EASC 302-3 Sedimentary Petrology

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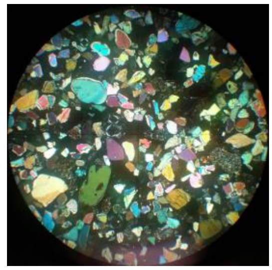
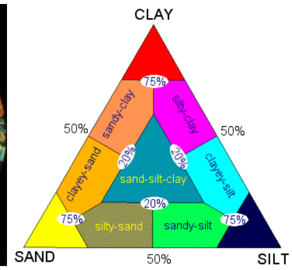
Office hours: on demand





Lecture: Mon/Wed (8:30-9:20am) Room TASC II 7530
Lab: Wednesday (11:30am-2:20pm) Room TASC II 7530

Bring: Notebook for sketches
- Hand lens
- Grain size card
- Pencil
- Coloured pencils (preferably erasable) and eraser

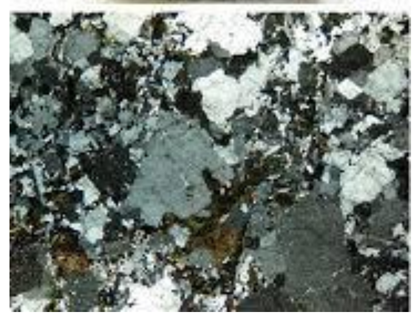
Course Grading:

Written Laboratory Assignments:	**10%**
Mid-Term Theory Exam 1 (Clastics + Mud):	**25%**
Mid-Term Laboratory Exam 1 (Clastics + Mud):	**20%**
Mid-Term Theory Exam 2 (Carbonates):	**25%**
Mid-Term Laboratory Exam 2 (Carbonates):	**20%**

Laboratory component is very important to this course, so students should make every effort to attend full laboratory sessions (lab material will be dealt with exhaustively in the Midterm Laboratory Exams)

Course Objectives:

1. Presentation of terms and concepts
2. Be able to identify and interpret most common sedimentary textures, fabrics, and compositions
3. Understand processes that deposit sediments (facies and depositional environments)
4. Summarize the processes that modify sediments *after* deposition (diagenesis)
5. Use mesoscopic and microscopic datasets to interpret megascopic processes

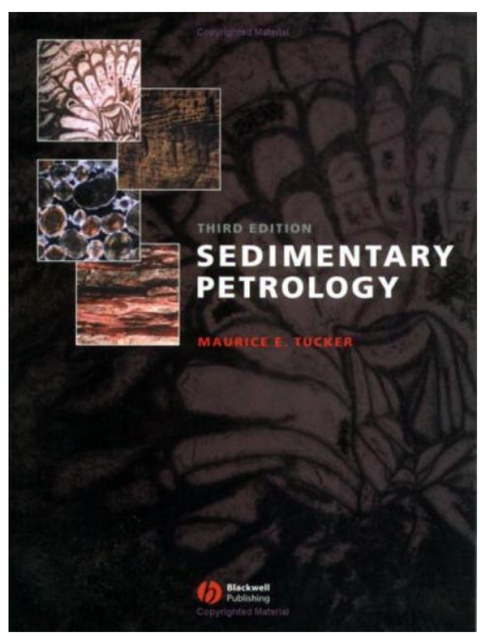


Study of the Origin of Sedimentary Rocks

Assessment of modern sedimentary processes

Interpret past environments, based on physical, chemical, and biological characteristics

Models to predict sedimentary rock heterogeneities (particularly in the subsurface)



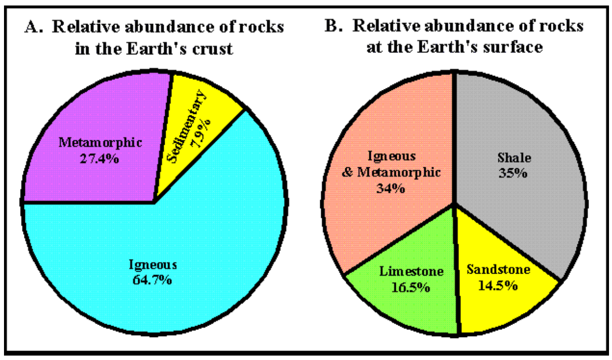
Why Do It?

