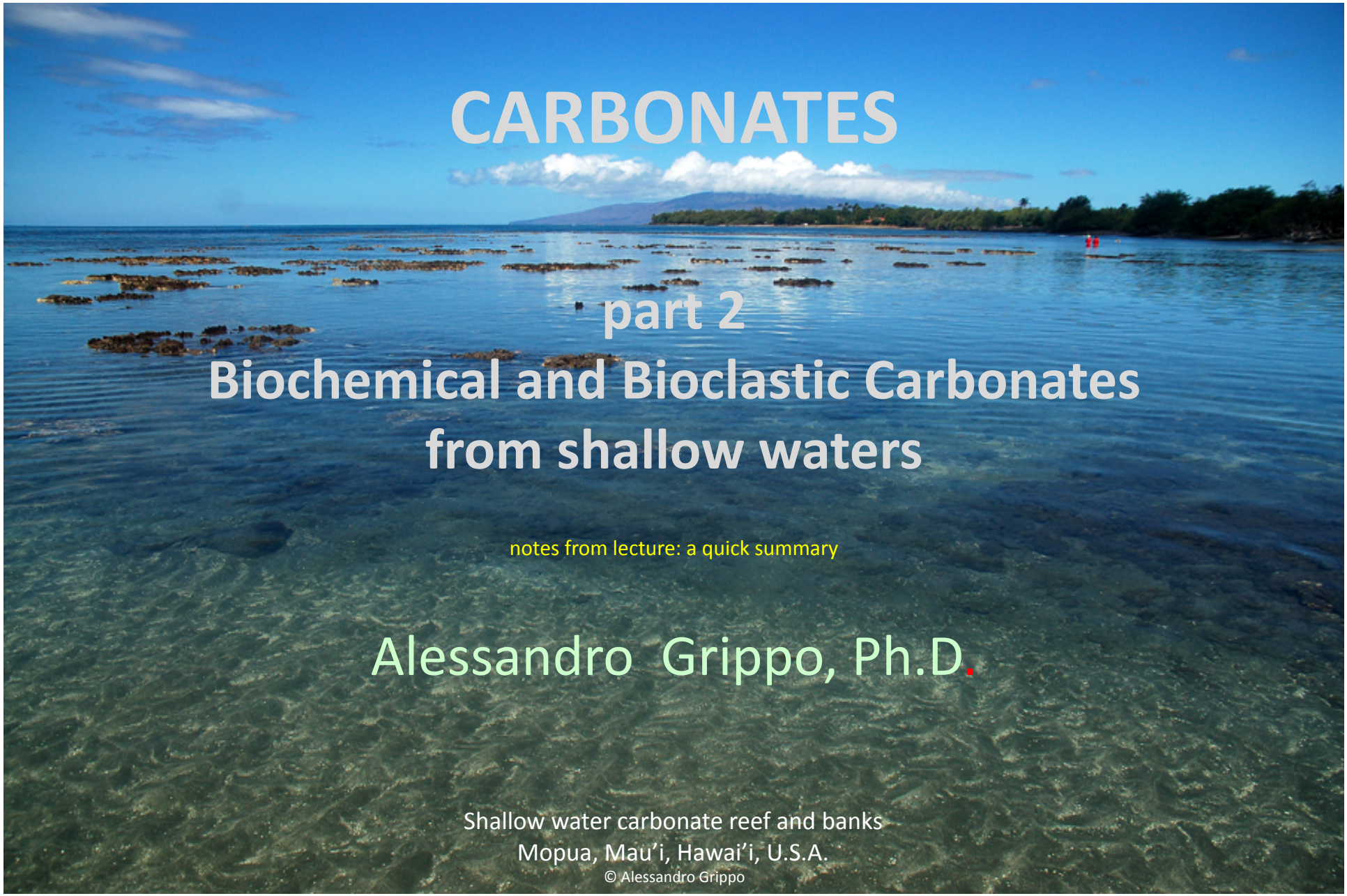


# CARBONATES

## part 2

## Biochemical and Bioclastic Carbonates from shallow waters

notes from lecture: a quick summary

Alessandro Grippo, Ph.D.

