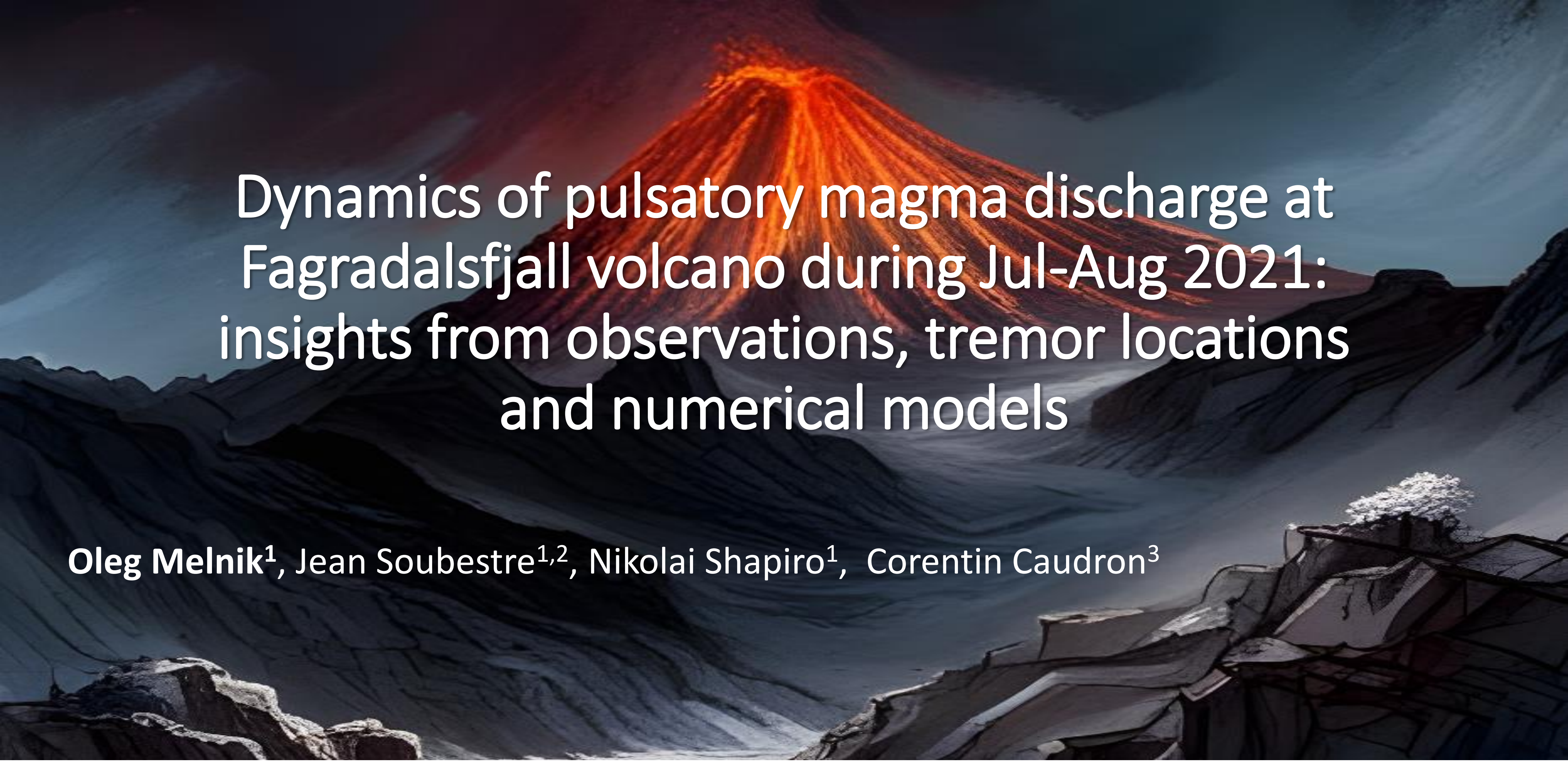


Dynamics of pulsatory magma discharge at Fagradalsfjall volcano during Jul-Aug 2021: insights from observations, tremor locations and numerical models

Oleg Melnik[1], Jean Soubestre[1,2], Nikolai Shapiro[1], Corentin Caudron[3]

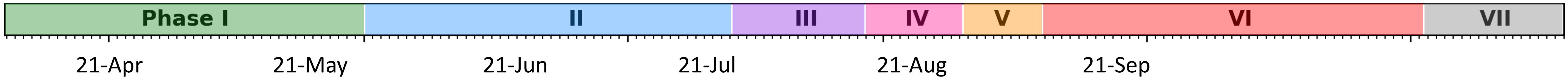
Icelandic Met Office

UGA Université Grenoble Alpes

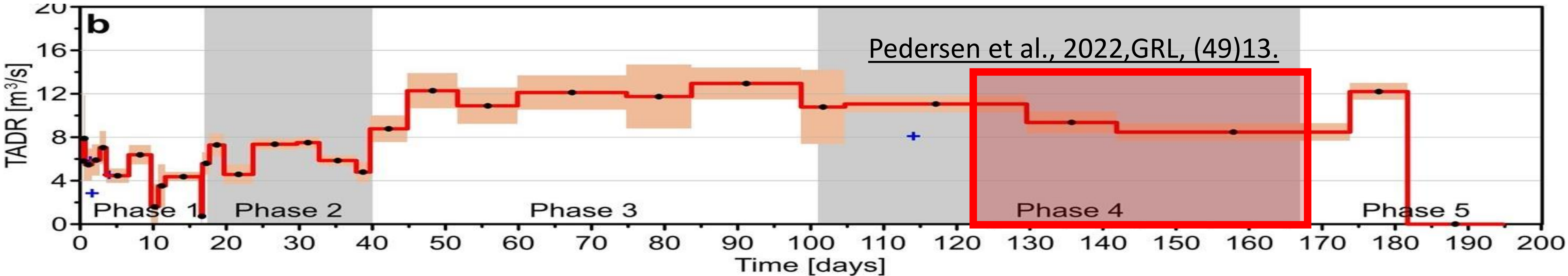
ISTerre

ULB

1 : Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, ISTerre, Grenoble, France
2 Icelandic Meteorological Office, Reykjavik, Iceland
3 Université Libre de Bruxelles, Brussels, Belgium

