RC3: 'Comment on nhess-2024-83', Anonymous Referee #2, 11 Mar 2025

The paper presents a paleoseismic record for Lake Aiguebelette, France, that extends back to ~10 ka BCE, based on the identification of event layers within sediment cores attributed to earthquakes, in combination with a robust age-depth model. Key to the paleoseismic interpretations is defining and applying a multiproxy sediment model, using XRF logarithmic geochemical ratios, D50 and D90 grain-size data, high AMS foliation values, and low IRM amplitudes, to identify seismically-triggered event layers. Thirty-two out of 55 identified event layers are inferred to be of coseismic origin, all being ≥0.5 cm in thickness. ‘Good’ and ‘moderate’ confidence levels are assigned to the ≥2 cm and between 0.5-2 cm event layers, respectively. The event layer-derived record is compared to the historical seismic record for the Lake Aiguebelette region and used to develop a paleoearthquake record expanded to 10 ka BCE that includes more moderate, local seismic activity. Modelled curves are fitted to histogram distributions of the number of seismic occurrences versus time gap between depositional events for two time periods of the post-10 ka BCE record. The paper potentially is of interest to an international audience and is within the scope of NHESS.

In the Introduction, the authors correctly identify that “to build a seismic chronicle based on sediment archives, a mandatory step is to demonstrate that event layer deposition is related to a seismically-induced process, in general by using comparison with historical seismicity...” (lines 48-50). However, they do not follow this advice by testing their proxy event layer data against probable seismically-related event layers identified from the combination of the presented age-depth model and the SisFrance and FCAT-17 seismic catalogs. There may be sedimentological characteristics common between the various event layers ≥0.5 cm, but the key unanswered question is whether there is a unique seismic triggering mechanism that is initiating the event layer sedimentation process. That the presented example of the multiproxy is based on a 5 cm thick bed does not provide the reader with confidence of a unique seismic origin for the much more numerous, thinner layers, between 0.5-2 cm. Nor is confidence provided by the widely-scattered, grain-size data shown on Fig. 5 that is compared to background sediments and those from, I believe, the thickest event layer in the record (83.6 cm). Importantly, there is no assessment of other plausible mechanisms for the thinner event layers, including severe flood events are the obvious candidate. Instead, all event layers ≥0.5 cm thick are inferred to represent seismic events and, surprisingly, there is no mention of what alternative triggering process(es) explains the deposition of the 13 layers <0.5 cm. Although ‘good’ and ‘moderate’ confidence levels are applied to these inferences, they are based solely on event layer thickness and are literally presented as ‘suggestions’ that are not supported independently by data. There is no mention if the 32 individual event layers inferred to be of coseismic origin are common to every core, several cores, or only one core. Strangely, and without justification, in *Section 5.3* (lines 516-517), the full dataset of 32 event layers (>0.5 cm thick), plus an additional 13 that are <0.5 cm, are considered as seismically induced and used on Fig. 12, Table 3 and in this part of the discussion. What may be important evidence supporting the coseismic explanation for the event layers, >0.5 cm thick, does not appear until late in the paper

(lines 565-567). Overall, the lack of testing to demonstrate that the event layers are an effective proxy for seismic events in Lake Aiguebelette is a fundamental weakness of the paper that the authors must address.
This paper, therefore, requires major revision to substantiate that the event layers, >0.5 cm thick, in Lake Aiguebelette are exclusively a proxy for seismic events as the authors infer them to be. This requires presenting defendable reasons why extreme flood events, and perhaps other processes, could also not form the event layers or that thicker flood-related event layers can be distinguished objectively from thinner seismically-related ones. This assessment also needs to use core-to-core frequency data for the event layers that can be presented diagrametically (i.e., Fig. 6), and summarized in a new Table. In particular, data should be presented in the body of the paper that makes it straightforward for the reader to determine if each event layer is common to every core, several cores, or only one core. The authors also need to consider if the latter information can be used to support the confidence level of the seismic interpretations.
There are a number of moderate and minor issues that the authors need to address to improve the content and presentation of the paper, as seen from the numerous editorial comments annotated on the returned pdf, and numbered comments keyed to annotations on the manuscript are in a separate pdf.
Citation: https://doi.org/10.5194/nhess-2024-83-RC3

Dear Reviewer,

We appreciate your detailed comments, suggestions and corrections throughout the manuscript. We will take them into account in the revised version of our manuscript.

