

## ***Interactive comment on “Recent revisions of phosphate rock reserves and resources: reassuring or misleading? An in-depth literature review of global estimates of phosphate rock reserves and resources” by J. D. Edixhoven et al.***

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The second review, written by Scholz and Wellmer, is less positive about our paper than the first review. The reviewers criticize the paper on a range of issues and formulate seven "concerns" in which these issues are discussed extensively.

Having carefully compared the review to our paper, there apparently is some misunderstanding as to what a scientific review entails. To review a paper implies that the reviewer discusses the research questions, the methods used and the research find-

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ings. However, unlike the first review, the second review does not discuss the research questions and their relevance, while only fractions of our methodology and research findings are discussed. Moreover, part of the reviewers' criticism appears to be that we should have discussed other issues in our paper (e.g. the dynamics of reserves and resources) which essentially entails that we should have written another paper. But the request to write a different paper is not based on a critique of the questions we have posed in the paper.

Below, we briefly revisit the research questions and the extent to which these questions, our methodology and our findings are discussed in the review. Following that, we will briefly summarize the reviewers' seven "concerns" and their relevance, as further discussed in the attached supplement.

I With respect to the first research question – Does IFDC's simplified classification terminology offer sufficient safeguards? – our method was to review three major classifications and their rationales (USGS, JORC and UNFC) and to compare them to IFDC's proposals. Our main finding was that discarding granulation and threshold criteria for reserves and resources, as proposed in the IFDC report, is at odds with each of the three resource classifications reviewed. Our main concern was that such simplified terminology is inherently vague and yields unclear data which is not comparable with data under these classification systems. We also expressed concern that the simplified terminology allows the individual analyst an overly broad discretion in determining the extent to which a deposit constitutes a reserve, rendering reporting of reserves inherently incomparable with estimates made under the reviewed classification systems and vulnerable to abuse. While Scholz and Wellmer comment on numerous aspects of resource classification and include some useful additions for our analysis (C 1 below), the research question and our research findings are not discussed.

II The second research question is whether the difference between ore reserves and reserves as concentrate is sufficiently understood in the scientific literature. Our methodology was to review the literature, including USGS' MSC and country reports, the IFDC

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report and Notholt et al (1989). We pointed out based on a multitude of documents and a detailed analysis that reserves for a number of countries in USGS' MSC are apparently reflecting ore, not concentrate. This analysis is not discussed in the review. Instead, the reviewers state that it is "understood" that global reporting of PR is in terms of concentrate, without providing a source for this statement. We also pointed at a number of papers where the difference between ore and concentrate is ignored, leading to incorrect longevity estimates. Again, this analysis is not discussed.

III The third research question is whether the estimate of PR reserves and resources contained in the IFDC report is reliable, focusing on IFDC's restatement of Moroccan reserves. As set forth in the paper, the Moroccan findings in the IDFC report were based on a single paper (Gharbi, 1998). Here, our method was to trace back the data sources used in the IFDC report and analyze whether they were consistent with the findings in the general literature. We provided a detailed analysis of Moroccan data which indicates that the deposits listed in Gharbi (1998) should probably be qualified as resources, not as ore reserves. The consequence of that would be that IFDC's conversion of (most of) these deposits to reserves as concentrate is not warranted. We based these findings on, inter alia: (i) numerous OCP annual accounts which report the same deposits described in the IFDC report as resources and an OCP annual account which lists a far smaller quantity of ore (20,000 Mt) as reserves; (ii) a paper by Gharbi and Mchichi (1996) which also reports the same deposits as resources; (iii) an extensive analysis of Moroccan PR deposits in Van Kauwenbergh (2006) in which both the Gharbi (1998) estimate and the USGS (2006) reserve estimates are discussed. In this publication, Van Kauwenbergh indicated that the numbers sourced from Gharbi (1998) were probably resources and adopted the USGS (2006) MSC reserve numbers as reserves. Finally, (iv) we compared data regarding the quantity of drill holes contained in the OCP annual accounts and Gharbi and Mchichi (1996) with the drill hole requirements in the USGS classification for US ore fields and concluded that this drill hole data also did not support a classification of these deposits as ore reserves. Scholz and Wellmer only discuss and criticize our findings with respect to the fourth element, which

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will be discussed below in the context of "Concern 4". While Scholz and Wellmer have made some suggestions that would improve our paper (and we have thus included these), they do not provide conclusive data to demonstrate that our analysis is incorrect (See the detailed information in section C4(10)the supplement) Moreover, they overlook the fact that the deposits are qualified as resources in the documents from which the grid hole data were obtained. Elements (i), (ii) and (iii) are not discussed in the review.

While the research questions and the related analysis remain largely undisputed, six out of the seven "concerns" of the reviewers relate to elements of the problem statement and the background section. Each of these "concerns" will be briefly discussed here. A more detailed discussion is contained in sections C1-7 of the supplement.

