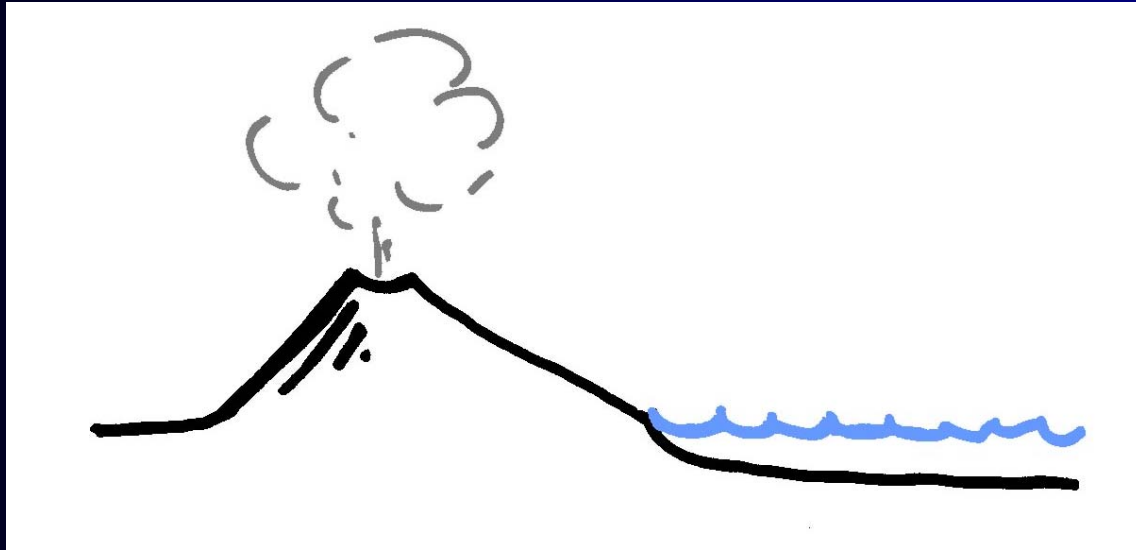




VOLCANOLOGY

VOLCANOLOGY

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



VOLCANO.....

..... structure where magma is erupted

..... includes the erupted products

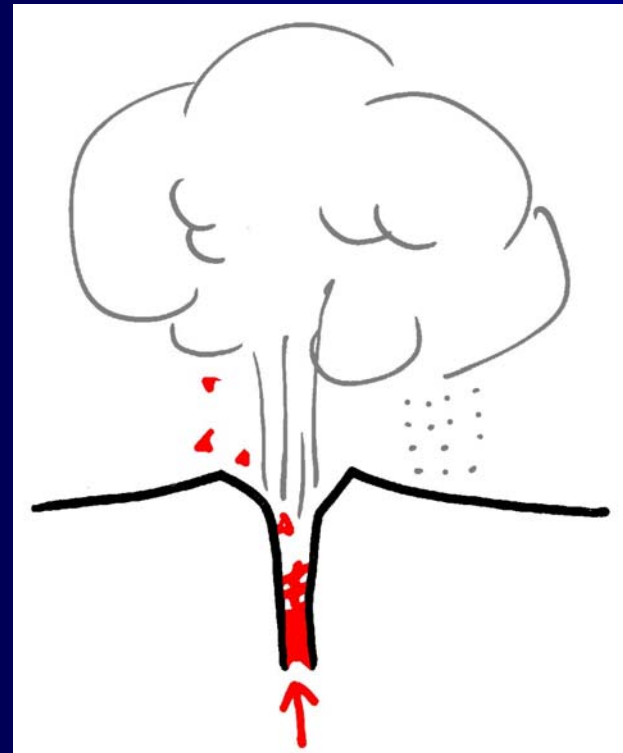
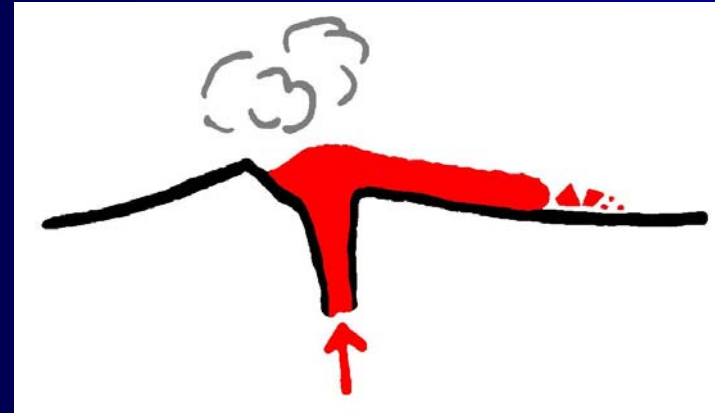
..... some products cool to form “instant” rock
eg. lavas

