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***Interactive comment on* “Comment on: “Recent revisions of phosphate rock reserves and resources: a critique” by Edixhoven et al. (2014) – Phosphate reserves and resources: what conceptions and data do stakeholders need for sustainable action?” by R. W. Scholz and F.-W. Wellmer**

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Received and published: 29 March 2015

Reply to B. Geissler and G. Steiner, ‘Thoughts on: the Scholz and Wellmer comments on Edixhoven et al. (2014) paper.

General comments

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This is a valuable comment. It illuminates and supplements the view and statements of our comment on the paper of Edixhoven et al. paper (Edixhoven, Gupta, & Savenije, 2014). We appreciate the refinement of the worst-case calculation of world resources of marketable phosphate rock based on data from the consultant CRU for country specific estimates of phosphate ore concentrations. This results in an estimate of 57.7 Gt PR-M instead of 58.5 Gt PR-M. This is a difference of 1.4uncertainty of these estimates is very high and that both numbers are rough estimations of the lower boundary of the reserves.

The Geissler and Steiner comment also includes valuable contributions for differentiating between criticality (which refers to short-term supply security issue based on production of phosphates), the global distribution of reserves (which shows that some of the large agro-producers have limited self-supply, given the current reserves) and the long term supply security (which is a matter of demand, technology development (both for mining but also of reducing the demand and of the geopotential and the knowledge we have about it.)

We disagree with Geissler and Steiner that the resources dynamics has not been the core topic of the Edixhoven et al. (2014) paper. This paper posed questions on the increase of the Morocco and Iraq data which asks for further comments and clarification and which ignored that reserve information can be based on different granularity. As we pointed out, this granularity depends on who is addressed (e. g., national geological surveys or the international public at large who are interested whether further exploration efforts are necessary) or investors which need detailed prospecting information about production costs. Here, Edixhoven et al. (2014) claimed for standards which did not differentiate between the different purposes reserve data (early warning on exploration efforts vs. investment information).

Specific feedback

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1. Geissler +Steiner C 57, 3. Para:” Although we are aware that the dynamics of reserves and resources were not the central issue of Edixhoven et al. (2013, 14) we feel that this central concept should have some more attention but not necessarily in the depth claimed by Scholz and Wellmer (2015) since this would have changed the overall focus of the paper itself.

As already stated above, we disagree in this topic. The correct understanding of dynamics of reserves and resources is the core theme of any paper dealing with reserve problems. The criticizing of the growth of reserves in Morocco has been a main issue in the Edixhoven et al. (2014) paper. The review by M. Mew as one of the most experienced phosphate consultant of the world with on-hand experience with the situation in Morocco on pages C7-C10 illustrates how reserve growth can be linked by economic parameters. Our paper as well as the paper of Mew showed that the 60 Gt PR M for Morocco is rather a conservative estimate.

2. Geissler + Steiner: Chapter Scarcity and Criticality within the near-, mid-, and long-term Future. Page C 58-C 62

First, we want to point out an error: Most of the Chinese deposits are not igneous, but sedimentary deposits with no large exploration problems (P. C62, 1. Para).

The data for reserve/consumption-ratios (R/C-ratios) calculated by Geissler and Steiner are not disputed by us. Two aspects have to be taken into account, however:

- (a) The R/C-ratio cannot be considered static. It is a dynamic figure, as we always say again. It is very much influenced by exploration activities. If customers see an increasing concentration trend ahead they will probably diversify to other supplier countries to minimize risks. This demand will stimulate exploration activities in other countries and thereby increase the

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R/C-ratio more than in other countries. The consequence: The R/C-ratio is not only influenced by geology and supply, but also by demand. How the consumption does not necessarily reflect the concentration of reserves has been shown by Scholz and Wellmer (Global Environmental Change 2013, p. 15, Fig.2). The concentration index, the Herfindahl-Hirschmann-Index, for phosphate reserves rose from 2150 in 2008 to 5500 in 2010, meaning in a critical range according to a classification by the German Geological Survey BGR, whereas the Herfindahl-Hirschmann-Index for production in the same time rose from 1700 to 1950, which places it below the critical range, in the medium range.

- (b) In the last two paragraphs of this Chapter, Geissler and Steiner on page 62 cast doubts about the ability of Morocco to increase production fast enough when needed. Going to other commodities one sees good examples how resilient the world commodity market is to sudden demand stress (see Figure 1 at the end of the document).

Caused by the dramatic industrialization of China and in consequence a tremendously increased demand of commodities by China (China today is the largest consumer for every major commodity with the exception of oil and gas, where it is second behind the USA) there was a raw materials boom starting 2003. Iron and aluminium are the most used metals. For iron ore, China is the most important importer. The world-wide iron-ore production could be increased by a factor of 3.2 from 2001 to 2011, for bauxite (the aluminium ore) by a factor of 1.8.

There is one world market for mining engineering services. Certainly, what can be done in iron ore and bauxite can be done in phosphate, too, if there is a high stress situation.

Geissler + Steiner. Chapter "Discussion on Reserve and Resource Estimations,
C133

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page C 62 to C 64.

In this Chapter Geissler and Steiner agree with our opinion about the exploration philosophy of companies. They touch then the subject of success in exploration. Numbers which primarily are derived from data about precious and base- metal exploration projects like the paper by Kreuzer and Etheridge (2010) can only be used for exploration for isolated lenticular deposits. These data might be applicable to magmatic phosphate deposits but certainly not to the sedimentary, stratabound deposits, which show a far better strata-controlled continuity than the lenticular deposits.

