The magmatic and eruptive response of arc volcanoes to deglaciation: insights from southern Chile

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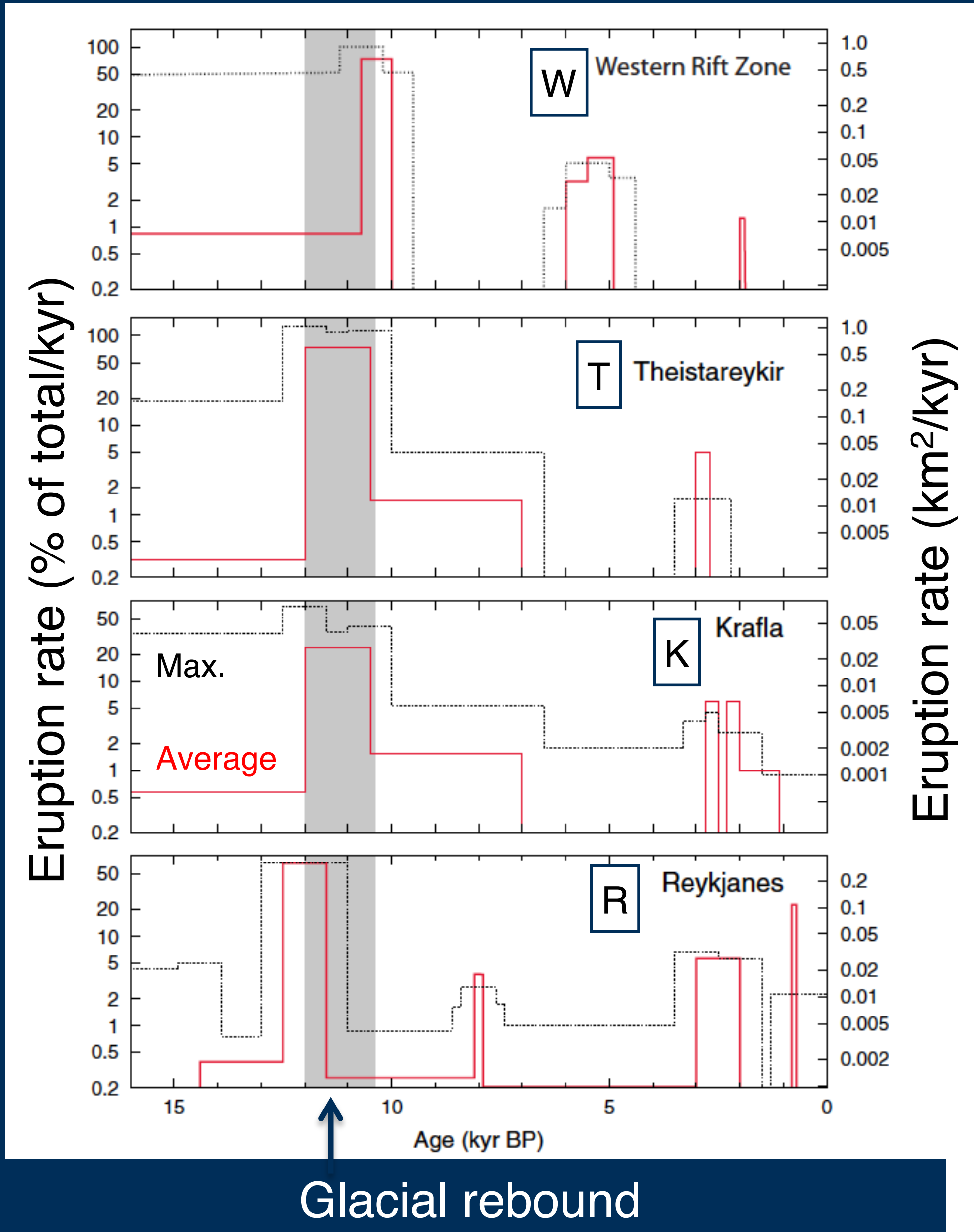
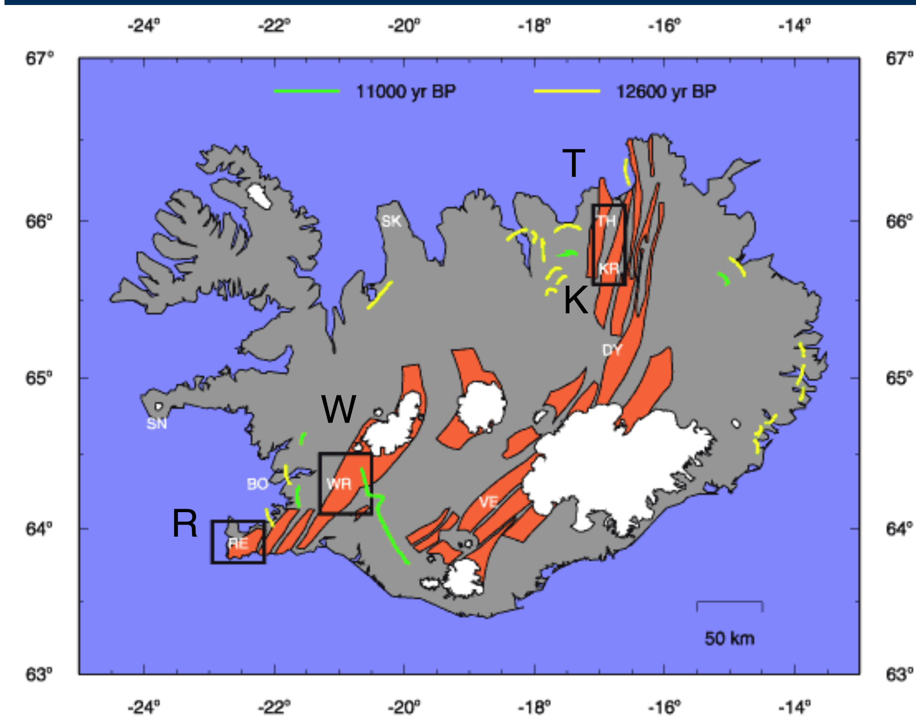
Rawson et al., Geology, April 2016

