Carbonates

Carbonates & Carbonate Platforms

- Carbonate production
- Carbonate Platforms
- Carbonate Buildups
- Sequences

Carbonate Production

- "Carbonate Factory":
  - Shallow, illuminated seafloor
  - Particles of all sizes: skeletons, mud (direct or biologically mediated precipitation)
  - Much sediment accumulates "in place", but some transported landward (peritidal flats/shoreline) or basinward (slope and basin margin)
  - Removed from siliciclastic sedimentation

Carbonate Production

- Climate
  - Evaporation, precipitation
  - Clastic sediment supply
  - Fauna: cool water: *Foramol* assemblage
    warm water: *Chlorozoan assemblage*
- Oceanography
  - Light penetration
  - Water temperature, circulation
  - Oxygenation
  - Salinity

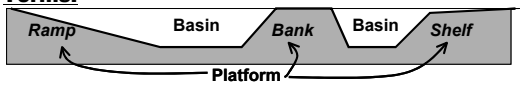
Carbonate Production

- Tectonics
  - Rate and style of subsidence
  - Terrigenous sediment supply

Carbonate Platforms

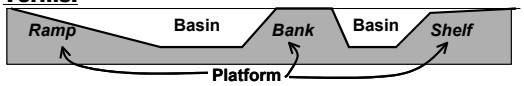
- *Ramp, Shelf, Bank, Epeiric*
- Rimmed or unrimmed
- Sediment texture a function of energy level and carbonate production
- Many different facies models (energy level, temperature, platform morphology, platform energy, siliciclastic input, etc.)

Terms:

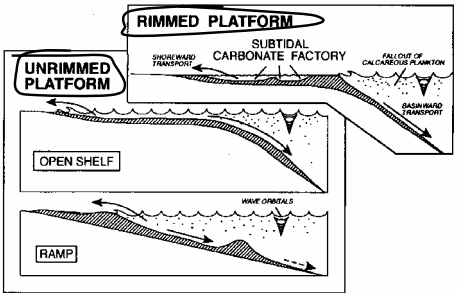


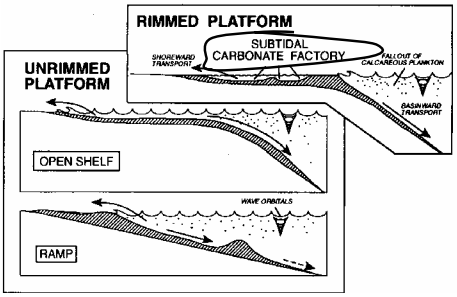
Platform:
- a large edifice formed by the accumulation of sediment in an area of subsidence
- Generally flat topped, with steep sides, many 100s of km^2 in extent

Terms:



Platform:
- *Shelf*: Platform linked to an adjacent landmass, and "distally steepened"
- *Ramp*: Shelf that dips gently (<1 deg. basinward) without a break in slope
- *Bank*: Isolated platform cut off from terrigenous clastics
- *Epeiric platform*: flooded cratonic areas





Carbonate Platforms

Rimmed platforms

- **Barrier reefs/shoals – high energy zones**
  - **Grainstones, bafflestones, framestones**
- **Back-barrier areas – variable energy**
  - **Skeletal/ooid grainstone shoals**
  - **Packstones, wackestones**
  - **Evaporites? (restricted circulation)**
  - **Patch reefs (framestones, boundstones)**
- **Shoreline – low energy**
  - **Boundstones, rudstones, evaporites**

Vertical Successions

Unrimmed platforms

- **Wave energy dissipated over entire platform**
- **Gradational facies boundaries**
  - **Outer shelf – low energy (mudstones)**
  - **"Inner shelf" (shoreface) – high energy (grainstones)**

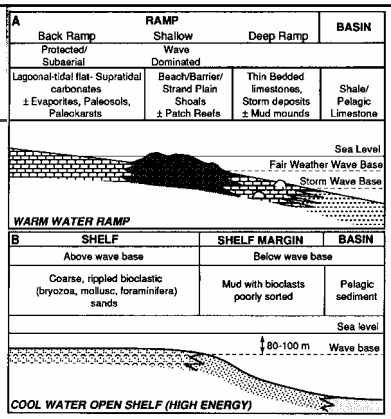
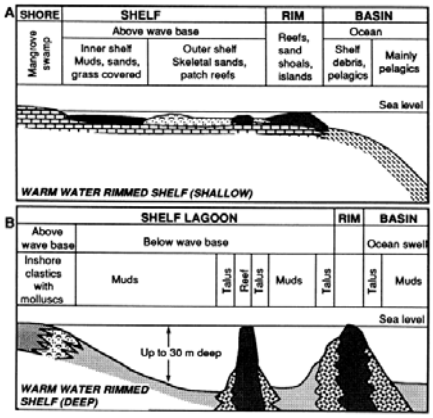


