Peer Review Report

Review Report on Bouncing spallation bombs during the 2021 La Palma eruption, Canary Islands, Spain

Original Research, Earth Sci. Syst. Soc.

Reviewer: George Williams
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EVALUATION

Q 1 Please summarize the main findings of the study.

This study documents field observations of ballistics ejected during the 2021 La Palma eruption, some of which travelled >1 km beyond their initial point of impact. This study describes and draws attention to the fact that such phenomena increase the range of ballistic hazard, potentially beyond what has been considered during previous ballistic hazard assessments that may not have considered such long distances of travel possible. The study uses their observations to support a call for wider appreciation of this hazard in future ballistic hazard assessments, or in updates to existing hazard assessments.

Q 2 Please highlight the limitations and strengths.

Strengths of this paper include:
That it is succinct but sufficiently detailed

That the data supplement includes a number of video files documenting the hazard that will likely be of interest and value to the volcanological community

It draws attention to what is most likely an under appreciated hazard at numerous volcanoes around the globe

Weakness include:
The main claim of this article, that the described hazard is one that has not been properly accounted for in previous ballistic hazard assessments, must be supported by more evidence. I would expect the text to contain examples of hazard maps or previous ballistic hazard assessment studies that have failed to consider the fact that ballistics can bounce or roll after landing. In simple terms, how do the authors (or future readers of this study) know that exisitng ballistic hazard assessments and hazard maps have not explicitly (or implicitly) accounted for the additional travel distance of blocks and bombs by adding some buffer distance beyond the point where ballistics are expected to initially land.

There are several parts of the study that would benefit from more precise language or the inclusion of specific quantitative information that the authors could likely include without too much additional effort.

Other minor weaknesses/corrections that could be made are included in the review report.

Q 3 Please comment on the methods, results and data interpretation. If there are any objective errors, or if the conclusions are not supported, you should detail your concerns.

Using field observations and footage the authors have documented how ballistics can travel well beyond their point of impact if specific circumstances are met during an eruption.

Some results of the study include the ranges of distances travelled by bombs, the velocity of one bomb as it travelled down slope and the observation that this hazard is a potential threat to life and property and can initiate fires in the areas it travels.

The study rightly interprets that the possibility of spallation bombs means the hazard footprint of ballistics can extend well beyond their initial landing point (perhaps further than was previously considered possible) and thus such considerations should be explicitly taken into account during future ballistic hazard assessments and subsequent risk mitigation efforts.

Q 4 Check List

Is the English language of sufficient quality?
Yes.

Is the quality of the figures and tables satisfactory?
Yes.

Does the reference list cover the relevant literature adequately and in an unbiased manner?
Yes.

Are the statistical methods valid and correctly applied? (e.g. sample size, choice of test)
Not Applicable.

If relevant, are the methods sufficiently documented to allow replication studies?
Yes.

Are the data underlying the study available in either the article, supplement, or deposited in a repository? (Sequence/expression data, protein/molecule characterizations, annotations, and taxonomy data are required to be deposited in public repositories prior to publication)
Yes.

Does the study adhere to ethical standards including ethics committee approval and consent procedure?
Not Applicable.

If relevant, have standard biosecurity and institutional safety procedures been adhered to?
Not Applicable.

Q 5 Please provide your detailed review report to the editor and authors (including any comments on the Q4 Check List):

I recommend this paper for publication with minor revisions and congratulate the authors on their well-written, succinct article that has documented and seeks to raise awareness of what I expect is a relatively underappreciated aspect of ballistic hazards. I found the article interesting and I believe it will be of interest and use to the volcanological community.

Below I have outlined the minor corrections and additions that I would consider necessary for publication to proceed. Additionally, I have included several suggestions that I would expect to increase the impact (pun intended) of this paper or make it more likely to be received favourably by the community.

Required corrections/additions

Line 58: The Whakaari eruption in 2019 is no longer the most recent eruption where ballistic or explosive volcanism has occurred with little to no forecasting. Semeru, 2021 and Popocatépetl, 2022 are two more recent fatality causing examples. To make this sentence valid valid, I would simply remove the word ‘most’.

Line 68: Volcanic projectiles (blocks and bombs) account for < 0.2% of the fatalities in the Brown et al. database so they cannot be considered “a major cause of fatalities in global volcanic eruptions”. They are instead the most frequent cause of fatalities within 5 km of the vent. The abstract of Brown et al. states

“Though normally accounting for small numbers of fatalities, ballistics are the most common cause of fatal incidents at this distance” [referring to 5 km].

