Sedimentary Rocks and Processes

Sedimentary Processes

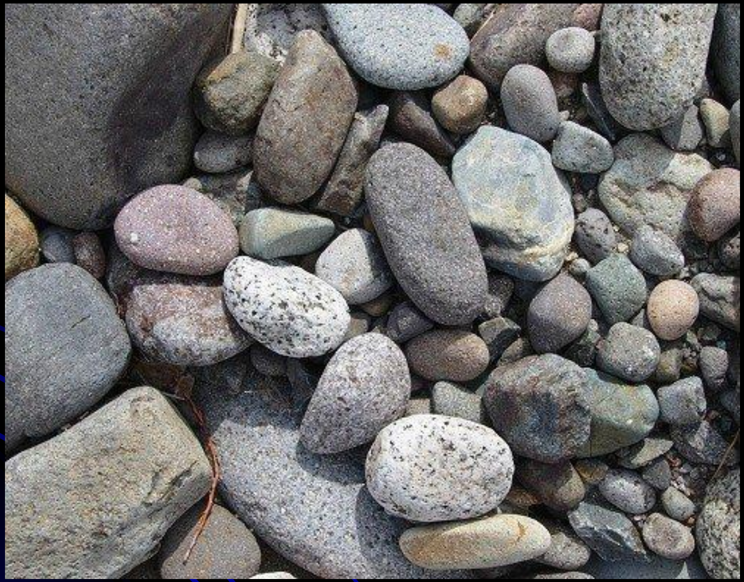
- Weathering
  - Breakdown of pre-existing rock by physical and chemical processes
- Transport
  - Movement of sediments from environments of relatively high potential energy
- Deposition
  - Settling of sediments in environments of relatively low potential energy
- Diagenesis
  - Chemical changes that occur after sediments are buried

Sedimentary Processes

- Weathering
  - Physical Weathering
    - Mechanical breaking of rock into smaller pieces (clasts)
    - No new minerals formed
  - Chemical Weathering
    - Reaction of rocks with air or water
    - New minerals formed at the expense of less stable minerals
- Transport
- Deposition
- Diagenesis