Below, you will find our responses to the global questions and remarks grouped by topics. Minor corrections related to spelling, typos, and grammar highlighted in the annotated manuscript will be taken into account, and the final version will be reviewed by a native English speaker.
In addition, our responses to the 34 numbered comments annotated in the manuscript are also provided below.
Thank you again for your time and consideration.

Best regards,

Mathilde Banjan and co-authors

1. Event layers as seismic proxies

We would like to emphasize that, unlike most lacustrine paleoseismological studies conducted in tectonically active regions, this study is set in a context of low to moderate seismicity. This setting reduces the frequency and intensity of shaking events capable of triggering thick and easily identifiable deposits, making the detection and attribution of event layers more challenging. The main challenge is that comparison between event layers and historical earthquakes is difficult, as very few significant events (Mw > 5) have been recorded within 30 km of the lake.

However, it also makes the resulting chronicle particularly valuable: it provides rare long-term data in a region where instrumental and historical seismic records are sparse. This context justifies the use of a conservative, multiproxy-based approach to distinguish seismic from non-seismic events and highlights the originality and relevance of our contribution.

You highlight that "to build a seismic chronicle based on sediment archives, a mandatory step is to demonstrate that event layer deposition is related to a seismically induced process" and question whether this has been rigorously applied.
This study aims to do this by using a multi-proxy approach that integrates:

- Visual observation of homogenite (Hm) and turbidite-homogenite (Tu+Hm) facies, which can be associated with earthquake-triggered mass transport deposits in lacustrine environments (Beck, 2009; Campos et al., 2013; Howarth et al., 2014);
- Grain-size data trends in a Passega diagram (Fig. 5), to distinguish remobilized versus background sedimentation processes (Beck et al., 1996; Moernaut et al., 2014);
- Geochemical signatures (XRF logarithmic ratios) indicating sediment remobilization from subaquatic slopes, as opposed to catchment-derived detrital input, thus excluding flood deposits as the likely origin (Chapron et al., 2004; Wirth et al., 2013) ;
- High AMS foliation values, a recognized indicator of seiche effects (Strasser et al., 2007; Beck et al., 2022);
- Low Isothermal Remanent Magnetization (IRM) amplitudes, linked to seismically induced redeposition (Yakupoğlu et al., 2022; Banjan et al., 2023).

This suite of criteria has been established in previous paleoseismic studies (Moernaut et al., 2007; Wirth et al., 2013; Beck, 2009) and is detailed in Section 4.2 of the manuscript (lines 195-232). Additionally, the highest confidence level is assigned only to deposits ≥2 cm, as they provide reliable AMS measurements, and these are consistently linked to seismically triggered deposits in comparable studies (Campos et al., 2013).

2. Consideration of alternative triggering mechanisms

You suggest that extreme flood events could also be responsible for the observed event layers and question why we do not systematically rule out non-seismic origins. In Section 5.1, we address this issue and demonstrate why floods are not a plausible alternative trigger:

- Lake Aiguebelette has no major river inflows, reducing the probability of large flood-induced deposits (line 482). Moreover, no sedimentological evidence or historical record suggests that extreme floods have ever deposited significant layers in this lake.

- Bathymetric control:
  - The main tributary (La Leysse) enters the northern basin (line 75, Preprint).
  - The southern basin (where AIG17III and seismic core analysis is focused) has independent, small catchments (<1 km²) and is hydrologically and morphologically separate from the north (lines 218–222, 482–484).
  - The bathymetry (Fig. 2) shows that the southern basin is relatively isolated, with intermediate depths and no major inflow connection mentioned or mapped to the northern basin.

  The northern sub-basin acts as a sediment trap for the main tributary, La Leysse. The cores used for seismic interpretation (AIG17III, AIG16-05, AIG16-06) are all located in the southern basin, isolated from this fluvial input. This is due to the lake's internal bathymetry being insufficient to transport coarse sediment from the north to the deep southern basin, where the seismic cores were taken. In contrast, the catchments feeding the southern basin are <1 km² and have limited sediment flux.

- No historical records of extreme floods correspond to the depositional age of the identified seismically triggered historical event layers, further reinforcing that seismic shaking is the more likely trigger.