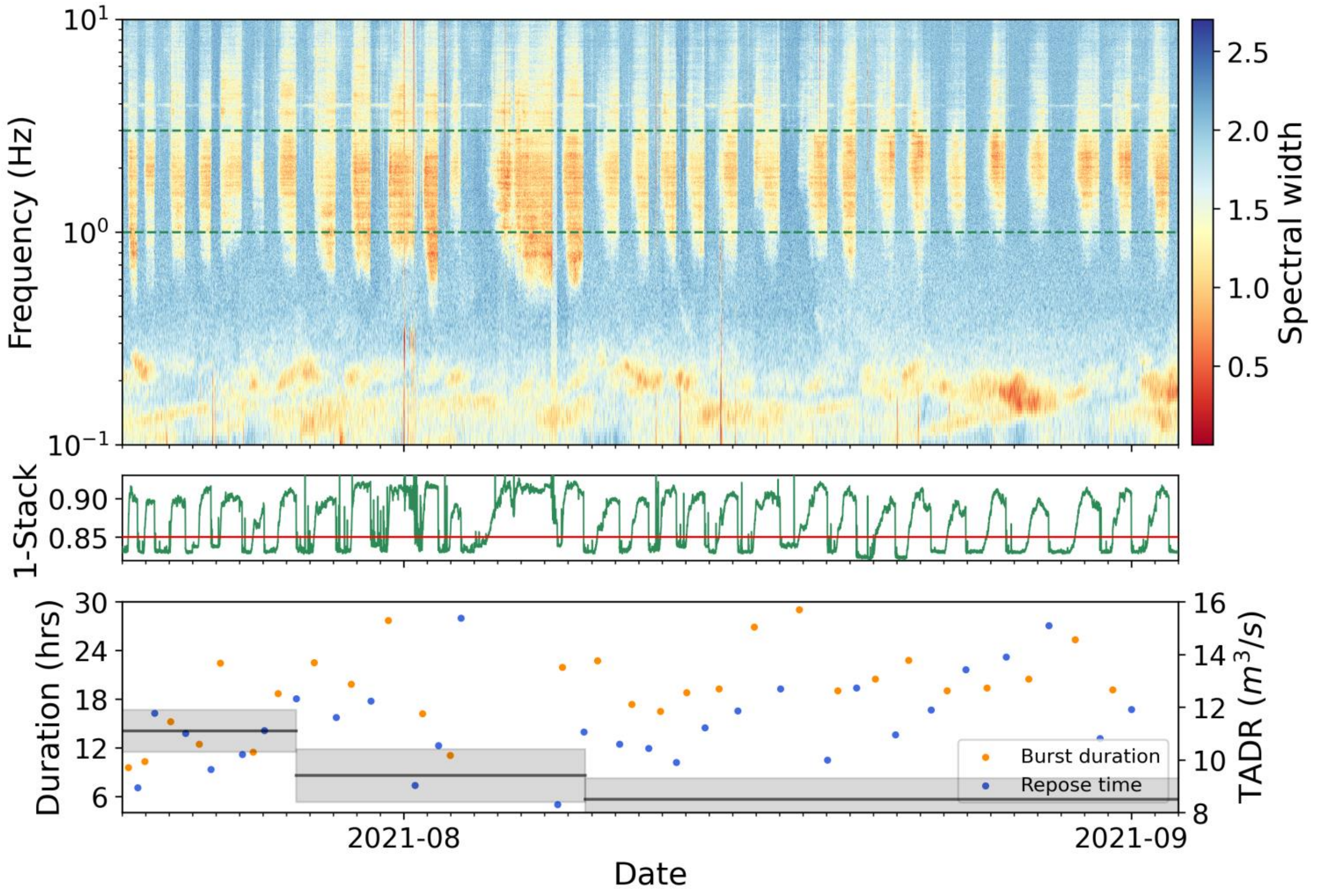


Tremor phase	Date	Tremor type	**Eruptive activity** [Barsotti et al., in review] **with Phases 1-2-3-4 from TADR** [Pederson et al., 2022]
I	Mar 19 – May 1	**Continuous**	**1** : Effusive from main fissure, **2-a** : Effusive from up to 8 fissures (vent openings), **2-b** : Effusive from up to 8 fissures, **3-a** : Lava fountains from vent #5
II	May 1 – Jun 13	**Minute-long pulses**	**3-b** : **Pulsating lava fountains** from vent #5 **3-c** : Occasional lava fountains + effusive from vent #5
III	Jun 13 – Jun 28	**Continuous**	,,
IV	Jun 28 – Jul 10	**Hour-long episodes**	**4-a** : **Episodic activity** at vent #5 with long pause intervals (hrs to days)
V	Jul 10 – Jul 19	**Minute-long pulses**	,,
VI	Jul 19 – Sep 2	**Hour-long episodes**	,,
VII	Sep 2 – Sep 18	**No tremor + Minute-long**	**4-b** : One week-long repose followed by one week-long activity



