Review Report for

Vanishing volcanics: Implications of mass wasting deposit sediment heterogeneity on downstream abrasion and the fluvial hazard cascade

Brian C. Pinke [1], Allison M. Pfeiffer* [1], Jonathan A. Czuba [2], Finn Coffin [1]

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Round 1 Review

Comments by reviewer 1 (Karen Gran)

Completed: 2025-11-21 05:53 PM
Recommendation: Minor revisions
Reviewer Comments
For author and editor
Review of Vanishing volcanics
This paper takes data collected on 5 volcanic debris flow deposits and uses data on rock strength and abrasion potential to model how the deposits will evolve downstream due to abrasion. Overall, I think this a great contribution.
I do have a few comments broadly as well as more detailed comments on the document itself.
The discussion is far-reaching and several sections focus on how the differences measured in each deposit came to be. Was it the mode of emplacement or the upstream geometry, or the fact that the authors were simply able to measure over a greater distance longitudinally, etc. However, I didn't think the paper was really about HOW the heterogeneity came to be. If it is, then that needs to be addressed in the methods and results, with more discussion of debris flow modeling, style of flow, etc. I think the paper would be stronger if it instead focused primarily on the modification of the deposits, using the heterogeneity seen in the field as a way to explain the importance of measuring lithology and strength and incorporating that information into forecasting of sediment transport and modification downstream. The parts where you focus on how the deposits came to be (sections 5.2 and 5.4) end up feeling very speculative and don't add to the major result focused on downstream modifications of volcanic debris flow deposits.
I have a few methodological questions as well. The first relates to the Schmitt hammer itself. I am a relative novice with a Schmitt hammer and have only used it on bedrock, but we found differences in strength in fractured vs. unfractured bedrock or even in how close the measurements were to fractures. How does this strength in the bulk rock unit translate into measurements made on boulders? I would think the matrix would have a substantial impact on the strength measured with the Schmitt hammer. How do you then separate out the impact of the strength of the underlying lithology from the complexity and structure of the matrix? The measurements presented are pretty strong. Can you include more information on how you actually collected the Schmitt hammer data on clasts?
Next, does the abrasion model include the impacts of both the reduction in grain size and the shift in lithology? How is the strength of the modeled deposit determined? Does it include both the shift in lithology as the weaker rocks break down and move into suspended load AND the change in grain size? How? Does grain size come in through tau* and strength through variable alphas? Could you add in a few lines on how this calculation is made?
Data were collected from the field that include grain size, lithology, and rock strength. Data are presented for bulk grain size distributions of the deposits (and individual GSDs for each site), bulk lithology for the site, rock strength for each lithology, etc., but data comparing rock strength and grain size are not presented. However, these data are described in the discussion. Can data comparing grain size and strength be included in the supplemental data file?
Please see the attached file for additional comments to address.

Comments by reviewer 2 (James Christie)

Completed: 2026-01-15 12:58 PM
Recommendation: Minor revisions
Reviewer Comments
For author and editor
(The following is more or less copy pasted from my general comment in the attached document.)

I would like to thank the authors for putting together this piece of work. It was an interesting read and ultimately comes to a pertinent conclusion about the importance of considering lithological/sedimentary factors when considering hazard cascades posed by mass wasting/mass flow events from volcanic edifices, and indeed further afield. I enjoyed reading it (very envious of the field sites!), learned form it, and do believe it is worthy of publication.

In general I feel that this manuscript is well written, so my recommendation is that minor, but important, corrections are made. Key points I would like to highlight are as follows:
- Some alteration needs to be made to figures and tables in terms of position in the manuscript (particularly Table 1 which I think should be made into two) and one figure needs improved quality.
- I think that there is insufficient introduction to some concepts, for example:
-- to avoid confusion, 'abrasion' should be defined by how it is being used in this work and language surrounding it should be consistent.
-- the importance of hydrothermal alteration as a weathering process in volcanic environments should be emphasised.
- To me, there are some contradictory points in the discussion sections 5.2 and 5.5 which obfuscate the conclusions and need consideration.

In this commented word document, I have added comments highlighting thoughts and suggestions for rephrasing where I felt more clarity was needed. At points I have also made tracked/suggested changes directly to the text where I felt punctuation/spelling/minor elements of wording was incorrect or could be enhanced. There are very few instances of this, but I would encourage the author to check consistency in their use of punctuation, e.g., dashes, spaced or not, i.e., '50-100' vs '50 - 100'.

I hope that the authors find this review constructive and helpful for improving their work.

