Geology 284 - Mineralogy, Fall 2006
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The Minerals of Sediments and Sedimentary Rocks

Result from Recycling of older Rock Materials

Sedimentary Rocks and Minerals

Sediments and Sedimentary Rocks cover about 80% of the Earth's surface, but form a very thin blanket, constituting only about 1% of the Earth's volume.

They're important to us, because we live at Earth's surface!

Two main kinds of Sediments and Sedimentary Rocks

- Clastic or Detrital Sedimentary Rocks (formed of mineral grains from or fragments of pre-existing rocks)
- Chemical Sedimentary Rocks (formed by precipitation of minerals from water or alteration of previously precipitated material)

Sedimentary Rock Types

Sediments form as a result of Weathering

- Physical Weathering
- Depends on hardness, cleavage, etc.
- Chemical Weathering
- Depends on chemical reactivity of minerals
- Relative susceptibility of common minerals to weathering is summarized in Goldich's Weathering Series

Goldich's Weathering Series - see handout

Products of Weathering

- Minerals
- Ions in solution

Detrital Grains are

- Rock Fragments or
- Mineral Grains
- What Minerals?
- Almost any mineral, but
- Mostly minerals that are physically and/or chemically stable or resistant to weathering

Common Detrital Minerals

- Quartz
- Feldspars
- Clay Minerals

Detrital Quartz Grains

- Abundant
- Clear and unaltered
- Larger than detrital feldspar
- Commonly rounded
- Commonly monocrystalline

Quartz-rich Sandstone

Polycrystalline Quartz in Ss

Detrital Feldspar Grains

- Generally less abundant than quartz
- Cloudy and highly altered
- K-feldspar and Na-rich plagioclase more abundant and less altered than Ca-rich plagioclase
- Commonly monocrystalline

Clear Quartz, Altered Feldspar

Microcline in Sandstone

Perthitic Alkali Feldspar in Sandstone

Other Detrital Grains

- Micas may be present: Musc > Biotite
- Olivine and Pyroxene rare
- Accessory (detrital) Minerals
- Hard, chemically resistant minerals without good cleavages
- Garnet ($(Mg,Fe)_3Al_2Si_3O_{12}$), zircon ($ZrSiO_4$), rutile (TiO_2), tourmaline, etc.
- Examples from heavy mineral separates of loose sediments

Detrital Zircon ($ZrSiO_4$) Separate – Why is zircon important?

Detrital Rutile (TiO_2) Separate

Grain Size is significant in Sedimentary Rocks

- Gravel Size
- greater than 2 mm
- Sand Size
- 0.062 to 2 mm
- quartz and feldspar common
- Silt Size
- 0.004 to 0.062 mm
- mostly quartz
- Clay Size
- less than 0.004 mm
- mostly clay minerals

Clays in Clastic Sedimentary Rocks

- Clays may be either
- Detrital = transported solid products of weathering

or

- Authigenic = formed in the sediment after deposition

Clay Minerals are Sheet Silicates much like Serpentine and Micas

- Kaolinite $Al_4(Si_4O_{10})(OH)_8$ is a dioctahedral, t-o sheet silicate (like serpentine)

Important Clay Minerals

- **Kaolinite**
- $Al_4(Si_4O_{10})(OH)_8$
- **Illite** (muscovite-like, more Si, less K)
- $K_{1-1.5}Al_4(Si,Al)_8O_{20}(OH)_4$
- **Montmorillonite** (expanding clays)
- $(Ca,Na)_{0.2-0.4}(Al,Mg,Fe)_2(Si, Al)_4O_{10})(OH)_2$
- expand when wet, shrink when dry

Kaolinite

Authigenic Kaolinite in Ss
(SEM 6µm width)

Authigenic Clay in Ss
(SEM 4.5 µm wide)

How Sediments become Sedimentary Rocks

- Diagenesis
  - Compaction
  - Cementation - growth of authigenic minerals
- Lithification - hardening, turning into a rock

Chemical/Organic Sedimentary Rocks

Carbonate Rocks or Limestones

Carbonate Minerals

Our first non-silicates!

What's the Anion?

The Carbonate Anion

- **$(CO_3)^{2-}$**

- flat triangular shape

Carbonate Minerals

- Calcite and Aragonite ($CaCO_3$)
- Rhodochrosite ($MnCO_3$)
- Siderite ($FeCO_3$)
- Magnesite ($MgCO_3$)
- Dolomite ($CaMg(CO_3)_2$)

Effervescence in cold, dilute HCl

- Calcite ($CaCO_3$) and Aragonite ($CaCO_3$) effervesce (fizz) in cold, dilute HCl
- Dolomite ($CaMg(CO_3)_2$) does not
- Some other less common carbonates also fizz:
- Malachite $Cu_2(CO_3)(OH)_2$
- Azurite $Cu_3(CO_3)_2(OH)_2$
- Smithsonite $Zn(CO_3)$
- Witherite $Ba(CO_3)$
- Strontianite $Sr(CO_3)$

The Rhombohedron is the cleavage form for most carbonates (not aragonite) and is a common carbonate growth form

A rhombohedron is a squashed (or stretched) cube.

Rhodochrosite Rhombohedra

Saddle-shaped crystals with curved faces are characteristic of Dolomite

Calcite and Dolomite and all other "Rhombohedral Carbonates" (not aragonite) have similar structures

They, therefore, have similar growth and cleavage forms and other similar properties

Carbonates are strongly anisotropic, WHY?

Calcite and other carbonates have extremely high birefringence (milky pastel-white) because they are so strongly anisotropic

Calcite and Aragonite are polymorphs of $CaCO_3$

See handout for ranges of stability.

In stained thin sections:

Calcite (red) can be distinguished from
Dolomite (clear) by staining

Stained Brachiopod Shell in Silty Carbonate

Brachiopod Shell Sections

Calcite Ooids (note structure)

Carbonate Ooids

Mollusk Molds filled with Calcite

Another kind of Chemical Sedimentary Rock

Evaporites

if Seawater gets trapped in a basin and evaporates

- The water eventually becomes saturated with certain minerals, and they precipitate
- Evaporite minerals: carbonates, halides and sulfates, begin to precipitate
- It takes 625 feet of seawater to produce 10 feet of evaporite sediment

in Silurian time in WV and Ohio

- The epicontinental seas that had covered most of the interior of North America receded (called a regression)
- Some seawater remained trapped in northern WV and Ohio
- It evaporated to form the Silurian Salina Formation (now about 5000 feet below the surface)

When seawater evaporates

- Potassium and Magnesium Chlorides precipitate last Top of sequence
- Halite (NaCl) precipitates next after 90% evap
- (about 80% of evaporite thickness)
- Sulfates precipitate next
- Gypsum $CaSO_4 \cdot 2H_2O$
- Anhydrite $CaSO_4$
- Carbonates precipitate first after 70% evap
- Calcite $Ca(CO_3)$ and Dolomite $CaMg(CO_3)_2$ Bottom of sequence

Halides

- What are the anions?

- Which of the evaporite minerals are halides?
- Properties?

Sulfates

- What is the anion?
- What evaporite minerals are sulfates?
- How are they different from sulfides?