It is stated (probably accurately) that the increased hazard footprint associated with a bomb’s potential to travel beyond its initial point of impact should be more widely accounted for in risk assessments. However, there is no evidence presented that bouncing/spallation bomb hazards are not already considered in the hazard mapping and/or risk assessment process at other volcanoes. If the claim is to be made that this hazard ought to be more widely appreciated outside of La Palma then the text should provide some evidence or examples of previous ballistic hazard maps or risk assessments that have failed to account for this hazard. I appreciate such evidence might be difficult or impossible to find, in which case it I would simply highlight the much broader issue (in the discussion) that the specific methods used in previous ballistic hazard assessments are unclear, which undermines their trustworthiness and credibility.

The relevance of the major- and trace-element analyses to this study needs to be given more context (in the introduction) prior to Section 2.2 where the analytical methods are described. There is no mention of the relevance of such analyses prior to this section. Furthermore, if the only reason for these analyses was to “confirm a heritage with the recent eruption” then I do not comprehend why it was decided to include these analyses in the article. Does the incandesce of the bombs not provide sufficient evidence of their heritage to the current eruption? Admittedly, I have little geochemistry knowledge but could these or similar analyses be used to constrain the temperature of the bombs, and hence give insight to their potential to start fires? Is there any additional, relevant information that can be gained from these analyses to justify their inclusion in the current article?

Lines 357 and 358: There are a couple of misplaced references here. Nurmawati and Konstantinou (2018) should be used on line 358 (instead of Brown et al. 2017). The reference on Line 357 should most likely be Yamada et al. (2018) for which I have included the link below. Titled: Impact resistance to ballistic ejecta of wooden buildings and a simple reinforcement method using aramid fabric (https://www.sciencedirect.com/science/article/pii/S0377027318301537).

Lines 364 to 366: It is stated that “that danger from volcanic pyroclasts can be at least double that normally assumed from ballistic bombs alone during events such as those witnessed in October 2021”. In order to double, ‘danger’ must be quantified somehow. Instead of saying ‘danger’ can be double, more precise language should be used. The area threatened by ballistics or the range of ballistics would be more appropriate here.

Reviewer suggestions (optional)

Throughout the article I strongly suggest replacing the gendered term ‘manmade’ with the more commonly used, non-gendered terms ‘built environment’ or ‘built structures’. If the authors insist on using ‘manmade’ then be consistent between ‘manmade’ and ‘man-made’ both of which are present in the article.

In the abstract I would suggest quantifying the additional distance the observed bombs travelled as a range of percentages (e.g. 55 - 110% farther). This seems like a simple addition that could serve as a quick hook or takeaway fact to enhance the impact of the study.

Lines 202 and 203: This sentence raises a critical question: What are the quantifiable conditions of the landscape that can lead to such a phenomenon? A measurement or estimate of the slopes where the bomb was a) travelling rapidly and b) where it came to rest would make for very useful additions here. Future studies could use this information to help model this phenomenon or to more robustly identify areas that should be included in a possible extension of ballistic hazard zones.

Considering the main contribution of this paper is the description of observed spallation bomb travel beyond the point initial ballistic impact I believe a map more precisely delineating the a) the likely areas of impact and b) the final locations where the bombs came to rest would be a valuable addition to this paper. Either a new stand-alone map showing these points or the addition of these locations more precisely to the existing map

(Figure 1B) would be appreciated. If these two areas are within the red box already on Figure 1B then that should be explicitly stated in the text.

Finally, I would have liked to see a simple list of features that make an eruption more likely to produce this hazard, which has been described as being a relatively rare phenomenon. In other words, what information can you give to help identify volcanoes where this hazard is most likely to occur in the future, so that steps can be taken to mitigate the risk more efficiently.

Congratulations once again on writing a very nice article. I look forward to hopefully seeing it in press in due time.

QUALITY ASSESSMENT

Q 6	Originality	■■■■■
Q 7	Rigor	■■■□□
Q 8	Significance to the field	■■■□□
Q 9	Interest to a general audience	■■■■□
Q 10	Quality of the writing	■■■■■
Q 11	Overall quality of the study	■■■■□