PLINIAN AND SUBPLINIAN ERUPTIONS

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A FIELD PERSPECTIVE

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DEFINITION

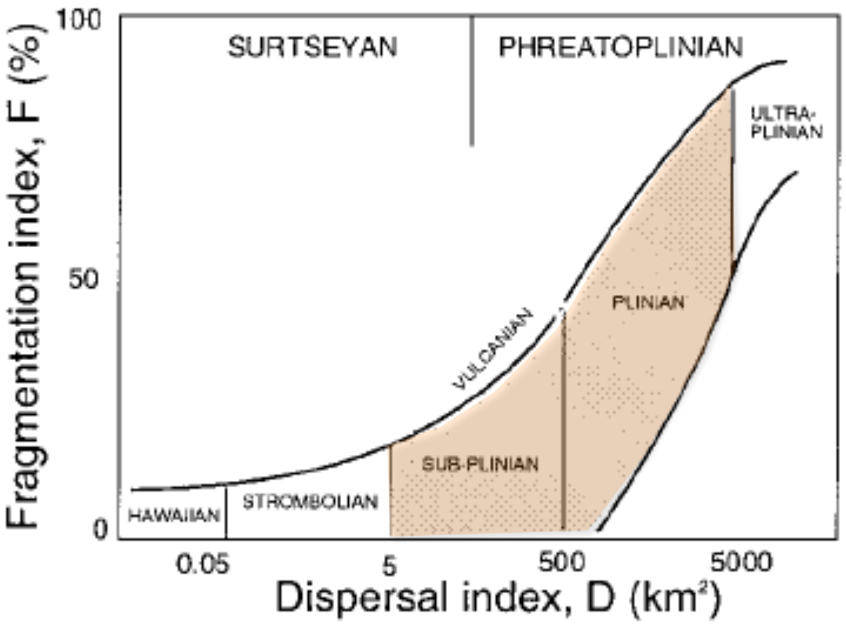
- PLINIAN: explosive eruptions characterized by the sustained, quasi-steady, hours-lasting discharge into the atmosphere of a high-temperature, multiphase mixture (gas, solid and liquid particles), forming a convective vertical column that reaches heights of tens of kilometers before spreading laterally.

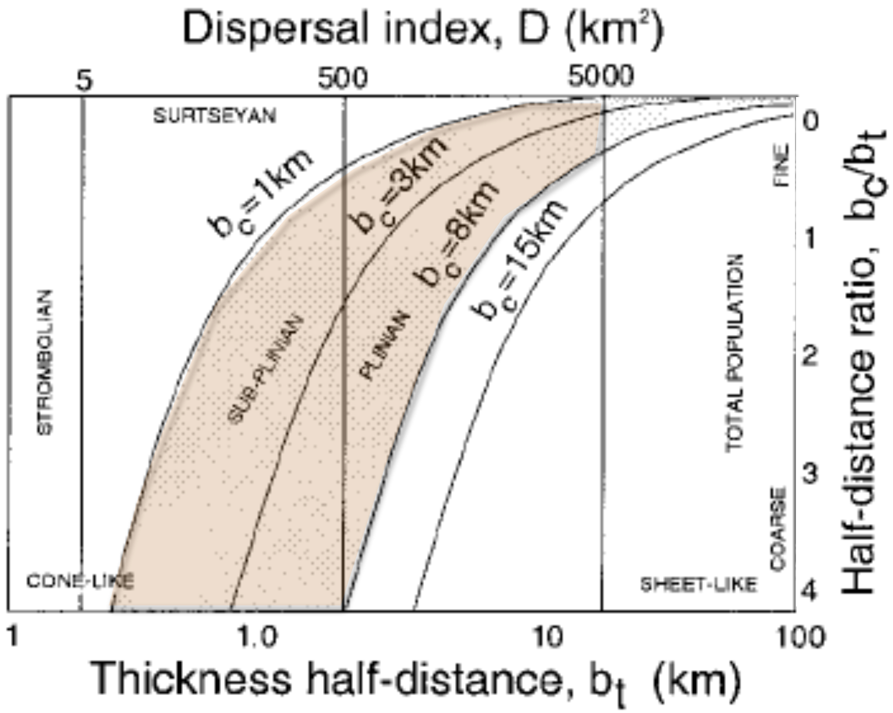
- DIFFERENCE BETWEEN PLINIAN AND SUBPLINIAN EVENTS IS GENERALLY CONSIDERED AS A MATTER OF SCALE AND A LARGER UNSTEADYNESS OF SUBPLINIAN EVENTS

Main features of Plinian-type eruptions

Type of eruption	*Subplinian*	*Plinian*	*ignimbritic*
Magnitude (kg)	$\approx 10^{11}$	10^{11}–10^{13}	$>10^{13}$
Intensity (kg/s)	$\approx 10^{6}$	10^{6}–10^{8}	$>10^{8}$
Column height (km)	<20	20–35	>35
Thickness half-distance (b_t, km)	0.5–4	2–10	>10
Clast half-distance (b_c, km)	1–3	3–8	8–15
Main phases	Unsteady sustained, convective column	Steady sustained convective column	Sustained fountaining
Associated eruptive styles	Surge generation, dome extrusion	Partial or total column collapse	Convective column with increasing flow rate
Dominant fallout deposits	**From thinly stratified to massive**	Massive to variously graded	Generally reversely graded
Dominant flow deposits	Surges and small sized pumice and scoria flows	Pumice and ash flows	High and low-grade ignimbrites
Fall/flow vol. ratio	>1	>1	$\ll 1$

Classification schemes





PLINIAN COLUMNS

CORDON CAULLE 2011 (CHILE)

PLINIAN ERUPTIONS: main problems

No serious problem of classification for plinian (s.s.) phases

- Classification based on dispersal of deposits (D index, Bt, Bc, etc.)
- Deposits can be studied and correlated over long distances
- MDR and other physical parameters can be estimated

WHY TO DISCUSS ABOUT THEM?

