**Island Arc Magmatism**

- Activity along arcuate volcanic island chains along subduction zones
- Distinctly different from the mainly basaltic provinces
  - Composition more diverse and silicic
  - Basalt generally occurs in subordinate quantities
  - More explosive than the quiescent basalts
  - Strato-volcanoes are the most common volcanic landform

**Subduction Products**

- Characteristic igneous associations
- Distinctive patterns of metamorphism
- Orogeny and mountain belts

**Structure of an Island Arc**

- Complex tectonic situation and broad spectrum
- High proportion of basaltic andesite and andesite
  - Most andesites occur in subduction zone settings
Major Elements and Magma Series

- Tholeiitic (MORB, OIT)
- Alkaline (OIA)
- Calc-Alkaline (~ restricted to SZ)

Sub-series of Calc-Alkaline

- $K_2O$ is an important discriminator $\rightarrow$ 3 sub-series


K$_2$O-SiO$_2$ diagram distinguishing high-K, medium-K and low-K series. Large squares = high-K, stars = med.-K, diamonds = low-K series from Table 16-2. Smaller symbols are identified in the caption. Differentiation within a series (presumably dominated by fractional crystallization) is indicated by the arrow. Different primary magmas (on the left) are distinguished by vertical variations in K$_2$O at low SiO$_2$. After Gill, 1981, Orogenic Andesites and Plate Tectonics. Springer-Verlag.

AFM diagram distinguishing tholeiitic and calc-alkaline series. Arrows represent differentiation trends within a series.

FeO*/MgO vs. SiO$_2$ diagram distinguishing tholeiitic and calc-alkaline series.
Calc-alkaline differentiation

- Early crystallization of an Fe-Ti oxide phase
  Probably related to the high water content of calc-alkaline magmas in arcs, dissolves → high $f_{O_2}$
- High water pressure also depresses the plagioclase liquidus and → more An-rich
- As hydrous magma rises, $\Delta P$ → plagioclase liquidus moves to higher $T$ → crystallization of considerable An-rich-SiO$_2$-poor plagioclase
- The crystallization of anorthitic plagioclase and low-silica, high-Fe hornblende is an alternative mechanism for the observed calc-alkaline differentiation trend

Island Arc Magmas

The main variables that can affect the isotherms in subduction zone systems are:

1) Rate of subduction
2) Age of the subduction zone
3) Age of the subducting slab
4) Extent to which the subducting slab induces flow in the mantle wedge

The principal source components → IA magmas

1. The crustal portion of the subducted slab
   1a Altered oceanic crust (hydrated by circulating seawater, and metamorphosed in large part to greenschist facies)
   1b Subducted oceanic and forearc sediments
   1c Seawater trapped in pore spaces
2. The mantle wedge between the slab and the arc crust
3. The arc crust
4. The lithospheric mantle of the subducting plate
5. The asthenosphere beneath the slab
Island Arc Petrogenesis

A proposed model for subduction zone magmatism with particular reference to island arcs. Dehydration of slab crust causes hydration of the mantle (violet), which undergoes partial melting as amphibole (A) and phlogopite (B) dehydrate. From Tatsumi (1989), J. Geophys. Res., 94, 4697-4707 and Tatsumi and Eggins (1995), Subduction Zone Magmatism, Blackwell. Oxford.

Multi-stage, Multi-source Process

- Dehydration of the slab provides the LIL enrichments + enriched Nd, Sr, and Pb isotopic signatures
  - These components, plus other dissolved silicate materials, are transferred to the wedge in a fluid phase (or melt?)
- The mantle wedge provides the HFS and other depleted and compatible element characteristics

- Phlogopite is stable in ultramafic rocks beyond the conditions at which amphibole breaks down
- P-T-t paths for the wedge reach the phlogopite-2-pyroxene dehydration reaction at about 200 km depth