Shallow water carbonate reef and banks
Mopua, Mau'i, Hawai'i, U.S.A.

# previously:

- Clastic Sedimentary Rocks

- Chemical Sedimentary Rocks
  - Phosphates
  - Ironstones (Hematite, Limonite, Magnetite, Siderite, Goethite, Banded Iron Formations, and more)
  - Evaporites (Halite, Gypsum, Anhydrite, and many more)
  - Carbonates (Limestones, Dolostones, and more)
  - Cherts

# Carbonates

- Inorganic
  - form directly in water because of changing chemical equilibrium in solution
    - Travertine, Tufa, Oolitic Limestone
- Biochemical/Bioclastic
  - form because of the biological activity of an organism (biochemical) and successive mechanical weathering of remains (bioclastic)
    - Coral Reefs and Stromatolites, Fossiliferous Limestone, Coquina, Chalk, Micrite

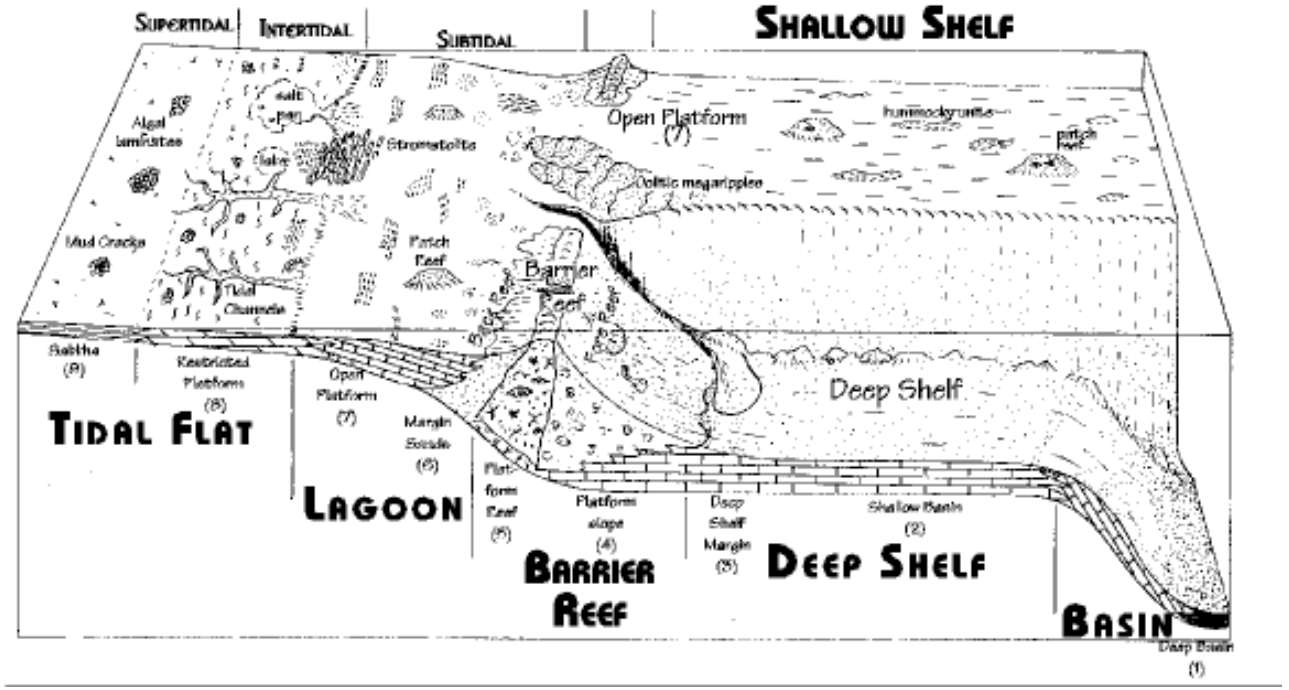
# Where do carbonates form?