DEFINITION

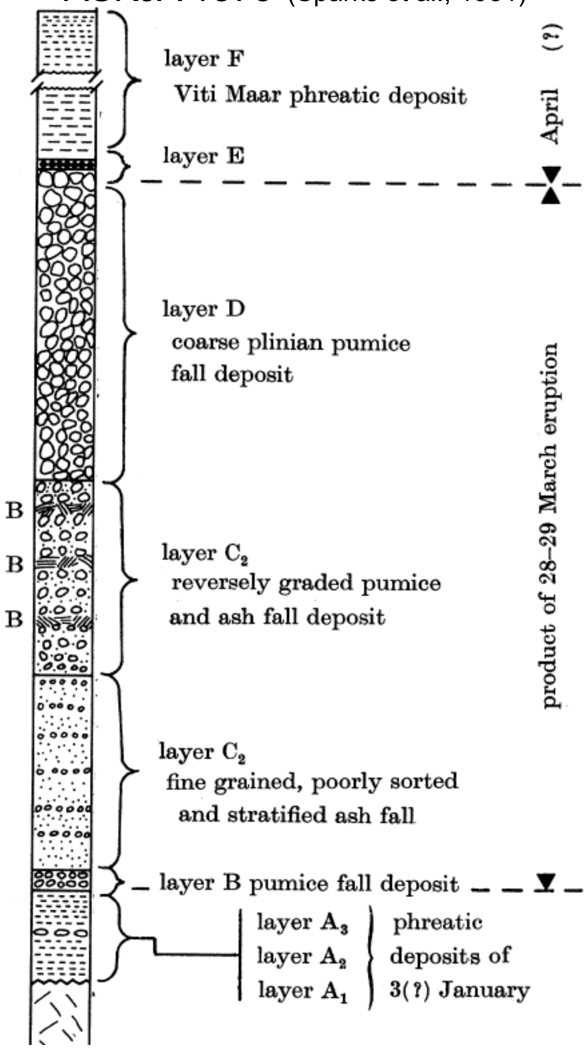
- COMPLEX EVENTS: although they always include a quasi-stationary phase, plinian (s.l.) eruptions may consist of a fairly rapid succession of volcanic pulses, in which phases of sustained convective plumes alternate with phases dominated by collapsing conditions and pulsatory explosive phases of different style, intensity and dynamics (vulcanian explosions, phases of prolonged ash emission, phreatomagmatic explosions, emission of lava flows or domes).

PLINIAN ERUPTIONS: how can be better describe them?

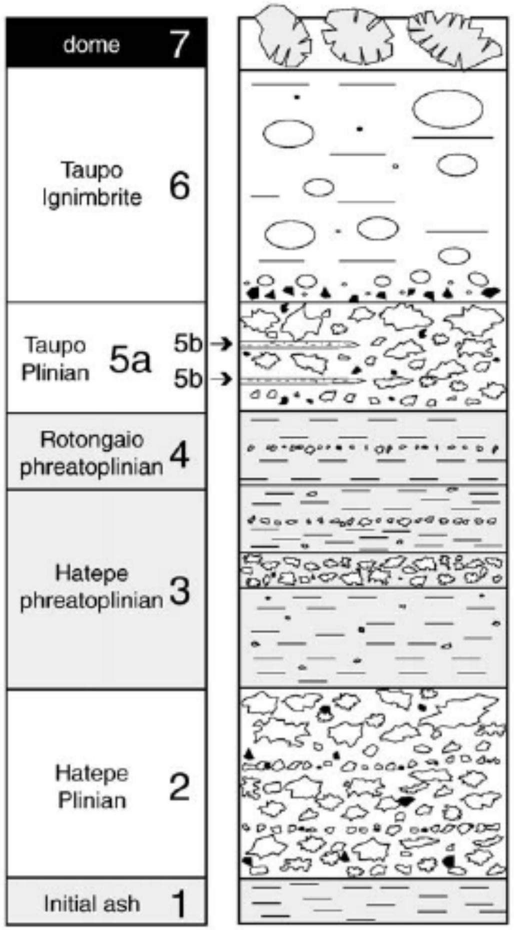
- Generally complex eruptions, with alternating phases of different style
- Deposits suggest different types of plinian pulses

PLINIAN ERUPTIONS: complex sequences

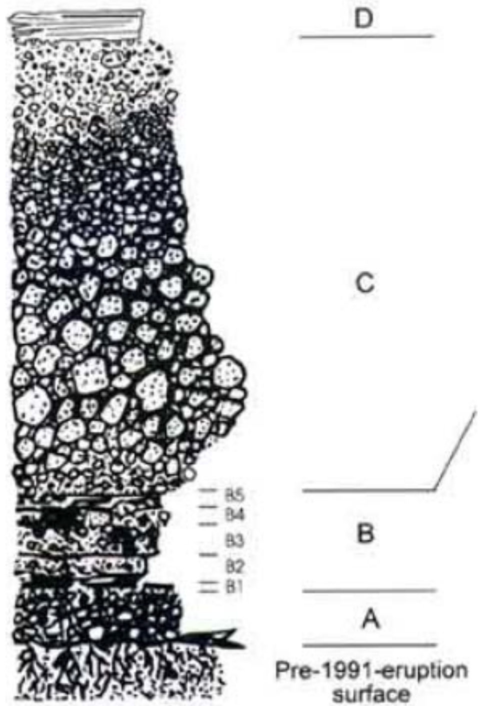
ASKJA 1875 (Sparks et al., 1981)



1.8 ka TAUPO (Houghton et al., 2010)



PINATUBO 1991
(Paladio-Melosantos et al. 1995))



PLINIAN ERUPTIONS: complex sequences

AD79 VESUVIUS – OPLONTIS EXCAVATIONS

Can we better describe Plinian deposits?

- Based on vertical grain size variations, Plinian deposits can be subdivided into three main categories:

  - *simple*
  - *stratified*
  - *multiple*

Rosi (1996)

Simple Plinian fall deposits

- Result from the accumulation from stable convective columns

- From non-stratified to weakly stratified, grain-size grading possible

- Example:
  - AD79 white,Vesuvius;
  - Minoan Plinian, Santorini
  - Pinatubo C, Philippines

Stratified Plinian fall deposits

- Derive from an unsteady, oscillating eruptive column, often alternating convective and collapsing phases
- Different fall beds separated by sharp grain-size variations
- Examples:
  - AD79 Grey, Vesuvius;
  - Taupo Plinian

Multiple Plinian fall deposits

- Different fall beds produced by discrete, short-lived Plinian columns
- Beds can be deposited under different wind conditions
- Examples:
  - El Chichon 1982, Mexico
  - Askja 1875, Iceland