Recommendation by Associate Editor 2 (Serina Diniega)

Completed: 2026-01-25 05:36 AM
Recommendation: Minor revisions
Reviewer Comments
For author and editor
Dear authors,
I read with interest your manuscript entitled "**Vanishing volcanics: Implications of mass wasting deposit sediment heterogeneity on downstream abrasion and the fluvial hazard cascade**", as well as the reviews from two anonymous reviewers. Based on my reading of your manuscript and the reviews, I would like to recommend for the manuscript to **be accepted after minor revisions**.
While there are a large number of reviewer comments, most comments are about minor edits to clarify meaning. For example, there are a few areas with questions about if a statement is about a full deposit unit, or about the grains within that deposit. And no comments indicated a technical issue with the methodology, results, or interpretation of the study.
All comments from the reviewers seemed reasonable so all should be addressed (including an explanation if a change is not adopted). The comments also seemed comprehensive and my only further editorial comment is that generally the conclusions were hidden in the middle of paragraphs in Section 5, and putting a clear statement about what was found (or not found) at the beginning or end of a paragraph would make them easier to identify. The paper is overall written well and the logical flow was easy to follow. I appreciated that the paper also included a discussion about 'implications for cascading hazards and flood mitigation' (§5.8).
Best wishes,
Anonymous Associate Editor

Decision by Editor-in-Chief (Alice Lefebvre)

2026-01-25

Dear Brian Pinke, Allison Pfeiffer, Jonathan A. Czuba, Finn Coffin,

Thank you for submitting your manuscript entitled "Vanishing volcanics: Implications of mass wasting deposit sediment heterogeneity on downstream abrasion and the fluvial hazard cascade " to Geomorphica. I have now received two reviews and an Associate Editor assessment (included at the bottom and/or attached to this email). I have looked at the paper, the reviews and the Associate Editor recommendation myself.

On this basis, I would like you to undertake a **minor revision** of your manuscript. As this is a minor revision decision, we will assess the revised version internally and we are unlikely to need to consult more widely before a final decision is made.

Authors' responses to review comments

2026-03-3

We thank the two reviewers and the AE for their insightful comments on the earlier version of this manuscript. Our revised submission includes minor changes overall as suggested by the reviewers, with most changes being grammatical in nature to improve clarity throughout. We also provide additional information where necessary on abrasion, hydrothermal alteration, and modeling. At the suggestion of a reviewer, we have removed two sections (5.2 and 5.4) which were focused on deposit emplacement, to strengthen the focus of the discussion on clast attributes and impact for downstream transport. To this end, we also add a section (now section 5.4) focusing on modeled uncertainties in downstream abrasion. We feel that these revisions improve the manuscript and hope that it is now fit for publication.
Our responses to reviewer comments are italicized below. Line numbers are from initial submission.

Anonymous Associate Editor:

Recommendation: Minor revisions

Remarks to Author:

I read with interest your manuscript entitled "Vanishing volcanics: Implications of mass wasting deposit sediment heterogeneity on downstream abrasion and the fluvial hazard cascade", as well as the reviews from two anonymous reviewers. Based on my reading of your manuscript and the reviews, I would like to recommend for the manuscript to be accepted after minor revisions.

While there are a large number of reviewer comments, most comments are about minor edits to clarify meaning. For example, there are a few areas with questions about if a statement is about a full deposit unit, or about the grains within that deposit. And no comments indicated a technical issue with the methodology, results, or interpretation of the study.

All comments from the reviewers seemed reasonable so all should be addressed (including an explanation if a change is not adopted). The comments also seemed comprehensive and my only further editorial comment is that generally the conclusions were hidden in the middle of paragraphs in Section 5, and putting a clear statement about what was found (or not found) at the beginning or end of a paragraph would make them easier to identify.

The paper is overall written well and the logical flow was easy to follow. I appreciated that the paper also included a discussion about 'implications for cascading hazards and flood mitigation' (§5.8).

Thank you for taking the time to review our submission. We have addressed all comments and have provided explanation where appropriate. We have also made changes to section 5 to improve clarity and focus: We have removed two sections (5.2 and 5.4) and added a new section (now section 5.4 – Uncertainties in downstream abrasion) in response to feedback from reviewer 1, and we have edited paragraphs in section 5 as to improve the clarity of the key points.

Reviewer 1:

Recommendation: Minor revisions

General Comments:

This paper takes data collected on 5 volcanic debris flow deposits and uses data on rock strength and abrasion potential to model how the deposits will evolve downstream due to abrasion. Overall, I think this a great contribution.

I do have a few comments broadly as well as more detailed comments on the document itself.

The discussion is far-reaching and several sections focus on how the differences measured in each deposit came to be. Was it the mode of emplacement or the upstream geometry, or the fact that the

authors were simply able to measure over a greater distance longitudinally, etc. However, I didn't think the paper was really about HOW the heterogeneity came to be. If it is, then that needs to be addressed in the methods and results, with more discussion of debris flow modeling, style of flow, etc. I think the paper would be stronger if it instead focused primarily on the modification of the deposits, using the heterogeneity seen in the field as a way to explain the importance of measuring lithology and strength and incorporating that information into forecasting of sediment transport and modification downstream. The parts where you focus on how the deposits came to be (sections 5.2 and 5.4) end up feeling very speculative and don't add to the major result focused on downstream modifications of volcanic debris flow deposits.

This is a great point. We have removed sections 5.2 and 5.4 in our revised manuscript and we have added a new section, now section 5.4, which briefly addresses uncertainty in grain size in modeling downstream sediment abrasion. These subtractions and addition improve the focus of our manuscript on clast attributes and impacts for downstream transport.

