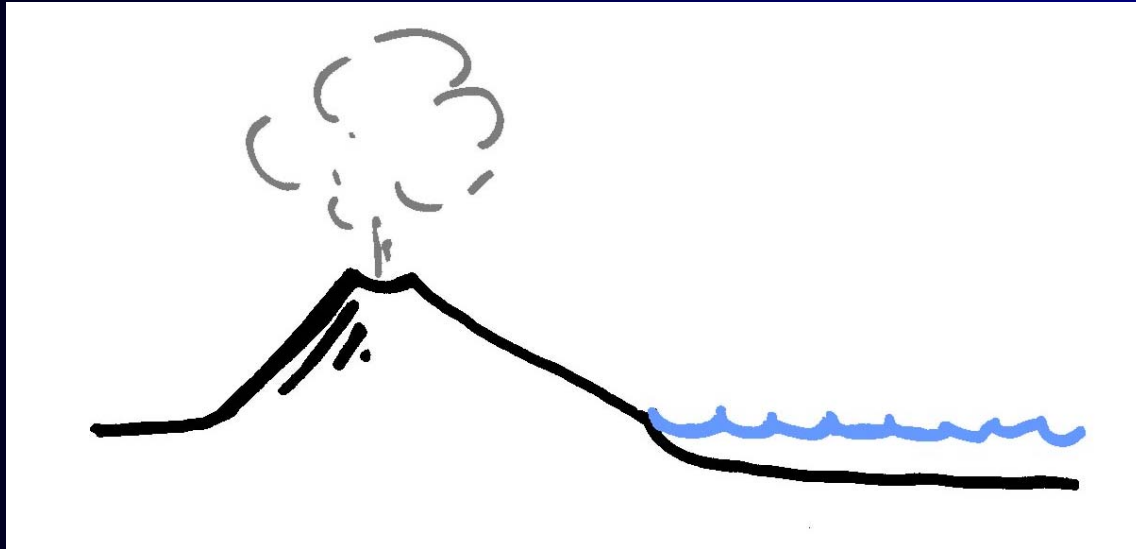




# VOLCANOLOGY

# VOLCANOLOGY

- **eruption mechanisms**
- **emplacement processes**
- **volcanic rocks**



# VOLCANO.....

..... structure where magma is erupted

..... includes the erupted products

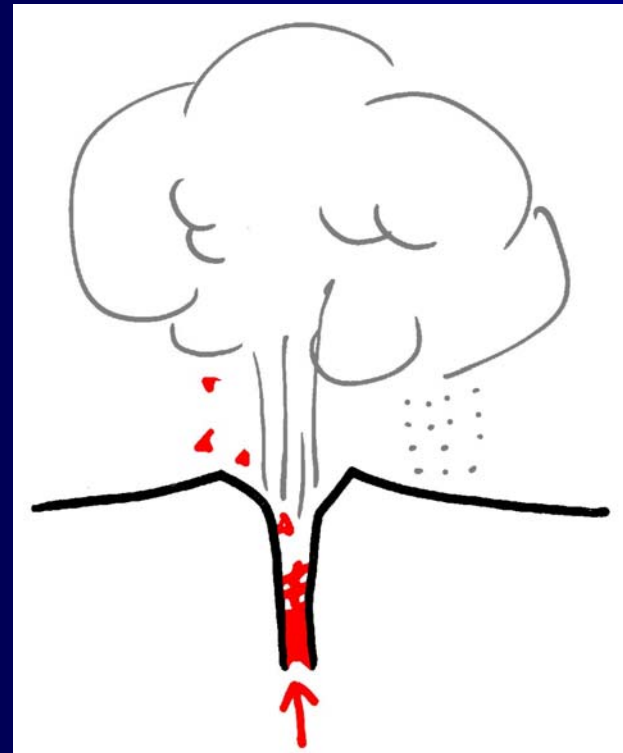
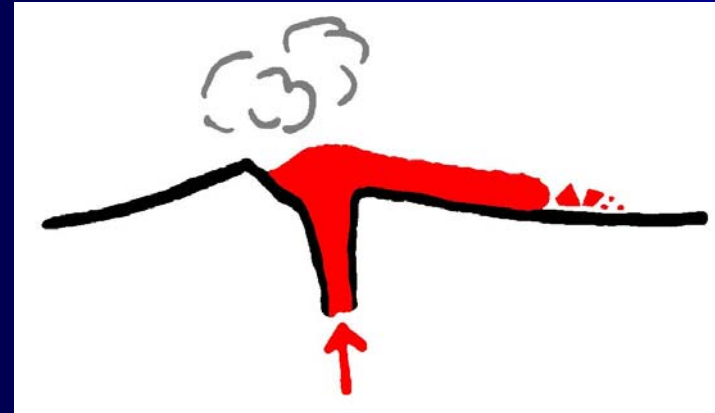
..... some products cool to form “instant” rock  
eg. lavas

