A laboratory model for melting erosion of a magma chamber roof and the generation of a rhythmic layering

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A hot magma chamber can ascend by melting the roof rock, a process which in turn affects the magma composition. The disaggregated mineral particles which consisted the roof rock will descend in the magma chamber to form a sedimentary cumulate. However the fluid dynamics leading to the formation of the sediment, and how we can decipher them is unknown. Here we extend the work by Shibano et al (2012) and conducted a series of experiments modeling melting erosion of the roof with particle size consisting the roof rock as the parameter. We find that there is a critical particle size below which the melting erosion occurs cyclically. Melting erosion stops because the disaggregated particles are suspended in the magma chamber, and suppress the vertical heat transfer. The suspension then separates into an upper clear layer and a lower suspension layer. Eventually, the heated stratified layers become unstable. An overturn occurs, and melting erosion resumes. When the particles consist of 2 sizes such that at least one of them is smaller than the critical size, a cyclic erosion occurs. Particles are sorted during each melting cycle, and a size-graded rhythmic layering is spontaneously generated. We estimate that rhythmic layering can be generated from melting erosion in a basaltic magma chamber when the grain size of the roof rock is <0.6 mm, assuming a vertical temperature difference of 10 ℃. We suggest that cyclic roof melting coupled with particle settling is one possible mechanism for generating the rhythmic layering which is commonly observed in solidified magma chambers.

Reference:

Shibano, Y., Namiki, A., Sumita, I., 2012, Experiments on upward migration of a liquid-rich layer in a granular medium : Implications for a crystalline magma chamber, G-Cubed, Q03007: doi:10.1029/2011GC003994.