Glaciation driving eruption behaviour



Well documented and compelling evidence in regions dominated by decompression melting e.g., Iceland and proposed mechanism

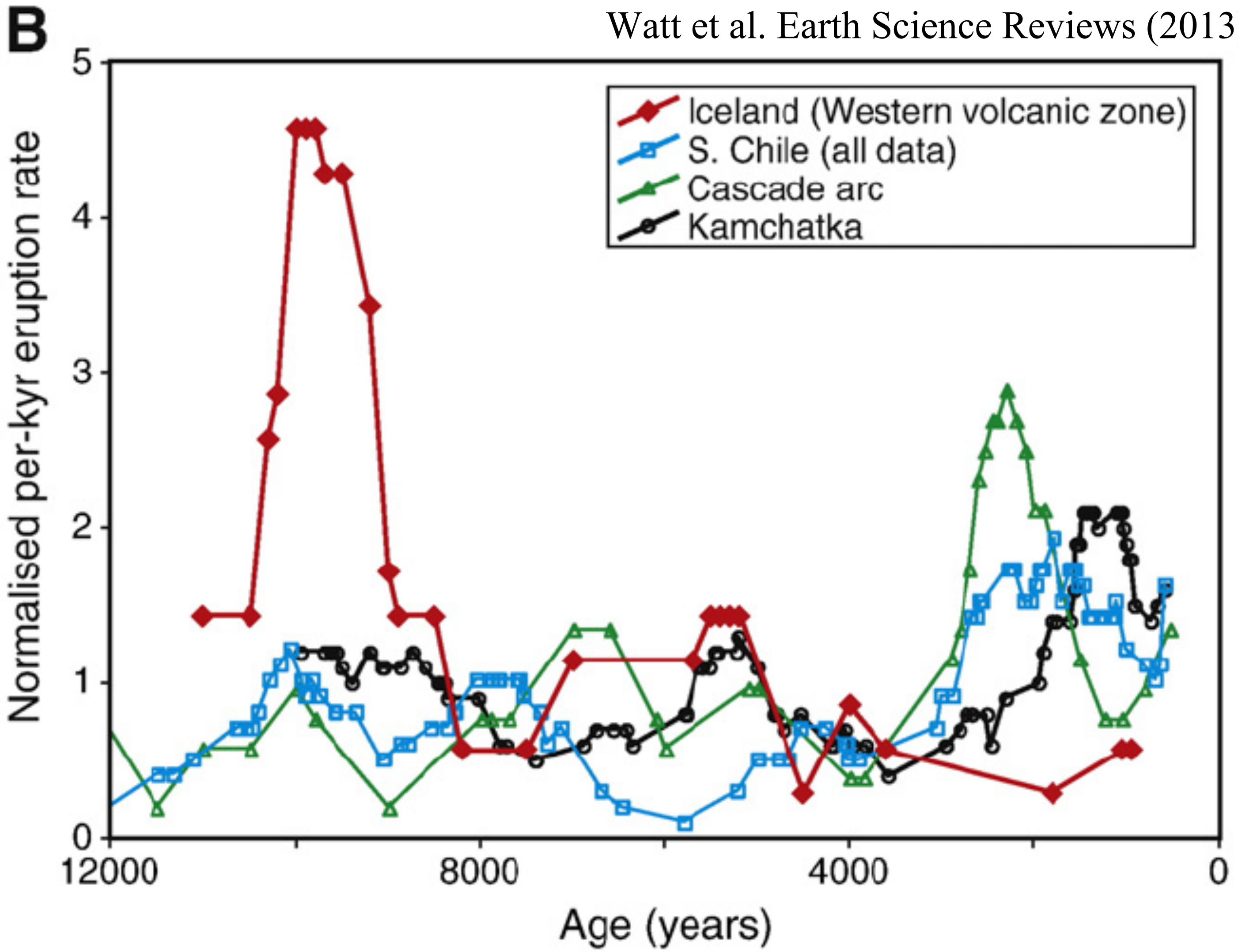


e.g., Maclennan et al. (2002)

Glaciation driving eruption behaviour

In an subduction zone setting (different melting mode) whether, or how, the volcanoes respond remain inconclusive.

