Lithostratigraphic Units

And a Quick Review of Sedimentary Rocks and Processes

GEOL 3000

North American Stratigraphic Code

A formulation of current views on stratigraphic principles and procedures designed to promote standardized classification and formal nomenclature of rock materials. Most recently updated -2005

Purpose: The North American Stratigraphic Code seeks to describe explicit practices for classifying and naming all formally defined geologic units.

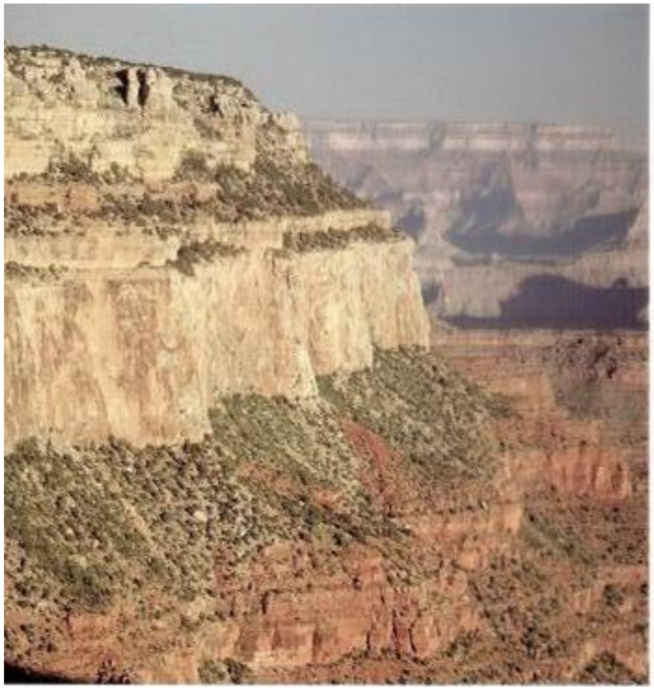
The objective of a system of classification is to promote unambiguous communication in a manner not so restrictive as to inhibit scientific progress. To minimize ambiguity, a code must promote recognition of the distinction between observable features (reproducible data) and inferences or interpretations.

Stratigraphy

The study of layered sequences of sedimentary and/or volcanic rock that conform to the principles of superposition

A ***geologic rock unit*** is a naturally occurring body of rock or rock material distinguished from adjoining bodies of rock on the basis of some stated property or properties. Commonly used properties include composition, texture, included fossils, magnetic signature, radioactivity, seismic velocity, and age.

A ***lithostratigraphic unit*** is a geologic rock unit that conform to the principles of superposition.



Biostratigraphy is the branch of stratigraphy that deals with the distribution of fossils in the stratigraphic record and the classification of bodies of rock or rock material into ***biostratigraphic units*** based on their contained fossils.

The Birth of Stratigraphy

Great Britain

Rock Units vs. Time Units

Table 1 *Alternative classifications for the British Lower Paleozoic in the latter part of the 19th century. After Second 1986, Fig. 9.4.*

Author	1	2	3	4	5	6	7	8	9
SEDGWICK 1855	Silurian		Upper Cambrian		Middle Cambrian				Lower Cambrian
MURCHISON 1859	Upper Silurian		Lower Silurian (Primordial Silurian)						Cambrian
GEOLOGICAL SURVEY 1866	Upper Silurian		Lower Silurian						Cambrian
JUKES 1857	Upper Silurian		Cambro-Silurian						Cambrian
PHILLIPS 1855	Upper Silurian		Lower Silurian				Cambrian		
LYELL 1865	Upper Silurian	Middle Silurian		Lower Silurian			Cambrian		
LYELL 1871	Upper Silurian			Lower Silurian			Cambrian		
HICKS 1874	Upper Silurian	Middle Silurian		Lower Silurian			Cambrian		
LAPWORTH 1879	Silurian			Ordovician			Cambrian		
Principal formations	1	2	3	4	5	6	7	8	9
	Ludlow	Wenlock	Upper Llandovery = May Hill / Lower Llandovery	Bala = Caradoc Sandstone	Llandeilo	Arenig	Tremadoc	Lingula Flags	Longmynd

From A. Hallam
Great Geological Controversies
Oxford Press, 1989

Categories of Geologic Rock Units

Units based on content or physical limits

Lithostratigraphic

Lithodemic

Magnetopolarity

Biostratigraphic

Pedostratigraphic

Allostratigraphic

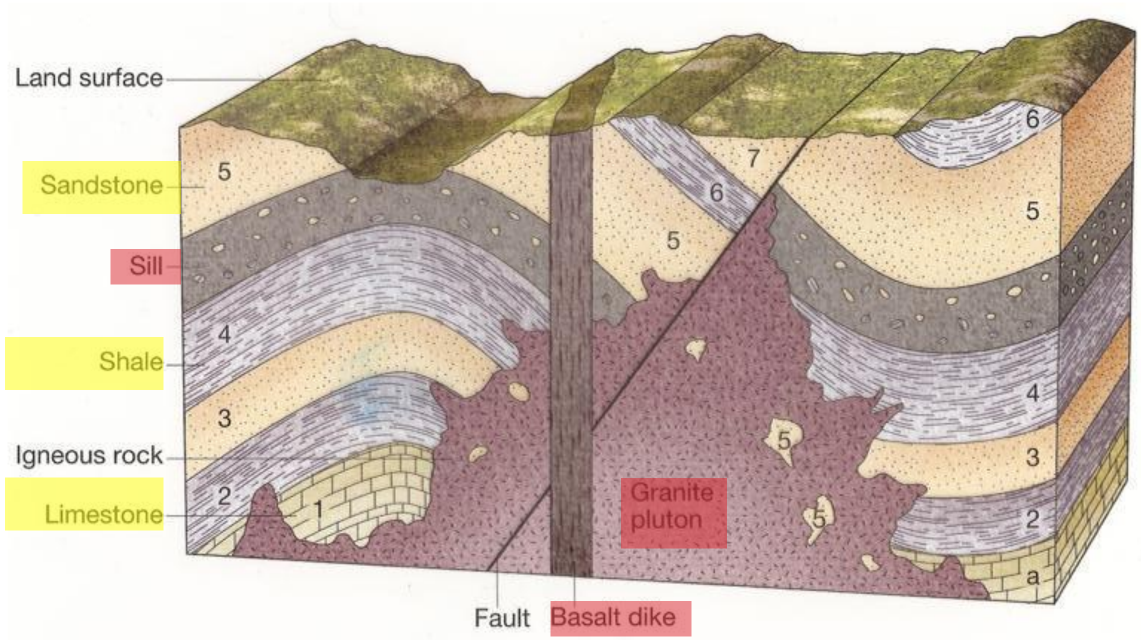


Figure 10.3

A lithodemic unit is a defined body of predominantly intrusive, highly deformed, and/or highly metamorphosed rock, distinguished and delimited on the basis of rock characteristics. In contrast to lithostratigraphic units, a lithodemic unit generally does not conform to the Law of Superposition.

Classes of Geologic Units

Units based on content or physical limits

Lithostratigraphic

Lithodemic

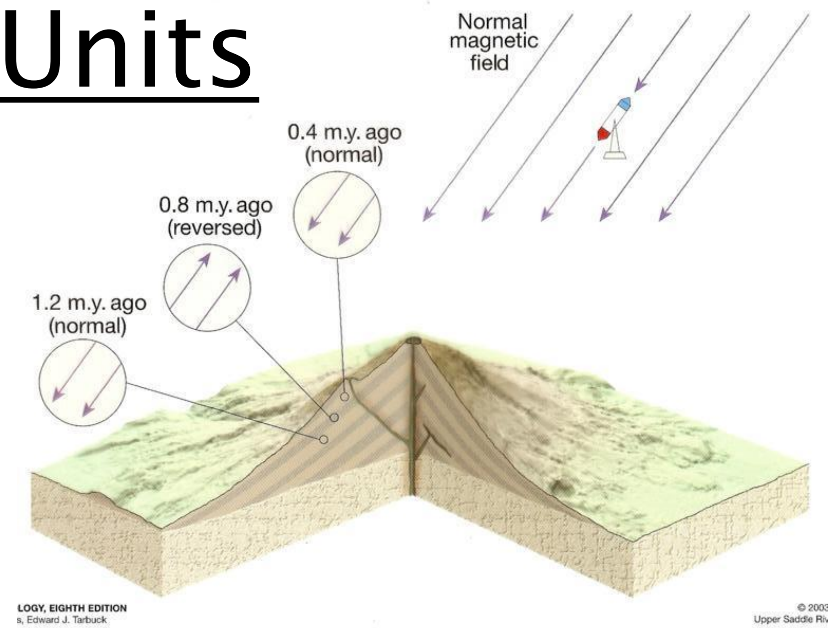
Magnetopolarity –alternating normal and reversed polarity

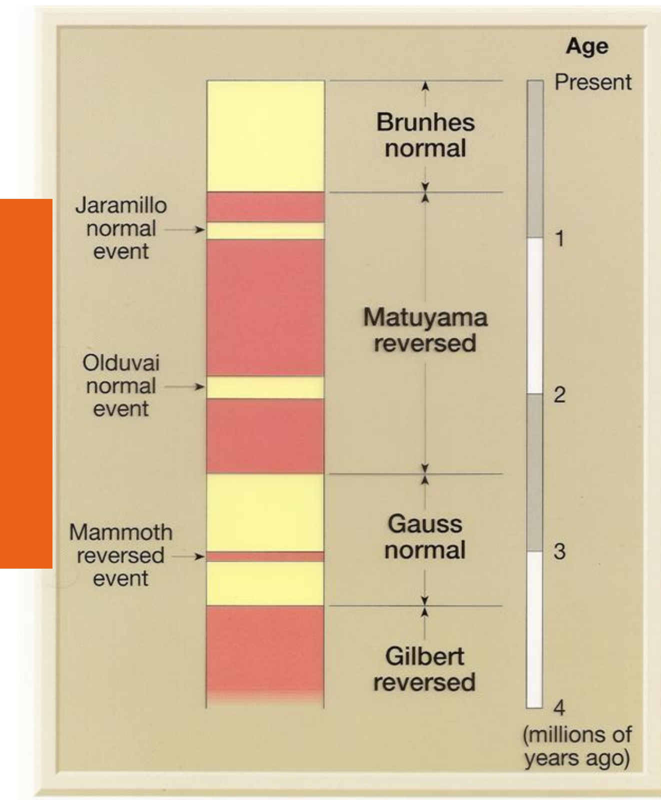
Biostratigraphic

Pedostratigraphic

Allostratigraphic

A magnetostratigraphic unit is a body of rock unified by specified remanent-magnetic properties and is distinct from underlying and overlying magnetostratigraphic units having different magnetic properties.





Classes of Geologic Units

Units based on content or physical limits

Lithostratigraphic

Lithodemic

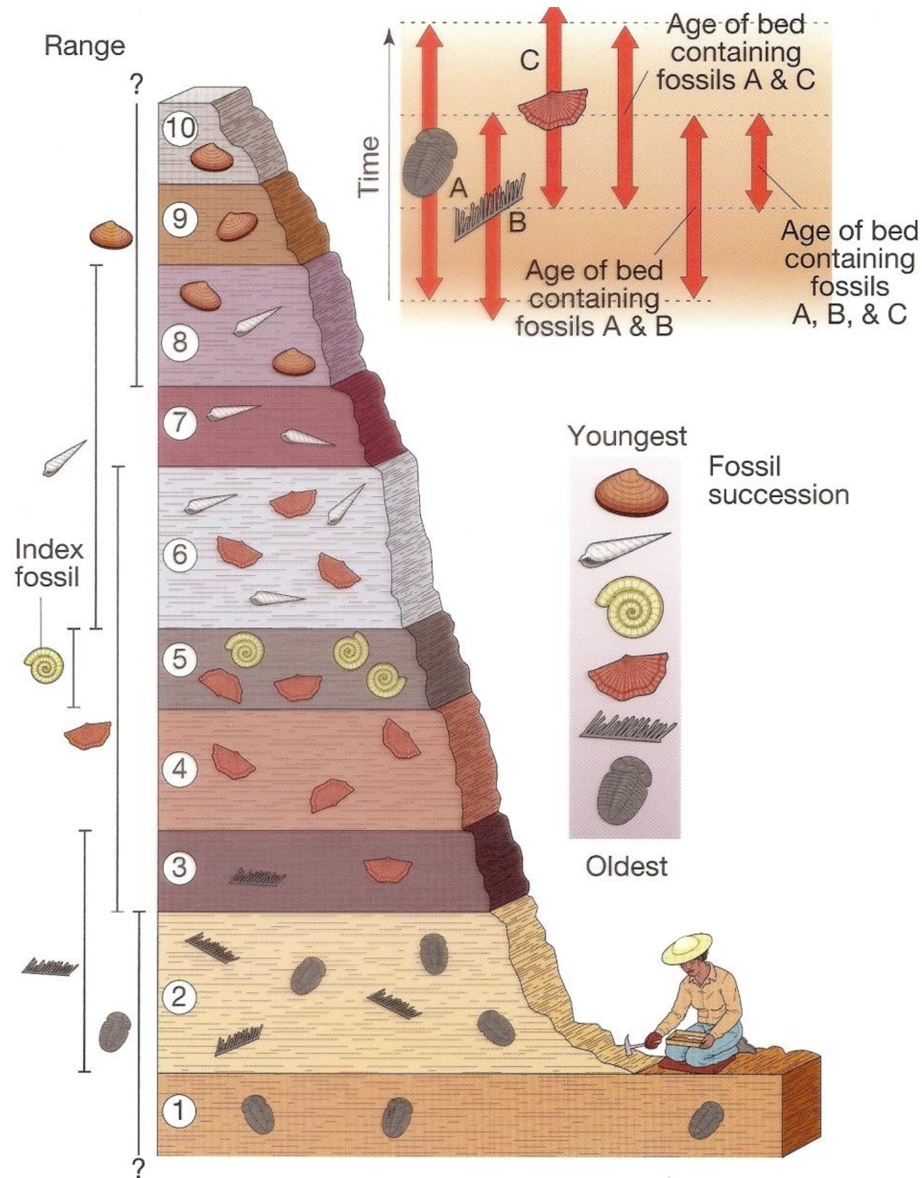
Magnetopolarity

Biostratigraphic – based on the principles of faunal succession and superposition

Pedostratigraphic

Allostratigraphic

A biostratigraphic unit is a body of rock that is defined or characterized by its fossil content.