- The geochemical signatures of the biggest event layer deposited at the Younger Dryas - Holocene transition (XRF data) suggest sediment remobilization from lake slopes, rather than a riverine source, which is expected for flood deposits. Additionally, the Passega diagram (Fig. 5) provides a comparison of grain-size trends between event layers and background sedimentation. The clustering of seismic event layers along a distinct depositional trajectory suggests a shared seismic trigger.

3. Confidence levels and event layer thicknesses

Your concern regarding confidence levels is addressed through several points summarized below.

The event layers ≥2 cm are classified with "high confidence" because:

- They consistently display high AMS foliation values (Fig. 4), indicative of seismically triggered seiche effects.
- They align with historical earthquakes from the SisFrance and FCAT-17 seismic catalogs (Table 3, SM-6).
- They are found in multiple cores at corresponding depths, reinforcing regional correlation (Fig. 6).

For event layers between 0.5-2 cm, we acknowledge a "moderate confidence" level, but we also validate their seismic origin based on:

- Passega diagram grain-size trends, which show alignment with thicker seismically attributed deposits (Banjan et al., 2023).
- XRF signatures, demonstrating sediment remobilization from the lake slopes rather than flood-related inputs. For example, the correlation coefficient between Ca and Ti (XRF data) is negative in the continuous background sediment above and below the thickest event layer, whereas it is positive in the thickest event layer (an additional figure will be added to the revised manuscript). This effect results from the grain size or sediment source being different in each facies. The geochemical profile of the event layers supports an origin by slope remobilization within the lake rather than catchment-derived flooding. Event layers are enriched in Ti and Fe, suggesting their remobilisation from the lacustrine slopes and background laminated sediment, while showing a relative depletion in K and Zr (mostly associated with detrital input during flood events). This observation aligns with previous lacustrine studies (Giguet-Covex et al. (2010); Sabatier et al. (2017, 2022)) where flood layers exhibit high K and Zr content due to mineral-rich erosion from the watershed. In contrast, the event layers (with sufficient thickness to have more than two geochemical measurements) share the geochemical signature of in-lake remobilized sediment. In addition, the morphological isolation of the southern basin from the main tributary excludes a flood origin.

  Thus, we do not assign confidence arbitrarily but on a structured, multi-criteria approach.

4. Core-to-core frequency comparisons

You request further clarity on the spatial distribution of event layers across cores. This information is already provided in Supplementary Materials (SM-2, SM-5), where correlations between cores (AIG17III and AIG16-05) are mapped. To further improve clarity, we will include a summary table in the revised manuscript (similar to Table 1) highlighting the presence of each event layer across multiple cores. The figure SM-2 will be placed in the main text as explained in the reply to point 11 below.

5. Consideration of thinner event layers (<0.5 cm)

We agree that the deposition mechanisms of thinner layers (<0.5 cm) should be explicitly discussed. These deposits are excluded from the recurrence analysis (Section 5.3, line 516), as we acknowledge that their origin is uncertain. However, we emphasize that the 32 identified seismically triggered event layers (≥0.5 cm) remain the focus of our study, as they meet the criteria for seismic attribution.

6. Additional comments

Numbered comments keyed to the manuscript

1 "little or no flood record" This statement is made without elaboration or reference, but has an important bearing later in the paper. It needs to be substantiated somewhere.

We will explain that the geochemical signatures and basin morphology support the absence of flood record. This point will be discussed in detail in Section 5.1, as already indicated in our response above.

2 Provide the lengths of the recovered core sediments.

We will include the lengths of each recovered core in the "Methods" section for clarity.

3 This statement is incorrect. Supplementary material SM1 shows a summary and the log for only AIG17III. For a paper focused on core sediments as the primary data source, you need to show all of the cores in the body of the paper. Also, see comment 16.

We will make sure the log of the cores are included in the revised manuscript. All these logs are available in Banjan's PhD.

4 Make it clear that these statements are inferred based on studies of other lakes in the region, not this specific paper.

We will state which interpretations are based on previous studies from other lakes and which are specific to our observations at Lake Aiguebelette.

5 Lines 181-185 are out of place. This should be presented in section 4.2.

Lines 181–185 will be moved to Section 4.2, as they are more relevant there.

6 Lines 205-218 are too detailed and difficult to follow. Simplify and focus on the key points.

We think it is important to describe precisely how event deposits were characterized. Each criterion will be presented individually in a dedicated sub-paragraph for clarity. We will shorten long sentences and rework the structure, as suggested.

