COURSE OUTLINE
GEOL 304 - SEDIMENTARY GEOLOGY, Spring 2006, Diecchio
text: Prothero & Schwab, *Sedimentary Geology*, 2nd edition

OVERVIEW ch. 1
- observation & description
- interpretation
  - how far can we take it?

STEPS IN THE FORMATION OF SEDIMENTARY ROCK
- weathering of parent rock
- erosion & transportation
- deposition — these processes may overlap
- diagenesis — ... may repeat
- burial and tectonism — ... may or may not occur

What you end up with is a product of…
- what you start with — parent rock (provenance)
- what happens to it — process(es)
- how long it takes — time over which it evolves

PRIMARY TYPES OF SEDIMENTARY ROCKS
- Clastic (siliciclastic, detrital, terrigenous)
- chemical
- biogenic or biochemical or organic
- other ch 14 (290-299)
  - pyroclastic
  - cataclastic
    - tectonic
    - collapse
    - meteoric

DISTRIBUTION OF SEDIMENTARY ROCKS
- space
- time

WEATHERING ch. 2
- degradation of rock
- production of sediment or soil
- mechanical/physical weathering
- chemical weathering
  - dissolution
  - hydration – dehydration
  - hydrolysis (clays)
  - oxidation - reduction
  - hydrolysis (clays)
- soils

EROSION – TRANSPORTATION – DEPOSITION ch. 3
- fluid & particle dynamics
  - Reynolds Number
  - Froude Number
  - types of transport
  - Hjulstrom diagram
  - types of flows

SEDIMENTARY STRUCTURES ch. 4

- primary
  - flow regime
  - bedding
    - planar
    - cross-beds
      - types
  - surface markings
- secondary
  - trace fossils

SEDIMENTARY PARTICLE SIZE ANALYSIS ch. 5

- Size scales
  - mm scale
  - phi scale
  - mesh sizes
- size categories
  - gravel
  - sand
  - silt
  - clay
- procedures for analysis
- particle size distributions
  - histogram
  - frequency curve
  - cumulative frequency (ogive) curve
- statistical treatments
  - measures of central value - specified as phi value
    - mean
    - median
    - mode
  - measures of dispersion or uniformity - specified as phi value
    - standard deviation
    - sorting
  - measures of symmetry - specified with no unit
    - skewness
  - measure of peakedness – specified with no unit
    - kurtosis

individual particle attributes

- composition (mineralogy or lithology)
- size
- physical properties
  - density (weight)
  - hardness
- shape
  - form
    - sphericity - how equidimensional
    - Zingg shape
  - roundness vs. angularity
- surface textures

- fabric - grain-to-grain relationships
  - orientation (eg imbrication)
  - packing
    - grain supported vs. matrix supported

- siliciclastic sediments & rocks
  - siliciclastic = pieces of silicates = clastic

  - components
    - grains vs. matrix
    - rock fragments
    - primary mineral grains (silicates)
      - weathering series
    - secondary minerals
      - clays, oxides
    - dissolved & precipitated components (cements)
  - ternary diagrams
    - percent lines
    - ratio lines

  - siliciclastic rock classifications
    - all clastics

    - RUDITES
      - intraformational vs. extraformational (epiclastic)
      - orthoconglomerate vs. paraconglomerate (diamictite)
      - oligomict vs. polymict vs. petromict

    - ARENITES & WACKES
      - Numerous classifications, some conflicting
        - Arenite vs. wacke (vs. mudrock)
        - Quartzarenite/quartz wacke
        - Arkose/arkosic wacke
        - Litharenite/lithic wacke
      - maturity
        - mineralogic (compositional)
        - textural (Folk)

    - MUDROCKS ch. 6
      - Clay vs. silt vs. mud
      - Clay minerals
      - Fissile vs. non-fissile
        - Controls of fissility

    - color (esp important for mudrocks)
      - oxidation state of fe-oxides
      - organic content