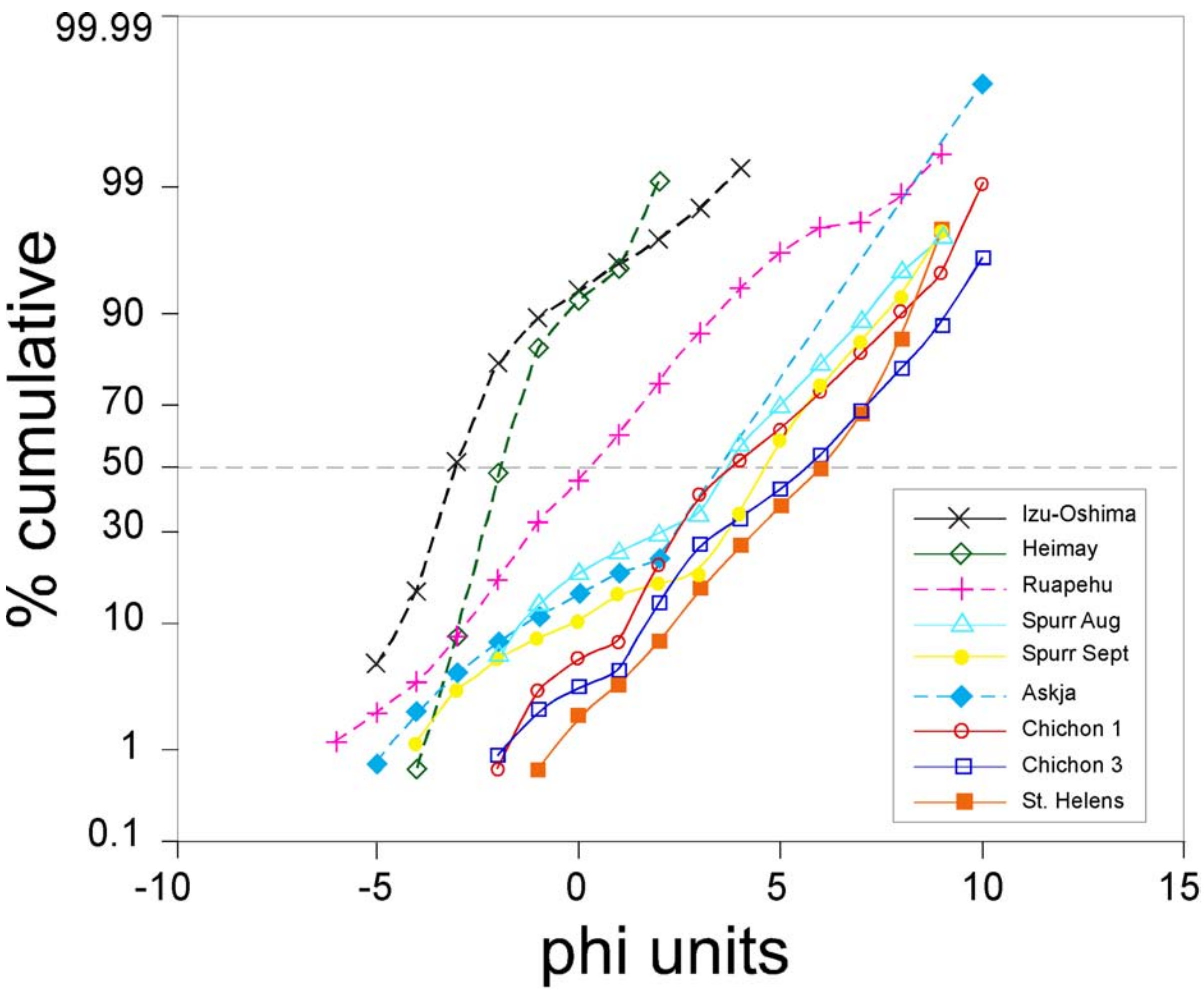
PLINIAN ERUPTIONS: how can be better describe them?

SOME PARAMETERS ARE DIFFICULT TO ESTIMATE

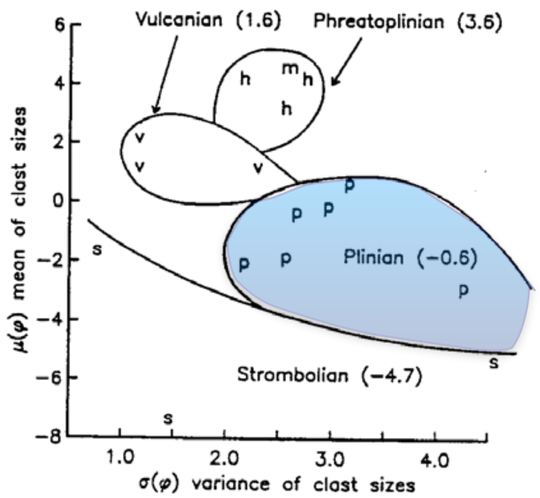
- Problems with volume calculations
  - volume from classical methods strongly differ from those used to estimate vitric ash lost (v.a.l. is about 60 wt% of the total!!)

- Problems with estimation of total grains size distribution
  - Is TGSD strongly bimodal? Is a fine population totally missing from our estimations?

