# The Rock Cycle: Sedimentary Rock

BI 201 Natural History of Guam

Class Presentation 11

- Sedimentary rock is a rock resulting from
  1) The lithification of loose sediment consisting of fragments of older rock transported from its source, or
  2) Precipitation from solution [= chemical rock] or secretions from plants or animals, or
     - [precipitation = formation of an insoluble solid, which separates out and settles to the bottom of a solution, from dissolved substances; may be caused by a change in temperature, pH, pressure, or ionic balance]
  3) consolidation of the remains of plants or animals

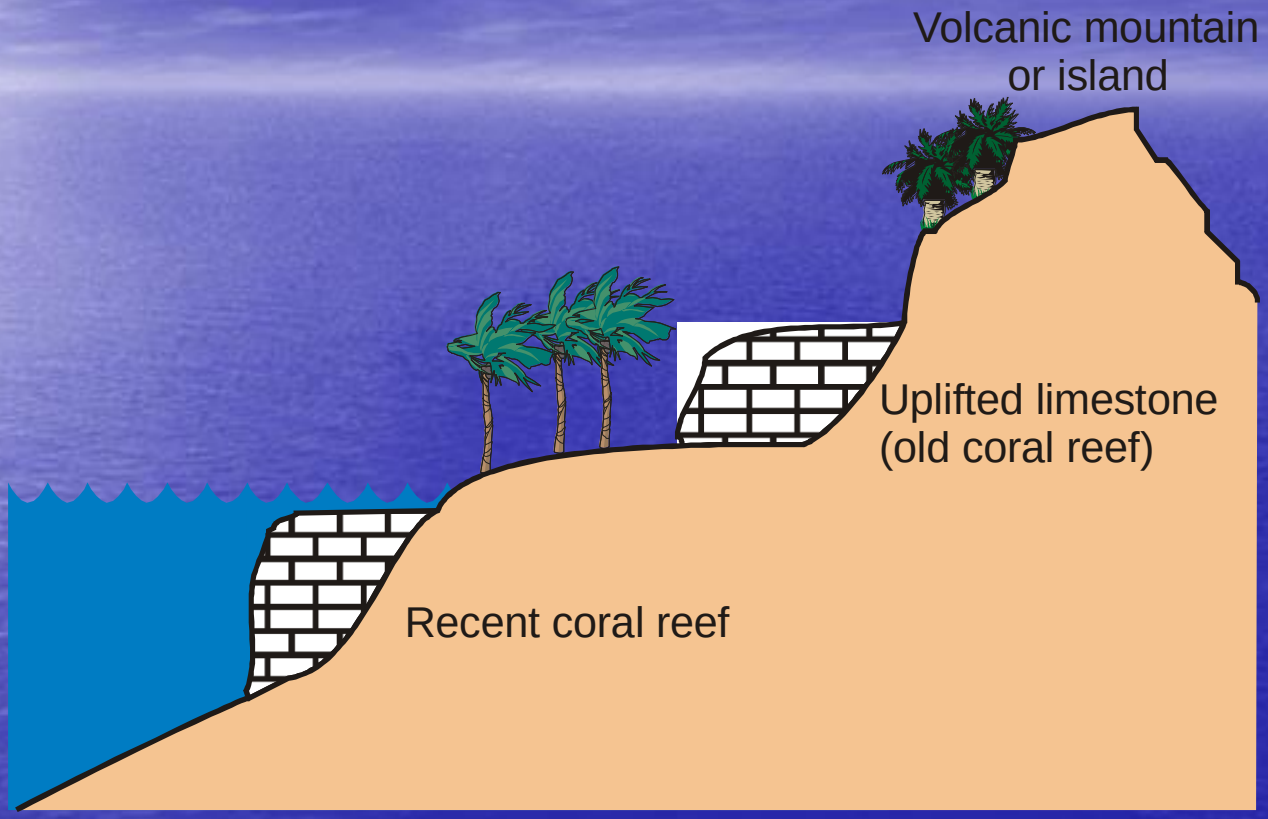
- Categories of sedimentary rock
  - **Clastic rock**
    - Clastic rock forms from detrital sources
      - detritus : 1. [geol.] = material derived from the mechanical breakdown of rock by the processes of weathering and erosion; 2. detritus [biol.] = decaying remains of plants and animals
    - Clastic rock is formed by lithification of fragments of pre-existing rock broken down by mechanical or chemical weathering