Classes of Geologic Units

Units based on content or physical limits

Lithostratigraphic

Lithodemic

Magnetopolarity

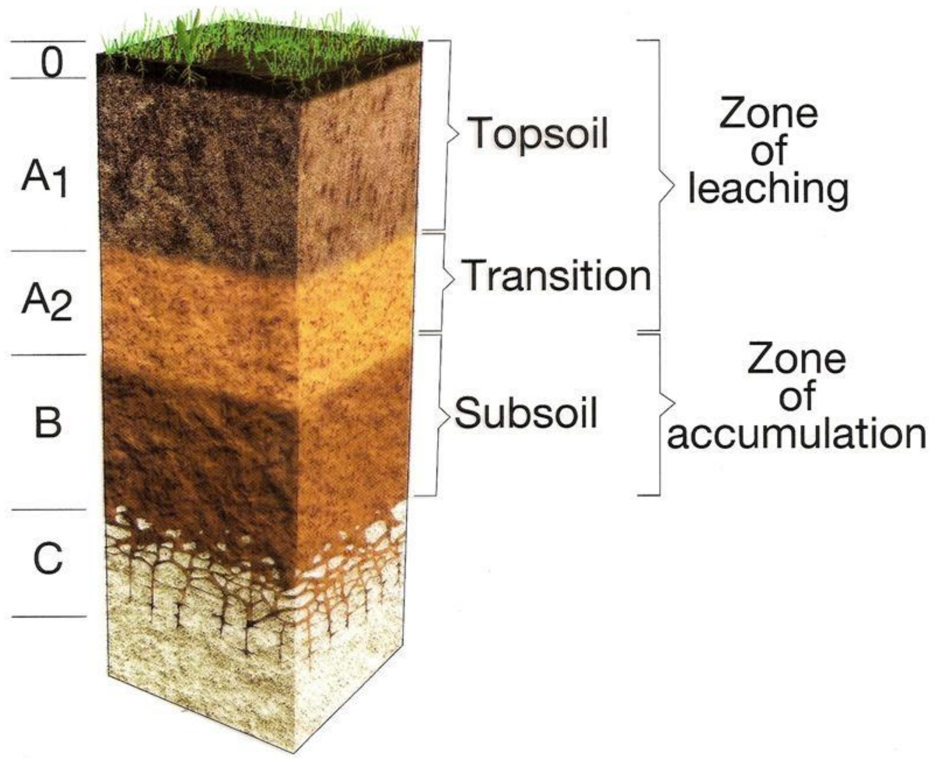
Biostratigraphic

Pedostratigraphic – Soil horizons (regolith)

Allostratigraphic

A pedostratigraphic unit is a body of rock that consists of one or more pedologic horizons

Figure 5.9b



Classes of Geologic Units

Units based on content or physical limits

Lithostratigraphic

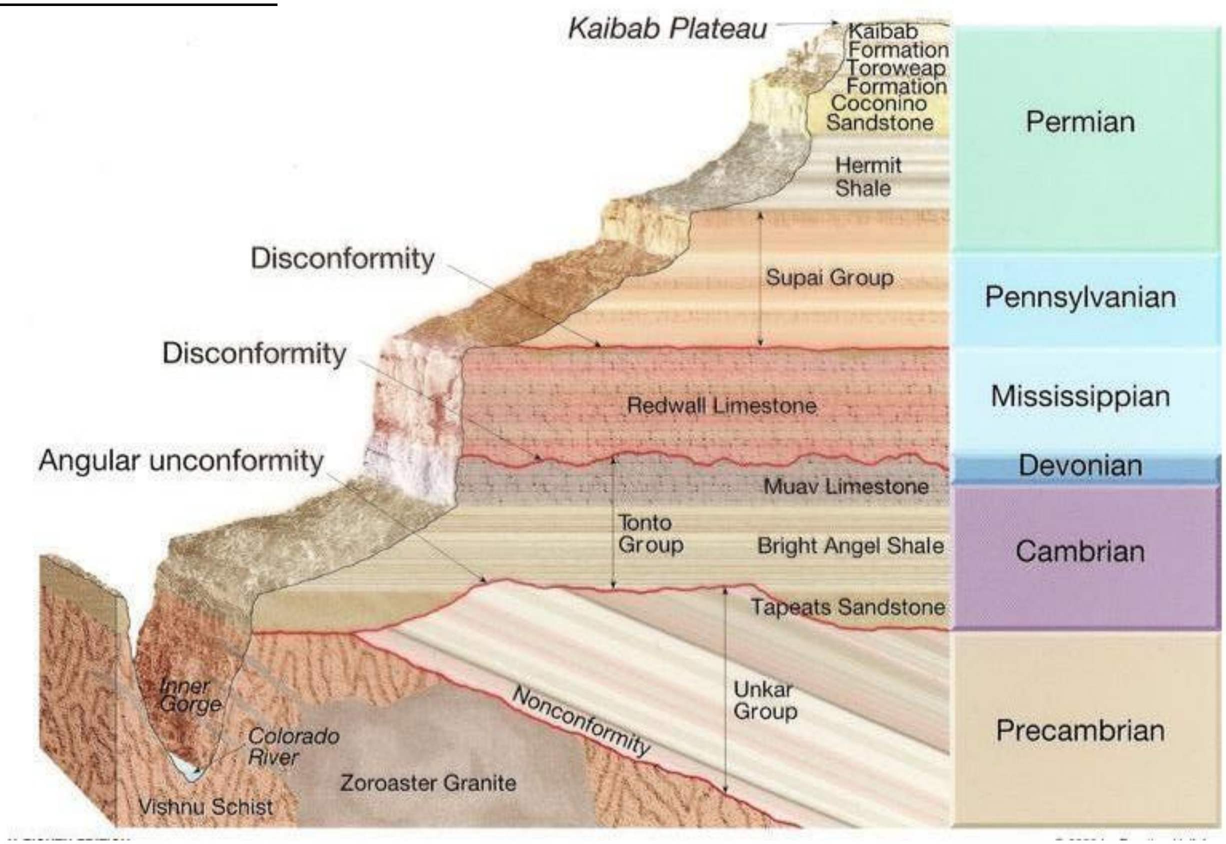
Lithodemic

Magnetopolarity

Biostratigraphic

Pedostratigraphic

Allostratigraphic



An allostratigraphic unit is a mappable body of rock that is defined and identified on the basis of its bounding discontinuities

Classes of Geologic Time Units

A ***geochronologic unit*** is a division of time distinguished on the basis of the rock record preserved in a chronostratigraphic unit. Example: Devonian Period.

A ***chronostratigraphic unit*** is a body of rock established to serve as the material reference for all rocks formed during the same span of time. Example: Devonian System

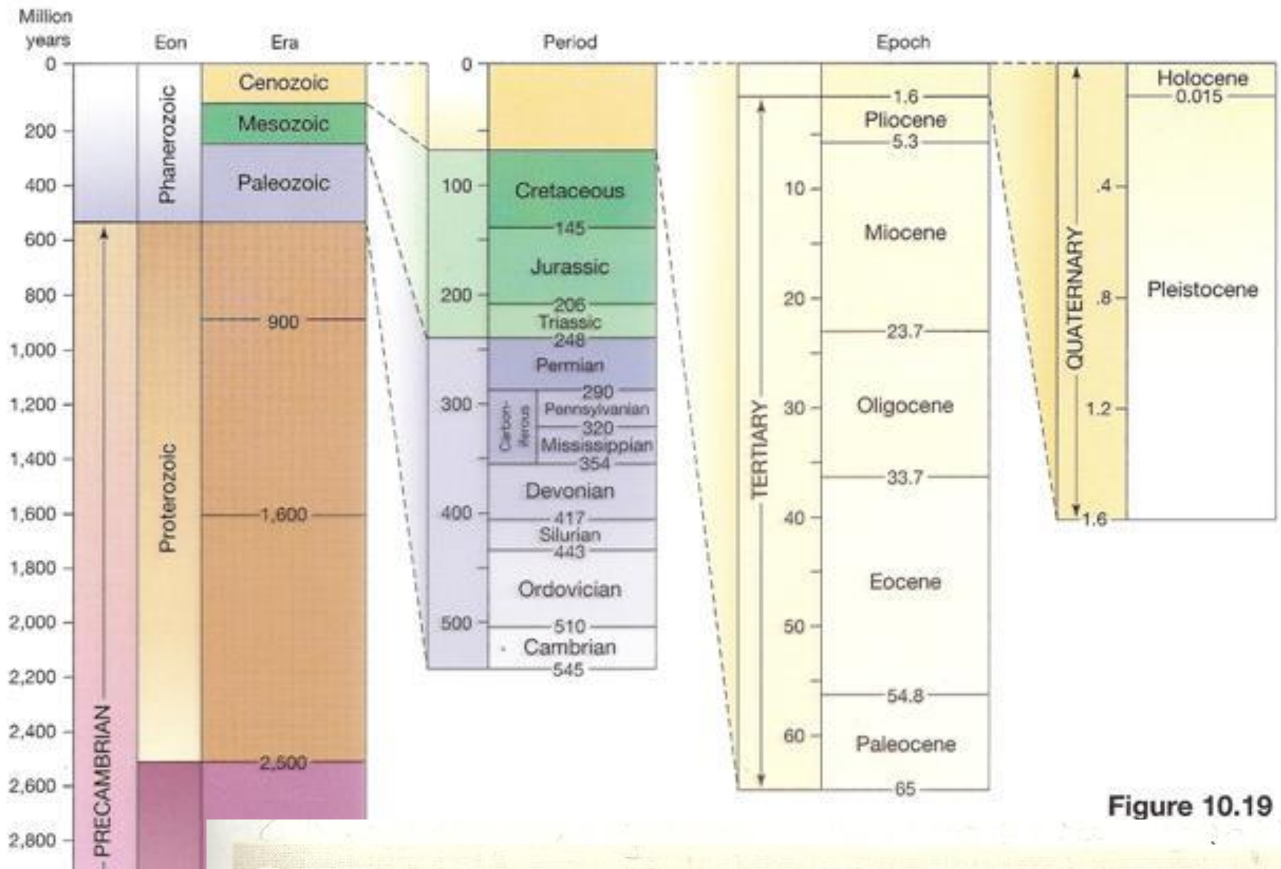


Figure 10.19

Relative Time Divisions	Equivalent Universal Rock Divisions
Eon	Eonothem
Era	Erathem
Period	System
Epoch	Series
Age	Stage

Subdivisions of Geologic Units

LITHOSTRATIGRAPHIC	LITHODEMIC	MAGNETOPOLARITY	BIOSTRATIGRAPHIC	PEDOSTRATIGRAPHIC	ALLOSTRATIGRAPHIC
Supergroup	Supersuite (Complex)				
Group	Suite (Complex)	Polarity Superzone			Allogroup
Formation	*Lithodeme*	*Polarity Zone*	*Biozone* (Range, Interval, Linneage, Assemblage or Abundance)	*Geosol*	*Alloformation*
Member (or Lens, or Tongue)		Polarity Subzone	Subbiozone		Allomember
Bed(s) or Flow(s)					

Fundamental Units

IIA. MATERIAL CATEGORIES USED TO DEFINE TEMPORAL SPANS

CHRONO-STRATIGRAPHIC	POLARITY CHRONO-STRATIGRAPHIC
Eonothem	Polarity Superchronozone
Erathem (Supersystem)	
System (Subsystem)	*Polarity Chronozone*
Series	
Stage (Substage)	Polarity Subchronozone
Chronozone	

IIB. NON-MATERIAL CATEGORIES RELATED TO GEOLOGIC AGE

GEOCHRONOLOGIC	POLARITY CHRONOLOGIC	DIACHRONIC	GEOCHRONOMETRIC
Eon	Polarity Superchron		Eon
Era (Superperiod)			Era (Superperiod)
Period (Subperiod)	*Polarity Chron*	Diachron: *Episode*	*Period* (Subperiod)
Epoch		Diachron: Phase	Epoch
Age (Subage)	Polarity Subchron	Diachron: Span	Age (Subage)
Chron		Diachron: Cline	Chron

From NASC, 2005

Lithostratigraphic Units

A lithostratigraphic unit is a defined body of sedimentary, extrusive igneous, metasedimentary, or metavolcanic strata which is distinguished and delimited on the basis of lithic characteristics and stratigraphic position. A lithostratigraphic unit generally conforms to the Law of Superposition and commonly is stratified and tabular in form.