Plinian and Subplinian TGSD

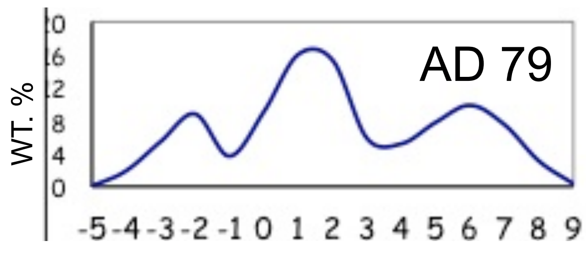


Redrawn from Rust and Cashman, 2011



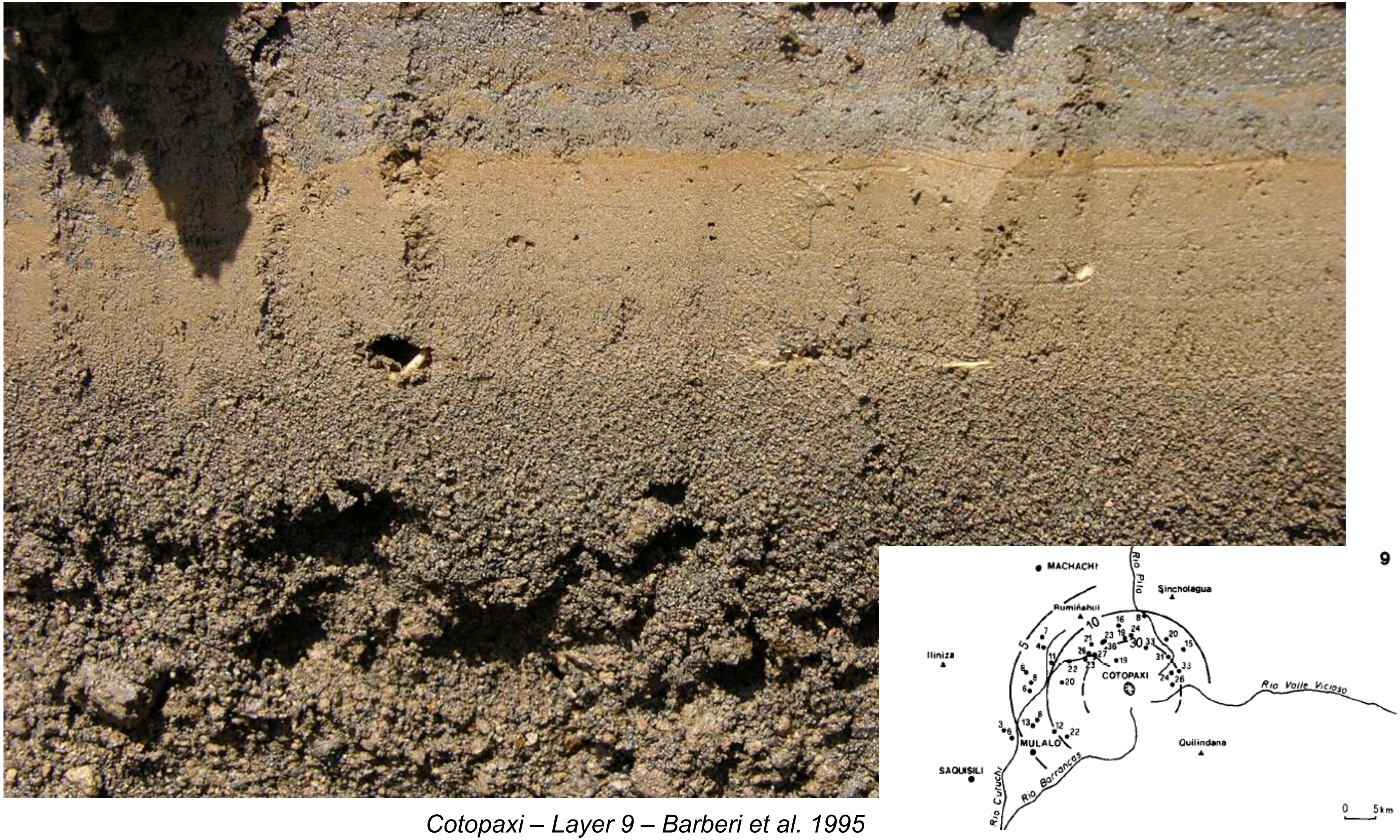
Woods and Bursik, 1991

VERY FEW DATA ON TGSD: STRONGLY POLIMODAL?



Cioni, unpublished

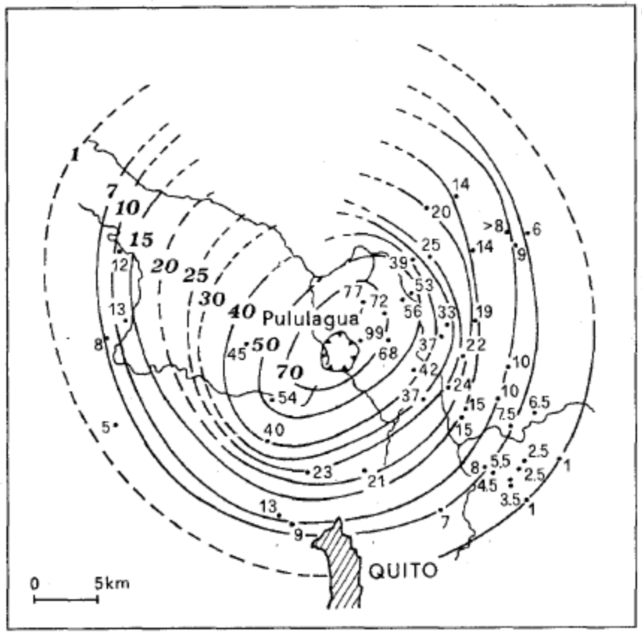
How can we better estimate TGSD (and volume)? Co-plinian ash

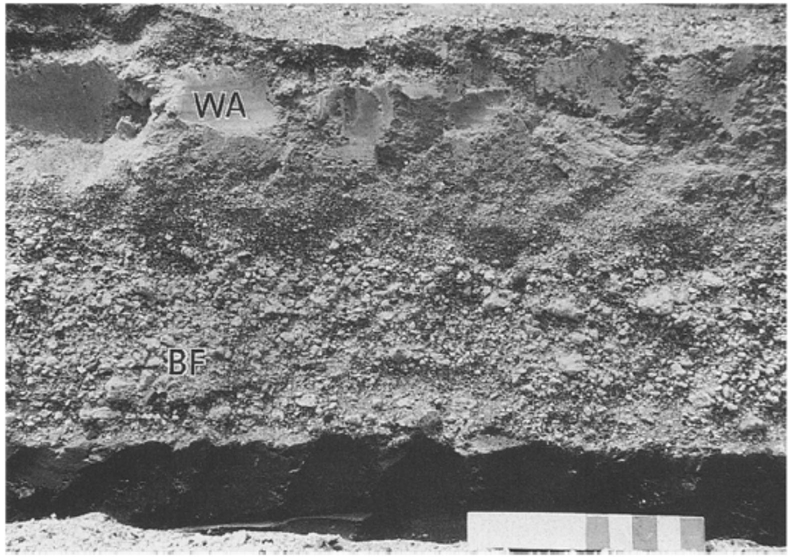


Cotopaxi – Layer 9 – Barberi et al. 1995

Co-Plinian ash

THE STUDY OF WELL PRESERVED DEPOSITS DISPERSED IN NO-WIND CONDITIONS COULD BE CRUCIAL FOR THE ASSESSMENT OF UNCERTAINTIES IN TGSD AND VOLUME ESTIMATIONS OF PLINIAN DEPOSITS





The Pululahua (Ecuador) Basal Fall (BF) and the co-Plinian ash (WA) *Rosi and Papale (1993)*

SUBPLINIAN ERUPTIONS

- LARGELY VARIABLE FEATURES OF THE DEPOSITS:
  - MASSIVE, PUMICE- OR SCORIA-BEARING

CORDON CAULLE 2011 (CHILE)

AD472 POLLENA (VESUVIUS)