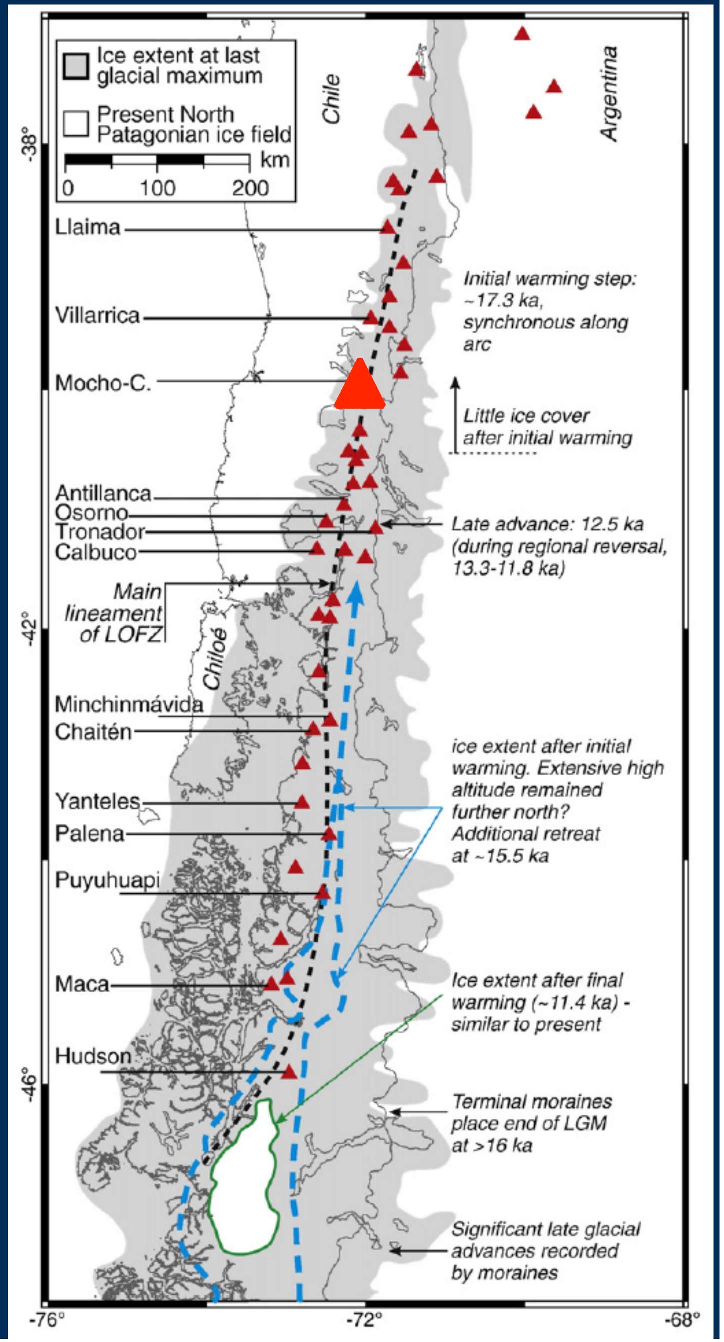
Watt et al. Earth Science Reviews (2013)



This could reflect uncertainties and incompleteness in the records or the absence of a response.