Supergroup. A supergroup is a formal assemblage of related or superposed groups, or of groups and formations. Such units have proved useful in regional and provincial syntheses. Supergroups should be named only where their recognition serves a clear purpose.

Group. A group is the lithostratigraphic unit next higher in rank to formation; a group may consist entirely of named formations, or alternatively, need not be composed entirely of named formations.

Formation. The formation is the fundamental unit in lithostratigraphic classification. A formation is a body of rock identified by lithic characteristics and stratigraphic position; it is prevailingly but not necessarily tabular and is mappable at the Earth's surface or traceable in the subsurface.

Member. A member is the formal lithostratigraphic unit next in rank below a formation and is always a part of some formation. It is recognized as a named entity within a formation because it possesses characteristics distinguishing it from adjacent parts of the formation. A formation need not be divided into members unless a useful purpose is served by doing so. Some formations may be divided completely into members; others may have only certain parts designated as members; still others may have no members.

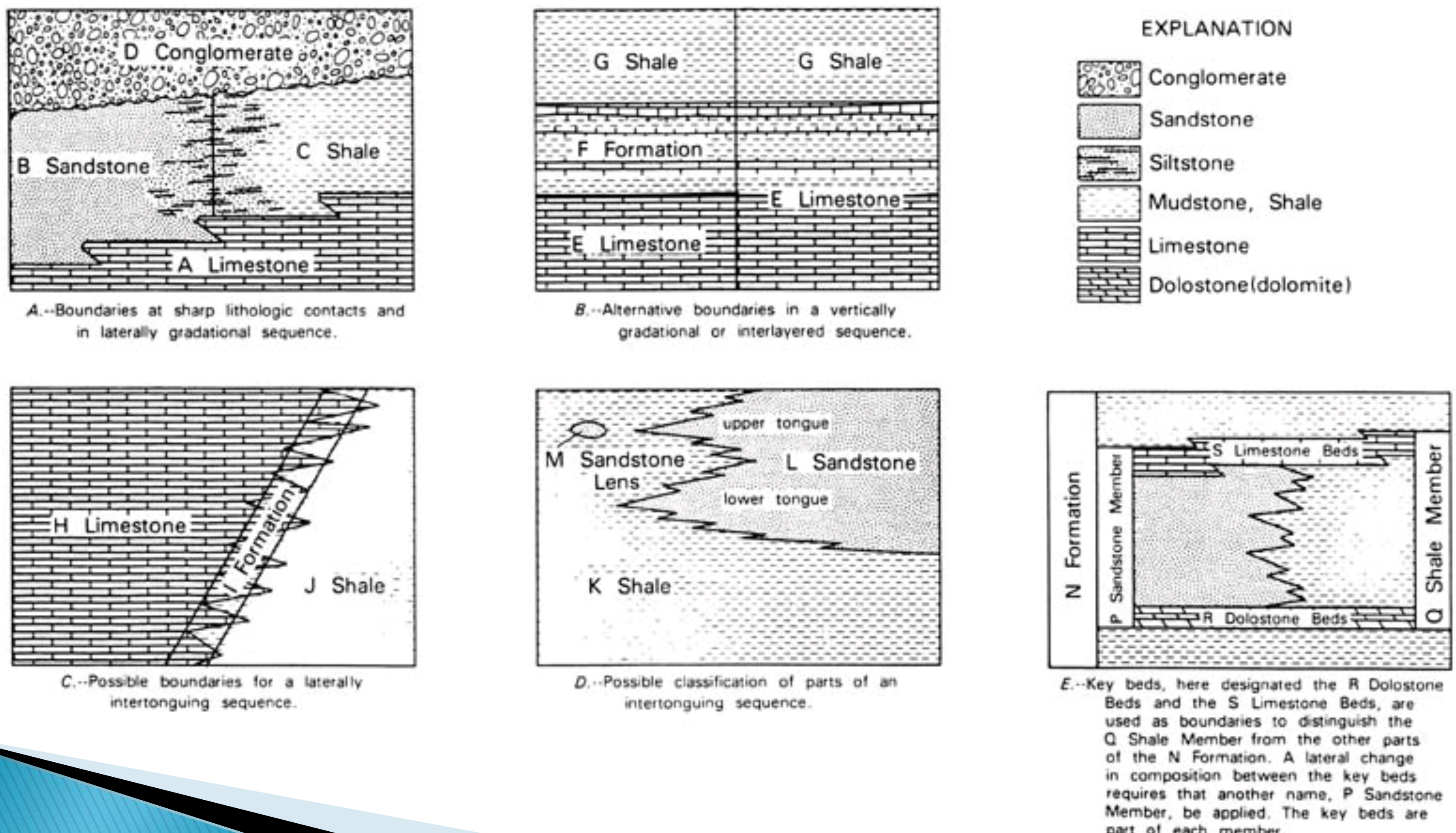
Bed(s). A bed, or beds, is the smallest formal lithostratigraphic unit of sedimentary rocks.

Flow. A flow is the smallest formal lithostratigraphic unit of volcanic flow rocks. A flow is a discrete, extrusive, volcanic body distinguishable by texture, composition, order of superposition, paleomagnetism, or other objective criteria.

From NASC, 2005

Boundaries between Lithostratigraphic Units

Boundaries of lithostratigraphic units are placed at positions of lithic change. Boundaries are placed at distinct contacts or may be selected at some arbitrary level within zones of gradation. Both vertical and lateral boundaries are based on the lithic criteria that provide the greatest unity and utility.



A.--Boundaries at sharp lithologic contacts and in laterally gradational sequence.

B.--Alternative boundaries in a vertically gradational or interlayered sequence.

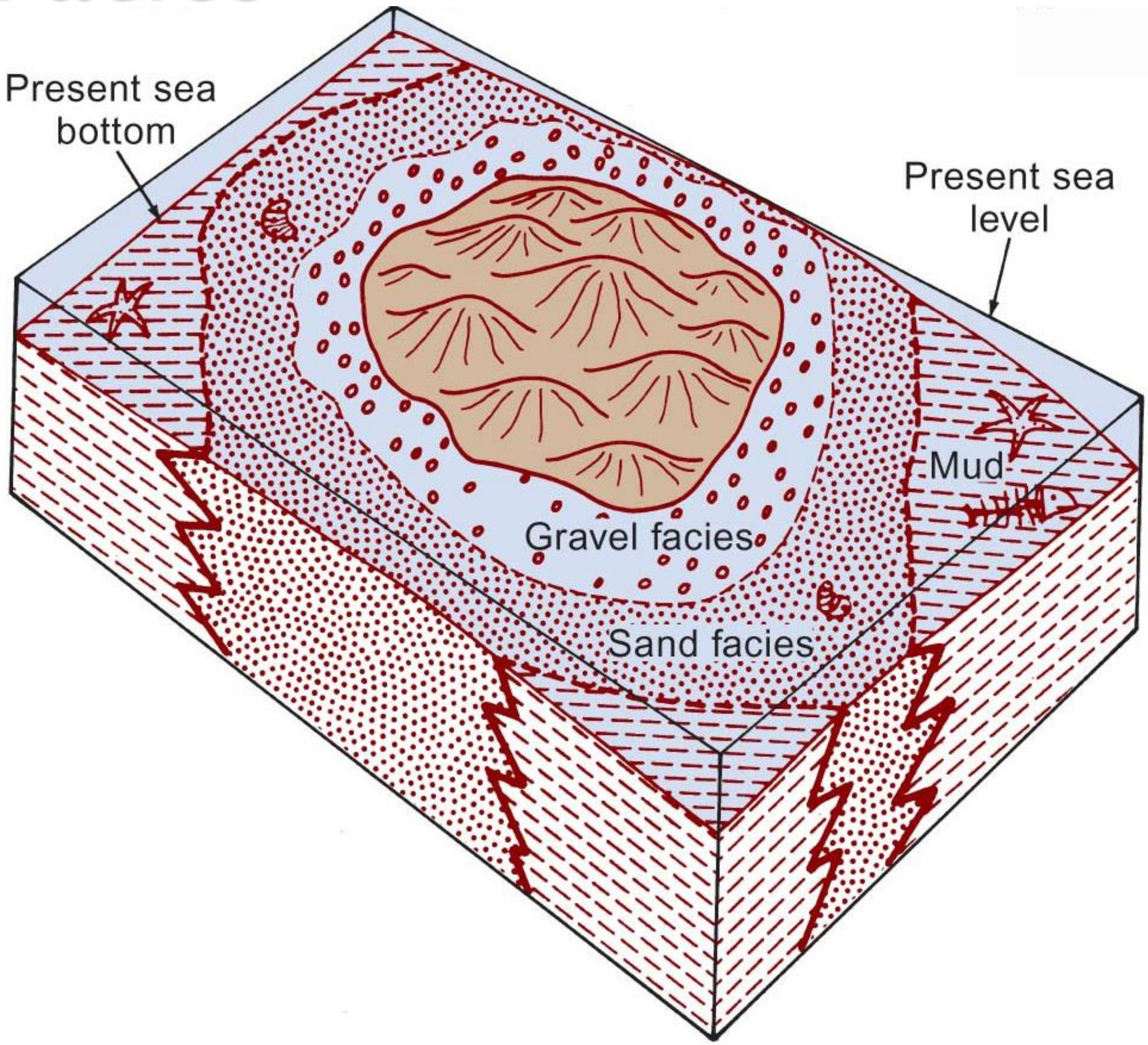
C.--Possible boundaries for a laterally intertonguing sequence.

D.--Possible classification of parts of an intertonguing sequence.

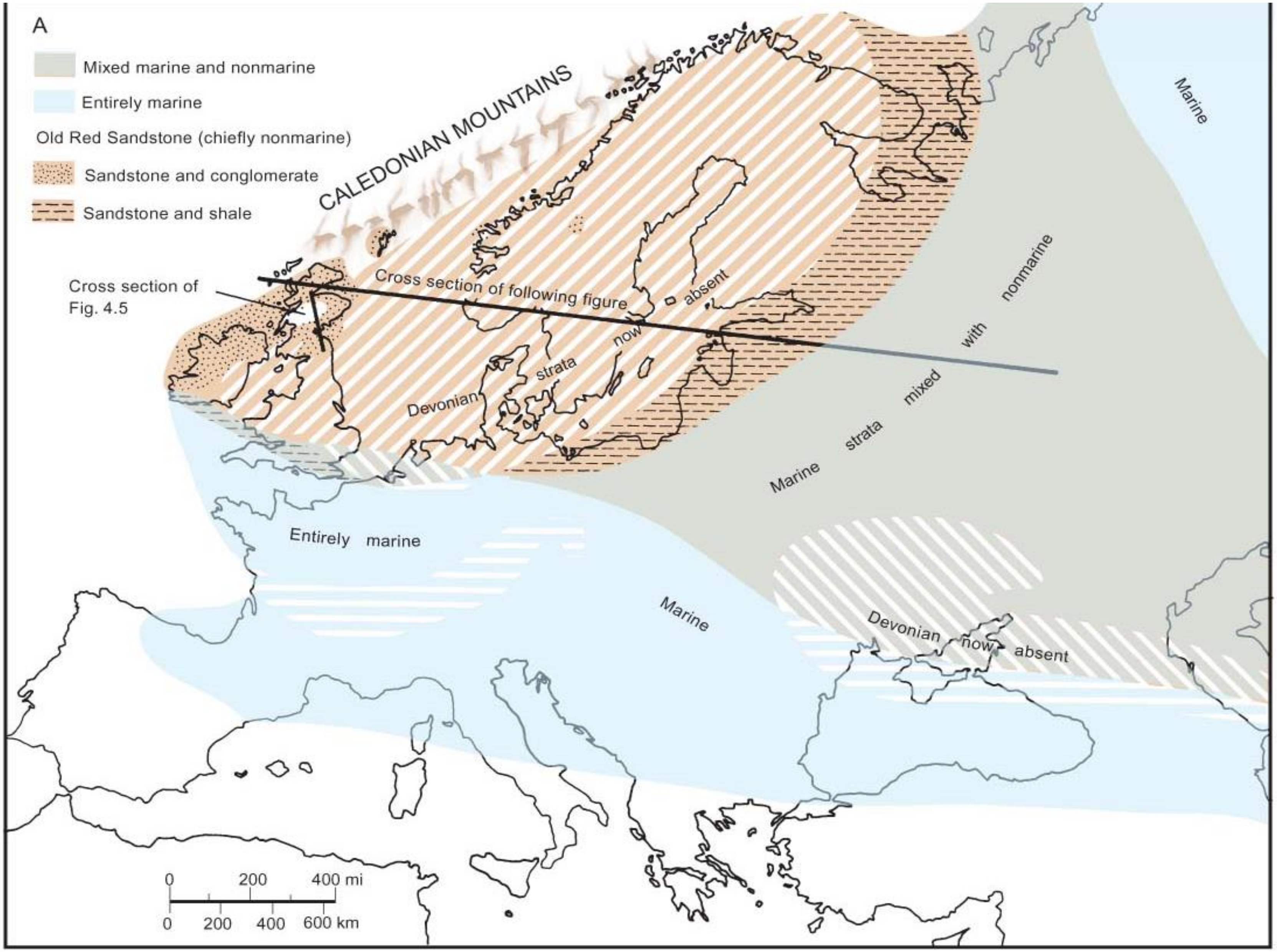
E.--Key beds, here designated the R Dolostone Beds and the S Limestone Beds, are used as boundaries to distinguish the Q Shale Member from the other parts of the N Formation. A lateral change in composition between the key beds requires that another name, P Sandstone Member, be applied. The key beds are part of each member.

