Significant changes in the magma dynamics of Stromboli steady-state volcano recorded by clinopyroxene crystals

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Stromboli: a steady-state volcano

- Steady-state volcanic activity implies equilibrium between the rate of magma replenishment and eruption of compositionally homogeneous magmas in an open-conduit system
- The steady-state can last for tens to thousand years
- Stromboli is a typical steady-state volcano since at least ~1.7 ka (Post-Pizzo activity, Petrone et al., 2018 EPSL)

Di Stefano et al., 2020, Lithos

Aim

- Evaluating how the steady-state is modulated by the magma dynamics and what are the implications for the eruptive behavior:
  - Are there any changes with time?
  - Is there any relationship with eruptive styles?

Approach

- Focus on two eruptive periods: Post-Pizzo (Recent activity, < 2.4ka) and 2003-2017 (Present-day)
- Chemical and textural study of the clinopyroxene crystal cargo
- Timescales of pre-eruptive processes (e.g., mafic injection events, magma mixing, magma homogenisation and eruption triggering) by Non-Isothermal Incremental Step Diffusion modelling (NIDIS, Petrone et al, 2016 Nat. Comms) on clinopyroxene (Fe-Mg elemental diffusion).

Recent & Present-day activity

Courtesy of P. Scarlato

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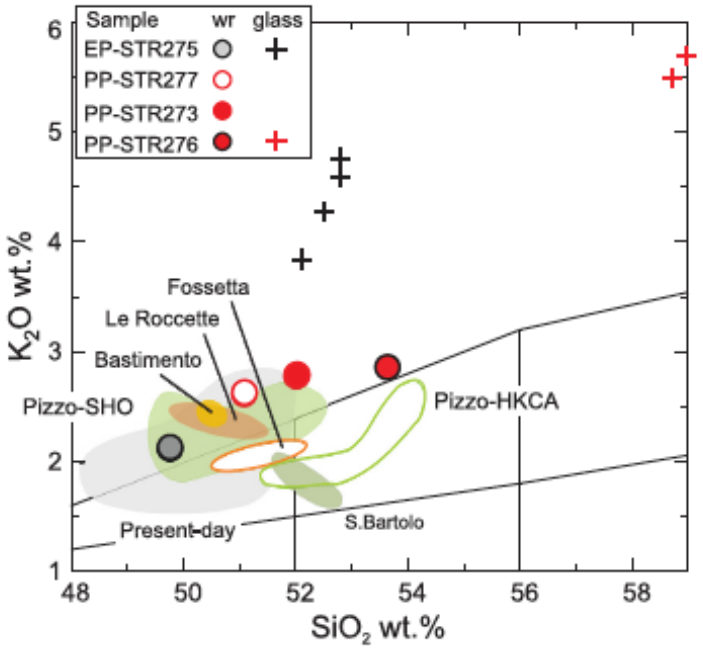
- Low-energy Strombolian eruptions alternating with episodic lava flows and rare violent explosive eruptions (major and paroxysms)
- Paroxysms usually occur at intervals of a few years but the two most recent occurred within a very short timescale: 3 July and 28 August 2019
- Two magma types erupted

(Francalanci et al., 1999 EPSL, 2004 JVGR):

- A degassed highly porphyritic magma (*hp-magma*) occupying a shallow reservoir
- A more mafic crystal-rich magma (*lp-magma*) only erupted during paroxysms