C 1 Scholz and Wellmer argue that we would have insufficiently incorporated the dynamics of reserves and resources i.e. the fact that reserves and resources are dynamic due to technical and economical developments. Section C1 ("Concern" 1) of the review contains a discussion of elements which are already incorporated in the background section of our paper and the section addressing the first research question. The reviewers also make certain statements which are part of their own theories which we do not support; this is addressed in the supplement. In respect of resource classifications, the reviewers rightly point out that classifications for financial purposes are somewhat more detailed and contain additional requirements for reserves in addition to requirements posed by certain government classifications (i.e. social, environmental and governmental modifying factors, on top of mining and economic modifying factors). We agree that this is a useful comment and will incorporate this in the paper.

C 2 Scholz and Wellmer submit that our paper is biased because it refers to the peak phosphorus hypothesis, without taking into account that this hypothesis is disputed in the literature (i.e. Vaccari and Strigul, 2011, Rustad, 2012 and Scholz and Wellmer, 2012). The reason why we identified the peak phosphorus hypothesis was because the IFDC report was issued partly in response to these papers. Peak phosphorus

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formed no part of the research questions, was not among the keywords submitted with the paper and has already been described extensively in the literature. Moreover, we have a number of articles in which peak phosphorus is rebutted, including Scholz and Wellmer, 2012, Mew, 2011 and Vaccari and Strigul, 2011, albeit in another context. To address this comment, we will briefly include references to these papers in relation to peak phosphorus, since this point is well covered in the scientific literature.

C 3 Scholz and Wellmer argue that we draw the wrong conclusions in respect of the lifetime of PR reserves and resources. We did not make any estimate of this in the paper but merely discussed a number of important papers in the field, including Van Vuuren et al, 2010 and Rosemarin et al, 2011. These papers discussed potential future trend extrapolations or scenarios in which PR future PR consumption could be significantly higher than the static extrapolation used in the IFDC report. As explained in the supplement, we deem the reviewers' statements made in this context largely unwarranted.

C4 In this section, the reviewers discuss elements of our research questions 1 and 3. In respect of research question 1, Scholz and Wellmer discuss why USGS discarded the reserve base (essentially: because of US government reduced funding). This could also be deduced from the IFDC report but is not relevant to the research question, which focused on the proposal to discard thresholds for reserves and resources. In respect of research question 3, Scholz and Wellmer dispute our findings in view of borehole grids for the Moroccan deposits, stating that it is inappropriate to use requirements for the US for Moroccan ore fields. This is a useful comment and we will include it in the paper, as specified in the supplement. However, the reviewers provide no data which prove our analysis is incorrect. The reviewers reference differences in grid requirements for coal which are different for a number of countries but provide no differing borehole requirements for PR. In the paper, we referenced Van Kauwenbergh, 2010a, who stated that grid requirements for "proven reserves" are assessed at drill holes bored at 100 meter centers in most countries. According to the OCP an-

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nual account over the year 2000, more than half of the aggregate Moroccan "resources" were established at boreholes spaced more than 2000 meters apart (OCP, 2000). The fact that these deposits were qualified as resources in OCP (2000) ("toutes qualités confondues", or "all qualities aggregated") and the fact that OCP (2007) used a much lower number for reserves (20 000 Mt PR, consistent with USGS' reserve base at the time), supports our analysis. We refer to our comments in relation to research question 3 above, as specified further in our response to comment C4(10) in the attached supplement.

C 5 Scholz and Wellmer indicate that we inadvertently stated that IFDC created the Global TraPs project while it was in fact initiated by Mr. Scholz, representing science. This is indeed correct and we will reflect that in the paper. Scholz and Wellmer also state that it is wrong to present the project as focusing on the supply chain. According to its newsletters, the project initially was supply chain oriented, as reflected in its name: Global transdisciplinary processes preparing for sustainably coping with phosphorus from a supply chain perspective." However, apparently, the scope was broadened and, while the name remained the same, the subheader was changed in: "Global Transdisciplinary processes for sustainable phosphorus management." We will edit the paper to reflect this.

C 6 The literature review in the background section where potential future PR consumption rates are described (see C3 above) contains a brief discussion reflecting various sources regarding the potential future PR footprint of biofuels. One of these papers (Van Vuuren et al, 2010) contained a scenario analysis based on the millennium assessment scenario's, one of which included high biofuel production. The other (Rosemarin et al, 2011) calculated how the consumption rate for PR could be affected if biofuels were to supply 10 % of global energy demands, assuming no recycling would take place. We did not discuss this further but identified this as an area for further research. Scholz and Wellmer refer to a publication in press (Scholz et al., 2013) arguing that there is a strong recycling loop in biofuel production. We will include this

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observation in the discussion and our suggestion for further research on this issue.

C 7 The reviewers argue that sustainable use of PR entails a progressive closing of the P cycle. We fully agree with this statement. The reviewers also state that PR use may be sustainable as long as reserves do not fall below a certain quantity, as measured by a "vulnerability indicator". Earlier in the review, Scholz and Wellmer indicated that the Reserve/Consumption ratio could be a useful yardstick for this. Given the dynamics of reserves and the essentiality of PR for humanity, we doubt whether the R/C ratio is a relevant indicator. If reserve data are to be used for this purpose, this underlines the need for transparent and reliable data on reserves and resources.

Please also note the supplement to this comment:

<http://www.earth-syst-dynam-discuss.net/4/C635/2013/esdd-4-C635-2013-supplement.pdf>

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