Chapter 6

Correlation and Dating of the Rock Record
Guiding Questions

• What are the basic units of stratigraphy
• How do facies differ from rock units?
• What is the difference between relative scale and absolute scale of geologic time?
• How are stable isotopes, marker beds, and unconformities used for correlation?
Scientists use fossils, radiometric dating, unconformities, isotope stratigraphy, and patterns of transgression and regression to correlate rocks with respect to time.
Time

• Relative
  – Order of deposition of a body of rock based on position

• Absolute
  – A number representing the time a body of rock was deposited
History of Geologic Time

- Nicolaus Steno
  - Ordered rocks
- William Smith
  - Correlated with fossils
- Georges Cuvier
  - Extinction
History of Geologic Time

- **Geologic Systems**
  - Body of rock that contains fossils of diverse animal life
  - Corresponds to geologic period

- **Sedgewick**
  - Named Cambrian

- **Murchison**
  - Named Silurian
Stratigraphy

- Study of stratified rocks, especially their geometric relations, compositions, origins, and age relations

- Stratigraphic units
  - Strata
    - Distinguished by some physical, chemical, or paleontological property
    - Units of time based on ages of strata
  - Geologic Systems

- Correlation
  - Demonstrate correspondence between geographically separated parts of a stratigraphic unit
    - Lithologic
    - Temporal
Units of Time

• Time-rock unit
  – Chronostratigraphic unit
  – All the strata in the world deposited during a particular interval of time
    • Erathem, System, Series, Stage

• Time unit
  – Geochronologic unit
  – Interval during which a time-rock unit is formed
    • Eras, Period, Epoch, Age

• Boundary stratotype
  – Boundary between two systems, series or stages, formally defined at a single locality
Biostratigraphy

- **Biostratigraphic unit**
  - Defined and characterized by their fossil content

- **Stratigraphic range**
  - Total vertical interval through which a species occurs in strata, from lowermost to uppermost occurrence
Biostratigraphy

• **Zone (biozone)**
  - Body of rock whose lower and upper boundaries are based on the ranges of one or more taxa in the stratigraphic record
  - Named for the taxon that occurs within it
Biostratigraphy
Biostratigraphy
Biostratigraphy

• Index fossil
  – Abundant enough in the stratigraphic record to be found easily
  – Easily distinguished from other taxa
  – Geographically widespread and thus can be used to correlate rocks over a large area
  – Occurs in many kinds of sedimentary rocks and therefore can be found in many places
  – Has a narrow stratigraphic range, which allows for precise correlation if its mere presence is used to define a zone
Magnetic Stratigraphy

- Use of magnetic properties of a rock to characterize and correlate rock units
- Magnetic field
  - Reversals in polarity of field are recorded in rocks when they crystallize or settle from water
Magnetic Stratigraphy

- **Chron**
  - Polarity time-rock unit
  - Period of normal or reversed polarity
    - **Normal interval**
      - Same as today
      - Black
    - **Reversed interval**
      - Opposite to today
      - White
Lithostratigraphy

• Subdivision of the stratigraphic record on the basis of physical or chemical characteristics of rock

• Lithostratigraphic units
  – Formation
    • Local three-dimensional bodies of rock
      – Group
      – Member

• Stratigraphic section
  – Local outcrop of a formation that displays a continuous vertical sequence

• Type section
  – Locality where the unit is well exposed that defines the unit
Lithologic Correlation

- Cross-sections of strata
  - Establish geometric relationships
  - Interpret mode of origin
Lithologic Correlation

- Grand Canyon
  - McKee
  - Used Trilobite biostratigraphy to determine age relationships
  - Eastern portion of units is younger than western
Facies

- **Transgression**
  - Landward migration of shoreline
  - Grand Canyon
    - Cambrian transgression

- **Facies**
  - Set of characteristics of a body of rock that presents a particular environment

- **Facies changes**
  - Later changes in the characteristics of ancient strata
Absolute Age

- Accepted age of the Earth is 4.6 billion years old
- Early estimates
  - Salts in the ocean
    - 90 million years old
  - Accumulation of sediment
    - 100 m.y. or less
    - Gaps in stratigraphic record
    - Unconformities represent large breaks in accumulation
    - Didn’t include metamorphosed sedimentary rocks
  - Earth’s temperature
    - Kelvin
    - 20-40 million years old
Absolute Age

• Radioactive decay
  – Becquerel, 1895
    • Uranium undergoes spontaneous decay
    • Atoms release subatomic particles and energy
    • Change to another element
  – Parent isotope decays; daughter isotope produced
Absolute Age

- Three modes of decay
  - Loss of alpha particle
    - Convert parent into element that has nucleus containing two fewer protons
  - Loss of beta particle
    - Convert parent into element whose nucleus contains one more proton by losing an electron
  - Capture of beta particle
    - Convert parent into element whose nucleus has one less proton

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Absolute Age

- Radiometric dating
  - Radioactive isotopes decay at constant geometric rate
    - After a certain amount of time, half of the parent present will survive and half will decay to daughter

- Half-life
  - Interval of time for half of parent to decay
Absolute Age

• Useful isotopes
  – Uranium 238 and thorium 232
    • Zircon grains
  – Uranium 238 and lead 206
    • Fission track dating
  – Rubidium-Strontium
  – Potassium-Argon, Argon-Argon
  – Radiocarbon dating
    • Produced in upper atmosphere
    • Half life = 5730 years
    • Maximum age for dating: 70,000 years
    • Bone, teeth, wood
Absolute Age

- Fission-Track Dating
  - Measure decay of uranium 238 by counting number of tracks
  - Tracks formed by subatomic particles that fly apart upon decay
Absolute Age

- Best candidates for most radiometric dating are igneous
  - Not necessarily useful for sediments

- Error in age estimate can be sizable
Absolute Age

- Absolute ages change
  - Error increases in older rocks
  - Techniques change
- Biostratigraphic correlations are usually more accurate
  - Radiometric dates used when fossils not present
Isotope Stratigraphy

- Strontium 86 and strontium 87
  - Change through time in seawater
  - Organisms incorporate Sr instead of Ca into their skeletons in the same ratio as the seawater they lived in
  - Changes in ratio used to identify position in time
Event Stratigraphy

- Marker bed
  - Bed of sediment
  - Same age throughout
    - Ash fall
  - Bishop Tuff
Event Stratigraphy

- Cretaceous volcanic eruption
- Deposited ash between marine sediments
Event Stratigraphy

• Evaporites
  – Distinct patterns and geochemistry of layers
  – Useful for correlation over wide regions
Facies Boundaries

- Correlating sections within a basin
  - Point of maximum transgression
Seismic Stratigraphy

- Interpretation of seismic reflections generated when artificially produced seismic waves bounce off physical discontinuities within buried sediments.
Seismic Stratigraphy

- Creates an image of the subsurface
- Discontinuities and unconformities can be identified
Eustatic Changes

• Global curve of Cenozoic sea-level changes
  – Extended to rest of Phanerozoic

• Eustatic change
  – Global change in sea level
Eustatic Changes

- Events on land can affect global change on a local level
- Uplift can mask eustatic change
- Sediment accumulation influences local response
Sequence Stratigraphy

- **Sequences**
  - Large bodies of marine sediment deposited on continents when the ocean rose in relation to continental surfaces and formed extensive epicontinental seas.

- **Sediment geometry is useful for “reading” sea-level change**