- While some form on land, **most carbonates are deposited in the ocean**

- On land:
  - Subaerial (travertine in caves, at waterfalls, at springs, cold but particularly hot springs)
  - lakes (tufa and travertine in alkaline and/or saline lakes)
  - carbonate sand dunes (along coastlines with carbonate sedimentation, such as Bahamas)

- Transitional environments:
  - Tidal flats (oolites, stromatolites)
  - Beaches (fossiliferous limestones, coquina)

# Carbonate depositional environments



# Bahamas: a modern carbonate shelf

micrites, oolites, carbonate sand dunes

Flying to Providence Island, Bahamas, from Miami, Florida

# Where do carbonates form?

- In the shallow ocean (particularly if water is warm):
  - Lagoons, bays (fossiliferous limestones, oolites, micrite)
  - Open carbonate shelves in general (fossiliferous limestones, coquina, oolites, coral reefs, stromatolites)
  - Isolated platforms - shallow water shelf sections separated from the main shelf (coral reefs, micrites, oolites)
- In the deep ocean:
  - Abyssal plain (chalk, micrite)

# Cyclic ancient shelf carbonates

Salamayuca, Chihuahua, Mexico
Mexico SR 45, Ciudad Juarez to Chihuahua, Chihuahua

# Carbonates in shallow waters: neritic deposits

- neritic deposits are in general dominated by sediments that come form land (gravel, sand, silt, clay)

- in certain areas, particularly in shallow tropical waters, carbonate deposits are abundant

- We speak of a **carbonate factory**
  - Carbonate minerals containing $CO_3$
  - Marine carbonates primarily limestone – $CaCO_3$
  - Most limestones contain fossil shells
    - Suggests biological origin
  - Ancient marine carbonates constitute 25% of all sedimentary rocks on Earth.

- Coral Reefs
  - Massive structure of carbonate
  - Warm, crystal-clear, shallow waters
  - Atolls, Barriers, Fringing Reefs

- Stromatolites
  - Fine layers of carbonate
  - Warm, shallow-ocean, high salinity
  - Cyanobacteria

(a)

# What is a Coral Reef?

- A reef is:
  - a structure rising above the sea floor
  - built by calcium carbonate secreting organisms
  - that stand on the remains of their ancestors
  - and are surrounded and often buried by the skeletal remains of the many small organisms that once lived on, beneath, and between them

# Who builds a Coral Reef?

- A reef is almost entirely the physical expression of a community of organisms, growing in one place for an extended period of time

- These communities have changed dramatically over geologic time, so today's reefs can be very different from those of the past

The Great Barrier Reef of Australia

# Modern Reefs

- While Coral Reefs are abundant today (Caribbean and Indo-Pacific), we must be aware of other in-place accumulations of skeletal calcium carbonate rising from the sea floor