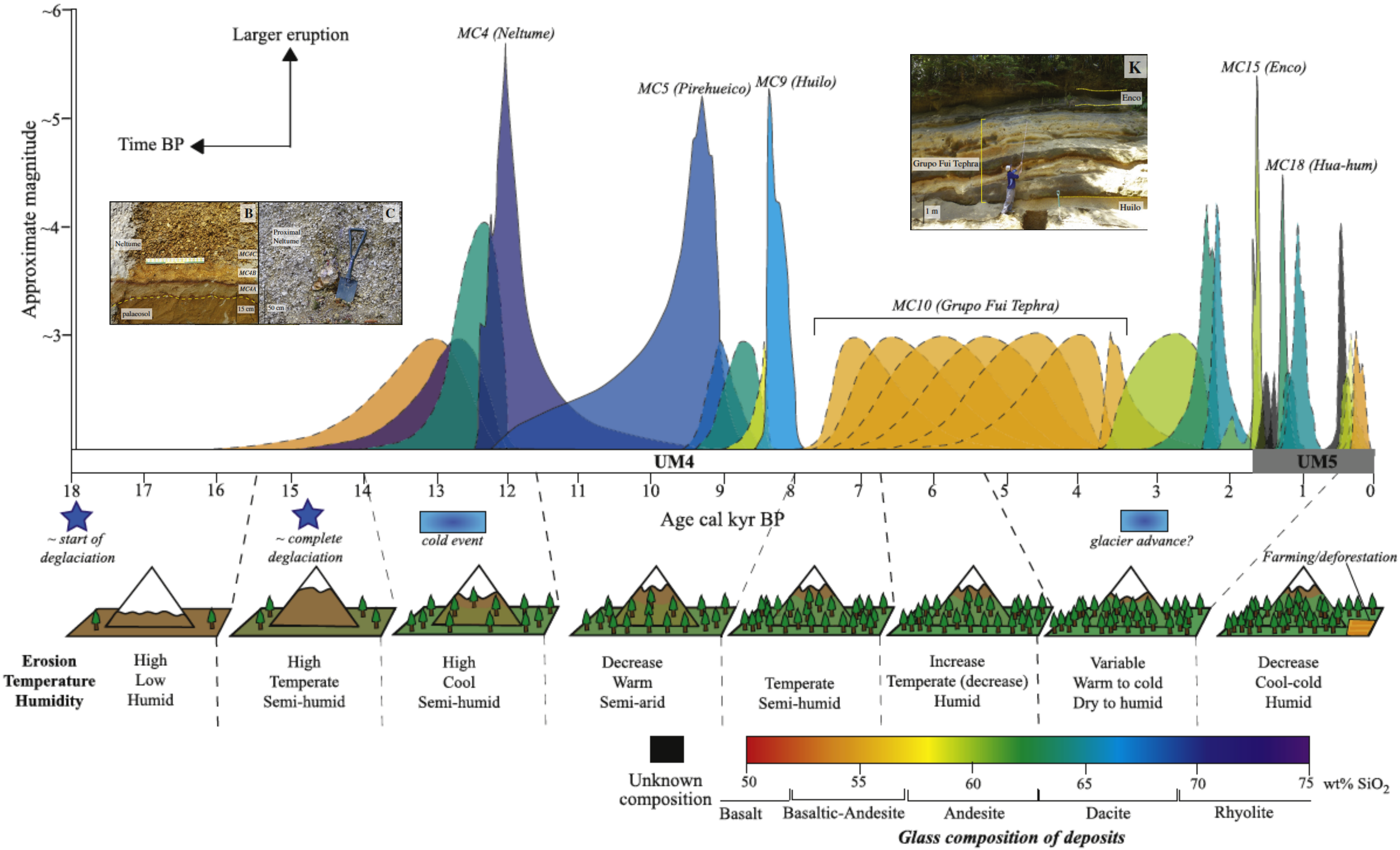
Case Study: Mocho-Choshuenco

- ca. 35 known post-glacial explosive eruptions
  - Well constrained age model
  - Eruption style e.g., size
  - Large geochemical dataset
- Extensively glaciated until ~18 kyrs BP



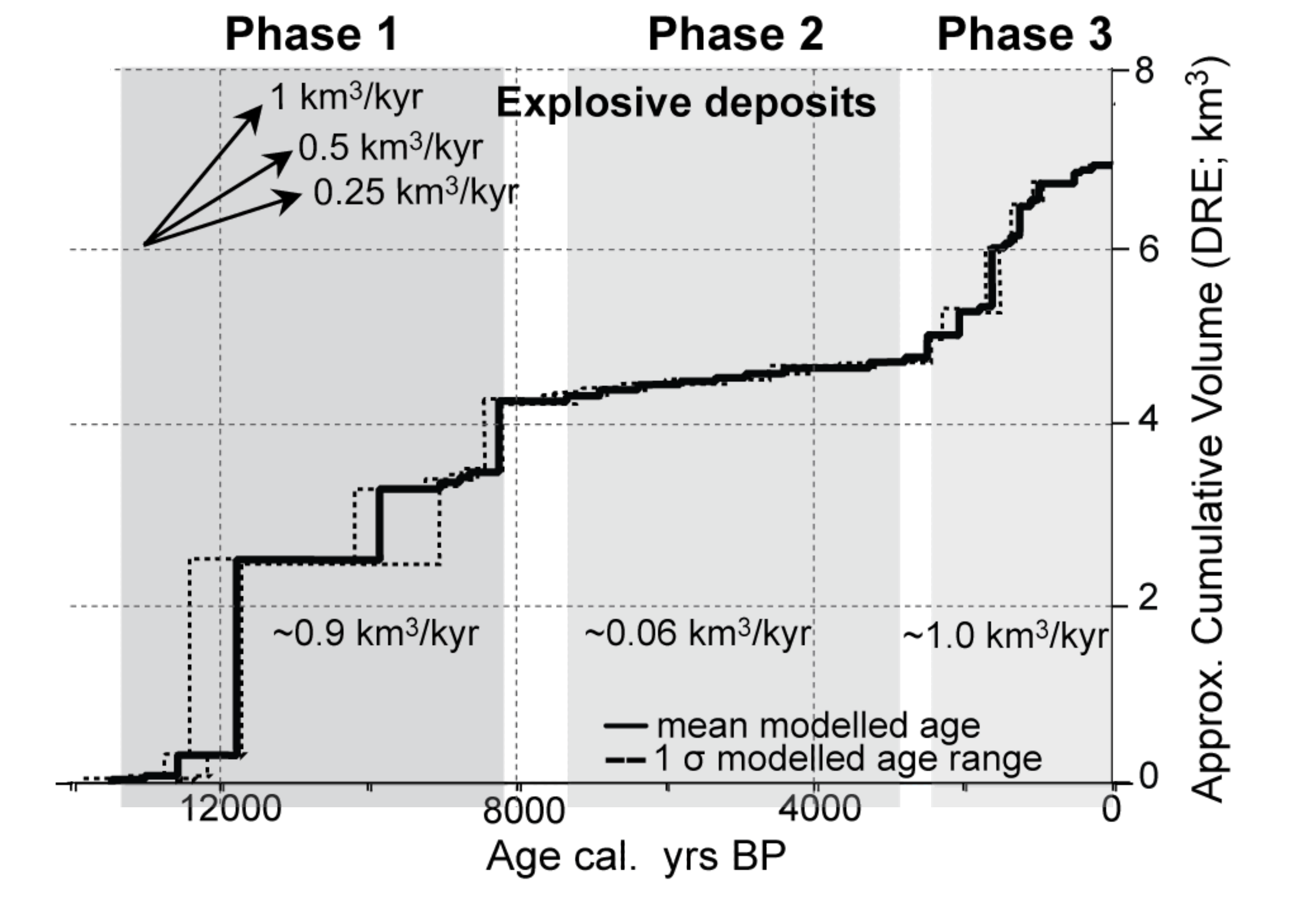
Rawson et al. JVGR (2015)

