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Interactive comment on “The complementary power of pH and lake water organic carbon reconstructions for discerning the influences on surface waters across decadal to millennial time scales” by P. Rosén et al.

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This paper contains some highly significant findings. Taking the NIRS-TOC reconstructions at face value, the results demonstrate that the introduction of early medieval farming profoundly altered the terrestrial carbon cycle; an important step towards direct demonstration of the Ruddiman effect (Ruddiman, 2003). The estimated 25% reduction in TOC on introduction of farming can be interpreted as a $\sim 25\%$ reduction of fast and medium soil carbon if we accept the soil mass balance model of Michalzik et al. (1993). This translates to a soil carbon loss of $\sim 4 \text{ kg C m}^{-2}$, based on modelled

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cool mixed forest soil (Wu et al., 2009), a value similar to that proposed for temperate Europe based on inferred Neolithic farming practices (Boyle et al., 2011), and constituting a substantial proportion of the C release needed to account for the Ruddiman effect. Thus, while there remains room to debate NIRS-TOC reconstruction, this work constitutes the most direct evidence yet that low intensity early farming could have substantially modified the global carbon budget.

The role of base supply from mineral weathering remains intriguing. Before 1100 AD the evidence reported is consistent with base depletion as suggested by Boyle (2007), though the predicted role of apatite is untested. The 1100 AD alkalinisation event is also shown to have resulted from changes in aqueous base concentration. However, though it is shown that the sediment K concentration increases, it is neither demonstrated that this could have caused an increase in dissolved base, nor is an explanation given for what cause a change in soil K concentration. Ruling out TOC change as the sole explanation for this alkalinisation is an important step forwards, but we still await a specific explanation for such substantial changes in base supply.

Boyle, J.F. 2007: Loss of apatite caused irreversible early Holocene lake acidification. *The Holocene* 17: 543–47.

Boyle, J.F., Gaillard, M.-J., Kaplan, J.O. and Dearing, J.A. 2011. Modelling pre-historic land use and carbon budgets: A critical review. *The Holocene*. DOI: 10.1177/0959683610386984

Michalzik, B., Tipping, E., Mulder, J., Gallardo Lancho, J.F., Matzner, E., Bryant, C.L., Clarke, N., Lofts, S. and Vicente Esteban, M.A. 2003: Modelling the production and transport of dissolved organic carbon in forest soils. *Biogeochemistry* 66, 241–64.

Ruddiman W.F. (2003) The anthropogenic greenhouse era began thousands of years ago. *Climatic Change* 61 261–293.

Wu H.B., Guiot J., Peng C.H. and Guo Z.T. 2009. New coupled model used inversely

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for reconstructing past terrestrial carbon storage from pollen data: Validation of model using modern data. *Global Change Biology* 15: 82–96.

Interpretational issues

Page 2446, lines 13-18. Yes K declines relative to Ti and Zr, but they are in different minerals, with different size distributions. K is mainly in feldspar (very coarse), Zr is mainly in zircon (medium to coarse silt), and Ti in oxides (also silt sized) and clay (very fine). So, changes in K/Ti and K/Zr can be expected with fining of the sediment. For this reason, we must be very cautious interpreting change K/Zr in terms of changes in the K content of the parent soil. It will also change with runoff energy and lake margin storage.

Page 2448, lines 24 to end. Same issue. Yes, there is change in sediment composition, but this needn't mean a change in the soil composition. Simply, "depletion of these elements " (line 27) is consistent with your data, but not "indicated" by it.

Page 2452, top paragraph. I don't question that this is possible, but you cannot rule out changes in base supply. That there are "almost constant concentrations of lithogenic elements ..." (page 2451, line 26) is no evidence that there haven't been substantial changes in base supply due to weathering. Why? First, there is no way of knowing whether the dissolved bases and the allogenic mineral fragments are coming from the same soil layer. Second, an increased rate of base supply due to, say, warming, could substantially increase the base supply rate but leave very little signal in the soil mineral matter (the base pool being so large).

Page 2453, line 4. As above, you really cannot argue that your " PCA also indicates an increased depletion of base cations"; it only indicates a change in sediment composition.

Page 2452, line 21 to next page line13. Very likely, but can you think of any calculations to do to assess the plausible magnitude of any of these processes?

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Minor wording changes

Page 2440, line 2. Replace "is causing" by "there is"

Page 2440, line 19. Replace "to be due" by "attributed"

Page 2440, line 24. Replace "impacts" by "change".

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