The key question is, however, are there any signs that exploration is abating. The answer obviously is: no. The authors quote figures from Ernst Young and support our arguments that major mining companies are moving into the phosphate business.

Another argument shall be put forward: Wellmer and Lampe (2015) investigated success rates in precious and base- metal exploration over 500 years. In the terminology used by Geissler and Steiner in analogue to Kreuzer and Etheridge (2010) it would be brown-brown-field (i.e. close to ore) exploration. Wellmer and Lampe (2015) discovered that the success ratios did not change significantly over 500 years, meaning the deposits have become harder to detect, but this has been compensated by better exploration methods. Why should this effect not also apply to future phosphate exploration?

Geissler + Steiner: Chapter “Dynamic Interactions of Reserves, Resources and Geopotential (page C64 to C65).

Geissler and Steiner stress the importance of taking into account all aspects including socioeconomic aspects. This certainly is true. It shall be pointed out that in the mineral fields learning curves frequently are very long with sufficient time to carefully consider many effects. Very often, it takes 20 years to achieve a

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breakthrough. Two examples: to develop a successful fracking method in the USA for shale gas took 20 years (Andruleit et al. 2010). In the Mattagami base metal camp in Northern Quebec in Canada at the end of the nineteen-fifties, there were a series of Cu-Zn-discoveries by airborne geophysical methods until a saturation occurred. It then took 20 years to develop a new exploration angle successful in discovering new deposits (Gingerich and Allard 2001).

Geissler + Steiner: page C 65, last para, first sentence:

“To finally conclude our comment, we deem that the recently raised global attention on phosphors should be shifted toward long-term strategies”. Scholz and Wellmer could not agree more. Therefore, we recently published in the “Journal of Industrial Ecology” the proposal for a solidly funded international body to regularly investigate the geopotential of phosphorus: The right to know the geopotential of minerals for ensuring food supply security (Wellmer and Scholz 2015).

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Interactive comment on Earth Syst. Dynam. Discuss., 6, 31, 2015.

ESDD

6, C130–C137, 2015

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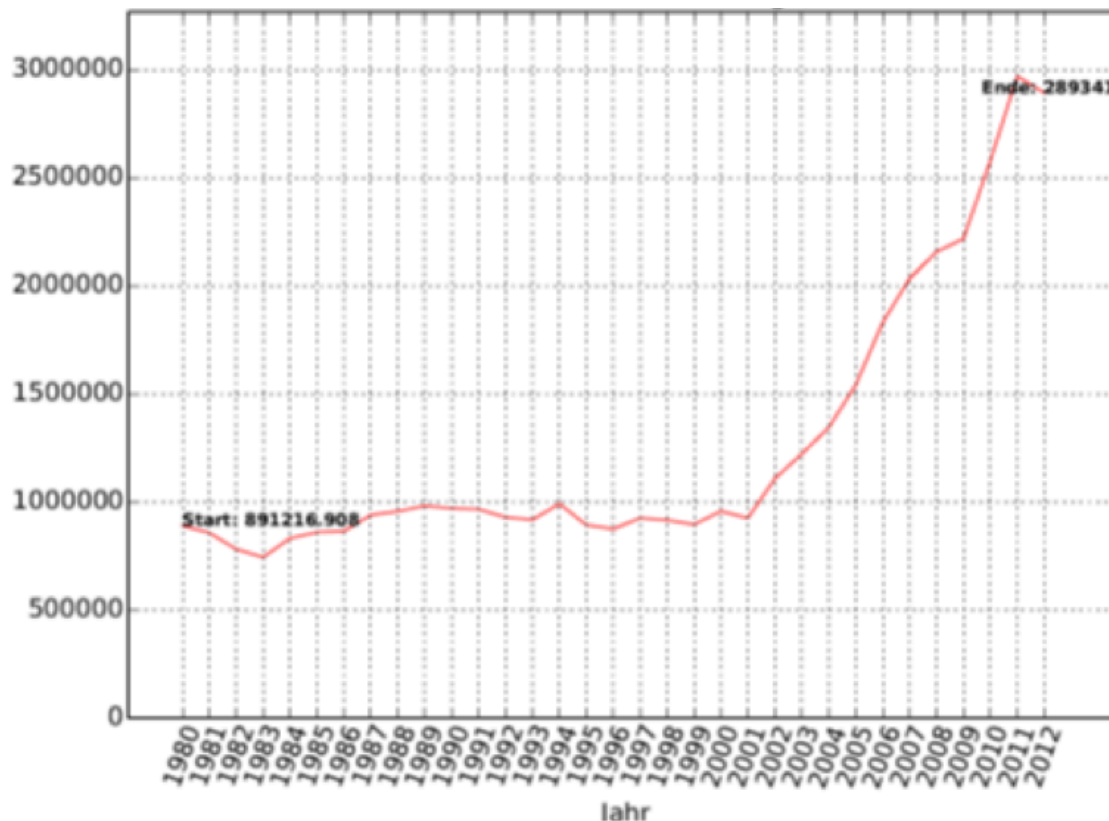


Fig. 1. World-wide iron ore (Eisenerz) production from 1980 to 2012) in kt. (source BGR data bank).

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