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

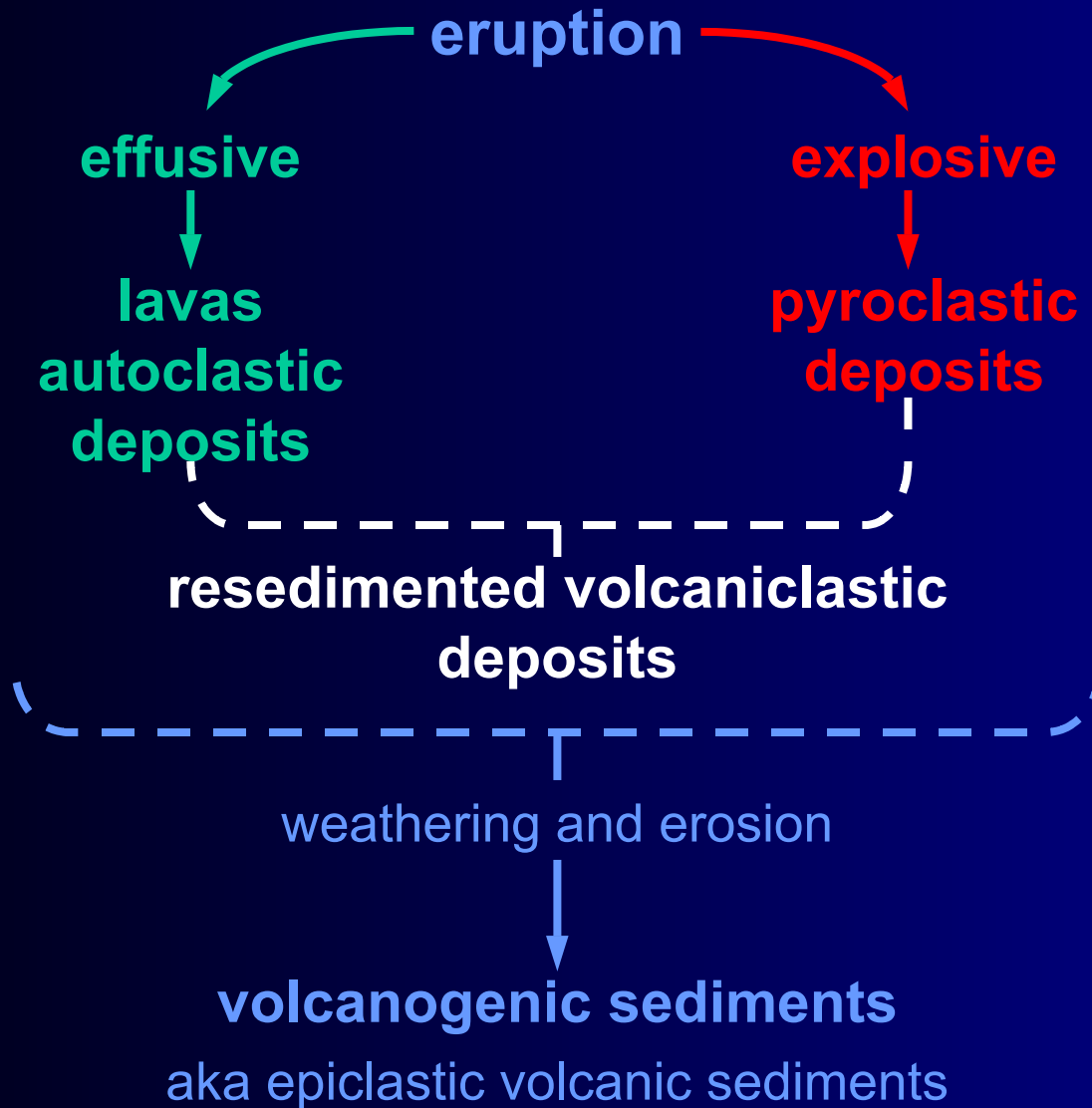
ERUPTIONS.....

