Experiments, Numerical moDelling and field observations of basaltic maGmA fragMEntation (ENDGAME)

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Horizon 2020

Introduction

For low viscosity magmas such as basalts, rapid and unpredictable transitions between effusive and explosive activity may occur. These transitions dramatically alter the impact of an eruption and pose a real challenge to policymakers tasked with mitigating the risks associated with basaltic eruptions. Mechanisms controlling these transitions, however, are not well understood, mainly due to the lack of a clear understanding of basaltic magma fragmentation.

What parameters control transitions in eruptive style at basaltic volcanoes?

Images from Thivet et al., Geochem. Geophy. Geosy. 2020

Transitions in eruptive style are strongly affected by whether magma is able to fragment during ascent or not

For basalts there is NOT a clear understanding of all the parameters affecting magma fragmentation

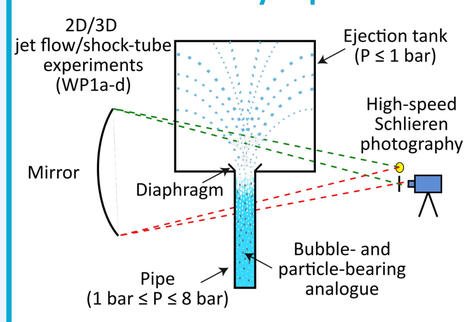
ENDGAME project

The ***new Marie Skłodowska-Curie Individual Fellowships ENDGAME*** (started on 09/2022) aims to ***investigate transitions in eruptive styles*** at basaltic volcanoes by **studying fragmentation of basaltic magmas** through a combination of ***targeted cutting-edge fluid dynamics experiments, new holistic numerical modelling of magma ascent and brand new field observations collected during a basaltic eruption.***

Objectives

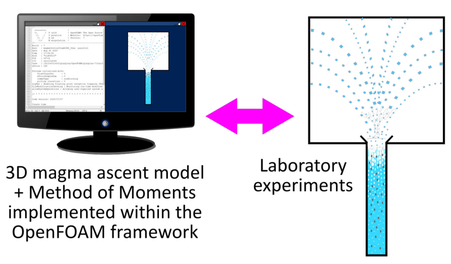
1) Define new constitutive equations for basaltic magma fragmentation by implementing and performing ***2D/3D jet flow and shock-tube experiments*** with a bubble- and particle-bearing analogue material in combination with ***high-speed Schlieren shadow photography***;

WP1: Laboratory experiments



Obj1. Definition of new empirically-constrained constitutive equations for basaltic magma fragmentation

WP2: Numerical modelling



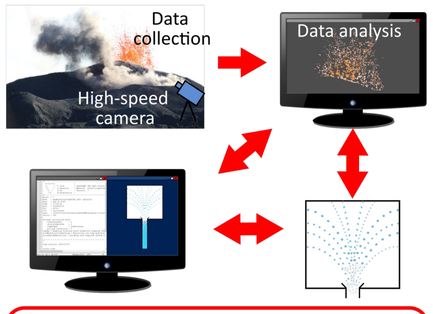
Obj2. Extension of the 3D magma ascent model to consider the evolution of particle size distribution through time

Obj3. Implementation (and validation) of the new constitutive equations into the 3D ascent model

2) Extend a ***3D transient model of magma ascent*** (developed within DisEqm project) to model ***the evolution of the particle-size distribution*** resulting from fragmentation through time by using a numerical technique which has been recently applied in volcanology, the ***"Method of Moments"***;

3) Use the new 3D magma ascent model to investigate the transitions in eruptive style by ***comparing numerical results with laboratory experiments and field observations*** that will be collected during an eruption at an active volcano (such as Piton de la Fournaise, Kilauea, or Etna).

WP3: Field observations

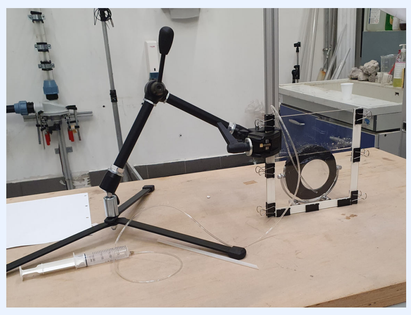


Obj4. Application of the new 3D ascent model to a case-study volcanic eruption, comparing numerical results and laboratory experiments with data collected during a field campaign

Preliminary setup

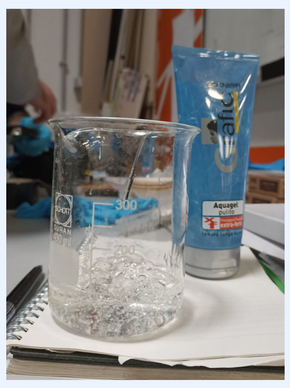
To have preliminary insights on how to design the new 2D apparatus and on the setup of the Schlieren shadow-photography with high speed cameras we performed some preliminary tests:

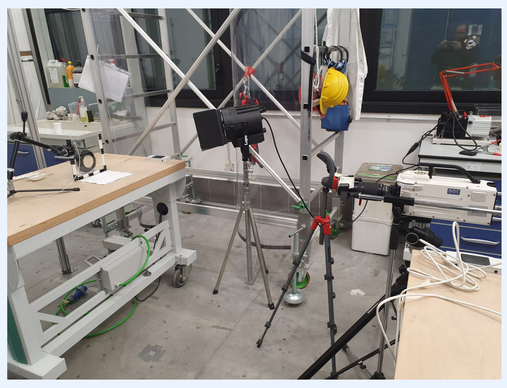
1) We created a 2D setup using either **2 parallel glass sheets (3 mm thickness)** or **2 parallel Plexiglas sheets (10 mm thickness)** separated by rubber seals and filled with a viscous liquid. The liquid was obtained **mixing hair gel and distilled water** with different proportions.



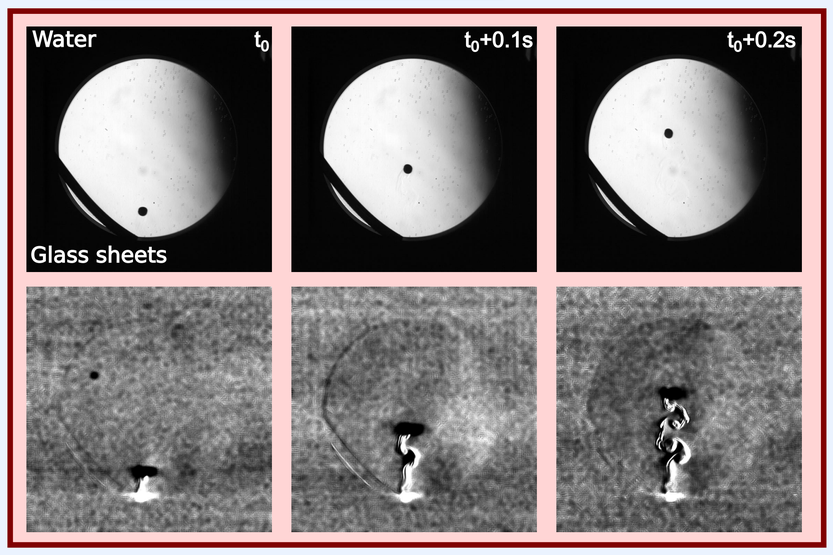
2) We used a **small spherical mirror (7.5 cm diameter, 75 cm focal length)** and a **high speed camera**.

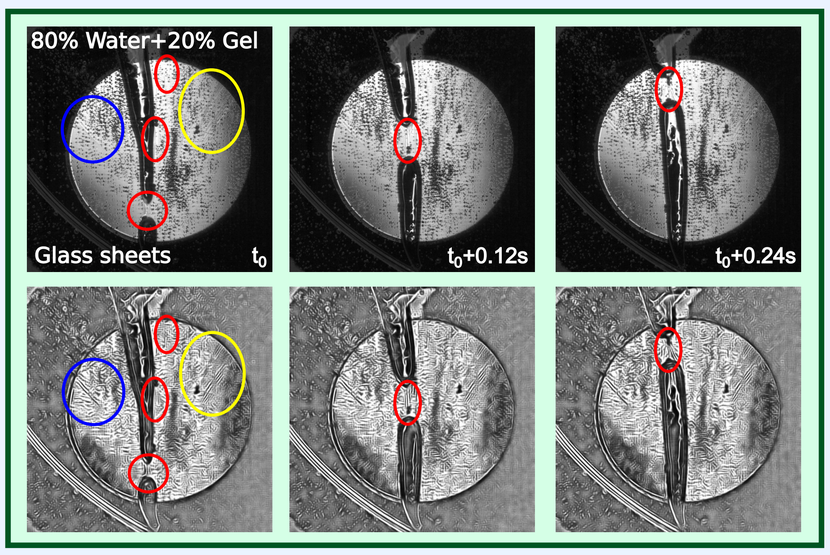
3) Air was injected into the 2D setup through a **capillary tube connected either to a syringe** or to a **continuous gas supply and a flowmeter** to control the air flow.