Sediments cover 70% of the Earth's surface

Storage units for vital energy, mineral, and water resources

Need to understand rock properties in order to predict the distribution of these resources

Gain insights into global processes (climate/ tectonism…)



Why Petrology? Sedimentary Petrology (EASC 302)

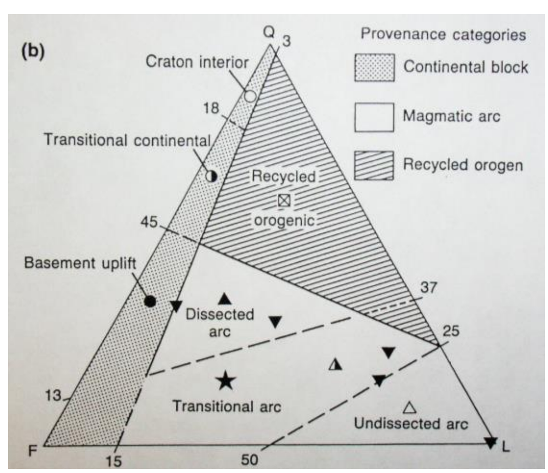
Why Do It?

Provenance studies (understanding of source terranes for sedimentary material)

Document the original grain constituents

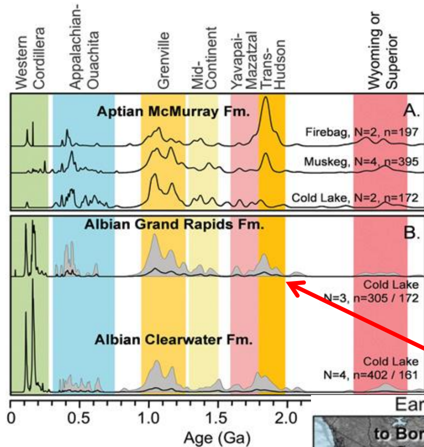
Assess post-depositional modifications

To develop interpretations that incorporate depositional processes, facies analysis, stratigraphy, and burial elements



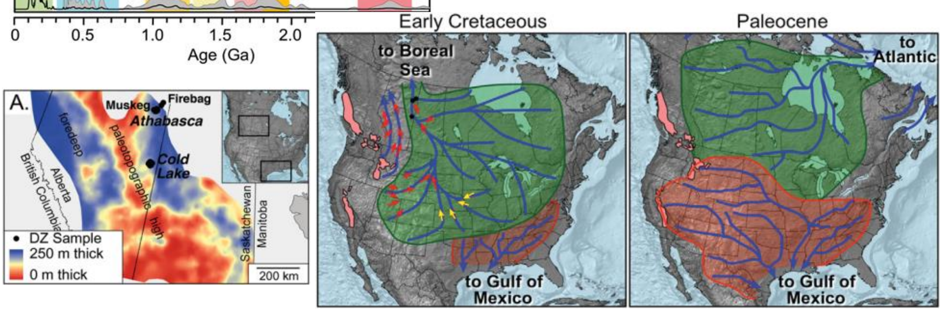
Why do it?

Detrital zircon geochronology used to establish paleo-drainage across the North American craton.



