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**Title of article:** Co- and postseismic subaquatic evidence for prehistoric fault activity near Coyhaique, Aysén Region, Chile

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**RC1:** Renaldo Gastineau

**RC1 review:** Indicated in blue

A. GENERAL COMMENT

I enjoyed reading the manuscript written by Vervoort et al, which presents a co- and post-seismic record at Lago Pollux, and shows that along with previously published studies (Lago Castor; Van Daele; 2016 and Aysén Fjord, Wils et al. 2020), local faults can also produce significant earthquakes. The authors use a 'common' methodology in lake palaeoseismology but brings here ground motion modelling to derive the most likely magnitude and source fault, which is quite innovative and interesting.

The manuscript is well written and organised, although I found it sometimes relies heavily on the findings of Van Daele et al. 2016 and Wils et al. 2020, which can overshadow its original contributions and make it difficult to follow without prior knowledge of these papers. I think making some more clarification or adding supplementary information in the methods and results sections could help reducing this issue.

Another point that concerned me a bit was the lack of important key information about how the age models were made. Although not from their study, the correlation between the Lago Castor and Aysén Fjord sediment cores is an important point in their discussion section. Their argument is based on synchronicity and then on the age models, which can be very different from one method to another. I then suggest please to write explicitly how they were modelled in the respective articles, at least briefly, which modelling settings and inputs.

Regarding the last part of the manuscript, I think that the results and discussion regarding the source fault model are very interesting, but the readability and visual quality of figures 9 and 10 do not allow readers to take full advantage of them. I believe that improving these figures will greatly enhance the impact of your study.

Therefore, I recommend minor/moderate revisions to address these concerns before considering final publication.

Thank you for your review. All comments are acknowledged and will be reviewed and discussed below. It is indeed true that the manuscript relies on previous research, therefore some lines will be added for clarification.

Furthermore, a few lines will be added on the age models. This is, the number of radiocarbon ages used and the type of material on the age models for both Lago Castor and Aysén Fjord. However, it is important to keep in mind that we made a correlation between both the Lago Castor and Aysén Fjord age model relative to the H2 tephra deposit, thus relying on sedimentation rates

rather than absolute ages. This implies that those details about the radiocarbon ages, material type and calibration should not be the main focus. However, the age models of Lago Castor and Aysén fjord will be added in the SI to illustrate that the sedimentation rates are very stable.

Lastly, both Figure 9 and 10 will be improved: 1) The map of Chile will be deleted and a box will be added on Figure 1 referring to the locations in Figure 9 and 10. 2) We will edit the figure to make room to enlarge the maps, improving the readability and visual quality of the images.

B. SPECIFIC COMMENTS

Introduction

Line 30: I think you should also mention that we can also observed co-seismic deformation with sediment cores on each part of faults. e.g.:

• Beck, C., Campos, C., Eriş, K. K., Çağatay, N., Mercier de Lepinay, B., & Jouanne, F. (2015). Estimation of successive coseismic vertical offsets using coeval sedimentary events–application to the southwestern limit of the Sea of Marmara's Central Basin (North Anatolian Fault). Natural Hazards and Earth System Sciences, 15(2), 247-259.

• Gastineau, R., De Sigoyer, J., Sabatier, P., Fabbri, S. C., Anselmetti, F. S., Develle, A. L., ... & Gebhardt, A. C. (2021). Active subaquatic fault segments in Lake Iznik along the middle strand of the North Anatolian Fault, NW Turkey. Tectonics, 40(1), e2020TC006404.

These references will be added to the manuscript.

Study area

Line 57: Sometimes you use “Figure. 1”, sometimes “Fig.”, please check the style of the journal and change accordingly. This will be updated so that it is consistent throughout the article (i.e. “Figure 1”).

Figure 1: If you know it, please say which type of fault you have (normal, reverse, strike-slipe). Fonts are hard to read. The type of fault is written in the text for the LOFZ (line 75) but will be added in the manuscript text for the local crustal faults (line 79). After the addition of an indicative rectangle for Figure 9 and 10 (see A. General Comment) and rivers in the Aysén catchment (see further), the figure and its fonts will be updated.

Method

Line 101: Please remove “(very)”: it does not help the reader and is not quantitative. This will be removed.

Line 114: It could be nice to add the CTD profile in the supplementary information. Since this is not the focus of the article, only the reference to the original study will be added (i.e. Van Daele et al., 2016).

