**Mineral Environments**

- Sedimentary
- Igneous
- Metamorphic
- Hydrothermal

**Sedimentary Environments**

*Equilibrated to atmospheric $O_2$, $H_2O*

- **Detrital**
  - Conglomerates, Sandstones, Shales
- **Evaporite**
  - Limestone,
  - Calcite - Gypsum - Halite - Sylvite

**Learning Goals:**

- Recognizing Geologic Environments and Common Minerals in Each

- Sedimentary
- Igneous
- Metamorphic
- Hydrothermal
The most abundant mineral in shale is clay.
- Shale breaks along the layers and is said to be fissile.
- Shales were deposited in standing water.
**Mudcracks**

**Most limestone is biogenic**

**Most limestone is biogenic**

**Stromatolites, Shark Bay**

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**Igneous:**

**High Temperature, Reducing**

- Basic Igneous Rocks
  - Ultra-mafic to mafic
  - Orthosilicates, Chain silicates, Oxides, Ca Feldspar
- Silicic (Felsic) Igneous Rocks
  - High Silica Activity
  - Sheet and framework silicates
- Pegmatites
  - Incompatible lithophile elements:
  - (Li, Be, B, P, Y, Rb, Cs etc.)

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**Polymerization of Silica**

- Each Si atom is surrounded by 4 oxygens.
- Polymerization is the degree to which the oxygens are shared with other Si atoms.
- Polymerization is the number of Si-O-Si bonds.
  - Olivine has none: isolated SiO$_4$ groups
  - Pyroxene has 50%: SiO$_3$ chains
  - Mica has has 75% shared: Si$_2$O$_{10}$ sheets
  - Quartz and feldspar have 100% (Si,Al)O$_2$ framework.
Polymerization of Silica

Tetrahedron

Olivine

Pyroxene

Mica (Sheet)

Quartz (Framework)

Quartz and Olivine are incompatible

\[
Mg_2SiO_4 + SiO_2 = Mg_2Si_2O_6
\]

Olivine + Quartz = Pyroxene

Reaction will proceed until one reactant is consumed. So, olivine is not compatible with quartz.

Mafic Magma Chamber (BIR)

Crystals form from magma cooling and settle to floor of chamber

Crystals from early cooling accumulate

Silicic Intrusion (SIR)

Hydrothermal Veins

Pegmatite
Pahoehoe, Hawaii (Basalt)

Aa, Hawaii (Basalt)

Composite Cone, Mt. Fuji, Japan

Granite

Granite
Metamorphic: High Temperature, Hydrous, Reducing

- High-grade Metamorphic HGM
  - High Al contents
  - High Pressure phases
- Low Grade Metamorphic LGM
  - Low Density hydrous silicates (Zeolites)

Metamorphic Environments

Metamorphic Sediments
Metamorphic Gneiss

Migmatite

Garnet Amphibolite Gneiss

Garnet Chlorite Schist

Meta basalt

Black Canyon of the Gunnison

Hydrothermal: Hot Aqueous Solutions

- High Temperature Hydrothermal (HTH)
  - Chalcophile and siderophile sulfides
- Low Temperature Hydrothermal
  - Ba, Sr sulfates, carbonates
- Oxidized Hydrothermal (Gossan) (OHY)
- Chalcophile sulfates, carbonates, hydroxides
Hydrothermal: Hot Aqueous Solutions

A. Igneous
B. Metamorphic
C. Sedimentary
D. Hydrothermal

Silicic Intrusion

A. Igneous
B. Metamorphic
C. Sedimentary
D. Hydrothermal

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A. Igneous
B. Metamorphic
C. Sedimentary
D. Hydrothermal
A. Igneous
B. Metamorphic
C. Sedimentary
D. Hydrothermal

Black Rock
A. Igneous
B. Metamorphic
C. Sedimentary
D. Hydrothermal

Red Rock
A. Igneous
B. Metamorphic
C. Sedimentary
D. Hydrothermal

A. Igneous
B. Metamorphic
C. Sedimentary

A. Igneous
B. Metamorphic
C. Sedimentary
What do you see?

A. Igneous
B. Metamorphic
C. Sedimentary
D. Hydrothermal