Geochronology Discuss., author comment AC1
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Reply on RC1

Andrea Madella et al.

Author comment on "How many grains are needed for quantifying catchment erosion from tracer thermochronology?" by Andrea Madella et al., Geochronology Discuss., https://doi.org/10.5194/gchron-2021-6-AC1, 2021

General reply

We thank the reviewer very much for their time. We note that all the issues raised here deal with the importance of taking mineral fertility into consideration. We do appreciate these concerns and we will address them in the revised manuscript. Moreover, we are happy to see that these remarks do not highlight any conceptual error inherent to either of scope, method, results and conclusions of our paper.

Line-by-line comments

lines 8-9: "If ages increase linearly with elevation, spatially uniform erosion is expected to yield a detrital age distribution that mirrors the catchment's hypsometric curve"
This statement is only true if mineral fertility is the same in any parts of the catchment, see Malusà, M. G., & Fitzgerald, P. G. (2020).The geologic interpretation of the detrital thermochronology record within a stratigraphic framework, with examples from the European Alps, Taiwan and the Himalayas. Earth-Science Reviews, 201, 103074.
Another important point is that ages are not always expected to increase linearly with elevation. Again, see Malusà and Fitzgerald 2020 - ESR about this point

We thank the reviewer for this remark, we are aware of the importance of mineral fertility, which we have addressed in multiple occasions throughout the manuscript. However, for the sake of brevity and simplicity of the abstract we will not mention either fertility or complex age-elevation relationships at this stage.

lines 33-37: "Geomorphologists have been able to infer changes in climatic parameters (Nibourel et al., 2015; Riebe et al., 2015), glacial erosional processes (Clinger et al., 2020; Ehlers et al., 2015; Enkelmann and Ehlers, 2015), sediment dynamics (Lang et al., 2018), relief evolution (McPhillips and Brandon, 2010), occurrence of mass wasting (Vermeesch, 2007; Whipp and Ehlers, 2019) and differences in rock uplift (Glotzbach et al., 2013, 2018; McPhillips and Brandon, 2010)."
Unfortunately, in most of those cases mineral fertility was not taken into account, which makes the above conclusions invalid. I suggest integrating this part of the manuscript.

We have added a remark along these lines to the revised manuscript.

line 60: "If a range of assumptions hold (Malusà et al., 2013)"
Here, the authors may also quote Malusà and Fitzgerald 2020 – ESR where assumptions are discussed in detail

We have added the suggested citation to the revised manuscript.

Figure 2: What is the difference in mineral fertility between "low" and "high" in figure 2? In natural systems, fertility values vary within two or three orders of magnitude (see Malusa et al. 2016 Gondwana Research; Asti et al. 2018 Basin Res; Resentini et al. 2020 EPSL; Malusà and Fitzgerald 2020 – ESR), whereas these differences appear to be much lower in this figure.

Figure 2 is a qualitative cartoon to illustrate how the combined effect of mineral fertility and erosion intensity affect detrital distributions. We have better specified this in the figure caption.

lines 341-342: "Uncertainty in the interpretation can stem from factors such as: (1) complex bedrock age-elevation relationship"
This issue is addressed in detail by Malusà and Fitzgerald 2020 – ESR in their section 3, to which the reader should be referred to for the sake of clarity.

We have added the suggested citation to the revised manuscript.

lines 342-343: "(2) spatial variability of sediment size resulting from transport distance (e.g. Lukens et al., 2019)"
These aspects are addressed in much greater detail in Malusa and Garzanti 2019 – Springer, to which the reader should be referred to for the sake of clarity. Here is the full reference: Malusà, M. G., & Garzanti, E. (2019). The sedimentology of detrital thermochronology. In Fission-Track Thermochronology and its Application to Geology (pp. 123-143). Springer, Cham.

We have added the suggested citation to the revised manuscript.

lines 344-345: "lithological differences (von Eynatten et al., 2012), or vegetation effects on weathering and erosion (Starke et al., 2020)."
This is still part of the mineral fertility issue

It is not clear to us what the reviewer is suggesting here.

lines 360-361: "Other possible sources of bias concern the grain size of the analyzed samples. One issue is that downstream sediment abrasion may significantly modify detrital grain-age distributions, as can the weathering and erosion processes associated

with a grain."
The problem is ill posed. The main issue is hydraulic sorting and selective entrainement rather than grain abrasion (see Malusa and Garzanti 2019 and Malusà and Fitzgerald 2020 and references therein for a discussion). Also, the impact of weathering is minimized by the single-mineral approach. I suggest rearranging the entire section.

We have reworded this section for clarification and included the suggested citation. We think that the work of both mentioned authors (Lukens, as well as Malusà) equally contribute to understand the grain size issue. We also think that weathering in the critical zone, especially for the case of studies relying on apatite U-Th/He geochronology, is an important point to account for in this discussion.