- **Chemical rock**
  - Most of the sedimentary rocks on Guam are chemical rocks
  - Four processes may result in the formation of chemical rock
    - **evaporation**
      - The evaporation of a *solvent* (i.e., water) leaves behind crystalized *solute* (e.g., halite)
    - **precipitation**
      - Precipitation is the formation of an insoluble solid when chemical equilibrium is shifted
      - A high concentration of ions is not necessary

- **secretion by plants or animals**
  - Secretions are one of greatest sources of chemical rocks
- **organic accumulation under acidic environments**
  - Decomposition of dead plants and animals is reduced by an acidic environment
  - Organic materials accumulate and may be lithified by pressure from overlying layers

- Sedimentary environments
  - The presence of sedimentary rock may provide additional information, because sedimentary rock forms only in depositional basins

- Specific types of sedimentary rocks are characteristic of certain environments
  - *Peat* indicates an acidic aquatic environment
  - *Limestone* indicates an aquatic environment
    - The old, raised limestone of northern Guam can be explained in either of two ways; either
      - Sea level was higher in the past and then dropped, or
      - The land mass was lower, and then tectonically uplifted


Volcanic mountain
or island
Uplifted limestone
(old coral reef)
Recent coral reef

- The presence of fossils may provide data on the age of rock
  - Geological time scales are partially based on fossil evidence through the study of *biostratigraphy*
  - The presence of fossils of particular organisms, e.g., dinosaurs, plants, and marine inverts, can provide an estimate of the relative age of rock, especially if the evolutionary history of the species is known
    - However, geologists cannot determine the absolute age of sedimentary rock, because methods such as radiometric dating determine the age of parent rock, not the weathering and formation of sedimentary rock

- Weathering of rock
  - Rock originates in the lithosphere, where there is high pressure and usually high heat, especially for igneous rock
  - When exposed at the surface, rock is subjected to low pressure and low heat, plus water, oxygen, carbon dioxide, and living organisms
  - Therefore, the physical environment of the rock changes, and the rock begins to undergo the process of weathering and transport, eventually being broken down to clay minerals in sediments
  - Sediments  may then be lithified to form sedimentary rock

Low pressure, low heat weathering, Transport

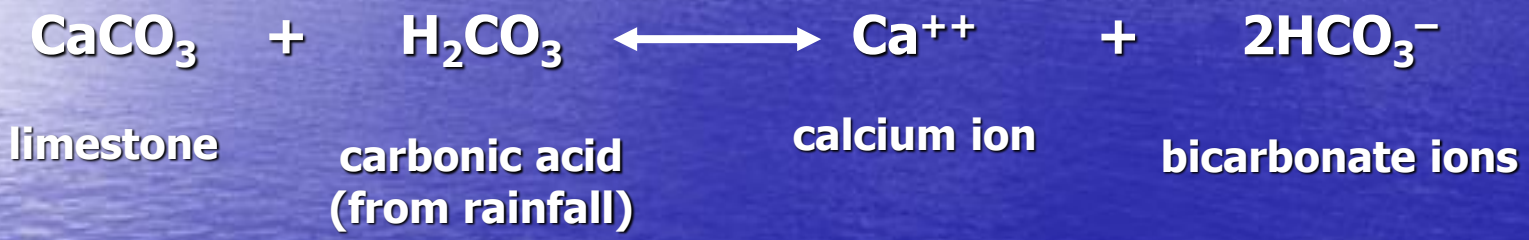
**Parent Rock** → **Clay Minerals** + **Dissolved Materials**

$H_2O$, $O_2$, $CO_2$, Living organisms

Residual gravel, sand Si, Al, Fe, K (insoluble) make up soil; Eventually transported to sea as particulates and sediments

Mg, Na, Ca (transported to sea as ions)