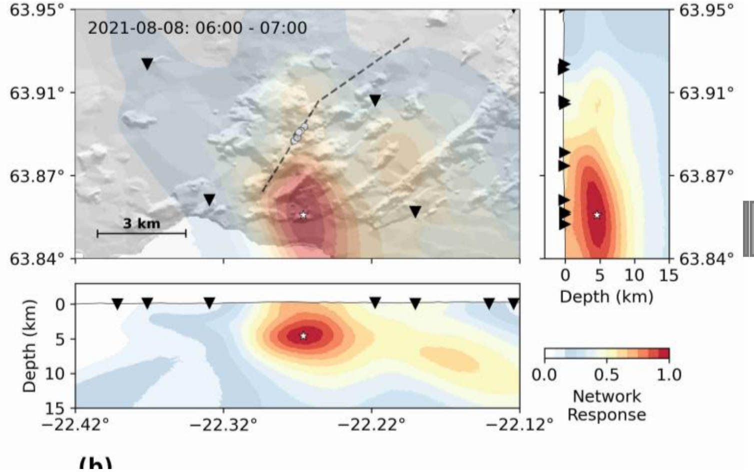
Intermittent tremor and activity

- ✓ Jul-Aug episode is characterized by the intermittent activity.
- ✓ During no lava extrusion the tremor is not detectable.
- ✓ Its amplitude increases when the lava starts to fill the crater.
- ✓ Intense tremor corresponds to lava flows from the crater rim.
- ✓ Tremor abruptly stops et the end of the cycle.