Line 122: “The present study focusses on sections VIII and IX of the core (9.5-12 m depth)”. This is not a useful information because in the article of Wils et al., 2020; I could not find these sections’ names. Better to refer to the depths maybe? Or to add the scheme of the composite core in supplementary information (SI) to help the reader to check the information you provide. A scheme of the composite core and core sections will be added in the SI, alongside the SI figure of the

Aysén Fjord age model (see A. General comment), and a reference to the data report from the original survey.

Line 159: Delta can also collapse spontaneously, maybe you could explicit that. Since the focus is on external triggering mechanisms, this will be added explicitly in the manuscript.

Line 163: I find this +1/2 unit uncertainty a bit arbitrary but this is true I don't have better to propose. Why not 1 then? Can you in one sentence argue about that? The ½ intensity unit is used because smaller increments constrain too much, and larger increments would imply that negative evidence has no effect on the outcome. The ½ increment is thus a good compromise, as was found by Kremer et al. (2017) and is also further explained in Vanneste et al. (2018). This will be added in the manuscript, including the explicit references.

Line 179: Please add a reference for all the fault characteristic values you provide. We hereby refer to the geological map of the area, an inline citation will be added.

Results

Line 188: "Figure 2c", the figures should appear in the chronological order. Same line 242 where we jump from figure 2 to figure 6b. Figure 2 will be set in chronological order: the bathymetry map is Figure 2a and the profiles Figure 2b, c. The reference to Figure 6 will be left out of this results section.

Line 201: To help the reader, you could add a scale in meters on the right of your figure 2. Besides, you mention an acoustic velocity of 1450 m/s in the water to produce the bathymetric map. What about the sediment? Is the velocity assumed constant? Is it based on the MSCL measurements for the topmost part of the seismic where you have a sediment core? Which value do you use? We missed such important information in the method. In Figure 2, on both seismic profiles a scale is visible, showing both a vertical estimation of 10 m of depth (and a horizontal scale). In line 112-113 it is noted that the acoustic velocities from Lago Castor were used to estimate the sediment thickness (with reference to the study on Lago Castor; Van Daele et al., 2016).

Figure 2:

- It is not super easy to make our own interpretation of the seismic profile due to the quality of the PDF. Can you please add uninterpreted profile in the SI at least, please? For example, the unit 3 I would have been happy to see a zoom of it. In the SI, for both profiles, the uninterpreted version will be added as a figure.

- In Figure 2c, add a scale please. A scale will be added on the bathymetry map in Figure 2.

- You talk in the method of both a centipede sparker and geopulse spinger source system data, but only present two profiles from the spinger source system, why? As mentioned in the methods, the sparker source resulted in a vertical resolution of ~0.5 m. As this resolution is low, the profiles were not used for the identification of the MTDs. However, these profiles were used to reconstruct the bathymetry and aid in the distribution (thickness/depth) of the different seismic units. This will now be clearly stated in the methods section.

- Please provide in the map the location of all the seismic profile that you have, and why did you choose to present these ones? If you don't present the sparker data please remove from the method section. The seismic profiles were not plotted on the bathymetry map in Figure 2, to not overshadow the bathymetry (as the whole lake was surveyed in a dense grid). However, a detailed

map of all the pinger and sparker profiles will be added in the SI. The two profiles shown in the manuscript are the best profiles to display the various seismic characteristics of the whole lake; i.e. the typical seismic facies of the units and the different MTD types and their presence in the different units.

Lines 247-255: This section is mainly based on the results of other studies. You should either create a section where you summarise the results of other studies, or reformulate your results so that they are better highlighted here. We will reformulate this in the manuscript to clarify that these results came from another study.

Line 257: “Section IX”; again, you refer to a numbered section, but I don’t get this information elsewhere so it doesn’t help to understand your text. A scheme of the composite core and sections will be added in the SI (see above).

Line 266: I would remove “clearly” This will be removed from the manuscript.

Line 271: Provide the values for the lowest and highest values in brackets. These values will be added.

Figure 5c, there is no colour scale to read the plot. The color scale is the same as shown in Figure 5d. However, this shall be made clear in the legend of the figure.

DISCUSSION

Line 313: “In Lago Castor Unit 2 is much thicker (up to 78 m) compared to Lago Pollux,” please give again here the thickness in Lago Pollux. The value will be added to this line.