Black lines = all grains
Grey = grains older than 275 Ma

From Blum and Pecha, 2013



Why Do It? – *e.g.*, Clay in Sandstone

Clay in pore throats

Impact on fines migration and pore-throat bridging

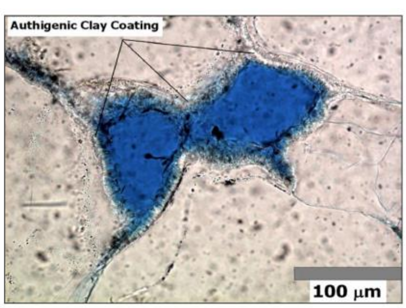


Figure 6.28: Authigenic clay coating as seen under plane-light. Well 2, Sample 17.

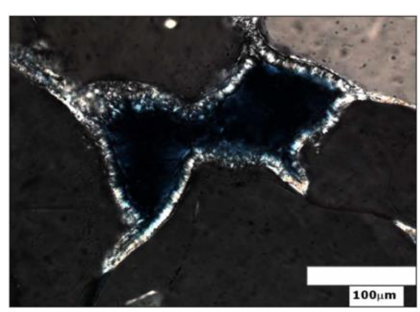


Figure 6.29: Authigenic clay coating under crossed polarized-light. Well 2, Sample 17.

Sedimentary Petrology (EASC 302)

Why Do It? – *e.g.*, Clay in Sandstone

Clay swelling (drilling/ fracking/ workover fluid interaction)

Petrophysical responses in logs influenced by architecture of minerals

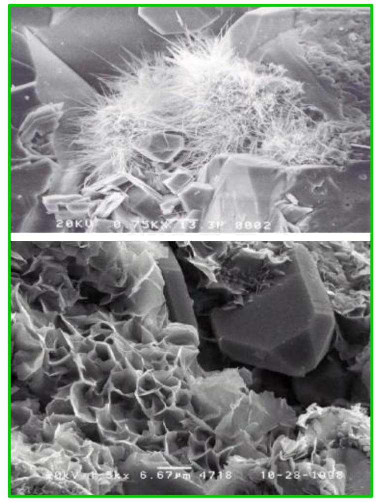
kaolinite

chlorite

Expanding clays

illite

smectite



Sedimentary Petrology (EASC 302)

Why Do It? – *e.g.*, Mineralogy of Mudstones

Gas and Oil Shales

Rocks with high silica (quartz) and low clay content typically are more brittle and more prone to natural fractures. These are good candidates for fracture stimulation.

Many shales exhibit covariance between silica and TOC (total organic carbon) suggesting a biogenic origin for some quartz.

Caprock Character

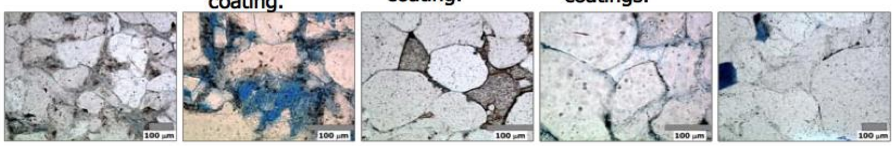
Strength and mineralogy are Linked.

Heavy oil seeping into lake after caprock failure – CNRL Primrose site, AB (norj.ca)

Why Do It? – *e.g.*, Type of Cement

Type of cement has an impact on strength of rock. Note disconnect between porosity and rock strength in below example.

Detrital clay matrix, with pressure solution.	Less detrital clay matrix, with detrital Clay coating.	Carbonate Cement replacement with clay coating.	Overgrowth against detrital grain with clay coatings.	Pure quartz Overgrowth.
3,873 psi	4,349 psi	12,317 psi	13,437 psi	36,053 psi
ϕ = 3.59	ϕ = 22.46	ϕ = 8.8	ϕ = 3.11	ϕ = 10.78



