Granitoid Rocks

Reading:

Winter (2001) Chapter 18

Granitoids

"Granitoids" (*sensu lato*): loosely applies to a wide range of felsic plutonic rocks

This lecture focuses on non-continental arc intrusives

Associated volcanics are common and have same origin, but are typically eroded away

Common Features

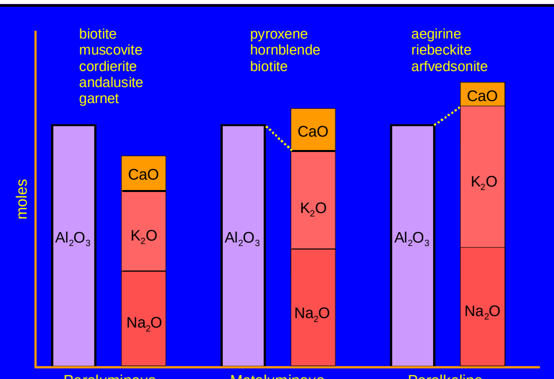
- Most large granitoid bodies occur in areas where the continental crust was thickened by orogeny
- Formed by either continental arc subduction or collision of sialic masses.
- Many granites, however, may post-date the thickening event by tens of millions of years.

Granitoid Classification

Based on feldspar aluminum ratio

$KALSi_3O_8$

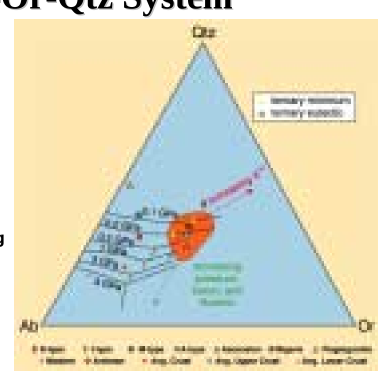
1:1:3



Alumina saturation classes based on the *molar* proportions of $Al_2O_3/(CaO+Na_2O+K_2O)$ ("A/CNK") after Shand (1927). Common non-quartzo-feldspathic minerals for each type are included. After Clarke (1992). Granitoid Rocks. Chapman Hall.

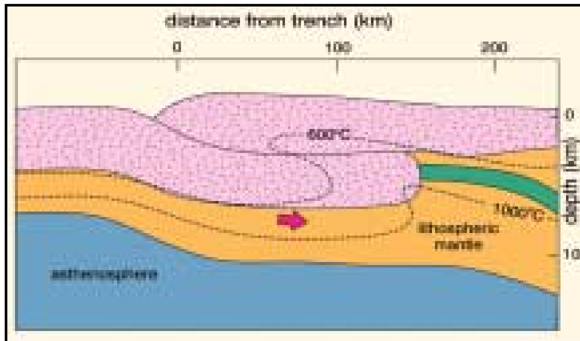
Ab-Or-Qtz System

Ternary cotectic curves and eutectic minima from 0.1 to 3 GPa. Locus of most granite compositions in orange and plotted positions of the norms from analyses. Note the effects of increasing pressure and the An, B, and F contents on the position of the thermal minima. From Winter (2001).



Anatexis?

- Because the crust normally is solid, some thermal disturbance is required to form granitoids
- Most workers believe that the majority of granitoids are derived by crustal anatexis, but that the mantle may also be involved in the process.
- The mantle contribution may range from being a source of heat for crustal anatexis to being the source of material as well.



SIAM Classification

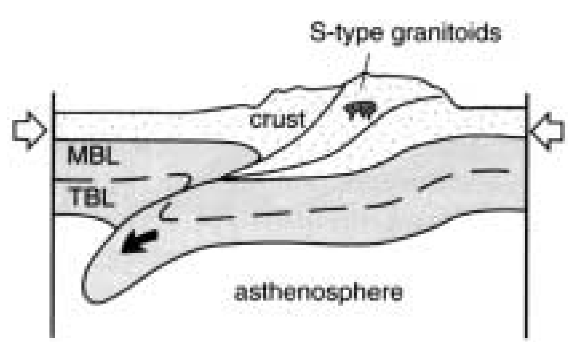
- Applies to granitic rocks
- Chappell and White (1974)
- Barbarin (1990)