From NASC, 2005

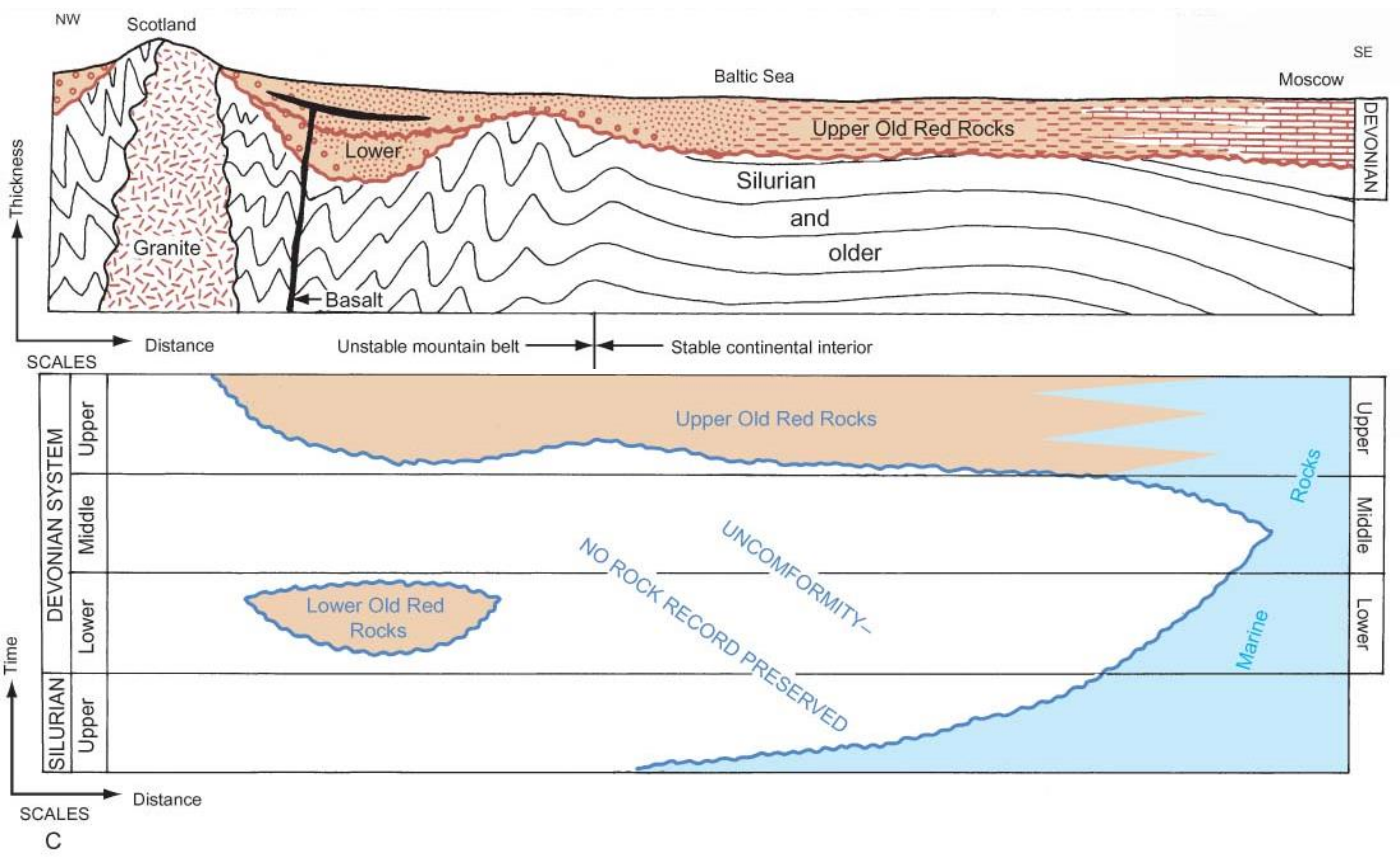
Depositional Environments and Sedimentary Facies



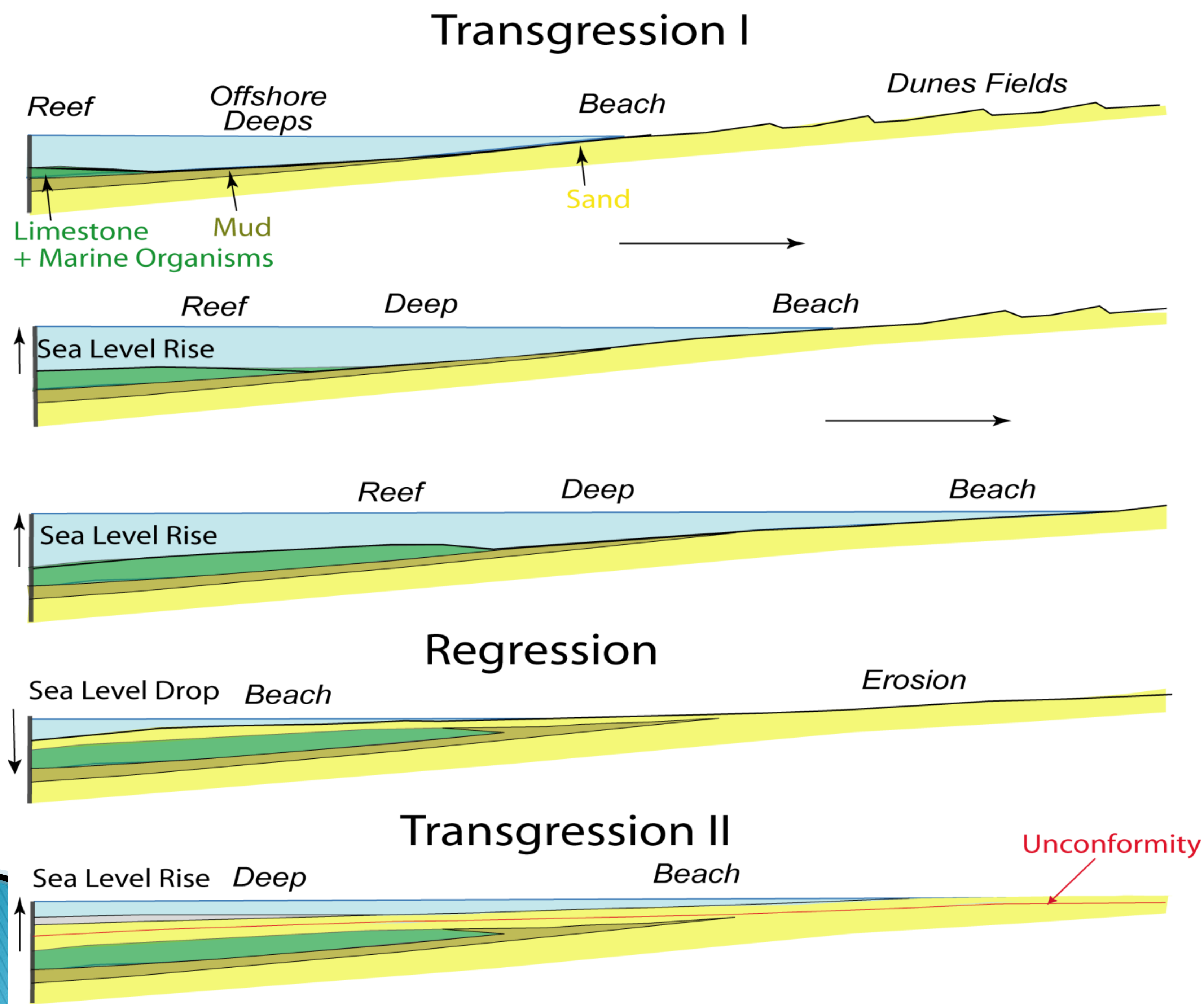
Depositional Environments and Sedimentary Facies



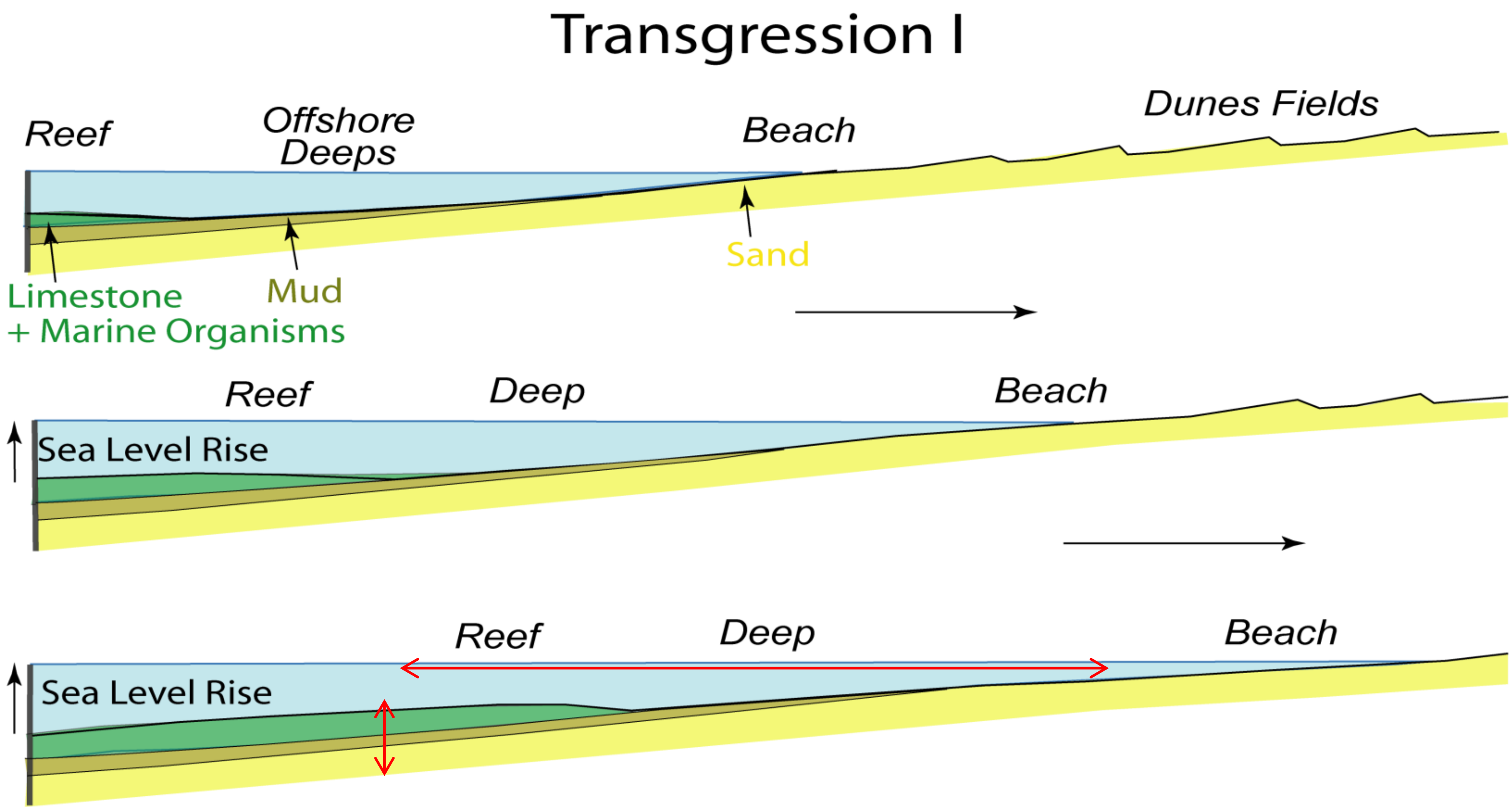
Depositional Environments and Sedimentary Facies



Transgression/Regression



Walther's Law



The vertical progression of facies will be the same as the corresponding lateral facies changes

Correlation of Lithostratigraphic Units

Correlation is a procedure for demonstrating correspondence between geographically separated parts of a geologic unit. The term is a general one having diverse meanings in different disciplines. Demonstration of temporal correspondence is one of the most important objectives of stratigraphy.

