UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Earth and Environmental Sciences

# Transient and pulsatory explosive activity

## A field and experimental perspective

Laura Pioli

# Introduction

- Two categories which span across different eruptive styles
- Not straightforward classification
- Very variable source mechanism
- Issues in deposit studies
- Classification: peculiar or could be hosted within traditional schemes?

# Pulsatory dynamics

- Unsteady, consisting of discrete pulses, can last over long times

(hundreds to thousands or even more explosions)

- Repeated/ unsteady fragmentation
- Variable frequencies ( ≤1-2 Hz)

Paricutin, 1946

- Strombolian and violent strombolian
- Vulcanian (?)
- Phreatomagmatic (Surtseyan)

...But not unique to these styles!

Etna, 2013

# Pulsatory dynamics-in the field

- Main factors : timing and scale of fluctuation

- Discrete pulses from the source convert into pulsatory dynamics of the eruptive plume– unsteady sedimentation– layering and stratification of the tephra layer/ repeated collapses

Cerro El Hungaro and its tephra blanket, Mexico

Paricutin 1943-1945 blanket, Mexico

# Pulsatory dynamics- in the field

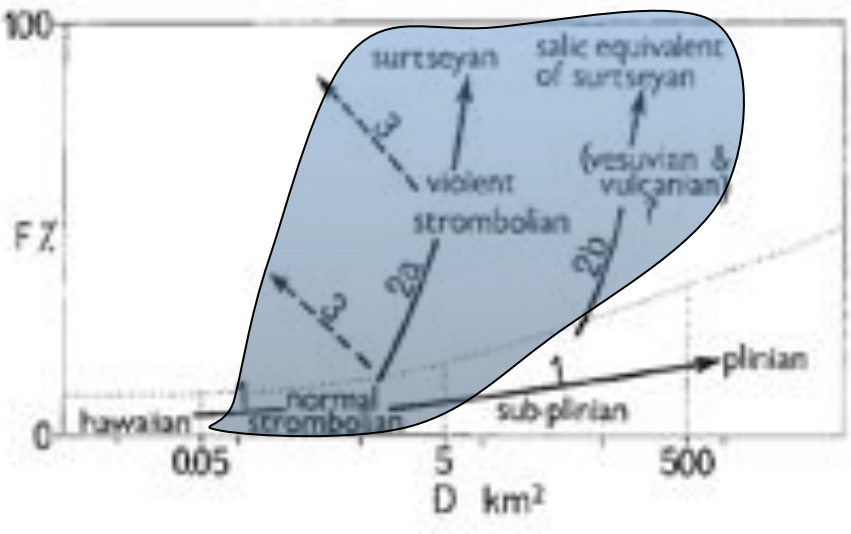
- Main factors : timing and scale of fluctuation

- Pulses there are so closely spaced that they do not convert into a unsteady deposition– massive deposit
- Single pulses do not form a continuous layer: faint stratification

Pre-Minoan fallout, Santorini

Soufriere Hills 1996-2005

# Pulsatory dynamics

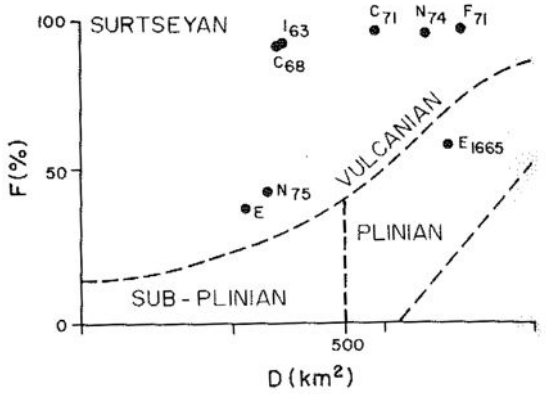



Walker, 1973

SOME TRADITIONAL CONCEPTS..

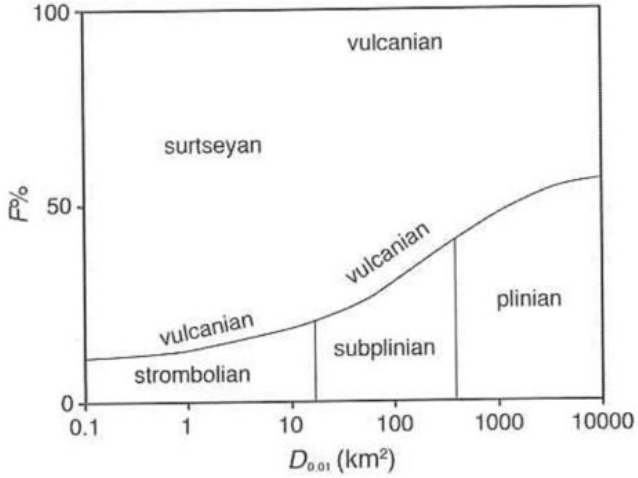
- 'Strombolian' and 'violent strombolian' are associated with low viscosity magmas
- Vulcanian are associated with high viscosity, crystal rich magmas
- Surtseyan explosivity is controlled by magma water interaction
- Strombolian and violent strombolian activity can be accompanied by lava flows
- Vulcanian activity is often associated with an active lava dome
- All these eruptions can have very long (months to years) durations

