Comments on the P Article

The issues raised in the article by J. D. Edixhoven et al. are ones that have interested me for a number of years. Consequently, although the opinions expressed in this review are my own, they have been formed/influenced by discussions with very many colleagues. Hence I would like to place on record my considerable debt to a number of them, namely Brian Birky, Mike Lloyd, Hari Tulsidas, Chris Dawson, Malika Moussaid, Yahia Bouabdelaoui, TK Haldar, Patrick Zhang, Patrice Bruneton, Olivier Vidal, Patrice Christmann, Jean Rene Blaise; my many colleagues on the UNECE Expert Working Group on Resource Classification with which I have had the pleasure of being associated since 2010, and hence with the UNFC process; and in particular I would like to thank Johnny Johnston for his constant and sage counsel over many years which, following the invitation of the editorial team to do so, I also drew on to review this article in particular.

The detailed appraisal by Roland Scholz and Freidrich-Wilhelm Wellmer much more accords with my reading of the article rather than that of Reviewer #1. Accordingly, I have largely restricted my comments to those not already covered in the existing reviews.

Background

We are all stakeholders in the management of the finite amount of phosphate that exists in the earth and there seems to be common ground that food security cannot be achieved for a global population of 7billion, still less the projected 9 billion by 2050 without the aid of fertilisers in general and phosphate in particular, irrespective of its source. Soil productivity in parts of the world where food security is already under greatest pressure is declining and the FAO's target of a 60% increase in food production by 2050 (revised November 2012 from the previous estimate of 70%) remains highly challenging.

There are sceptics as to whether or not these fertilisers should be mineral in origin. I am not one nor, apparently, are the authors of the paper. Given the degree to which the performance of the other two key nutrients (nitrogen and potassium) in sustaining fertile soils is determined by P, (Syers et al 2008, Johnston, 2013) the focus on P is all the more appropriate. I can also only agree with the authors that it is not just a supply-side question: we are indeed at risk "if society fails to take the appropriate steps to use this finite resource in a more diligent manner", although I would suggest substituting "efficient" for diligent".

Our increasing predilection worldwide for animal protein certainly has a major bearing on the issue and as consumers of meat we create the forces that drive 85% of the demand for phosphate fertilisers (Sutton et al (UNEP) 2013). But the question is how should society address this issue? What are the appropriate steps? Are we clear what the problem is that we are trying to solve? What for that matter is meant by society? The paradox of the current time is that ~1bn people suffer from hunger and chronic food insecurity, while approximately the same number, and growing, suffer from obesity and high risk of type 2 diabetes. Is it, as the authors conclude, to find out what "society" should do "once today's reserves and resources are depleted"; or is it that at least part of the answer lies in the here and now and concerns our eating habits. Surely the assumption that PR resources will inevitably be depleted is wrong; but I agree that if we do not change a variety of industrial and consumer behaviours the risk of depletion certainly goes up.

The authors roundly accuse Steve van Kauenwenbergh, author of the IFDC 2010 report of "[adding] little but confusion" to the current state of analysis of phosphate resources and reserves. So, the reviewer asks, have they done any better?

Some Causes of Uncertainty and Error in Reporting PR Resources and Reserves

There are many factors influencing why it is so difficult to generate accurate and transparent data about global PR resources and reserves. These include:

1. The very uneven distribution and varying genesis (sedimentary, igneous, etc) of PR worldwide
2. Reporting requirements such as JORC and National Instrument 43-101 (Canada) serve primarily to protect investor interest. The major mining and processing companies are notorious for understating reserves, while Juniors tend to over report, because they want to attract investors. UNFC may in part address such an asymmetry by making statements about resources and reserves, and about resource progression, easier to compare across classification and reporting systems. But there is no immediate prospect of either JORC or National Instrument 43-101 being replaced by UNFC. UNFC (2009) is itself relatively silent in its current form on sustainability issues, a matter now being addressed by UNECE EWGRC.
3. The shift in the balance of power, and of production, in the phosphate sector from developed to developing / emerging economies. For example, the United States now imports rock from Morocco to keep up with fertiliser production targets in significant measure because of resistance to PR mining in the US.
4. Many emerging/ developing economies depend heavily on their P resources for earning hard currency, for example Morocco, Jordan, Tunisia, each of which also relies on the PR mining and processing industry to be one of its principal pillars of GDP. These countries are under no equivalent pressure to public companies listed in Europe, North America or Australia to disclose what resources and reserves they command; and given current trends of acquisition by China and Russia mining companies reporting under JORC or National Instrument 43-101 are likely to represent an ever smaller proportion of the mining industry in general, and PR in particular. So resource data may be withheld for commercial and/or strategic reasons over which stock exchanges and UNFC have no control. (data on water resources is commonly withheld by governments for similar reasons).There is an obvious commercial risk to a highly traded product such as PR and its derivatives that increasing the stated reserve base would cause market volatility or correction and hence harm the fragile economies which depend on them. Several such market corrections have been experienced since mineral prices peaked in 2008. This recent period of volatility is likely to continue and throws into question another key premise on which the authors base their case. They argue “that the reserve base was created to mitigate the effect of fluctuating prices which impacts, or should impact, the reserves even more than the reserve base (USGS, 1982).” This may have been true thirty years ago when the US totally dominated the PR market, during which time it was arguably in its national commercial interest to reduce volatility and protect its national farming industry. But this quasi monopolistic control is no longer the case, power and market share having being wrested away by other producers, while the US industry is now consolidating through mergers and acquisitions.
5. Large resource hungry countries such as China will guard their PR resources as a strategic resource and hence not disclose quantities available or tenor. Others such as India, with very little national PR resource will continue to invest in joint ventures with overseas producers or, if possible, seek vertical integration into the PR mining business of other countries by acquisition.
6. As well as the commercial risk to a producing country of full disclosure of resources and reserves, the global trend in the PR industry is to sell value-add products such as acid and fertiliser not rock. This further reduces the appetite of key producers to declare what resources they command. Some countries, for example Indonesia, have now made the export of raw minerals illegal, export only being allowed for value-add product.