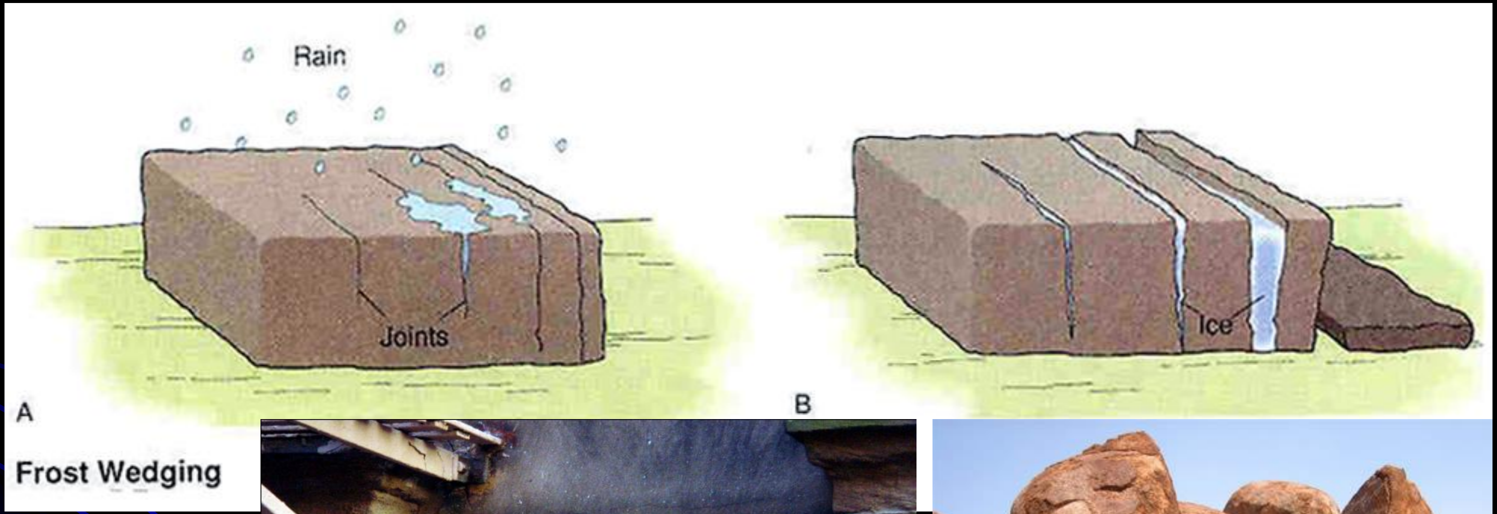
Physical Weathering

- Abrasion
  - Grinding/scratching by rock fragments (e.g., sandblasting)



Physical Weathering

- Frost Wedging
  - Ice has approximately 8% greater volume than liquid water
  - Ice in cracks expands and creates an extensional stress



Frost Wedging

Physical Weathering

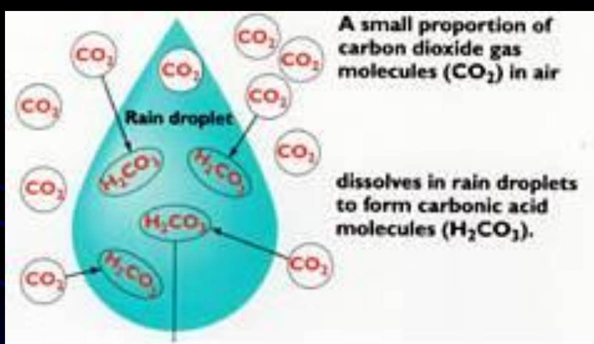
- Root Wedging
  - Trees take root in existing cracks in rocks
  - As tree grows, the expanding root pries rock apart

Physical Weathering

- Salt Wedging
  - Salt crystals that precipitate in pores due to evaporation of saline solutions will expand when heated and create stress

Chemical Weathering

- Dissolution
  - $H_2CO_3 + CaCO_3 \rightarrow Ca^{2+}_{(aq)} + 2HCO_3^{-}{}_{(aq)}$
    - Dissolution of calcite in carbonic acid
    - All rainwater is a weak carbonic acid solution
      - $CO_{2\,(g)} + H_2O_{\,(l)} \leftrightarrow H_2CO_{3(aq)} \leftrightarrow H^+_{(aq)} + HCO_{3-\,(aq)}$



Chemical Weathering

- Hydrolysis
  - In hydrolysis a molecule is split into two parts by reacting with water. One product includes an OH^- from the water molecule, whereas H^+ is added to another