# Pulsatory dynamics/Vulcanian




Cas and Wright , 1987

Erupted magma <1 km$^3$ DRE
Intermediate compositions
Vulcanian plumes: <10km
Most Vulcanian eruptions eject dense material- some also scoria




Clarke, 2013

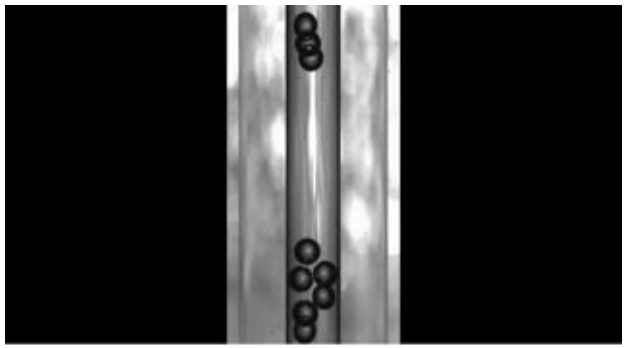
Short lived-discrete eruptions
Vulcanian plumes: <20km
Erupted magma <0.1 km$^3$ DRE
They occur by '*rupture of a competent sealing conduit plug or dome*'
Intermediate to silicic magmas

# Separated two-phase flow dynamics

- In two-phase separate flow, gas bubbles tend to cluster because their rise velocity varies with gas volume fraction

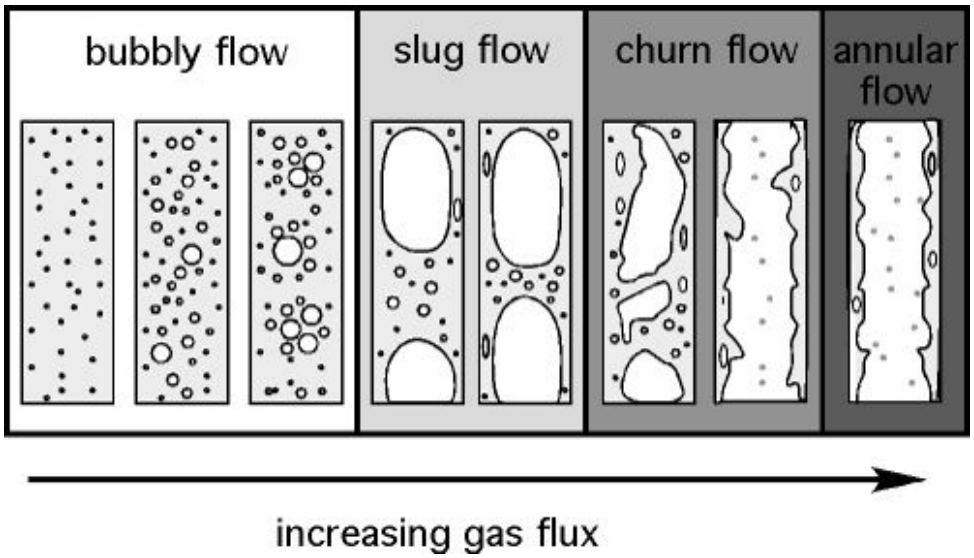
$$U_0(\varepsilon) = U_t(1-\varepsilon)^q$$

- At stationary conditions, clustering forms *stable kinematic waves*--generated by mass transport phenomena



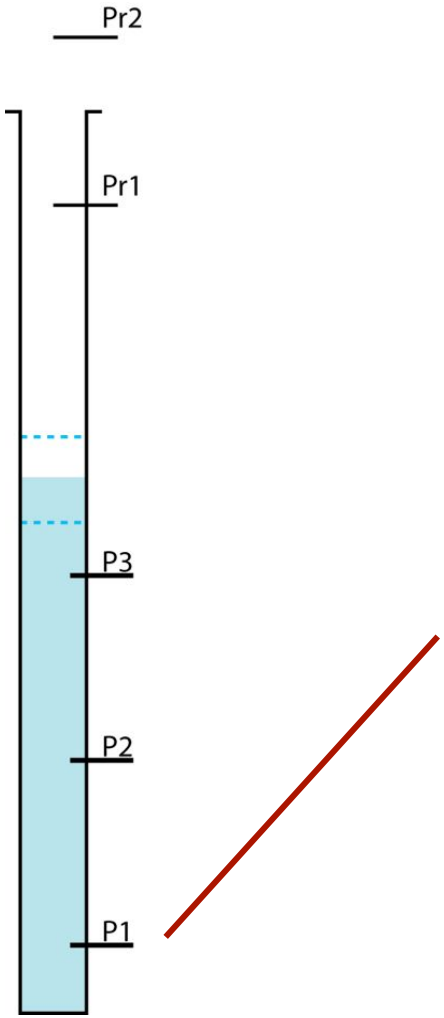
$\varepsilon$= gas volume fraction
$U_t$= terminal velocity of a single bubble
$U_0$= rise velocity of a cluster of bubbles

