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Interactive comment on "Spatial Patterns of Phosphorus Fractions in Soils of Temperate Forest Ecosystems with Silicate Parent Material" *by* Florian Werner et al.

Anonymous Referee #1

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I am afraid I do not think this paper is suitable for publication, despite an enormous amount of work that went into it. I think this for three reasons, none of which are easily addressed, but which might be at least partially addressed with major revisions. I hope my comments below are useful in that effort.

1) The authors do not set up why the reader should care about small horizontal variation in soil properties (each of the many samples are taken from a 70x100cm grid). As far as I can tell there was only one grid per site. If the question is how do soils vary horizontally vs. vertically, this sampling design seems unlikely to be informative in any way that is ecologically relevant.

2) All of the krigging done basically reproduces a lot of what is know, there is strong

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variation in soil properties (including C and P) with depth, and in very small areas less variation horizontally.

3) Any comparison of trends between the 4 sites, which differ in parent material, climate and elevation, is compromised by the issue of pseudo replication. At least from my reading there was only one soil pit excavated at each site, and soils were taken (in exhausting detail) from different parts of one pit. Thus comparison of the sites (e.g. effects of pedogenesis on basalt vs. gneiss) has only one true replicate for each site.

4) Even if one allows the samples from a single pit to count as true replicates, little can be inferred about the role of parent material, "pedogenic state" or anything else that varies between the sites because so much varies - there is almost 1000 mm/yr difference in rainfall between the sites, as well as very big differences in parent material, and differences in temperature.

Thus in my opinion the study is not appropriately set up to explore horizontal vs. vertical variation within a site, nor to study differences between sites. The major results (that there is large variation in soils with depth) is well known and the mechanisms for this have been explored for decades. The detailed work on P is interesting, but much of it has been published at a coarser scale by the same group.

I'm sorry I can't be more positive about this manuscript. I think a more robust introduction that sets up the questions and what is already known would go a long way to helping the reader, but I'm not sure that would over come the limitations of study design that I perceive here.

In general I think the introduction could be fleshed out. There should be some discussion of the different ways of assessing P forms (fractionation, NMR for organic P), and what their pros and cons are. If the ultimate goal is to understand pedogenic effects on P availability to organisms, there is a lot more literature that could be cited. If the goal is to see how P forms vary across this particular "geosequence" then I think more material is need to convince the reader that this a compelling question.

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Along those lines, given that rainfall differs by almost 1000 mm/yr between sites, and there are different parent materials, it's hard to understand how these can be considered any sort of sequence. Rather it seems to me that it's four sites that have different soils, for a variety of reasons that can not be disentangled.

P1 L12 - what is a geosequence? Perhaps better to explain as you did in the introduction, as a series of sites that differ in P status due to differences in parent material and age.

L22 - I do not think that documenting different pools can be translated into an understanding of the pools from which P is acquired. There can be large pools of P that are not useful to organisms on short timescales.

L24 - Presumably the pedogenesis you refer to is all fairly early stage, and thus P availability is increasing as primary mineral P dissolves.

L25 - I am not sure what is novel about this result. The idea that soil development influences P forms and availability is quite old. What is the novel contribution of this work?

P2

L19 - How is soil age determined in this geosequence?

L22 - Why is the depth distribution important? Are rooting depths different across the geosequence? If so, how?

L24 - There is a great deal of literature on the distribution of P in soils, though less about P forms. Steven's work in the early 1970s in New Zealand had a wealth of information about P fractions with depth across the Franz Joseph and other chronosequences. The works from Hawaii (Crews et al, 1995 and subsequent) also has information. I believe Paul Selments has P fractions across the San Francisco Volcanic chronosequence, though I can't remember how much depth information he has. And of course Ben Turner has done a lot of work exploring organic N forms in myriad places and across

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chronosequences.

L26 - I'm not sure from this intro how your data differ from Prietzel et al, 2016b. I'm sure they are different, but your introduction does not set up that difference very well. From my reading of that paper they also looked at P and what it's bound to across these sites.

P3

L8 - Basalt, gneiss and Pleistocene sand are very different parent materials, so I can understand why they would have wildly different P availability, and might host very different forms of P. However, there is no information given as to why the authors suggest these soils are of different age. In Prietzel et al., 2016b it is said that the 10 sites differ in lithology, but I can find no description of how they vary in soil age.

P3

L13 - This reads as if sampling at each site took place in a single 10cm square. But in truth it took place in a 70x100cm rectangle at every 10cm intersection. Is that correct? If so this text could be clarified?

On a more scientific note, why would a single grid be used to get a spatial variation, rather than many different locations? Some more explanation of why this approach was taken is warranted.

P4 - The motivation for the geospatial aspect of this paper is unclear to me. Until coming to the statistical analysis section of the methods, I had no idea there even was a geostatistical analysis, and even at this point in the paper I'm not sure what the goal of such a small spatial scale analysis is. I think this points to the fact that the introduction is so short that it does not really set up the motivation for the study or the questions as well as it needs to to bring the reader along.

P5

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L4 - I don't think anyone would expect uniform distributions of P or any of its forms, and in general would expect higher concentrations of total P and organic P in the upper soils. So I'm not sure why this is a major result.

First paragaraph - I'm not sure why these results are being reported in this order. Is the major question about the difference between sites? This reads a bit like a long list without structure, and what is said here can be garnered from the table. It would be useful if the authors laid out guiding questions in the introduction, the methods used to answer those questions, and then structured the results in the same order.

L21 - The fact that organic carbon is concentrated in the upper soil has been reported for these exact soils, P8 -

L12 - This result has been observed many times before. I am left with wondering with what is gained by the extraordinary effort presented in this paper.

Figure 5 - It strikes me that this model would be very useful in the introduction. But I would also think that providing some justification for where you place the sites along the "pedogenesis" threshold is warranted. Since these are coming from different parent materials, where these are placed verge on the tautological. That is, one has a notion of how pedogenesis "should" progress, and then the soils are placed along the curve in a way that best fits the expectation. Given the wild differences in parent material, it seems like pedogenesis might take different tracks (see Vitousek and Chadwick 2013 for a similar idea as to how climate might influence pedogenic thresholds). Nevertheless, if this is your conceptual model, and you think your spatial analysis can inform the model, it might be useful to have this up front to guide the readers to your questions.

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