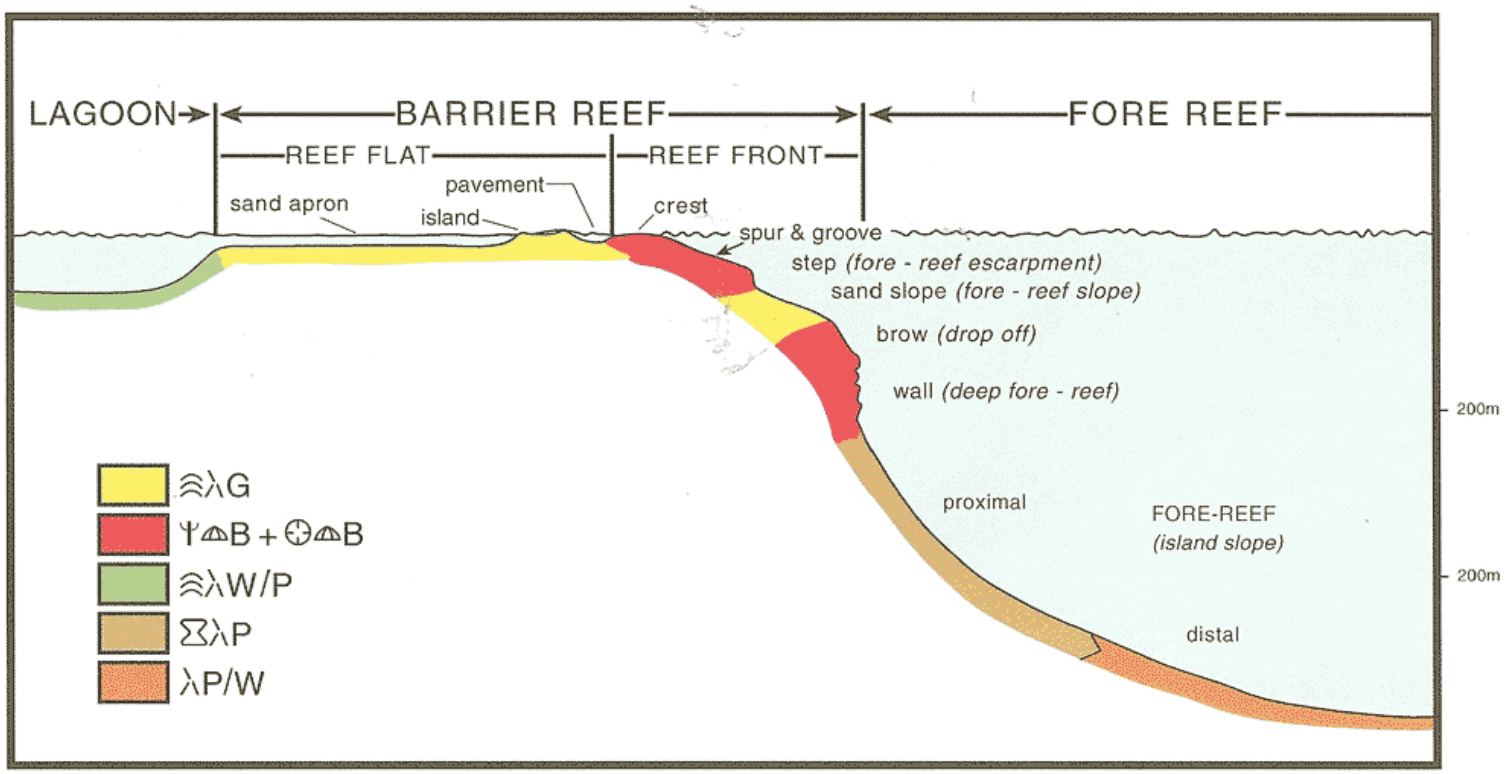
- That includes reefs made of almost entirely of algae, banks of branching coral, and common skeletal sediment in deep water

# Coral Reefs

- Today, the most widespread and massive reefs are constructed by corals and algae

- These organisms (either Cnidarian polyps or algae) require the following conditions for growth:
  - Tropical shallow waters
    - warmth favors secretion of carbonate
    - Shallow waters allow algae, either on their own or living in symbiosis with polyps, to make photosynthesis
  - Distance form sources of sediment
    - Rivers, coastlines, would be sources of fine sand and mud
    - Reef-building organisms are intolerant of fine sediment

# Anatomy of a Coral Reef



# What is a Stromatolite?
# **from Cyanobacteria to Stromatolites**

- Some filamentous cyanobacteria float as greenish scum on lake, streams, or ocean waters

- Others form “algal” mats on the seafloor that can trap sediment to produce distinctive 3-D structures (stromatolites)

Modern Stromatolites from Shark Bay, Australia

# Stromatolites

## in four “simple” steps

① **Accretionary organosedimentary structures**

the structure build up (accretes), and forms a structure through interaction of biological and physical processes

② **commonly thin-layered, megascopic, and calcareous**

made of thin, stacked laminae, visible to the naked eye, partially composed of calcium carbonate minerals

③ **produced by the activity of mat-building communities of mucilage-secreting microorganisms**

microscopic organisms living together generate mats, or layers by secreting sticky gelatin-like slime