Comparing two periods of activity

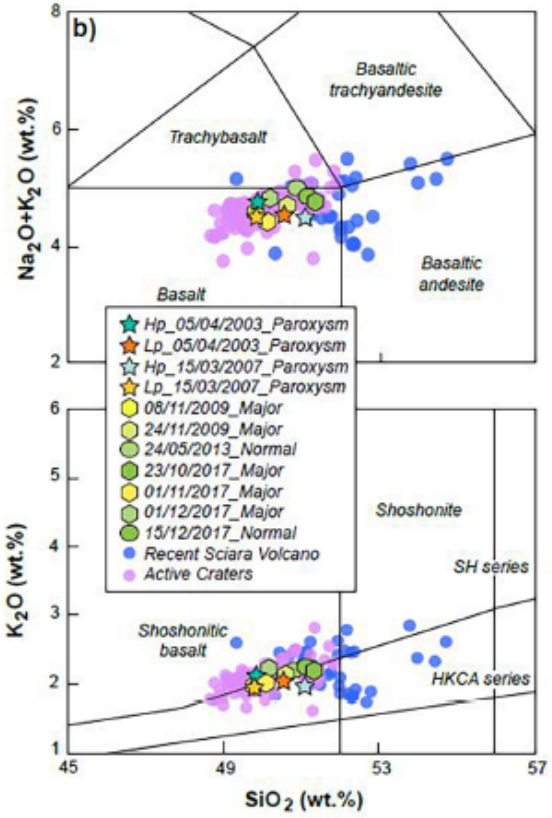
Recent = Post Pizzo



Petrone et al., 2018, EPSL

PP (red) = spatter from Post-Pizzo in stratigraphic sequence (STR273 & 276 bottom, STR 277 top)
EP (grey) = Early Paroxysm of the Present-day