two main styles of eruption:

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

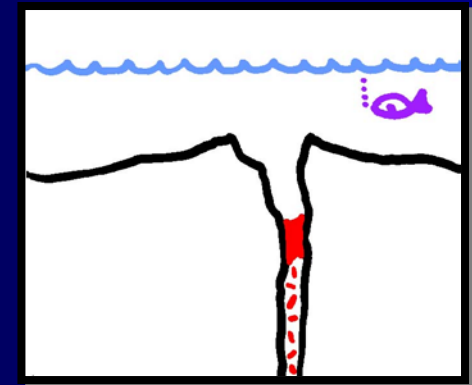
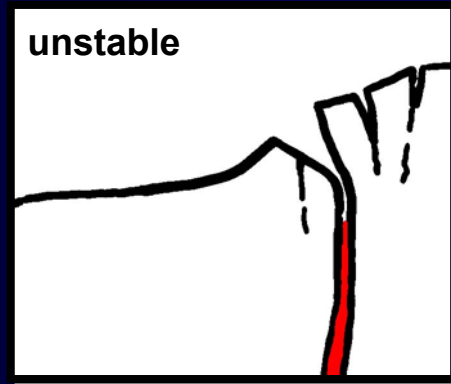
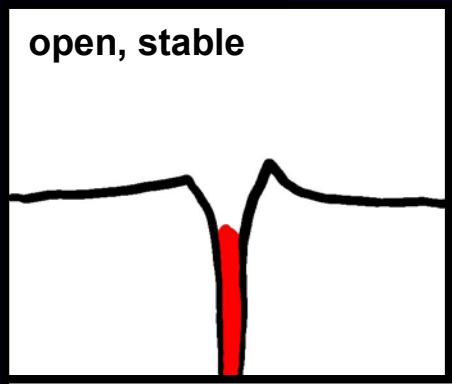


GENETIC CLASSIFICATION



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**:

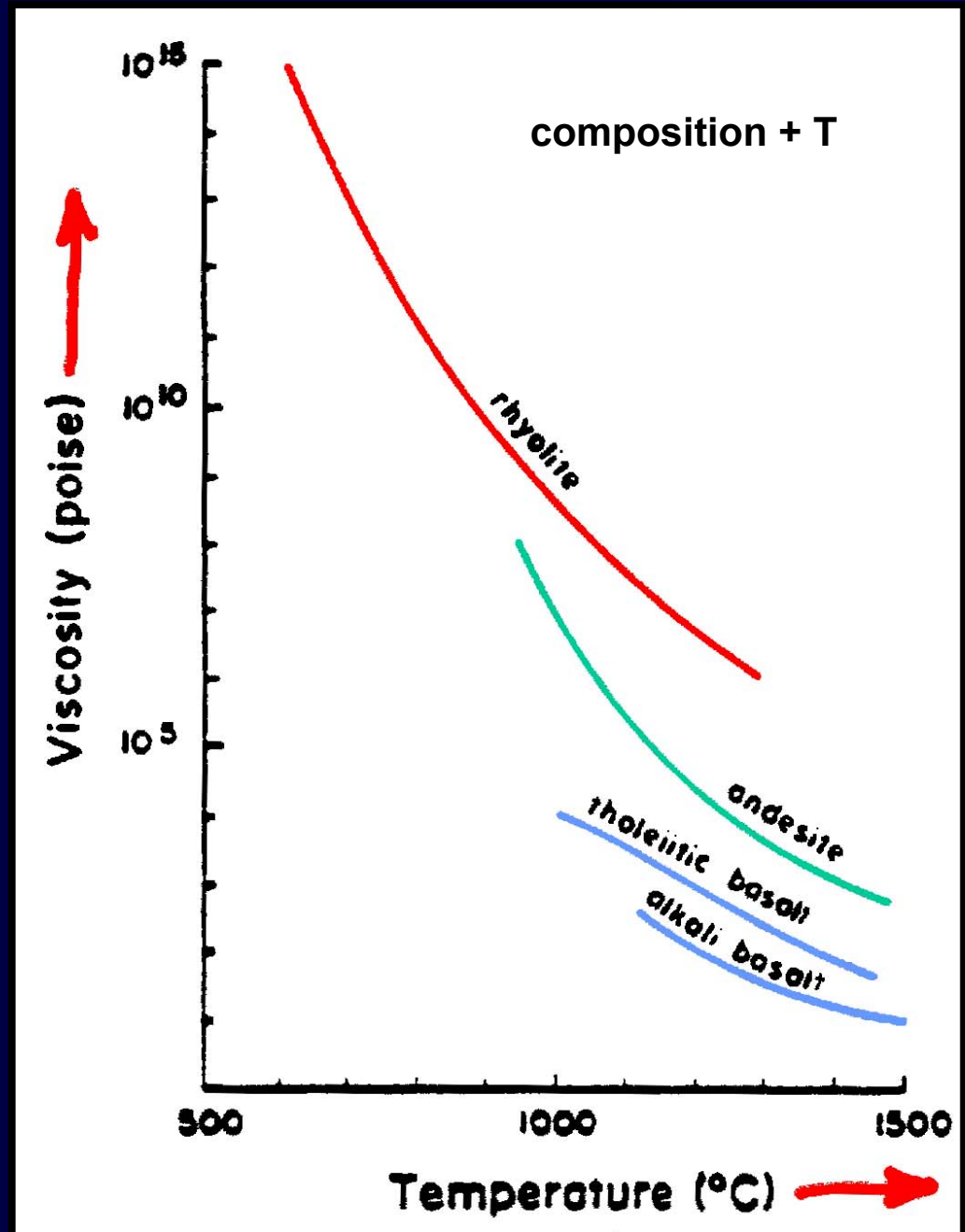
- **composition**, especially SiO_2 :
usually, higher $\text{SiO}_2 \Rightarrow$ higher viscosity
& **volatiles**, mainly H_2O
higher dissolved $\text{H}_2\text{O} \Rightarrow$ lower viscosity