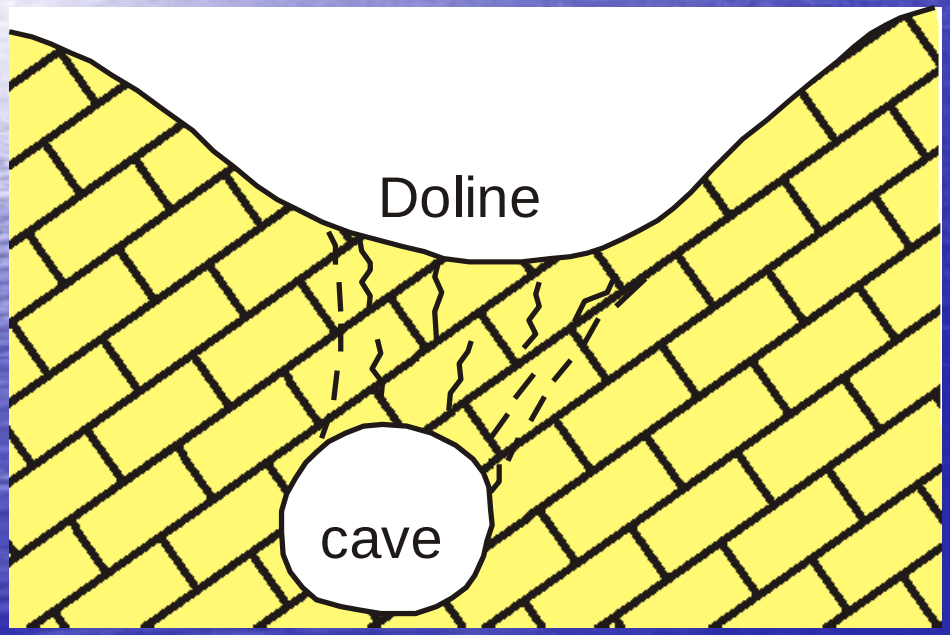
For example, the limestone of Guam is mostly in the crystalline form called calcite.
Calcite is calcium carbonate ($CaCO_3$), which is dissolved by acids.
Rain falling on the island is mildly acidic.

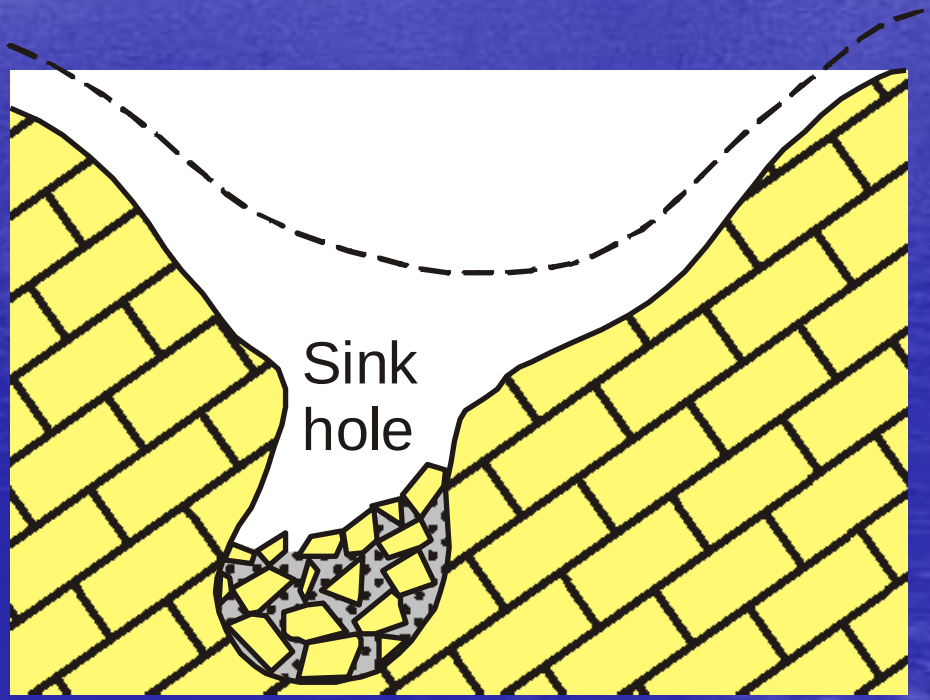



Therefore, all the limestone above sea level will be dissolved over geological time without leaving a trace.