Case Study: Mocho-Choshuenco



Rawson et al. JVGR (2015)

Eruption Flux



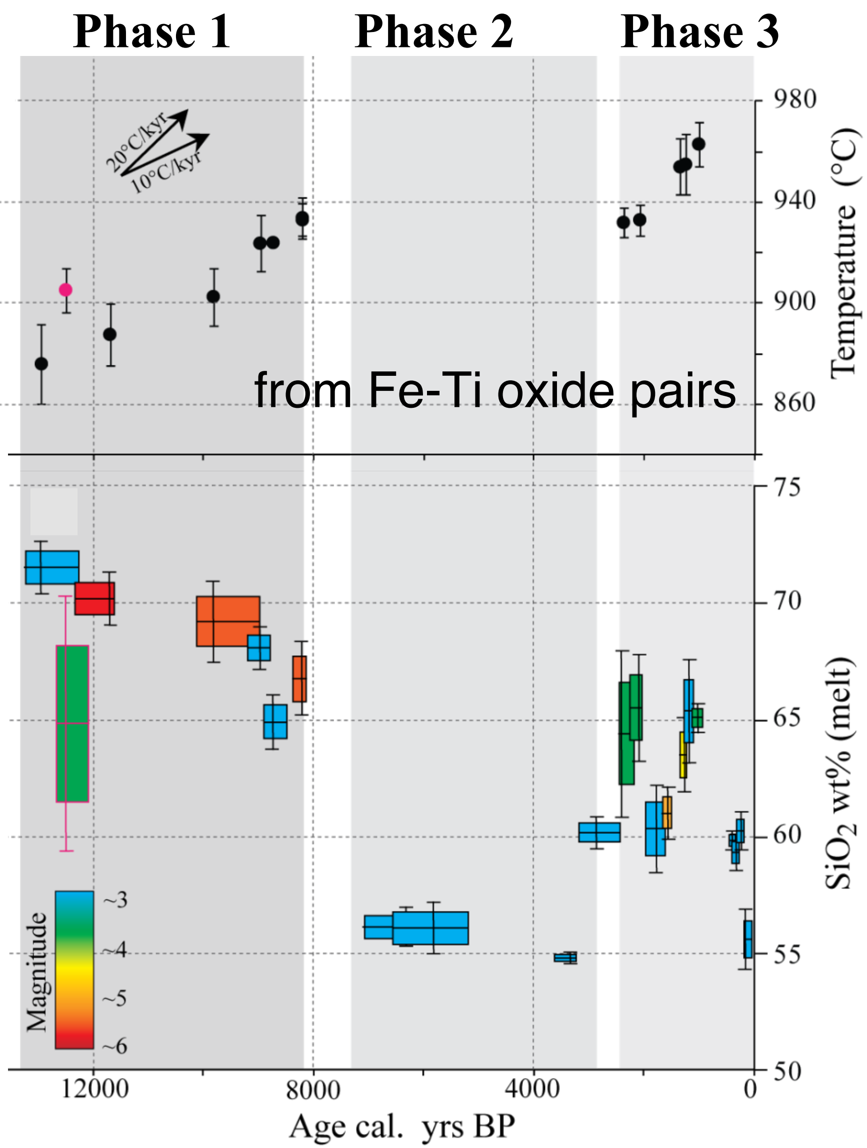
Can use edifice volume to approximate effusive flux (~0.5 km^3/kyr) and composition to approximate intrusive flux.

Temperature, magnitude and composition

- System is warming

(pink symbol mixing rather than FC)

- Erupted melts are becoming more mafic (less evolved)



Data from Rawson et al. (2015; JVGR)