- **temperature**: higher $T \Rightarrow$ lower viscosity
- **pressure**: higher $P \Rightarrow$ lower viscosity
- **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)

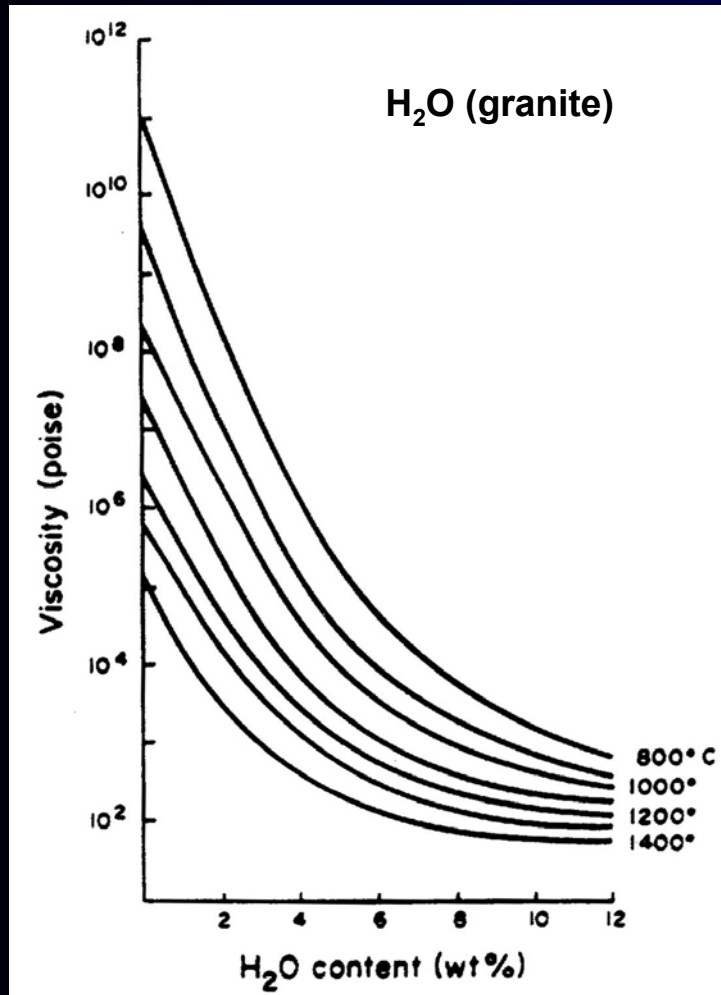
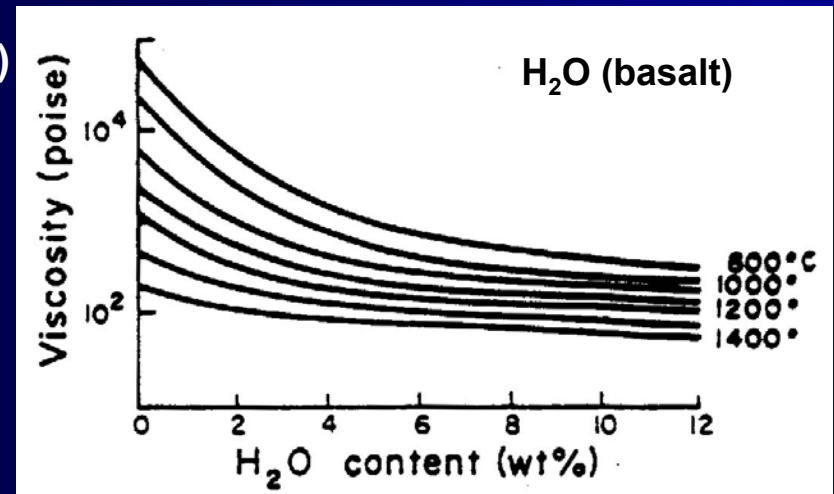