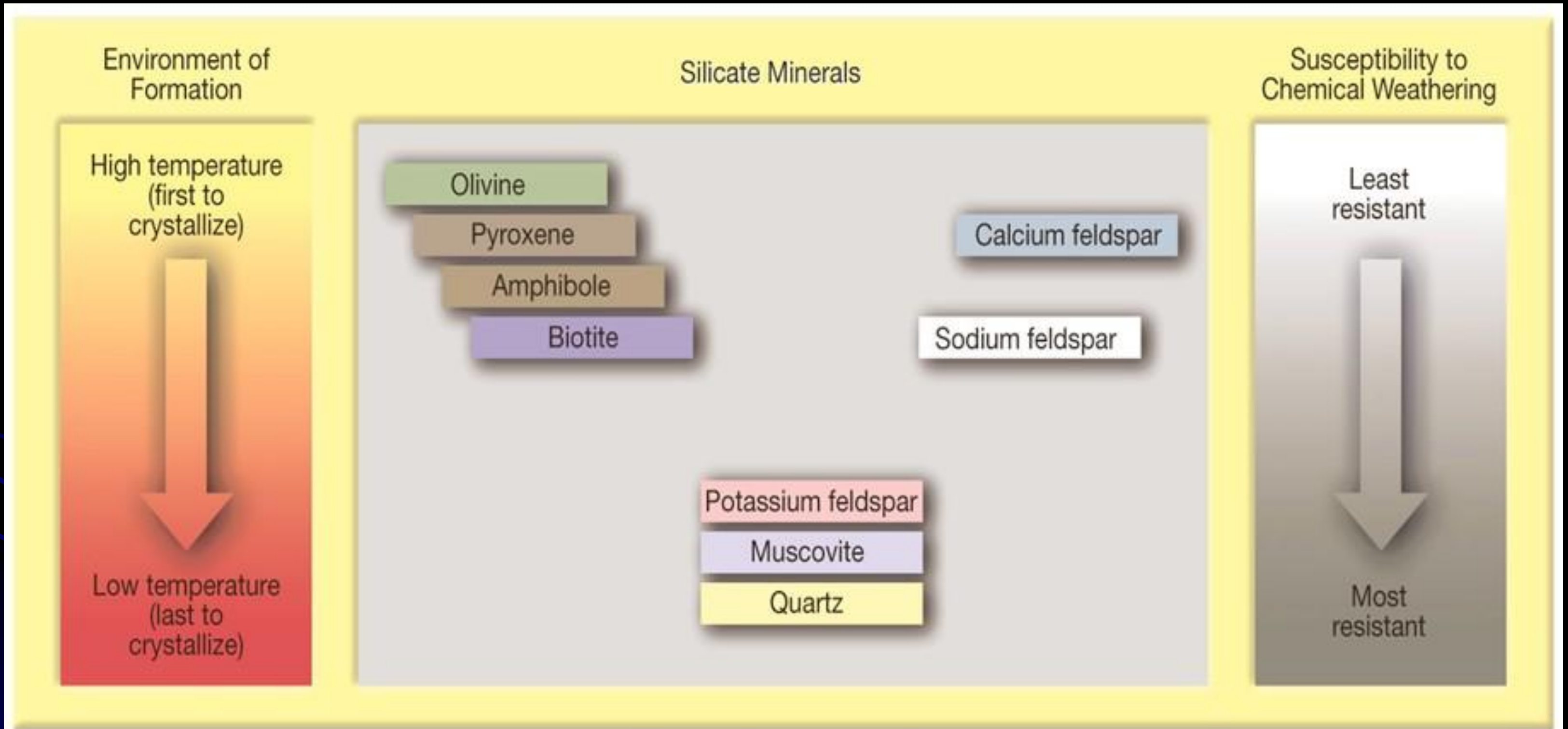
Silicic Acid
(Dissolved Silica)

  - $Mg_2SiO_4 + H_2O \rightleftharpoons 2Mg^{2+}_{(aq)} + 4OH^- + 4H_4SiO_{4\ (aq)}$
    - Hydrolysis of olivine produces a solution (mineral dissolves)
  - $2KAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightleftharpoons Al_2Si_2O_5(OH)_4 + 4H_4SiO_{4\ (aq)} + 2K^+ + 2HCO_3^-$
    - Hydrolysis of K-feldspar produces kaolinite (clay product)

Chemical Weathering

- Oxidation
  - $4FeS_2 + 15O_2 + 22H_2O \longrightarrow 4FeO(OH) + 8SO_4^{2-} + 16H^+$
    - Oxidation of pyrite to form limonite
  - $4\ FeSiO_{3(s)} + O_{2(g)} + 8H_2O \rightarrow 2Fe_2O_{3(s)} + 4H_4SiO_{4(aq)}$
    - Oxidation and hydrolysis of pyroxene to form hematite

