Counting currents: correlating flow units to understand how pyroclastic density currents wax and wane in time and space

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Counting currents: correlating flow units to understand how pyroclastic density currents wax and wane in time and space

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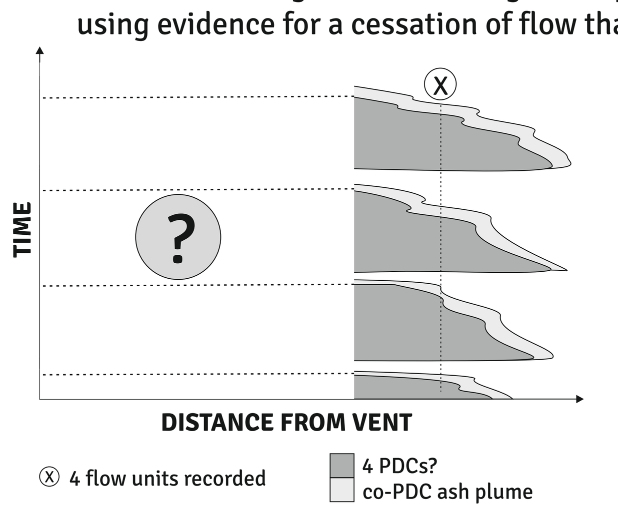
The challenge

- Pyroclastic density currents (PDCs) are inherently unsteady and non-uniform in time and space.
- A full picture of PDC behaviour is important for hazard analysis, but rare due to a lack of proximal exposures.

How does unsteadiness impact our interpretation of the number of hazardous PDCs generated during an eruption?

The number of PDCs generated during an eruption has typically been interpreted using evidence for a cessation of flow that defines discrete "flow units"



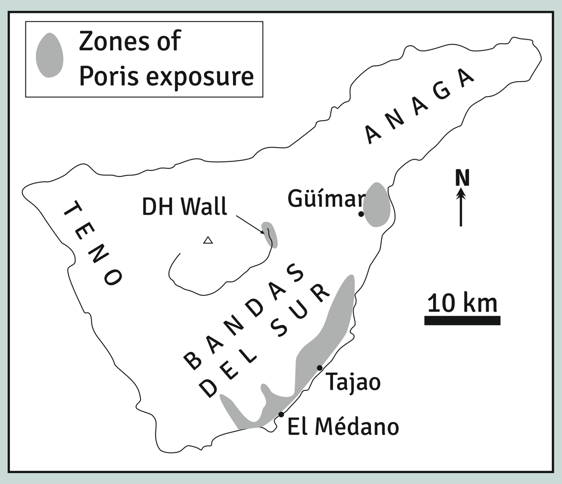
At location X, 10s km distal from the vent, ignimbrite stratigraphy may contain multiple ash fallout layers that could be interpreted as evidence for multiple discrete PDC events. But can we make a reliable interpretation of PDC history based upon distal exposures alone?

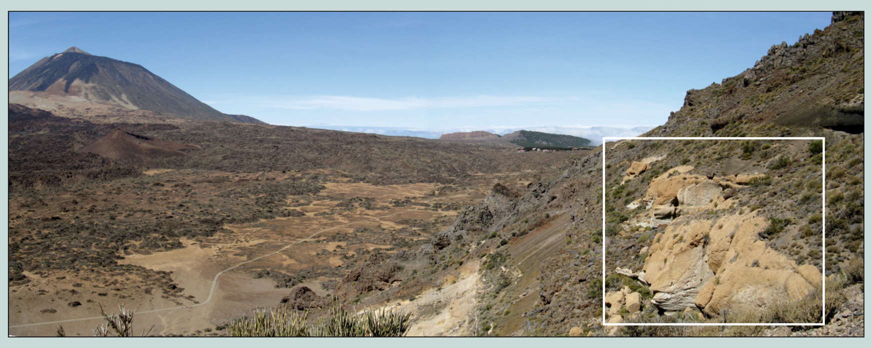
The approach

This study interrogates unsteady PDC behaviour by correlating proximal and distal counterparts of the well-exposed 273 Ka Poris ignimbrite on Tenerife. Previous work indicates that the only one flow hiatus is recorded in the proximal[1] succession, whereas the distal[2,3] succession records at least three.

Correlation was achieved by:

- X-Ray fluorescence analysis of pumice material.
- Identification of temporal correlatives in lithofacies architecture (entrachrons[4]).

