

## ***Interactive comment on “Environmental changes on the Balkans recorded in the sediments from lakes Prespa and Ohrid” by B. Wagner et al.***

**B. Wagner et al.**

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First of all, we would like to thank both reviewers for very fruitful comments and suggestions to improve the manuscript. We made a point to point reply to the comments and suggestions.

Reviewer #1, RC C1871, 18 Jul 2010:

... My detailed comments are indicated below on specific aspects of the paper:

Table 1: calendar age of KIA36356 must have a typographical error and is the only calibrated older age so this needs to be corrected. Maybe its supposed to be 37,990?  
- There was a typographical error. Age is changed in the table to 37,990

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Fig. 1 Add the names of the countries to the maps and the political boundaries to the shaded relief map. - Done, see Fig. 1

Fig. 2 – perhaps need to add arrow so show circulation? Nothing is clear in my printed version. What are the regional winds that control surface mixing and how are past changes in the winds related to what is known about large scale Earth system dynamics in the Mediterranean. I don't see this addressed in the text (or I missed it?) - We added arrows in the figure to better indicate the surface currents. The main wind is from southern or northern directions at Lake Ohrid today, as the valley is oriented along the longitudinal axis. However, we do not have information about major reorganisation of wind directions in the past, except of changes in the wind strength (discussed in the text).

Fig. 3 – Laminated intervals are not shown here with any clarity. Could a close up be added to figure 4? Fig 3 also needs to have the interval of the line scan at the right edge show with arrows between the Mn column and the scan. This would make it clear that there is an intentional scale change here to show details of the transition between depositional units. - We deleted Fig. 4 completely (see comment reviewer #2) and added arrows to indicate, which interval is shown by the line scan at the right edge.

Fig. 5 – add error bars to the radiocarbon ages. - Error bars are shown for all (radiocarbon and tephra) ages, but are partly too small to become visible in Fig. 5 (see also Table 1).

Fig 6. And 7. – These figures are fine but would be improved by adding the names of the lakes next to the core names. There is plenty of room for that. Fig. 7 – One can't really see the link for the 8.2 event in Lake Ohrid vs. Lake Prespa. Perhaps you need to add a dashed line for this – I don't see any connection or there is something funny about the way the columns are lined up here (I suspect the latter based on your text). - We added the names of the respective lakes in both figures. Furthermore, the dashed line for the 8.2 event was added. However, the correlation of the 8.2 event has to be

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regarded critical, as there are only a few reliable radiocarbon ages existing around this period.

Abstract: line 3 to 7 should read – From Lake Ohrid, several sediment cores up to 15 m long have been studied over the past few years. Here we document the first long sediment core from nearby Lake Prespa to clarify the influence of Lake Prespa on Lake Ohrid and the environmental history of the region. - Done (see also comment below).

Abstract line 8 – should read. . . .dated tephra layers provide robust age control. . . . - Done (see also comment below).

Page 3367 – Not sure why Lake Ohrid is the only ancient lake in Europe. What does ancient mean geologically? - This word is defined in Albrecht and Wilke 2008 (Ancient lake: Extant lake that has existed since before the last glacial maximum. There is controversy as to the minimum age of an ancient lake. Whereas Gorthner (1994) proposed an age of at least 0.1 My, other workers suggest a considerably older minimum age). As there is no exact geological age for the use of this word, we deleted the word “ancient”.

Page 3367 – line 6 – by faunal compositions, do you mean modern faunal inhabitants? Or extant faunas, is another way to say this. - Done (see also comment below).

Page 3367 – line 8 – lake diversity and surface area? Relationship/significance unclear. If the lake is smaller with the same number of species is it more diverse? - Done (see also comment below).

Page 3367 – line 16 . . . . During the past few decades. . . . - Done (see also comment below).

Page 3367 – 0mit the sentence in line 20. - Done (see also comment below).

Page 3367 – line 24 – Until this study, the sedimentary . . . . - Done (see also comment below).

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Page 3367 – line 26 – from both lakes document their recent eutrophication and. . . . - Done (see also comment below).

Page 3367 – line 28 – Longer sediment sequences recovered so far only from Lake Ohrid indicate that. . . . I can't redo all of the English for this review but above gives you an idea of what I think the paper needs. - Done. In addition to the changes the reviewer suggested and we made, Melanie Leng checked the whole manuscript, improved the English and also gave comments and suggestions.

Page 3369 – throughout this page – instead of mixis, I would use “mixing”, given that this is not a limnology journal. - Done.

Page 3370 – first sentence should read: An 8.85 m long sediment record was recovered from Lake Ohrid in 1973. . . . - Done.