SUBPLINIAN ERUPTIONS

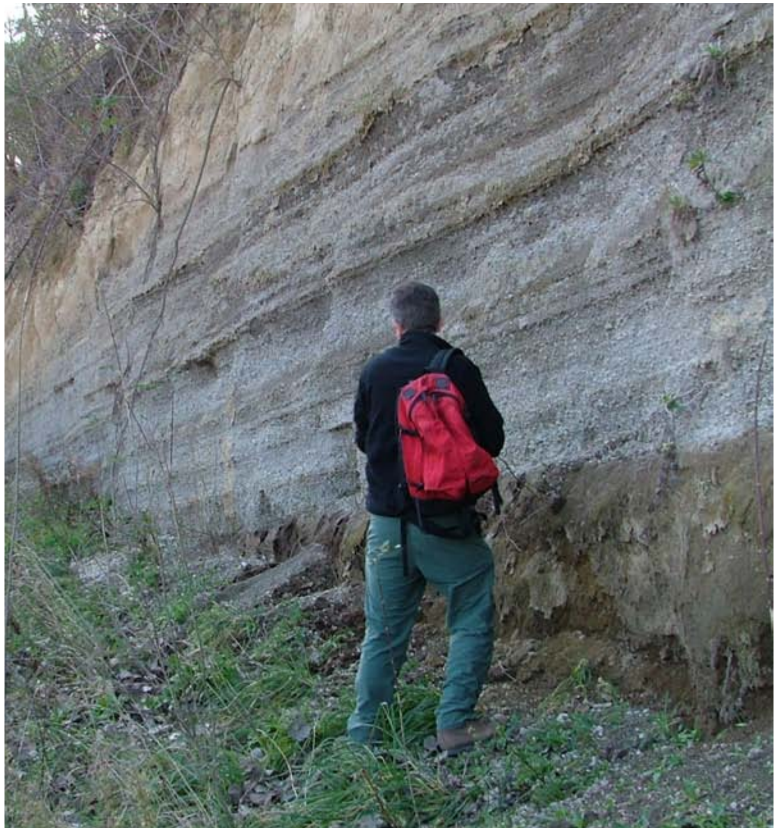
- LARGELY VARIABLE FEATURES OF THE DEPOSITS:
  - MASSIVE, PUMICE- OR SCORIA-BEARING

G.PICHICNHA 1660 (ECUADOR)

AD1906 (VESUVIUS)

SUBPLINIAN ERUPTIONS

- LARGELY VARIABLE FEATURES OF THE DEPOSITS:
  - STRATIFIED TO THINLY BEDDED



16 ka GREENISH (VESUVIUS)

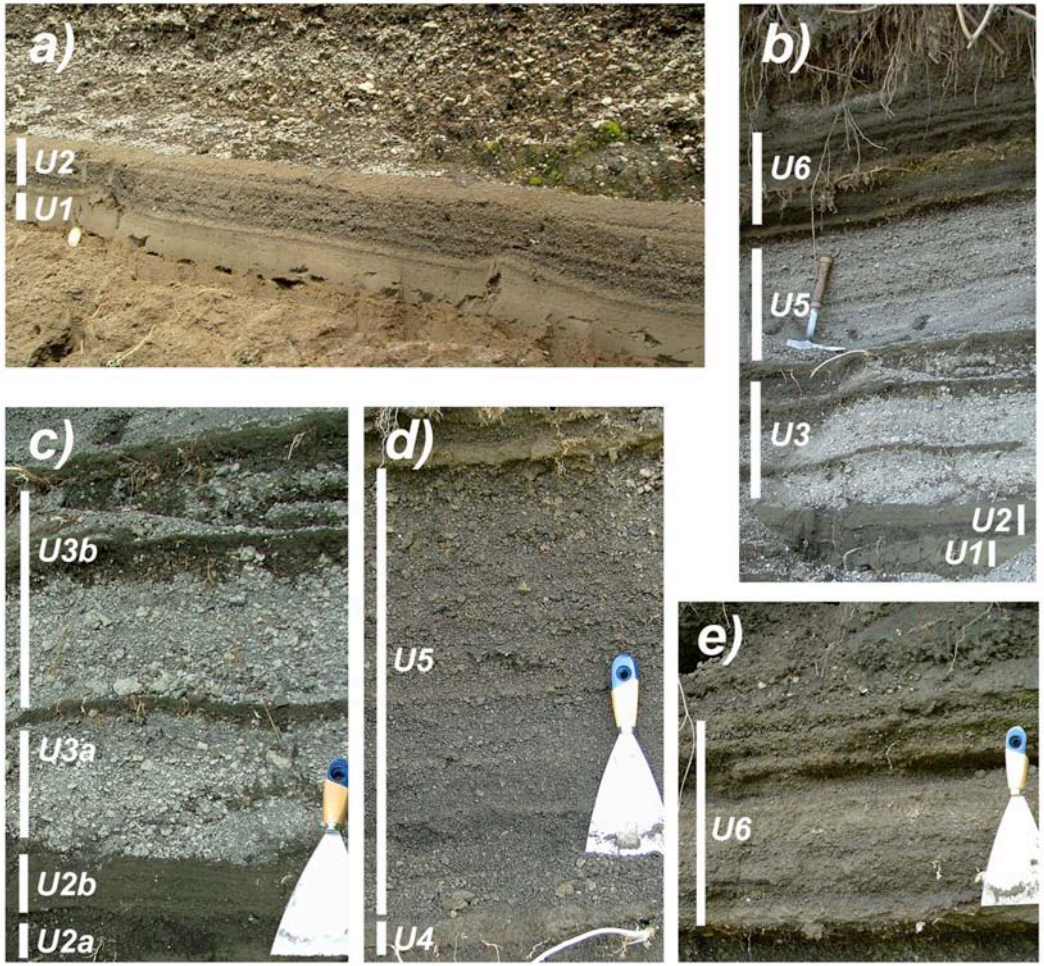
SUBPLINIAN ERUPTIONS

- LARGELY VARIABLE FEATURES OF THE DEPOSITS:
  - STRATIFIED TO THINLY BEDDED

512 AD (VESUVIUS)

SUBPLINIAN ERUPTIONS

- LARGELY VARIABLE FEATURES OF THE DEPOSITS:
  - COMPLEX SEQUENCES



AD 512 (VESUVIUS)

EU1-2 opening phase
EU3 stable subplinian
EU5 oscillatory subplinian
EU6 subplinian/violent strombolian