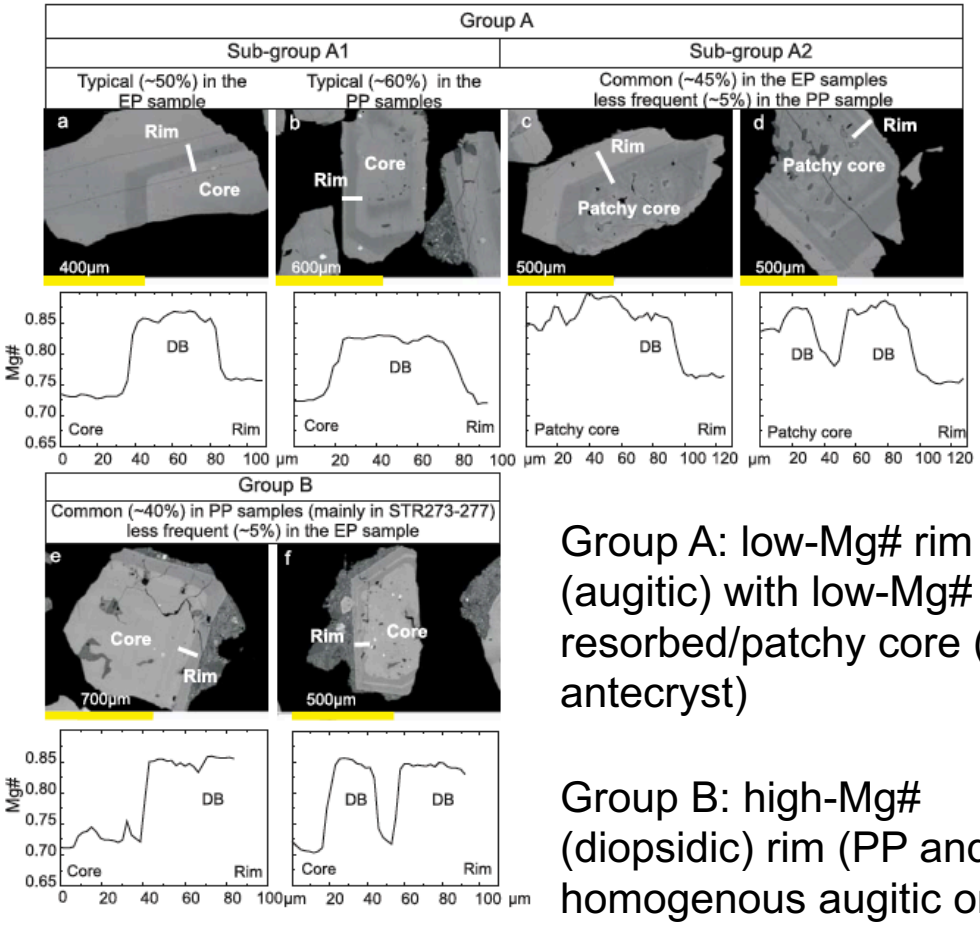
Present-day = 2003-2017



Di Stefano et al., 2020, Lithos

Clinopyroxene textures

Recent = Post Pizzo

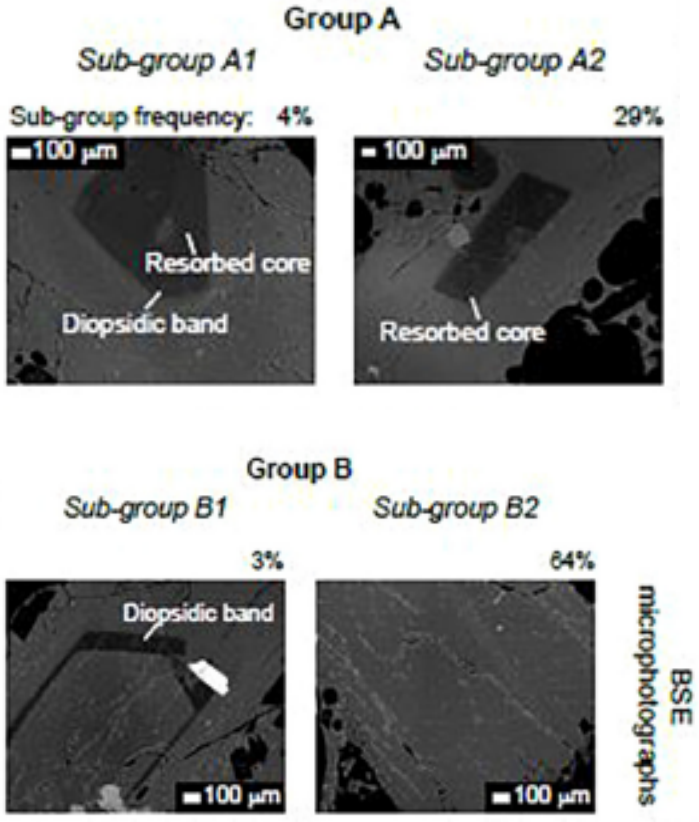


Petrone et al., 2018, EPSL

Group A: low-Mg# rim (augitic) with low-Mg# or resorbed/patchy core (i.e., antecryst)

Group B: high-Mg# (diopsidic) rim (PP and EP); homogenous augitic or a diopsidic band (2003-2017)