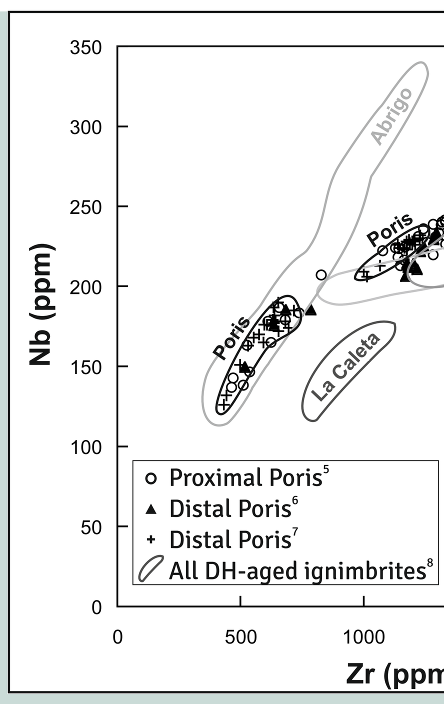




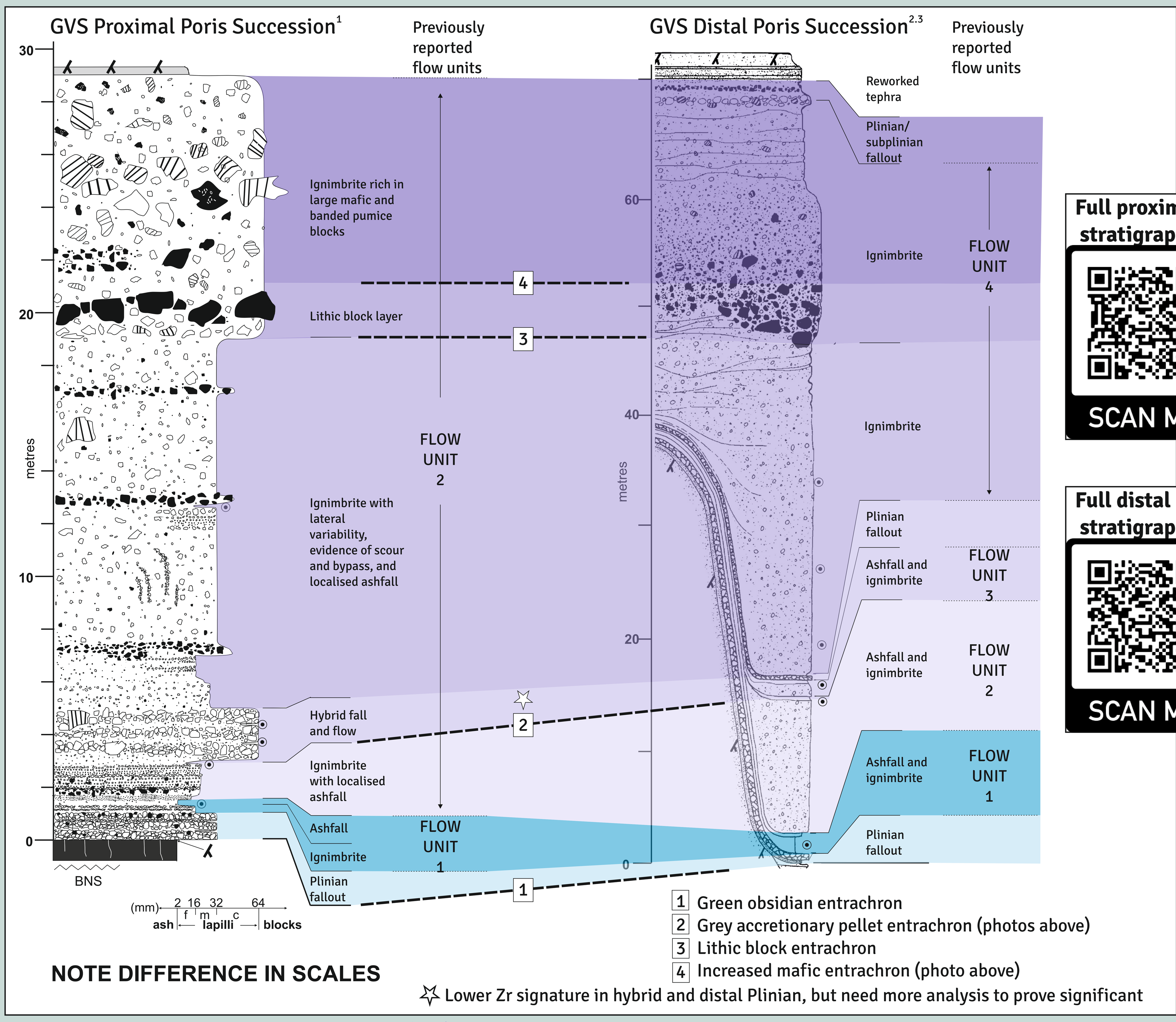
Tenerife map shows location of distal Poris outcrops in the Bandas del Sur and proximal Poris outcrops in the Diego Hernandez (DH) wall. Photo shows part of the proximal succession (box).

Correlating PDC deposits

Temporal correlatives included green obsidian clasts, distinctive grey accretionary pellets, and influxes of lithic blocks and mafic pumice. Two widespread distal ash beds were found to correlate to proximal ignimbrite.



The proximal record was proven to be equivalent to the distal record using XRF analysis of pumice samples.