Bowen’s Reaction Series and Chemical Weathering

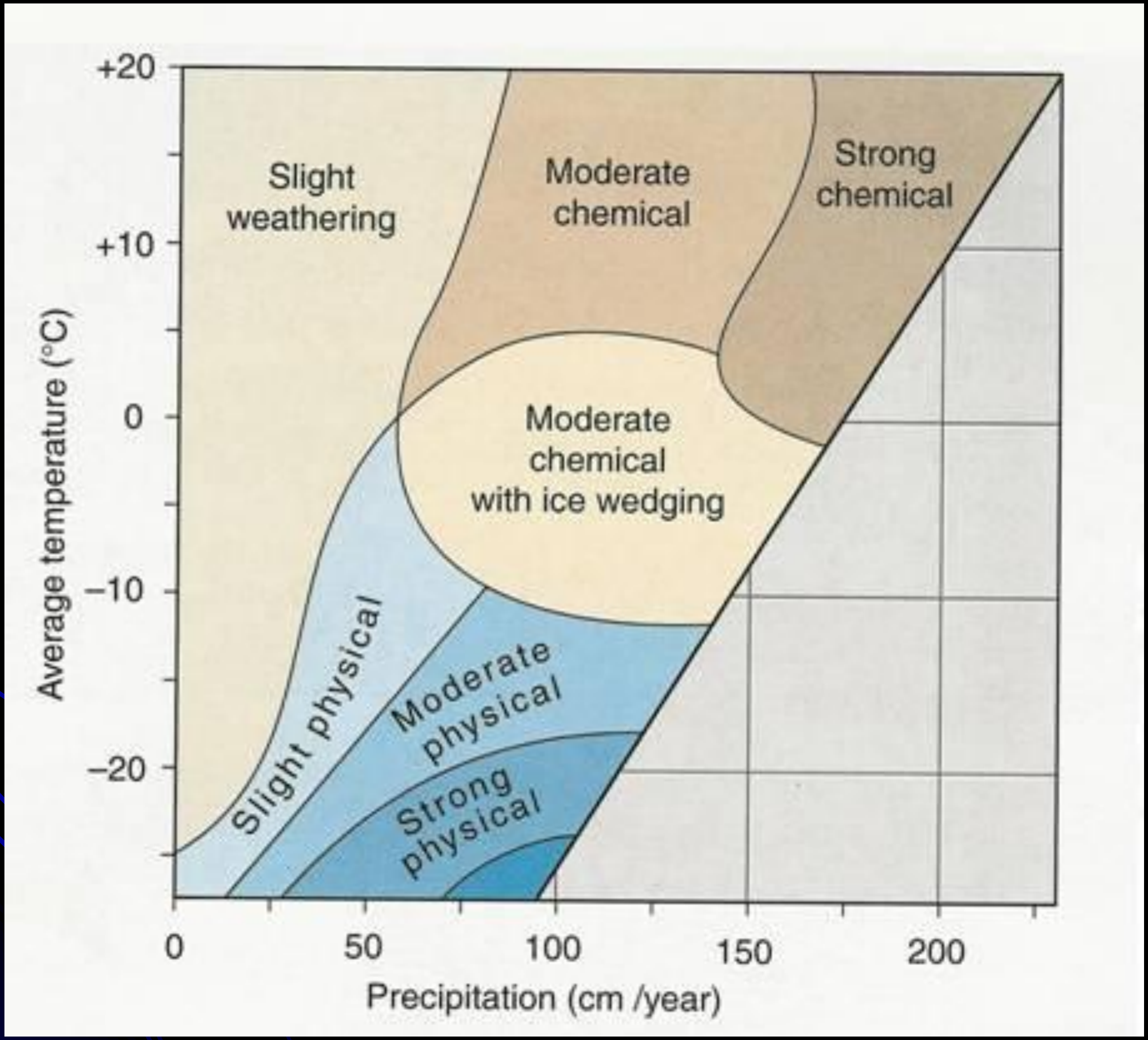


Chemical Weathering

Start with feldspars and Fe-bearing
Silicate minerals…

End with clays, limonite, hematite, and a loss of Si, Ca, Na, and K into solution