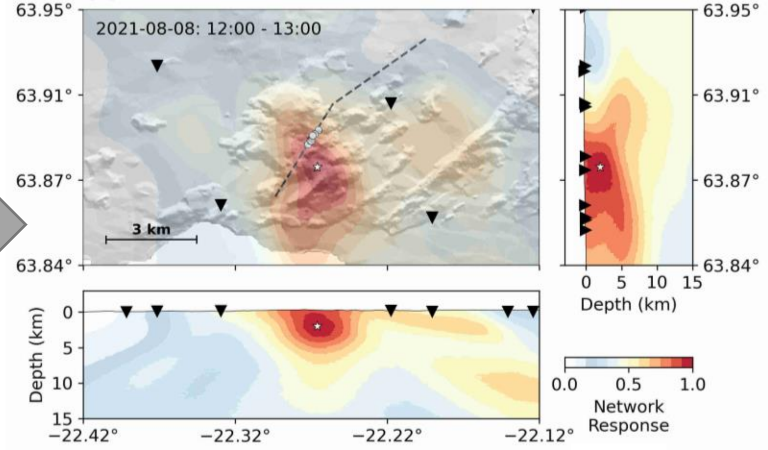


Observations: 2 tremor sources and migration

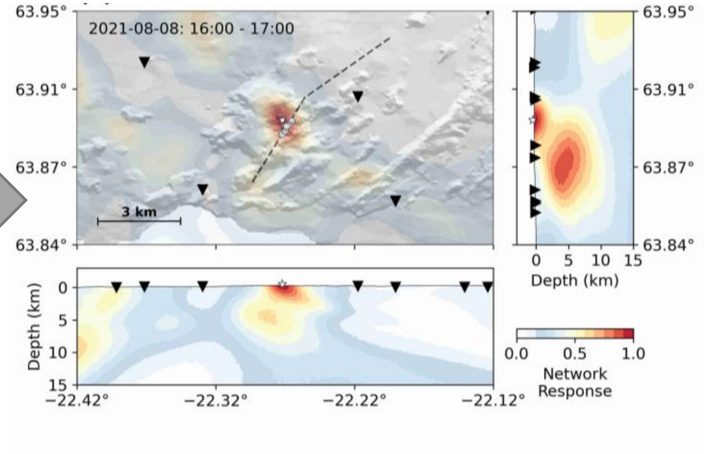
Mostly deep

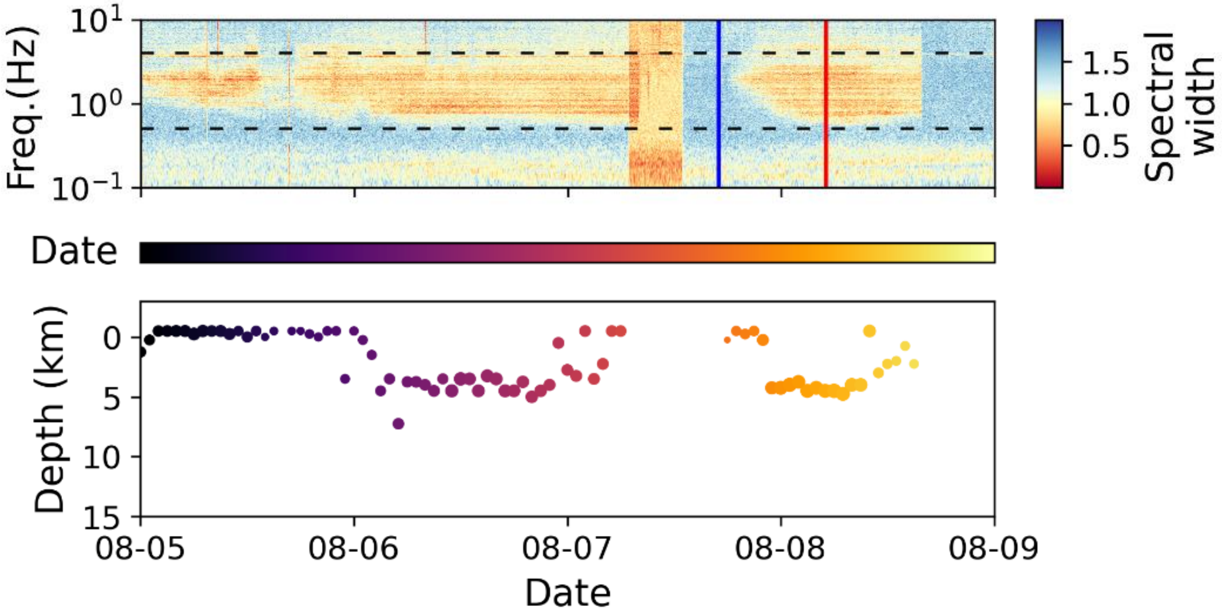


Both sources



Mostly shallow

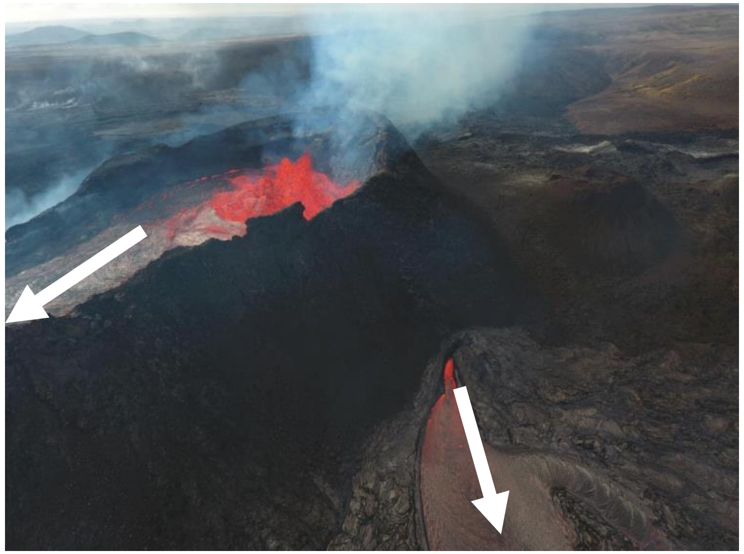


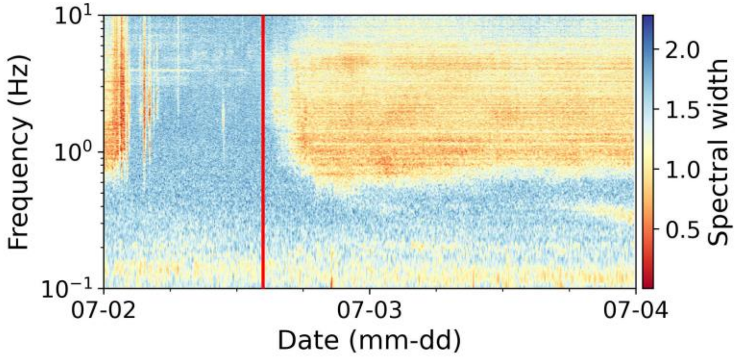


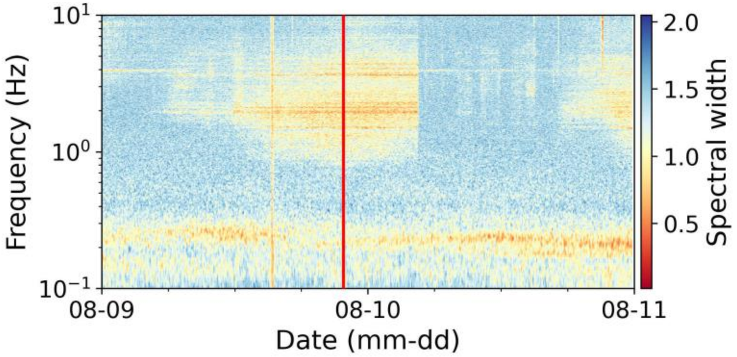
Two tremor sources are detected during active phases of the cycle: deep (~5 km) and shallow at the surface.

Seismic activity migrates within the system

Observations: start of the cycle, main eruption, side conduit.