7 The reviewer is not experienced with magnetic susceptibility foliation data. However, the difference between background and the exemplified event layer seems very slight (between 1.005-1.01 and 1.02-1.025, respectively). Can one range really be considered as 'high' relative to the other? Also, showing the

numbers as ≤1.01 and ≥1.02 is deceptive because each range is very narrow! You need to say more about the significance of these differences in foliation data to make this more convincing.

Foliation values of 1.01 and 1.02 correspond to 1% and 2% anisotropy, respectively, meaning the difference represents a doubling in anisotropy. The foliation measured in homogenites is typically between 2 and 5 times higher than in the background sedimentation. The sensitivity of the MFK1 device used to measure magnetic susceptibility and its anisotropy is better than 5×10^{-8} SI, while bulk susceptibility in our samples ranges from 50 to 100×10^{-6} SI. These values allow us to detect meaningful differences in sediment fabric between event layers and background deposits.

8 There is no comment 8.

9 Ok, there might be a common depositional mechanism, but is it representative of a common triggering mechanism that puts the sediment into the water column? Can this be determined objectively?

We will specify that the observation of similar grain-size trends between thinner and thicker event layers suggests a possible common triggering mechanism. While this cannot be demonstrated with certainty, it reflects our interpretation based on consistent patterns in the data. This reasoning is common in paleoseismological studies, where multiple indicators are used to build confidence in interpretations.

10 This caption does not say this explicitly, but I believe that the thickest event layer in the deep basin is 83.6 cm thick (SM1 and SM6). In either case, the layer may have been interpreted by Banjan et al. (2023) as seismically induced, but neither the presence of this thick event layer nor the Bajan et al. interpretation are proof that every event layer between 0.5-2 cm thick was seismically induced.

We will modify the caption as follows: "Blue dots: grain-size data of the homogenite constituting the thickest event layer of the deep basin sequence, presented in Banjan et al. (2023)." We agree that the comparison with this thick deposit is not proof of a seismic origin for thinner deposits. This limitation will be acknowledged in the revised manuscript.

11 The core-to-core correlations are fundamental to the paper, but are not presented in any detail. These correlations also need to be presented after the age-depth modelsince the chronology is critical to the correlating process. The new locaton should be after 4.4.3. Fig. 6 only shows correlations based on the IRM data. No chronology data has been presented for AIG17III at this point in the paper, yet it is being drawn upon for these correlations. In other words, the order of the presented materials is incorrect and needs to be modified.

We will use the SM-2 figure and revise it to present a clear core-to-core correlation based on IRM, XRF, and chronological data. This new figure will be included in the main manuscript and placed within a new Section 4.3 titled “Core-to-core correlation,” which will follow Section 4.4 on the age-depth model. This reorganization supports the correlations with chronological context.

12 “To improve the count of the event layers”? What do you mean and how does this work?

We will explain that the correlation with a longer core sequence allows us to detect more event layers, particularly in the recent historical period, improving the record of event layers.

13 Fig. 6 shows chronology in years CE, but the ages in SM-2 (Correlations between cores from Lake Aiguebelette deep basin) are in yr BP. For your purposes, using yr CE seems to make the most sense to use. Be consistent in the chronology format between the paper and the supplementary materials.

Keeping both is necessary in this study. The use of yr cal BP (before present) is consistent with standard practice in sedimentology and age-depth modeling, particularly with radiocarbon-based chronologies and long Holocene records. We use the yr cal CE format when discussing historical and instrumental seismic events, for comparison with calendar-dated archives such as FCAT-17 or historical records. We will make sure that the use of both formats is clearly explained in the revised manuscript.

14 Are these laminae composed of the triplet of layers that represent a varve? If yes, then consider referring to varve ‘layers’ that are composed of triplets of ‘laminae’.

We prefer the term “lamina” rather than “varve”, as the latter implies an annual deposition, which requires evidence to validate. We will consistently use 'lamina' to avoid overstating the chronological resolution before demonstrating that their deposition is annual to seasonal.

15 This paragraph is an inadequate summary of the chronology of event layers. The varves were presented in section 4.1 and the radioisotopic data in section 4.4.1. Why are these themes being introduced here as something new? Modify/reorganize as necessary.