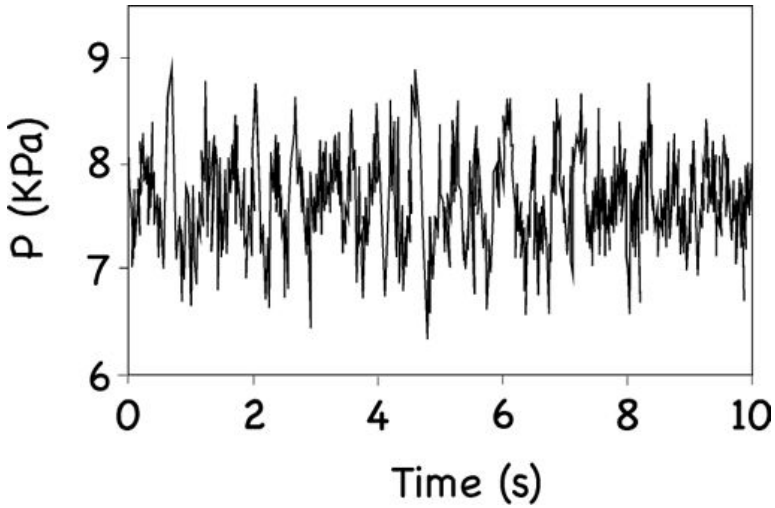
# Gas segregation in low viscosity magmas




- Separate two phase flow dynamics is *always* pulsatory even for steady feeding rates

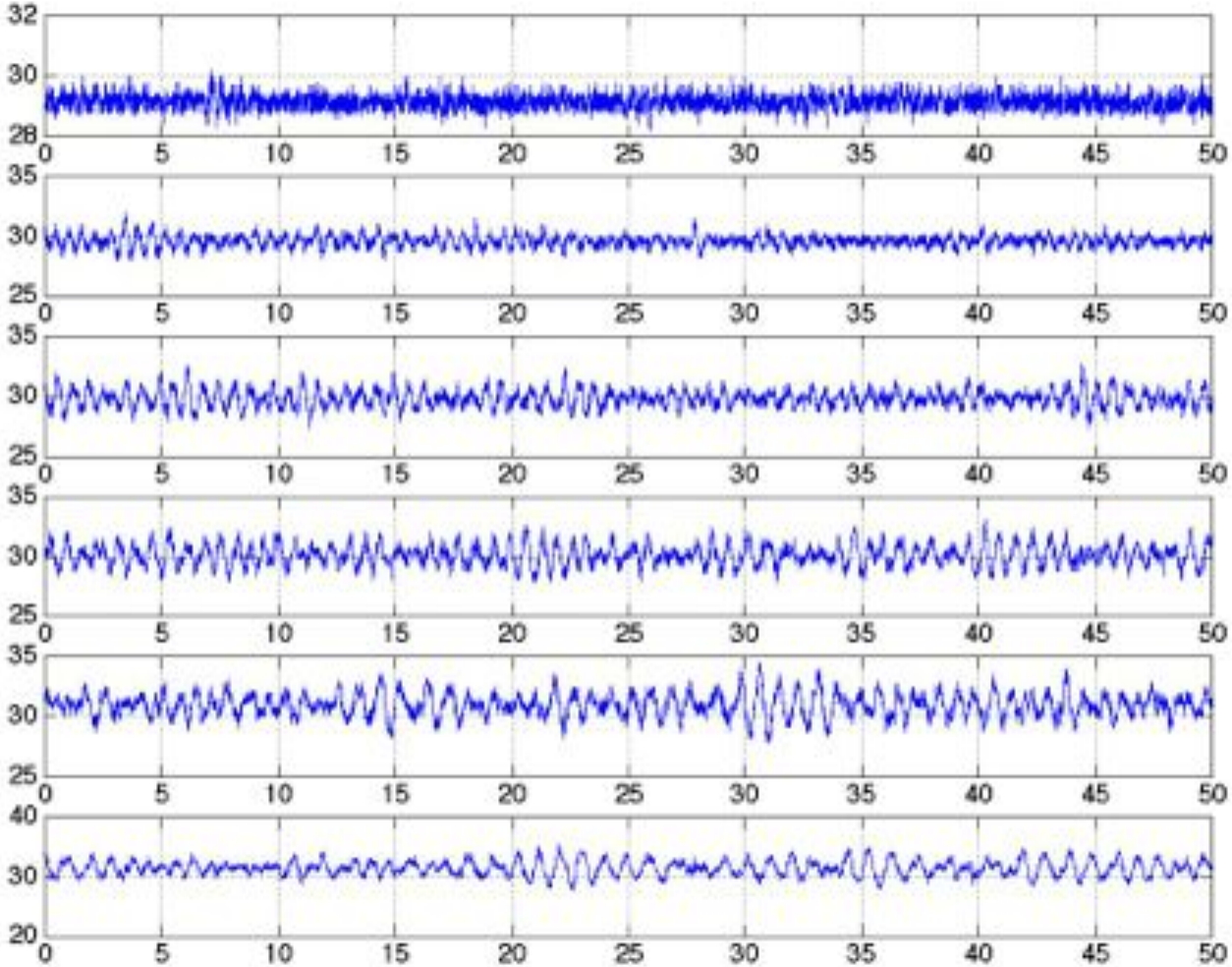
# Outgassing is a dynamic process!