I have a few methodological questions as well. The first relates to the Schmitt hammer itself. I am a relative novice with a Schmitt hammer and have only used it on bedrock, but we found differences in strength in fractured vs. unfractured bedrock or even in how close the measurements were to fractures. How does this strength in the bulk rock unit translate into measurements made on boulders? I would think the matrix would have a substantial impact on the strength measured with the Schmitt hammer. How do you then separate out the impact of the strength of the underlying lithology from the complexity and structure of the matrix? The measurements presented are pretty strong. Can you include more information on how you actually collected the Schmitt hammer data on clasts?

You are absolutely right, a SHRS values definitely depend on fractured vs. unfractured bedrock. This has important implications for measuring the strength of boulders and smaller clasts. In short, a non-vesicular clast with (effectively no fractures) would be expected to have a higher SHRS value and a highly vesicular clast (effectively highly fractured) would be expected to have a lower SHRS value. We see this play out in our data, both with SHRS to lithology trends and with SHRS to tumbler derived abrasion rates trends. We did not collect data on whether we measured SHRS on the clast in-situ or removed from the deposit. In all cases, the deposit was unconsolidated and thus not a very strong matrix for the in-situ clasts. As such we measured SHRS on all clasts wherever it was most suitable to given stability underfoot and transportability of the clast which was largely dependent on size. Dermidag et al. (2009) addresses the size dependence and in-situ matrix relationship and determined that if the shortest edge of the clast is >11 cm, then the in-situ SHRS value is equal to the pulled out SHRS value on the same clast. We unfortunately used the b-axis when measuring clasts and thus found it necessary to remove smaller clasts from the analysis – deciding to keep clasts >=25 cm. We have edited the text for clarity on how we collect the SHRS measurements.

Next, does the abrasion model include the impacts of both the reduction in grain size and the shift in lithology? How is the strength of the modeled deposit determined? Does it include both the shift in lithology as the weaker rocks break down and move into suspended load AND the change in grain size? How? Does grain size come in through tau* and strength through variable alphas? Could you add in a few lines on how this calculation is made?

To address the reviewer's concerns, text has been added to sections 3.2 and 3.3 to improve clarity of how this works. We direct you to Pfeiffer et al. (2022) for further, more detailed explanation of the modeling approach. In short, the abrasion model effectively tracks individual clasts as they lose mass (grain size) via exponential decay (Equation 1). We use Equation 2 to build on the base equation by assigning abrasion rates to each clast based on clast strength (lithology, an immutable value for a given clast), and transport stage which is based on grain size, density, and reach shear stress (variable

downstream for a given clast), as in Pfeiffer et al. (2022). As the clasts from a deposit are transported downstream, the weaker strength lithology clasts abrade to wash load over shorter distances and are no longer tracked. As downstream abrasion decreases clast grain size, the transport stage changes, and thus rate of abrasion increases. The strength of a clast is used to ascertain the alpha baseline given the empirical best-fit relationship derived from tumbler derived abrasion rates in section 3.2.
Data were collected from the field that include grain size, lithology, and rock strength. Data are presented for bulk grain size distributions of the deposits (and individual GSDs for each site), bulk lithology for the site, rock strength for each lithology, etc., but data comparing rock strength and grain size are not presented. However, these data are described in the discussion. Can data comparing grain size and strength be included in the supplemental data file?
We now include a supplemental figure comparing grain size and strength. There is no correlation.
Please see the attached file for additional comments to address.
Thank you for taking the time to provide thoughtful detailed comments.
Detailed Comments:
Line Comment
269 Can you explain the procedure you used for using a Schmitt hammer on individual clasts? Did you leave them in situ? How do you factor in the differences between rock strength in terms of the inherent strength of the lithology vs. the characteristics of the matrix it sits in?
Schmidt Hammer methodology is discussed at the end of this section. Clarification on in-situ vs. pulled out has been added. Strength vs size vs matrix is addressed in subsequent comment.
279 How did you handle fine sediment? (like in the Mt. Meager deposit discussed below?)
This is addressed two paragraphs below - "Clasts <5 mm were classified as "fines" and lithology was not identified."
287 What does this mean?
Text edited for clarity – Since these hummocks contributed relatively little coarse sediment relative to the other portions of the deposit, we did not weight these measurements more heavily, despite the smaller number of measurements.
311 As the clasts shrink in size, the proximity to the matrix becomes more important. We've seen the same kind of affect on bedrock close to fractures vs. far from fractures. It might be "real" in terms of the strength of the deposit in and around that smaller clast rather than just being the strength of that clast. Did you see any correlation between rock strength and clast size for the clasts >25 cm?
Unfortunately, we did not collect data on whether the clast was sampled in-situ or pulled out. Dermidag et al., 2009 addresses size dependence such that if the shortest edge is >11cm, the in-situ SHRS is equal to a pulled out clast. However, we measured b-axis and thus found it necessary to remove the smaller clasts from the analysis. We have added a supplemental figure for SHRS vs. clasts >25cm - there is no correlation.
313 Where was the clast while you were taking measurements? In situ? Pulled out?
Clasts were sampled either in-situ or pulled out depending on size and maneuverability. This has been added to text.
323 If the chosen samples were >25cm, wouldn't they all be large enough to cut (>8cm)?
Due to size/weight and the field team's transport capacity, we had to collect subsamples of most clasts. These subsamples were considerably smaller such that we could collect 20 from each exposure. Subsample collection is noted in section 3.1 paragraph 2 and text is edited here for clarity.
327 How big is the rock tumbler?
It has a 4.3 liter capacity. This has been added to the text.