T-218 Figure 18-9 Correlation of strata on the Colorado Plateau

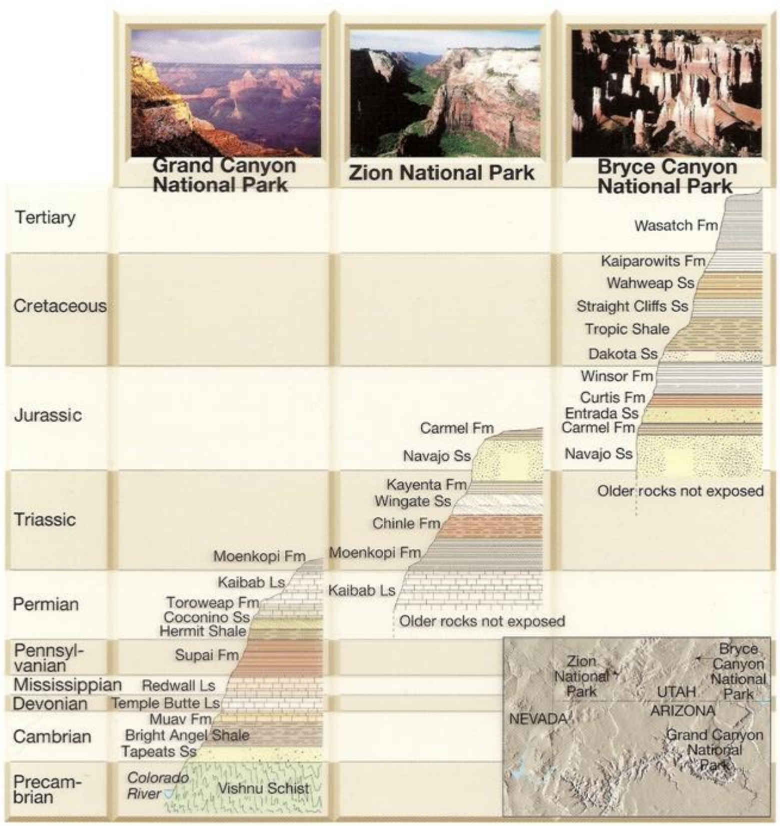
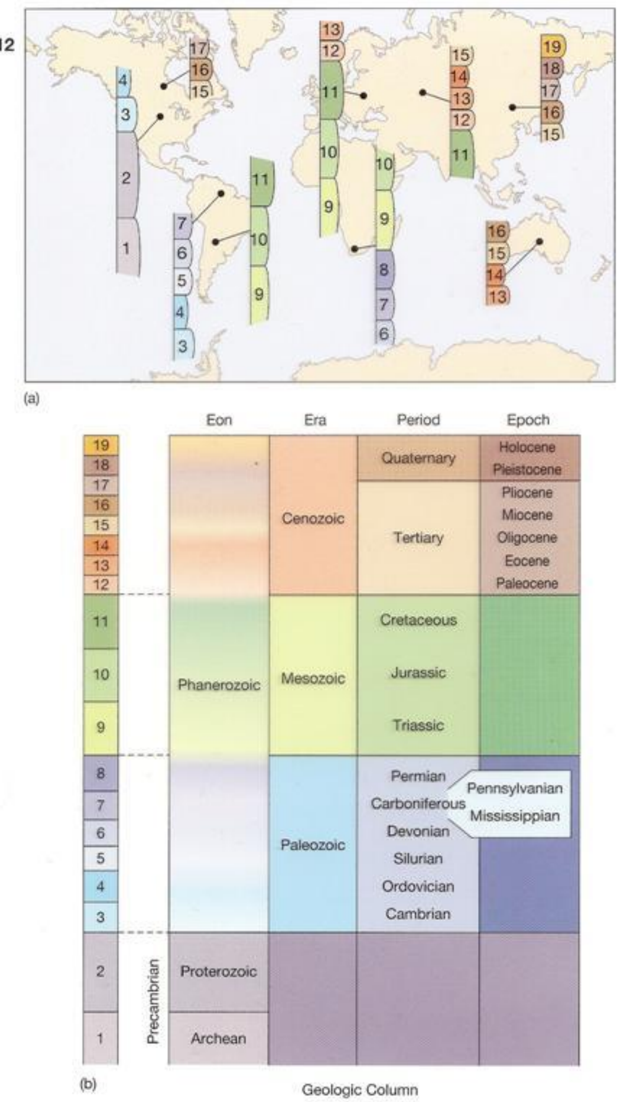


Figure 10.12



Formal and Informal Lithostratigraphic Units

Formally named units are those that are named in accordance with an established scheme of classification; the fact of formality is conveyed by capitalization of the initial letter of the *rank* or *unit* term (for example, Morrison Formation). Informal units, whose unit terms are ordinary nouns, are not protected by the stability provided by proper formalization and recommended classification procedures.

Requirements for Formally Named Geologic Units. Naming, establishing, revising, redefining, and abandoning formal geologic units require publication in a recognized scientific medium of a comprehensive statement which includes:

- intent to designate or modify a formal unit;
- designation of category and rank of unit;
- selection and derivation of name;
- specification of stratotype (where applicable);
- description of unit;
- definition of boundaries;
- historical background;
- dimensions, shape, and other regional aspects;
- geologic age;
- correlations; and possibly
- genesis (where applicable).

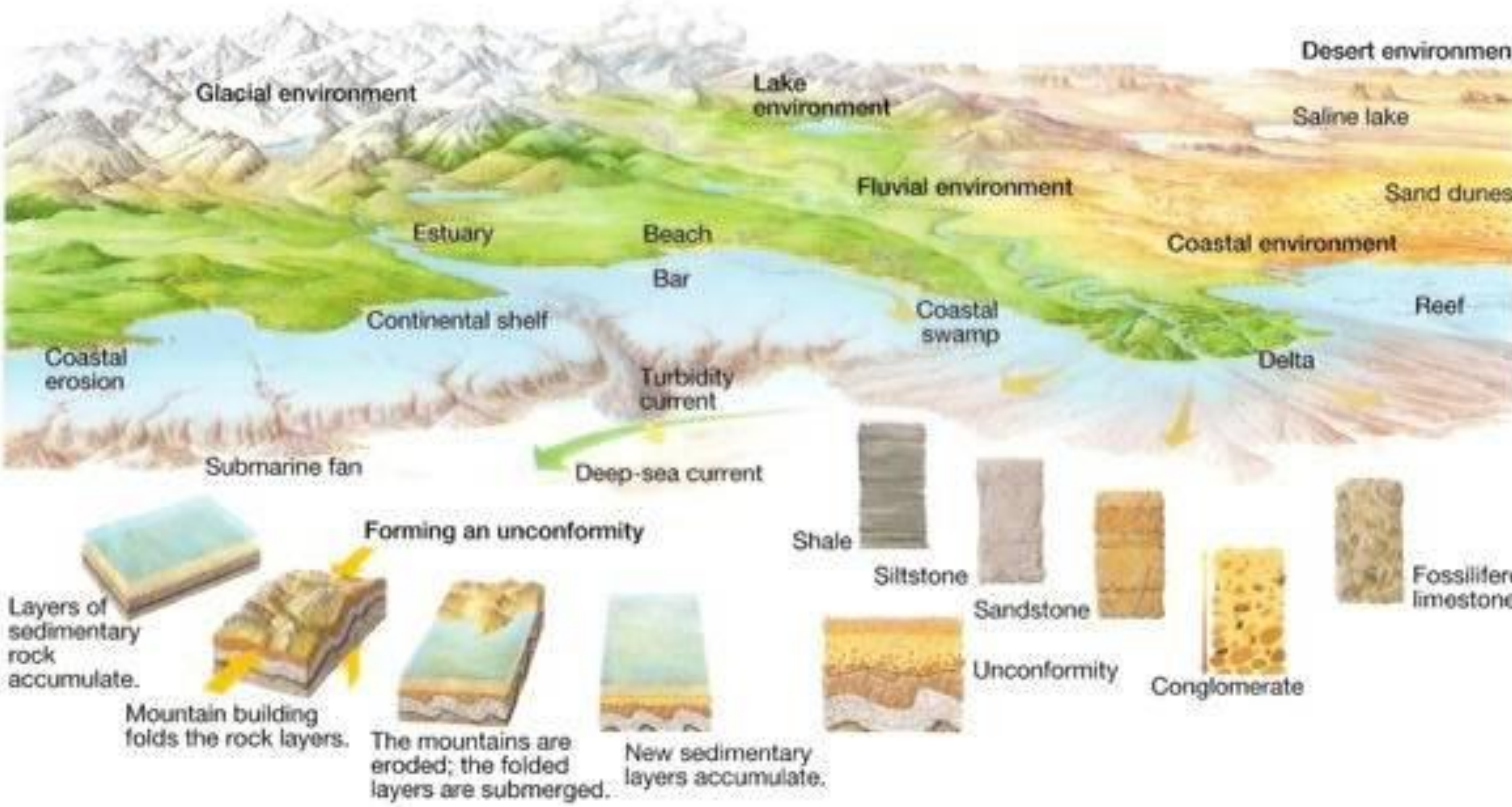
From NASC, 2005

Quick Review of Sedimentary Rocks and Processes

SEDIMENTARY ROCK – Compacted and cemented accumulations of sediment, which can be of two general types – clastic and chemical.

Clastic – composed of fragments of pre-existing rock that have been weathered, eroded and transported by wind, water, ice, or mass movement to a site of deposition.

Chemical –composed of minerals precipitated from water (usually ocean water) due to evaporation or to the metabolic action of organisms (biogenic).



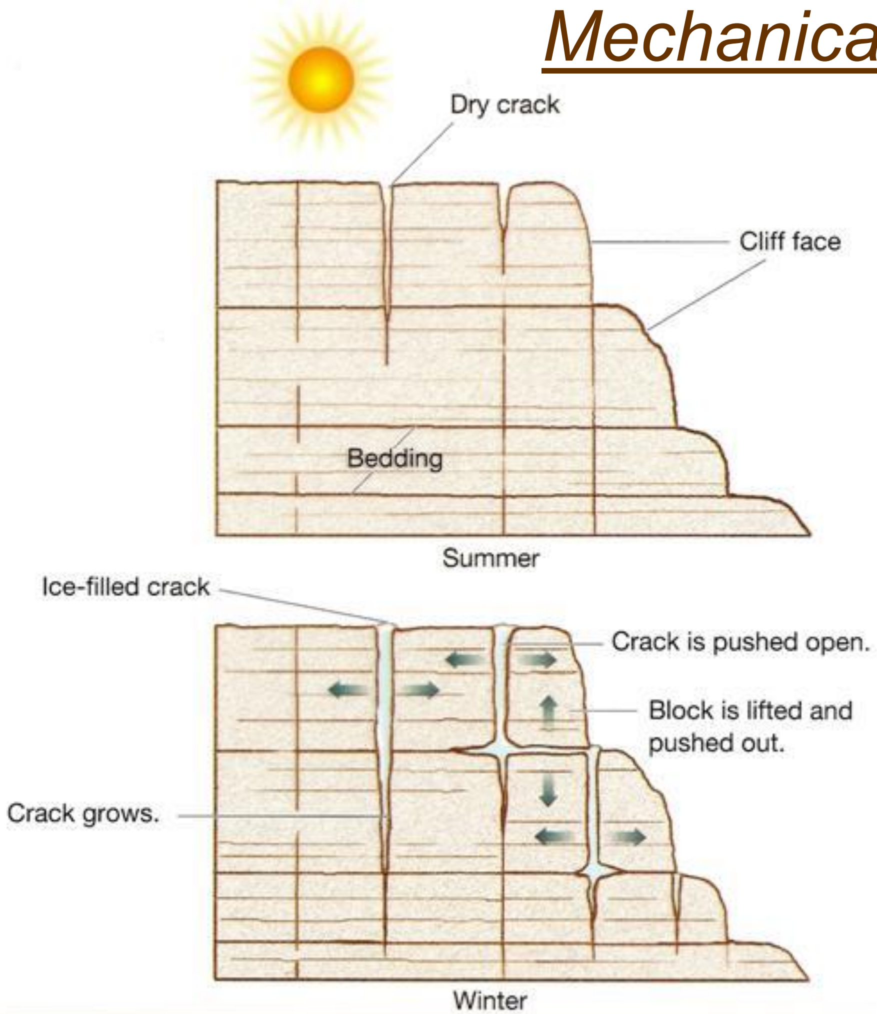
The Formation of Sedimentary Rocks

Hincks p. 146-147

Clastic Sedimentary Rocks

Composed of fragments of pre-existing rock that have been weathered,...

Mechanical Weathering



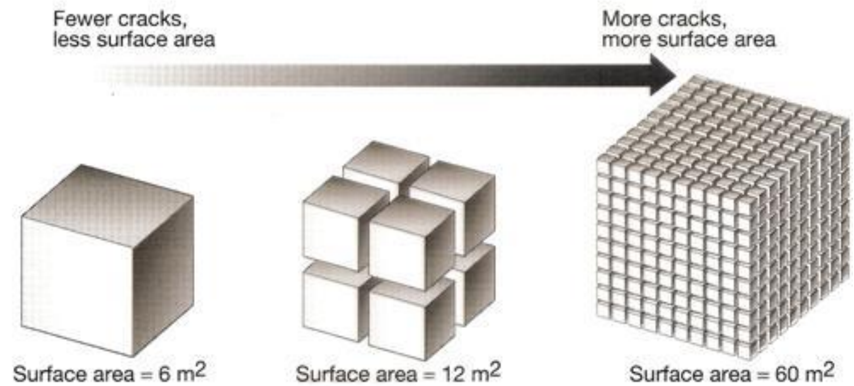


Figure 5.6

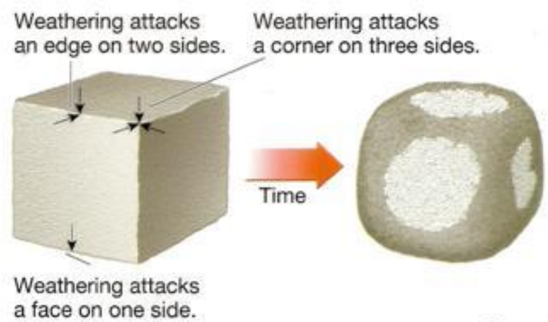


Figure 5.7a

Clastic Sedimentary Rocks

Composed of fragments of pre-existing rock that have been weathered,...