    - porosity & permeability
      - primary
        - texture (sorting, etc)
        - matrix
      - secondary
        - diagenetic

clastic diagenesis ch. 7
- importance of porosity
- compaction
- infilling with matrix (clays, oxides)
- dissolution
- authigenesis
- recrystallization
- replacement (includes in situ weathering)
- cementation
  - pore-filling & authigenic mineral growth
  - macroscopic
  - microscopic
    - syntaxial overgrowths - shallow depths
    - quartz pressure solution - deep subsurface
    - pore-filling
- temperature/pressure indicators
- diagenetic history

SILICICLASTIC DEPOSITIONAL ENVIRONMENTS

TERRESTRIAL ENVIRONMENTS ch. 8
- preservation potential

FLUVIAL-ALLUVIAL SYSTEMS
- dry climate/ internal drainage - alluvial
- humid climate/ external drainage - fluvial

ALLUVIAL FANS
- Tectonic settings
- Geometry
  - Changes over time
- Transport/paleocurrent directions
- Sediment types
- Proximal vs. distal facies
  - Progradational sequence
  - Vertical section – coarsening upward

HUMID FLUVIAL SYSTEMS
- upstream – downstream variations
  - gradient
  - stream size
  - sinuosity
    - transport directions
  - geometry of deposits
  - sediment types
  - bar types
  - vertical sections – fining upwards
- braided streams
  - Longitudinal bars
  - Transverse bars
- Meandering streams
  - channel, point bars, floodplain
    - point bar section
- baselevel
  - controls on baselevel
  - baselevel and stream preservation potential

LACUSTRINE
- shoreline sands - lake basin muds
- progradation of sands over muds
  - coarsening-upwards

EOLIAN
GLACIAL
PALUDAL

COASTAL ENVIRONMENTS – CLASTIC ch. 9
- fluvial vs. wave vs. tidal influence
- current directions
- geometry of deposits
- sediment types
- progradation
  - coarsening-upward vertical section
    - regressive section
    - independent of most sea-level changes

- DELTAS
  - deltaic facies model
    - clastic wedge

- BEACHES - BARRIER COMPLEXES - CHENIERS
  - beach facies model
    - regressive vs. transgressive section
    - progradation vs. sea-level change
      - regressive sections
      - transgressive surfaces

- TIDAL FLATS
  - facies model
    - distal is coarse, proximal is fine
  - progradation
    - fining-upward REGRESSIVE sequence

MARINE & PELAGIC ENVIRONMENTS ch. 10
- SHELF DEPOSITS
  - Little to no sedimentation on today's shelves
  - tidal sand waves or ribbons
  - storm wave - linear sand ridges
- SLOPE & RISE DEPOSITS
  - submarine fan
    - turbidites
      - Bouma sequence
    - distal vs proximal fan facies
      - progradation
        - coarsening-upward

- PELAGIC DEPOSITS
  - red clays
    - continuous sedimentation
  - calcareous oozes
    - carbonate compensation depth
  - siliceous oozes

INTRABASINAL OR CHEMICAL SEDIMENTARY ROCKS

- LIMESTONES (CARBONATES): more than 50% carbonate — ch. 11 (212-226)
  - minor components:
    - silicates & oxides
  - major components
    - precipitates of calcite, aragonite, dolomite
      - allochems (carbonate grains)
      - matrix
        - micrite
        - cement
          - aragonite or calcite spar
  - limestone classifications
    - Folk
      - based on types of allochems & types of matrix
    - Dunham
      - based on allochem-micrite relationships
      - based on assumed original texture
  - limestone mineral species
  - EH-pH diagram

- EVAPORITES — ch. 14 (276-279, 283-290)
  - evaporate column of seawater to dryness
  - Eh-pH diagram

- limestone diagenesis — ch. 11 (226-234)
  - stability of carbonates in marine environment
  - terrestrial (weathering conditions)
  - types of diagenetic mineralogic alteration
    - replacement
    - recrystallization
    - inversion

