Author comment to the reviews on Leicher et al.

First of all, we would like to express our thanks to the anonymous reviewer and to the second reviewer S. Davies for reviewing the MS. We considered all comments on the tephrostratigraphy of the DEEP site carefully, which significantly improved the established correlations and the general quality and structure of the MS. Below, we will provide a point-to-point reply to the comments.

Anonymous Referee #1
Received and published: 15 October 2015

General comments:

My main comments concern the discussion section i.e. the data analysis. I have some difficulties in taking into account the proposed correlations mainly for the ancient tephras (prior to X-6). The correlation of a tephra with a volcanic source and/or event cannot be solely based on the TAS classification diagram as the authors did. It is known that the sum of alkalis cannot be a diagnostic criterion due to the mobility of the two oxides. Moreover, there is heavy overlap of compositions related to the Italian volcanic rocks. The use of TAS as the only instrument of major element analysis can lead to misinterpretations and ambiguous correlations. I suggest to the authors to perform a more accurate data analysis and to provide significant figures concerning this issue.

We agree with the reviewer that the former way of presenting the proposed correlations using the TAS classification diagram alone is not enough for establishing reliable correlations of tephra layers. We are aware of the mobility of the alkali-oxides and the overlap in the geochemical composition of pyroclasts from Italy's volcanoes. Actually, we established our correlations using also other major elements, but in the original manuscript, we decided to show only the TAS-diagram as a general overview and correlation figure. Therefore, in the revised version, in order to improve and present a more accurate data analysis, we will add other oxides plots to proof the proposed correlations for the tephra older than P-11/OH-DP-06xx. Additional oxide plots also for the younger tephra layers will be given as supplementary material.

The ancient tephras analysed here represent the most original aspect of this paper and therefore deserve a more significant approach. I think that a research paper should provide all the main informations to let the reader follow the discussion and the aimed results in the proper way. This work deals with the correlations of 13 tephras with a number of likely correlatives both at proximal and distal sites. This means a large dataset of major element compositions from literature which the authors should have used in order to make comparison with OH-DP-

tephra and to establish the proposed correlations. A table where at least the average composition of all the many tephras, used in the TAS for comparison e cited in the text must be reported. It is hard for the reader to have such a long text without a reference table.

We will add a table showing the average major element compositions of all tephra layers used in our study and agree that this will help to make the suggested correlations more robust and easier to follow for the reader.

Detailed comments

1. *It is not clear to me if the cryptotephra correlated with the Mercato event has been analysed in terms of major element content. Actually, there are no data in table 1. Is the correlation merely based on similar tephrostratigraphic features in other cores from Lake Ohrid and Lake Prespa? Please, specify.*

   In the meantime, we carried out SEM-EDS analysis on the glass shards and micro-pumices found in the specific depth. We will use this major element data to strengthen the proposed correlation between OH-DP-0027 and the Mercato eruption, so that the correlation is not only based on (tephro-)stratigraphic features from other cores of lakes Ohrid and Prespa.

2. *Please, locate in Fig.1 all the drilling and outcrop sites cited in the text and discussed to establish correlations with OH-DP-tephras. The paper must be easily managed by anybody interested in the field but not necessarily expert of Mediterranean tephrochronology.*

   We will add a map showing all drillings and outcrops cited in the text in order to give the reader a better overview of the Mediterranean area.

3. *Since some of the analysed tephras in this work aim to be good markers beyond Italy and the Balkan region, I suggest to insert a figure where the tephrostratigraphic framework for the area might be sketched. This figure can sum the conclusions of the paper which are too long in the text after all.*
   We appreciate this idea and will add a tephrostratigraphic sketch merging all the used tephra layers in order to highlight the potential of Lake Ohrid linking individual sections to a continuous record. Furthermore, this will help to sum up the proposed correlations and provide the basis for e.g. future paleoclimatic studies, comparing different archives.

4. *The authors report in the text a low and high silica end-member for tephra OH-DP-0115/Y-3. This feature should be displayed in table 1 with two average compositions for the layer.*

   We will add this to Table 1 and highlight the variation in silica in some of the new oxide plots.

5. *Trimodal composition of the CI deposits? I don't see anything of this in your OH-DPO169/Y-5 tephra.*

   We will revise the specific sentences explaining the tri-modal composition of the CI deposits in order to prevent the misunderstanding born from the three different compositions. Our aim was to show that there is a trimodal composition of the CI deposits, but only two of the three populations are found in OH-DP-0169. The differences in composition are described in Civetta et al. (1997); Pappalardo et al. (2002); Marianelli et al. (2006) and can be seen in the alkali ratio. Such differences in the alkali ratio have also been described for the CI-tephra layer equivalents from previous studies at Lake Ohrid (Sulpizio et al., 2010). We will highlight the differences in the alkali ratio of OH-DP-0169 in a specific table. We will further discuss that one pole is missing in the revised version. In short it could be related to either limited number of analysis performed on glass shards of OH-DP-0169 or the relatively low abundance of the third composition of the CI in distal setting, which to great existent (up to 80%), is represented by the component characterized by a low alkali ratio (K_2O/Na_2O=~1.2) .

