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COMMENT

Comment on "Effects in North Africa of the 934–940 CE Eldgjá and 1783–1784 CE Laki eruptions (Iceland) revealed by previously unrecognized written sources" by Brugnatelli, V., and Tibaldi, A. [Bull. Volcanol. (2020) 82:73]

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There is no doubting that historical sources can help us reconstruct volcanic eruptions and their effects. We must treat those sources with caution and care, however. The more contemporary the source is to the eruption generally the better, but even eyewitness accounts can present challenges. Passages of interest, contemporaneous or not, must be read in the context of the source they are encountered in as well as in the context of other sources written in the same milieu, and alongside relevant scholarship. Brugnatelli and Tibaldi present overlooked evidence for atmospheric phenomena in the Mediterranean region possibly associated with the tenth-century Icelandic "lava flood" eruption of Eldgjá. This evidence is tantalising, but Brugnatelli and Tibaldi leave its exegesis underdeveloped, leading us to question the inferences they draw. Brugnatelli and Tibaldi also mishandle three previously discussed potential witnesses of the optical effects of Eldgjá's aerosol and mischaracterise existing scholarship on those passages. These shortcomings underscore the complexities entailed in working with historical sources and the significance of collaborative interdisciplinarity.

Possible accounts of Eldgjá's veiling require careful treatment. A passage at 939 CE in the *Chronicon Scotorum* (*CS*, 1866)—"the sun was the colour of blood from the beginning of one day to the middle of the following day"—has been identified repeatedly as a likely witness of the optical effects of Eldgjá's aerosol. McCarthy and Breen (1997), McCormick et al. (2007), Ludlow et al. (2013), Kostick and Ludlow (2015), Sigl et al. (2015 SM) and Oppenheimer et al. (2018), among others, discuss this passage and problems associated with an erroneously dated (933 CE) similar passage in the *Annals of Clonmacnoise* (*AC*, 1896, Supplementary Material 1). Produced in the seventeenth century from no longer extant texts, the *CS* and *AC* belong to the Clonmacnoise group of Irish annals. Their accounts of a bloodlike Sun stem from a common source and do not, as Brugnatelli and Tibaldi and others have recognised, corroborate one another. Problematically, Brugnatelli and Tibaldi imply that this sanguine Sun's date is in question, so too the date of the Eldgjá eruption itself. They misleadingly fix the eruption to 934–940 CE (title, text, first figure), but the *CS*/*AC* passage has long been firmly dated to 939 CE through careful scholarship (McCarthy and Breen 1997; McCarthy 2005; Sigl et al. 2015 SM), and high-resolution glaciochemical records from Greenland show that the Eldgjá eruption was underway by spring 939 CE and likely continued until autumn 940 CE (Oppenheimer et al. 2018), confirming the 939 eruption date discussed for more than 20 years (McCarthy and Breen 1997; Ludlow et al. 2013; Kostick and Ludlow 2015; Baillie and McAneney 2015; Sigl et al. 2015; Toohey and Sigl 2017).

Brugnatelli and Tibaldi also mishandle independent passages in the *Annales Casinates* (*ACas*, 1839, p. 172) and *Res Gestae Saxonicae* (*RSG*, 1935, II.30, pp. 93–94), previously connected with the Eldgjá eruption. The relevant portion of the *RSG*—"the sky without a cloud, the light of the Sun was almost not visible outside, however inside it poured in through the windows of houses red as blood" (SM1)—does not date "to before 936". Brugnatelli

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and Tibaldi reach this conclusion by accepting the text verbatim and overlooking existing scholarship. As Oppenheimer et al. (2018 SM) detail, Widukind of Corvey wrote the *RGS* in the 960 s CE drawing on continental sources. Although considered a reliable witness of tenth-century affairs, Widukind occasionally, like other medieval historians, rearranges the chronological sequence of events for narrative effect. Here, Widukind reorders several remarkable phenomena, so they portend the 936 CE death of Ottonian King Henry I. Widukind sandwiches a witness of a poorly visible Sun and bloodlike sunrays between accounts of comets other contemporary texts date to 941 CE and an animal mortality other texts date to 940–942 CE (Oppenheimer et al. 2018 SM). He likewise catalogues the miraculous regeneration of a man's severed hand. One might question its historicity, but the unsevered hand also postdates Henry's passing in other contemporary texts (Flodoard of Rheims, 1839, p. 391). While Widukind loosely dates these portents to "before the death of King Henry", the sunlight turned bloodlike circa 940 CE. That the *CS*/*AC* passage dates to 939 CE and accounts of bloodlike Suns (or sunlight) are outstandingly rare (Irish annals, e.g. span centuries, but the 939 CE bloody Sun is the only one mentioned (Ludlow 2010)) shores up this argument.