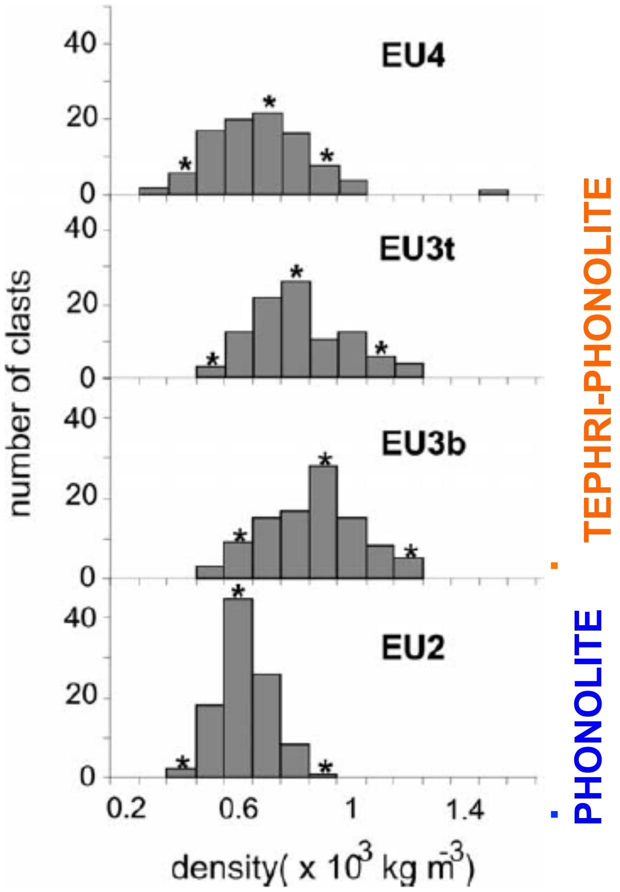
Are all these the "subplinian" phases the result of similar processes?
How should we describe and classify all these phases?