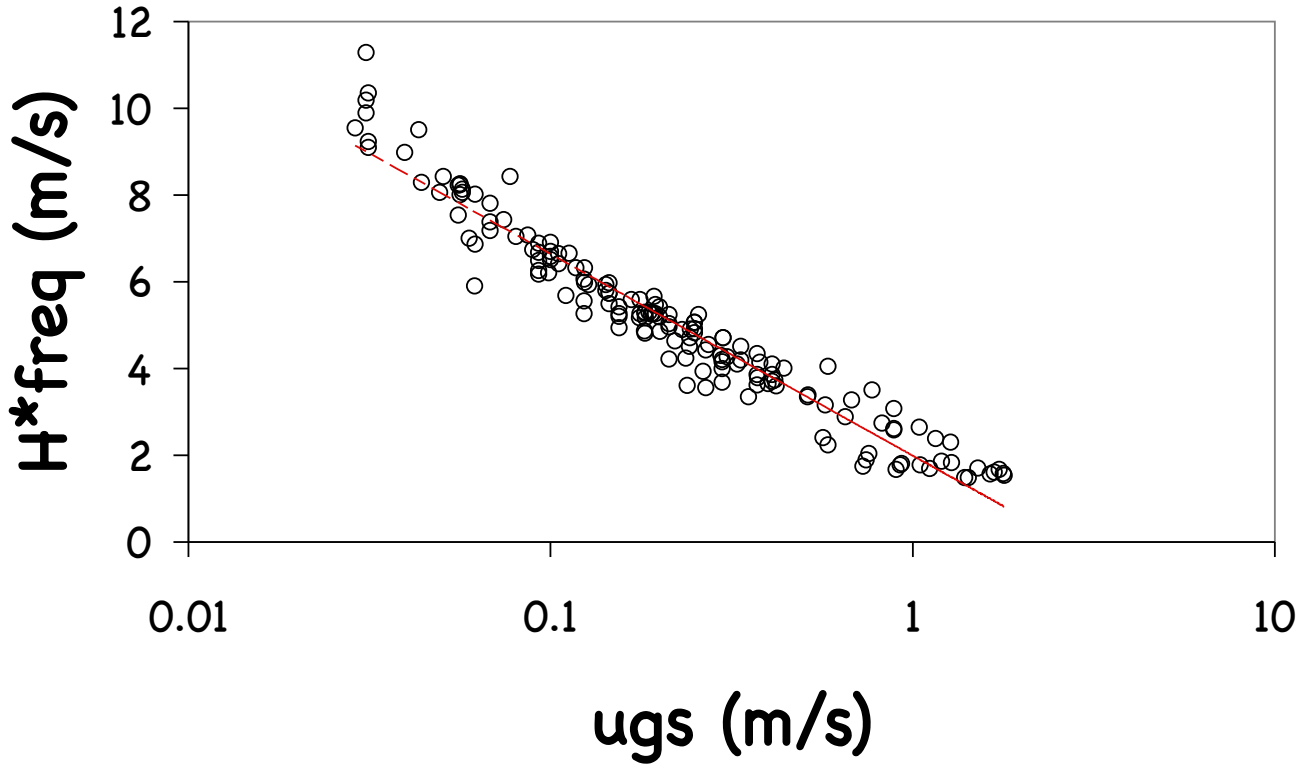

Pressure at P1, ugs=1.14 m/s, $h_0$= 4.5 m

# Pressure oscillations



# Pressure oscillations

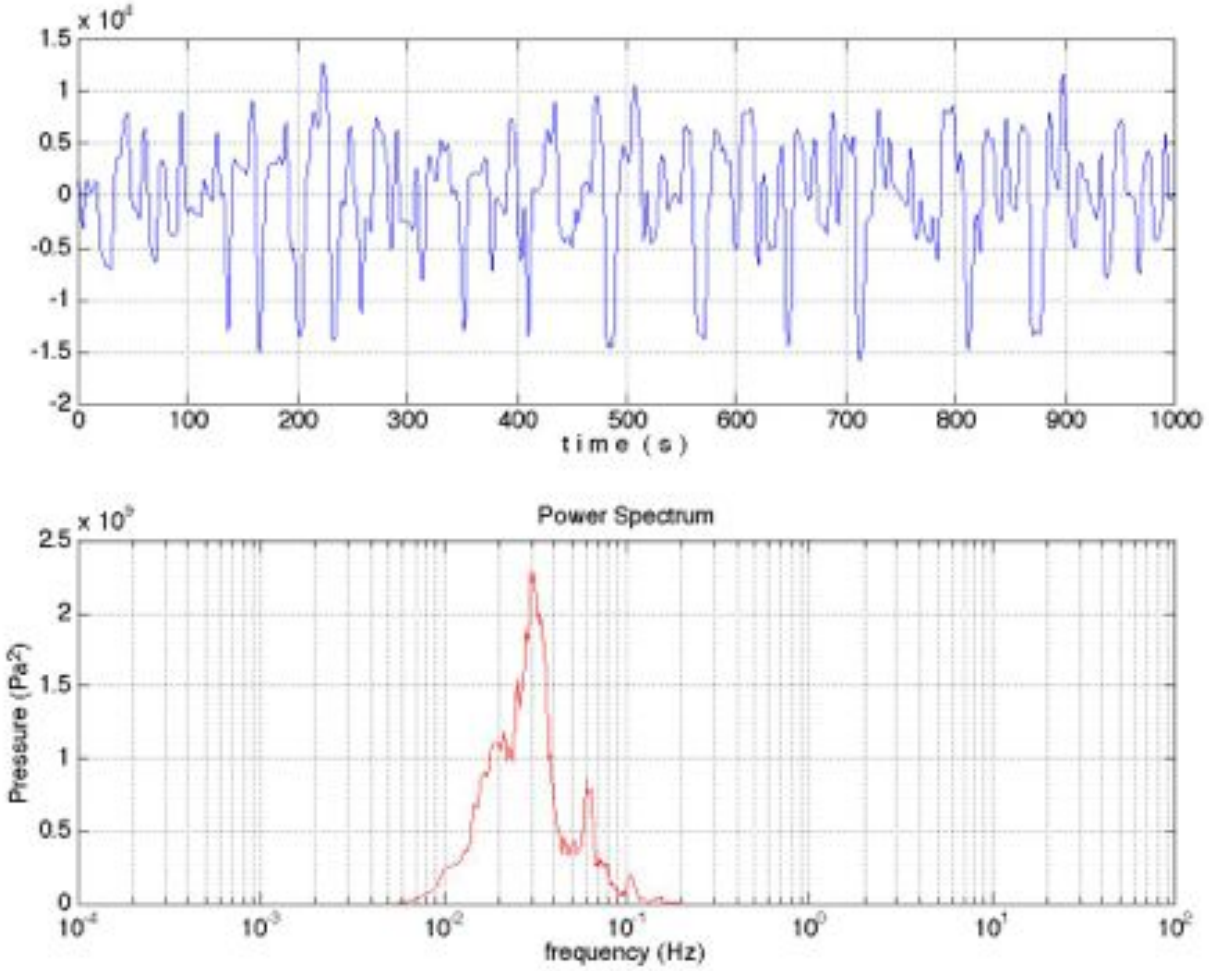
- For any regimes, the periodicity is controlled primarily by gas flow volume rates