7. New technologies are rapidly emerging for processing lower value ores. Hence what has traditionally been regarded as a BPL value of 70 as the standard for selling PR on the commodity market is likely to fall in future perhaps even into the 50s.
8. Current wet process technology typically requires a feedstock (concentrate) of 28% P_2O_5 or higher – some major new production facilities require concentrate in the order of 31 or 32%. This led to a widespread practice of discarding ores with lower values over the past sixty years. Not all producing countries did this; Kazakhstan and Uzbekistan both co-mined uranium and phosphate deposits, the phosphate content being well below levels mined elsewhere. This practice now seems visionary with new phosphate and uranium joint ventures being planned, such as Santa Quiteria in Brazil, starting 2017. Many countries are now changing this approach. China for example is seeking to prevent such waste by closing small, inefficient producers which have not had the ability to beneficiate lower-grade ores, while refocusing on larger production units and vertical integration. Policies such as zero waste and zero discharge are also being applied to PR resources as a whole with a view to achieving significant gains in extraction efficiency. In other countries which have long discarded large quantities of useable PR are now returning to mine tailings piles with a view to exploiting them. Some initial studies, eg conducted in Tunisia, indicate that up to 40% increases in useable ore will be achieved this way, and hence alter estimates of reserves.
9. Off-shore PR mining is just starting up, eg in Namibia. It is known that there are very large PR deposits off-shore around the world, for example off North Carolina. Major producers such as Brazil and the European Union are now planning deep-sea mining for all minerals not just PR.
10. In Europe improved exploration and analytical techniques are predicting major reappraisals of the state of resources and reserves of a wide range of "critical" or "essential" minerals, especially in countries previously thought to be mined out. The ERA-MIN network, of which I have been part, estimates an increase of some 50% in resource quantification by these means. The more policies of national or regional self-sufficiency in mineral supply are pursued – and the EU looks to be intent on pursuing them – the more such resources will become reserves. Criticality factors will therefore, progressively be included in the definition of "reserve", even when the economics as referenced to international costing benchmarks are not viable.
11. New on-shore deposits are being discovered all the time as many emerging economies start significant geological survey and exploration activity across a wide spectrum of mineral and oil and gas resources. Many such countries have little or no data as yet; and where data does exist it tends to be from the end of the British or French colonial periods.
12. As the concept of the "social licence to operate" gains more and more ground, it is clear that even when resources and reserves are accurately and transparently calculated and reported, as for example in Florida, resistance to mining, of any kind, can put resource progression into reverse. Such evidence of the "social licence to operate" being withdrawn not for economic but political reasons, further puts in question the value to "societal" decision-making of abstract data, however accurate.
13. Currently the social licence is generally withheld by consumers in developed markets from the practice of reprocessing human waste for P recovery. But as Justus von Liebig pointed out in the 1850s many of the answers to sustainable soil fertility lie in how we recover and recycle nutrients, as well as how we produce them in the first place.

With these and other factors in play, it becomes less and less likely that the major PR producers will disclose their hands, especially where the production base is financed through the world's stock exchanges or belongs to state-owned companies which are principally interested in food security or national self-sufficiency in food.

The authors seem intent on adopting a tone of moral indignation with perhaps the intention to shame PR producers into disclosure of the reserves and resources they hold. Will this work In view of the many factors involved in this issue?