Increasing Mechanical strength →

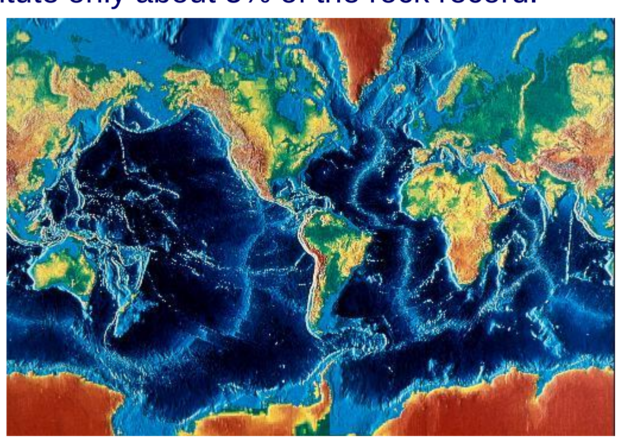
Increasing quartz overgrowth

Major Sedimentary Rock Types

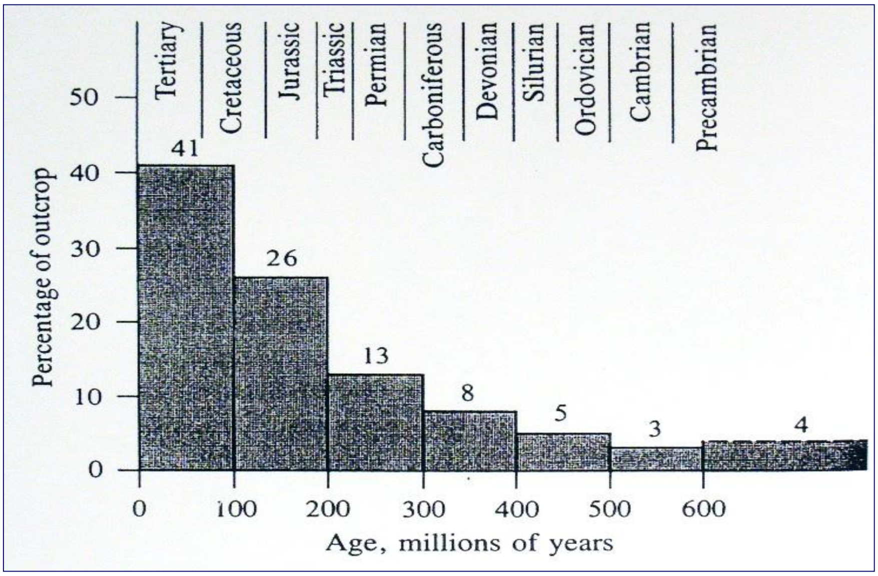
1. Detrital (clastic) — source of material? Rock record comprises ~65% Mudstones, and ~20% Sandstones.
2. Chemical (precipitates and biogenic): Rock Record comprises ~10% Carbonates.

Most other rocks constitute only about 5% of the rock record.

All deposited on (or very near to) the Earth's surface

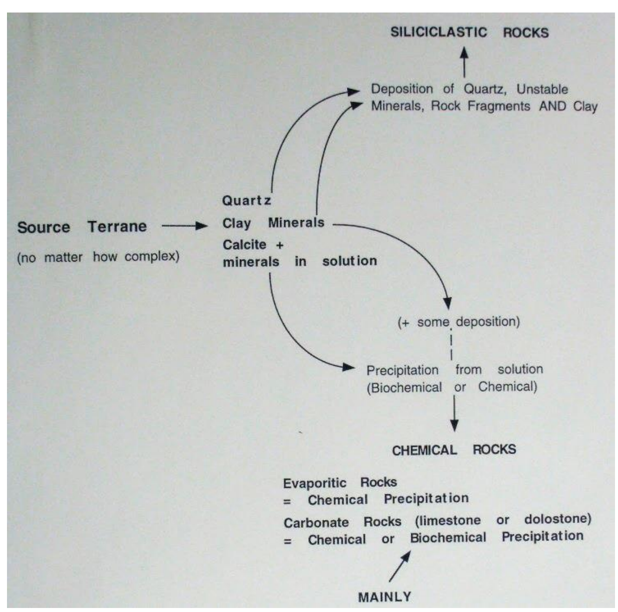


The exposed rock record is very biased towards the Cenozoic. Material lost with time