Page 3370, line 16 – Correlation of individual sediment cores measuring up to 3 m in length, but taken during different coring drives, was accomplished using . . . . . The composite record totals 10.5 m below lake floor. - Done.

Page 3371 – line 25. I suggest calling the IRD something like “lake IRD” or LIRD, to make it clear that you are not implying that glaciers were calving into these lakes. In figure 7, you have IRD for the marine cores so you don’t want to confuse readers by your meaning. We changed the text accordingly and used the abbreviation IRD only for the marine record used for comparison (in the text and in the revised Fig. 6).

Page 3372 – line 1-2; should read: gravel and coarse sand were transported by ice floes. - Done.

Page 3372 – lines 20-25 needs to be rewritten into parallel construction for each tephra. Better yet, I suggest you put the tephra IDs, ages and chemistry into a new table. - We added a new table (Table 2) to the manuscript. This table indicates the most important data of the tephras. The chemistry of the tephras was not added, because this and the thorough discussion of the chemical data are part of another manuscript, which shall

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be published in the same special issue (Sulpizio et al). A reference to this paper is given in the text.

Page 3372 – line 28 – reference back to Fig. 5 here where you show the tephras. - Done.

Page 3373 – line 6 – age munsell colors to olive and grayish – you probably have these numbers anyway. - Munsell soil colours were not determined and the sediment changed the color relatively soon after the opening of the cores due to oxygenation. So we are not able to provide more exact information to the color of the sediment. However, we tried to describe more exactly the colours that were observed directly after opening of the cores.

Page 3373 – line 8-9 – by “relatively calm sedimentation conditions”? so do you mean normal or undisturbed pelagic sedimentation? I think you do. - Text is changed accordingly.

Page 3374 – lines 10-13 – this is a run on sentence and needs to be rewritten into 2-3 sentences. - Done.

Page 3374 – line 17: Start sentence here. . . .Other evidence for stronger aeolian activity. . . - Done.

Page 3374 Interpretation section: There are several places in this section that make reference to temperature but its all rather indirect. The pollen data is provided for trees and shrubs without reference to paleotemperatures from these data. Are there no diatoms in the lake to provide paleotemperature information? Also I see that Roelofs and Kilham is listed for diatom work in the references but this reference is not used in the paper. (or there is a spelling error somewhere). It would be extremely useful if the critical paleo data like the diatom data could be added to figure 7. - Pollen and diatom data were not used so far for quantitative reconstructions for the entire period discussed in our manuscript. Ongoing work on the cores from Prespa and Ohrid will

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focus on such quantitative paleotemperature changes. Roelofs and Kilham (1983) had a spelling error, which is now corrected. Fossil diatom assemblages were so far only determined for Lake Ohrid. These data are main subject of another paper (Reed et al., Biogeosciences Discuss., 7, 4689-4714, 2010). Comparable studies on Lake Prespa sediments are ongoing.

Page 3376 – line 3, add reference to figure 3 here next to figure 7 for the carbonate proxy data to really be seen well. - Done.

Page 3376 – can you add some discussion here about the variations in strength of the Heinrich events in Lake Prespa/Ohrid. Is there evidence for differences in the strength to which the ITCZ was deflected southward during these events across Europe. Is H4 less pronounced in other records as one gets more far a field from the North Atlantic? - We added a brief discussion about the variations in strength of the Heinrich events. A clear statement (e.g., decreasing influence with increasing distance from the North Atlantic) cannot be given according to our opinion based on our and other existing data, as different proxies were used and even in a single record the used proxies are not unambiguous (see text for further details).

The Mn counts and the carbonate proxy (TIC) in Lake Prespa for H0, H1, H2 and H3 are all very different in character and imply something more complex than just lake level lowering (text around line 14). What more might be different about the response of these lakes to these events? - We added some sentences about the formation of Mn concretions in sediments (see also reply to reviewer #2). Most probably the Mn concretions are formed by distinct changes in mixing conditions of Lake Prespa. A change in mixing conditions can at least partly be due to significant lake level fluctuations, but there are other factors such as temperature, wind, etc. which also have a high influence on lake mixing.

