Response to Reviewers #1

August 19, 2026

- Reviewer comment in black.
- Authors reply in red.
- Change in the manuscript in green.

1 Answer to referee

The referee writes This interesting work models the material involved in volcanic eruptions as resulting from the transport of magma blobs driven by the accretion of gas bubbles. The main point is that the distribution of blobs coalescing during diffusive dynamics matches the distribution of eruption sizes, which follows a power law with exponent 3/2. The text is clear and the proposed model is intriguing. The manuscript is an original addition to the literature with quantitative predictive power. I recommend its publication, provided that the main assumption of Brownian dynamics is discussed in more detail. Also some other points and logical passages should be made clearer.

Answer We thank the referee for appreciating our work. We hope that the new version of the manuscript represents a satisfactory answer to her/his questions.

The referee writes The crucial mechanism in the model is diffusion plus aggregation, but it is not clear what corresponds to white noise and Brownian dynamics at the macroscopic scale of erupted blobs.

Answer We thank the referee for enlightening the necessity of a better description of the mechanism leading to the diffusive process. In the new version of the manuscript we added a short paragraph on the inherent random forces leading to the random walk of the magma blobs.

The referee writes At line 232, the "Mapping of reduced units into physical ones" does not discuss the values of the diffusion constants in physical units. I think that the paper would benefit from a richer discussion of these points.

Answer Being the spatial scale $\approx 10^2$m and the time scale $\tau \approx 10^3$s, the diffusion coefficient $D \approx 10\text{m}^2{\cdot}\text{s}^{-1}$. We have reported this value in the new version of the manuscript.

The referee writes Moreover, it would be interesting to check whether a more deterministic form of convective dynamics (i.e. some stirring) plus aggregation still effectively reproduces the $V^{-3/2}$ scaling of volumes. This would make the mechanism more universal, and in fact it is mentioned as a modeled process at line 118.

Answer We thank the Referee for this interesting observation. The integration of our model with large scale convective motion in the magma chambers requires a lot of efforts and deserves to be published in a next paper. We are already at work for this generalization of the model.

The referee writes A second question concerns the empirical statistics of erupted magma volumes: is VOGRIPA a global catalogue collecting eruption statistics from many volcanoes? If so, is it a weighted average biased towards the statistics of the more active volcanoes, with an upper size that averages single-volcano distributions with different cutoffs? The data in Fig. 2 do not show a clear cutoff in the tail.

Answer The answer is yes to both the questions. It is clear that the use of a global catalogue causes an averaging process. However, the definition of a volume distribution for a single volcano is impossible due to the small number of data available. Concerning the cutoff: We agree with the referee that the cutoff is not too much clear. However the fit of the distribution is better using a Gamma like distribution as already enlightened by Papale and Marzocchi.

The referee writes In this context, what is a potentially erupted volume Ve? And how is it related to the blob of volume V from (11) to (12)?

Answer Relation (9) defines the time interval Δt necessary to have a blob of volume V_e and is used to express the Poissonian distribution of the intertimes between successive eruptions, in terms of a volume V_e of the possible eruption. Then the volume is erupted if we observe it in the magma chamber with a probability defined by relation (8). Finally, we get relation (11) simply multiplying the two probability densities. In the new version of the manuscript we added few sentences in order to better explain $V_e = V$.

The referee writes Section 2.2.1 on bubble formation is interesting, but the model then does not make much use of the detailed physical laws it describes, because it assumes a linear increase in buoyancy. As such, the section seems a bit detached from the main body of the paper.

Answer We agree with the referee the section 2.2.1 could be considered detached from the model. However, it has been introduced for the sake of completeness. A new sentence clarifies this aspect.

The referee writes Furthermore, (3) scales as ΔP^{-2}, hence it is not clear why the increase of ΔG with decreasing ΔP "makes easy the bubble formation even for small ΔP," as stated at line 83.

Answer This is because as ΔP decreases quadratically, ΔG increases due to the scaling ΔP^{-2}.

The referee writes Another doubt concerns (7), termed the minimum radius for trapped bubbles: is it instead a maximum?

Answer We thank the referee for enlightening our mistake. It is the maximum. We changed the manuscript accordingly.

The referee writes At line 19, "new bubbles are generated due to Eq. (3)" sounds a bit too much like a shortcut.

Answer We added a sentence in the revised version of the manuscript to better illustrate our argument.

The referee writes The last question is why assuming a very large viscosity of the magma allows the force due to gravity to be neglected. Both the gravitational force (18) and the buoyancy force (19) are divided by the viscous coefficient.

Answer We agree with the referee. Both gravity and buoyancy become negligible when the viscosity assumes high values. In fact, the only forces acting on our blobs are the one due to the bubble and the Brownian one. In the new version of the manuscript we added some sentences better enlightening this aspect.

The referee writes Finally, in the abstract, I would suggest associating the word "coalescence" more explicitly with the quantity it refers to.

Answer Following the Referee suggestion, in the revised version of the manuscript we added a sentence in the abstract.