

Nov 3, 2005

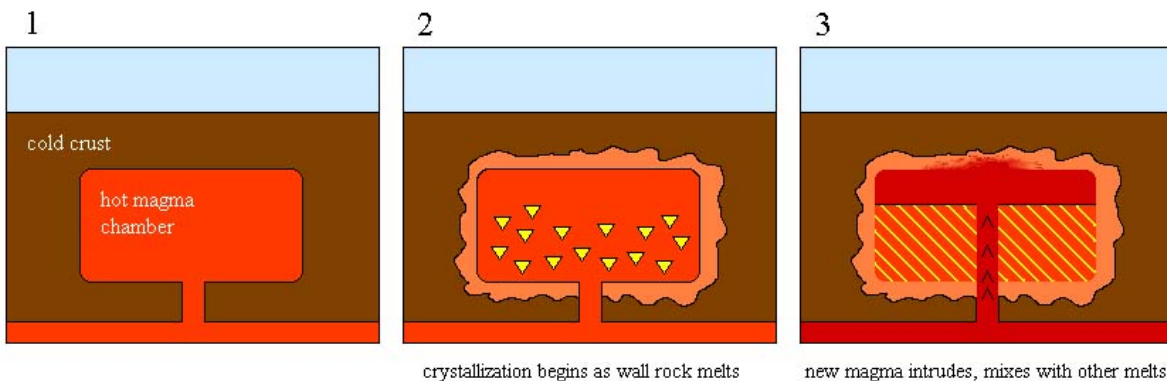
Magmatic processes, granitic rocks, rapakivi

Handout: Magmatic Processes

Phase equilibrium controls include fractional crystallization and partial melting. In addition, the following magmatic processes are important:

Magma mixing – natural consequence of periodicity or episodicity of volcanic/plutonic eruptions, usually mixing between magmas in different stages of evolution by fractional crystallization

Assimilation of wall rock – heat up and melt rock in close proximity to magma. This requires a LOT of heat, so the periodic recharge of magma is important



Ex. Imagine a crustal intrusion of basalt, geotherm  $30^{\circ}\text{C}/\text{km}$ . At 6 km depth,  $200^{\circ}\text{C}$  granite wall rock (melts at  $900^{\circ}\text{C}$ ). Intrude basalt at  $1200^{\circ}\text{C}$ . To heat the country rock and melt it cools the basalt. The specific heat of the granite is about  $.3 \text{ cal}/\text{gram}/^{\circ}\text{C}$ , and the latent heat of fusion is about  $100 \text{ cal}/\text{gram}$  → requires  $310 \text{ cal}/\text{gram}$  to melt from  $200^{\circ}\text{C}$ . Basalt cools and crystallizes at solidus  $1000^{\circ}\text{C}$ . With similar specific heat and latent heat of fusion, the basalt will lose only  $160 \text{ cal}/\text{gram}$  of heat before it solidifies. If the basalt is solidified before the granite is melted, the melts can't mix. BUT if magmas continue to intrude, there will be enough heat to mix melts.

Soret diffusion – temperature gradient effect (non-equilibrium process), elements rearrange to minimize entropy production. Rates of diffusion are slow relative to heat transfer rate, by about an order of 5.

Metasomatize – to change composition in the solid state, usually by fluid exchange with rock

## Granites

Igneous processes, phase equilibrium evidence (1958)... see handout.  
The old granite problem has been solved.

New problem – granite batholiths (with granodiorites and diorites) – how could a large scale batholith form by fractional crystallization from a basalt parent? There is no evidence for other crystals underneath the batholiths. Where are the accumulated products of fractional crystallization?

Tuttle and Bowen showed that granites are best visualized as products of fractional crystallization. They plotted the compositions of natural granites to show that ONLY fractional crystallization after H<sub>2</sub>O saturated melting could explain granites—the compositions are all nearly the same. He explained this with the phase diagram of the granite system, which has a ternary minimum.

If there is a ternary minimum...

- the first melt composition depends on bulk composition
- you cannot make liquids of similar composition by melting solids with different compositions
- you can make solids with composition at the ternary minimum by taking compositionally variable materials and allowing fractional crystallization to occur

However, Bowen didn't know that at higher pressures, the phase diagram for granite has a eutectic, not a minimum.