Page 3378 – line 13 – more work needs to be done on fig 7 to show evidence of any 8.2 event in Lake Ohrid. Or why would this be recorded well in Lake Prespa but not

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in Lake Ohrid? This is not addressed or I am missing something. - We think that the 8.2 event is recorded in all shown records from lakes Prespa and Ohrid, although with differing intensities. A more sophisticated study of the 8.2 event in Lake Ohrid is made by Holtvoeth et al. (Biogeosciences Discuss., 7, 4607-4640, 2010). We are still speculating, why the 8.2 event seems to be most pronounced in Lake Prespa. A possible explanation could be that Lake Prespa is more influenced by changes in clastic matter supply from the inlets than Lake Ohrid, which is mainly fed by karstic inflows being depleted in clastic matter. Hence, we may have a distinct change in sedimentation rates in Lake Prespa, which is less pronounced in Lake Ohrid.

I suggest this paper be published but only after some major revisions. The record is very important and these revisions would make this a much stronger paper. Revisions of the English will make it flow better as well. - The English was checked and improved by Melanie Leng.

Reviewer #2, RC C1959, 22 Jul 2010:

This paper presents a few new proxies from Lake Prespa covering  $\Delta^{13}\text{C}$  50 kyr and they are compared to earlier published data of lake Ohrid. Today the lakes are hydrologically connected through karst aquifers and the authors were aiming for testing/evidencing connections in the past. The discussion is focussing on rather well-dated lithological changes occurring coeval in both archives. Pleistocene short - lived lithological changes are related to Heinrich events and in Holocene to the 8.2 kyr event - an interpretation which has already been proposed based on vegetation changes (see Wagner et al., 2009). Changes in proxy records (e.g., TOC) are mainly attributed to different eutrophication regimes in the two lakes. Yet the paper is rather descriptive and the interpretation contains often short statement (partly previously published) not supported by other facts and discussed properly. I think the paper could be considerably improved if the data would be embedded into a more conceptual discussion of (hydrologic, diagenetic) (i) processes relevant to these limnic archives and (ii) climate records (including other proxies from lakes in the nearest vicinity) from other (Mediterranean)

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climate archives. - We added diagenetic aspects in the discussion, particularly with respect to the formation of the concretionary horizons (example from Lake Baldegger See, Switzerland). Hydrological aspects cannot be discussed based on our data and on existing data from other studies (except those cited in Popovska and Bonacci 2007), as sophisticated long-term data to mixing conditions of Lake Prespa do not exist. This is different to Lake Ohrid, which is known to have a complete overturn irregularly every few years based on long-term measurements (already cited in the text). Some speculations about past hydrological changes can be derived from isotope studies, which are published in another paper in this special issue (Leng et al. Biogeosciences Discuss., 7, 3815-3853, 2010). This paper is cited in the text. With respect to other climate archives from the region, we checked the relevant literature and tried to focus on the most important records covering the same period. We also checked, whether a statement that the influence of the Heinrich events decreases with increasing distance from the North Atlantic can be made (see also reply to reviewer #1). However, there are only a few records, which cover the same period (50 ka) and which use similar proxies. Even within individual archives, different proxies indicate a different strength of Heinrich events. Some of the proxies used are related to temperature and/or precipitation (e.g. pollen), other are directly related to lake level fluctuations (e.g. Dead Sea; Stein et al. 2009) and clear statements can hardly be made. We added relevant parts of this discussion in the text.

The paper needs a thorough rewriting as problems often arise due to unclear wording. - Done, see reply reviewer #1

Curtailments of some chapters would make it easier for readers (taking into account that there are several papers published or in press on this matter (e.g., Wagner et al., 2008, 2009; Sulpicio et al. 2010 in prep., Biogeosciences Discuss.; Vogel et al. 2010 a, b, c) (see page 3383/4). - We checked the text throughout and shortened, wherever possible.

A few more specific comments below: - p3366 line 12-14: TOC contents (bioproduction

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vs. preservation): elaborate more explicit in your discussion how you infer on past changes of primary production / eutrophication (today TOC wt % quite similar 1, 2 wt% respect. in Ohrid and Prespa: Holocene climate optimum 1:4) (further information needed?) - The trophic state of the lakes can only be estimated based on the surface sediments and on recent measurements (e.g. Matzinger et al. 2006a, b, 2007). For the past, higher organic matter contents in the sediments imply a higher trophic level, particularly in Lake Prespa. The higher content of organic matter is an indication that warmer temperatures as they likely occurred during the early Holocene (see also other records from the region) more affected the productivity of Lake Prespa than that of Lake Ohrid (see Fig. 5). We checked the text in the relevant paragraphs and tried to be more precise in the discussion. Diatoms were not yet determined in the record from Lake Prespa and are only partly preserved in the record from Lake Ohrid.