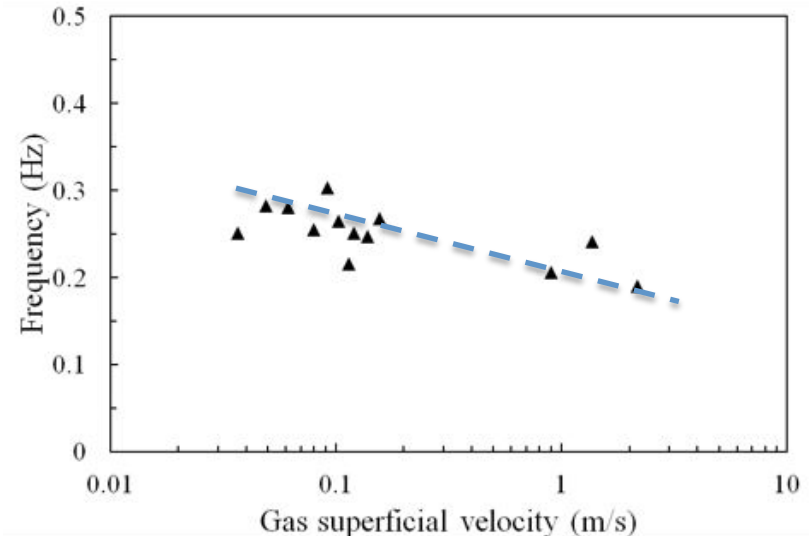

Pioli et al., 2012

# Pressure oscillations

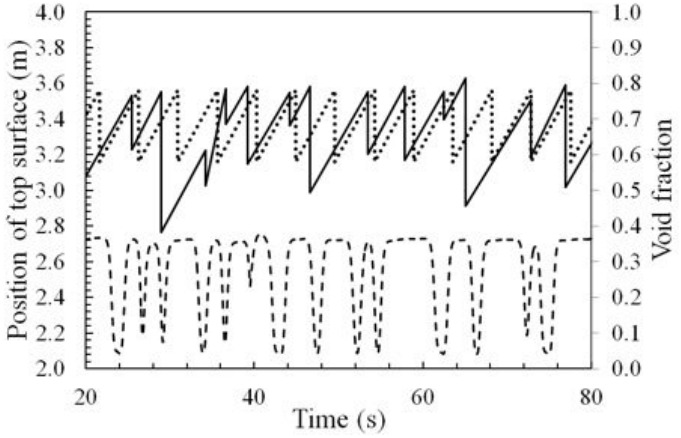


# Pressure oscillations

- For any regimes, the periodicity is controlled primarily by gas flow volume rates