Chemical Weathering

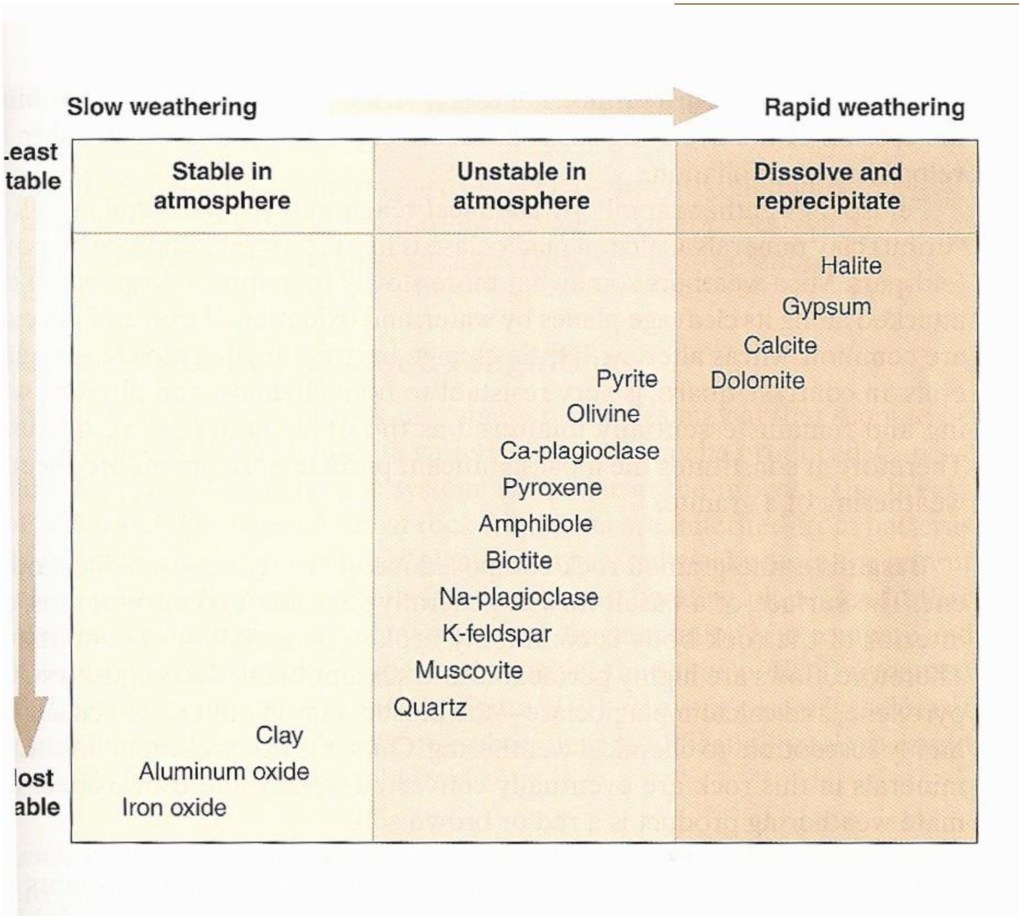
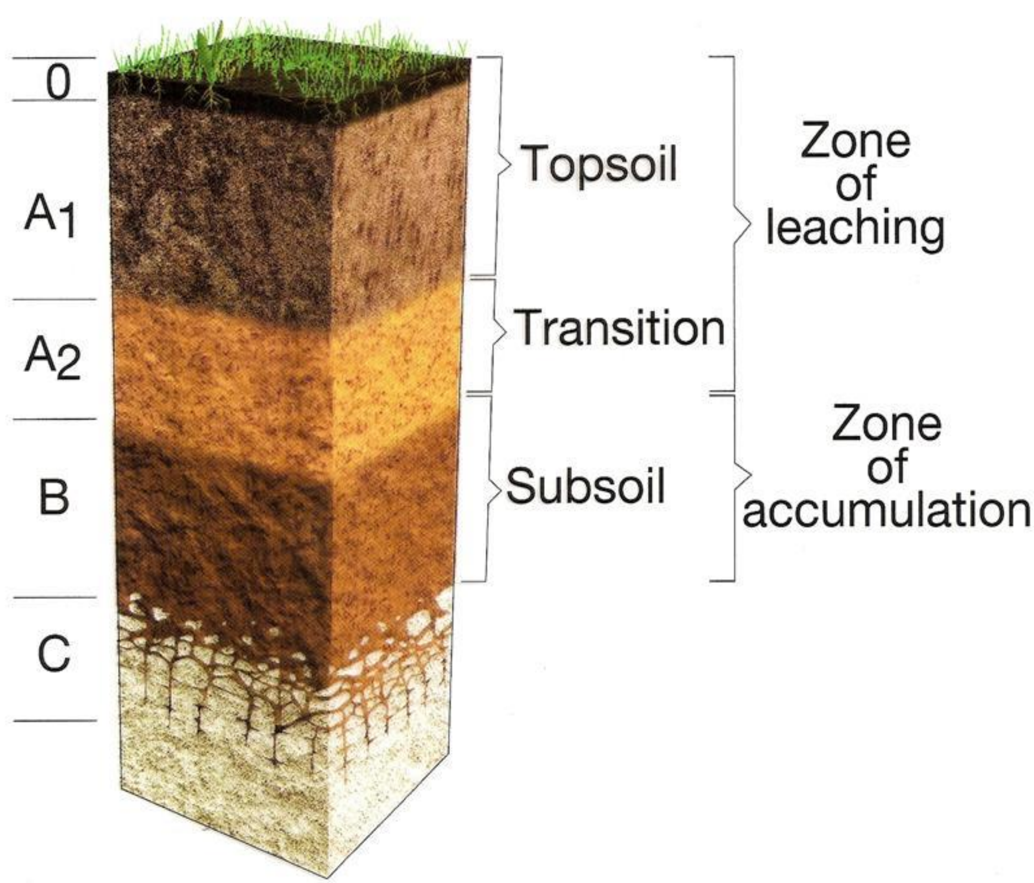
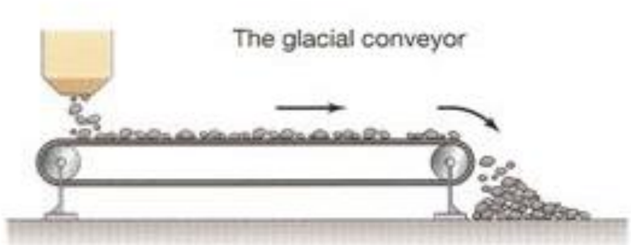


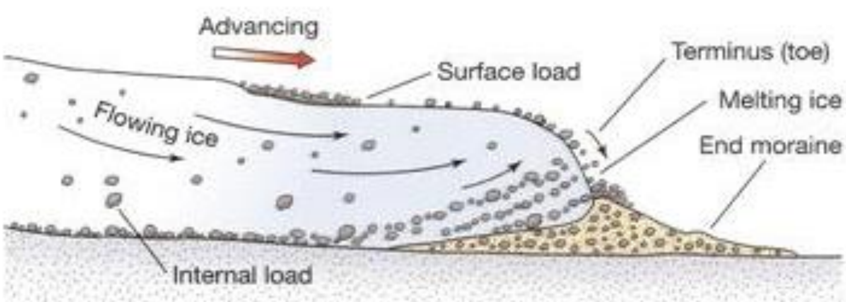
Figure 5.9b



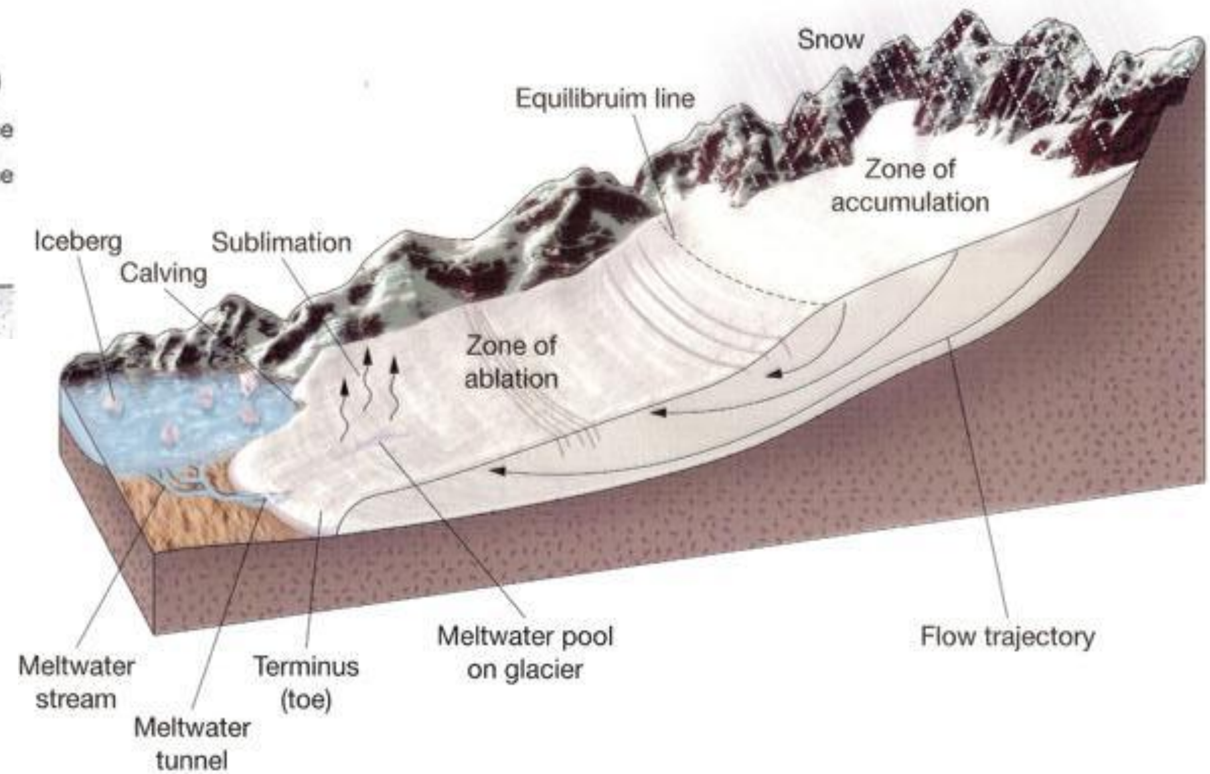
Clastic Sedimentary Rocks

Composed of fragments of pre-existing rock that have been weathered, transported...

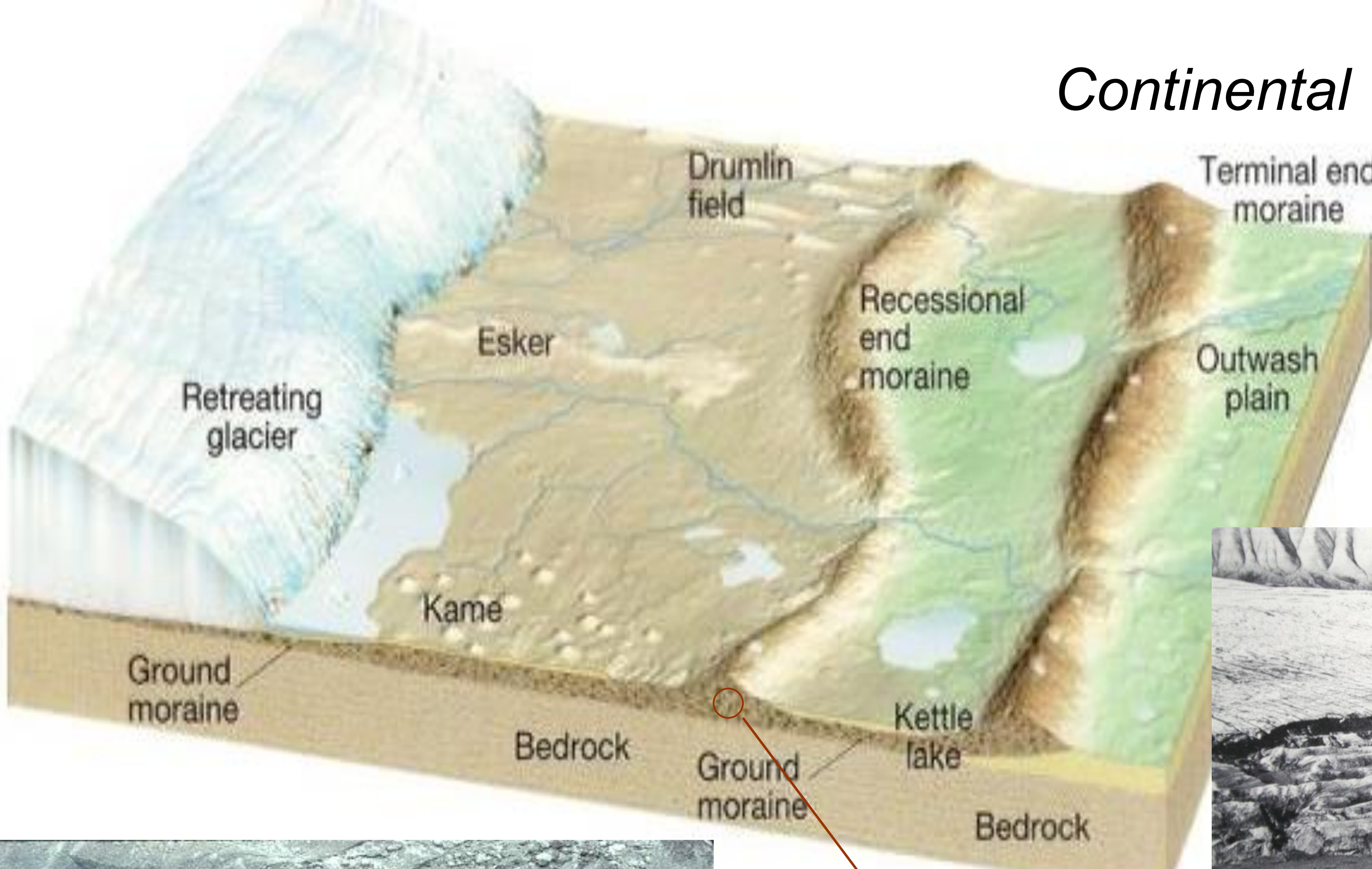




by Ice (Glaciers)