.....some products are loose clastic deposits  
eg. some pyroclastic deposits

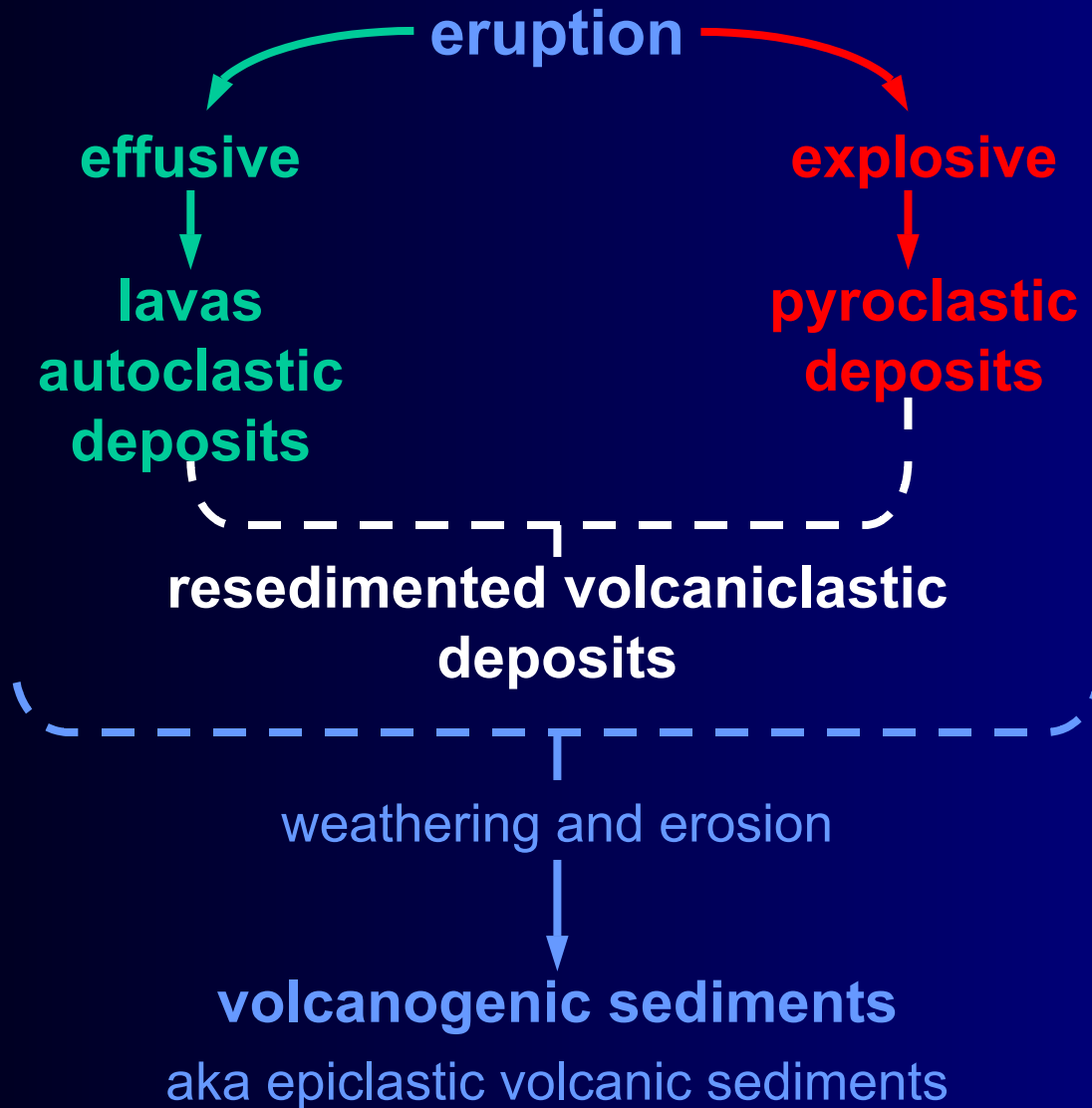
# ERUPTIONS.....

two main styles of eruption:

- **effusive** - outpouring of molten magma from the vent  
(⇒ lavas)
- **explosive** - gas-driven violent eruptions  
(⇒ pyroclastic deposits)