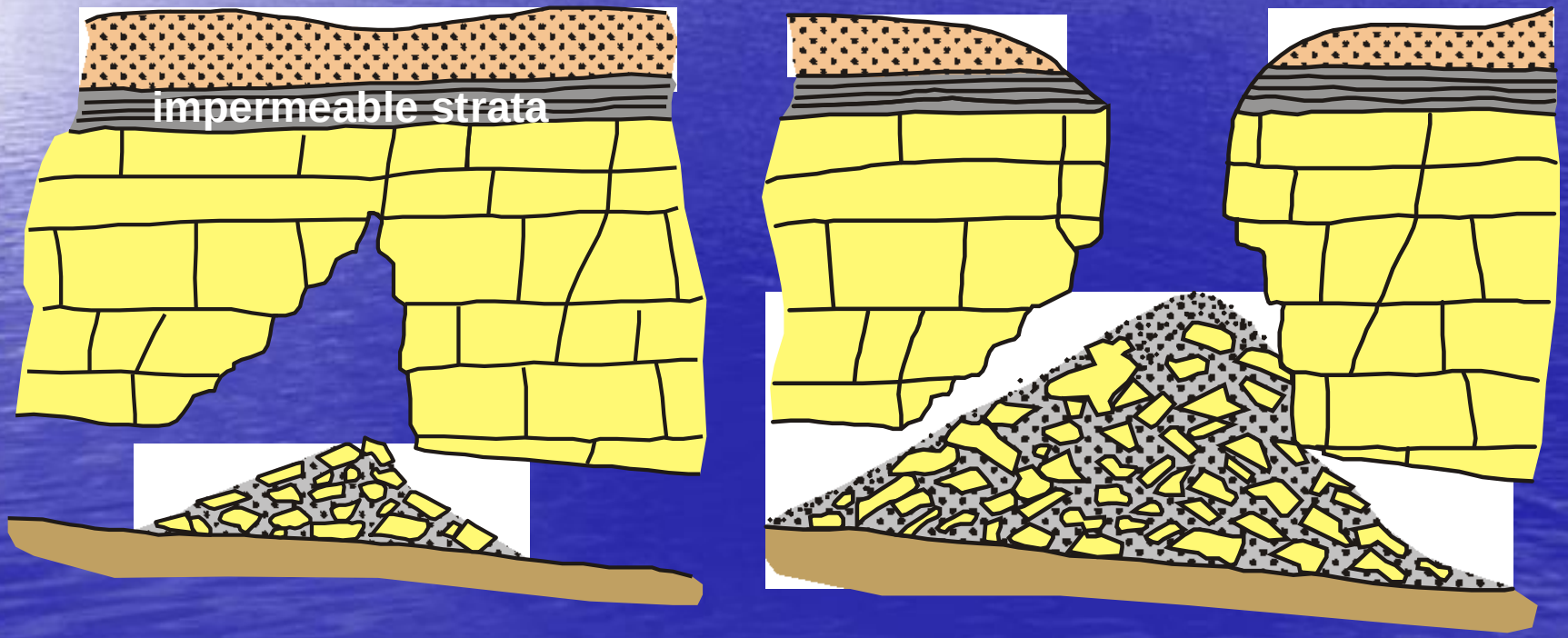
- During dissolution, limestone is dissolved unevenly, forming a topography called karst.
  - Karst topography describes an area characterized by many sinkholes and a cave system beneath the land surface, and usually lacking a surface stream or river
  - Karst may develop by any of three means
    - Solution from above
    - Undermining from below
    - Removal of buoyant support