330 How far downstream? And was the host GSD the same as the river? Or the same but down-scaled?
We followed the methodology and distribution of that found in Pfeiffer et al. (2022) which is to use the gsd of gravel bars found in the lower mainstem of the Suiattle River.
396 a baseline?
Yes, 'baseline' has been added.
415 Do you expect all bedload to eventually become washload? Or do some lithologies remain stubbornly stuck with sand particles too coarse to become washload but too strong to break down further?
If the clasts diameter is reduced to <0.002 m we treat it as wash load, regardless of clast lithology/strength. This is addressed at the end of section 3.3. We acknowledge that this is an assumption and simplifies the dynamics of fine sediment generation and transport. However we pose that in high energy mountain rivers like these, even sand sized particles are likely to evacuate the system rapidly.
429 Does this end up being a bit circular? You specify a diameter loss coefficient, use that to calculate shear stress, then use the shear stress to determine an abrasion coefficient. How important is the diameter loss coefficient? Where did 0.1 come from?
The diameter loss coefficient is simply used to create a downstream shear stress curve, and is based on the D_{50} of the channel bed. The modeled abrasion (as in, Equation 2) considers the pulse material which represents just a fraction of the total sediment supply to a river channel. helps control exponential fining of the clasts as in Equation 5. We follow methodology used in Pfeiffer et al. (2022), who found that a diameter loss coefficient of 0.01 yields downstream fining trends that match their downstream grain size data from the Suiattle River. We have added text to explain this.
449 Is this what is referred to earlier as "washload"?
Yes this is wash load. Text has been edited to only refer to it as wash load.
463 This doesn't fit the data - White R, Meager, and Lillooet all have > 50% vesicular.
Thank you for catching this error, it should be 'all have >50% vesicular material". The text has been edited.
466 I'm a little confused. I realize you used different criteria to classify each site, but why would you not have an altered vesicular classification at a site where the vesicular material is altered?
This is unfortunately a result of the order in which we went to each deposit. Glacier Peak was completed first (Pfeiffer et al., 2022) which had no hydrothermal alteration. When embarking on the field campaign for this project, we made the decision to create a classification scheme specific to each deposit that was also comparable to the Glacier Peak Scheme (Table S1). Mt. Adams was our third field visit (Little Tahoma was second) - and is where we used the scheme that distinguished altered material to non-altered material. We ultimately decided to use this as the umbrella scheme (discussed in section 3.1) as it unifies all the deposits specific schemes well. We would have absolutely used this scheme for Little Tahoma if we knew then what we know now. Reference to Table S1 has been added to the text here.
472 Fix wording
Reworded for clarity: 'Within each deposit, lithologic trends are generally consistent across exposures, although some variability is present (Table S2)."
478 Provide units - you should be able to convert to MPa
We agree, it would be great to know what the MPa are for each of these lithologies. Unfortunately, SHRS can only be converted to MPa using lithology-specific empirical relationships developed by testing both the SHRS and UCS for each lithology, which we did not do. Empirical relationships for

many rock types do exist in the literature, however we did not use a petrologic classification scheme. This paper compiles a nice review: Aydin, A., and Basu, A., 2005, The Schmidt hammer in rock material characterization: Engineering Geology, v. 81, p. 1–14, doi:10.1016/j.enggeo.2005.06.006.

561 How did you determine the new SHRS given the new mix of grain size and lithologies downstream? Can you add a few lines on this in the methods section? Is it just the changing mix of lithologies? Or are you incorporating grain size changes as well?

As clasts abrade to <0.002 m they are treated as wash load. We can compare the starting make up of clast gsd/lithology/SHRS to the end make up. A new summary paragraph has been added to the end of section 3.3 to clarify.

618 Part of this statement makes sense - if the fine material is carried away quickly, the D50 should go up. But part of it doesn't. If the weak coarse material is broken down, it should lead to a finer distribution overall. You need selective transport to remove the fine material relative to the coarse material to coarsen up the bed (this was seen at volcanoes like Pinatubo). And that has to exceed the rate of abrasion which is taking coarse material and making it finer.

We have edited the text to improve logic and clarity. We propose that the weaker and thus less dense bed material is more easily transported downstream and thus subject to abrasion.

657 Were these data presented here? Or just in Pinke 2024? This could be useful to present in this paper, too (esp. if Pinke is an author). It's actually a question that came up to me while thinking about your methods - is there a connection between rock strength and the size of the clasts? You could include the data in the supplement.

There is no correlation. The figure has been added to supplemental material.

662 Could you be observing the weathering that has happened since the deposit was emplaced? We see the same thing with some of the vesicular basalt clasts in our region - clasts that have clearly been traveling as bedload can be shattered by hand when picked up off a gravel bar. They don't last long when subjected to subaerial weathering (wet-dry, freeze-thaw, etc.).

Thank you, this is a great point. We have added it to the text.