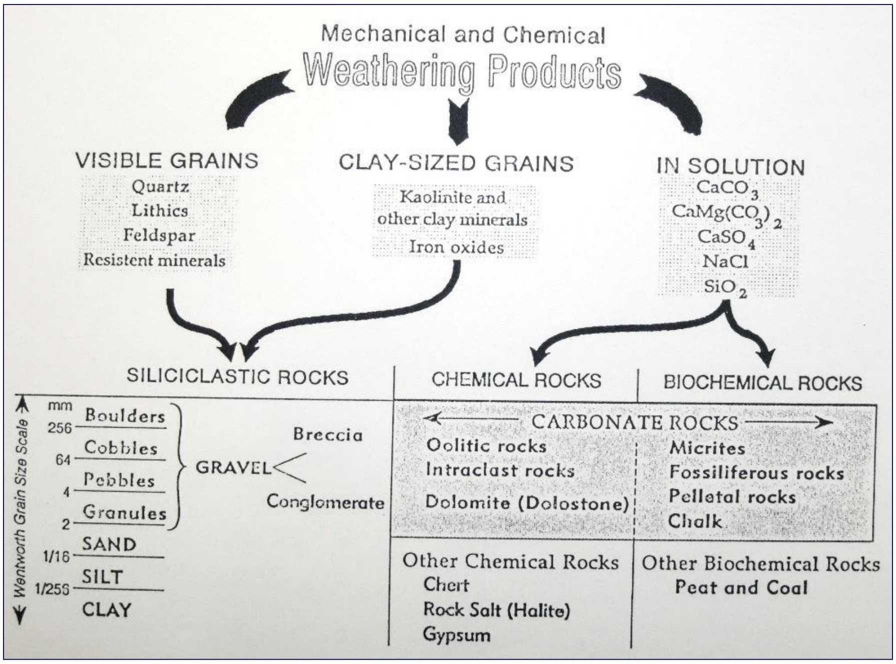


No matter the original source composition, the chemical stability of minerals results in the progressive change to quartz, clay and chemicals in solution.

With sufficient weathering, all material breaks down to these products!



Sedimentary Rocks **Sedimentary Petrology (EASC 302)**



Siliciclastic Rocks **Sedimentary Petrology (EASC 302)**

‘Clastics’

Products of physical weathering

Predominantly quartz and clay minerals (~85%)

Sand: all grains 2.0-0.06mm in diameter---Not Mineral!

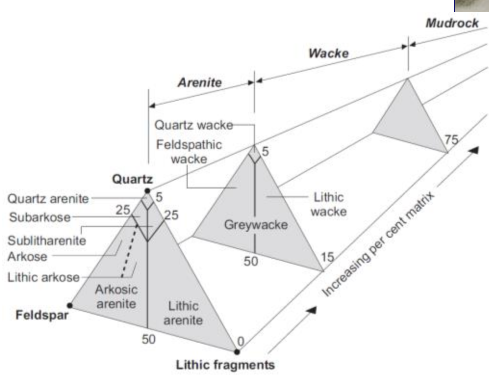
Mud: all grains <0.006mm diameter (silt and clay)---Not Mineral!

Clay is problematic—used as a grain size *and* mineral group

Q: Why is the mud fraction so abundant?

A: Much clastic material originates as igneous or metamorphic rock fragments (unstable at the surface)!