Full proximal stratigraphy: SCAN ME

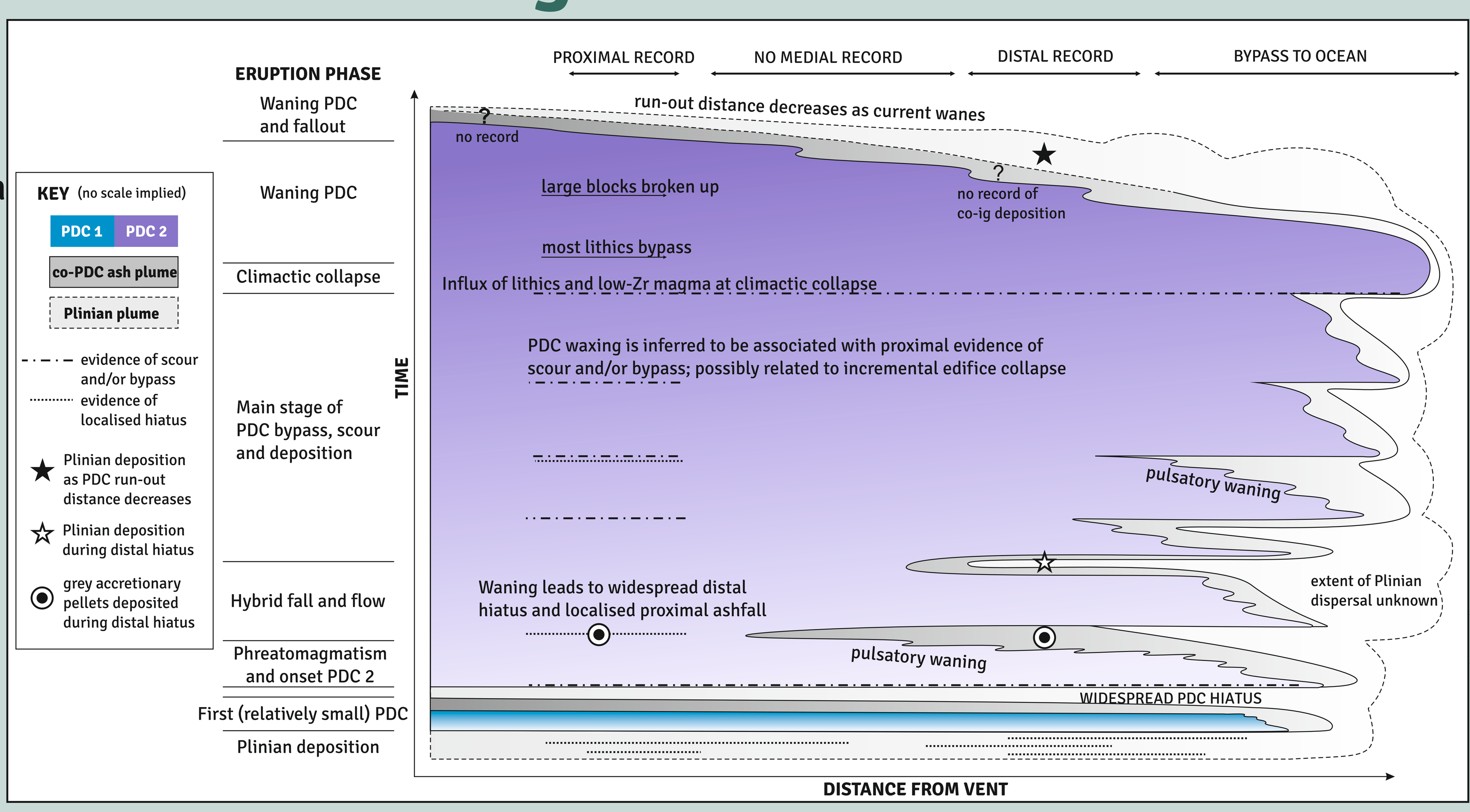
Full distal stratigraphy: SCAN ME

Implications for understanding hazards

The Poris record was generated by two PDCs (relatively small then large and unsteady) and not four, as the distal succession alone would indicate.

Distal hiatus can occur as a result of PDC waning and reduced runout, with flow continuing proximally. PDC waxing is likely related to changes in eruption mass flux.

This work highlights the caveats of using flow units to understand the number and behaviour of PDCs generated during ancient eruptions.



Future work

Potential questions for future research:

- Can we model PDC unsteadiness using an experimental flume set-up?
- Can we reproduce patterns observed in the rock record using analogue modelling of pulsatory PDCs?
- Can we geochemically fingerprint the stages of unsteady PDC deposition to understand links between current dynamics and chemical change?

- How does the interaction of different batches of magma during an eruption influence mass flux and hazard dynamics?

Waxing and waning of pulsatory PDCs can cause temporary hiatus, leading to a conflicting record of PDC activity in proximal and distal areas. The use of flow units to interpret the number of PDCs generated during an eruption should therefore be carried out with caution.

[1] Smith and Kokelaar (2013) Bull Volc 75:768
[2] Brown and Branney (2004) Bull Volc 66:392
[3] Brown and Branney (2013) Bull Volc 75:727
[4] Branney and Kokelaar (2002) Geol Soc Mem 27
[5] Smith, Thesis (2012)
[6] Brown, Thesis (2001)
[7] Edgar et al. JVGR (2002)
[8] Edgar et al. JVGR (2007)