670 Both this section and section 5.2 seem to be focused more on the mechanics of the debris flows and valley geometry, etc. and how that influenced the initial conditions in the deposit. I didn't get the impression from the rest of the paper that you were focusing on how the deposits came to be but rather how the initial deposits impact how the sediment is modified as it moves downstream. It feels out of place and feels like you are reaching to pull something out to explain why they are different even though you didn't really look at flow mechanics or modeling of flow emplacement, etc. I would suggest just focusing on the deposits and their heterogeneity as a means to study a variety of systems and how they might evolve downstream.

Point well taken. Upon review, we agree and have removed sections 5.2 and 5.4 from the manuscript. In addition, we add a new section, now section 5.4 (Uncertainties in downstream abrasion).

678 What longitudinal distance were you able to measure at the other sites? Perhaps you could include that information in Table 1.

We have removed this section per a prior comment.

717 By "material is considerably stronger" are you specifically referring to the clasts within the deposit? Rather than the deposit itself? There's a difference between the deposit being strong and the rocks within the deposit being strong, especially given the variability in fines content.

We are discussing the rocks that make up the deposit as 'material'. We collected data on individual clasts. We have clarified in the text that we are referring to the clasts.

834 This is a really great example to bring up.

Thank you, we are excited about this application.

844 100s or over 100?
We simulated for 100 km of transport. Text has been edited: 'over 100 kilometers'.

Reviewer 2:
Recommendation: Minor revisions
I would like to thank the authors for putting together this piece of work. It was an interesting read and ultimately comes to a pertinent conclusion about the importance of considering lithological/sedimentary factors when considering hazard cascades posed by mass wasting/mass flow events from volcanic edifices, and indeed further afield. I enjoyed reading it (very envious of the field sites!), learned from it, and do believe it is worthy of publication.
In general, I feel that this manuscript is well written, so my recommendation is that minor, but important, corrections are made. Key points I would like to highlight are as follows:
Some alteration needs to be made to figures and tables in terms of position in the manuscript (particularly Table 1, which I think should be made into two) and one figure needs improved quality.
In accordance with your suggestions, we have: 1. moved figures and tables as necessary, 2. removed the last three columns of Table 1 since, as you noted, the data is presented in the figures throughout, and 3. included a higher resolution and modified version of Figure 1.
I think that there is insufficient introduction to some concepts, for example:

- To avoid confusion, 'abrasion' should be defined by how it is being used in this work and language surrounding it should be consistent.
- The importance of hydrothermal alteration as a weathering process in volcanic environments should be emphasised.

We now define abrasion in the text and have edited the manuscript to keep the language surrounding it consistent throughout. Additionally, we have added information on hydrothermal alteration and its role in volcanic slope stability to the introduction section.
To me, there are some contradictory points in the discussion sections 5.2 and 5.5 which obfuscate the conclusions and need consideration.
Thank you for pointing out this contradiction. We have edited section 5.5 for clarity and section 5.2 has been removed per another reviewer's feedback.
In this commented Word document, I have added comments highlighting thoughts and suggestions for rephrasing where I felt more clarity was needed. At points, I have also made tracked/suggested changes directly to the text where I felt punctuation, spelling, or minor elements of wording were incorrect or could be enhanced. There are very few instances of this, but I would encourage the author to check consistency in their use of punctuation, e.g., dashes, spaced or not, i.e., '50-100' vs '50 - 100'.
I hope that the authors find this review constructive and helpful for improving their work.
We have accepted all in-line suggested changes and suggestions for rephrasing either as provided or modified and feel that these changes do enhance clarity of the text. Thank you for taking the time to provide constructive and helpful feedback on our manuscript.
Detailed Comments:
Line Comment
8 Wording a little ambiguous here. Are you referring to mass wasting events in general, or those from volcanic edifices? Regardless of the cause, mass wasting contributes significant sediment to fluvial systems. I would suggest rewording to along the lines of '.., more than half of all catastrophic mass