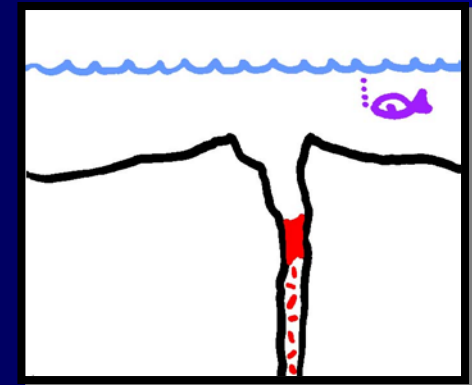
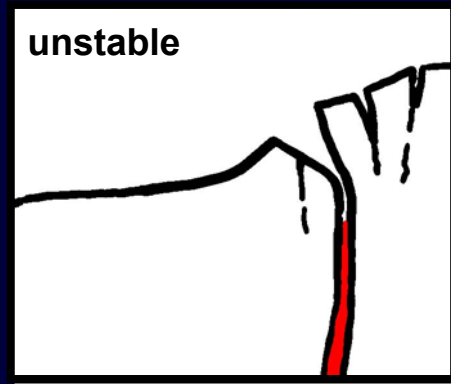
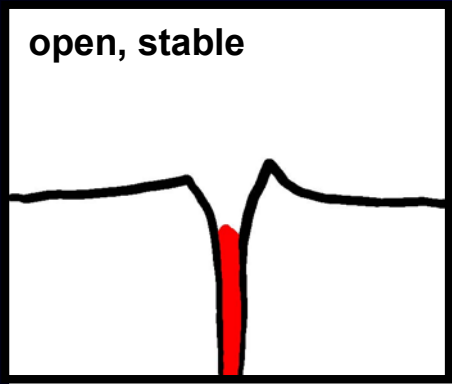


# GENETIC CLASSIFICATION



# CONTROLS ON ERUPTION STYLES

- **magma physical properties**  
especially viscosity and density
- **decompression history**  
(how and how fast magma rises)
- **degassing history**  
(how and when volatiles are exsolved)
- **vent setting**



- **vent configuration**  
(shape, dimensions, stability)

# VISCOSITY

..... internal resistance to flow of a substance  
when a shear stress is applied.....

## viscosity of **magma**:

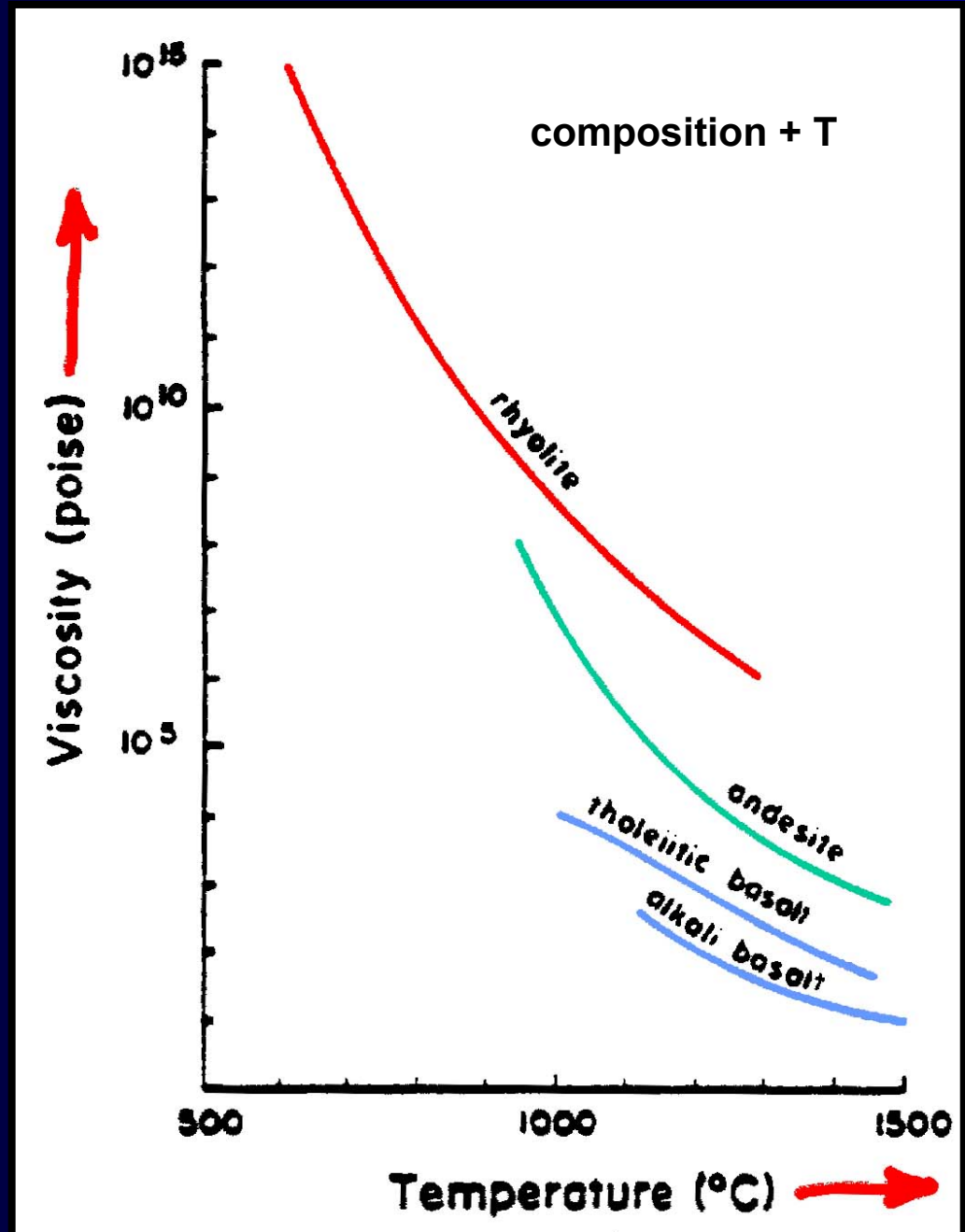
- **composition**, especially  $\text{SiO}_2$ :  
usually, higher  $\text{SiO}_2 \Rightarrow$  higher viscosity  
& **volatiles**, mainly  $\text{H}_2\text{O}$   
higher dissolved  $\text{H}_2\text{O} \Rightarrow$  lower viscosity
- **temperature**: higher  $T \Rightarrow$  lower viscosity
- **pressure**: higher  $P \Rightarrow$  lower viscosity
- **crystal content**, especially  $>25\%$  by volume:  
higher crystal content  $\Rightarrow$  higher viscosity
- **vesicles**: depends on composition