Cioni et al., 2011

CLAST DENSITY

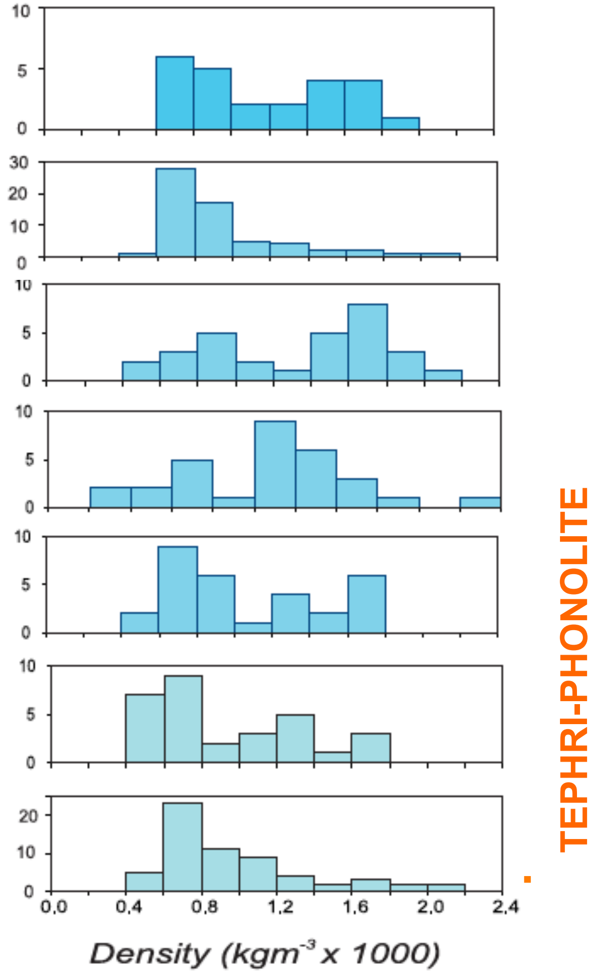
AD 79 Vesuvius - PLINIAN

Gurioli et al., 2004



AD 512Vesuvius - SUBPLINIAN

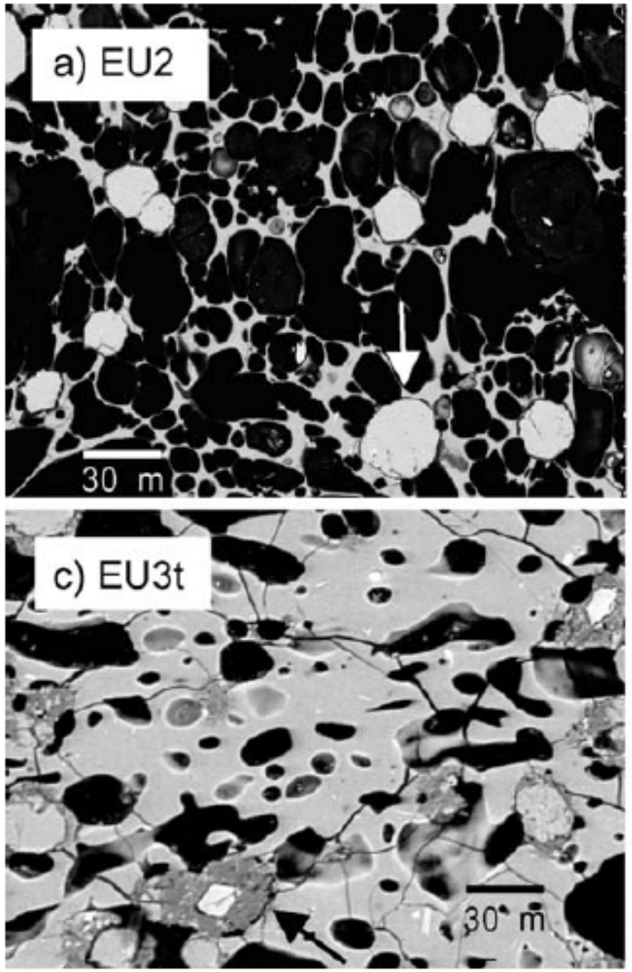
Cioni et al., 2011



Clast density of subplinian deposits is often polymodal

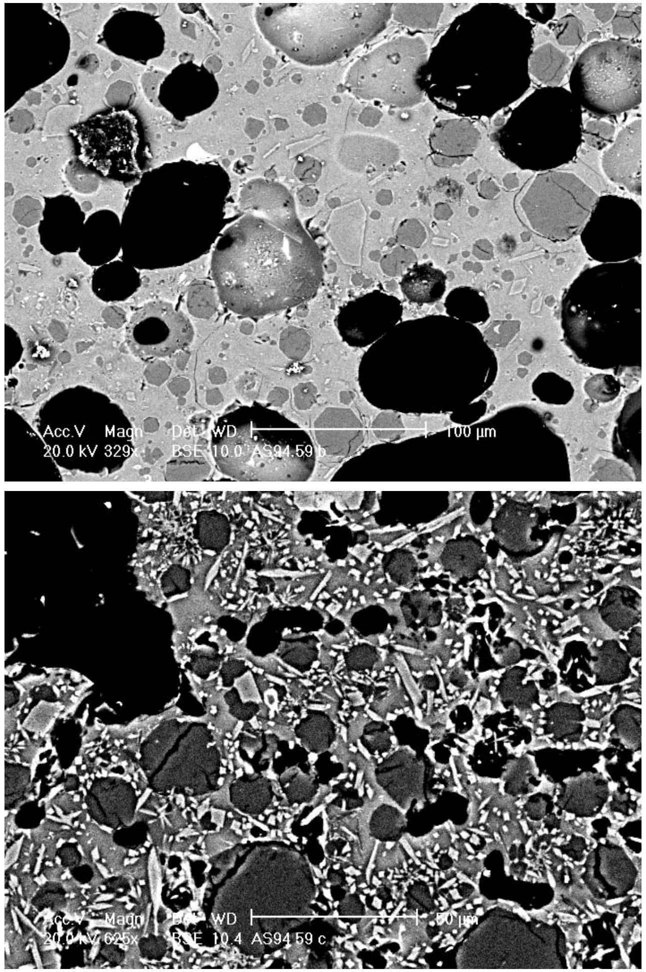
GROUNDMASS CRISTALLINITY

AD 79 Vesuvius - PLINIAN

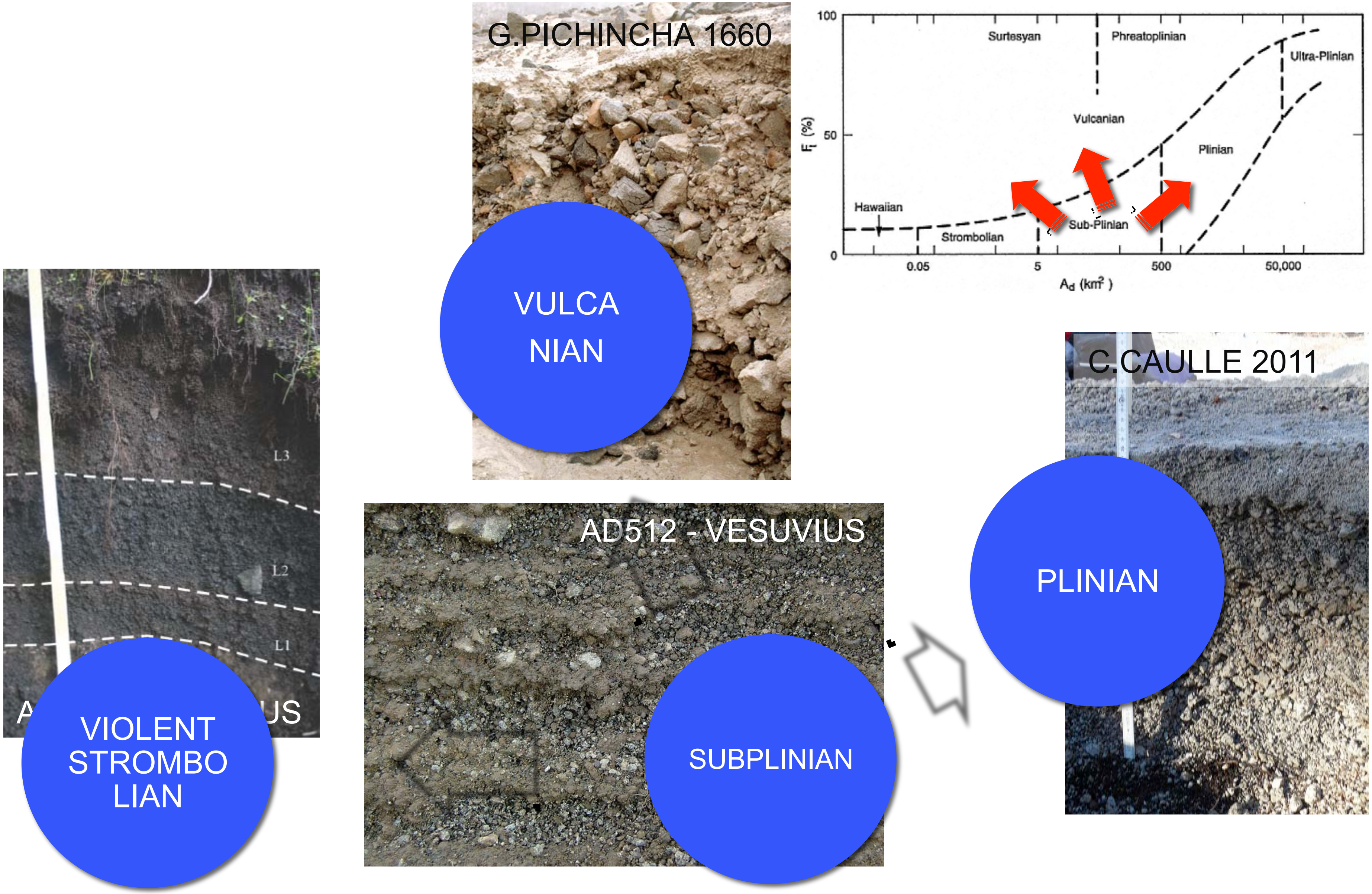


Gurioli et al., 2004

AD 512Vesuvius - SUBPLINIAN



Products from subplinan deposits are more crystal-rich than plinian ones



“SUBPLINIAN” DEPOSITS RECORD A LARGE RANGE OF ERUPTIVE STYLES

Time-scale of unsteadyness from deposits

LOW FREQUENCY INSTABILITIES (HOURS?)

Pre-minoan deposit – Santorini http://www.photovolcanica.com/

Time-scale of unsteadyness from deposits

LOW FREQUENCY INSTABILITIES (HOURS?)

MINOAN ERUPTION - SANTORINI

8 ka BP MERCATO - VESUVIUS

Time-scale of unsteadyness from deposits

INTERMEDIATE TO HIGH FREQUENCY INSTABILITIES (MINUTES?)

