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### Reply [to "Comment on "Dynamics and energetics of bubble growth in magmas: Analytical formulation and numerical modeling" by A. A. Proussevitch and D. L. Sahagian"]

Dork L. Sahagian  
*Lehigh University*

Alexander A. Prusevich  
*University of New Hampshire, Durham, alex.proussevitch@unh.edu*

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## Reply

D. Sahagian and A. Proussevitch

Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham

The authors would like to begin by expressing sincere gratitude to Flavio Dobran for his most comprehensive and detailed review of our paper [Proussevitch and Sahagian, 1998]. It is seldom that a reviewer succeeds in following every detail of a complex formulation and identifying inconsistencies or other errors. In the case of this paper, we agreed with many of his suggestions, each of which led to an improvement or clarification in the paper before it was published. There were two issues, mentioned in his comment [Dobran, this issue], which unfortunately leaked through the process. Both were caused by missing symbols in the notation of the internal formulation in Appendix A. Fortunately, neither type of missing printed symbol led to any carry through or error in the formulation itself.

The first missing symbol is a  $\partial$  in equations (A1), (B5), (B6b), (B12c), and (B12e) as is pointed out by Dobran [this issue], but it is also missing elsewhere (equations (B2a), (B4), and (B7)). It showed on the monitor, but the printer failed to print it (and we all failed to notice until Dobran pointed it out in his comment). However, this first missing symbol is relatively obvious, so it should not terribly confuse the reader.

The second missing symbol is much more subtle and leads to a misleading notation inconsistency between equations (A3)-(A5) and equation (A6). The missing symbol is an apostrophe on the total stress tensor  $\tau'$  in equation (A6). This must not be confused with the viscous stress  $\tau$  in equations (A3)-(A5). Because of this missing apostrophe, one is led to believe that equation (A6) referred to the viscous stress rather than to the total stress, in which case, Dobran [this issue] is quite correct in insisting that the  $-p$  term should be removed. However, equation (A6) involves the total stress, which must include the  $-p$  term. We did not make this sufficiently clear, and indeed, with the missing apostrophe, misunderstanding is not surprising. In his thorough and accurate way, Dobran found a way to alter our formulation to make it correct in his comment, on the assumption that we were concerned with viscous stress in equation (A6). In his comment, Dobran uses  $\sigma$  for stress, but in the paper,  $\sigma$  was already used for surface tension [see Proussevitch and Sahagian,

1998, Table A1]. The discussion in Appendix A should have read as follows:

In this case the total stress tensor ( $\tau'$ ) for a Newtonian incompressible liquid is [Landau and Lifshitz, 1987]

$$\tau'_{rr} = -p + 2\eta \frac{\partial v_r}{\partial r} \quad (\text{A6a})$$

$$\tau'_{\theta\theta} = \tau'_{\phi\phi} = -p + 2\eta \frac{v_r}{r} \quad (\text{A6b})$$

In addition to the missing symbols noted by Dobran [this issue], there is a missing  $\hat{D}$  in equations (B12b) and (B12c). Fortunately, these printer errors only occurred in the printed hard copy. The analytical and numerical formulation, as well as the computer codes used in the analysis, was based on the correct notation, as were all of the results discussed in the paper.

The authors are very grateful to Dobran for his insightful and conscientious reviews, and hope that future publications will benefit from his detailed analyses.

## References

- Dobran, F., Comment on "Dynamics and energetics of bubble growth in magmas: Analytical formulation and numerical modeling" by A. A. Proussevitch and D. L. Sahagian, *J. Geophys. Res.*, this issue.
- Landau, L. D., and E. M. Lifshitz, *Fluid Mechanics*, Pergamon, Tarrytown, N. Y., 1987.
- Proussevitch, A. A., and D. L. Sahagian, Dynamics and energetics of bubble growth in magmas: Analytical formulation and numerical modeling, *J. Geophys. Res.*, 103, 18,223-18,251, 1998.

A. A. Proussevitch and D. L. Sahagian, Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, NH 03824-3525. (E-mail: dork.sahagian@unh.edu; alex.proussevitch@unh.edu)

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