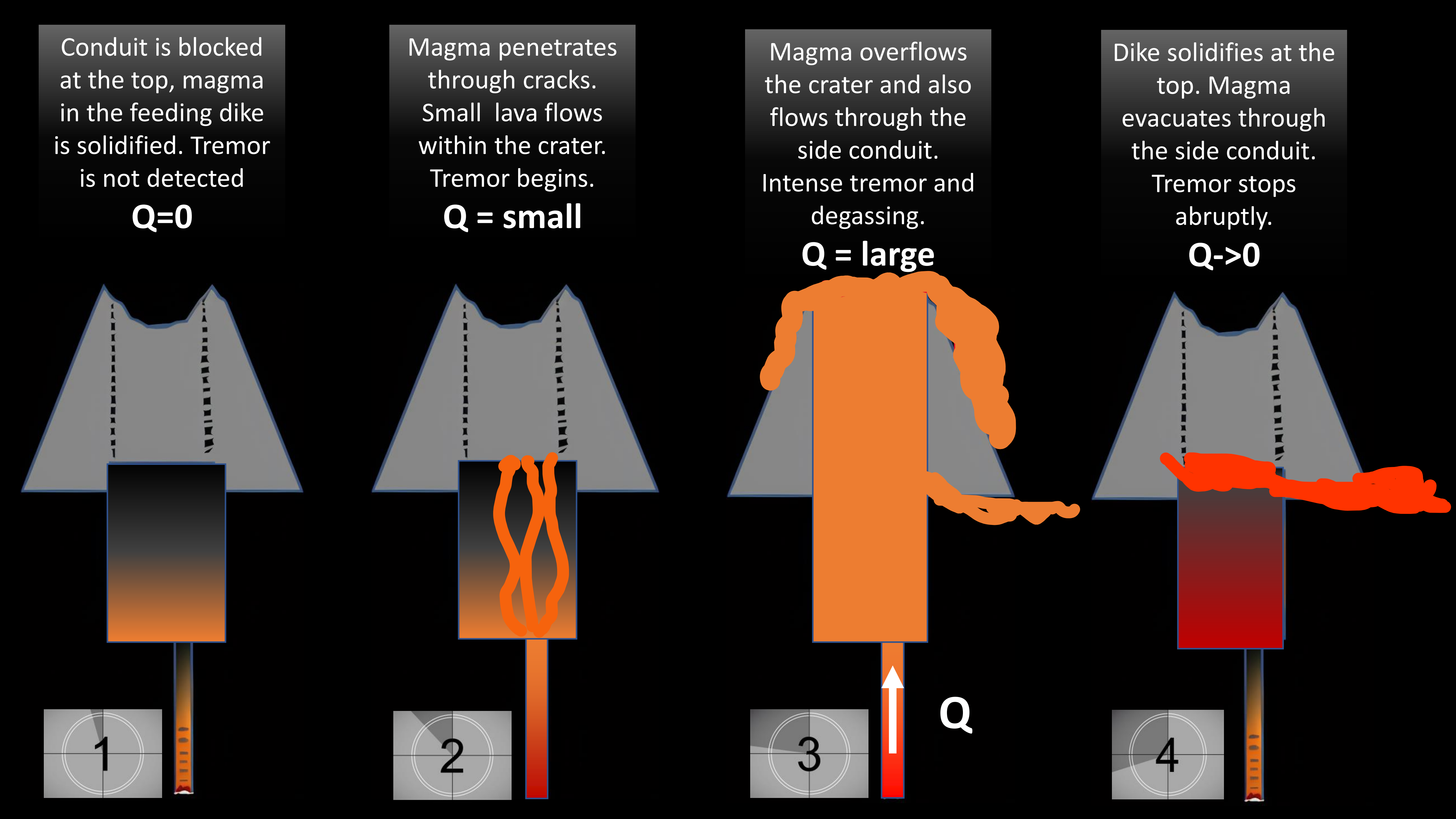




Lava comes out from the top of the crater and from the side conduit.

Photo sent to IMO monitoring room

Drone videos from the Volcanology and Natural Hazards Research Group, University of Iceland


Conduit is blocked at the top, magma in the feeding dike is solidified. Tremor is not detected
Q=0
Magma penetrates through cracks. Small lava flows within the crater. Tremor begins.
Q = small
Magma overflows the crater and also flows through the side conduit. Intense tremor and degassing.
Q = large
Dike solidifies at the top. Magma evacuates through the side conduit. Tremor stops abruptly.
Q->0
1
2
3
Q
4

Mathematical model

$$(1)\ \frac{\partial S}{\partial t}+\frac{\partial Q}{\partial z}=0;\ S=\pi a_0 b;$$

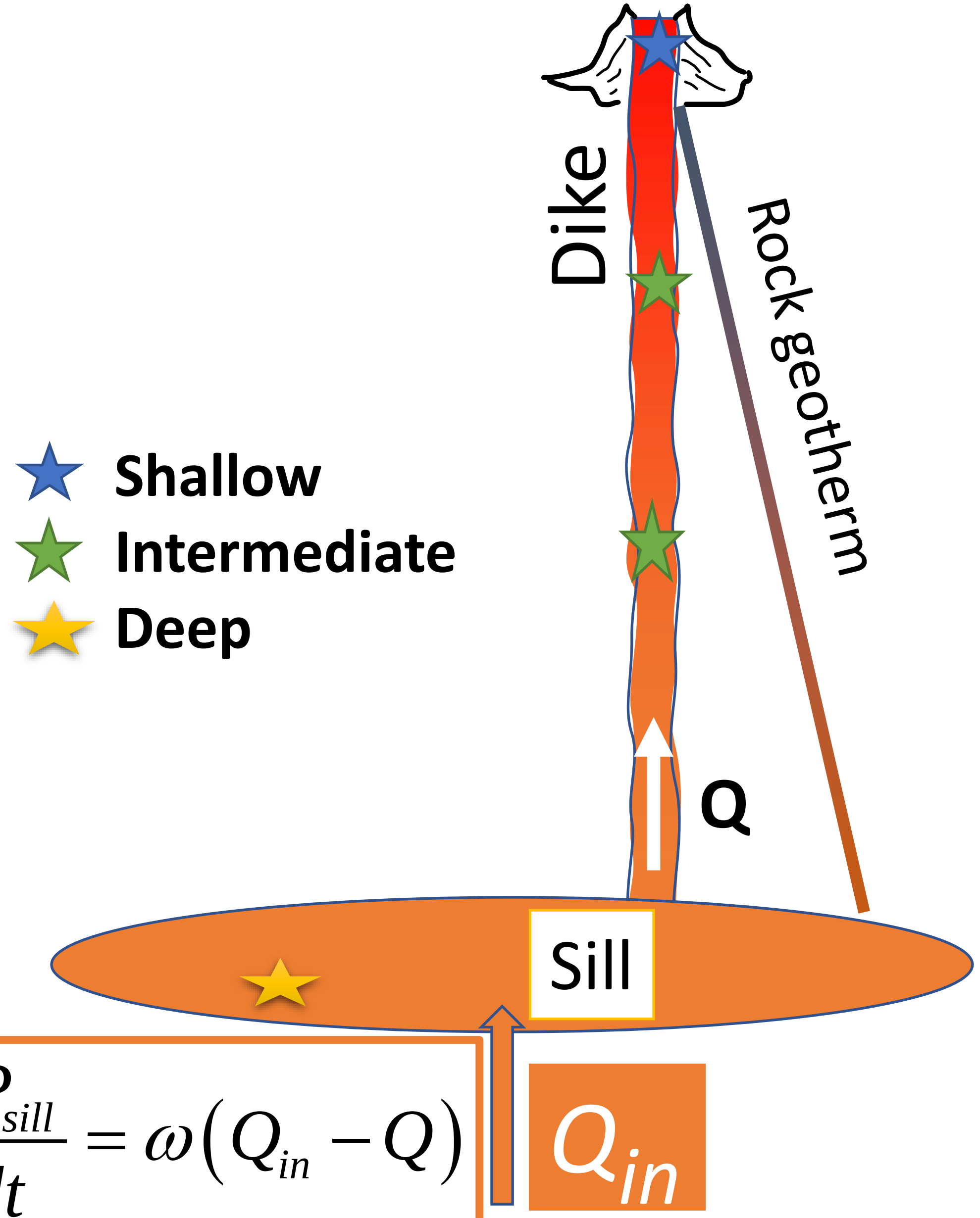
$$(2)\ Q=-\frac{\pi a_0 b^3}{4\mu(T)}\left(\frac{\partial P}{\partial z}+\rho_m g\right);$$

