

EPSc 352: Lecture Overview for Part 3, Growth and Form of Minerals

☺☺ **Read pp. 217-234 in your text.** (For those who are interested, chapter 7 in the book by Blackburn and Dennen is very informative.)

👉 **Formation and Growth of Crystals** (pp. 217-222 in text)

Crystal (crystalline solid): homogeneous solid with long-range, 3-D order internally (whether or not it has well formed external faces).

Internally: Long-range, medium-range, short-range order OR amorphous (glass)

Externally: Grain size (macro-morphology) is macro-crystalline, micro-crystalline, crypto-crystalline, or amorphous.

Perfection of formation of faces: euhedral (all flat, smooth, well formed), subhedral (some good faces), anhedral (faces not formed well)

“The plan”: discuss a little about crystal growth from chemical, morphological view; then discuss from viewpoint of internal structure and geometry why crystals are shaped as they are.

Crystal formation processes:

vapor → solid	condensation/sublimation
solution → solid	precipitation
melt → solid	freezing/crystallization
solid A → solid B	phase transformation (e.g., polymorphic phase transition)

→ → *4 mechanisms of crystal formation*: evaporation, decrease in temperature, change in pressure, reaction (e.g., during metamorphism of pre-existing minerals)

Driving force for crystal formation and growth: ENERGY. Products should have lower free energy than initial phases.

Two stages of growth are **nucleation** and **grain growth**.

⇒ **Saturation** is key: solution/melt cannot dissolve any more of some components; ppt. occurs

Degree of supersaturation:

See hand-out 35.

Large degree: many nuclei; form a “gel”
Moderate degree: many small crystals form
Small degree: few, large crystals

⇒ **Nucleation** can be homogeneous or heterogeneous
see nuclei form in the solution/melt
nucleation on walls of vessel, on “dust”

Pathway to nucleation and grain growth is shown on free-energy diagram. **See hand-out 36.**

Formation of critical-size nucleus depends on surface area:volume ratio.

⇒ Growth

differential rates
 fill in sites as in “parent”
 changes in shape
 euhedral, subhedral, anhedral shapes
 rapid growth – supersaturated, hopper/dendritic growth **See hand-out 37.**
 crystal growth limited by diffusion

How does growth take place? Physical nature of growth **See hand-out 38.**
 stepwise, trying to satisfy bonds
 growth often favored on “accidental sites”
defects/dislocations frequently form, affect mineral’s properties
 “growth faults” can be propagated by continued growth along surface of mismatch

☹☹ **For these next topics, please read textbook chapter 10 (pp. 222-234).**

⇒ **Defects** are of 3 types: point, linear, planar
 Schottky – missing ion
 Frenkel – misplacement POINT DEFECTS
 interstitial
 substitution SOLID SOLUTION

Edge and screw dislocations – by initial growth or secondary process

Slip – usually secondary process (stress)

TEM (transmission electron microscope) to image individual atoms, as well as these defects

⇒ Growth forms of same mineral with itself

Polygranular growth phenomena
 random intergrowths
 parallel growth – accidental, interrupted
 twins – 2 or more parts of a complex object are identical; related by symmetry operation
 created by errors in the first...coordination sphere of an atom

Contrast with Oriented intergrowths of unlike crystals

epitaxy: B grows on A

topotaxy: overgrowing phase B is a reaction product of underlying phase A

Twin operation – adds symmetry not available in the original single crystal

Primary (growth) and secondary (glide, deformation) twins

Phase transformations (polymorphism) can create twins

Multiple (polysynthetic) twinning – striations

Contact vs. penetration twins

☺☺ **For these next topics, please read textbook chapter 12 (pp. 266-281).**

⇒ Relations among Mineral Structures

Isostructural – same structure, but different composition, e.g., among NaCl, KCl, PbS.
Classification, e.g., “calcite group” vs. “aragonite group”

Polymorphism – different structure, but same composition (e.g., TiO₂, SiO₂, C).

3 types of solid-solid transformation:

displacive: energetically easy, rapid, reversible. Example, α - β quartz transition.

reconstructive: energetically demanding, sluggish. Example, graphite-diamond transition.

order-disorder: more subtle, re-arranging of atoms in a structure (e.g., K-feldspar)
1) temp., 2) degree of disorder, 3) symmetry
sanidine, orthoclase, microcline

Polytypes – compare to stacking choices with the ping-pong-ball layers

Pseudomorphs – chemical replacement, with retention of original (physical) morphology.
Example: goethite pseudo after pyrite.

Environments of Mineral Formation

temperature, pressure
chemical components
degree of saturation
effects on grain size, shape, mineralogy