eEarth Discuss., 2, S68–S71, 2007
www.electronic-earth-discuss.net/2/S68/2007/

eEarth Discussions

Interactive comment on "Noble gas signature of the late heavy bombardment in the Earth's atmosphere" *by* B. Marty and A. Meibom

R. Wieler (Referee)

wieler@erdw.ethz.ch

Received and published: 30 July 2007

This is a thought-provoking manuscript presenting an interesting hypothesis, with overall a reasonable argumentation. I therefore think that the manuscript should be published in suitable form in eEarth. However, I think in its present form, it is too speculative, in that it presents the hypothesis as a proven fact. The hypothesis is that the terrestrial atmosphere shows that the famous hypothesized late heavy bombardment some 3.9 Ga ago really occurred, and – moreover – that the noble gases allow one to infer that it consisted only to about half a percent of cometary material, the rest being asteroidal. I argue below why I think that this cannot really be formulated as a firm conclusion, since uncertainties in the noble gas inventories of both the Earth and comets are too large, and since in my view there are some discrepancies and gaps in

the authors' interpretation.

The numbering below refers to the places I marked in the pdf file of the manuscript.

Nr. 1: This figure of a 200-1000 times higher impact frequency during the 60 Ma of the heavy bombardment allows me to illustrate one of my main points, also mentioned further down (Nr. 7): Is it not conceivable that the noble gas (esp. Ar and Kr) enrichment the authors find in the atmosphere is not the result of a heavy bombardment but of continuous comet delivery over some 4 Ga with a "background flux". A 200-1000 times higher flux during 60 Ma corresponds to a 3 – 15 times higher fluence during the 60 Ma than over 4 Ga with present-day flux. (I have not checked other people's perhaps better founded estimates on this, but such estimates certainly exist). If so, a roughly 5% contribution (instead of the 0.5% inferred for the late heavy bombardment) of cometary material in the background impactor flux could explain the noble gas enrichment in the atmosphere equally well as the late heavy bombardment. The 5% sound perfectly reasonable to me (I have not checked the latest numbers for the comet contribution to the impactor flux today, but if I remember well they have been revised downwards from some 25% some time ago). The authors should seriously address this possibility, which they do not mention at all. I don't know whether the 200-1000 times higher flux is the correct number for the argument above, but if it's not, the authors need in any case to elaborate why not. Also, the 0.5% estimate of cometary contribution necessarily has a large uncertainty, presumably at least an order of magnitude in either direction, see comment Nr. 7. If the true figure would be, say, 0.5 permil, instead, this would make it another order of magnitude easier to explain the data with "normal" cometary influx, without having to rely on a heavy bombardment. Furthermore, there are abundant publications claiming occasional or periodic increases in the impactor flux on Earth, in particular comets.

Nr. 2: This comment relates rather to the paper by Marty 1995 (note that in the Ref. section the year is erroneously given as 1985!) than to this one, and may well simply reflect my ignorance, but I wonder somewhat: is it just coincidental that the atmosphere,

eED

2, S68–S71, 2007

crust and mantle all have comparable N/40Ar ratios? 40Ar from the Earth's interior is not completely degassed, hence the similarity cannot be due to mixing between atmosphere and interior by subduction etc. Also, atmospheric N is quickly recycled trough the crust, I guess. Is then the atmospheric N inventory not governed by this cycle? I do not necessarily request the authors to take action here, although they may add some further explanations if they wish, of course.

Nr. 3: The mantle volatiles show a roughly chondritic pattern, but a depletion by 3 orders of magnitude. So, the early loss must not have fractionated the elemental abundances of the tiny remaining fraction. Is this not rather unexpected? Okay, the data scatter by a factor of 5 – 10 or so, but there is no light-heavy trend visible. Perhaps the authors want to comment on this.

Nr. 4: The discussion here (see also below) is not really self-consistent, in particular concerning Ne. First, it's not the "heavy" noble gas abundances which are enriched in the atmosphere, as stated on line 6 of this paragraph. Either the authors consider only Ar and Kr enrichments to be relevant, or then all noble gases, including Ne and Xe are enriched. If Ne is mentioned on line 11 of the paragraph, then also Xe should be listed there as being enriched (see also Nr. 6).

Nr. 5: The way I read Bockelée-Morvan et al. (and also as I remember from a discussion with Toby Owen), this statement (about the one order of magnitude difference in inferred Ar abundances) still is too optimistic. What they really say is that there is no reliable information on noble gas abundances in comets (see the last paragraph in their section 5.7). Then, also the staement further down in this paragraph, that the captured heavy noble gas abundances in the simulation experiments are consistent with the "abundance variability detected in comets" does'nt really make sense.

Nr. 6: (see also Nr. 4). Here only Ar and Kr excesses are mentioned. However, in section 3 also a Ne excess was noted. Obviously, according to Fig. 3, such a Ne excess cannot be explained in the framework of the hypothesis postulated here, as Fig.

eED
2, S68–S71, 2007

EGU

3 shows. The argumentation is thus not really self-consistent, or at least ambiguous. This needs to be clarified. Also, on line 5 of section 5, it is stated that the hypothesized mechanism can also explain a Xe overabundance, but Xe was not listed among the clearly overabundant atmospheric species in section 3.

Nr. 7, a & b: Two comments in the 0.5% figure. The first has been listed above (comment 1): if such a small cometary contribution is needed, does it then need the late heavy bombardment at all? This is a crucial question which needs to be addressed. Second, given all the uncertainties (of the excess gases in the atmosphere and especially the amount of gases contained in comets (the temperature difference 25 K vs. 50 K alone causes an order of magnitude difference). Therefore, the 0.5% figure needs a qualification. Is there a reasonable range of uncertainty which can be stated (in the framework of the hypothesis). If not, say that this figure is very uncertain. Otherwise, dynamicists may use it at face value, which may not be justified.

Interactive comment on eEarth Discuss., 2, 99, 2007.