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Interactive comment on "Non-invasive imaging methods applied to neo- and paleontological cephalopod research" *by* R. Hoffmann et al.

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We thank the anonymous referee #2 for their comments. Regrettably the comments are not very specific, however in the following we will address the main criticisms in order to clarify some uncertainties and include corrections where feasible. We are responding to the main issues raised by the referee in the following, in each case we include the referee comment in italics followed by our response.

1. However, as it stands, the paper does not satisfactory develop any of its declared goals, notable that of "diversity and disparity", ...

For each of the presented methods a potential application was provided. We developed a strategy using different non-invasive methods in order to conduct a reliability study

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for the calculation of precise volumes which is necessary for subsequent buoyancy calculations which has not been done before. The quantitative morphological approach (diversity vs. disparity) is mainly based on the outer shell characteristics – therefore we not only focus on internal structure but also external shell features. A full diversity vs. disparity study is far beyond the scope of our manuscript and would dramatically extend the manuscript if such paleobiological issues are to be covered properly. Therefore the diversity vs. disparity study of ammonoids will be part of a forthcoming article. We indicate that the traditional method of using sectioned specimens provides data only for every 180° or 90°. Non-invasive methods can deliver morphological data for every single degree which is a significant advancement. Internal features can be added to this as well and therefore might be of interest for people working in the field of geometrics and morphometrics.

2. The introductory section widely fluctuates between a number of (paleo)biological and technological issues

In the introduction we classically presented a short historical overview and stressed that we focus on cephalopods for several reasons i.e. availability, accretionary growth recording ontogeny, and complex internal structure.

3. nor providing any valuable hypothesis to be tested.

The paper is not meant to address a single specific hypothesis. However we include a variety of topics (diversity/disparity and buoyancy) from which important hypothesis can be drawn from. In the introduction we stressed the discussion about the swimming ability of extinct ammonoids and employed a reliability study for buoyancy calculations based on CT-data with a level of precision never reached before.

4. ...very poor scientific value and interest (I cannot rate it higher than a Master level),...the text is quit boring, after all.

These are rather subjective comments. We strongly disagree with the view of the

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referee especially given the fact that our study is filling an existing gap of knowledge. We may emphasize here that our study is moreover important for a wider scientific community interested in paleoenvironmental changes. It aims at clarifying the question whether ammonoids were benthic crawler or could freely swim in the water column. It may therefore be of critical importance for those interested by the interpretation of δ18O signatures derived from ammonoid shells, as well as for the reconstruction of the evolution of paleoenvironments.

5. , thus having encountered similar difficulties in finding a reasonable and satisfying compromise between “techniques” and “scientific research”.

Perhaps the reviewer would be generous enough to provide a citation so that we might draw some inspiration from his experience. For our reliability study we stressed that nanofocus-CT, a technique that wasn′t available before 2007, is the best compromise between “techniques” and calculation of volumes used for a subsequent buoyancy calculation. For morphometry of the outer shell morphology a surface scanner seems to be best solution.

6. Paucity of citations

We agree with the referee that there exists a great diversity of articles dealing with non-invasive methods but only a few focussing on cephalopods e.g. Mietchen et al. 2008 or Hoffmann & Zachow 2010. The mentioned references Sutton, 2008 and El Albani et al., 2010 do not cover both the field of cephalopod research and the calculation of volumes on which we are focus on in our article. Sutton, 2008 compares different tomograms generated using different techniques from already published sources. In our article we generally used the same shells of Spirula, Nautilus and Cadoceras to compare the effect of the applied different techniques. The famous work of Sutton is based on grinding tomography. We did not mention his work in our article but comment on potential errors that may occur with this method when calculating volumes. Volume calculation however was not done by Sutton for obvious reasons. We do not understand

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for what reason the article by El Albani et al. 2010: “Large colonial organisms with coordinated growth in oxygenated environments 2.1 Gyr ago” was mentioned. Both articles also do not discuss diversity vs. disparity.

7. ...it does not integrate any quantitative GM and/or FEA application,

The FEA application for shelled cephalopods we will deal with in another forthcoming paper.

8. (iii) to avoid the sections on SRμCT and MRI techniques, as they have not used in any original analysis reported in this paper. In sum, in my modest view, as it stands this paper is useless for professional paleobiologists.

The data presented in the section application of SRμCT are original data coming from the APS synchrotron facility in Chicago (USA) and the MRI data coming from the experiments of Mietchen et al. 2005 donated by one of our co-authors (HK). As the intention of the paper is a comparison of data acquisition coming from non-invasive methods the analysis of the obtained SRμCT and MRI data will be not part of the paper here. The running title of the contribution clearly explains that we focus on non-invasive methods that can be applied to paleobiological questions in cephalopod research, excluding the two sections would lead to an incomplete list of applications. As our intention was a collection of non-invasive methods that can be applied to different paleontological questions, we feel that for a great number of paleobiologists a review of existing methods in the fast developing field of non-invasive imaging is not useless at all.

9. In sum, in my modest view, as it stands this paper is useless for professional paleobiologists.

We are sorry to hear that the reviewer, with his obvious expertise and experience, found our contribution about non-invasive techniques used in cephalopod research to be uninformative. Within the wide field of cephalopod research and the large number of contributions dealing with paleobiological questions of cephalopods only few studies

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take advantage of these techniques different than apparently in the field of anthropology/primate paleobiology. This was however the inspiration for this paper, namely to summarize and give brief insight into the potential use of non-invasive methods specifically for cephalopod researchers but of course we are convinced such a survey is also of interest for experts from other fields.

Final statement: One cannot expect to completely cover all fields of potential applications of non-invasive methods for cephalopod research which will surely fill a book. So an extended discussion of diversity vs. disparity as well as FEA are far beyond the scope of this paper and will be discussed in future contributions. With the presentation of the major methods we would rather stimulate other colleagues to apply these methods.

Interactive comment on Biogeosciences Discuss., 10, 18803, 2013.