wasting events occur on volcanic slopes and supply significant quantities of sediment to downstream channels'.
This paper is focusing on mass wasting events from volcanic edifices. The intent is to indicate that these are a frequent occurrence on volcanic edifices and therefore worthy of focused study. "Them" is referencing the volcanic edifices, we have reworded for clarity.
9 When I first read this manuscript, I felt that there was inconsistency with regards to the use of terms 'abrasion' and 'attrition'. Particle evolution isn't my area of expertise, but my prior understanding was that in-transport particle erosion/size reduction via particle-to-particle interaction would generally be termed 'attrition', while the erosion of substrates (e.g., beds/banks) would be 'abrasion'. I did some further reading and note that abrasion is used in this way (i.e., to describe clast volumetric loss) within a lot of geological literature so is correct. However, abrasion and attrition are specific terms in some literature, with attrition being dominant in particle size reduction (hence my confusion; see papers pasted below). To avoid potential confusion for other readers, I suggest you specifically introduce the term 'abrasion' and what you mean by it in the main text (I have flagged where I think this could fit nicely). Perhaps you could also remain consistent throughout the text by not referring to attrition and abrasion interchangeably (this is how it reads to me, at least). See particularly: https://esurf.copernicus.org/articles/9/755/2021/esurf-9-755-2021.pdf, https://www.science.org/doi/10.1126/sciadv.aao4946. Use of abrasion is also made clearer in the Attal paper you cite: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2009JF001328.
Thank you for taking the time to dive into the nuances here and point out our improper use of these words interchangeably. The use of 'abrasion' and 'attrition' do seem to vary across works. We view abrasion as the larger umbrella term that includes several forms of clast size reduction, including attrition. This matches the use of abrasion in Pfeiffer et al., 2022 and as you note - Attal and Lave, 2009. We have edited the text to define abrasion and removed uses of attrition to maintain consistency.
12 See comment above re use of abrasion vs attrition. I think for the abstract, keep it consistent. Also, while not very logical, the way this is written might be taken to mean a change to the deposit at large, rather than the sediment within the deposits. I suggest being specific e.g., '...simulated downstream attrition[*] of sediment particles within four additional...' [*] or 'abrasion', if you were to keep it consistent.
Thank you for pointing this out, text has been edited for clarity
28 Personal preference as someone from a more hazards-related background, but I would advise against the use of 'predict' here. You are using a model to simulate or forecast a best estimate of what might occur given the parameters you are able to measure.
Changed 'predict' to 'simulate'.
43 This intro is generally good, but for me it's lacking some key introductory information, to summarise: 1. Please highlight the prevalence of hydrothermal alteration as a weathering process in volcanic systems which sets them part from the standard understanding of high/low elevation weathering you describe. Also emphasise its importance for potential mass wasting and edifice collapse. Suggest you can add a paragraph. 2. Please define 'abrasion' given the subtle variability of its use elsewhere. Please specifically explain that when you use this term you mean reduction in clast size by a range of processes, e.g., including attrition and frictional abrasion.
Thank you for highlighting these two main concerns. We have now added text on hydrothermal alteration and have defined 'abrasion'.
52 Suggested rephrase: 'Comparatively few studies consider what happens to these large mass wasting deposits after deposition into river valleys; for example, how the initial characteristics of mass wasting sediment affects how it subsequently evolves as it is transported through the fluvial system.'

Done.

61 Suggested rephrase for clarity: '...climate change, e.g., via increased rates of glacial melt/retreat, accelerated freeze-thaw cycles, and increased rainfall intensity,...'

Done.

65 'has relied'

Done.

67 'has lacked', as this is referring to 'previous research'

Done.

92 Suggest you have a new paragraph here focussing on hydrothermal alteration (HA). This is a good opportunity to emphasise that HA is a prevalent and important form of chemical weathering in volcanic systems, including at high altitude (it is altitude independent), and that it is a major contributor to the generation of volcanic mass wasting events. This sets volcanoes apart from other types of terrain. Rainier a very good example as HA is implicated in the Osceola flow, the Electron Mudflow, and other potential lahars derived from possible high elevation collapses of HA rocks (e.g., George et al., 2022). HA also implicated in other major volcanic collapses, e.g., 26 December '97 lateral blast of Soufrière Hills Volcano (e.g., Sparks et al., 2002). Can you find literature that demonstrates the impact of hydrothermal alteration on rock strength and grain size? I think emphasising this point, and having evidence of impact on rock would strengthen the rationale here.

Thank you for these in depth thoughts and for providing references to work off of. We agree that brief discussion of these notes improves the point and have added text on hydrothermal alteration weakening rocks (in sections 2 and 5.1) and increasing susceptibility of mass wasting on volcanic slopes (in section 2).

100 To avoid the confusion I note in a previous comment, define what you mean by abrasion. After this sentence is where you could introduce what you mean by this terms and acknowledge the difference across literature and that here you use it to generally mean the reduction in size of sediment particles via a range of processes, which includes frictional abrasion and attrition (e.g., chipping or fragmentation).

Thank you for noting this along with your other thoughtful comments on abrasion/attrition. We now define abrasion in the text.

131 In this section you describe flows derived from different initiation mechanisms: actual mass wasting (L. Tahoma, Meager, Adams) and glacial lake outburst floods (which I would argue are hydrological events rather than mass wasting events). This difference is likely to have implications for the type of sediments in the flow/deposits as they will be derived from different parts of the edifice, i.e., volcanic slope/flanks (including hydrothermal areas) vs valley floor/margins (e.g., pyroclastics/glacial). I suggest you highlight this distinction here in the first paragraph. It's also why Table 1 should be here, not in the results, as this provides a good overview of this variability (see later comment).

Thank you for this comment and continued feedback throughout this section on where we can be more specific and clearer with terminology. We now highlight the range of mass wasting processes resulting in the study deposits in the text here and we have clarified initiation and entrainment mechanisms throughout the section.

132 Table 1 has been put on page 17 in the results section. However, if you are referring to it here, by standard convention, it should be as close to here as possible. My suggestion is that you have Table 1 in this section, but remove the three columns that list results (i.e., the final four columns) - these tabulated results are, as far as I can tell, captured in your figures. If you feel you need to have these numbers shown somewhere, you can make a new table where Table 1 is now, or you could add them onto the relevant plots.

We have removed those last three columns as the data is available in figures and moved the table to section 2 where it is mentioned.

136 Suggest 'While' to avoid repetition with next sentence

Done.