Weathering and Climate



Sedimentary Processes

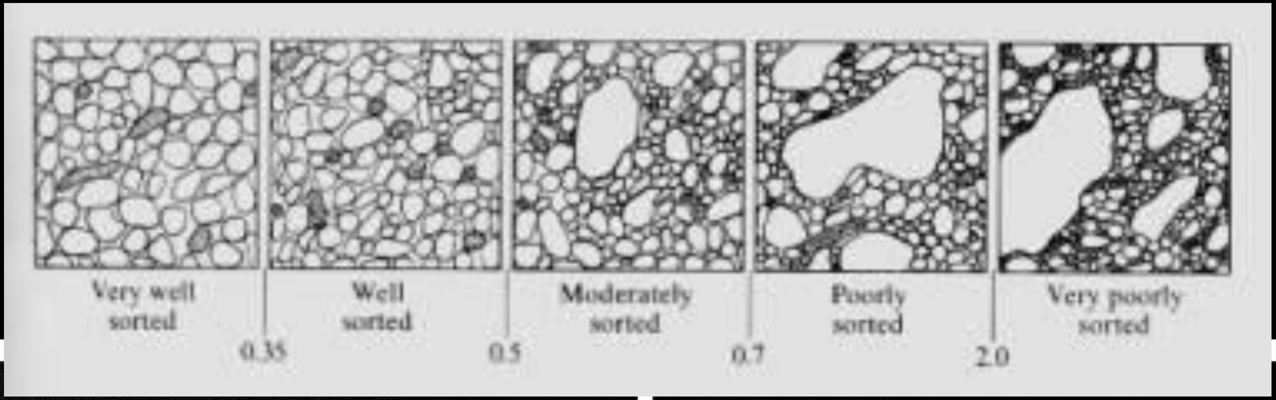
- Weathering

- Transport
  - Movement of sediments from environments of relatively high potential energy
  - Moved by wind or water
    - Sorted and stratified
    - Relatively fine-grained (sand by air; pebbles by water)
  - Moved by glacier or gravity flow
    - Unsorted and unstratified
    - Clay to boulders

- Deposition

- Diagenesis

Sorted vs Unsorted Sediments



Well-sorted sand

Poorly sorted sand

Sorted vs Unsorted Sediments

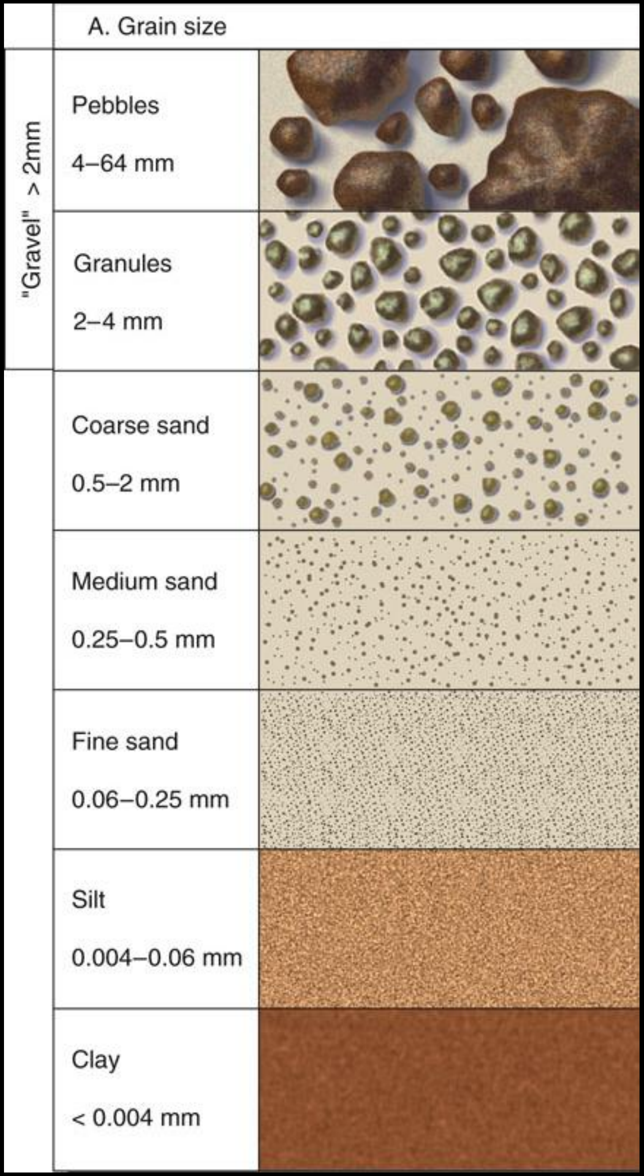
Well-Sorted Stream Deposits

Poorly Sorted Glacial Deposits

Sedimentary Processes

- Weathering
- Transport
- Deposition
  - Settling
    - Sediment grains stop moving when there is insufficient energy to move them farther
  - Precipitation
    - Growth of new minerals from oversaturated water
- Diagenesis