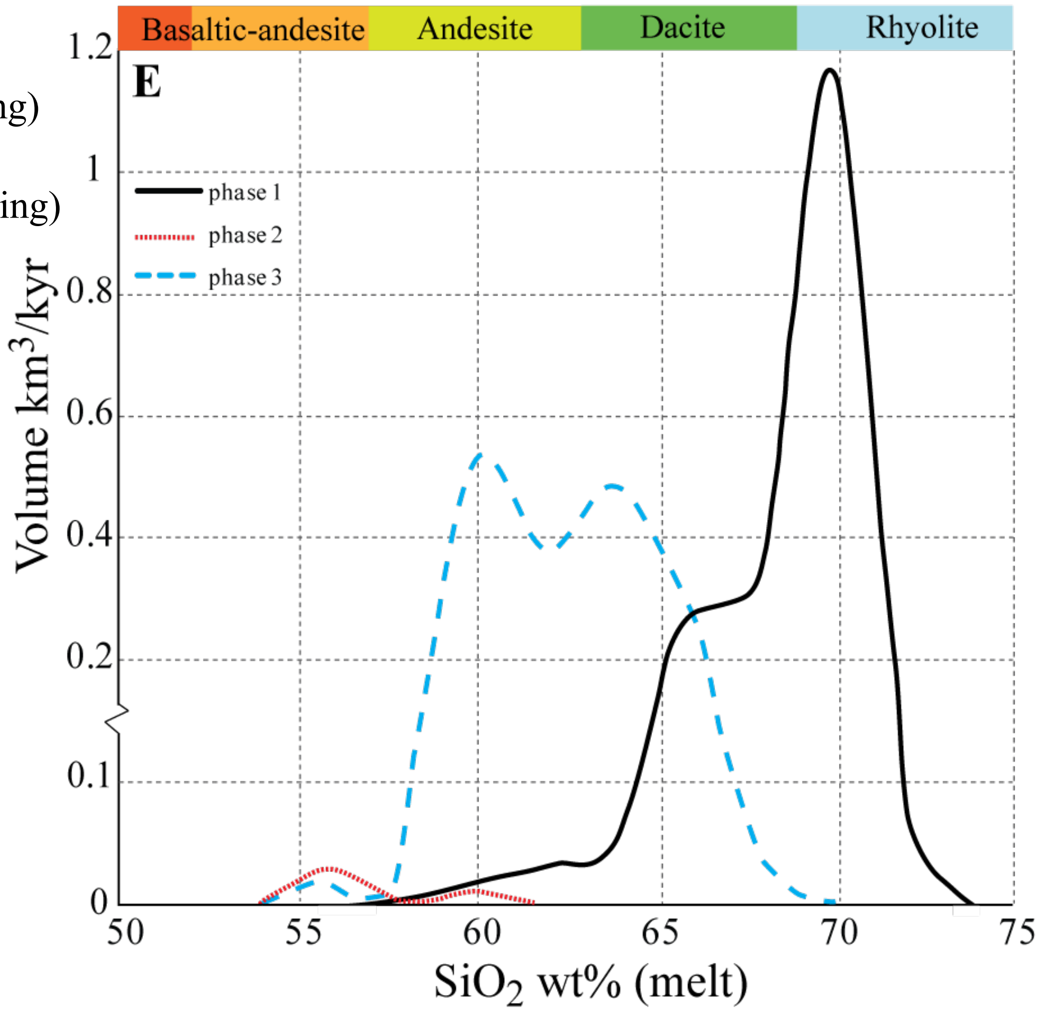
Melt composition

- Phase 1- Evolved (most crustal processing)
- Phase 2- Primitive (least crustal processing)
- Phase 3- Intermediate

Magma supply rate required to sustain the eruptive fluxes:

Greatest in Phase 1

Smallest in Phase 2



Normalised by eruption volume, number of analyses and phase duration

Summary of observations at M-C

Phase 1

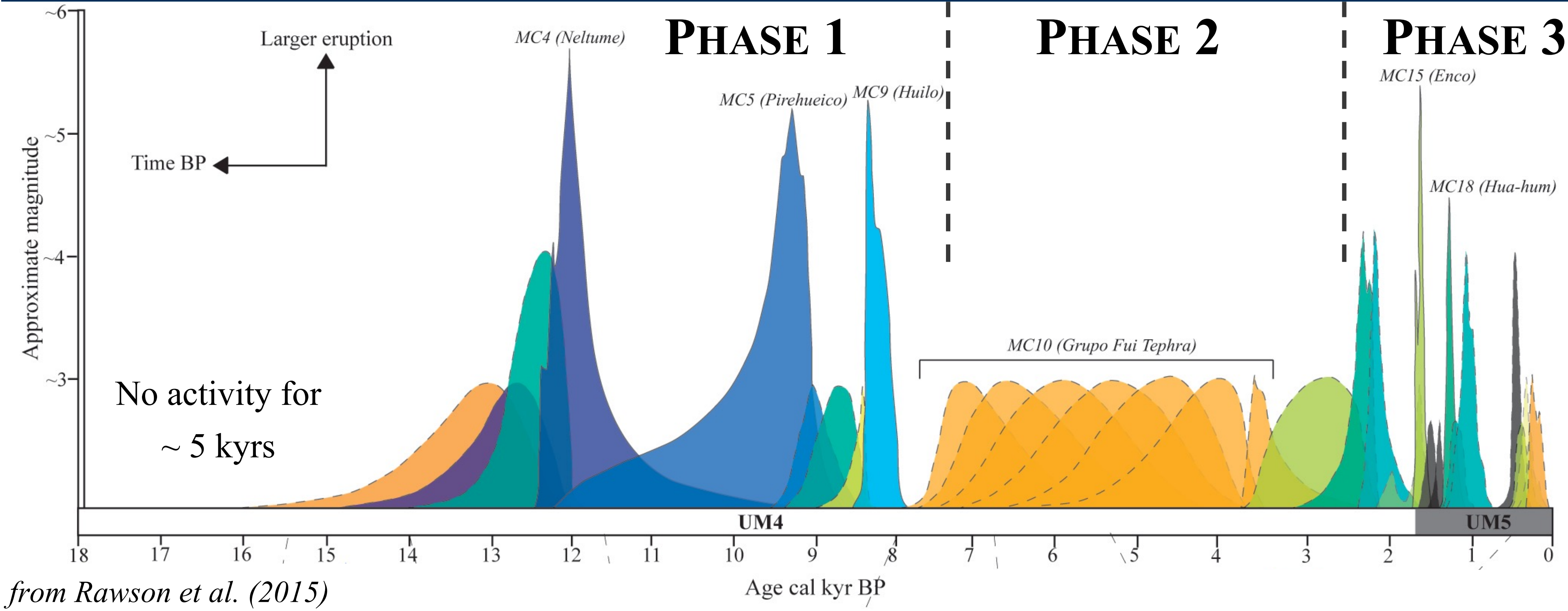
- Evolved (most crustal processing)
- Large eruptions
- Low eruption frequency
- High magma supply rate