1. Solution from above

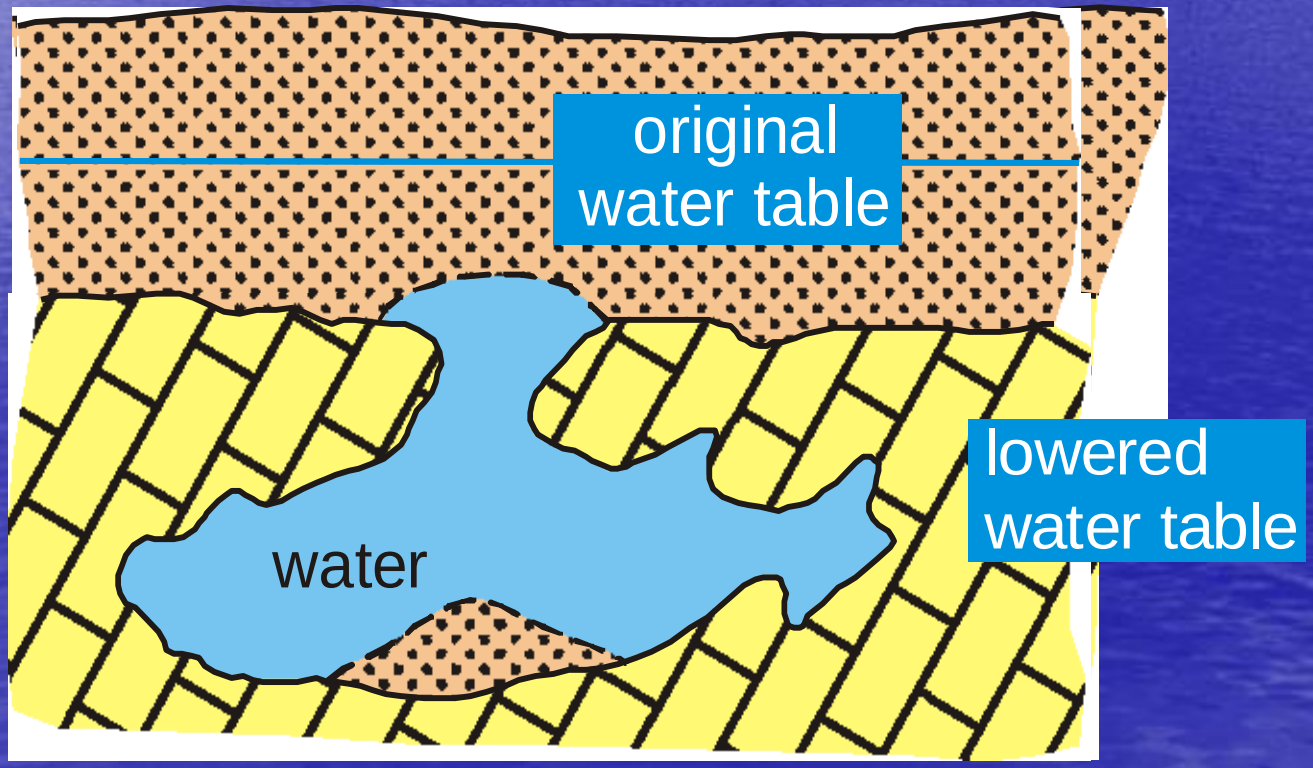


2. Undermining from below



3. Removal of buoyant support



- Classification of clastic sedimentary rocks
  - Sedimentary rock is classified by the texture of the sediment particles that form the rock

1) **Sedimentary breccia**
   - coarse-grained sedimentary rock formed by cementation of coarse, angular fragments of rubble
2) **Conglomerate**
   - coarse-grained sedimentary rock formed by cementation of rounded gravel
3) **Sandstone**
   - medium-grained sedimentary formed by cementation of sand grains
4) **Shale, Siltsone, Mudstone**
   - fine-grained sedimentary rock formed by cementation of silt and clay particles
   - Shale is usually laminated or stratified

| Diameter (mm) | Sediment | | Sedimentary Rock |
|---|---|---|---|
| 256 | Boulder | Gravel | **Conglomerate** (rounded particles) |
| | Cobble | | |
| 64 | Pebble | | **Breccia** (angular particles) |
| 2 | Sand | | **Sandstone** |
| 1/16 | Silt | "Mud" | **Shale** **Siltsone** **Mudstone** |
| 1/256 | Clay | | |

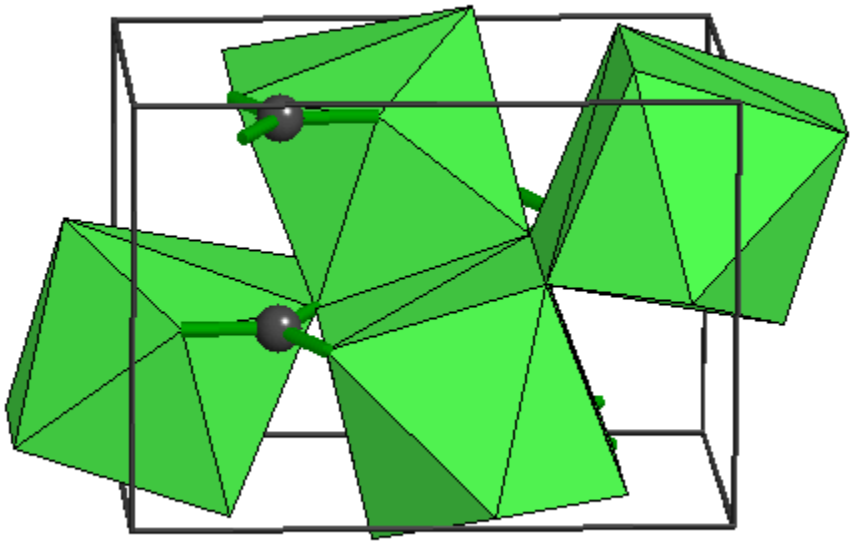
- Carbonate rock
  - Carbonate rock usually refers to rock with 95% or cacite
  - Limestone is a sedimentary rock composed mostly of calcite ($CaCO_3$), often precipitated in shallow seawater by living organisms
  - Limestone may be precipitated directly as a solid rock in the core of a reef by corals and encrusting coralline algae
    - Such limestone would have crystalline texture and would contain fossil remains of organisms still in their growth position
    - These limestones are called **framework** limestones