Sediment Classification by Grain Size



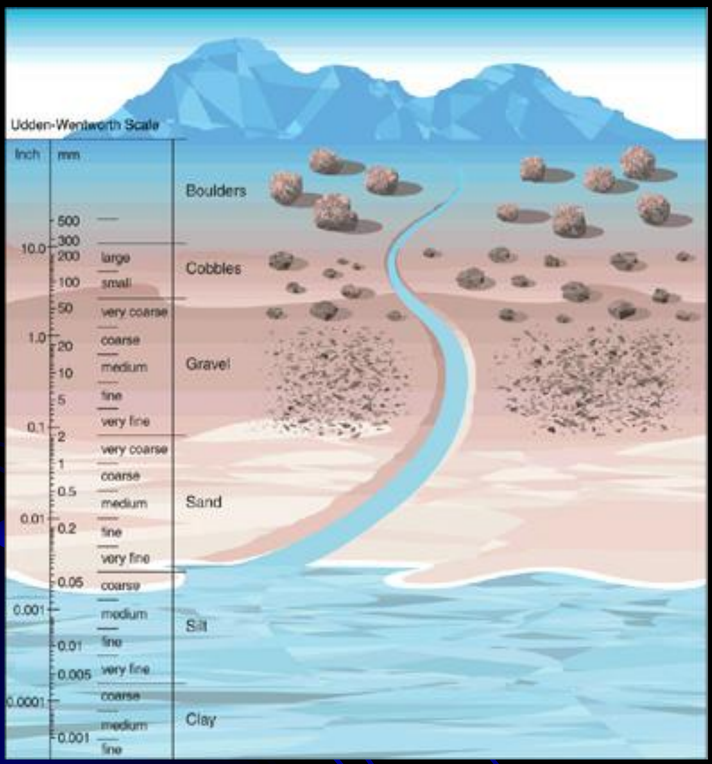
Conglomerate

Sandstone

Siltstone

Mudstone/Shale

Grain Size and Depositional Environments



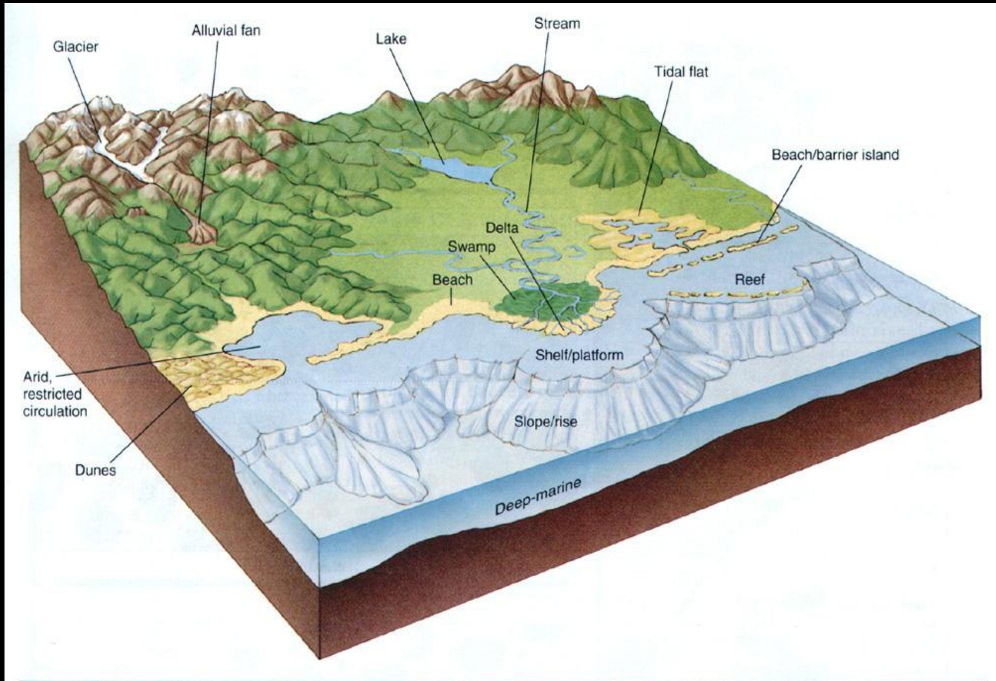


FIGURE 4.2
Typical sedimentary depositional environments.
(Adapted from Jones, 2001: Laboratory Manual for Physical Geology, 3rd edition.)

