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Numerical modeling of bubble coalescence in basaltic magma flow

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Although basaltic volcanism is usually described as effusive, the presence of dissolved gas in the magma can lead to explosive activity. The mechanism of these explosive basaltic eruptions is contentious. Two competing theories are currently in usage, the Rise-Speed-Dependent model (RSD) and the Collapsing-Foam model (CF). The key difference between these two models is related to where and when the gas accumulation occurs within the magmatic system. The RSD model assumes that it is possible for magma bubbles to coalesce during ascent, provided that the rise speed of the magma is sufficiently low. The CF model challenges that assumption and instead suggests that the gas bubbles accumulate at structural heterogeneities at depth, where they form a growing foam layer which ultimately collapses. Therefore, the validity of the two models critically hinges upon a more detailed understanding of the conditions under which coalescence of magma bubbles can occur in magmatic flow. This paper addresses this important question by simulating bubble coalescence during magma ascent numerically. The numeric approach combines a Navier-Stokes solver based on the projection method on a staggered grid with a levelset solver for tracking the interface. Additionally, we make use of the Ghost Fluid Method to model the gas-magma interface as a perfectly sharp discontinuity in material properties.