p3391 Fig.6: it would be quite nice to have a close-up for the time window 0- ca. 16 kyrs. This could help to make the discussion of Holocene changes/comparison (including other data; e.g. pollen from A.Lotter) more specific. but age range could be limited to 50 kyrs, the TIC record in Ohrid is not so exciting, but if needed rather include it in Fig.7 - We limited the age range to 50 ka, which also led to better resolution of the late Pleistocene and Holocene (<16 ka) part of the cores. A close-up for the period < 16 ka would imply a high reliability of the radiocarbon dates. However, this is not provided as different organic fractions were used for dating (see also comment below). We also would like to keep TIC in Fig. 6 (now Fig. 5), as the comparison of organic matter (TOC) and carbonate (TIC) contents is one of the major aspects of this paper.

p 3392 Fig.7 : mechanisms for an increased detritic input (Zr/Ti, sand size fraction) during the Holocene climatic optimum ( aeolian activity is higher) and during the coolings assigned to Heinrich events are different: elaborate a little bit on this statement.... (Fig. 7 and p 3376 line 21-23) at some stage in Wagner et al 2009 the authors mention (refering to the vegetation) "...The observed changes, however, cannot be related clearly to a change in temperature or humidity... " - The statement made by Wagner et

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al. 2009 was based on a pollen record with a relatively low resolution. Heinrich events were only tentatively indicated in a shift towards more steppe vegetation, thus indicating cooler and / or more arid conditions. Other records from the vicinity also indicate that the Heinrich events were related to cooler and / or drier conditions in the region. The work by Vogel et al. 2010a has shown that also changes in aeolian activity likely occurred. As aeolian activity is the main trigger for mixing of the water column, this might have also affected the formation of Mn concretions in the sediment record from Lake Prespa. We tried to include this discussion more explicitly in the text.

Why ist the diagenetic regime (as documented by relative Mn increase) disturbed during the glacial intervals but also during the late Holocene? - We think that the diagenetic regime is not disturbed, but there was better mixing of the water column (likely twice a year during the glacial). This likely affected the formation of Mn concretions, as shown (and cited in the text) by the example from Lake Baldegger See in Switzerland, where the formation of Mn concretions was investigated in detail.

Is there a reason for offsets in age assignments between Prespa and Ohrid? - A part of the offsets between the records from lakes Prespa and Ohrid in the period < 16 ka could be based on the different organic material used for radiocarbon dating. Terrestrial macrofossils were used for dating, when they were found in the sediments. In Lake Ohrid, only very few macrofossils were observed and bulk sediment was used for dating. However, past studies have shown that hardwater and reservoir effects in this lake can lead to too old ages (probably up to 1500 years).

Some minor comments: p3366 line 10: explain why you conclude from comparison of results (which show similar trends; see Fig.6) that Lake Prespa is more sensitive to environmental changes - The lower volume of Lake Prespa and the lower water depth amplifies environmental changes. Lake Prespa water warms up faster in spring and summer and that similar nutrient input would lead to a higher trophic state due to the lower buffer capacity. Lake Ohrid, with a much larger volume and water depth, remained oligotrophic during the Holocene, whilst Lake Prespa turned into mesotrophic

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conditions. Similar observations were made at the end of MIS3 (page 3375). Another hint for a higher sensitivity of Lake Prespa is given by the 8.2 event. This event seems to be much more pronounced in Lake Prespa compared to Lake Ohrid. Either the cooling had a higher direct impact on productivity in Lake Prespa or there was a distinct change in sedimentation rates and significantly higher input of clastic matter (see also reply to reviewer #1). However, further dating would be needed to clarify this hypothesis.

p3385 the age of KIA36356 needs some attention - Error is deleted (see reply reviewer #1)

p 3386 useful for readers if core numbers show up in figures - Done.

p 3387 omit - We changed the figure according to the suggestions made by reviewer #1- Part of the problems with the figures (also line scan photos) probably are due to differences in the quality of the online pdf vs printed versions, which probably show not enough contrast to make the currents visible.

p 3388 why did you select the  $>20 \mu\text{m}$  (vol. %) grain size fraction? Is there a reason that I did not find a discussion of the grain size analyses data but just a statement on the sand size fraction. Did I overlook it? - From the discussion of the grain size measurement results, we selected the fraction with the highest significance to keep the discussion as short as possible. The other fractions ( $< 20 \mu\text{m}$ ) did not show significant changes or did not indicate additional information. The coarse fraction should best document changes in aeolian input or changes in the currents of the lakes (see also Vogel et al. 2010).

p 3389 merge Fig.4 with Fig 3 - We merged Figs 3 and 4, i.e. we deleted Fig. 4 and added the Mn counts of the XRF scan to Fig. 3

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Interactive comment on Biogeosciences Discuss., 7, 3365, 2010.

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