Point-by-point response to Referee#1 comments:

Dear Mr. Dupla,

We would like to thank you for the thorough evaluation of our manuscript “Soil geochemistry as a driver of soil organic matter composition: insights from a soil chronosequence” by Mainka et al. 2021 (bg-2021-295; https://doi.org/10.5194/bg-2021-295). We are very pleased about your positive assessment of our work and recognition of its relevance. Your comments helped us to significantly improve our manuscript and we want to sincerely thank you for the constructive and valuable insights. We have addressed all comments and suggestions to the best of our ability. Please find below a point-by-point response to all the concerns raised and how we will address them. Reviewer original comments are highlighted in grey. New text to be added or modified in the manuscript can be found at the end of each response.

We hope you find our response and changes to the manuscript satisfying and we are looking forward to hearing from you.

Yours sincerely,

The authors

Reviewer#1 Comment#1 (l. 58):

remove thereby which is misleading with the previous sentence

Our response: We thank the reviewer for this comment. The misleading word was deleted.

“The sorptive capacity of clay minerals ~~thereby~~ decreases as 2:1 layer type silicates (e.g. smectite) are substituted by 1:1 layer type silicates (e.g. kaolinite) (Sposito et al., 1999).”

Reviewer#1 Comment#1 (l. 61):

oxide do not "become" positively charged at low pH values, they are positively charged on the whole pH range of almost all soils (check pzc values). If you want to open the pandora box of variable charges, it is difficult to speak about the protonation of surfaces without saying that several OM functional groups too protonates when pH becomes acidic. Furthermore, if you want to maintain this sentence about acidic soils, then you could more explicitly mention that soil acidification is a key process behind soil weathering.

Our response: Indeed, the high complexity of variable charges of minerals AND organic matter compounds was described too simplistically. Therefore, we will modify the sentence to avoid an in-depth discussion of this topic (as it is not the main focus of our study) but keep the link between soil acidification and soil weathering.

~~Moreover, oxides become positively charged (protonated) at low pH values allowing for ligand exchange with OM compounds~~ As soil acidification progresses with soil weathering, the importance of these oxides to stabilize OM compounds becomes more pronounced (Kleber et al., 2021).

Reviewer#1 Comment#3 (l. 79):

this section contradicts what you say from line 47 onwards. Rephrasing either the upper section (lines 47-52) of this one (lines 79-85) might help

Our response: We thank the referee for making us aware of this issue. We will rephrase the hypotheses statements in lines 79-85 as suggested below. With these changes it should be clearer why we expected S-POM to decrease with mineral weathering on the presented time span. The high dependency of S-POM on mineral protection leads to decreases with soil age since less binding sites are available in highly weathered soils.

"Based on previous studies, we hypothesized that absorbance peak areas related to simple plant-derived OM (S-POM) would decrease with increasing soil formation as binding sites for ~~minerals become increasingly weathered and~~ the formation of OMAs are reduced. Consequently, ~~hence decreasing~~ the protection of S-POM compounds from microbial degradation and transformation decreases."

Reviewer#1 Comment#4 (Discussion):

overall excellent. However, you did not notice any significant decrease in base saturation along your chrono-sequence which contradicts general description of soil weathering sequences. This aspect is extremely interesting and should be discussed.

Our response: We thank the reviewer for this positive feedback regarding our discussion section. We acknowledge the issue raised by the reviewer and would kindly like to state that the behaviour of pedogenic (DCB-extractable) iron oxides along the chronosequence behaves consistently with the base saturation values and might offset the decreases in CEC and pH that occurred with increasing weathering. We decided to include the following sentence in the discussion section (in 4.1, l. 231-232):

"At the same time, lower total C in strongly weathered soils were accompanied by increasing amounts of pedogenic iron oxides, i.e. Fe_{DCB} that likely contributed to the unaltered base saturation values."

Reviewer#1 Comment#5 (non-binding suggestion):

your discussion sticks very closely to the parameters. I was expecting your paper to zoom out at some point in order to 1) discuss how the climate and geomorphological changes that happened in your 3 million-year sequence may have impacted your results 2) discuss the general impact of your findings on our understanding of soil weathering, 2) outline the limits of your study and what should be done to go further

Our response: We thank the author for this comment. While we do understand the importance of zooming out to assess the broader implications of our research, our aim was to keep the scope of the current paper narrow and to strictly focus on the impact of mineralogical changes on soil organic matter composition and decomposition proxies across this particular chronosequence. As different processes occur under different soil types and across different timescales, our results are not necessarily applicable or thus generalizable across a larger

scale. However, to add a final, summarizing sentence, we added the following at the end of the conclusion section:

"Our study shows that soil mineralogy plays an important role in shaping SOM composition during soil weathering across large timescales. We therefore recommend further studies to assess these trends in contrasting soil mineralogies in order to gain a better understanding across larger geographical areas."