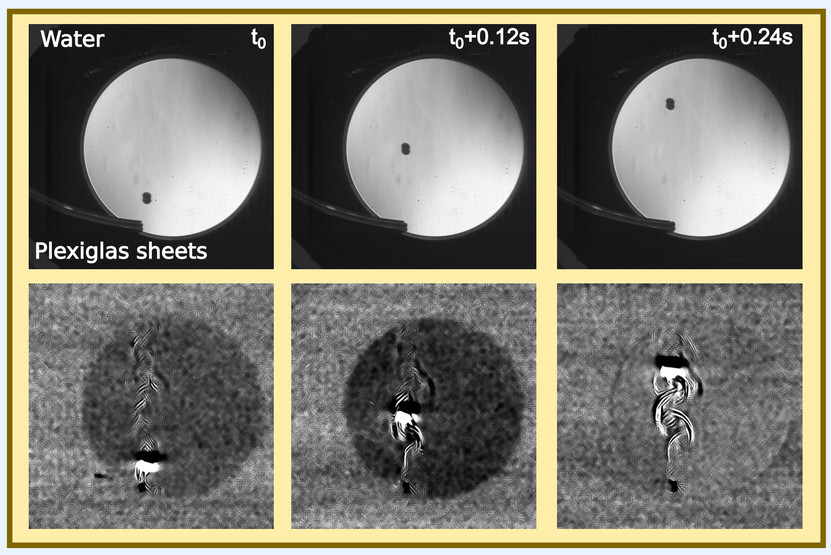


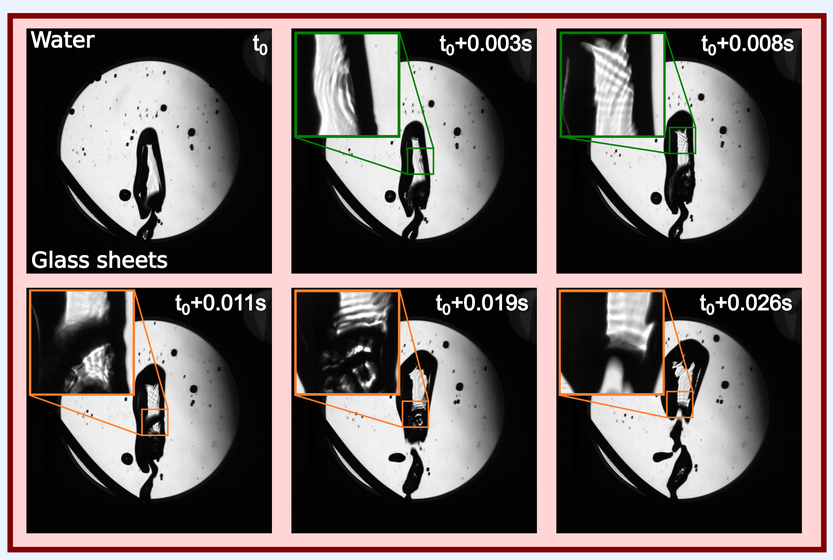


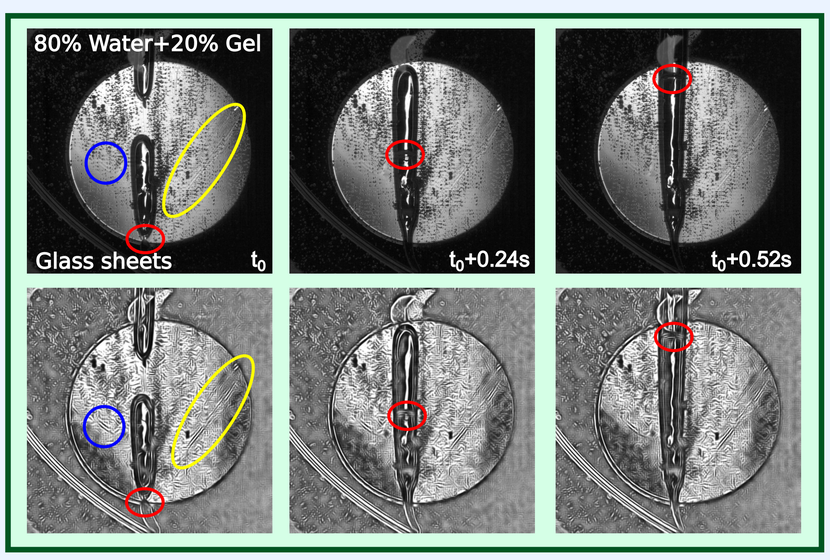
Preliminary results











Take home messages

We can see **density perturbations** within water and a viscous liquid, so our setup is working, also using 10 mm Plexiglas sheets.

We can see **shock waves within large bubbles when coalescence is occurring**, likely due to the rupture of the bubble wall.

Are density perturbations affecting the trajectories of the rising bubbles, **creating preferential patways during ascent?**