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We understand the reviewer’s concern. The presence of varves is indeed established earlier in the manuscript (lines 288–291, Section 4.1), based on previous studies and on the observation of seasonal lamination. However, Section 4.4.1 is the appropriate place to present all dating results, including radionuclide profiles, as it provides the complete overview of the age-depth constraints. This section is structured to present the results and interpretations based on all dating methods used, and it cannot be moved or split, as it consolidates all chronological information. The discussion section later recalls these elements briefly to connect the methodological basis with the broader interpretation of the event layer chronology.

16 The “SM-2 Correlations between cores from Lake Aiguebelette deep basin”, which is in Supplementary material, absolutely needs to appear in the paper.

We will move the content from SM-2 into the revised version of the manuscript.

17 There is no Table 2.

This refers to Table 2 from Banjan et al. (2023). We will add the reference to make this clear in the revised manuscript.

18 No information in the body of the manuscript is given on whether the event layers are common to every core, several cores, or only one core. This is key information that the authors are ignoring and which needs to be used in assessing the interpretations of the various event layers.

This information is available in SM2 and SM5. SM2 will be moved to the main manuscript (revised version). SM5 contains a detailed table that indicates whether each event layer is present in one or both cores, along with the thickness and depth of each event layer. These elements provide the necessary information to support our interpretation.

19 Cores AIG16-05 and AIG16-06 are about 100 m from AIG17III yet have different stratigraphies from the latter. See Fig. 2. Are you sure each event layer has a seismic origin?

We will explain that although AIG16-05 and AIG16-06 are located only ~100 m from AIG17III, differences in slope, micro-basin morphology, and sediment transport can lead to variations in deposit thickness or preservation. Sediment availability is a limiting factor: some slope failures may remobilize sediment and only deposit material in one part of the basin. Comparing information across cores helps improve the event layers identification. This variability is taken into account when evaluating the seismic origin through a multi-proxy approach of each deposit and will be mentioned in the revised version of the manuscript.

20 This statement is based on circumstantial evidence and, as the authors indicate, is a *suggestion*. The 'good confidence level' of a seismic origin is not supported by data.

In the referred sentence, we made it clear that the 'good confidence level' assigned to event layers >2 cm is based on our interpretation of converging proxy evidence. Specifically, the combination of grain-size data, geochemical markers, high AMS foliation, and low IRM amplitudes supports our assessment that these deposits are likely seismically triggered. This multiproxy agreement across cores forms the basis for our classification and will be emphasized more clearly in the revised manuscript with a reference to Figure 9.

21 Again, this is another suggestion. The 'moderate confidence level' of a seismic origin also is not supported by data.

In the same way, we will refer this label to Figure 9. This figure will subsequently be placed before these mentions.

22 This is a reasonable decision.

This decision will therefore remain unchanged.

23 The font size on this chart is far too small to read.

We will make the font size on this chart bigger to improve readability in the revised manuscript.

24 Does this mean that one of the events is not recorded in the lake, but would be expected? What does this say about the event layer methodology? You need to comment on this.

We agree that the ESTI approach alone does not allow for definitive matching between event layers and specific historical earthquakes, particularly in a region with limited and incomplete historical records. Our goal with the ESTI method is not to provide a one-to-one correlation, but to identify periods where seismic triggering is plausible based on the archive's temporal resolution and the regional seismicity. The absence of a deposit associated with a known earthquake (or vice versa) highlights the archive's sensitivity limits. We will include a sentence to make this methodological limitation clearer in the new version of the manuscript: “The absence of a sedimentary deposit corresponding to a known regional earthquake (or the presence of an event layer, that was not deposited at a time compatible with a known earthquake) highlights both the sensitivity threshold of the sediment archive and the limitations of the ESTI method, which is not intended to present clear one-to-one correlations but to assess the plausibility of seismic triggering across time windows of sufficient resolution.”

25 What is the chance that this event layer does not represent a seismic event at all? This also needs to be considered and mentioned. You also need to make the case for this specific event layer being seismically-triggered if the hypothesis that it represents an unrecorded earthquake is being be stated.

We agree that we cannot exclude a non-seismic origin. This interpretation is presented as a plausible working hypothesis, in line with the approach used throughout this study.

We will rephrase as follows:
The event layer dated between 1327 and 1372 yr cal CE may not correspond to the 1356 CE Basel earthquake but could instead reflect a local moderate earthquake that was not archived in historical catalogs. Given the limited reliability and spatial coverage of historical seismic records for the 14th century, and in the absence of a better alternative, a local seismic origin remains a plausible hypothesis, though it cannot be confirmed with certainty.

