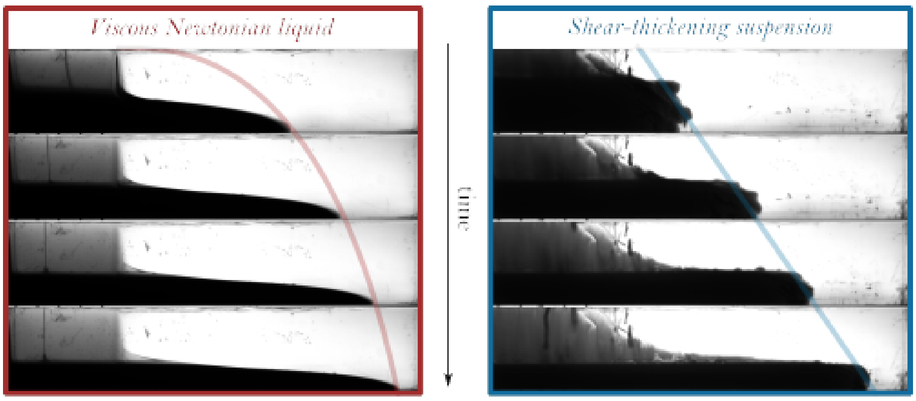
EGU24-1455, updated on 18 Jan 2025
https://doi.org/10.5194/egusphere-egu24-1455
EGU General Assembly 2024

Dam-break of shear-thickening suspensions: A new perspective for crystal-rich lava flows and lahars -

Alexis Bougouin, Henri Lhuissier, Yoel Forterre, and Bloen Metzger
IUSTI, France (alexis.bougouin@univ-amu.fr)

The physical mechanism governing the peculiar behavior of discontinuous shear-thickening suspensions, i.e. a change from liquid-like to solid-like state with increasing applied stress, has recently been described as a frictional transition occuring at the grain scale above a critical shear stress [1, 2, 3]. This understanding offers a new view for describing complex grain-fluid flows, and especially crystal-rich lava flows, which can shear-thicken [4], or lahars, whose heterogeneities affect local friction [5].

In this context, we performed macroscopic and local measurements to characterize dam-break laboratory experiments of model shear-thickening suspensions, for which the volume and the solid fraction of the suspension are varied. Below a critical stress related to the gravitational pressure gradient, the suspension flow is close to that of a viscous Newtonian liquid, i.e. strongly decelerating and with a thickness decreasing progressively from the release side to the spreading front [6]. By contrast, above this critical stress, the front velocity becomes constant, i.e. independent of flow height, and the layer thickness is close to be uniform (Figure 1). We interpret this remarquable behavior by the formation of a highly-dissipative (shear-thickened) flow structure at the front, which keeps the suspension upstream essentially stress-free with a low (frictionless) viscosity. We model the front and provide scaling laws for its velocity in good agreement with experimental observations. These results offer a new perspective for the interpretation and modeling of heavily particle-laden geophysical flows, such as crystal-rich lava flows and lahars, which could also be essentially controlled by their highly-dissipative front.



1. M. Wyart and M. Cates (2014). Discontinuous shear thickening without inertia in dense non-Brownian suspensions. Phys. Rev. Lett., 112:098302, 2014.

2. R. Mari, R. Seto, J. Morris, and M. Denn (2014). Shear thickening, frictionless and frictional rheologies in non-Brownian suspensions. J. Rheol., 58:1693–1724, 2014.

3. C. Clavaud, A. Bérut, B. Metzger, and Y. Forterre (2017). Revealing the frictional transition in shear-thickening suspensions. Proc. Natl. Acad. Sci., 114:5147–52, 2017.

4. J. V. Smith (1997). Shear thickening dilatancy in crystal-rich flows. J. Volcanol. Geotherm. Res., 79:1-8.

5. C. Ancey (2007). Plasticity and geophysical flows : A review. J. Non-Newton. Fluid Mech., 142:4-35.

6. H. E. Huppert (1982). The propagation of two-dimensional and axisymmetric viscous gravity currents over a rigid horizontal surface. J. Fluid Mech., 121:43-58.