Intrusive igneous activity

I. Plutons from magma cooled below surface
   A. Named by shape and size of the igneous body
      a. Dike—Thin, tabular fine-grained layers cutting across sedimentary beds
      b. Sill—Thin, tabular fine-grained layers parallel to sedimentary beds
      c. Laccolith—bulged body parallel to sedimentary beds
      d. Batholith—large intrusive body perhaps hundreds of km wide
   B. May take millions of years to cool

II. Origin of magma—formed by melting solid rock
   1. Heat—geothermal gradient
      a. 20-30^{o}C / 1 km depth
      b. 100 km down—1200-1400^{o}C—near melting temperature of granitic rock
      c. Rocks that are subducted are heated to this temperature
      d. Basaltic magma is hotter—heats almost melted granitic rock
   2. Pressure—
      a. confining pressure raises melting temperature
         1) Release of pressure on hot solid rock can trigger melting
         2) Can occur when rock is brought higher in crust by convection
         3) This happens at mid-ocean ridges where lithosphere diverges
      b. melting increases volume
         1) pushes rock out of the way
         2) forces cracks to open
         3) causes uplift

   3. Volatiles—water content affects melting temperature (other volatiles too)
      a. Wetting a dry, hot rock can trigger melting
      b. Subduction draws water-laden sediments into asthenosphere
         1) Water is driven off
         2) Causes overlying crust to melt

III. Partial melting
   A. Since minerals melt in a specific order (see Bowen's reaction series, pg 60), triggers of melting likely result in only part of solid rock melting
   B. Result is magma with higher silica content than rock from which it melted
   C. Leaving behind a silica-depleted solid rock
   D. The magma is nearer to granite than the rock it comes from

IV. Plate motion provides the mechanisms to melt rocks into magma
   A. Convergent plate boundaries—volatiles drive melting
      1. From sinking subducted slab—creates basaltic magma
      2. Migrates upward and creates volcanic peaks parallel to trench of subduction
      3. Continental volcanic arcs form andesitic magma because the basaltic magma melts and assimilates some of the underlying continental crust

   B. Divergent plate boundaries
      1. Release of pressure allows partial melting of mantle by decompression melting
      2. Basaltic magma is generated
      3. Either cools in place as gabbro, or erupts to ridge as basalt
      4. Lava erupting below water forms 'pillow lava'
      5. Some divergent plate boundaries occur with continents also—East African Rift zone

   C. Intraplate volcanism
      1. Mantle plumes
         a. Yellowstone
         b. Hawaiian Islands
         c. Canary Islands
      2. Over 100 hot-spots across Earth have been recognized

V. Plate tectonics and igneous activity
   A. Ring of Fire—
      1. composite volcanoes surrounding the Pacific basin
      2. Andesite magma—explosive eruptions
   B. Hot-spot and oceanic ridge volcanoes—
      1. fluid basalts of Hawaii and Iceland
      2. Most submarine volcanoes are also are of this type
   C. Continental interior volcanoes—diverse in type
      1. Yellowstone—explosive super-volcano/caldera giant
      2. Columbia Plateau basalt
VI. Economic mineral resources
   A. Ore: concentration that is currently feasible to be mined
      1. Reserves—profitable, identified deposits
      2. Economic factors may change
   B. Ores—metallic minerals that can be mined at a profit
      1. Disseminated: gold, copper, lead, zinc
      2. Vein: sulfides with gold, copper, silver
      3. Placer: gold, tin, titanium, diamond
      4. Industrial minerals: Sand and gravel, Cement, clay, sulfur, salt