④ **mainly filamentous photoautotrophic prokaryotes such as cyanobacteria**

most organisms are developing threads (and not spheres), are photosynthetic, are Bacteria and Archaea, and most of the times are cyanobacteria

# Fossil Stromatolites

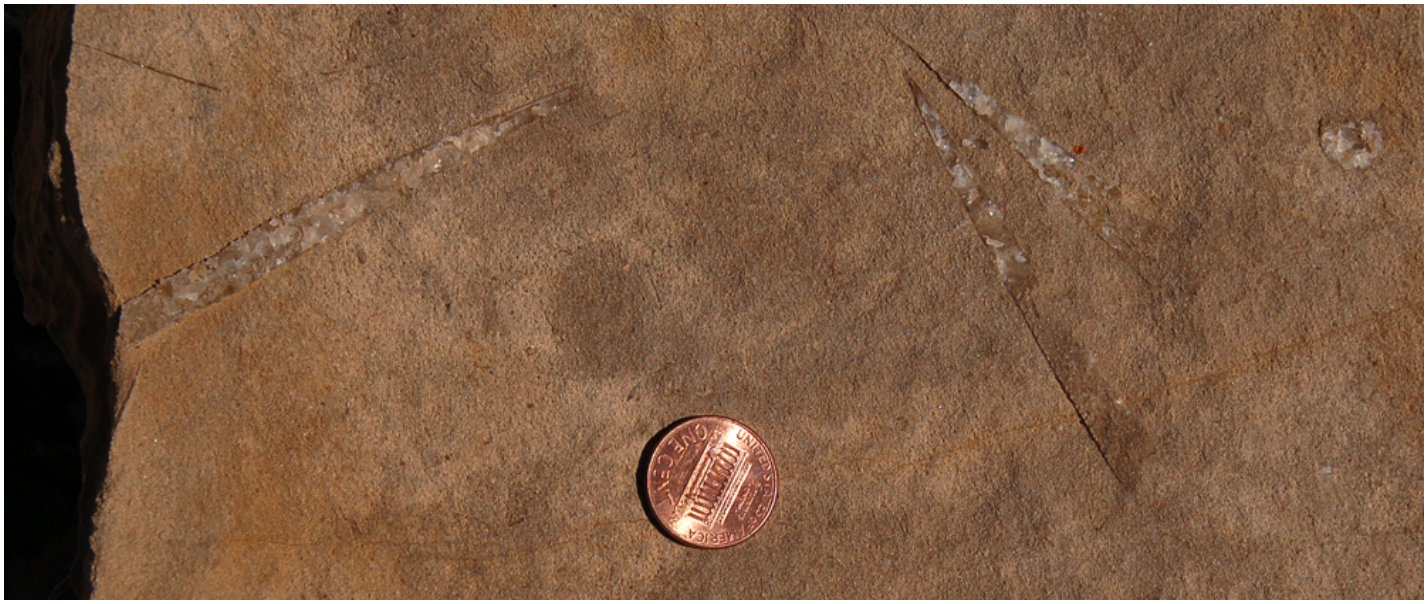
from Glacier National Park, Montana



# Fossiliferous Limestones

- Any type of limestone, made mostly of $CaCO_3$ (as calcite or aragonite) that contains an abundance of fossils or fossil traces

- The fossils in these rocks may be of macroscopic or microscopic size



Cretaceous fossiliferous limestone with recrystallized belemnites
Panther Junction, Big Bend National Park, Texas

# Coquina

- A type of limestone formed almost entirely of sorted and cemented fossil debris, most commonly coarse shells and shell fragments

- Indicates deposition in a high-energy environment

Coquina was used to build the fortified city of San Agustin in Spanish Florida. See the whole story at
https://www.nps.gov/casa/learn/historyculture/coquina-the-rock-that-saved-st-augustine.htm

Saint Augustine, Florida

# More carbonates?

- Yes, what happens in deep waters?
- High pressure, low temperatures, there should not be any carbonate!
- To be continued…