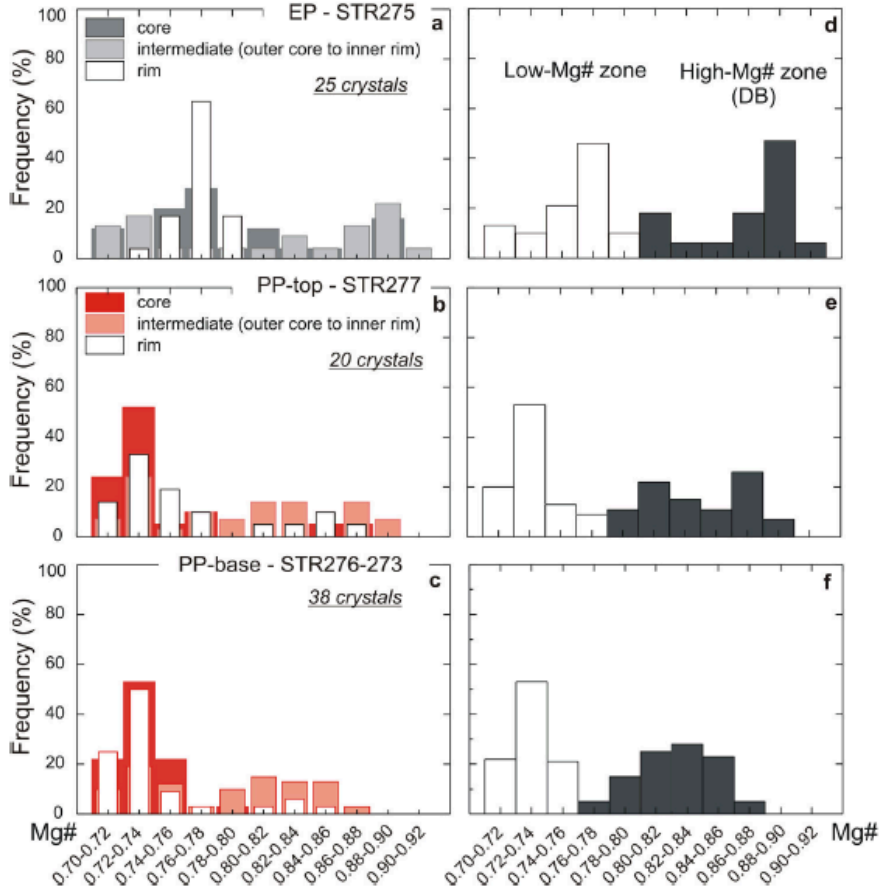
Present-day = 2003-2017



Di Stefano et al., 2020, Lithos

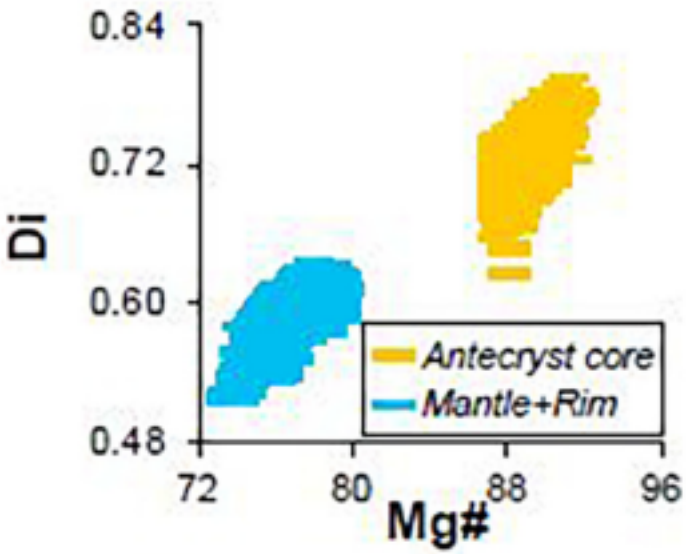
Magma mixing and hybridisation

Recent = Post Pizzo



Petrone et al., 2018, EPSL

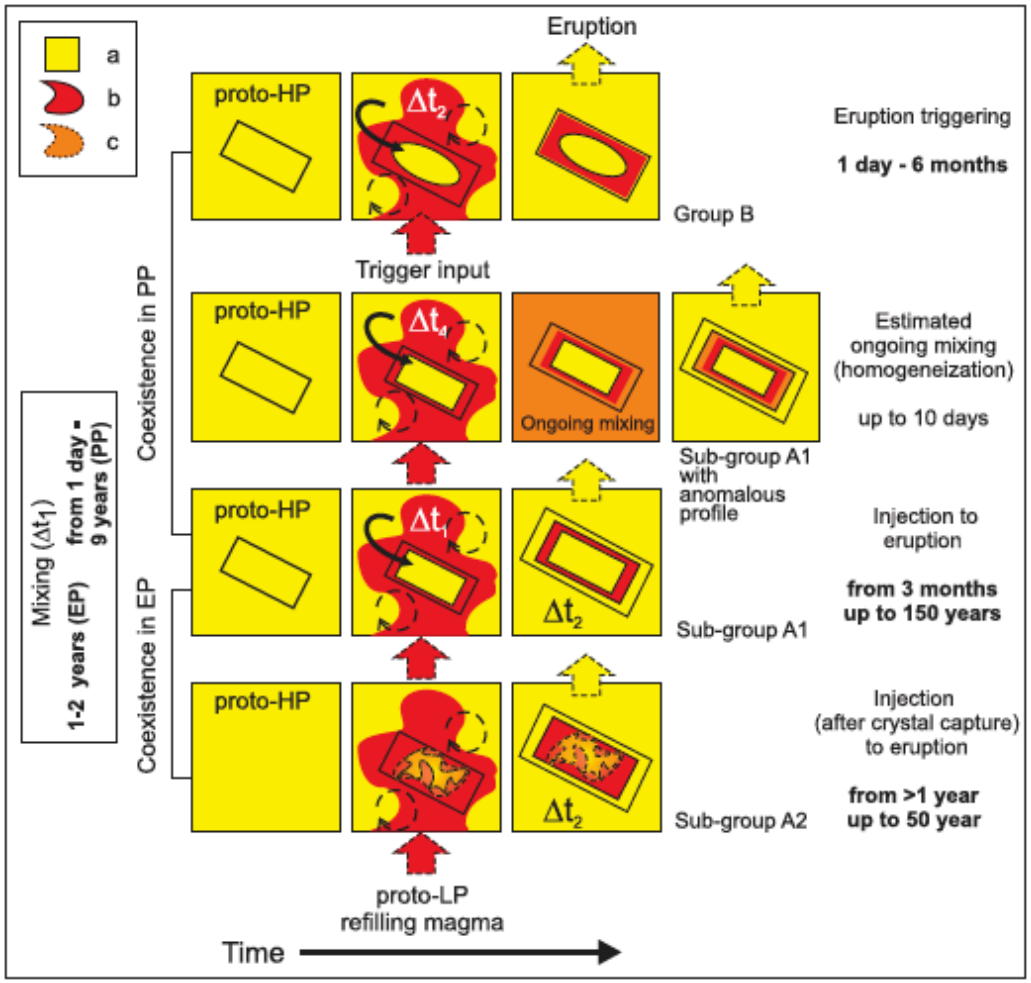
Present-day = 2003-2017



Di Stefano et al., 2020, Lithos

Clinopyroxenes from the two eruptive periods have mostly overlapping compositions with diopsidic and augitic portions that nevertheless tend to become more mafic with time.