26 This only works if the triplet laminations within varves are present within the overlying sediments, but you do not say they are before making this interpretation. If the varves are not present, then I don’t follow how you are able to make this interpretation.

In the case of the 1760-1824 yr cal CE deposit, we observe a succession of laminated structures immediately above and below the event layer in core AIG16-05 (see Figure 3). These laminations show a geochemical triplet consistent with seasonal deposition (Si-rich in spring, Ca-rich in summer, Al-rich in winter), as described by Giguet-Covex et al. (2020). This

continuity of laminated sediment at the top and bottom of the event layer allows us to suggest that the deposit was emplaced between a summer and a winter lamina, supporting the interpretation of an autumn event. We already describe in lines 470-476, the presence of Ca-rich and Al-rich laminae below and above the event layer provides geochemical evidence of seasonal deposition (see Figure 3). These features allow us to constrain the timing of the event to between summer and winter, based on varves continuity. This interpretation is specifically written in the discussion section, which seems to be the right place to explore interpretations in more depth.
There are two additional points that support our interpretation, already mentioned in the manuscript:

(1) Core AIG17III presents laminated sediment interpreted as varves from the present day back to the Little Ice Age. Core AIG16-05, deposited in the same basin, also contains evident lamination with geochemical characteristics compatible with varves.

(2) Core AIG20-01, retrieved from the same deep basin, shows laminated sediments that are clearly identified as varves, validated through radionuclide dating. As described in the manuscript, the short-lived radionuclide profiles confirm annual deposition and support the varve chronology. These varves present the same geochemical characteristics observed in AIG16-05.

27 You need to explain this in more detail.

We will explain this in more detail as follows: It also confirms that this lake is more sensitive to high frequencies of the PSA content. This means that seismic waves rich in high-frequency energy, such as those produced by nearby, moderate-magnitude earthquakes, are more likely to induce sediment remobilization in Lake Aiguebelette than low-frequency, long-period ground motions typically associated with larger but more distant events. This point is supported by the calculated PSA values (Fig. 11), where nearby events show relatively higher spectral accelerations at 5 Hz than distant events. The absence of deposits corresponding to strong but remote earthquakes reinforces this interpretation. The sedimentary archive appears more responsive to local ground motions with higher frequency content.

28 Not clear. What “situation” are you talking about?

We agree that the word "situation" is vague. For the 14th century, the lack of reliable seismic records makes interpretation difficult. Please see the answer to the following comment 29 (below), with the new rephrasing.

29 Make a more definitive interpretation/statement about the 1327-1372 yr cal CE event layer. Reword lines 490-492.

We will reword lines 490-492 as suggested in the annotated manuscript, which improves the clarity of the sentence. The revised version will read: “1327-1372 yr cal CE: The interpretation is difficult for the 14th century, with gaps in the records. As discussed before, even though the major Basel earthquake may correspond in age with the event layer, it is highly probable that a local moderate earthquake would not be archived in the SisFrance database.”

30 The seismically-triggered layers have been defined to be 0.5-2cm and >2 cm, as presented on lines 344-351. On what basis can it now be decided to consider that all of the event layers ≤0.5 cm thick were also seismically triggered? It is not defendable to do so late into the paper. Rethink? Reword?

We are not assigning a seismic origin to all event layers ≤0.5 cm thick. As clearly stated in lines 516-518 of the manuscript, we are exploring two hypotheses: (1) considering all identified event layers as seismically induced, and (2) taking into account only the ≥0.5 cm thick event layers, for which greater confidence can be placed in their seismic origin. These scenarios are tested to evaluate the archive's sensitivity and the impact of different inclusion thresholds. They are presented as working hypotheses and not as definitive conclusions. This discussion appears in the dedicated discussion section, which seems to be the appropriate place to explore such interpretations and push the limits of scientific reasoning based on the available data.

31 The text here summarizes three stages that are shown on Fig. 12D, which implies that the stages are defined based on shifts in the sedimentation rate. Stage 1 spans about 8000 yr, which is about twice that of stages 2 and 3. Stage 1 also consists of two obvious sub-stages between -9500 to -6000 and -6000 to -2000 CE. Why are there not four stages? The text needs to clearly indicate how these stages are defined.