Continental Glaciation

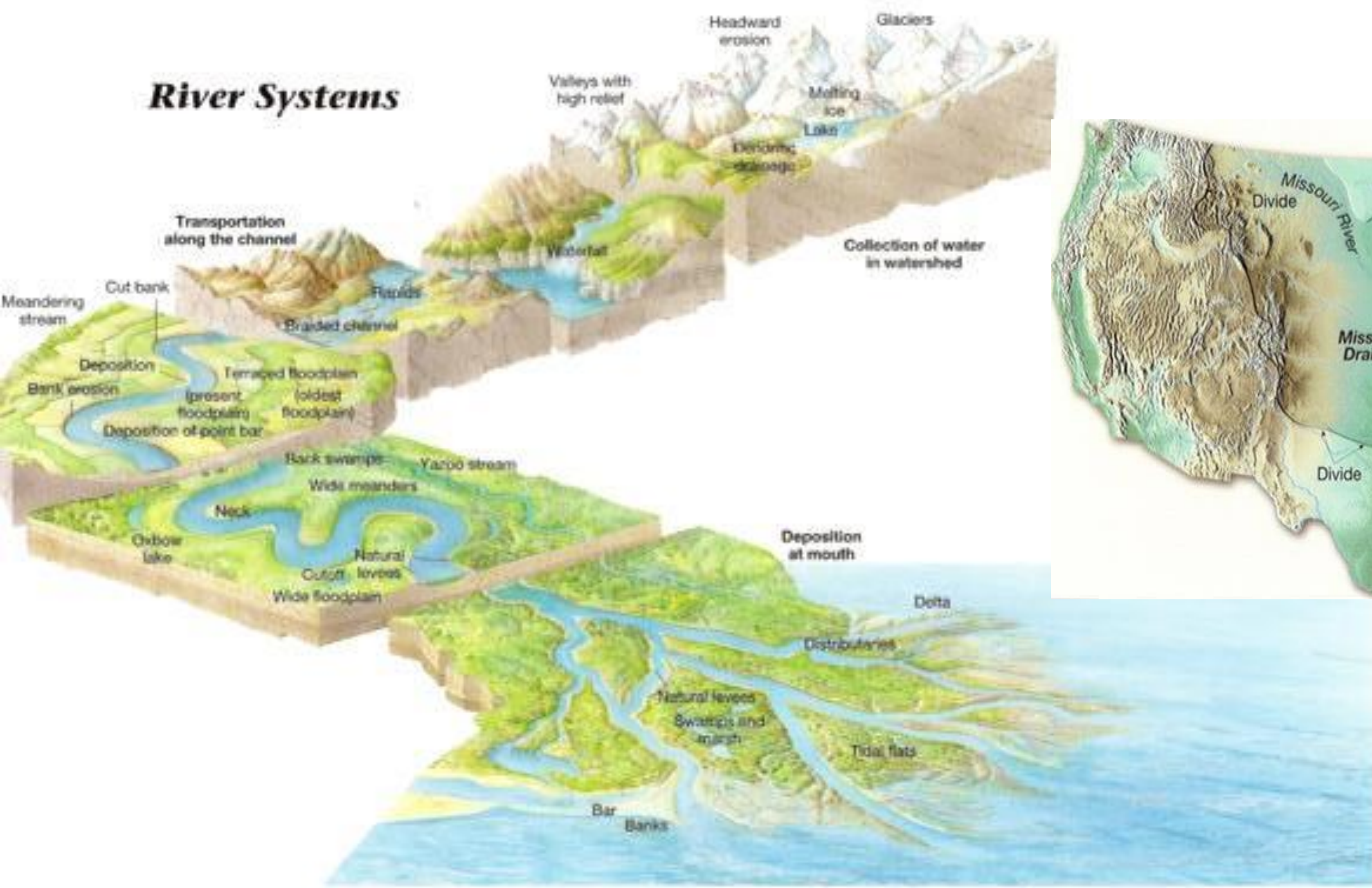


Till→
Tillite

Clastic Sedimentary Rocks

Composed of fragments of pre-existing rock that have been weathered, transported,...

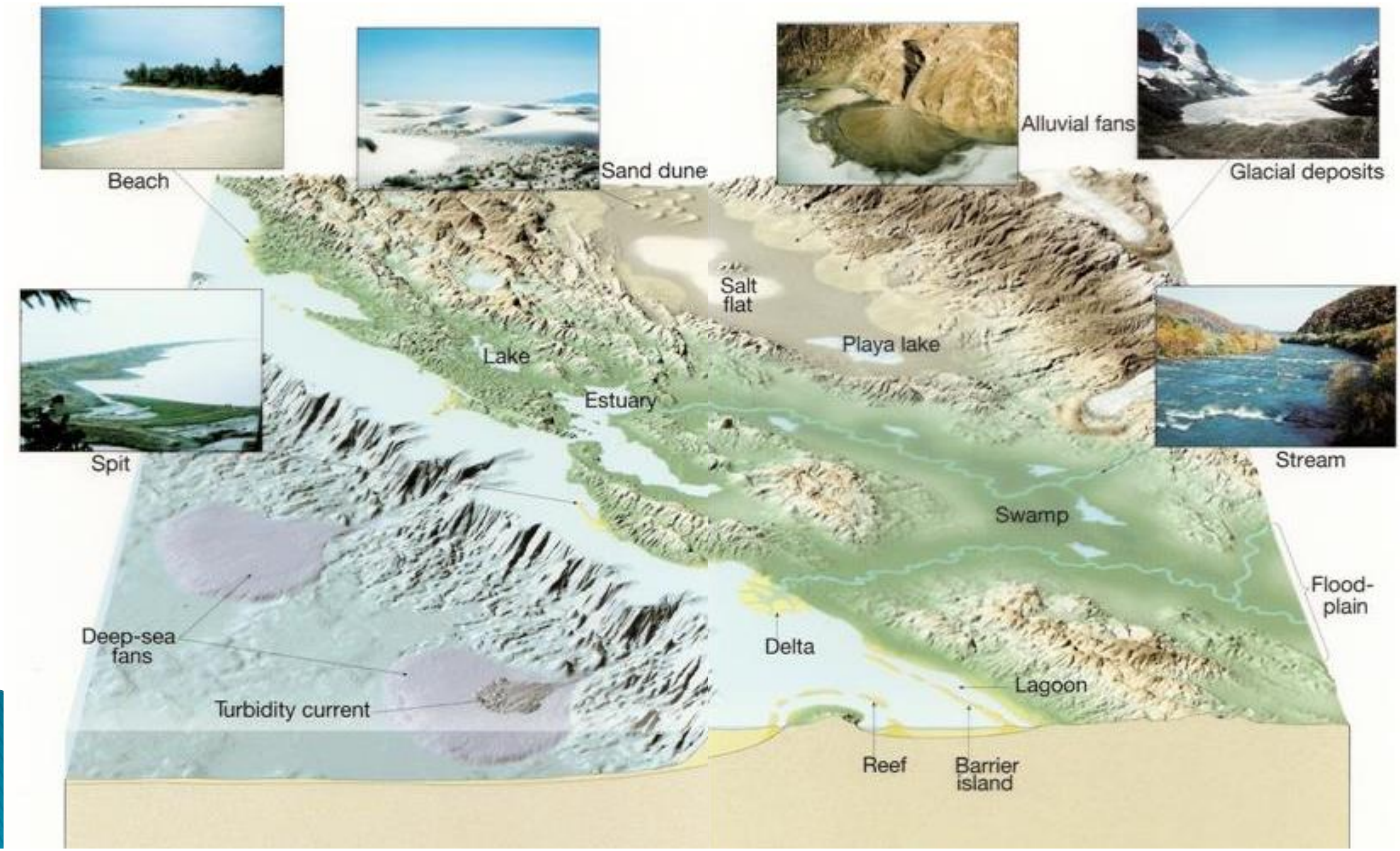
by Water



Clastic Sedimentary Rocks

Composed of fragments of pre-existing rock that have been weathered, eroded, and transported ...

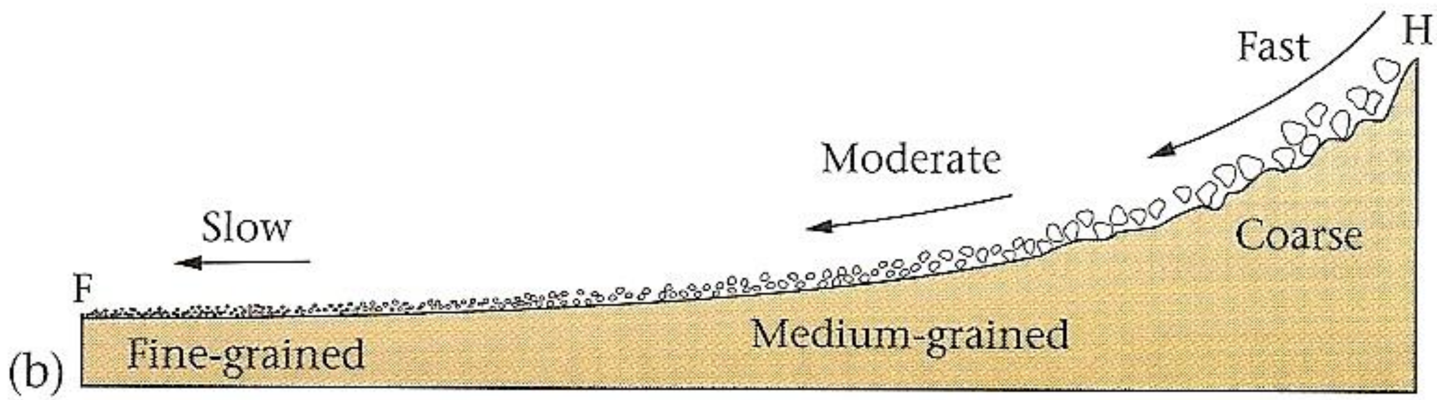
to a site of deposition



Distinguishing Characteristics of Clastic Sediments:

Grain Size – particle size reflects **energy** (velocity) of the transport and depositional system.

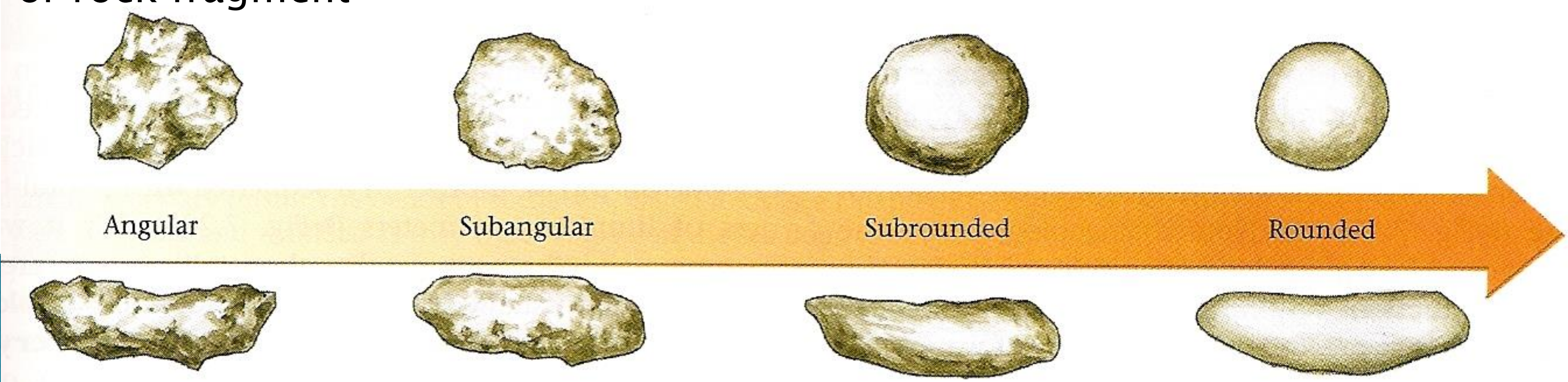
Size Range (millimeters)	Particle Name	Common Sediment Name	Detrital Rock
> 256	Boulder	Gravel	Conglomerate or breccia
64–256	Cobble		
4–64	Pebble		
2–4	Granule		
1/16–2	Sand	Sand	Sandstone
1/256–1/16	Silt	Mud	Shale or mudstone
<1/256	Clay		



Distinguishing Characteristics of Clastic Sediments

Sorting – Well-sorted sediment indicates prolonged reworking by wind or water; poorly sorted sediment may indicate rapid deposition, or deposition by ice or mass movement.