**viscosity changes with time and spatially!!!**

# VISCOSITY

Fig. 1: Relationship between viscosity & temperature for some volcanic rocks. The rhyolite was glassy or liquid through the entire temperature range. (Murase & McBirney, 1973)





# VISCOSITY

(a)

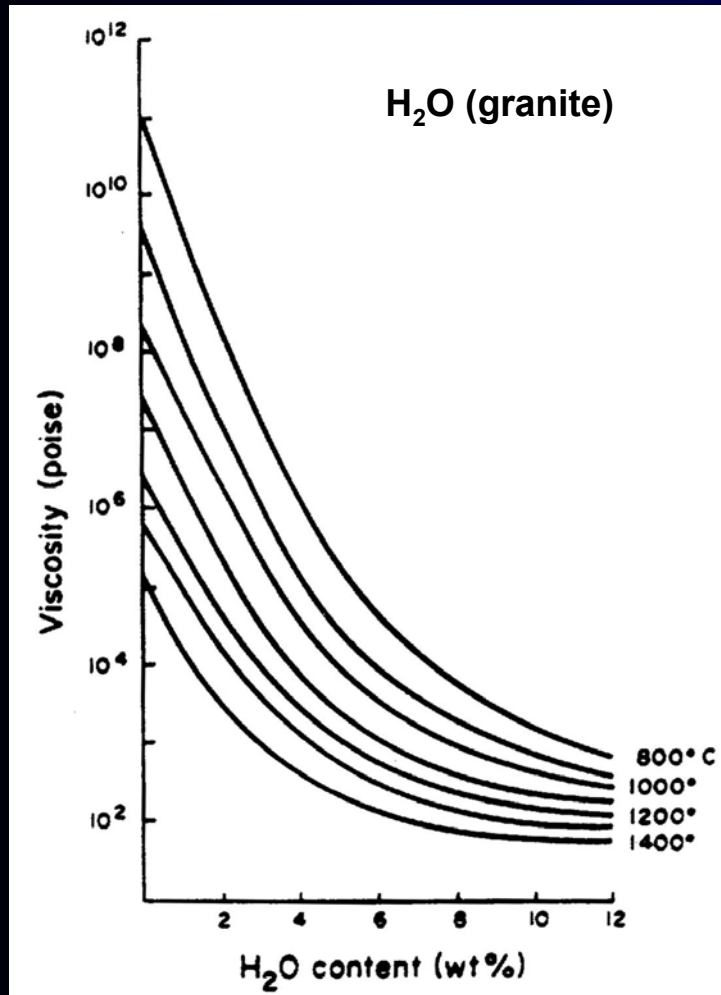
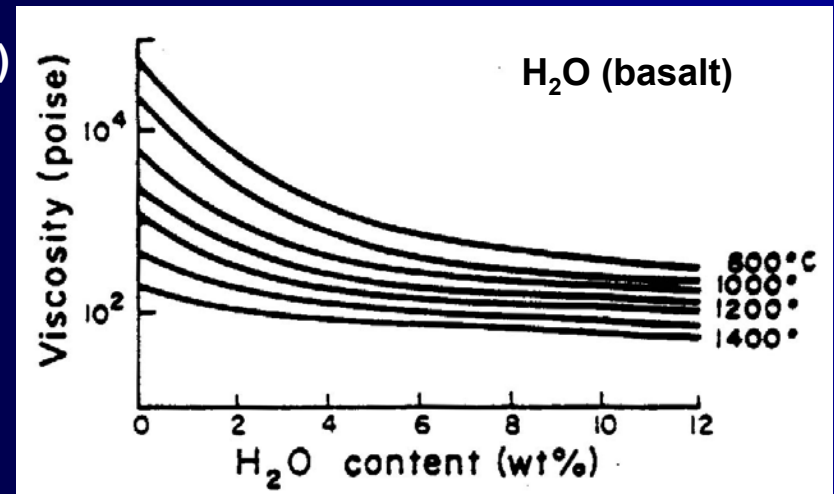