Interpretation is another issue. Brugnatelli and Tibaldi propose Widukind's passage is "more indicative of an eclipse" than volcanic veiling partly because Widukind clarifies the sky was cloudless. A circa 940 CE date roughly aligns the passage with the solar eclipse of July 939 CE that discussed repeatedly in connection with Eldgjá (McCarthy and Breen 1997; Kostick and Ludlow 2015; Sigl et al 2015 SM; Oppenheimer et al. 2018 SM). Yet, that Widukind has the Sun hardly visible and sunlight bloodlike, despite a cloudless sky, does not mean he reports only an eclipse or an eclipse at all. The middle-atmosphere veiling associated with volcanic sulphate aerosols is unlikely to have been confused with common cloud cover. As in the *ACas*, the Sun may have been visible, but its force weakened and colour altered. A contemporary witness in Europe of the atmospheric optical effects of emissions from the comparable 1783 CE Laki eruption reported the Sun muted, poorly visible and bloodlike (White, 1813, LXIV, pp. 297–298). Additionally, the *CS* independently testifies that the Sun appeared bloody in 939 and it seems, considering just how uncommon such observations are, that blood-coloured Suns (or sunlight) were especially noteworthy. Further, solar eclipses are generally not described as possessing a bloody quality in historical sources, nor should we expect them to be. Yet, that sulphur deposition in Greenland ice cores is contiguous from spring 939 to autumn 940 CE suggests that Eldgjá's associated middle-atmosphere aerosol was present through the summer of 939 CE, meaning that the veiling and eclipse may have co-occurred in Germany and Widukind may have referenced both in a single passage.

Brugnatelli and Tibaldi similarly overlook scholarship on the weak, muted Sun encountered in the *ACas* at 939 CE. The *ACas* is not a "chronicle", but a collection of 14 marginal manuscript notations. The substance of the notations varies and their provenances are somewhat uncertain, though they are thought to have been compiled at Monte Cassino in the eleventh century. Brugnatelli and Tibaldi do not mention the argument (discussed in Sigl et al 2015 SM and Oppenheimer et al. 2018 SM) that the 939 CE *ACas* passage is a "two-parter"—that the reported eclipse and the dim, discoloured Sun may be unconnected. Considering the brevity of the *ACas* and that four of the 14 notations concern atmospheric or astronomical phenomena, there is a reason to suppose that if two remarkable such events occurred in the same year, they would be recorded in one marginal notation. From "We looked", it is plausible the *ACas* records Sun dimming and discolouring due to the Eldgjá eruption's aerosol: "939, 12 indiction, on 13 July, 6 feria, 29 moon. The Sun was obscured from the 3rd almost to the 5th hour of the day. We looked at the Sun, and it had no strength either for brightness or for colour. Indeed, we saw the sky, but its colour was altered, as if leaden, and some people said that they saw the Sun almost halved" (SM1). Further, we found this obscured Sun in other near-contemporary Italian writing, but not the weak, colour-altered Sun. That neither the *Annales Beneventani* (1839) nor the annals associated with Lupus Protospatarius (1844, SM1) refer to the second segment of the *ACas* passage strongly suggests that the second segment is indeed distinct from the first and that it was recorded separately and stitched to the notice of the obscured Sun in the *ACas*. A wider reading of the *ACas* itself reinforces this interpretation. Another *ACas* marginal notation witnesses a solar eclipse at 969 CE. The report is brief and fixed to a reference of an unrelated phenomenon.

By obscuring the significance of the *CS*, *RSG* and *ACas*, Brugnatelli and Tibaldi emphasize the import of the unaddressed sources they introduce. They present passages from the early fourteenth-century *Rawḍ al-Qirṭās* (*RQ*, 1843), often attributed to Ibn Abī Zarʿ, and Giacomo Foresti de Bergamo's late fifteenth-century *Supplementum Chronicarum* (*SC*, 1483, 1486 and 1513). The treatment that Brugnatelli and Tibaldi give these passages is akin to the treatment they give to the *ACas* and *RSG*: Required textual analysis and context is wanting. As it stands, with the provenance of neither passage established, the *RQ* and *SC* cannot be confidently interwoven into the history of Eldgjá's eruption.

Unlike the *CS*, *RSG* or *ACas*, the *RQ* and *SC* were composed many centuries after Eldgjá erupted. To use the passages Brugnatelli and Tibaldi identify, one must ascertain the sources that informed them. Noncontemporary sections of premodern histories can be highly synthetic. Neither the

author of the *RQ* nor Foresti de Bergamo may have consulted directly the original account of the phenomenon they relate, but instead another noncontemporary text. The original passage may have passed through several filters and been altered, abbreviated, interpolated and redated, purposefully or mistakenly, on multiple occasions. Brugnatelli and Tibaldi's scarce analysis leaves open the possibility that the *RQ* and *SC* passages are derivative of passages already brought to light or that they are based on accounts written neither in Morocco nor Italy and that they do not refer to a weak or bloody Sun in the Maghreb or Italy, contrary to what Brugnatelli and Tibaldi propose.

