Magma rheology – moving forwards

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Magma is one of the most physically complex materials in the natural world. As a parent silicate melt moves through the magmatic and volcanic system, it decomposes into a multiphase mixture of crystals, bubbles, and liquid. The proportions and properties of the phases undergo dramatic changes in response to changes in pressure, temperature, strain, and with the passage of time. Consequently, the rheology of magma and lava is both complex and dynamic. Understanding and quantifying this rheology is, nonetheless, essential for all aspects of physical volcanology, since rheology dictates the response of magma and lava to the stresses that drive it through the crust and over the ground.

Decades of research into multiphase rheology – much of it driven by the volcanological community – has brought us to the point where rheological models that are general, theoretically-grounded, and experimentally-validated are available only for two-phase systems of low to intermediate suspended fraction. Whilst considerable progress has been made towards understanding and characterising more complex systems, there is much work left to do.

In this contribution, I will explore recent and ongoing work at the frontier of the discipline, addressing three-phase systems, highly-concentrated systems, and systems that are out of equilibrium. I will consider the role that emerging experimental and numerical technologies are playing in pushing the frontier. Finally, I will offer a personal view of the disciplinary priorities for the new decade, as we work towards a more complete and general understanding of the rheology of magma in its natural complexity.