

Granites

Best, Ch. 4

Granites

- Petrography
- Field relations
- Origin
- Time-space patterns in plutons
- S-type and I-type compositions

Petrography

- Fabric
- Classification
- Alteration

Fabric

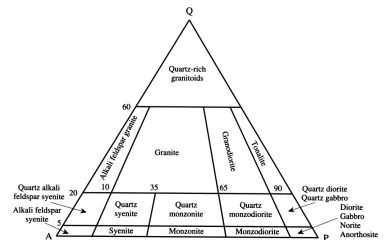
- Hypidiomorphic granular
- Equigranular
- Porphyritic
- Pegmatitic
- Graphic

Anisotropy

- Foliation
- Lineation
- Segregation layers

Compositional Classification

- Q-Ab-Or diagram
- Chemical classification is useful
- Quartz, K-spar, Plagioclase diagram
- Modal classification also is good



Textural Classification

- **Porphyry**
 - Large crystals in a fine-grained matrix
- **Aplite**
 - Leucocratic, fine sugary texture
- **Granophyre**
 - Micrographic texture

Pegmatite

- Extremely coarse-grained with rare euhedral minerals
- Li, Be, Zr, Nb, Mo, Sn, Ta, W, Th, U concentrated
- Late-phase of granitic intrusions
- Lit-par-lit metamorphism

Alteration

- Most granites show some degree of alteration
- High temperature minerals replaced by low temperature ones

Field Relations

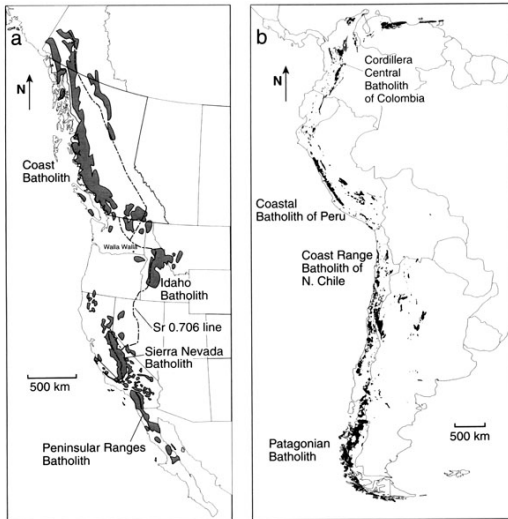
- General distribution
- External contacts
- Form of intrusions
- Internal features
- Time and depth of emplacement

General Distribution of Granites

- Concentrated in orogenic belts
- Located at the margins of continents
- Also in deeply eroded Precambrian shields
- Alkaline granites occur in rift zones

Mesozoic Batholiths, USA

- Sr isotopes lower in west than east
 - Boundary between shelf (ss, ls, sh) and back arc basin (greywacke, basalt, cherts)
 - 0.706 line represents old craton margin
- Two eastward migrating plutonic series
 - Concentric zoned plutons



External Contacts

- Sharp contacts
- Gradational border zones
- Contact breccia
- Migmatite

Form of the Intrusion

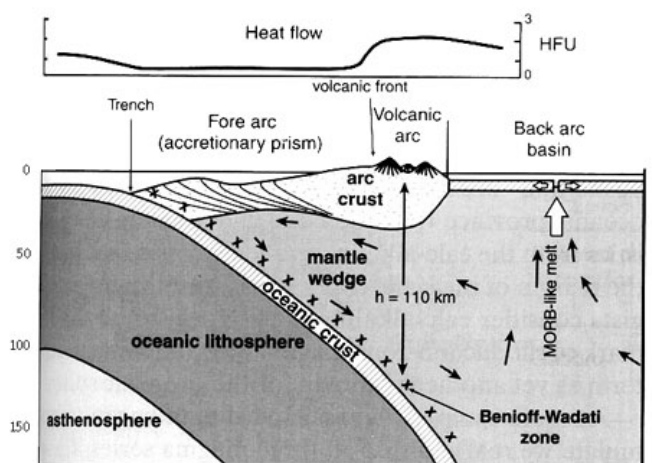
- Dike
 - Ring dikes
 - Cone Sheets
- Sill
- Laccolith
- Batholith

Interior of Bodies

- Zoned plutons
 - Mafic to felsic
- Mafic inclusions
 - Arrangement
 - Abundance
- Stoping

Origin

- Magmas vs. granitization
- Room problem
- Form of large batholiths
- Zoned plutons
- Origin of magmas



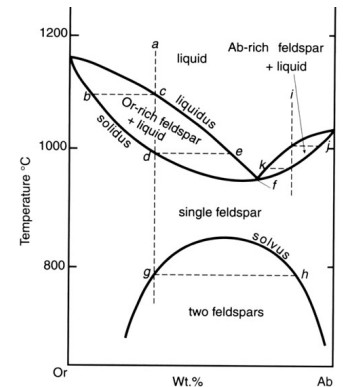
Gill, 1981

Origin of Plutons: Compositional Arguments

- Lowest temperature melts have subequal amounts of Q, Or and Ab
- Partial melting of crustal rocks produces a liquid in the thermal valley
- Crystal/liquid fractionation would produce a liquid which crystallizes Q, Or, AB in subequal amounts