Line 325: I think it is important to show explicitly those onlaps on the figure. This will be indicated in Figure 2.

Figure 7: the caption should say (b) Lago Pollux and (c) Lago Castor and you must then write a caption for (a). Please add scales. If you have all those seismic profiles why not displaying the thickness of those MTDs? The maps in b and c are quite empty: you could also add some info on the slopes to help to better constrain the uncertainties that you have “To accommodate for variability in preconditioning factors, such as slope angle or availability of sediment”. Also, maybe add the rivers etc to see where we have more sediment accumulation? I think this figure can be significantly improve, you have a lot of useful information that would help in terms of interpretations and reasoning. The caption will be updated. Thickness maps of the MTDs could not be made because of two main reasons: The sparker profiles have a vertical resolution that is too low (~0.5 m) to properly identify the MTDs. As the pinger and sparker profiles alternate (not every survey line is both a pinger and sparker profile), and based on the pinger profiles alone, the gridding of the reflectors would give too much of an error. On Figure 7b, c the rivers will be added, as well as the bathymetry, to aid in the interpretation and reasoning.

Figure 8: I have a concern regarding the approach and this figure. We do not have in the method section any information regarding the age modelling part. I know both cores are from another study; but as it is the main part of your argumentation you should be clear on how the age model were performed in both papers. If they are not run using the parameter then I would be happy to see how it is with rBacon for example. Please be more explicit about that in your manuscript. This information will be added to the manuscript (see A. General Comment).

Line 389: “are located along the lake slopes”. More or less, at least it is hard to see that on the actual figure. Figure 7 will be updated (see comment Figure 7), to aid the reader while reading this section.

Line 391: “cfr”? This will be removed from the manuscript.

Line 392: I thought it was VI1/2 + 1/2 = VII? from your method line 158. Then I am a bit lost. By explaining this in the methods section (see above), we hope that this will be clear.

Figure 9: In general, the fonts of this figure are too small. The maps are hard to read. The isolines are hardly perceptible. etc. This need to be significantly changed please. Same for the GPS coordinates, they are too small. I can unfortunately can’t review it properly. Figure 9 (and 10) will be modified to enhance the readability (see A. General Comment).

Line 423: Figure 9c I presume? But I can’t see what you mean. Throughout this section, the references to Figure 9 will be updated and clearly point to a certain part of the figure.

Line 437: I see your point, and I am not working in subduction zone, but 30 km is not a lot for such strong earthquakes to my opinion? The slab window resulting from the subduction zone is 30-40 km away. However, the trench itself is located more than 300 km from the Lago Pollux area, making this too distant to cause significant shaking in the area. Moreover, the absence of a coseismic deposit in the more trench-proximal Aysén Fjord advocates for an inland seismic source. This explanation will be added to the manuscript to clarify.

Figure 10: I have several questions regarding this model.

- From where do you take the fault map? The fault map is a simplified version of the geological map of the area (SERNAGEOMIN, 2003). This reference will be added in the manuscript (and in the caption of Figure 9 and 10).

- Is there any study on the faults themselves (e.g., trenches)? Data regarding the movement of the faults? No; a simplified geological model was used.

- You will not have the same wave propagation with a strike slip or a normal fault. How sure are you about this tectonic map? Here you mentioned for example “Grey fault traces are not sufficiently long to cause a rupture with the tested magnitude”; Then you should maybe mention it. I feel there are some key information missing regarding tectonics. And I have the same remark as Figure 9, this figure it generally too small and really hard to read. Although the overall stress regime in the region is related to strike-slip faulting due to the oblique subduction of the Nazca plate below the South American plate, it is indeed true that individual faults in the region may exhibit some normal component of slip. This would indeed affect wave propagation and thus intensity distributions. However, the considered IPE relies on epicentral distances, and the modelling outcomes would thus not change when considering a different focal mechanism. To avoid any confusion, we will clarify this in the methods, and add some background on how earthquake magnitude scales with fault length (using a magnitude scaling relationship) – thus explaining why some faults are not capable of causing certain tested earthquake scenarios.

C. TECHNICAL CORRECTIONS

Line 38: Please remove ‘~’.

Line 104: Missing dot after “receiver”

Line 106: typo “m in” and not “m)in”

Caption Figure 1: area and not are.

Line 252: add a space after “(2015)”.

All the above will be corrected in the manuscript.