AD 512 - VESUVIUS

19ka BP GREENISH- VESUVIUS
9 KA P.PRINCIPALI – C. FLEGREI

SOME POINTS FOR DISCUSSION

- HOW CAN WE ADDRESS THE PROBLEM OF CLASSIFICATION OF DIFFERENT DEPOSITS WITH SIMILAR DISPERSAL (SUBPLINIAN S.L.)?
- WHICH ARE THE MOST IMPORTANT PARAMETERS TO BETTER DESCRIBE PLINIAN AND SUBPLINIAN ERUPTIONS?
- HOW CAN WE IMPROVE OUR CAPABILITY OF MEASURING VOLUME, TGSD, TIMESCALE OF UNSTEADYNESS

SOME POINTS FOR DISCUSSION

- PROBLEMS WITH CLASSIFYING COMPLEX ERUPTIONS: IS A PLINIAN ERUPTION A COMPLEX SEQUENCE FORMED BY DIFFERENT PULSES, OR SHOULD WE CLASSIFY SEPARATELY EACH DIFFERENT PULSE?

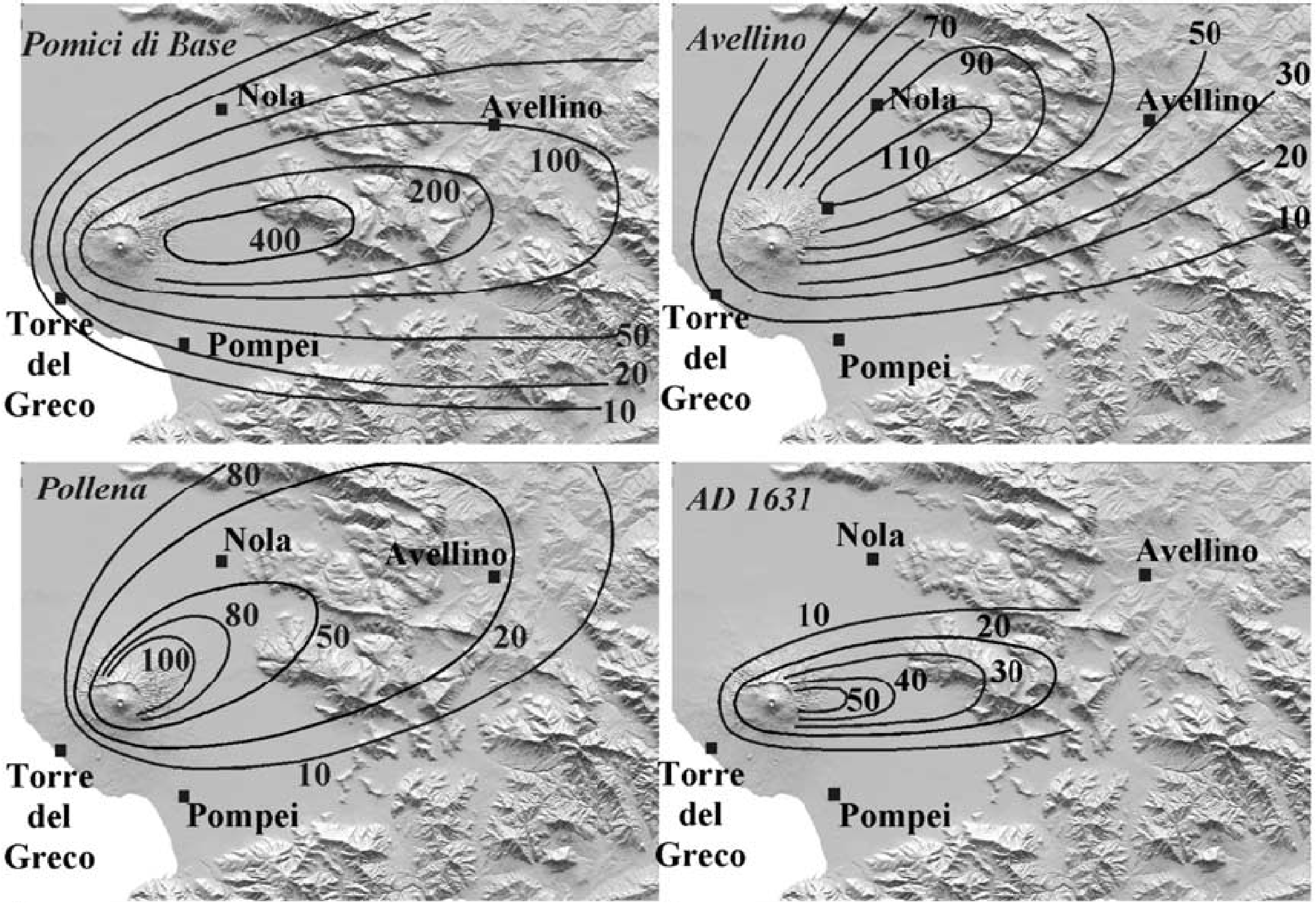
- HOW CAN WE DESCRIBE QUANTITATIVELY UNSTEADYNESS, AND WHICH ARE THE MAIN DRIVING PROCESSES?

POINTS FOR DISCUSSION:

CAN A VOLCANO-BASED CLASSIFICATION HELP IMPROVING OUR UNDERSTANDING OF PL& SUBPL?

PLINIAN

Cioni et al., 2003



SUBPLINIAN I

PLINIAN ERUPTIONS
“Volcano based” classification - Vesuvius

Eruption style	Composition	SiO_2 (wt%)	Alkali (wt %)	H_2O (wt %)	CO_2 ppm
Plinian	Trachyte	54 – 61	8 – 12.5	No data	No data
	Phonolite to T-Phon.	54 – 62	11 - 16	5-6(Avell)	0-2000
				6 (AD 79)	bdl
Sub-Plinian I	T-Phon. to P-Tephrite	48 - 52	11 – 16 (8 – 12 AD1631)	2.5 (salic)	0 – 200
				<5 (mafic)	2000
Sub-Plinian II	T-Phon. to P-Tephrite	48 - 54	8 - 11	No data	No data

Cioni et al., 2008

PLINIAN ERUPTIONS
"Volcano based" classification - Vesuvius

Eruption style	Column height (km)	Total volume (m^3)	Accum. Rate (cm/hour @ 10 km from vent)	Duration	Isopach 10 cm (km^2)	Density (kg/m^3)	100 kg/m^2 Distance (km)
Plinian	> 20	÷ 10^9	10 - 20	hours	> 1500	500 - 1000	÷ 100
Sub-Plinian I	15 - 20	÷ 10^8	5 - 15	hours	300 - 1000	800 - 1500	20 - 50
Sub-Plinian II	10 - 15	10^7-10^8	5 - 15	Hours - days	200	800 - 1500	15 - 25

Cioni et al., 2008