$$(3)\ \rho_m C\left(\frac{\partial ST}{\partial t}+\frac{\partial QT}{\partial z}\right)=-\Pi h\left(T_r-T\right);$$

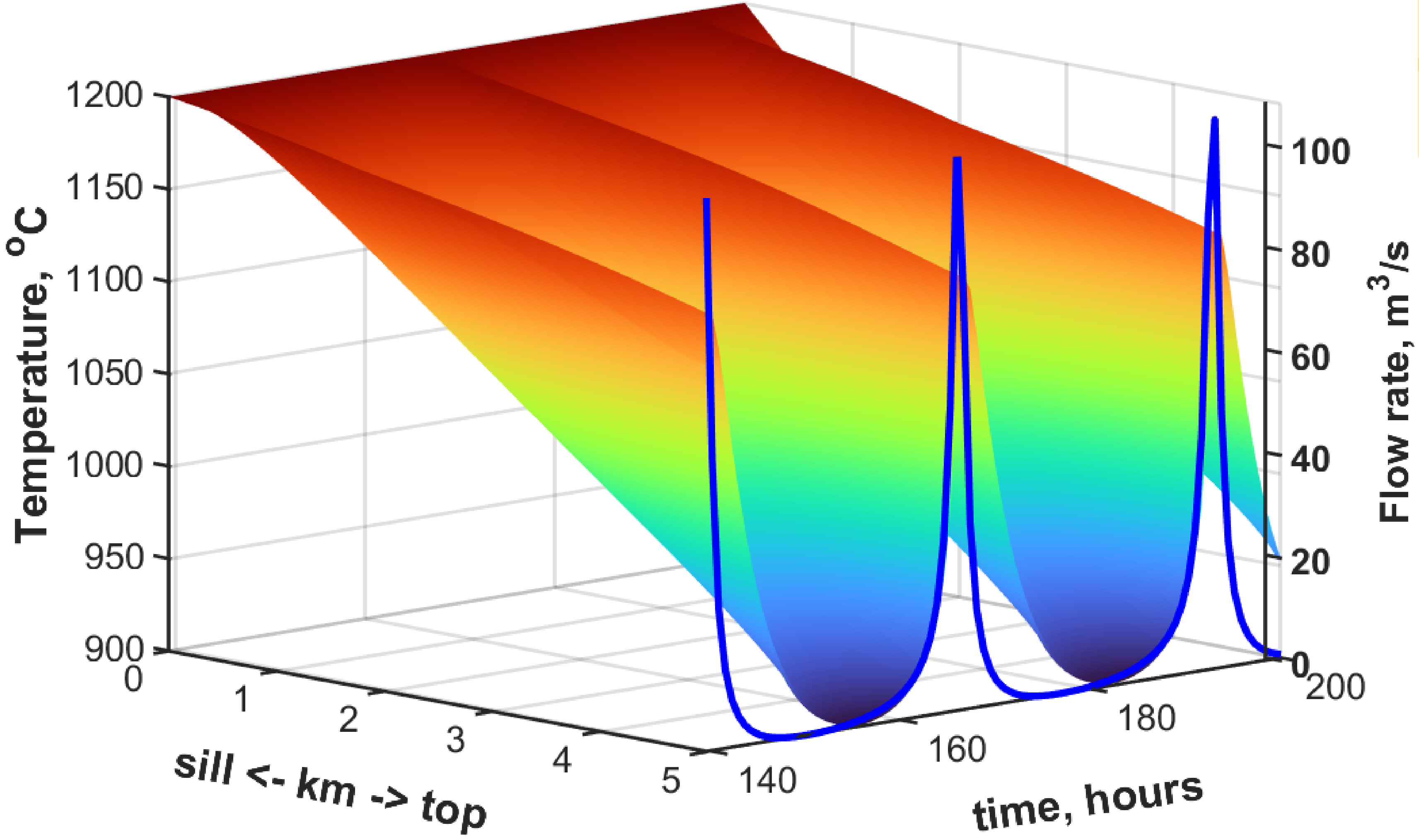
$$\log_{10}\mu=A+\frac{B}{T-T_*};b=\frac{a_0(1-\nu)}{G}\left(P-P_L\right).$$

(1) – Mass conservation for magma in the dike
(2) – Momentum equation
(3) – Energy equation.