Frequency of gas slugs




Oscillations of the free surface



Azzopardi et al., submitted

# Pulsatory dynamics/strombolian to violent strombolian

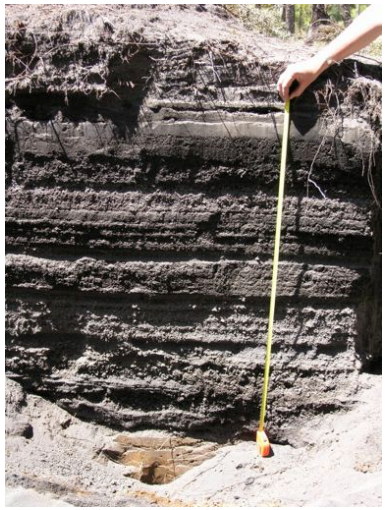
Cerro Malacate, Mexico

# Pulsatory dynamics/strombolian to violent strombolian

Cerro El Hungaro and its tephra blanket, Mexico

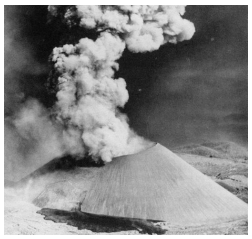
Jorullo tephra blanket, Mexico

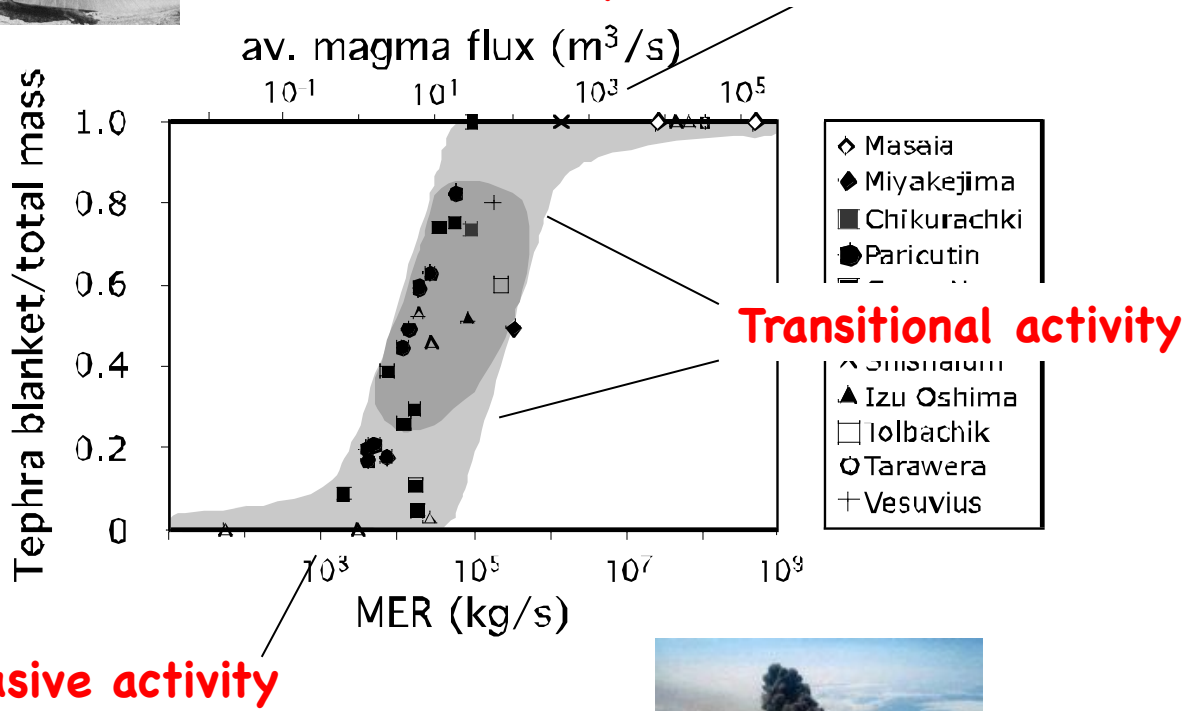
Paricutin tephra blanket, Mexico



Sunset crater tephra blanket, USA

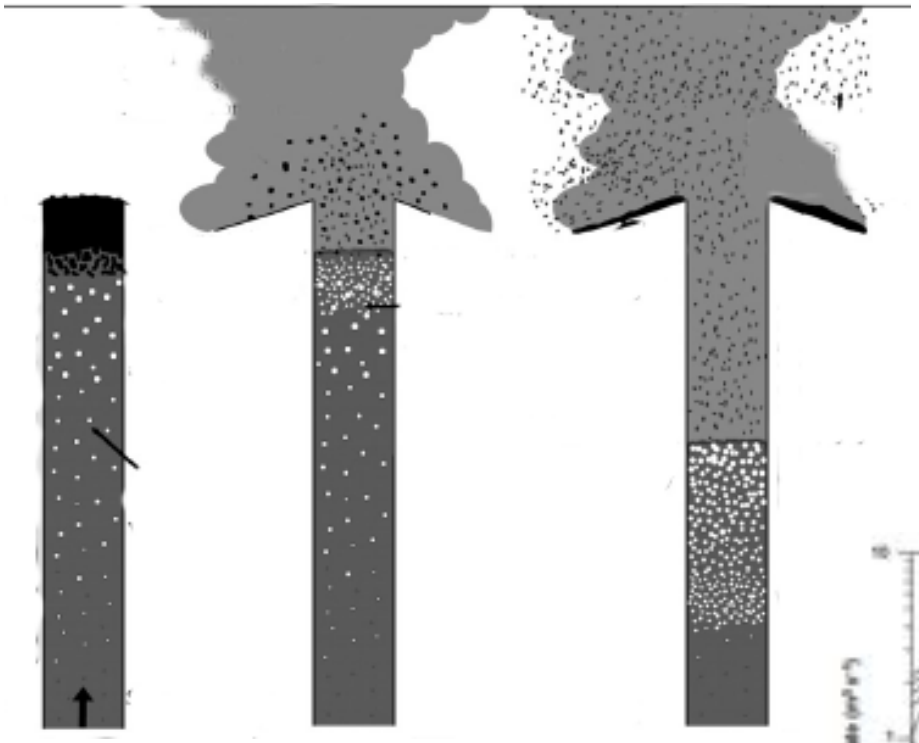
# Pulsatory dynamics/strombolian to violent strombolian





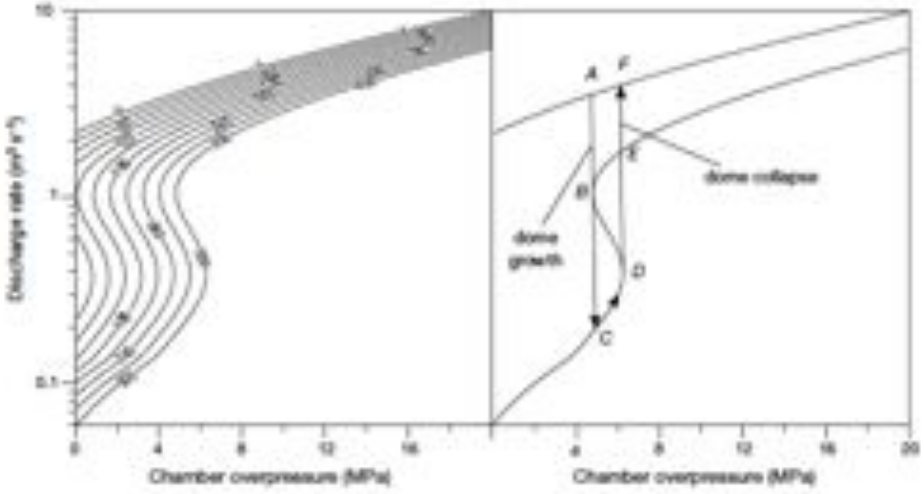

