

## 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: Rebecca Fitzgerald

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### EVALUATION

#### **Q 1** Please summarize the main findings of the study.

- Bombs can bounce and roll >1 km from their ballistically emplaced landing spot
- Bombs can spall incandescent material while travelling downslope which can be a fire hazard
- Bouncing and rolling of ballistics, in addition to purely ballistic transport, needs to be considered when assessing hazard extent and creating hazard zones on volcanoes with steep slopes
- Individual bombs created multiple impact craters/indents. This can affect estimates of bomb numbers/hazard intensity if using craters as a proxy for bombs.
- Spallation bombs can have multiple potential ignition sites from both the bomb as well as the spalled material

#### **Q 2** Please highlight the limitations and strengths.

Strengths:

- Attempt at quantification of bouncing and rolling distances from landing position to final resting spot which helps to better constrain/estimate hazard footprint and subsequently hazard zones
- Observations of spalling fragments from bombs and recognition that there may be multiple sites of ignition of fires from spallation bombs

Limitations:

- Only a few observations/videos of complete spallation bomb transport (ballistic and bouncing/rolling) which may not reflect average travel distances for both modes of transport for the whole deposit
- Definition of spallation bomb not clear in manuscript which may lead to incorrect identification and attribution from others in the future

#### **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.

See detailed report and annotated pdf for comments on methods, results and data interpretation

#### **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?

No.

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.

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

This study summarises observations of bombs erupted from La Palma (Canary Islands) in the October 2021 eruption episode. The authors observed bombs bouncing and rolling downslope, in some places > 1km from their original landing position where they were ballistically emplaced. These bombs spalled on impact with the slope leaving incandescent fragments behind. The authors propose a new type of bomb to describe this behaviour: spallation bomb. They highlight that the bouncing and rolling portion of transport is not typically considered in ballistic hazard and risk assessments and that this aspect of transport would increase the size of ballistic hazard zones.

These observations are invaluable in understanding ballistic hazard and being able to quantify the bouncing/rolling aspect of travel and area of spallation hazard. The findings here will help to improve estimates of ballistic hazard extent for volcanoes with steep slopes. The manuscript is generally well written though I do have some concerns which I have listed below, with minor and more detailed suggestions/comments annotated onto the manuscript pdf.

Larger concerns:

1) There is not a clear definition for the proposed new spallation bomb type. Many factors and characteristics are mentioned in the manuscript but it is unclear what is actually required to be considered a spallation bomb. The authors provide the definition of "We therefore suggest the term 'spallation bomb' for this bouncing and spalling ejecta, which is consistent with the requirement for relatively viscous lava to provide shape and with the observation of fragmentation or spalling during rolling and bouncing." However, different shapes/bomb roundness, substrate hardness/tephra cushioning, size, incandescence, slope, concentric texture, and formation of rolling tracks and bouncing craters are also mentioned as either aspects that differ from other bombs, observations from La Palma bombs, or controls on bomb formation. A lot of bomb types are named from their shape on impact or through the air, though largely controlled by transport mechanism or impact. Both variation in shape as well as transport mechanism are described in this manuscript. Can spallation bombs have the same transport mechanism but look different at the end (i.e. rounding, diameter, roughness etc) or do they need to look a certain way to know they have gone through the same transport process? Would a spindle bomb that bounces out of its crater downslope once and fragments through this transport be considered as a spallation bomb? Is bouncing/rolling and fragmenting just a phenomenon that can happen to any bomb while in transit down a slope?

2) The definition of spallation bomb comes quite late in the manuscript, only formally being introduced in the discussion despite it being mentioned many times in the text before. This adds to the confusion around the point above. This could be remedied by either moving the definition to the introduction/first mention or removing the term 'spallation bomb' until it is proposed in the discussion.