In the first place, they seem to be courting controversy for its own sake. The opening sentence of the abstract describes “Phosphate rock (PR)” [as] a finite mineral indispensable for fertilizer production and a major pollutant”. The wording suggesting that PR is inherently polluting is clearly incorrect, and for reasons that are not clear the claim is not substantiated. The authors seem to have forgotten the classic observation of Paracelsus “Alle Ding' *sind Gift*, und nichts ohn' *Gift*; allein die Dosis macht, daß ein Ding kein *Gift ist”* Any mineral can be a pollutant if you apply too high a dose. PR is not a major pollutant as such; but bad practices along the PR value chain can cause pollution. The opening lapse into confusing the inherent properties of minerals with the way people use them is echoed in the indignation addressed to Steve van Kauwenbergh as author of the IFDC 2010 report (Van Kauwenbergh, 2010). It is as if the authors feel offended by the degree to which PR has made us dependent on it, (“indispensable”). Is this a sensible basis on which to conduct a reasoned appraisal of the very significant geological, taxonomic, economic, social and environmental challenges posed by trying to classify and quantify any resource from the geological endowment, whether phosphate or oil and gas resources and do so in a transparent, comprehensible manner?

The authors further argue: “Given the near total dependence of food production on PR, data on PR deposits must be transparent, comparable, reliable and credible.” “Must” by whose reckoning? And is food production in a state of “total dependence” on PR? Is the critical issue for the future “food production” or “food security”. It is clearly the case that since the end of WWII the emphasis has been on production; but this is changing fast.

The context in which the IFDC Report was published was in effect as a response, following a small piece in Nature (Gilbert 2009), to almost apocalyptic fears that the world’s phosphate reserves were about to run out (Cordell et al 2009). An analogy was argued between peak oil and peak phosphorus, and the peak phosphorus issue has caused much confusion and discussion. Some, including myself, argued that the analogy did not hold at all (Hilton et al 2010, Dawson and Hilton, 2011); more recently the theory of peak oil itself has been challenged, further weakening the basis on which the quantitative estimates were based. In this reviewer’s opinion all that Steve van Kauwenbergh has done is to use his best interpretation of the data that was available to him to indicate that there is no “peak phosphorus” event current, or imminent. Very importantly, he has been equally clear that the basis on which the great majority of data about phosphate resources and reserves is founded is open to considerable question and doubt. The 2010 IFDC Report makes frequent reference to its provisional nature and argues: "A collaborative effort by phosphate rock producers, government agencies, international organisations and academia will be required to make a more definitive current estimate of world phosphate rock reserves and resources". So has the Report “thoroughly shaped the PR depletion debate”? In my experience the debate is not that coherent.

UNFC

The authors take IFDC to task for “simplification”: “IFDC’s simplification appears at odds with this gradual global movement toward uniform resource reporting.” They have clearly not understood that the whole point of the UNFC EFG axes and the simple numerical resource progression coding that goes with them is to simplify.

A Solution?

It is unlikely that the many issues around getting reliable estimates of the world’s economically recoverable phosphate reserves will be resolved in the foreseeable future but there are important

opportunities that involve all stakeholders for using phosphorus more efficiently in agriculture and thus lengthening the life of the existing reserve.

The solution to the phosphate management challenge is for all of us to realise that it can be managed as a near closed cycle. Industry (supply-side) has to markedly improve the efficiency of mining and beneficiation in the primary processing segment of the cycle, and engage fully in the recycling segment whether from wastewater, food processing plants or biosolids. There are encouraging signs, as for example in Berlin and in a number of Dutch cities, that recycling is beginning to happen. The demand segment of the overall cycle must increase as population increases. However, our collective behaviour, and perhaps societal choices to change our behaviours in relation to the quantity and type of food we consume, on human health, especially obesity and the type-2 diabetes epidemic, requires attention. We have done it with drinking and driving; we are doing it with waste reduction and prevention; so maybe we can do it with food.

And the supply-chain also has its part to play. The Economists in the UK Government Foresight Study [UK Foresight Report, 2011] point out that a 150year cycle during which food costs as a proportion of household income steadily declined has ended; food prices are going to go up from now on. The other major segment of the overall P cycle is in the soil where it is managed by farmers who must (re)learn the basics of managing soils, whether to safeguard their physical condition or to optimise the fertility of their soils by applying the right nutrients, in the right form, at the right time and in the right quantities, just as Paracelsus would have asked. They can do so in the knowledge that, contrary to the prevailing opinion up to 2008 that PR once put onto land in the form of mineral fertiliser was part of an essentially open system - P either got locked into the soil, or ran off into water courses and hence became “a major pollutant” - in fact in their FAO Study (Syers, Johnston, Curtin, 2008) the authors showed that the P system was largely closed and could hence be efficiently managed. The fulcrum is the critical P value which must be maintained for any soil, a value which is established by accurate soil and crop data, and which is sustained by the Paracelsan mechanism of dose control. Speaking at one of the Global TraPs meetings, Zurich August 2012, Terry Roberts cited this work as now the reference for all analysis of the management of P in soils, indicating his agreement with a paper I published with IFS (Hilton 2010) that this was the real game changer. Given that soil fertility can be demonstrably shown to be a managed and manageable outcome, the real issue for the sustainability of P resources and reserves is efficient management, across the whole value chain. This includes both primary and secondary P.

Professor Julian Hilton

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