Main Types

- S-type granites
- I-type granites
- A-type granitoids
- M-type granitoids

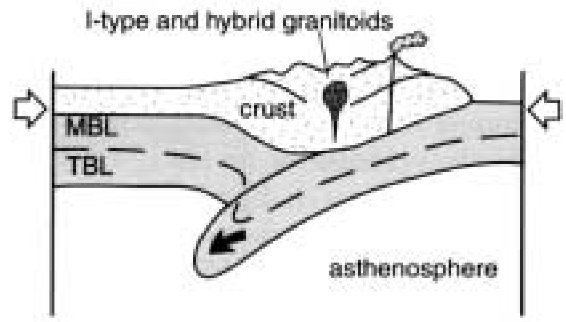
S-Type Granites

- 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



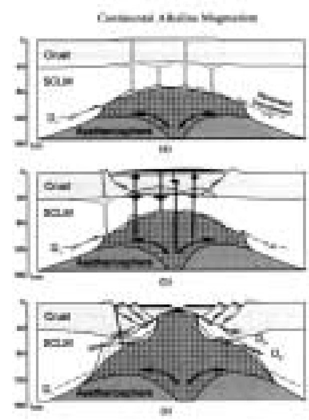
I-Type Granites

- 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



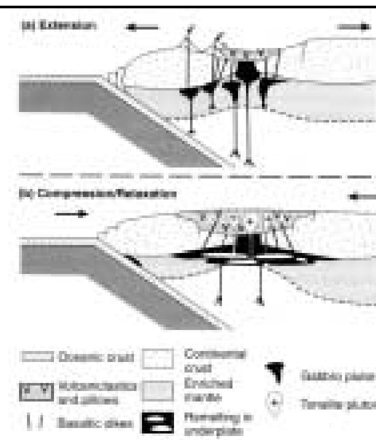
A-Type Granitoids

- Anorogenic origin
- High in SiO_2, up to 77%
- High alkalies, Fe/Mg, halogens
- Peralkaline?
- Stable craton environment



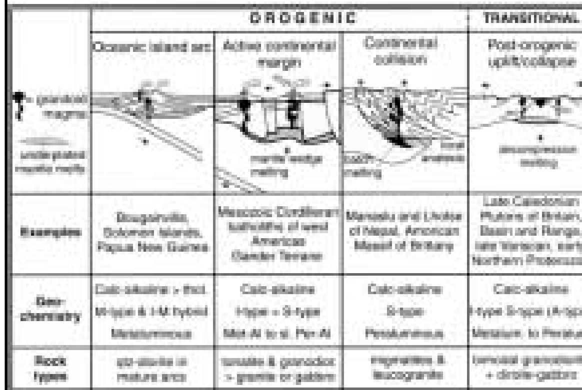
M-Type Granitoids

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

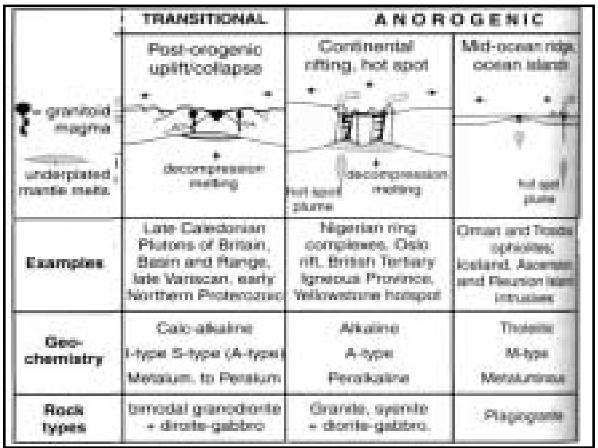


Time and Depth of Emplacement

- 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
= granitoid magma; underplated mantle melts		mantle wedge melting	melting; local anatexis	decompression melting
Examples	Bougainville, Solomon Islands, Papua New Guinea	Mesozoic Cordilleran batholiths of west Americas Gander Terrane	Manaslu and Lhotse of Nepal, Armorican 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

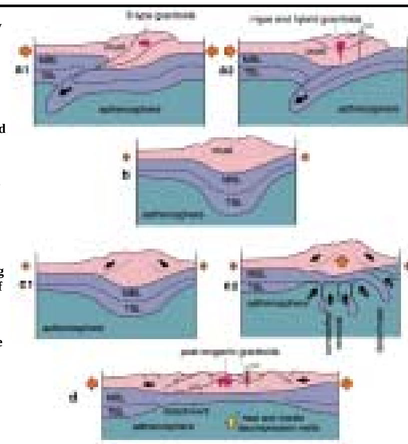
Subduction thickens crust by continental collision (a1) or compression of the continental arc (a2).

Both thicken crust and mechanical and thermal boundary layers ("MBL" and "TBL") (b)

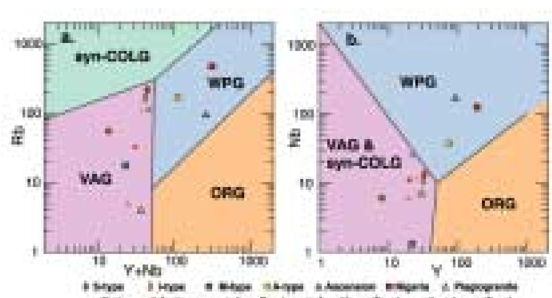
Then, either compression ceases (c1) or the thick dense thermal boundary layer is removed by delamination or convective erosion (c2).

The result is extension and collapse of the crust, thinning of the lithosphere, and rise of hot asthenosphere (d).

Increased heat flux plus decompression melting of the rising asthenosphere results in bimodal post-orogenic magmatism with both mafic mantle and silicic crustal melts. Winter (2001)



Discrimination Diagrams



Granitoid discrimination diagrams used by Pearce *et al*. (1984, *J. Petrol.*, 25, 956-983) with the granitoids of Table 18-2 plotted. From Winter (2001)

Spider Diagrams

MORB-normalized spider diagrams for the analyses in Table 18-2 . From Winter (2001)