148 Image is slightly too low in quality/pixelated, e.g., please enhance resolution of text, north arrow, and coordinate markers. Suggest adding additional contextual labels e.g., 'CANADA' and 'WA'/'OR' given you have no broader contextual map.

Done and done.

161 'result'

Done.

162 'that contribute'

Done.

165 date

Done.

187 Suggest rephrasing to 'In c.1938, a debris flow...'

Done.

188 Could be specific here about the fact that sediment would have been entrained from the valley margins/floor by this hydrological event, i.e., not initiated as a 'true' mass wasting event.

Text has been edited for specificity.

189 Possible rephrase: '...likely associated with a period of warming...'

Done.

192 Rephrase for specificity: 'mean recurrence interval'

Done.

192 Suggest rephrasing: '(individual intervals range between 2-16 years)'

Done.

215 Suggest you be specific about which event you mean and state 'this explosion'

Done.

216 Could just say 'collapse'?

Done.

225 Suggest rewording: '...high magnitude runoff and surface discharge...'

Done.

226 Suggest rewording: '...undercut the glacier, causing masses of ice to topple.'

Done.

227 Suggest rewording: '...until they collapsed and released outburst floods...'

Done.

228 Suggest rewording: '..., ultimately entraining and depositing...'. You are describing a dilute outburst flood which eroded into the substrate and bulked to debris flow, rather than a mass wasting event (i.e., the gravitational collapse of a mass of rock/regolith), per se, so I think being specific about it entraining material is important.

Done.

236 Suggest being more specific here: '...from dilute outburst flood to debris flow...'

Done.

237 Not sure what you mean here by 'bypassed'?

We mean 'overtaken' by a faster, more dilute hyper-concentrated flow. Text has been edited for clarity.

237 Date

Done.

244 This figure reference should be removed. According to the caption of Figure 2, 2h is showing Mt Adams site MA3, not Rainier/Kautz Creek.
Done.
251 You have mentioned two, not several, so I would phrase it as so. If there are more that you haven't mentioned, you could say 'two key processes'.
Done.
251 Suggest: 'Firstly, weak...'
Done.
252 With what implication?? Be specific. '...exposed to freeze-thaw weathering and rendered unstable and more prone to collapse' or something along those lines.
Done. Reworded to 'rendering them unstable and prone to collapse".
264 Generally felt this was well explained and justified. Just a couple of points.
We thank you for your thoughtful feedback!
290 Suggest rewording: 'In some instances it was not possible to collect 100 sample as intended'
Done.
327 Is this an equal number from each deposit? Or is it generally representative of each of the lithologies you found? Perhaps you could be clearer here.
It is not an equal number from each deposit, we chose samples to be representative of the lithologies we found. Text has been edited for clarity.
464 This figure needs to be on a later page in the results section after it is first mentioned in the main text
Done.
503 As with a previous comment, this Table is referred to much earlier in the main text and needs to be moved there. I suggest that this is moved to where it is mentioned and the final four columns are put into a different table placed here. This table is also not mentioned anywhere in the results section - please add reference to it in the main text.
As per the prior comment, the table has been moved and modified.
518 I think you mean figure 4 because this doesn't add up: Figure 5 is showing GSD not SHRS? Figure 5 b and d refer to Meager and L Tahoma, not Kautz/GP?
Thank you - it is in reference to Figure 4 b and d.
560 Flagging for consistency as this seems to be being used interchangeably with abrasion.
Thank you for flagging. We now solely use 'abrasion'.
565 Is this being lost from the system as fines washing out? If so, I suggest you be specific.
Yes, text edited for clarity. In response to another comment, modifications were made to the methods section that should make this clearer as well.
571 Perhaps I have missed something, but it's not clear to me why strength is increasing or how this has been computed. Suggest you make this concept clearer somewhere.
We track the individual clasts throughout the model run. These clasts have an initial diameter, are associated to their own lithology, SHRS, and density. As clasts abrade to wash load they are no longer tracked. Generally the clasts with lower SHRS (weaker) abrade to fines first, leaving the clasts that are stronger and raising the mean SHRS of the remaining material. Text has been added to the methods section to make this concept clearer.
584 Fair enough, but you are relying on the reader to remember this and if they don't they have to scroll back to figure it out. I think explicit labelling is better especially when you are asking them to remember two colour schemes for lithology and site.

We have added the deposit colors to the name of each deposit and noted as such in the caption to help clarify colors for panel F. We have also added that colors for A-E are as in Figures 3 and 4.

590 This section is generally alright - I like how you tie it together with hazard implications at the end and consider some real-world examples, that's great. However, your sections 5.2 and 5.5 state contradictory conclusions about initiation mechanism and GSD. Please check these.

Thank you for that feedback and for catching that error, we edited section 5.5 and section 5.2 has been removed per another reviewer's feedback.

613 Hydrothermal alteration is worthy of explicit mention in this paragraph given its importance for grain size? e.g., generation of clays, or the potential break up of larger clasts during emplacement?

Thank you for this point, we have added it to the section.

638 Flagging this for a comment I have made in 5.5

Thank you for noticing this error. Section 5.5 has been edited for clarity and this section has been removed, per another reviewer's comments.