Fig. 2: The effect of H₂O on the viscosity of (a) granitic & (b) basaltic melts at varying temperatures. (After Murase, 1962)

(b)



VISCOSITY

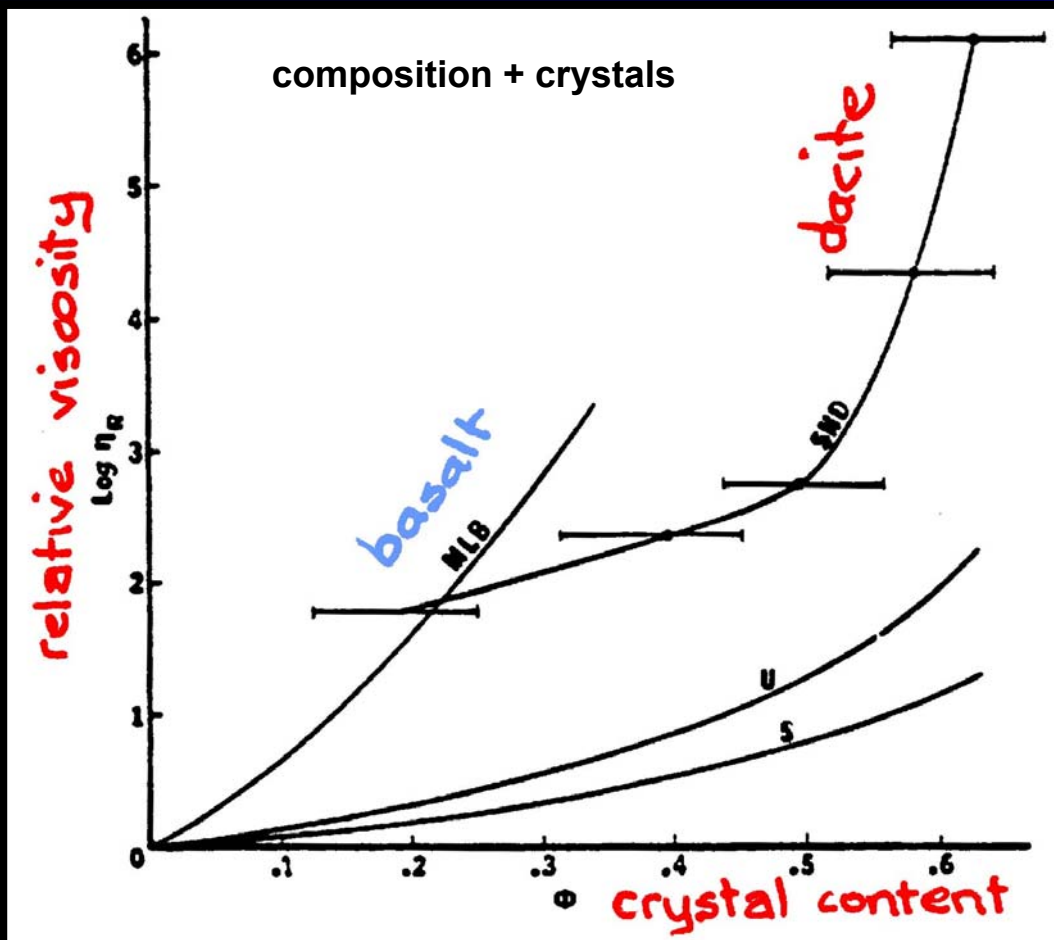


Fig. 3: Effects of crystal content on the relative viscosity of a Hawaiian tholeiitic basalt (MLB) and a Mount St. Helens dacite (SHD). Relative viscosity η_R is defined as the ratio of the viscosity of the liquid-crystal suspension to that of the crystal-free liquid at the same temperature. Crystal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