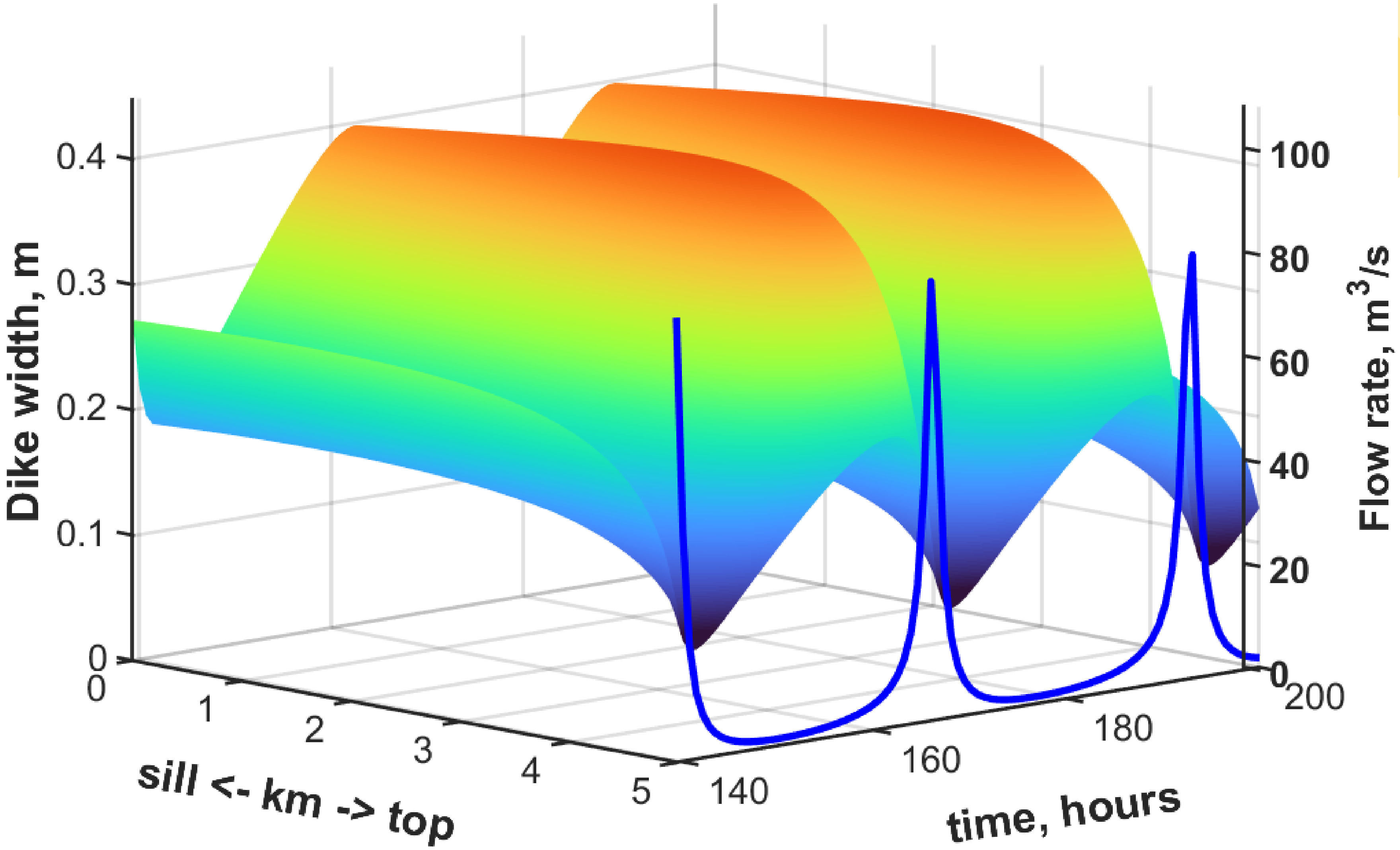
S – cross-section area of the dike, a and b – semi-axis, Q – flow rate, P – pressure (L – lithostatic), ρ – density of magma, C - heat capacity, Π – dike perimeter, h – heat conduction coefficient, ν and G - Poisson ratio and shear modulus, μ – magma viscosity.