Phase 2

- Mafic (least crustal processing)
- Small eruptions
- Moderate eruption frequency
- Low magma supply rate

Phase 3

- Intermediate
- Range of eruption sizes
- High eruption frequency
- Moderate magma supply rate



from Rawson et al. (2015)

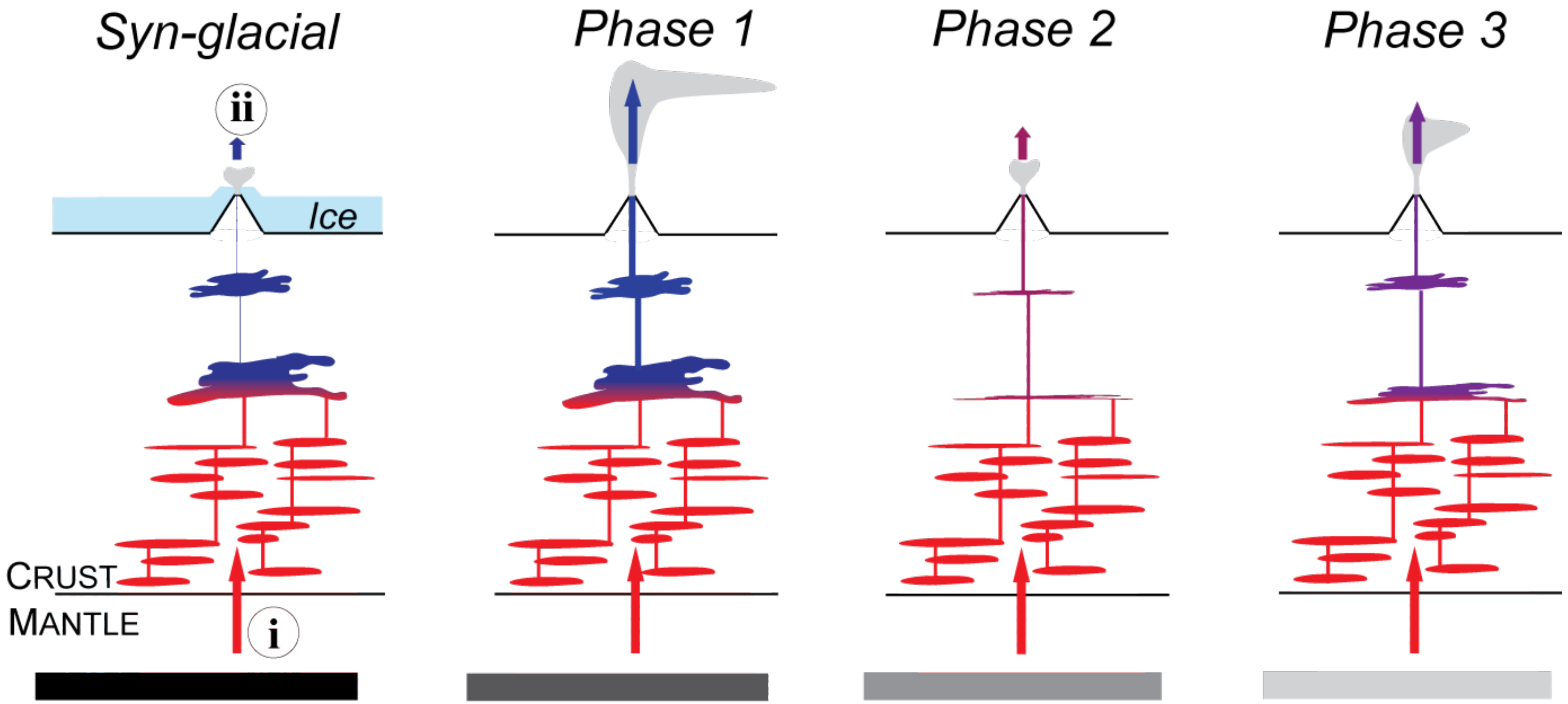
Influence of glacial unloading

1. Changes in magma flux *into* the crust with time?
   - In subduction setting melting rates are thought to be governed primarily by subduction inputs and parameters
   - Make first order assumption magma fluxes *into* the crust are approximately constant

2. Changes in timescales of magma storage *within* the crust
   - Ice unloading will change the regional stress field, which influences dyke formation
   - Ice load will cause magma to "stall" leading to magma accumulation in the crust during glaciation
   - Unloading during deglaciation enables dykes to form/widen

Jellinek et al., 2004

The Hypothesis



Syn-glacial

PHASE 1
'Evacuation'

PHASE 2
'Relaxation'

PHASE 3
'Recovery'