Effect of Water Content

Hypersolvus granite
vs.
Subsolvus granite

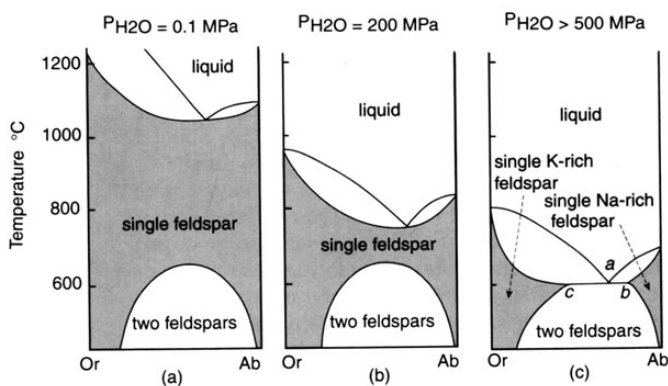


Hypersolvus Granite

- Crystallize a homogeneous feldspar containing Na, K, and Ca components
- This subsequently exsolves to Perthite
- This indicates a relatively dry magma

Subsolvus Granite

- Both plagioclase and K-spar crystallize together
- Little exsolution
- Relatively wet melts



S-I-A-M Classification

- Chappell and White
- S-type granites
- I-type granites
- A-type granitoids
- M-type granitoids

S-Type Granites

- Occur in regional metamorphic terranes
- Partial melting of metasediments
- High Al but contain no hornblende
- Biotite, muscovite, cordierite, & garnet
- High Rb in source rocks
- Initial Sr ratios > 0.710

I-Type Granites

- Subduction zone continental margin
- High Ca and Na
 - Contain hornblende and sphene
- Hornblende-rich inclusions
- Melting of deep crustal igneous rocks
- Source region poor in Rb
- Initial Sr isotope ratios < 0.708

A-Type Granitoids

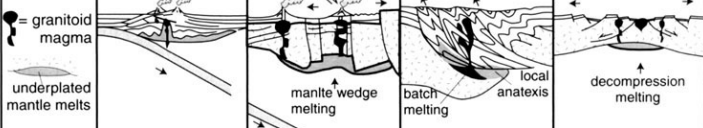
- Anorogenic origin
- High in SiO₂, up to 77%
- High alkalis, Fe/Mg, halogens
- Peralkaline?
- Stable craton environment

M-Type Granitoids

- Originate as fractionated mantle melts
- Underplated mantle melts
 - May assimilate crustal materials
 - May mix with crustal melts
- Low Rb, Th, U
- Initial Sr ratios < 0.705
- Form tonalites

Time and Depth of Emplacement

- **Post-tectonic**
 - Cross cutting contacts
- **Syntectonic**
 - Concordant fabrics
- **Pretectonic**
 - Metamorphic imprint on fabric

	OROGENIC			TRANSITIONAL
	Oceanic island arc	Active continental margin	Continental collision	Post-orogenic uplift/collapse
				
Examples	Bougainville, Solomon Islands, Papua New Guinea	Mesozoic Cordilleran batholiths of west Americas Gander Terrane	Manaslu and Lhotse of Nepal, American Massif of Brittany	Late Caledonian Plutons of Britain, Basin and Range, late Variscan, early Northern Proterozoic
Geo-chemistry	Calc-alkaline > thol. M-type & I-M hybrid Metaluminous	Calc-alkaline I-type > S-type Met-Al to sl. Per-Al	Calc-alkaline S-type Peraluminous	Calc-alkaline I-type S-type (A-type) Metalum. to Peralum
Rock types	qtz-diorite in mature arcs	tonalite & granodior. > granite or gabbro	migmatites & leucogranite	bimodal granodiorite + diorite-gabbro

	TRANSITIONAL	ANOROGENIC	
	Post-orogenic uplift/collapse	Continental rifting, hot spot	Mid-ocean ridge, ocean islands
 = granitoid magma underplated mantle melts	 decompression melting	 hot spot plume decompression melting	 hot spot plume
Examples	Late Caledonian Plutons of Britain, Basin and Range, late Variscan, early Northern Proterozoic	Nigerian ring complexes, Oslo rift, British Tertiary Igneous Province, Yellowstone hotspot	Oman and Troodos ophiolites; Iceland, Ascension, and Reunion Island intrusives
Geo-chemistry	Calc-alkaline I-type S-type (A-type) Metalum. to Peralum	Alkaline A-type Peralkaline	Tholeiitic M-type Metaluminous
Rock types	bimodal granodiorite + diorite-gabbro	Granite, syenite + diorite-gabbro.	Plagiogranite