  - DOLOMITIZATION
    - abundance of major ions in seawater
    - seawater supersaturated wrt/ dolomite
      - BUT dolomite does NOT precipitate
    - secondary to penecontemporaneous
    - dolomitization models
    - mineralogic controls on dolomitization
    - textural controls on dolomitization

- CARBONATE ENVIRONMENTS — CH. 12
  - intrabasinal
    - not sourced from land, may not prograde
      - vertical facies
    - carbonate geochemistry
      - marine vs fresh water
      - carbonates vs clastics
        - default contition in shallow marine environment
          - carbonates if clastics are absent
      - mechanisms for removal of CO2
      - roles of organisms
      - inorganic carbonate production
      - bathymetric control on carbonates
        - conditions for thick carbonate sections
      - Wilson's facies models
      - reefs
        - substrate control
        - +/- fixed position (vertical facies)

- SILICASTONES/CHERTS — ch 13 (263-265)
  - Eh-pH controls
  - opal - chalcedony - chert
    - primary
    - skeletal
    - replacement
- PHOSPHORITES — ch 13 (265-269)
  - Eh-pH
  - Forms of phosphate minerals
  - oceanic upwelling
- IRONSTONES — ch 14 (279-283)
  - Eh-pH controls
  - shoreline progression model
  - iron formations
    - Precambrian banded iron ores
    - Phanerozic ironstones
    - Redbeds
- FOSSIL FUELS & CARBONACEOUS SEDIMENTS — ch 13 (269-274)
  - Humic series / humulith / coal series
    - Kerogen
    - carbon
  - Sapric series / sapropel / petroleum series
    - butumen
    - hydrocarbons
  - classification
    - coal
      - rank
      - components
    - petroleum
      - maturation
      - migration of fluids
      - necessary geologic conditions
        - source bed
        - reservoir
        - cap rock
          - trapping mechanism
          - stratigraphic & structural analyses

STRATIGRAPHY — ch. 15

- facies
  - definitions
  - facies change
  - Walther's Law
  - regressive vs transgressive pattern
- the vertical section or stratigraphic column
  - vertical dimension
    - thickness
    - time
    - controls on thickness
  - information from a vertical section
    - geologic history of one specific place
    - comparison of 2 or more sections
      - regional analyses

gaps in the record - "unconformity", hiatus, lacuna
- nonconformity
- angular unconformity
- disconformity
- paraconformity
  - diastem
- incompleteness of stratigraphic record

stratigraphic units App. A
- rock vs. time-rock vs. time
- material units
  - rock (lithostratigraphic) units
    - formation (basic unit)
      - definition
      - naming of formations
      - rules:
        - every stratum is part of 1 and only 1 formation
        - formations do NOT repeat in vertical section
    - groups, supergroups - optional
    - members, beds - optional
    - boundaries
      - vertical vs. lateral
      - gradational vs. abrupt
  - other material units
    - lithodemic
    - magnetostratigraphic
    - biostratigraphic
    - pedostratigraphic
    - allostratigraphic
- time (geochronologic) units
  - eon era period epoch age
- time-rock (chronostratigraphic) units
  - eonothem erathem system series stage zone
- polarity units
  - polarity chronostratigraphic
  - polarity chronologic
- diachronic

TIME IN STRATIGRAPHY

TIME SIGNIFICANT EVENTS ch. 15(328-331), 17(377-384)
- OPTIMAL criteria
  - rapidly occurring
  - recognizable in some way
  - widespread (optimally global)
- significance of periodic events
- non-paleontologic events
  - magnetic reversals
  - ash layers (bentonites)
  - astronomic events
    - Milankovitch events
    - meteorite impact-influenced horizons
  - distinctive beds
  - widespread climate changes/facies shifts
    - sea-level changes: local vs. eustatic
    - Israelsky wedge
- Paleontologic events
  - Fossils as time-significant events

BIOSTRATIGRAPHY ch. 16

- biozone = basic material unit, subbiozone
  - interval zones
  - assemblage zones
  - abundance zones & acme zones

*** biozones may or may not include the total known range of each taxa
*** up to here there is no mention of time significance of these zones