Fig. 2: The effect of H<sub>2</sub>O on the viscosity of (a) granitic & (b) basaltic melts at varying temperatures. (After Murase, 1962)

(b)



# VISCOSITY

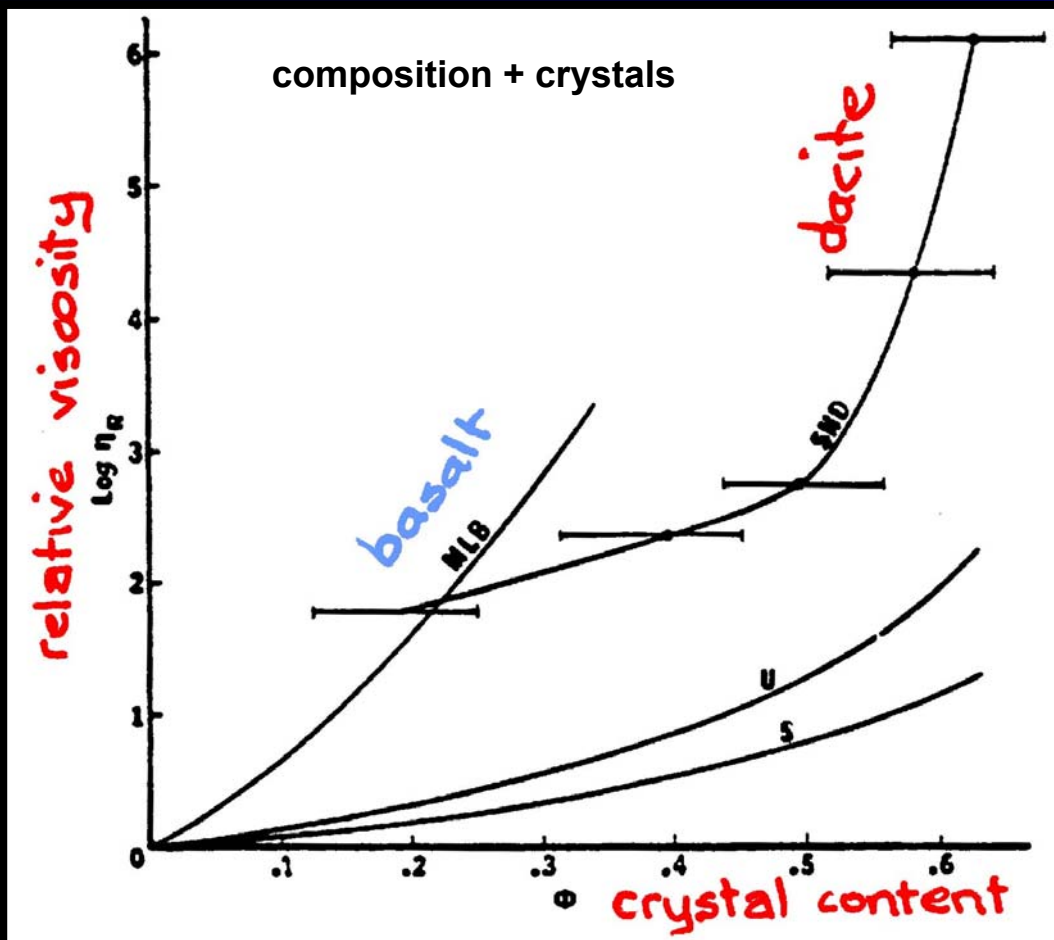


Fig. 3: Effects of crystal content on the relative viscosity of a Hawaiian tholeiitic basalt (MLB) and a Mount St. Helens dacite (SHD). Relative viscosity  $\eta_R$  is defined as the ratio of the viscosity of the liquid-crystal suspension to that of the crystal-free liquid at the same temperature. Crystal content is given in terms of the volume fraction  $\phi$  of suspended crystals. Curves labelled U & S are calculated for spheres of uniform and serial sizes, respectively. (McBirney & Murase, 1984)