Siliciclastic (Clastic) Rocks



Primary concerns are with texture (principally grain size and ranges in grain size) and composition

Carbonates (Limestones and Dolostones)

$CaCO_3$ (calcite or aragonite), and $CaMg(CO_3)_2$ (dolomite)

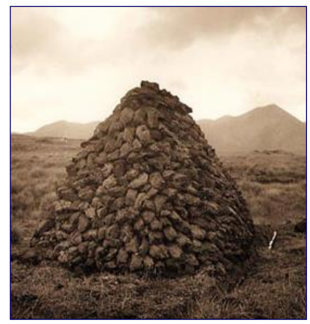
Generally composed of *in situ* or detrital fragments of mineralized skeletal material

Very susceptible to recrystallization during burial (due to migrating subsurface fluids)

Sediment types / depositional rates strongly dependent on surface conditions (shallow marine mostly)

Preservation potential of grains very influential in resultant rock properties (mineral stabilities)

Other Sedimentary Rocks: Carbonaceous Rocks



Primarily organic (plant) material (coals, peats, lignites)

Don't really fit into physical or chemical rock classifications: they are Organo-Sedimentary Rocks!

Less common in rock record, but commonly constitute important energy resources

Largely of terrestrial origin (especially coastal margins)

Other Sedimentary Rocks: Evaporites and Precipitates

Evaporites: gypsum, anhydrite, halite, sulfosalts

Precipitates: phosphorites, glauconites, ironstones

Generally less common in the rock record, but often have important implications when present

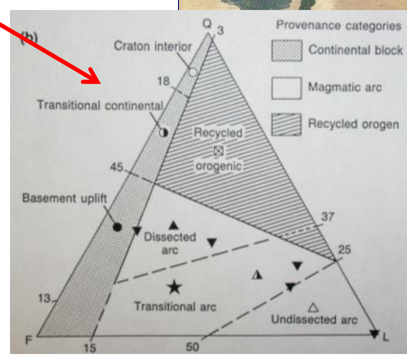
Typically indicate stressed conditions or areas with very high nutrient supply

Tectonic configuration strongly influences rock types

Basins control thicknesses and distributions of facies

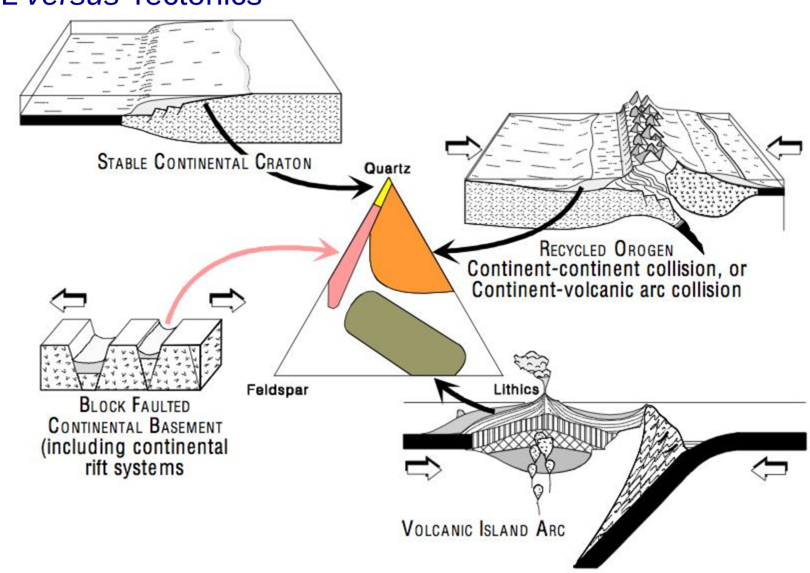
Can use rock types to reconstruct basin type/morphology (provenance)

Plate Tectonic Theory has greatly advanced our ability to reconstruct past conditions from limited lithologic data (different margin types/ basins yield different rocks)



Sedimentary Basins

QFL *versus* Tectonics



Sedimentary Petrology

Analysis of sedimentary petrology is critical for evaluation of:

Sediment provenance of depositional units and link to tectonic basins

Petrographic description of composition, texture, and fabric

Characterization of environmental processes

Insights into diagenetic history

Evaluation of porosity/permeability of sedimentary reservoirs

(Still, it can be pretty boring!)