Tephra Fallout

Reading:
*Volcanic Successions*, Chapter 6

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**Parametric Equations**

\[
X = x_0 + v_x t \\
Z = z_0 + v_z t \\
Y = y_0 + v_y t - \frac{1}{2} g t^2
\]

Where \( x \) and \( z \) are horizontal and \( y \) is vertical

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**Strombolian type cone growth**

- McGetchin and others (1974)] model
- Parameters to be understood
  - Cone profile
  - Rim location
  - Limit of continuous ejecta
  - Ballistic limit
    - (maximum range of ejected fragment)
    - Size and location of talus slopes

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**Stages of growth**

- Simple cone with mantle bedding and low rounded rim
- Onset of an exterior talus slope
- Destruction of original rounded rim by backward migration of the talus
- Outward growth of talus beyond the ballistic limit
Tephra Transport

- If $v_t < $ convective rise then particles lift
- If $v_t > $ convective rise then particles fall
- Stagnation point locates balance

Fallout of Tephra

Terminal fall velocity ($v_t$)

$$v_t = C_d \left( d g \frac{\sigma}{\beta} \right)^{1/2}$$

- $d =$ clast diameter
- $C_d =$ drag coefficient
- $\sigma =$ clast density
- $\beta =$ atmospheric density

Clast support envelopes

- Isopleths mark fallout pattern
- Isopleths spread with column height
- Cross winds deform plume dispersion
**Isopach & Isopleth**

- Isopach lines trace outcrops of equal deposit thickness.
  - They can be used to measure the volume of the deposit and the prevailing wind conditions.
- Isopleth lines trace positions of equal clast size.
  - They can be used to reconstruct the height of the eruption column.

**Calculation of Plume Height**

- Fallout a function of several factors
  - column height, clast density, and wind speed
- A single isopleth can estimate parameters
- Nomogram developed for calculation
- Caution must be used, nature is fickle

**Dispersal and Fragmentation**

- Dispersal (D) is the area contained within the isopach given by $0.01 \times T_{\text{max}}$.
  - Fragmentation (F) is measured by the fraction of the deposit less than 2 mm where the deposit reaches $0.1 \times T_{\text{max}}$. 

**Plinian Eruptions**

- Ejection velocity $100+ \text{ m/s}$
- Bubbles rise slowly relative to magma rise
- Continuous supply of vesiculating magma
- Relatively well-maintained disruption surface
- Results in sustained jets

**Mount St. Helens Umbrella**

- 10 minutes for full umbrella to develop
- Reached 25 km high in 7 minutes
- Diameter: 20 km (base) to 70 km (top)
- Vertical rise of $\sim 110 \text{ m/s}$
- Horizontal spread of $\sim 55 \text{ m/s}$