# VISCOSITY

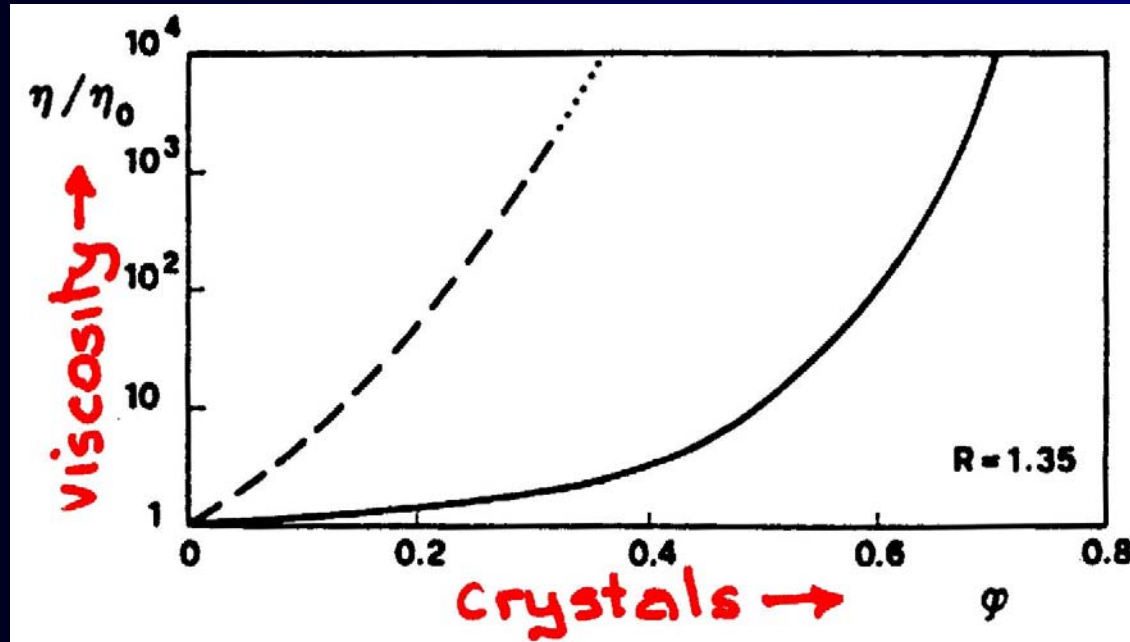


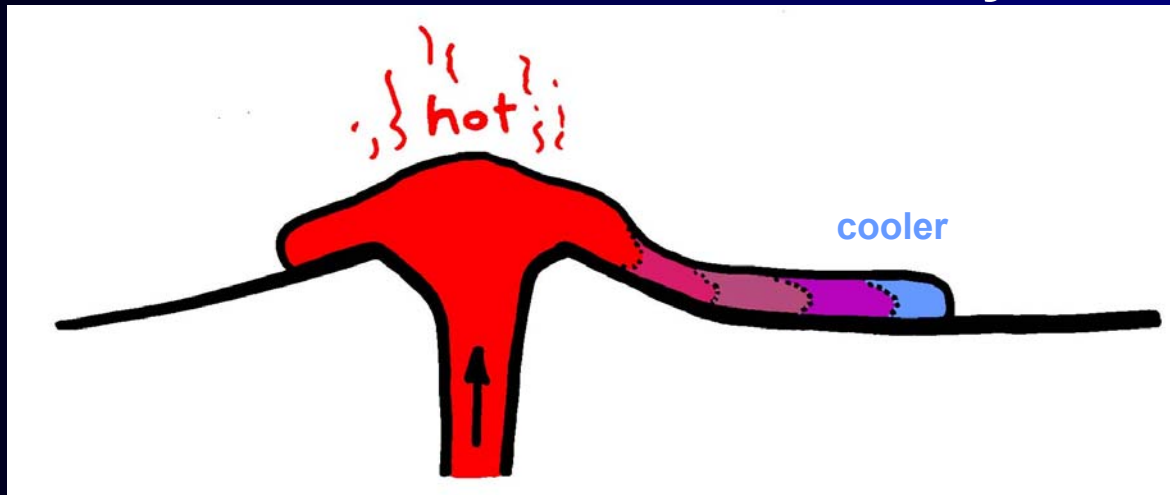
Fig. 4: Apparent viscosity  $\eta$  of a liquid/crystal suspension relative to viscosity  $\eta_0$  of the liquid alone, as a function of the volume fraction  $\phi$  of crystals, according to the theoretical relation 9.10 (solid curve), compared with data from Hawaiian lava (dashed curve). (After Shaw 1969 and Johnson & Pollard, 1973)