6. *In Fig. 3g the label for the tephra plotted in the TAS diagram is OH-DP-0617 but actually it should be OH-DP-0624 according to the text.*

   We will correct the labelling.

7. *The authors report a trachy-andesitic to phonolitic trend for tephra OH-DP-1955. Are you sure it can be considered one population instead of two? Such magmatic trend is very unlikely. Moreover, since Sr-isotope ratios of the correlative SC5 tephra infer an origin for these layers from the Roccamonfina volcano, why do the authors discuss a possible origin from Sabatini vents despite geochemical differences? It is a useless part of the discussion.*

   By using plots of oxides such as MgO, CaO it becomes obvious that the composition shows a linear magmatic trend rather than two different populations. We will add such

specific plots to rule out these doubts, clarify our description of a magmatic trend, and ensure our correlation with the SC-5 tephra.

We do not think that the discussion of Sabatini products is useless at that point. Our reference to Fall B is in fact intended to clear up any doubts about considering it as possible counterpart of OH-DP-1955. Fall B has in fact an age compatible with OH-DP-1955 and thus avoiding to mention it might be considered a lack of our assessment. This part of the discussion is substantially intended to emphasize our correlation with SC5 while ruling out a correlation with the products of Fall B. Fall B is described having also a phonolitic composition, which makes it somehow similar to OH-DP-0624. However, a closer look offers geochemical differences. The second reviewer S. Davies (see reviewer point 3) also demands such discussion.

8. *Concerning tephra OH-DP-2010/Fall A, the authors cite the Tufi Terrosi Eruptive Cycle of the Sabatini volcanic district as the source for the deposit. Please, report the age of this cycle and the reason why they make this correlation.*

   We will report the age of the Tufi Terrosi Eruptive Cycle and further explain the correlation using oxides plots.

9. *In section 5.14 the authors mention two flux standards: FCs and ACs-2. I suppose the one used to recalculate 40Ar/39Ar ages is the latter one (as it is reported in the caption of table 2). Please, correct the sentence.*

   Flux standards are intercalibrated (FCs at 28.02Ma correspond to ACs-2 at 1.194Ma or FCs at 28.201 is equivalent to ACs2 at 1.201Ma). Therefore, the ages obtained with one of the two standards are comparable to each other. Depending on the source we used for the ages we recalculated all ages used in the MS with respect to the proportionality between these two standards . We added the following important information: All ages are recalculated to an age of 1.194 Ma for ACs, which corresponds to FCs at 28.02Ma.

10. *The exact reference for the TAS diagram is Le Bas et al., 1986 and not Bas et al., 11 Please, note in the Introduction section that the tephrochronological record published for KC01B core in the Ionian Sea (Insinga et al., 2014) extends down to 200 ka, then Middle Pleistocene.*

    We will change the citation to “Le Bas et al., 1986”.

    We will revise the specific sentences in the introduction dealing with KC01B.

S. Davies (Referee)
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Specific comments

1. *Please consider merging the results (4) and discussion sections (5.1-5.13) so that descriptions of the tephra deposits can be discussed in tandem with the geochemical signatures and potential correlations. This will shorten the paper and allow the Discussion section to focus on the implications of the results.*

   We will merge the two sections in order to get a more compact MS and increase the focus on the results.

2. *I would suggest re-structuring the Discussion to two sub-sections. The first should describe the intricacies of the age-depth model for the Lake Ohrid record. The second section needs to focus on the implications of the tephra results beyond just the development of the Ohrid age-depth model. In its current form, the value of this tephra framework to other studies and researchers is somewhat lost. Some important but brief points are made in the conclusions e.g. clarifying the eruptive order of events, new insights on tephra distribution patterns, potential for linking different palaeo-records, evidence of large-magnitude eruptions and new records of previously unknown events. These points should be expanded in a section on the implications of these discoveries. This sub-section would greatly benefit from a figure of the tephra record or template plotted alongside an appropriate climato-stratigraphical framework extending from MIS1-15. This would represent a focus for discussing the implications of these results. For instance, key marker horizons for different climatic periods could be identified that could aid in the interpretation of other Middle and Late Pleistocene records in the Eastern Mediterranean region and beyond. Other points touched upon in the Conclusions and mentioned above could also use the visualization of the tephra framework as a focus.*

   We will divide the Discussion chapter into two parts in order to strengthen and expand the mentioned implications and conclusions. However, it is not possible for all points mentioned by the reviewer. The main focus of this MS is to establish independent and precise tie points to create a chronology for the DEEP site sequence. With the proposed implications in the conclusions, we tried to highlight the future potential of tephrostratigraphic studies on the DEEP site, because general implications on the older tephra layers are hard to establish with the current knowledge.

