumed. We thus include this event but rank it Possible, only.
[9] This event's description is not fully certain. Wittman & Xu (1987) translate it as: "There was a Sun's fighting, and yellow fog covered all around". The sun's fighting may refer to an eclipse or sunspot, which can be more easily observed when the sun is veiled by high-altitude dust or aerosol and are thus often associated with volcanic dust-veils (Scuderi, 1990). The reference to yellow fog is also notable. We rank this event as Possible.
[10] No solar eclipse occurred for 360 CE in the Mediterranean region. An eclipse occurred further east, visible from central present-day Iraq and eastward into the Pacific (Espenak & Meeus, 2006). Because Ammianus Marcellinus, a major Roman historian, is unlikely to have witnessed this eclipse himself, and because of the incompatibility of many aspects of Ammianus's description with a solar eclipse, the event has generated considerable debate. Scholars have advanced theories concerning communication networks available to Ammianus, his location at the date of the eclipse, and the historical reliability of his reporting (see, e.g., Barnes (1998) and references therein). Few appear to have considered that this report may incorporate genuine aspects of a volcanic dust-veil observation, consistent with much of the description. We thus include the event, ranked Possible.
[11] Marcellinus simply reports that "there was darkness during the day". This stands in marked contrast to his explicit and verifiably correct (see Espenak & Meeus (2006)) report of a solar eclipse occurring in 418 CE, thereby leaving open the nature and duration of the phenomena described here. Moreover, no appropriate eclipse was visible in 416 or 417 CE (Espenak & Meeus, 2006). The exact Julian year date is uncertain because Marcellinus dates according to the Indiction, i.e. the event is dated to the "15th indiction, consulship of Honorius (11th) and Constantius (2nd)", spanning 1 September 416 to 31 August 417 CE (see Croke (1995)). We rank this candidate dust-veil as Probable.
[12] This phenomenon bears many hallmarks of a volcanic dust-veil observation, also occurring for too long to be a solar eclipse. It is reported in several sources (see literature in References column, and citations therein), though with slightly divergent dating. We rank this event a Probable dust-veil, and prefer the date of 499 from Pseudo-Joshua the Stylite (Trombley & Watt, 2000), in being a broadly reliable and probable eye-witness to events at this time.

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Supplementary Data: Monte Carlo equal means test of association between NEEM volcanic events and historical validation points

Validation points and probably-only subset	*Margin (years)*	*Validation points with NEEM volcanic events within margin*	*Mean number of NEEM volcanic events observed within each margin (whole period mean, 258 BCE to 504 CE, is 0.11155)*	*Probability of observed value occurring randomly*
All 32 validation points	+/-3	24 of 32 (75.0%)	0.24017 (n = 229, i.e. sum of years in margins)	<0.001
All 32 validation points	+/-2	20 of 32 (62.5%)	0.26061 (n = 165)	<0.001
All 32 validation points	+/-1	16 of 32 (50.0%)	0.30693 (n = 101)	<0.001
24 probable points only	+/-3	18 of 24 (75.0%)	0.21935 (n = 155)	<0.001
24 probable points only	+/-2	14 of 24 (58.3%)	0.25000 (n = 124)	<0.001
24 probable points only	+/-1	11 of 24 (45.8%)	0.28947 (n = 76)	<0.001

Note: We employed a Monte Carlo equal means test (1,000,000 iterations) to compare the number of NEEM volcanic event years on the NS1-2011 timescale that occurred near to our historical validation points (i.e., within each uncertainty margin) to the number that would be expected randomly. We calculated probabilities based upon the number of volcanic event years observed in the period 258 BCE to 504 CE, matching the period covered by our validation points (earliest and latest at 255 BCE and 501 CE), with an additional three years on each side. For reference, the mean number of volcanic event years from 258 BCE to 504 CE (inclusive) is 0.11155. Note that consistent results are obtained when employing an alternative Mann-Whitney (Rank Sum) test (i.e., comparing medians rather than means) in both standard and Monte Carlo implementations.