Outline 4: Sedimentary Rocks

Basic Aspects of their Study

Main Points
- Environments of Deposition
- Color of Sedimentary Rocks
- Grain Size
- Grain Sorting
- Sedimentary Structures

Main Points, cont’d
- Clastic Sedimentary Rocks
- Chemical Sedimentary Rocks
- Rock Units
- Time Units
- Facies
- Correlation
Environments of Deposition

• 3 Major Environments
• Marine
• Continental or Terrestrial
• Transitional

Marine Environments

• Continental Shelf
• Shelf Edge
• Slope
• Ocean Floor – continental rise and abyssal plain

Continental or Terrestrial Environments

• Glacial – both Alpine and Continental
• Alluvial Fans – at the base of mountains
• Lakes
• Rivers and Floodplains = Fluvial
• Swamps
• Deserts
Transitional Environments

- Beaches
- Barrier Islands
- Tidal Flats
- Lagoons and Bays
- Estuaries
- River Deltas

Major sedimentary environments

Color of Sedimentary Rocks

- Color can be useful in the interpretation of depositional environments.
- **Black color** – indicates deposition in the absence of oxygen in either the ocean, lakes, or swamps.
- **Red color** – indicates deposition in the presence of abundant oxygen in a warm, humid terrestrial environment.
Black Shale, Anoxic Environment

Outcrop of Black Marcellus Shale in WV. Produces natural gas in deep underground reservoirs.

Red Beds, Oxygenated Environment
Grain Size

- Grain size can be an indicator of the energy of the environment.
- Generally speaking, higher energy water or wind currents are required to move larger grain sizes.

Grain Size, cont’d

- Size ranges: small to large
  - clay, <1/256 mm
  - silt, >1/256 mm
  - sand, 1/8–2 mm
  - granules, 2–4 mm
  - pebbles, >4mm
  - cobbles, >64mm (>3 in.)
  - boulders, >256 mm (>1 ft.)
Grain Sorting

- Grain sorting can also be an indicator of the energy of the environment.
- Well-sorted sediments are deposited in high energy environments. Currents sort the grains by size.
- Poorly-sorted sediments may indicate weak currents, or transport by glaciers.
Well sorted sand grains

Poorly sorted sand grains. Wide size range.

Very poorly sorted glacial sediments
Mud-sized sediment

Sedimentary Structures

- Provide clues to depositional environments. Some examples:
- **Cross bedding** – rivers, dunes, tidal channels
- **Graded bedding** – storms and turbidites
- **Ripple marks** – lower energy
- **Mud cracks** – subaerial exposure

Geometry of sand dunes, both eolian and aquatic.
Cross bedding in sandstone

Sand waves on the sea floor formed by underwater sand dunes, Florida Keys

Graded Bedding in Sandstone – formed by storms or turbidite deposition
Clastic Sedimentary Rocks

• Produced by weathering of rocks.
• **Breccia** – large, angular grains
• **Conglomerate** – large, rounded grains
• **Sandstone**
• **Siltstone**
• **Shale or Mudstone**

**Conglomerate**

Conglomerate deposited as an alluvial fan, Cretaceous of Utah
Alluvial Fans

Chemical Sedimentary Rocks

- Produced by chemical precipitation.
- Evaporites – formed by evaporation of seawater
  - Salt, NaCl
  - Gypsum, CaSO₄
- Carbonates
  - Limestone, made of calcite, CaCO₃
  - Dolostone, made of dolomite, CaMg(CO₃)₂

Carbonates

- Typically, carbonates form in warm, clear water free of clastic sediment.
- Carbonate grainstone – composed of sand-sized grains from invertebrate skeletons or ooids (form oolites).
- Carbonate mudstone – clay and silt-sized grains from pellets and calcareous algae.
Carbonate Depositional Environments

Carbonate Depositional Environments in the Bahama Islands

Carbonate Depositional Environments
Carbonate Depositional Environments
Fossil Reef, Devonian of Australia

Carbonate Depositional Environments
Modern Reef, South Pacific

Living Coral Reef
Fossiliferous Limestone

Ooids that form oolites
Oolite under the microscope

Carbonate Grainstone: Oolitic Limestone

Oolite Shoals, Bahamas
Sedimentary rocks are divided into formations. Formations can be divided into members. Formations can be combined into groups.
• Formation name consists of two parts:
  – Geographic name
  – Lithology or simply Formation
• Examples:
  – Burlington Limestone
  – Morgantown Sandstone
  – Juniata Formation (no dominant lithology)

• Example of rock unit divisions:
• Borden Group: 3 formations
  – Edwardsville Formation
  – Carwood Sandstone
  – New Providence Shale
    - Kenwood Siltstone Member
      (within the New Providence)
Kenwood Siltstone Member within the New Providence Shale, Louisville, KY

Time Units

- Time can be separated into “pure” time and “rock” time. Rock time is divided into time stratigraphic units.
- Time stratigraphic units sometimes parallel formation boundaries, but often they cross formation boundaries.

Time Units

- Time Units
  - Era
    - Period
  - Epoch
  - Age
  - Devonian Period
- Time Stratigraphic
  - (Erathem)
    - System
  - Series
    - Stage
  - Devonian System
Sedimentary Facies

- **Facies** – general appearance or aspect of sedimentary rocks. Often correspond to rock units.
- A reflection of the depositional environment.
- **Lithofacies** – defined by lithologic features
- **Biofacies** – defined by organic features

Sedimentary Facies

- Facies occur laterally adjacent to one another just as do their depositional environments.
- Two different facies can have similar lithofacies but different biofacies, or vice-versa.

Sedimentary Facies – a Delta
Sedimentary Facies – a Delta

Transitional Environments: a Barrier Island

Transitional Environments: Tidal Inlets between Barrier Islands
Sedimentary Facies

- Facies migrate laterally with changes in sea level.
- Falling sea level = regression. Nonmarine facies overlie marine facies.
Transgression, regression, and stratigraphic cycles-
How facies become stacked in rock layers.
Stratigraphic Correlation

The Grand Canyon of the Colorado River in Arizona

Grand Canyon Stratigraphy
Stratigraphic correlation between Grand Canyon, Zion, and Bryce Canyon national parks allows construction of a composite stratigraphic column.
Correlation

- Determination of the equivalence of bodies of rock at different locations. There are two kinds of correlation:
  - Lithostratigraphic – matching up continuous formations.
  - Chronostratigraphic – matching up rocks of the same age. Usually done with fossils, i.e. Biostratigraphy
Correlation

- Over short distances lithostratigraphic correlation is the same as chronostratigraphic correlation.
- Over medium distances they are not the same.
- Over long distances only chronostratigraphic correlation can be used.

Original Lateral Continuity: permits lithostratigraphic correlation

Same bed marked by red arrows

Correlation Using Fossils
Detailed lithostratigraphic correlation of the Cambrian strata of the Grand Canyon, plus biostratigraphic zones. Note the facies interfingering.

Interfingering of strata due to shifting of facies during deposition

Zone of middle Cambrian trilobites
Zone of early Cambrian trilobites

Cambrian strata of the Grand Canyon: Note the two time lines from biostratigraphy: biostratigraphic correlation.

Time lines established by biostratigraphy

Depositional Model for the Cambrian strata of the Grand Canyon: Tapeats Sandstone, Bright Angel Shale, and Muav Limestone