We looked into Foresti de Bergamo's passage. Brugnatelli and Tibaldi provide the Italian from a sixteenth-century translation, but the *SC* was published in Latin in the 1480s CE. The relevant passage reads, "for some days the sun appeared like blood" (SM1). Across initial publications of the *SC*, the marginal date fixed to this passage shifts between 938 and 942 CE, but as Brugnatelli and Tibaldi note, Foresti de Bergamo places the reference within the context of the short rule (939–942 CE) of a little-known Venetian doge. Rather than working back and reconstructing Foresti de Bergamo's sources, we turned to the transmission of Widukind's bloody sunlight. The *RSG* was (and remains) a foundational work for reconstructing tenth-century continental European history, quite unlike the *CS* and *ACas*. There is reason to suppose, therefore, that Foresti de Bergamo's passage may be derivative of that in the *RSG*. Direct parallels between the *RSG* and *SC* passages are few, though both are short and feature the nouns *sol*, *-is* and *sanguis*, *-nis* and the verb *appareo*, *-ere*, and no elements encountered in Foresti de Bergamo's passage are not encountered in Widukind's. Among the differences, the sunlight is bloody in the *RSG*, but the Sun itself is bloodlike in the *SC*, and the context in which the passages appear is remarkably dissimilar. Nonetheless, Widukind's catalogue of portents proved popular. While it was transmitted in several medieval histories nearly verbatim (SM2), some medieval writers whittled it down, reframing the sanguine sunrays. At least two thirteenth-century texts (SM2: *Chronica universalis mettensis*, 1879, and *Chronicon pontificum et imperatorum*, 1872) present what may be an abruptly truncated version of the *RSG* passage: "The sun became bloodlike". In both texts, as in the *SC*, this brief entry is followed with terse and ambiguous notice of many human deaths (SM1). The passage and sequence in these thirteenth-century texts are strikingly similar to what we find in Foresti de Bergamo's chronicle, enough so to establish the *SC* account is not original (SM2).

Although the circulation of Widukind's passage remains to be ascertained, and so too what source Foresti de Bergamo encountered a bloody Sun in, it is probable that the bloodlike Sun the fifteenth-century Italian chronicler reports was observed north of the Alps and that Foresti de Bergamo's passage is ultimately derivative of Widukind's (SM2). There persists a possibility that the passage encountered in thirteenth-century texts is independent of the *RSG* and that

Table 1 Sources Discussed in the Text

Source	Siglum	Notes
Chronicon Scotorum	*CS*	One of the Clonmacnoise group of Irish annals, the *CS* survives in a mid-seventeenth-century copy. The medieval manuscript from which the copy was made, like earlier manuscripts containing the original, contemporarily written annals, is lost. Internal references suggest most tenth-century entries in the *CS* were composed at Clonard or Clonmacnoise
Annals of Clonmacnoise	*AC*	Also belonging to the Clonmacnoise group of Irish annals, the *AC* survives in an early seventeenth-century English translation known as *Mag Eoghagan's Book*. Medieval manuscripts of the annals are lost, but comparison with other Clonmancoise-group texts makes evident that the *AC*'s chronological apparatus is problematic. Many events from the sixth through tenth centuries are inaccurately dated by multiple years
Res Gestae Saxonicae	*RSG*	Widukind of Corvey (born c.920–925) wrote the *RSG*, a history of the Saxons centered on the tenth-century reigns of Henry I and Otto I, at Corvey using diverse continental sources, eyewitness reports, hearsay and oral tradition. Book II of the *RSG*, containing the sanguine sunrays, was likely completed in the late 960 s
Annales Casinates	*ACas*	The *ACas* is a collection of 14 separate notations, spanning 914 to 1042, compiled from earlier sources likely in the eleventh century at Monte Cassino and encountered in the margins of a tenth- or eleventh-century parchment of Bede's Paschal Cycle
Supplementum Chronicarum	*SC*	Giacomo Foresti de Bergamo (1434–1520) first published his *SC* in 1483. The text, a compendium of history from Creation, supplemented existing "universal histories" with numerous biographies of prominent figures. Highly synthetic, it draws on numerous sources, many of which are themselves composites of numerous sources
Rawḍ al-Qirṭās	*RQ*	Composed in the early fourteenth century, the *RQ*, attributed to Maghrebi writer Ibn Abī Zarʿ (died after 1326), is a prominent source for the history of northwestern Africa. Like the *SC*, it is synthetic, relying on earlier sources, which often themselves rely on earlier sources

it represents another transalpine witness of the visible effects of Eldgjá's aerosol on the atmosphere (SM2), but either way the *SC* does not testify that Eldgjá veiled Bergamese skies (Table 1).

When not treated with care, historical sources can mislead our collective understanding of the nature and extent of influence of past volcanism. Pitfalls can be avoided through attention to historical method. Passages of interest must be read in the context of the source in which they are encountered and against other sources composed in the same milieu. Whether newly uncovered noncontemporary passages are derivative of known contemporary passages must be determined, partly by examining the transmission history of contemporary witnesses. Detective work is essential and interdisciplinary collaboration is recommended.

Edition and publication details are provided in the References and additional details discussed in the text and SM.

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Author's contributions TN identified the issues addressed in this Comment and drafted the Comment with contributions from CO, who provided extensive feedback through multiple drafts.

Data availability Key passages consulted for this Comment are made available in the SM.

Declarations

Conflicts of interest The authors declare no conflicts of interest.

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