We will write a clearer explanation: the three-stage structure was defined based on shifts in both sedimentation rate and event layer frequency. We will clarify that Stage 1 cannot be divided into two sub-stages, as both sedimentation rate and event layer frequency do not allow it.

32 Be clear that you are talking about event layers between 0.5-2 cm thick, which I think you are. However, there are four event layers <0.5 cm between -2000-0 CE. Couldn't these be from floods? I am not sure that the absence of event layers that could be floods really helps support the inference that the layers between 0.5-2 cm were in fact formed by seismic events.

Yes, we are talking about event layers ≥0.5 cm thick. This will be clearly stated in the revised manuscript. Regarding the four event layers <0.5 cm between -2000 and 0 CE, their limited thickness and the lack of proxy resolution prevent us from determining their origin. We do not interpret these as seismically induced. What is clearly stated in the current manuscript (Figure 12, Table 3) is that no event layers ≥0.5 cm are recorded during this -2000 to 0 CE interval, meaning no reliable marker of seismically induced deposition is archived in the sediments. This is explicitly stated in lines 526–528: "In the event layers chronicle, a period of quiescence is visible between -2000 and 0 yr cal CE (Fig. 12; 13), where no event layer ≥ 0.5 cm is archived in the lake."

33 How the mean sedimentation rates were determined needs to be explained briefly somewhere. Also, lacustrine sediments are subject to compaction over time, which is not apparent from an age-depth model. The determination of these rates need tconsider this or at least it needs to be acknowledge that these are *apparent* rates that do not consider sediment compaction over time.

The sedimentation rates are derived from the constructed age-depth models (using CLAM age-depth modeling). Sedimentation rates are calculated by determining the change in depth over the change in age between successive points on the curve, expressed in centimeters per year (cm/yr). These rates do not account for post-depositional compaction.
The mean sedimentation rates were calculated over specific time intervals based on the outputs of these models. We will clearly explain that these rates are apparent and do not consider sediment compaction over time. This information will be clearly stated in the revised manuscript.

34 The utility of the modelled curves fitted to histogram distributions of the number of seismic occurrences versus time gap between depositional events (see lines 582-614) is outside of the expertise of the reviewer. Nevertheless, the reviewer is not sure that anything meaningful is represented by these curves. Delete?

We consider the modelled fit curves to be relevant, as the specific distributions observed (time-gap frequencies between events) are characteristic of seismically triggered deposits and recurrence patterns (Goldfinger et al., 2012; Hubert-Ferrari et al., 2020; Strasser et al., 2013). These curves help to evaluate temporal clustering, recurrence variability, as well as potential episodic seismic activity.This is already addressed in the manuscript (lines 584-594), where we present how different statistical laws (Weibull, lognormal, gamma, and exponential) correspond to specific types of seismic behavior. These modelled distributions, applied to time-gap frequencies between events, enable us to assess whether the observed recurrence intervals reflect a known pattern.

Goldfinger, C., Nelson, C. H., Morey, A. E., Johnson, J. E., Patton, J. R., Karabanov, E. B., ... & Vallier, T. (2012). *Turbidite event history—Methods and implications for Holocene paleoseismicity of the Cascadia subduction zone* (No. 1661-F). US Geological Survey.

Hubert-Ferrari, A., Lamair, L., Hage, S., Schmidt, S., Çağatay, M. N., & Avşar, U. (2020). A 3800 yr paleoseismic record (Lake Hazar sediments, eastern Turkey): Implications for the East Anatolian Fault seismic cycle. *Earth and Planetary Science Letters*, *538*, 116152.

Strasser, M., Monecke, K., Schnellmann, M., & Anselmetti, F. S. (2013). Lake sediments as natural seismographs: A compiled record of Late Quaternary earthquakes in Central Switzerland and its implication for Alpine deformation. *Sedimentology*, *60*(1), 319-341.

Conclusion

Your global comment highlights the importance of rigorously establishing seismic attribution for event layers, and we have shown that our methodology fits this requirement. Our use of multi-proxy sedimentological analysis, historical seismic correlations, and core-to-core comparisons provides a robust basis for identifying seismically triggered event layers. We will make clarifications in the revised manuscript (and include a summary table of event layers) to ensure that the conclusions are additionally substantiated.

We appreciate your feedback and hope that this response addresses your concerns.

Best regards,
Mathilde Banjan and co-authors