689 Suggest rephrase: '...we were able to obtain here...'

Done.

716 This contradicts what you say in 5.2

Thank you for noticing this error. This section has been edited for clarity and Section 5.2 has been removed, per another reviewer's comments.

735 Figure needs to come after the first reference to it in the main text

Done.

737 Perhaps also say it is in colour? This is the most distinctive thing about the data presented from this study in this plot (could then remove the need for asterisk)

Caption has been edited.

745 Again, this process of strengthening is not clear to me based on the information you have provided

In response to prior comments modifications and additions have been made to the methods section that should clear this up.

790 Nice section here

Thank you!

792 Suggested rephrase: '..., with the aim of better understanding and ultimately forecasting the magnitude...'

Done.

803 The implication being that they were kept in suspension rather than being deposited because they are fines? Suggest you be specific for clarity

Yes, exactly. Text edited for clarity.

832 This is the first time I have read this term? It's not shown on any of your classification plots? Only features in the supplementary material. Please check or refer to the sup. mat.

Thank you, this should just be '...vesicular, V...', the text has been edited.

849 This is a good word - I think you could say it earlier on in the paper, like right at the start, because this is why understanding these systems is important, right?

Great point, it has been added.

Round 2 Review

Recommendation by Associate Editor 2 (Serina Diniega)

Completed: 2026-03-11 10:36 PM
Recommendation: Minor revisions

Dear authors,
I have re-reviewed manuscript entitled “Vanishing volcanics: Implications of mass wasting deposit sediment heterogeneity on downstream abrasion and the fluvial hazard cascade”, as well as the response to reviewers. Based on my reading of your manuscript and the edits made, I would like to recommend for the manuscript to be accepted - but after a couple of very minor revisions to improve clarity of the conclusions.

In general, the responses to suggestions from the reviewers look reasonable and well developed. In particular, the tightened scope (including large edits of parts of Section 5/Discussion) created a simpler logic flow and overall improved manuscript. The study (still) shows interesting measurements with important ties to flooding hazards.

However, I still had trouble figuring out, from just Section 5/Discussion, what the results of this study were. I found qualitative statements about all the different factors that can influence the evolution of the grain sizes within a sediment load downstream and over time (and how complicated things can be), but these statements felt "loose" -- as in the "conclusion" statements in each subsection were both hard to relate to the observations presented in the prior sections and hard to extend to a clear and quantitative advancement in understanding. Results of the study were presented with a more quantitative, "definitive/actionable" feel in the conclusion text. To strengthen the full logic-linkages from observations -> interpretations/discussion -> conclusion, I suggest (1) adding a brief paragraph to the start of Section 5 to map the logic flow through the subsections in 5 (i.e., that you are checking for specific, individual influences) and (2) to make the "results" statements in each part of Section 5 more quantitative. Note that (2) might bring in a bit of redundancy with the conclusion text, but that repetition is okay as it helps the reader easily follow the logic flow.

Best wishes,
Anonymous Associate Editor

Decision by Editor-in-Chief (Alice Lefebvre)

2026-03-12

Dear Brian Pinke, Allison Pfeiffer, Jonathan A. Czuba, Finn Coffin,

Thank you for submitting your manuscript entitled "Vanishing volcanics: Implications of mass wasting deposit sediment heterogeneity on downstream abrasion and the fluvial hazard cascade " (66) to Geomorphica. I have now received an Associate Editor assessment (included at the bottom and/or attached to this email). I have looked at the paper, and the Associate Editor recommendation myself.

Following the Associate Editor's recommendation, I would like you to undertake a **minor revision** of your manuscript. As this is a very minor revision decision, we will quickly assess the revised version internally we hope to be able to quickly provide a decision once you submit a revised version.

Alice Lefebvre

Authors' responses to review comments

2026-04-2

Thank you to the AE for further constructive feedback on the earlier version of this manuscript. Our revised submission aims to improve the clarity of the discussion section by addressing the components advised by the AE. We now include a brief introduction at the start of the discussion section that outlines the subsections and we add or modify concluding statements to the subsections where necessary to improve clarity of results and important points. We lightly modify text in a few subsections to improve clarity as well. We feel that these revisions improve the manuscript and hope that it is now fit for publication.

Our responses to reviewer comments are italicized below.

Anonymous Associate Editor:

Recommendation: Minor revisions

Remarks to Author:

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Best wishes,

Anonymous Associate Editor

Thank you for taking the time to review our submission. We have made changes to address all components of this feedback and feel that the manuscript is considerably improved.

Round 3 Review

Decision by Editor-in-Chief (Alice Lefebvre)

2026-04-07

Dear Brian Pinke, Allison Pfeiffer, Jonathan A. Czuba, Finn Coffin,

Congratulations! I am pleased to inform you that your manuscript entitled "Vanishing volcanics: Implications of mass wasting deposit sediment heterogeneity on downstream abrasion and the fluvial hazard cascade " has been accepted for publication in Geomorphica. AE1 had a look at your resubmission and told me:

The authors revised the discussion sections as suggested AE2, this paper is an important contribution to the field and is most suitable to Geomorphica.

Alice Lefebvre