Pyroclastic transport and deposition

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Two main types of pyroclastic transport and deposit:

1. Fallout > deposit = tephra
2. Flow

Mt. St. Helens, 1980
Phonolitic fallout deposit, Meidob Hills, NW Sudan

Fallout layer between ignimbrites; Bandelier Tuffs, Jemez Mtns, New Mexico

Diagenetically compacted fallout deposit, Permian, N Chile
Laacher See, Eifel, W Germany, ballistic block

Lacustrine fallout deposit, Permian, N Italy

Various types of grading!

Fallout upon water - water-lain fallout deposits

Formation of pyroclastic flows:
- lava(dome) collapse
- eruption column collapse

Branney & Kokelaar 2002
Mt. Pelee, 1902/3, Martinique

Mt. Unzen 1991-1995

Block-and-ash-flow deposit: result of an explosive lava dome eruption

Meidob Hills, NW Sudan
Fig. 2.5 Stability fields for convecting and collapsing columns in terms of vent radius and magmatic volatile content. Magma discharge rate (right side) is largely a function of vent radius (left side) whereas exit velocity (bottom) is largely a function of volatile content (top) (Orton 1996, from Wilson, Sparks & Walker, 1980).

Parameters controlling eruption column collapse:

What drives pyroclastic flows?
    Kinetic energy, gravity, turbulence and fluidisation!

Large spectrum of processes and deposits:

    Cool          Hot
    dilute turbulent  hot dense
    often phreatomagmatic  weakly turbulent to laminar

Surges and cool pyroclastic flows s.s.
Hot pyroclastic flows s.s.

Ngauruhoe 1978, New Zealand
Surge deposits: pyroclastic cross stratification!

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G. Wörner
Laacher See, Eifel, W Germany

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Lithofacies types of surge deposits

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Ground surge deposit, E California
Se genera cuando la parte inferior de la CDP es lo suficientemente diluida (escasa a nula interacción de partículas) y la velocidad es muy baja (procesos de tracción o saltación). Las partículas caen directamente.

Características de los depósitos: Macizos y sin estratificación, aunque una débil fábrica direccional puede formarse si la velocidad es suficiente para orientar las partículas.

Branney & Kokelaar (2002)
Pyroclastic fractionation: >> important compositional changes in crystal-rich flows!

Gradation

Pyroclastic flow deposits may show various types of grading:

Accretionary Lapilli

Hailstone-like ash-aggregates from wet eruption clouds and co-flow-ash clouds,
Trigger by rain possible!
Vesiculated Tuff: surge/fall deposits from wet fine ash clouds

Osteifel

Professor!
Don’t forget to make some drawings about…

Proximal – distal facies variation
Lateral facies variation

Can pyroclastic flows climb mountains?
- kinetic energy from column collapse (e.g. Taupo, New Zealand)
- "expanded flow" concept (Branney & Kokelaar 1992) (e.g. Campanian Ignimbrite, Italy, Fisher et al. 1993)
Post-depositional processes in hot pyroclastic flow deposits:

1. welding compaction, in extreme cases: rheomorphism
2. gas + fluid escape >> vapor phase crystallisation
Eutaxitic texture

From Marcelo Arnosio

Parataxic texture

In hot thick deposits:
Adsorption of volatiles back into the glass >> disappearance of vesicles and interclast pores
(Sparks et al. 1999)

Post-depositional processes in hot pyroclastic flow deposits:

1. welding compaction, in extreme cases: rheomorphism
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Concept:
- Depositional unit
- Cooling unit

Smith 1961
Bishop Tuff, Owens Gorge, E California

Non-welded ignimbrite

"Sillar" Facies: lithification by vapor phase crystallisation; typical crystals in SiO₂-rich systems: cristobalite, tridymite, sanidine

Vapor phase crystals on ash fragment, SEM image (experiment by Grunder et al. 2005)

Deansing pipes

Fines-depleted
Partially eroded degassing pipes, Bishop Tuff, E California

Fig. 5.21. Occurrences of gas segregation structures in pyroclastic flows. 1. Pipes and pods generated either initially or formed entirely by intraflow gas sources during emplacement; 1a, formed by continued post-emplacement gas flow; 2, formed from heated ground water and incorporating fluviatile pebbles; 3, formed above brine evaporation and highs (From Cas & Wright 1987).

Fig. 5.20. Zones of vapour-phase crystallization and devitrification in the Bishop Tuff. Fumarole mounds project from top of vapour-phase zone through non-welded ash (From Cas & Wright 1987, after Sheridan 1970).

Sillar facies with fumarole mounds and curved cooling joints

Hydroclastic flow deposit (from collapse of a phreatomagmatic eruption column)

Szentbékálla, Hungary
How to distinguish a pyroclastic flow deposit from a sedimentary mass flow deposit?

Criteria for a hot emplacement
- welding-compaction (careful with diagenetic compaction (Branney and Sparks 1990) !)
- high T crystallisation domains: spherulites and lithophysae
- degassing pipes
- in-situ cooling joints in large lava clasts and lithics
- AMS

Problem: there are hot Lahars (e.g. Argudan and Rudolfo 1990)!