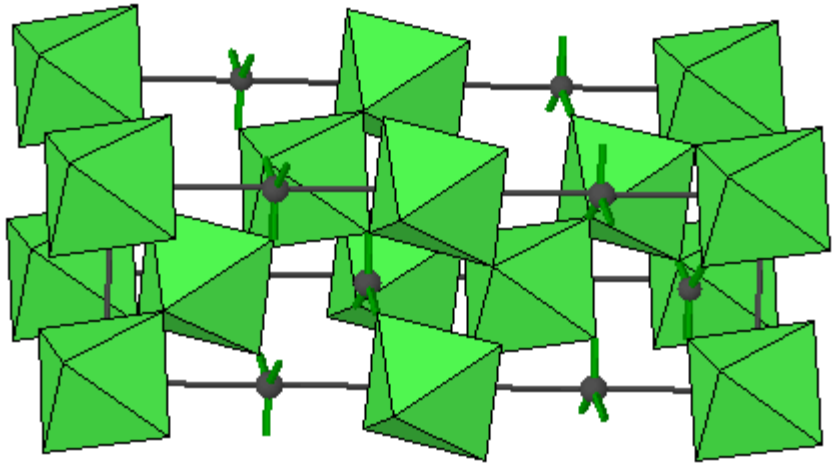
- One variety of limestone, called coquina, forms from the cementation of mollusc shells that accumulated on the seafloor
  - Coquina has a clastic texture and is usually coarse-grained, with easily recognizable shells and shell fragments in it
- The great majority of limestones, including coquina, are formed of wave-broken fragments of algae, corals, and molluscs
  - Fragments may be of any size (i.e., gravel, sand, silt, or clay)
  - These detrital limestones are referred to as **bioclastic** limestones

- Both framework and detrital limestones are described by the presence or absence of contamination by clay particles
  - pure limestone is uncontaminated by clay and is snowy white in color
  - argillaceous limestone is contaminated by clay particles and is dirty white, light yellow, or pink in color, depending upon the source of contamination

- Limestones are particularly susceptible to recrystallization
  - Recrystallization is the process in which crystals in a rock are rearranged into a new crystalline lattice
  - Most reef limestones are deposited by living organisms as aragonite, which recrystallizes to calcite after tectonic uplift and exposure to the atmosphere

Crystalline structure of aragonite





Crystalline structure of calcite

- Other sedimentary rocks
  - Evaporites are rocks formed from crystals that precipitate during evaporation of water
    - e.g., rock gypsum = $CaSO_4 \bullet 2H_2O$
    - e.g., halite = NaCl [a.k.a. rock salt; fractures in sheets]
    - e.g., salt = NaCl [fractures in cubes]

- Coal is a sedimentary rock formed from the accumulation and consolidation of plant material, e.g., leaves, roots, woody tree trunks, and stems
  - Coal usually develops from peat, a brown, lightweight, semi-consolidated deposit of moss and other plant material that accumulates in wet bogs
  - Peat is transformed into coal by compaction

# The Rock Cycle: Metamorphic Rock

- When rock strata are buried deeply in lithosphere, they may be subjected to intense temperatures [but not to melting point] and high pressure, causing metamorphosis
  - Metamorphism is the solid-state transformation of pre-existing rock into texturally or mineralogically distinct new rock as a result of high temperature, high pressure, or both

- The new rock is called **metamorphic rock**
- Metamorphic rock has a texture that is distinctly different from that of the parent rock
- Metamorphic rock may also be mineralogically distinct from the parent rock
- Metamorphic rock is found only in areas where rock from the deep lithosphere is tectonically pushed to the surface
  - Therefore, metamorphic rock is not commonly found on the surface at Guam

- Metamorphic rock is classified by the intensity of the metamorphic processes and by the chemical constituents of the parent rock
- Therefore, the same parent rock may produce different metamorphic rock, depending upon the intensity of the metamorphic processes
  - For example, the greenschist commonly found on the surface in Yap formed from basalt metamorphosed at relatively low temperatures and pressure; at higher temperatures and pressure, the same basalt would metamorphose into *amphibolite*

– Some common metamorphic rock and its parent rock include:

| Metamorphic Rock | Parent Rock |
|---|---|
| Marble | Limestone |
| Graphite | Coal, peat |
| Diamond | Graphite |
| Gneiss | Granite |