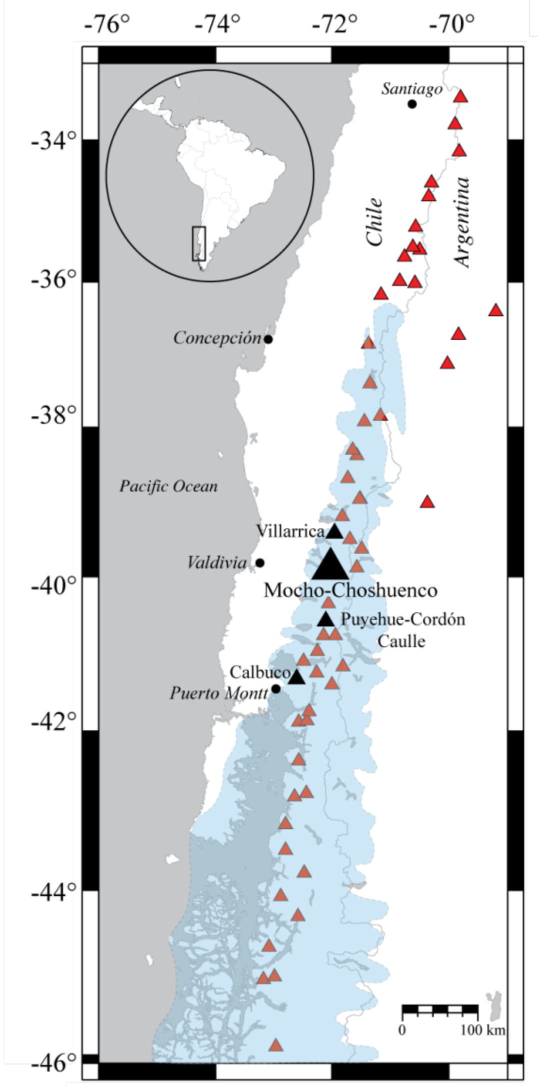
magma accumulates forming large volumes of differentiated magma

large evolved eruptions drain the crustal storage system

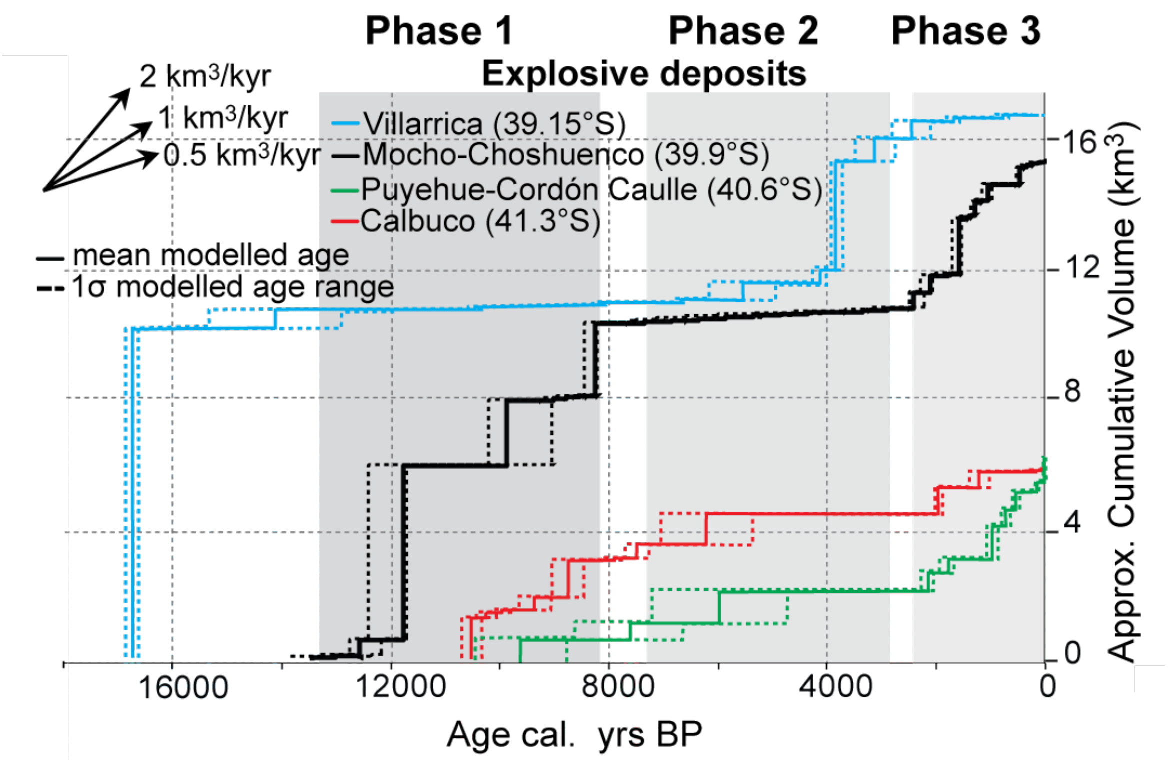
mafic magmas are able to infiltrate to shallower levels in the crust

system starts to refill and recover

Neighbouring Volcanoes



Map adapted from Watt et al. 2013



- First activity dependent on timing of deglaciation
- Cumulative volumes exhibit same temporal changes

Summary:

Rawson et al., Geology, April 2016

- Significant changes in eruption behaviour on millennial timescales

- Eruption size and frequency, magma composition and temperature etc.
- E.g., from periods of large, evolved eruptions to small mafic eruptions
- Requires high resolution records to see temporal changes

- Changes in timescales of magma storage *within* the crust?

- Explains temporal variations
- Maybe driven by changes in the crustal stress regime due to glaciation
- The magnitude of these variations will differ between volcanoes

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