VISCOSITY

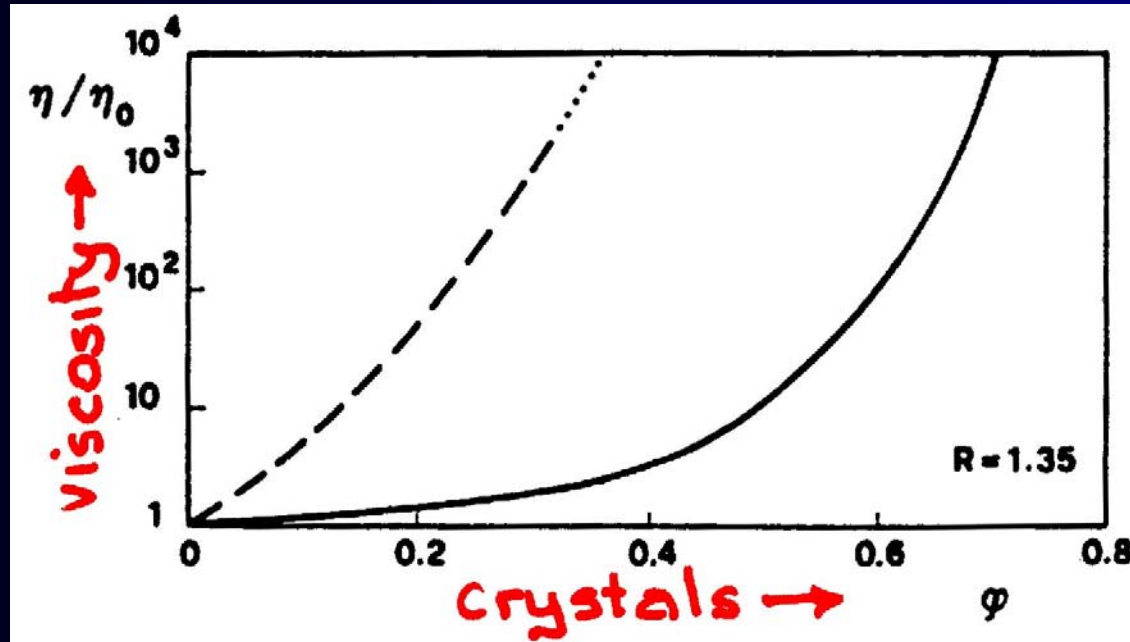


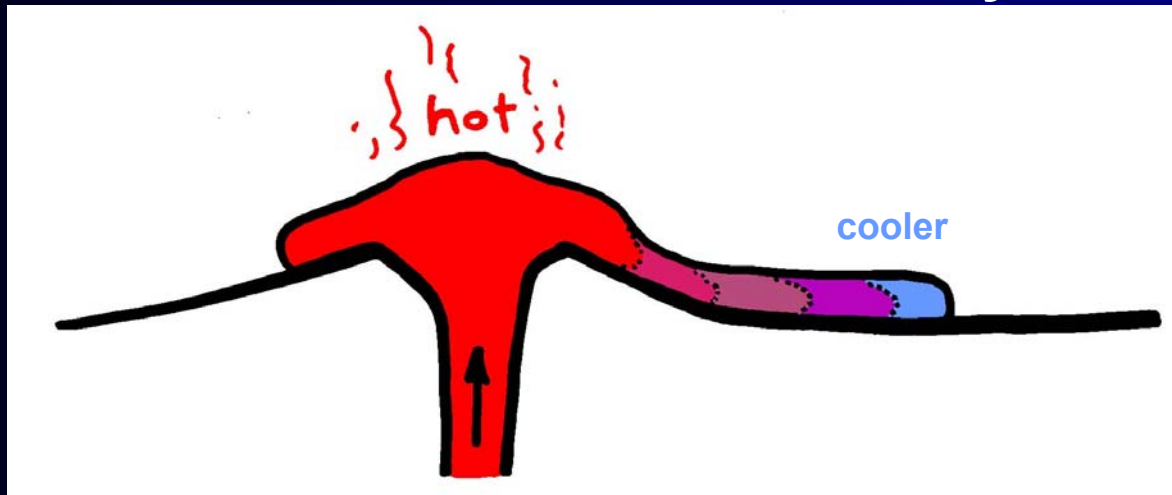
Fig. 4: Apparent viscosity η of a liquid/crystal suspension relative to viscosity η_0 of the liquid alone, as a function of the volume fraction ϕ of crystals, according to the theoretical relation 9.10 (solid curve), compared with data from Hawaiian lava (dashed curve). (After Shaw 1969 and Johnson & 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)

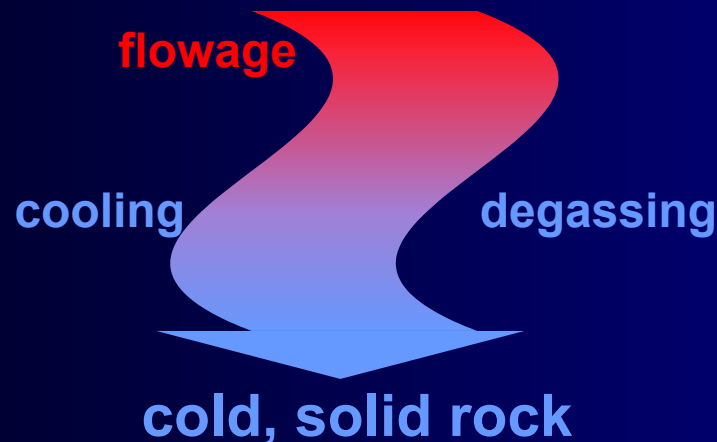
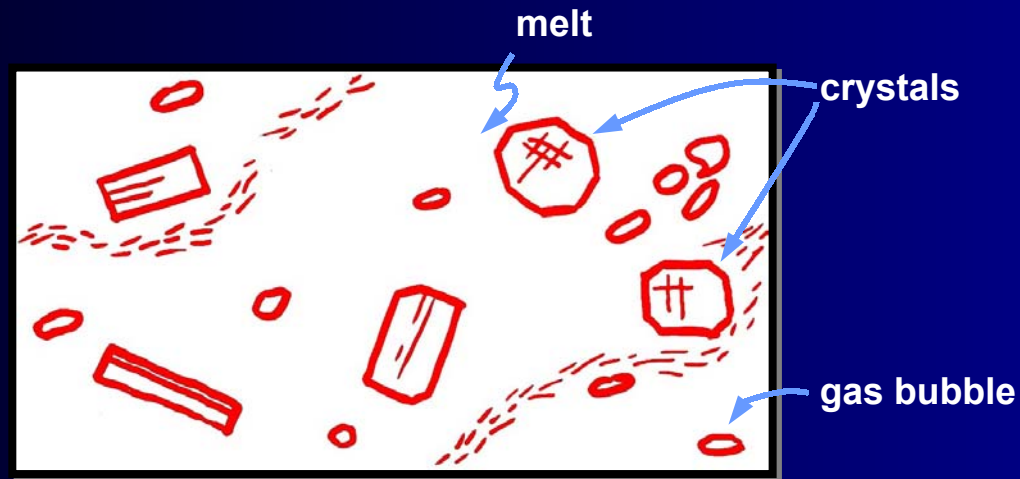
\rightarrow viscosity \uparrow