$$\frac{dP_{sill}}{dt}=\omega\left(Q_{in}-Q\right)$$

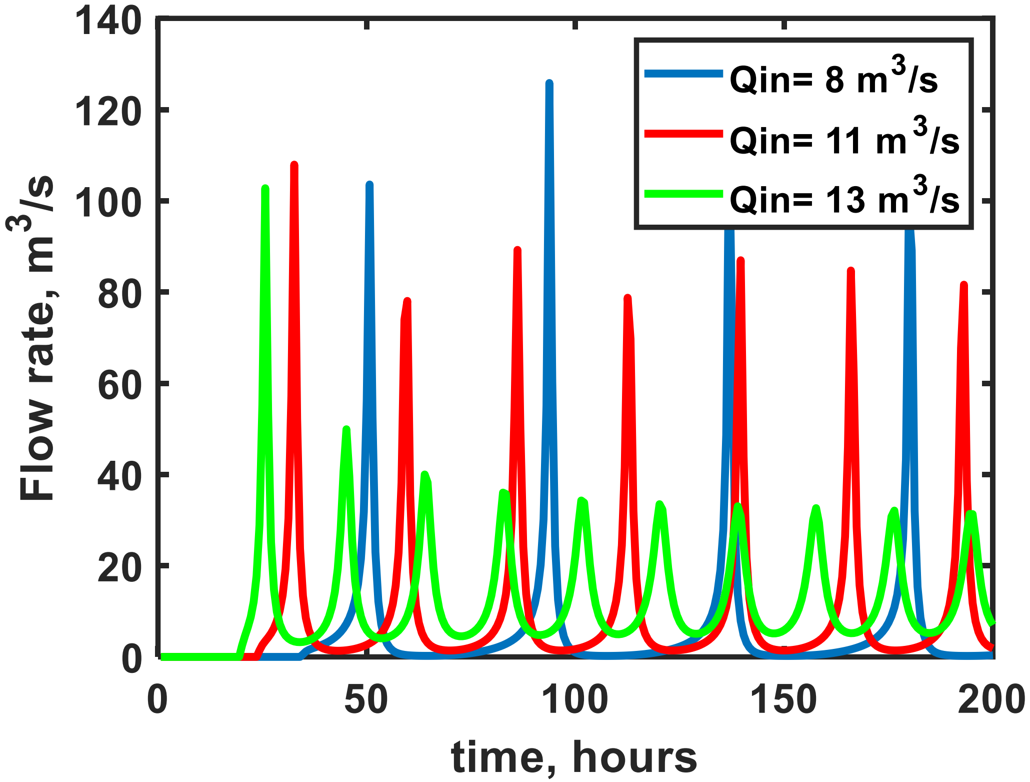


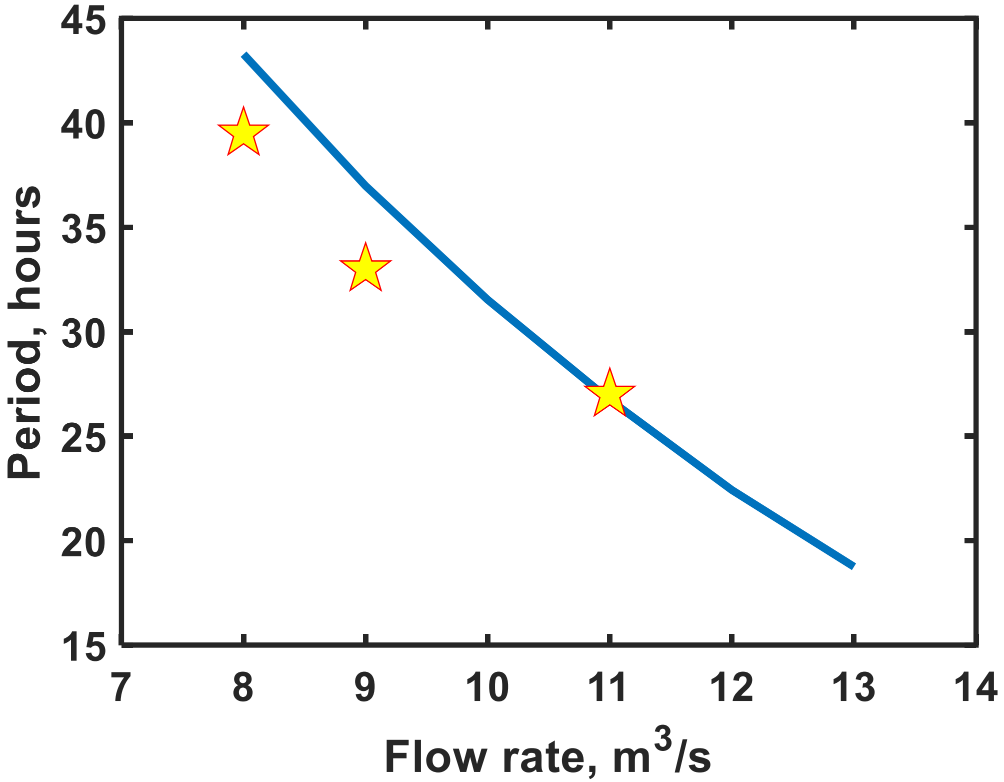
Magma enters the dike with a fixed temperature. During high discharge rate the cooling is insignificant. As the flow rate decreases magma cools down, its viscosity increases and the rheological stiffening at the top of the dike prevents magma from flow until high pressure gradient pushes the plug out.



After a period of high discharge rate the dike shrinks and solidifies at the top. Due to injection of a new magma from the bottom of it start to inflate but magma remains cold at the top. After cold magma plug disruption flow rate rapidly increases and dike deflates.

Periodic regimes at different Q_{in}





Left: periodic variations in flow rate with different influx intensities Q_{in}. At large Q_{in} eruption continues with relatively small variations in flow rates. Small Q_{in} correspond to large repose periods and intense discharge. At Q_{in} > 14 m^3/s eruption stabilizes.
Right: Predicted variations in the period of pulsations vs. Q_{in}. Stars – observed values.

¿Questions?

All artworks are generated by playgroundai.com Playground