- Typically pulsatory (Mac Donalds, 1972)
- Typical of low viscosity magmas
- Higher eruption columns ( 4-8 km) than Strombolian
- Higher fragmentation efficiency than Strombolian
- Gas segregation is still efficient: contemporaneous lava effusions and explosions

# Pulsatory dynamics/Vulcanian



Giachetti et. al (2010)

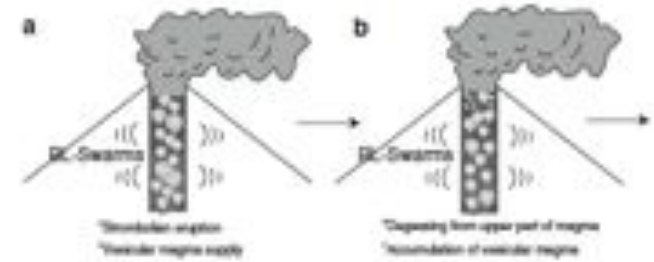

DOME GROWTH



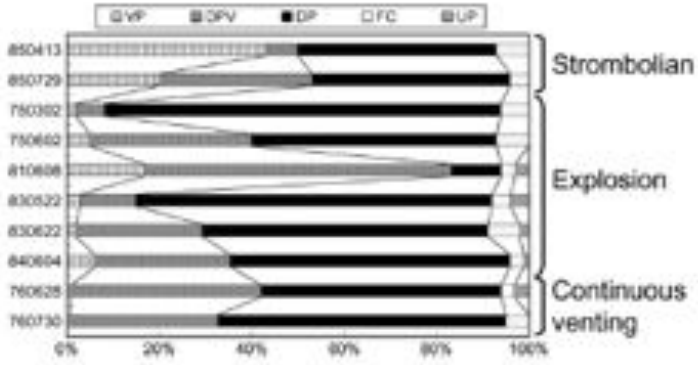

Melnik and Sparks 1999

# Pulsatory dynamics/Strombolian to vulcanian…..

## Sakurajima



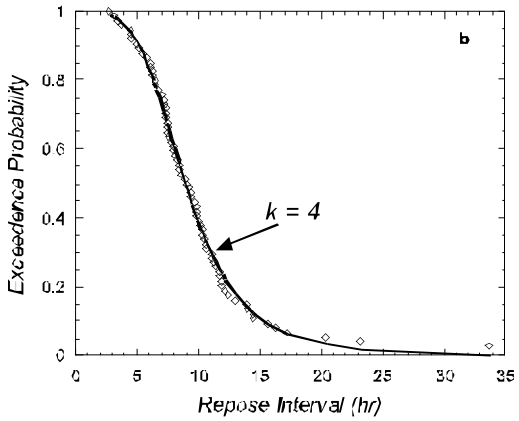

Vesicular ash dense ash




Yamanoi et al. (2008)