Angularity/Roundness and Shape – Well rounded sediment also indicate prolonged reworking by transporting agent; the shape of grains often indicates the transport system, but also may be related to the type of mineral or rock fragment



Distinguishing Characteristics of Clastic Sediments

Compositional Maturity – mature sediment contains only Quartz and Clay and reflects prolonged weathering of the source rocks. Immature sediment contains other minerals or rock fragments that may imply mostly mechanical weathering in the source region and short transport distance.

Table 5.1 Products of weathering.

Mineral	Residual Products	Material in Solution
Quartz	Quartz grains	Silica
Feldspars	Clay minerals	Silica, K^+, Na^+, Ca^{2+}
Amphibole (hornblende)	Clay minerals Limonite Hematite	Silica, Ca^{2+}, Mg^{2+}
Olivine	Limonite Hematite	Silica, Mg^{2+}

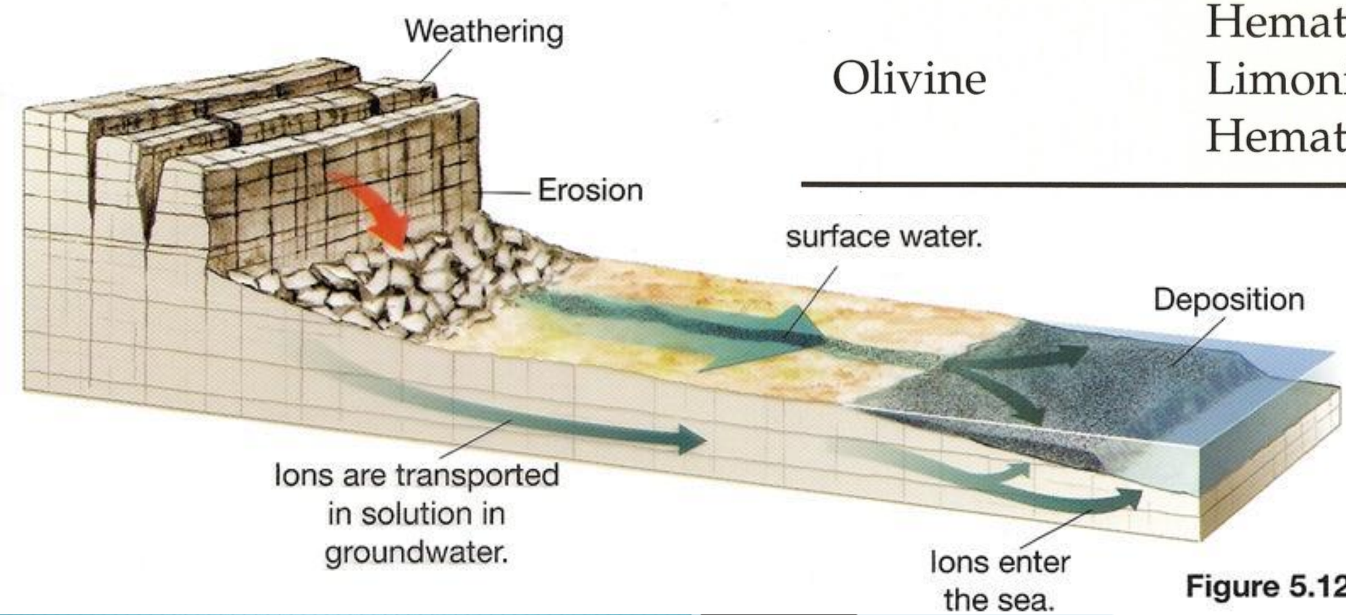
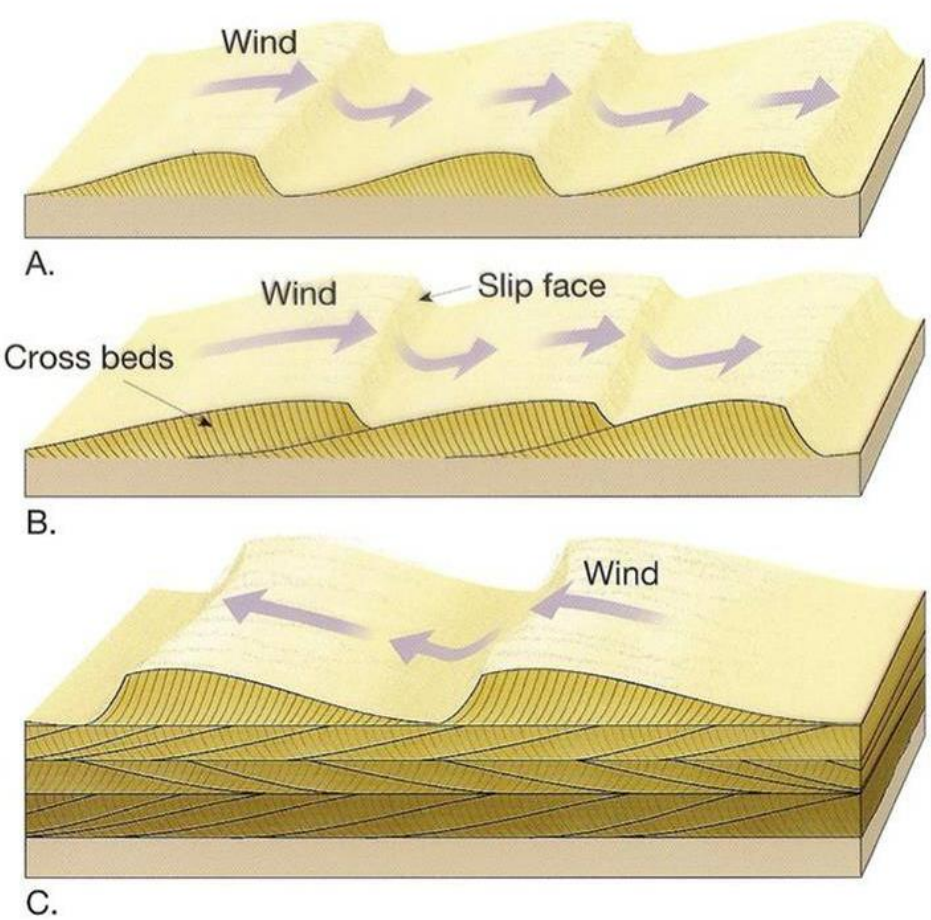
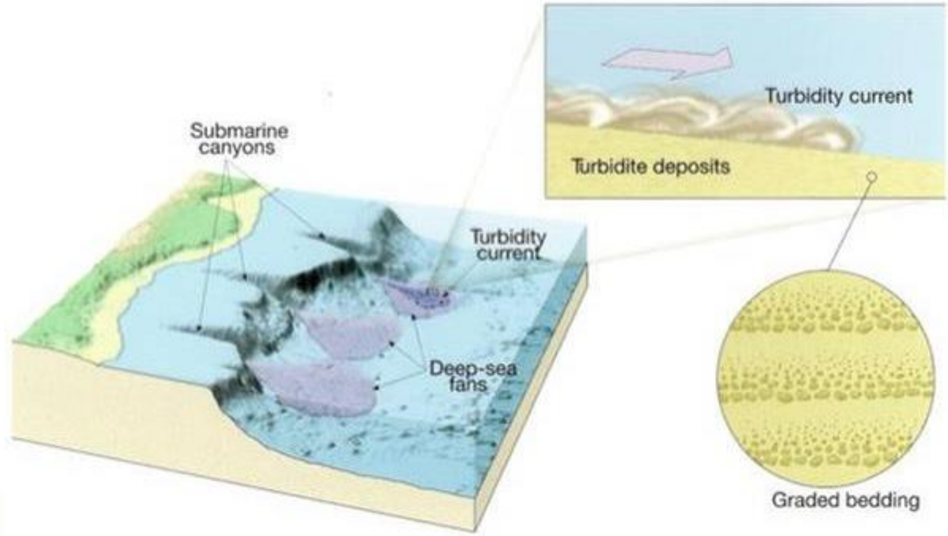


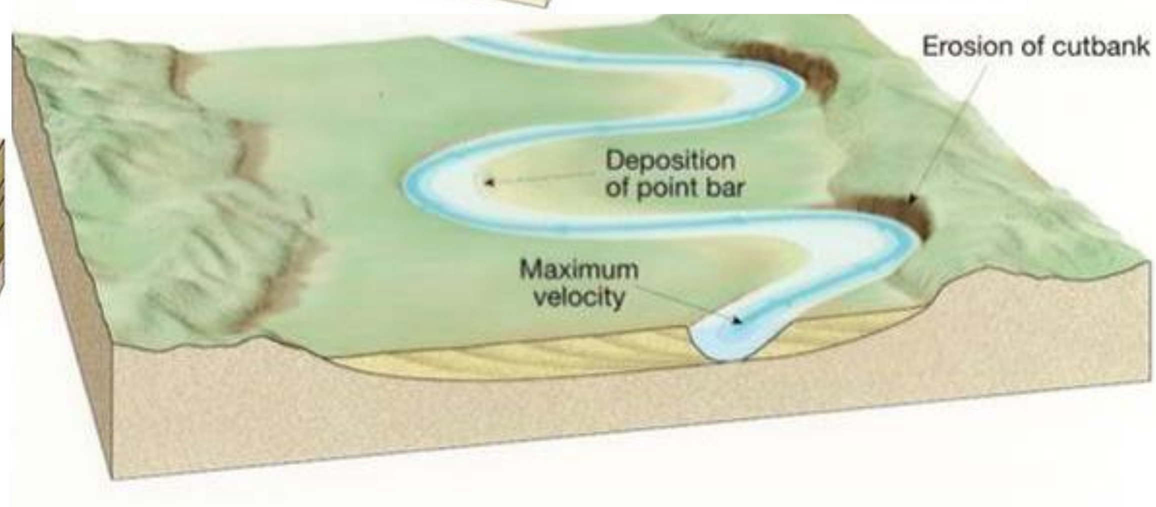
Figure 5.12

Distinguishing Characteristics of Clastic Sediments

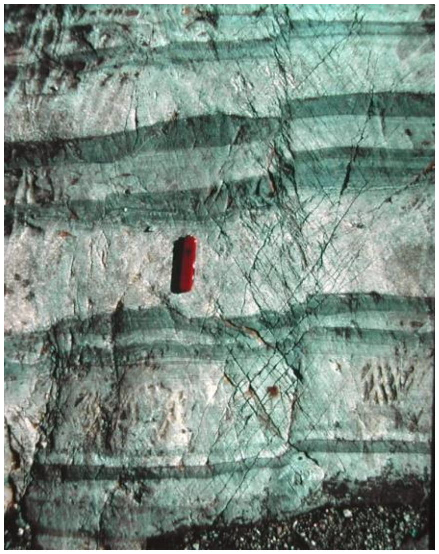
<u>Bedding/Stratification</u> – Sediments transported by water and wind are typically bedded (or stratified) due to fluccuations in the velocity of transport and sediment load. **<u>Graded bedding</u>** is a gradual change from coarse particles at the base to fine particles at the top of a bed that reflects a gradual decrease in the energy of the depositional environment. **<u>Cross-bedding</u>** forms by dune migration in fluvial (stream), marine, or eolian environments. Sediment transported by ice or mass movement are typically unbedded (massive).







Types of Clastic Sediments & Environments of Formation



- **MUDSTONE/SHALE** – Well-sorted, mature, clay-sized particles ; generally implies deposition into quiet water
- **SANDSTONE** – Well-sorted, mature, commonly bedded, sand-sized particles typically transported by wind or moderate water movement (e.g. rivers, beaches)
- **GREYWACKE** – Moderately sorted, immature, clay- to sand-sized particles commonly showing graded bedding. Commonly deposited in deep waters off mountainous coasts.
- **CONGLOMERATE** – Poorly sorted, immature, clay to boulder-sized particles transported only a short distance from their source and typically deposited by fast moving water.
- **TILL** – Very poorly sorted, clay to boulder-sized particles; non-bedded; deposited from glaciers.

Chemical Sedimentary Rocks

composed of minerals precipitated from water (usually ocean water) due to evaporation or to the metabolic action of organisms (biogenic)

- **IRON-FORMATION – Iron oxide** minerals, usually magnetite (taconite ore) or hematite (natural ore), interlayered with **chert** (microcrystalline quartz) and clay minerals. Common chemical sedimentary rock biogenically formed in shallow marine environments older than about 1.8 billion years.

- **LIMESTONE –** Calcium carbonate (calcite) typically composed of abundant marine fossils. Most common type of chemical sediment forming today by biogenic processing of seawater. Dolomite (or dolostone) is created by replacement of calcium by magnesium after shallow burial of limestone. Forms in tropical shallow marine environments.

- **EVAPORITE DEPOSITS** (Gypsum, Halite, Anhydrite) – mineral precipitated from saline water in arid environments with high evaporation rates (e.g., playa lakes)

- **PEAT/COAL** – Carbonaceous material created by the accumulation, compaction and heating of organic matter. Forms in temperate to tropical, low energy, terrestrial environments (lagoons, floodplains).

Environments of Chemical Sedimentation

Evaporites

Coal

Limestone