# VICOSITY

## viscosity changes:

- eg. **due to loss of volatiles**
- decompression as magma rises  
( $\Rightarrow$  vesicles nucleate and grow)
- crystallisation of the magma  
("second boiling")

$\rightarrow$  viscosity  $\uparrow$



eg. due to T decrease (cools down)

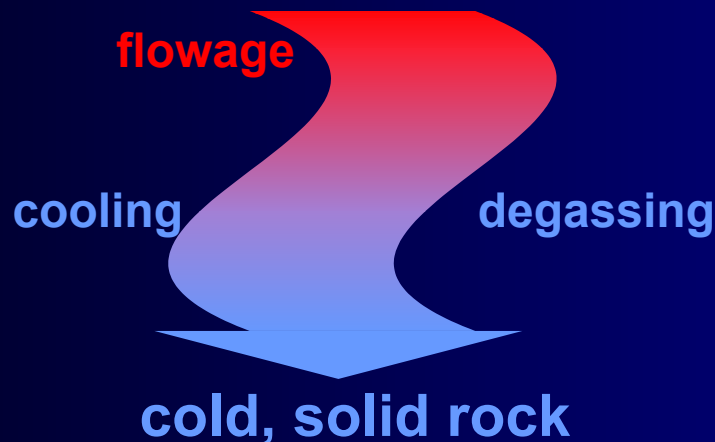
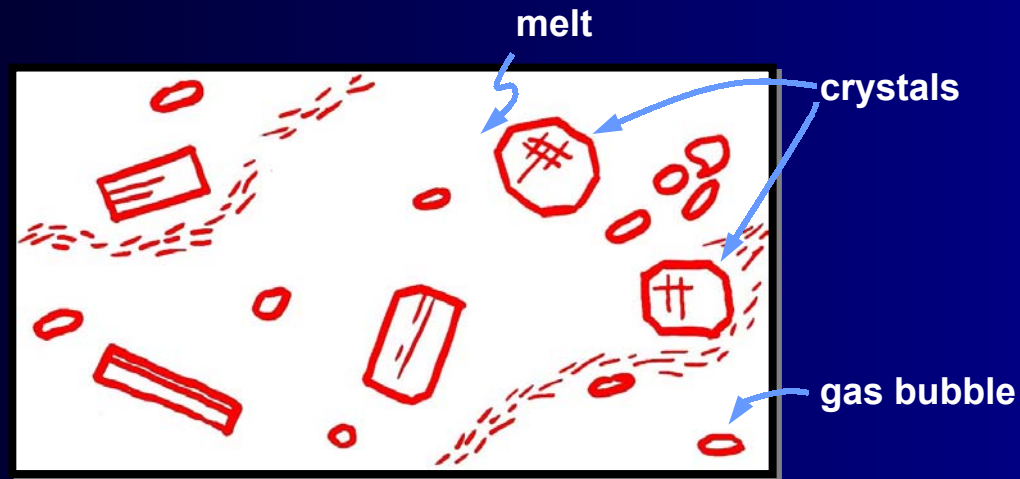
$\rightarrow$  viscosity  $\uparrow$

# EFFUSIVE ERUPTION

effusive eruption  $\rightarrow$  hot, largely molten lava

- melt (liquid,  $T \sim 700-1250^\circ\text{C}$ )
- crystals (microlites, phenocrysts)
- gas bubbles

$$T_{\text{solidus}} < T < T_{\text{liquidus}}$$



# TEXTURES & STRUCTURES IN LAVAS

vesicles: entrapped gas bubbles

- may form before & during eruption and during & after outflow;
- stop growing when volatile P drops or when solidification occurs;
- can be infilled by secondary minerals  
( $\Rightarrow$  amygdale)
- abundant close-packed vesicles  
( $\Rightarrow$  pumiceous or scoriaceous lava)

# TEXTURES & STRUCTURES IN LAVAS

## crystals

- microlites: microscopic;



straight



curved



chains

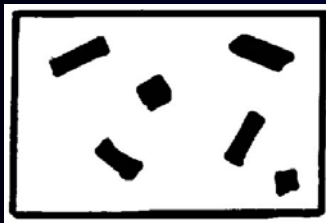
may be aligned or random

- phenocrysts: euhedral or subhedral;



may contain inclusions or be zoned;

evenly distributed or systematically distributed.