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

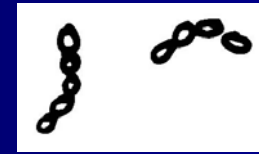
- microlites: microscopic;



straight



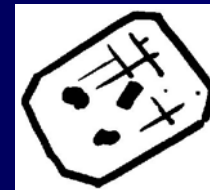
curved



chains

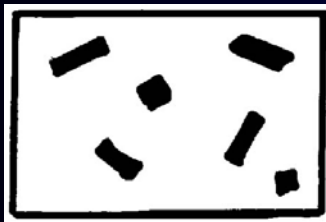
may be aligned or random

- 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

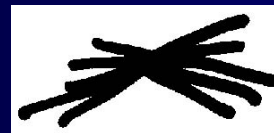
OR cools more slowly

\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

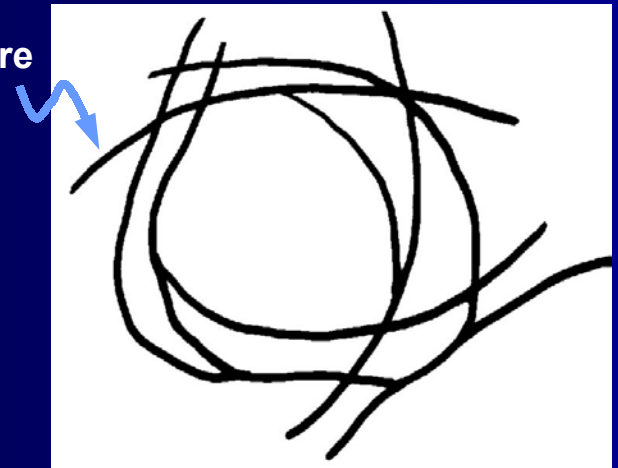
- micropoikilitic texture (aka “snowflake”)
- granophyric texture

TEXTURES & STRUCTURES IN LAVAS

after solidification:

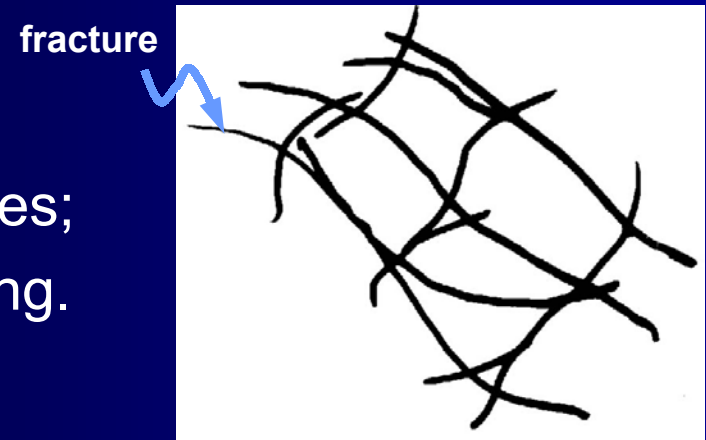
- hydration of rapidly chilled glass \Rightarrow perlite
 - strain inherited from rapid cooling-contraction
 - strain due to volume changes associated with hydration
 - \rightarrow brittle fracture occurs (perlitic fractures)
- classical perlite
 - common;
 - overlapping arcuate fractures.

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 H₂O content.

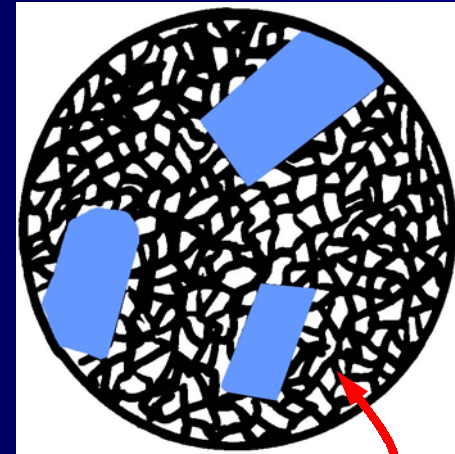
TEXTURES & STRUCTURES IN LAVAS

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