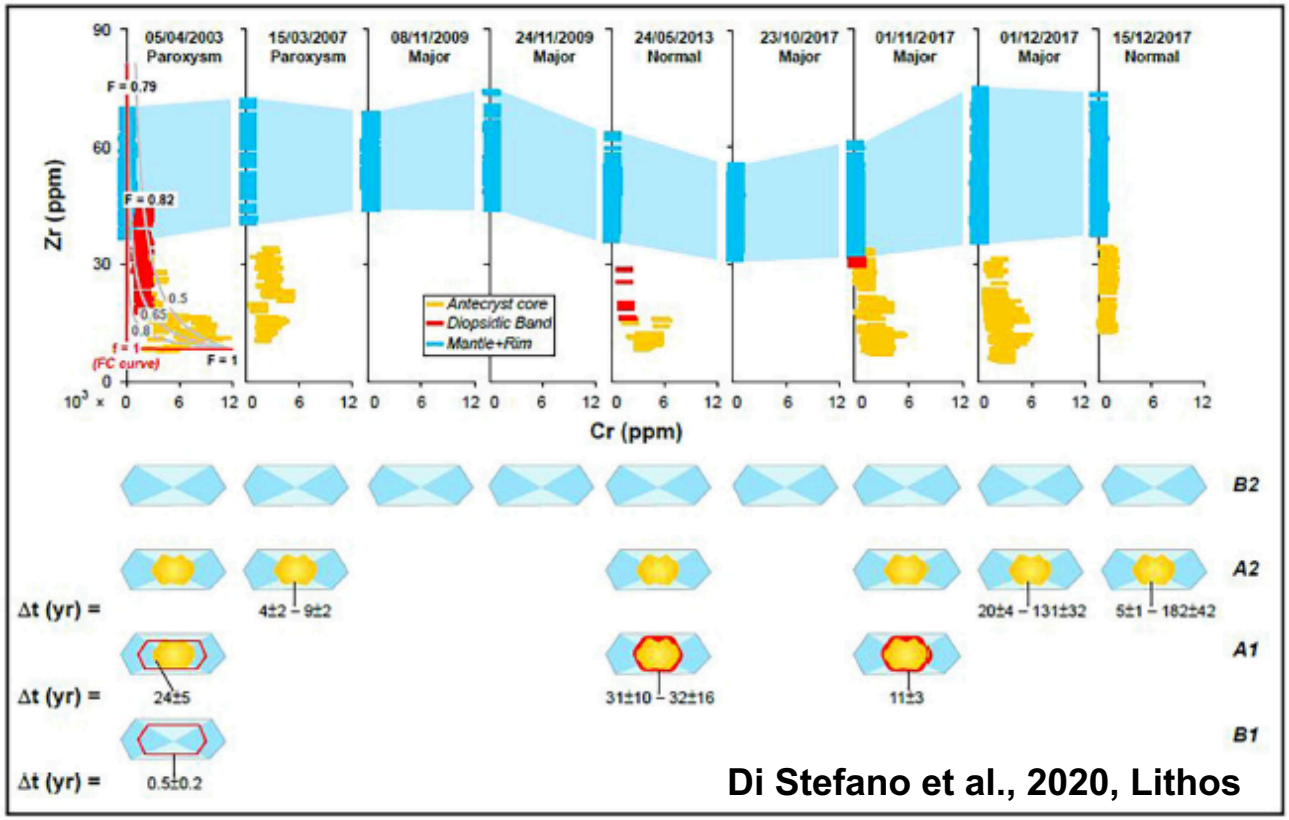
Elemental Diffusion Timescales: Post-Pizzo