# Vulcanian regimes

Statistical analysis of TIME intervals between eruptions

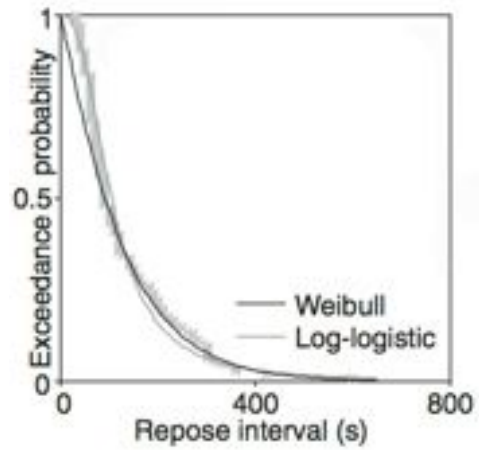



Soufriere Hills, 1997; from Connor et al, 2003

Log- logistic distribution: the log of the time between two different events has a logistic distribution..

The probability that the time between two consecutive events is larger than $T_{av}$ rapidly decreases.

Distribution of time intervals is not symmetrical

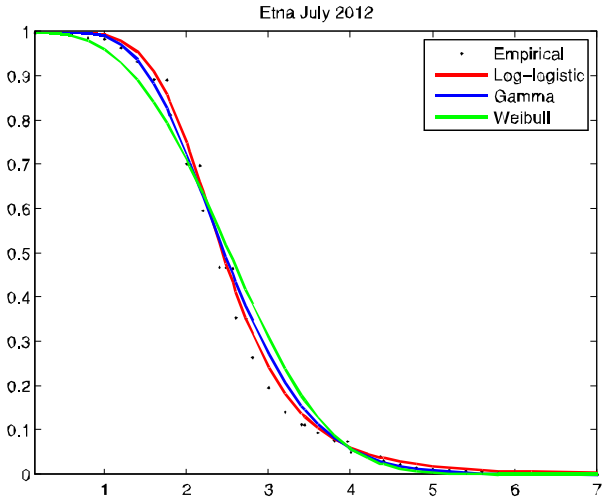



Anak Krakatau, 1960; from Watts et al, 2007

# Pulses in Strombolian regimes

Statistical analysis of TIME intervals between eruptions

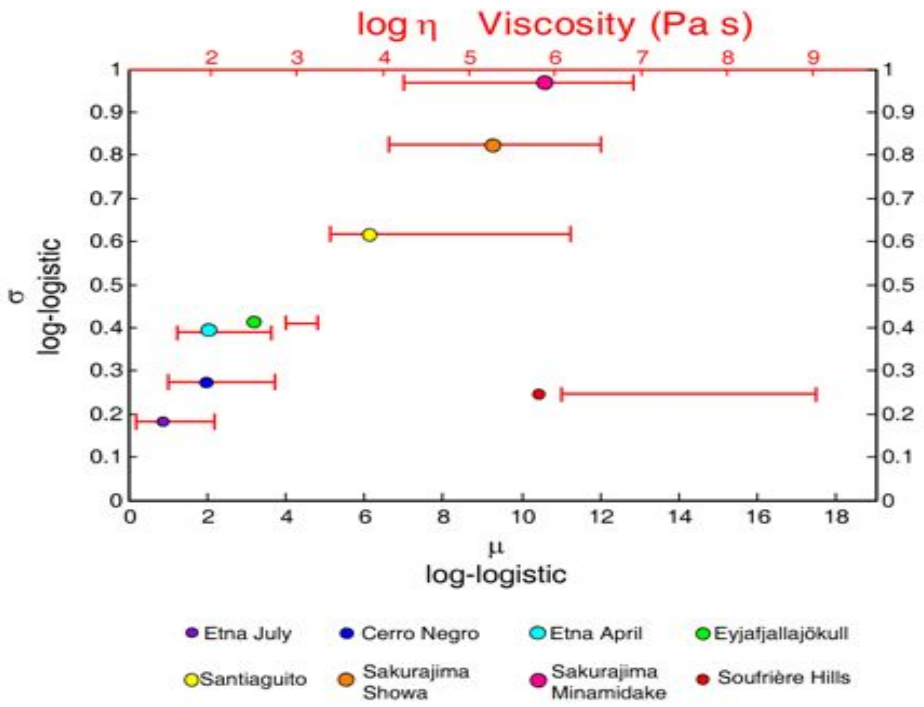
Works at different open-conduit volcanoes- also for pulses within the same event




The properties of the distribution appear related to the properties of magmas..

# Periodicity

- Log logistic distribution fits all data (Strombolian to Vulcanian)
- The process is not random (distribution does not fit a Poisson model)
- Explosion frequency and regularity decrease with increasing magma viscosity




Dominguez et al., 2014.. Check the poster!