# TEXTURES & STRUCTURES IN LAVAS

## melt solidification:

- quenched  $\Rightarrow$  cold, solid volcanic glass

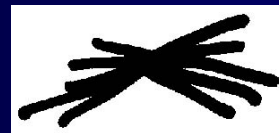
OR cools more slowly

$\Rightarrow$  crystals grown in hot, very viscous melt

## $\rightarrow$ spherulites:



radial



“bowtie”



sheaf



axiolitic

- diameter  $<1$  mm to  $>20$  cm
- may be isolated, linked, closely packed
- in silicic lavas, fibres are alkali feldspar  $\pm$  quartz
- in mafic lavas, fibres are pyroxene  $\pm$  plagioclase



# TEXTURES & STRUCTURES IN LAVAS

→ lithophysae:



- spherulites with a central vugh
- often infilled by secondary minerals

OR cools slowly → crystalline

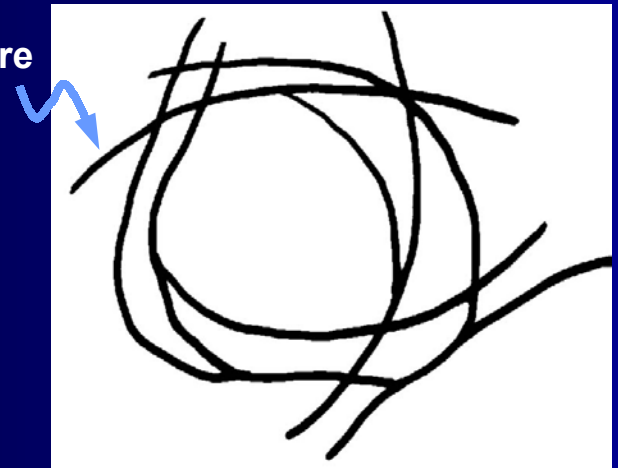
- micropoikilitic texture (aka “snowflake”)
- granophyric texture

# TEXTURES & STRUCTURES IN LAVAS

## after solidification:

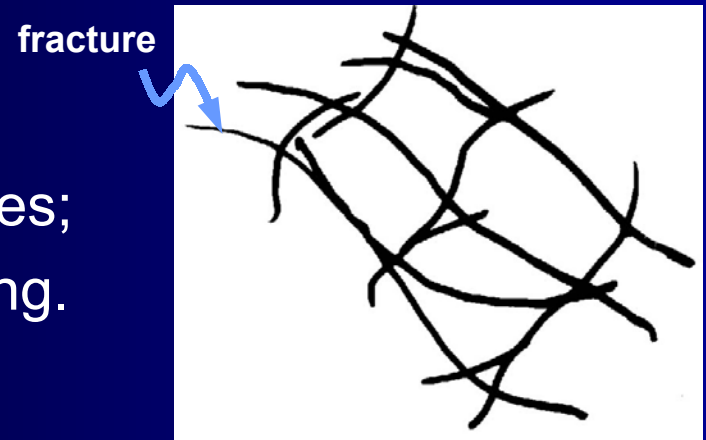
- hydration of rapidly chilled glass  $\Rightarrow$  perlite
  - strain inherited from rapid cooling-contraction
  - strain due to volume changes associated with hydration
    - $\rightarrow$  brittle fracture occurs (perlitic fractures)
- classical perlite
  - common;
  - overlapping arcuate fractures.

fracture



# TEXTURES & STRUCTURES IN LAVAS

- banded perlite
  - less common
  - overlapping rectangular fractures;
  - shape controlled by flow banding.



- dimensions:

mm

cm

several cm

diameter

“perlite”

“macroperlite”

- perlitic fractures may cut phenocrysts and pre-existing spherulites
- hydration rate depends on T and H<sub>2</sub>O content.

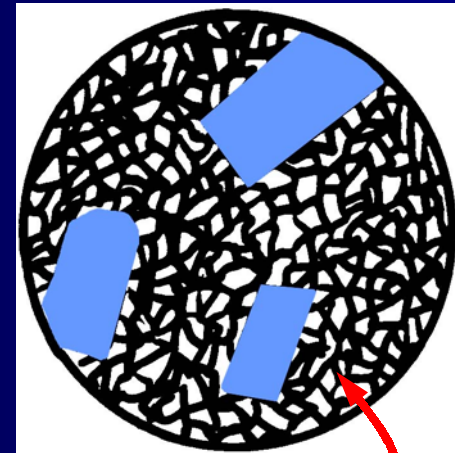
# TEXTURES & STRUCTURES IN LAVAS

## after solidification:

- crystallisation of the glassy parts

### “devitrification”

- result of re-heating events  
eg. metamorphism  
hydrothermal alteration
- time (glass is unstable)



groundmass

- commonly produces fine grained g'dmass aggregates of interlocking crystals
- may produce structures similar to spherulites
- rate of devitrification is higher if the glass is already hydrated

# TEXTURES & STRUCTURES IN LAVAS

- flow banding
- columnar joints
- autoclastic facies
- tube & channels
- lobes
- domes & coulees