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

\[ \text{KALSi}_3\text{O}_8 \]

\[ 1:1:3 \]

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 SiO₂, 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 ratios <0.705
- Forms tonalites
Time and Depth of Emplacement

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

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)