Petrone et al., 2018, EPSL

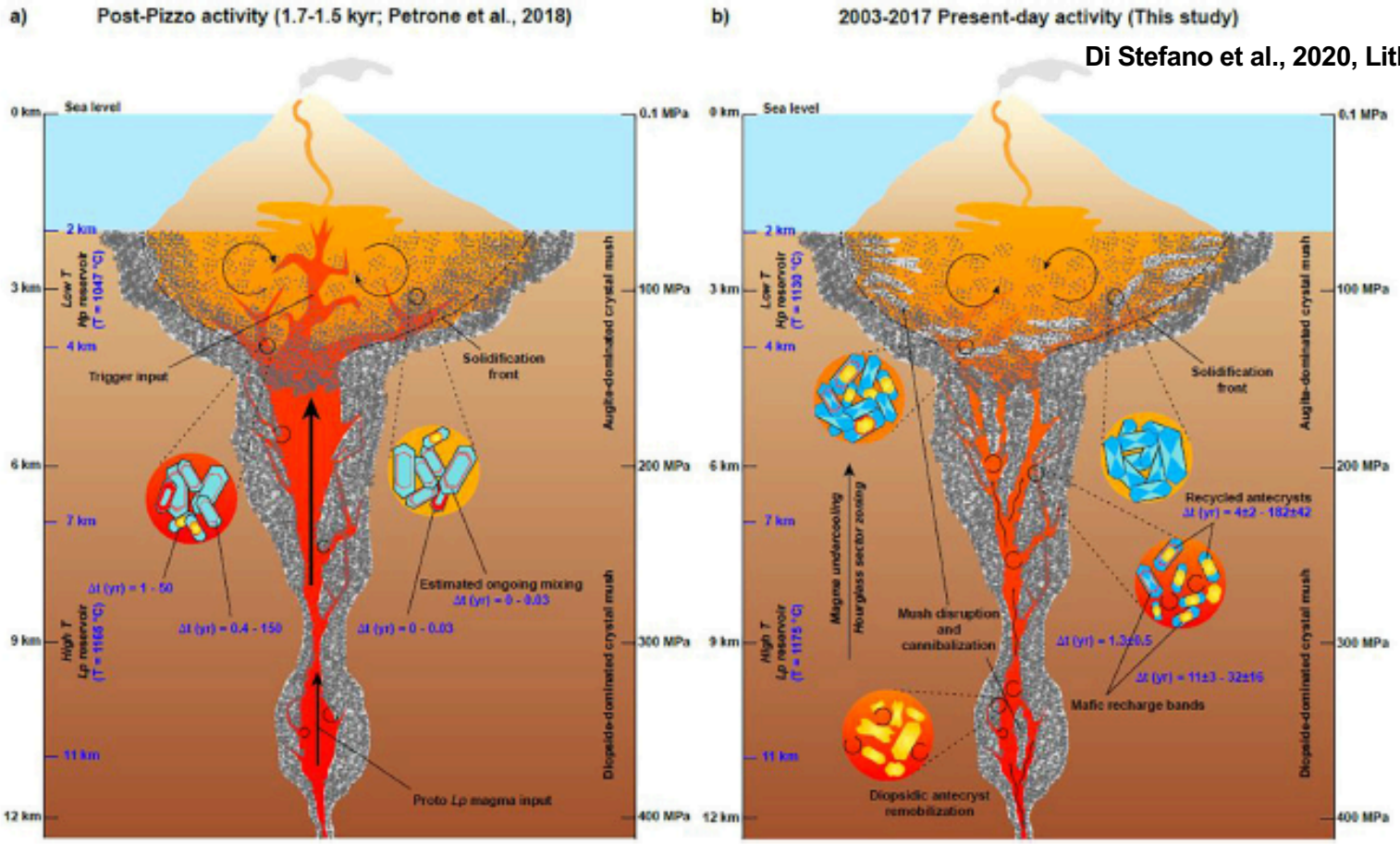
- Total residence times of 1-50 years are observed during the Post-Pizzo, with some crystals that record up to > 150 years.
- Injections of more mafic magmas (*lp)* result in an instantaneous growth of high-Mg# domains indicating rapid homogenization of the *lp*-magma within the resident *hp*-magma
- Residence time in the resident *hp*-magma are longer than the homogenisation time pointing to a repeatedly erupting and steady-state system
- Timescales of mafic triggering events, as recorded by high-Mg# rims, ranges from 1 day to 6 months

Elemental Diffusion Timescales: 2003-2017



- 2003 Paroxysm: injections of more mafic magmas (*lp)* occur in a very short timescales (6 months-1 year) indicating a short time interval between mafic injections and eruptions
- Longer timescales (4-182 years) are recorded for the remobilization of antecrysts similarly to the Post-Pizzo period, but the frequency of resorbed antecrysts increases with time pointing to a major remobilization of older portion of the crystal mush

Plumbing system changes with time



Di Stefano et al., 2020, Lithos

- Post-Pizzo: Efficient mixing of *lp*-magma in the resident *hp*-magma indicates that the *lp*-magmas do not stall in the crystal mush, but antecrysts increase during the Early Paroxysm of the Present-day activity
- 2003-2017: recycled antecrysts are ubiquitous suggesting efficient mush cannibalization and disruption and signaling a new-phase in the life evolution of Stromboli.

Conclusions

- A distinct phase in the life of Stromboli volcano commenced after the violent 2003 paroxysm
- Magma dynamics is characterised by efficient mechanism of mush disruption and cannibalisation
- Over time magmatic injections feeding the persistent Present-day activity are more intensively mixed and homogenised prior to eruption
- Preliminary data on the 2019 paroxysms suggest rapid and continuous inputs of *lp*-magmas, perhaps in a rejuvenated magmatic system

More information can be found here:

- Petrone et al, 2018 EPSL: doi: 10.1016/j.epsl.2018.03.055
- Di Stefano et al., 2020 Lithos: doi: 10.1016/j.lithos.2020.105440

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