Vibrations, liquefaction, and immiscible break-up: a new model for peperite formation

W.D Downey and C.S. Shaw

Department of Earth Sciences, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick E3B 5A3, Canada

<warna.downey@unb.ca>

Peperite is a genetic term for a rock formed by the disruption of magma intruding into and mingling with unconsolidated or poorly consolidated, typically wet sediments. The current models of peperite formation (magma mingling and breakup driven by sediment fluidization and explosive fuel coolant reactions) do not explain the wide variety of features seen in rocks with peperitic textures. In addition, the peperitic textures catalogued by over 90 authors do not show any evidence of fine-scale break up, as would be expected if mingling and explosive fuel coolant reactions were driving the process. The inherent space problem associated with moderate- to large-scale fluidization can also not be addressed using the current models.

To gain a thorough understanding of peperite formation, sediment liquefaction, heat flow and boiling at the sediment interface, and the fluid dynamic breakup of viscous liquids have been examined. It is the combination of these factors working together that drive the formation of peperites and control the textures observed in the rock record. It is well known that unconsolidated sediments, especially nonplastic ones, respond to high frequency oscillations. The vibrational forces provided by vapour film perturbations and oscillations during magmatic intrusion into wet sediments leads to an increase in the pore pressure of trapped water causing the effective stress to decrease to the point where it vanishes, and all of the weight bearing capacity of the sediments is lost. When this occurs, the insulated magma is capable of deforming under the same principles that produce load, resulting in a situation where the dense magma will sink below the less dense liquefied sediments. This can be modeled by numerical simulations of immiscible fluid breakup using OpenFOAM.

A new model is proposed to explain the formation of peperitic textures — the vibrational-liquefaction model. This model accounts for the effect that the vibrational energy of the vapour film oscillation and collapse has on transmitting mechanical energy to the surrounding sediments, inevitably leading to liquefaction, providing the magma with the space needed to behave in a ductile or brittle fashion, producing peperite without the need of moving large volumes of sediment out of the immediate surrounding area.

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