Deposition by Precipitation (Chemical Sediments)

- Normal seawater has a salinity of 35g/kg
- Only 6 ions comprise 99% of the ions dissolved in seawater:
  - Cl^- 55.04 wt%
  - Na^+ 30.61 wt%
  - $SO4^{2-}$ 7.68 wt%
  - Mg^{2+} 3.69 wt%
  - Ca^{2+} 1.16 wt%
  - K^+ 1.10 wt%

- Marine precipitates will be composed of these ions.

Deposition by Precipitation (Chemical Sediments)

Mineral	Composition	Solubility (mol/l)
Calcite	$CaCO_3$	0.00014
Gypsum	$CaSO_4•2H_2O$	0.0154
Magnesite	$MgCO_3$	0.001
Halite	NaCl	6.15
-----	$CaCl_2•6H_2O$	7.38

Why is $CaCl_2•6H_2O$ not a naturally occurring evaporite mineral?

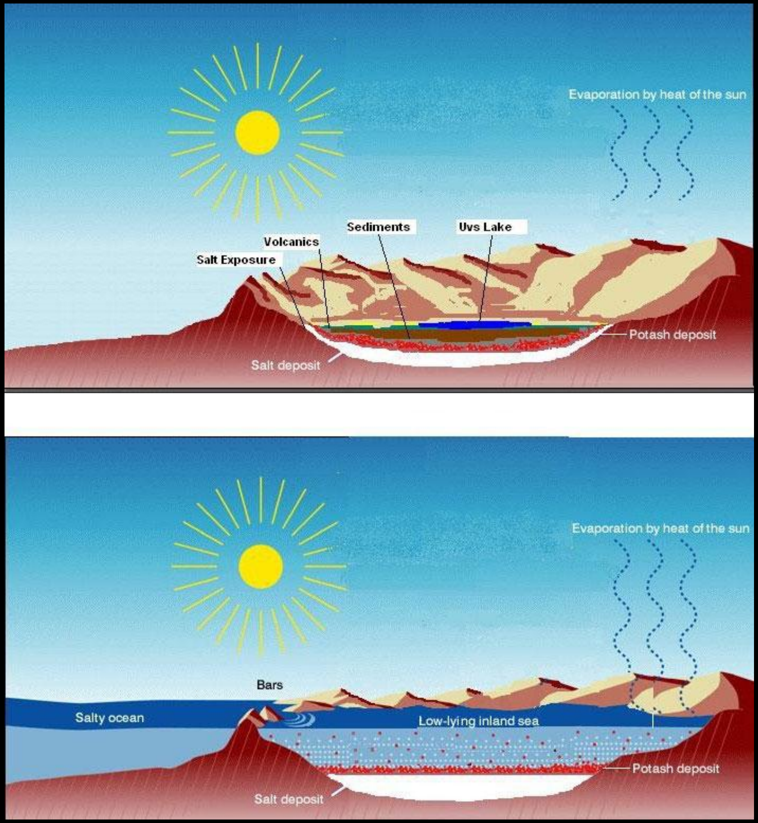
Chemical Sediments

- Limestone are the most common chemical sediment
  - Common in shallow, tropical, marine environments
- Evaporites (deposits of gypsum and halite) are restricted to hot, arid environments where evaporation rates are high

Limestone Reef and Lagoon

Fossiliferous Limestone

Evaporite Deposits



Diagenesis: Cementation

- Precipitation of minerals from solutions in pore water
- Composition of ground water varies greatly depending on such variables as bedrock composition and rainfall
  - *Calcite and dolomite might develop in hard-water areas*
  - *Clays and quartz might develop in soft-water areas*
  - *Limonite and hematite may occur in environments rich in iron (terrestrial)*
  - *Pyrite may occur in rocks where the pore waters were anoxic*