- Index fossil
  - Observable
  - Widespread
  - Repidly occurring

- guide fossil - very nebulous term
  - any fossil used to recognize a stratigraphic unit
    - may be restricted to specific facies
    - may be indicative of a specific formation
  - sometimes used to mean index fossil
    - indicative of a time-rock interval

- What do zones signify?
  - for index species
  - non-index species
    - may or may not have time significance
  - local vs. widespread index species
  - limited vertical extent
  - limited geographic extent
  - diachronous biozones

- incompleteness of fossil record
  - preservation problems
  - reworking of fossils
  - leaking of fossils
  - size considerations
  - effect of sedimentation rate, diagenesis

- quantitative methods
  - Shaw's method of graphic correlation

Time-significant events (continued)

- Sequence statigraphy
  - define sequence

SEISMIC STRATIGRAPHY ch 17 (361-376)

- source
- receivers (geophones, hydrophones)
- reflection profile
  - structural relationships
  - bedding relationships
    - seismic sequences (reflection packages)
      - bounded by discontinuities
        - sequence stratigraphy
      - controlled by sea-level changes

- SEQUENCE STRATIGRAPHY
  - sequence terminology
    - type 1 sequence boundary
    - type 2 sequence boundary
    - depositional system
    - systems tract
    - lowstand – lowstand progradational wedge
    - shelf-margin
    - transgressive systems tract
      - or transgressive surface
    - highstand tract
    - parasequence set
      - bounded by marine flooding surface
    - parasequence
    - marine flooding surface
  - sea-level changes — ch 15 (322-328)
    - comparison of relative SL curves from different areas
      - local vs. global sea-level change
      - eustacy
        - glacio-eustacy
    - Vail sea-level curves
      - Orders of cycles
      - Relation to Wilson cycle
    - Oxygen isotopes
      - paleotemperatures
      - ice volume indicator
      - relationship between paleotemperature and sea-level
    - symmetry/asymmetry in sea-level curves

- DEVELOPMENT OF GEOLOGIC TIMESCALE — ch. 18
  - relative dating
    - stratigraphic relationships
    - biostratigraphy
    - magnetostratigraphy
  - calibration and checking of the geologic timescale
    - isotopic dating
      - direct dating of strata
      - dating of crosscutting features
      - what is dated
  - chronostratigraphic analyses
  - geologic time scale — App. B

- ISOSTASY — Matthews ch. 9
  - Stratigraphis thickness
    - accumulation
    - space
    - filling available space with sediment
      - mass balance
      - isostasy & isostatic subsidence
      - relationship of available space to sediment thickness
        - continental shelf thickness
        - geosyncline thickness

BASIN ANALYSIS — ch. 19 (423-454)

- topographic basin
- structural basin
- sedimentary basin

- time/thickness = time/subsidence plots
- stratigraphic maps
  - structure contour maps
  - isopach maps
  - lithofacies maps
  - paleocurrent maps
  - subcrop & supercrop maps
  - cross-sections & fence diagrams

SEDIMENTARY TECTONICS

- Tectonic settings
  - cratonic (shield + platform)
    - epeiric (epicontinental) seas
      - carbonate environments
      - clastic environments
    - emergent terrestrial environments
  - oceanic
    - pelagic
  - continental margins - geosynclines
    - rift margins
      - mechanisms of rifting
      - lithologic associations
    - passive (drift, mid-plate) margins
      - no tectonic effects
      - isostatic subsidence
      - noticeable sea-level changes
      - lithologic associations
    - convergent (active) margins
      - mechanisms of subduction
      - convergent margin basins
      - lithologic associations
  - geosyncline concept
    - miogeosyncline vs. eugeosyncline
    - stages in geosyncline development
    - sandstone compositions wrt/ geosyncline
      - QFL diagram

SECULAR CHANGES IN STRATIGRAPHIC RECORD — ch 12 (259-261)

- climate change — Fig 15.6
- atmospheric changes — ch 19 (454-459)
- sea-water chemistry
- expansion of biosphere
- continental accretion