The implications transferred from the tephras younger than OH-DP-0499/P-11 are already described in published studies, summarized in Sulpizio et al. (2010). Discussing implications of Middle Pleistocene tephra layers we discovered is at that point premature since this is the first continuous distal archive being analysed. For instance, implications on the dispersal patterns of these tephras are hardly to establish since some of them are just correlated to single occurrence (e.g. OH-DP-1955/SC5 or OH-DP-201/A11-12). The current state of the art barely allows implications of the eruptive order of tephra layers, since we only presented selected correlations and not the complete tephrostratigraphy of the DEEP site. Additional studies on the geochemical composition of tephras are not discussed in this article. The study of cryptotephras in specific intervals may be necessary to improve our knowledge and allow further implications. However, this is well beyond the scope of this MS.

Adding a figure, showing the framework of current knowledge of Middle Pleistocene tephrostratigraphy, is an excellent suggestion and will help to visualize the links and possible synchronisation of the different archives of the Mediterranean area. We agree that this figure will be helpful and may give more space for implications.

3. *Figure 3 is very difficult to see and interpret. Further figures and additional biplots are needed to support the proposed correlations. In most cases, only the data that support a correlation are provided. Are there other tephras of similar ages and com position that should also be plotted to test other potential correlations? For instance, how does the data for OH-DP-0169 compare with pre-CI data presented in Tomlinson et al. 2012 (Geochmica et Cosmochimia Acta). Further consideration of other potential matches is required and should be shown on plots, where appropriate.*

We agree with the reviewer request, so we have added an additional oxide-biplot and improved the visual appearance of Figure 3 (please see the reply letter to the anonymous reviewer (general comment).

For the tephra layers younger than OH-DP-0499/P-11, tephrostratigraphical correlations were well established for lakes Ohrid and Prespa in several studies (e.g. Sulpizio et al. (2010)) and we decided to show only data of the equivalent layers that support the established correlations. This helped to shorten the MS and keep it clearer. However, for the older tephras we will constrain further considerations with alternative tephra deposits more in detail, where appropriate.

4. *Please provide average secondary standard data alongside the WDS data summarized in Table 1 (average) and individual analyses in the supplementary file.*

   We will add this information to Table 1 and the supplementary.

5. *It would be useful to provide some context for the cryptotephra discovery (OH-DP-0027). What is the shard concentration and how does the concentration profile vary around the peak concentration? Are the glass shards confined to a few centimetres or dispersed within the profile? This is important to pinpoint the exact stratigraphic position of the tephra for age-modeling purposes.*

   The main focus of this MS was to identify all macroscopic tephra layers in the DEEP site. No detailed high-resolution cryptotephra studies have been performed yet (e.g. glass shard counting). Since many studies have shown, that the XRF-scanning technique is a suitable tool for detecting cryptotephra (Vogel et al., 2010; Damaschke et al., 2013), we identified this cryptotephra layer by analysing XRF-downcore data and comparing this data with homologous data of previous cores from Lake Ohrid. In these previous cores peaks in XRF-scanning data and subsequent cryptotephra investigations revealed occurrence of the Mercato tephra by. A maximum of K in the XRF scanning data of the DEEP site sequence was used to infer the stratigraphic position of OH-DP-0027 . The subsequent analyses (microscope, SEM-EDS) were performed on a one cm thick interval, where K showed the maximum. We added this additional information to the MS.

Technical corrections

1. Page 15414 line 4 replace Rosetta stone with template or framework.
   Will change to “template”.
2. Page 15417, line 16 change to “opened lengthwise” and “visually described”
   Will change as suggested.
3. Page 15419 line 1 – grammar - revise sentence.
   Will revise sentence.
4. 15419, line 10 –grammar revise sentence
   Will revise sentence.
5. Page 15420, line 4 – grammar – revise sentence
   Will revise sentence.
6. Page 15423, line 26 – should this be OT0702-3 as shown on figure 3?
   Will change to OT0702-3!
7. Page 15424, line 26 - grammar, revise sentence.
   Will revise sentence.

8. Page 15425, line 3 delete the “in light of new geochemical data”
   Will delate this part and revise the sentence.
9. Figure 3g – should this be OH-DP-0624?
   Will change to OH-0624.
10. Page 15440, line 5-7– grammar please revise.
    Will revise sentence.

References:

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