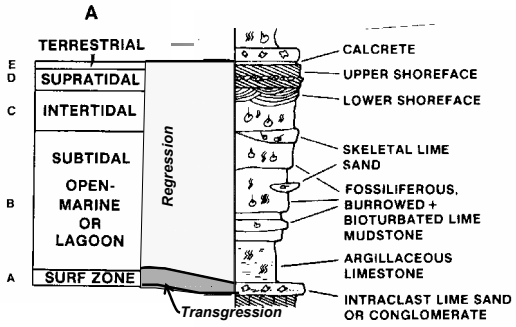
Figure 15 Facies models for unrimmed shelves (A) warm water ramps, and (B) cool water



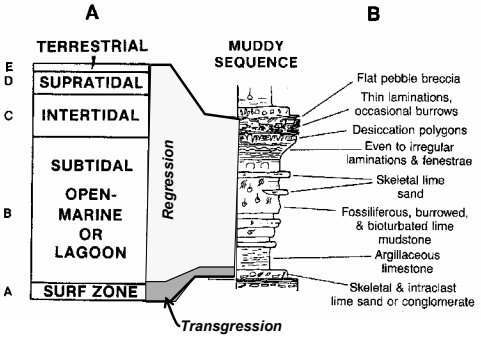
Vertical Successions

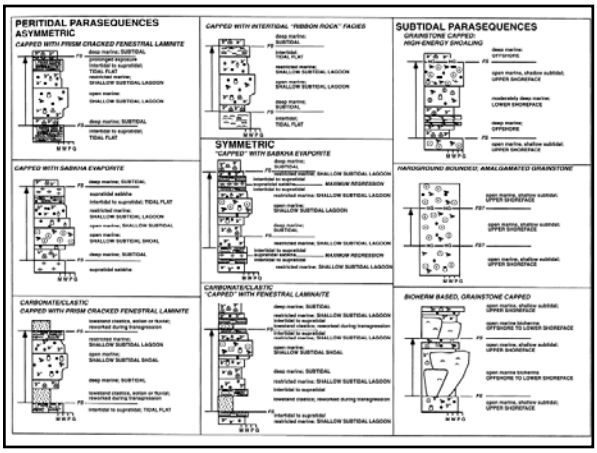
- **Vertical succession depends on:**
  - **Platform/shelf morphology**
  - **Energy level (waves)**
  - **Rimmed *versus* unrimmed**
  - **Climate (temperature, precipitation)**
  - **Sea-level change (sequence stratigraphy)**
- **Shoaling-upward successions common**
  - **Like siliciclastic shelf/shoreline systems**

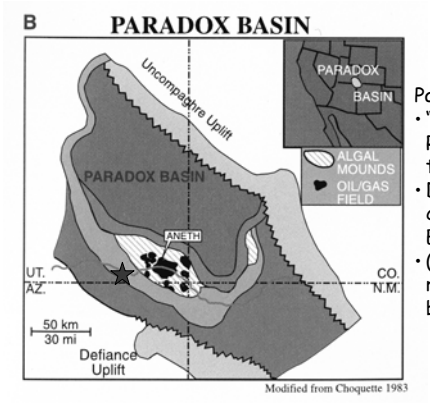
Shoaling-upward succession:
High-energy carbonate shelf



Shoaling-upward succession:
Low-energy carbonate shelf



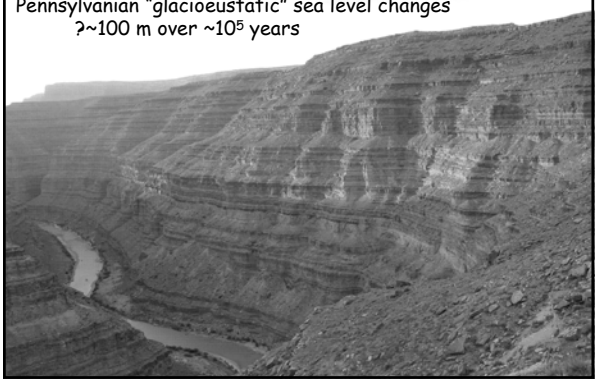




Paradox Basin
- "Ancestral Rocky Mtns" to NE
- Deposition close to Equator
- (Semi) restricted basin

Paradox Group

Pennsylvanian "glacioeustatic" sea level changes
?~100 m over ~10^5 years



Ordovician Platform Carbonates – Montreal Area

Carbonate Buildups

- **Reef (Boggs):**
  - **"Any biologically influenced buildup of carbonate sediment which affected deposition in adjacent areas (and thus differed to some degree from surrounding sediments), and stood topographically higher than surrounding sediments during deposition" (Longman, 1981)**

Buildups Through the Ages

- **Modern reefs:**
  - **Barrier reefs – platform margins**
  - **Fringe reefs – adjacent to shoreline**
  - **Atolls – around tops of seamounts**
  - **Patch reefs, pinnacle reefs, table reefs – shelf margins or middle shelf**

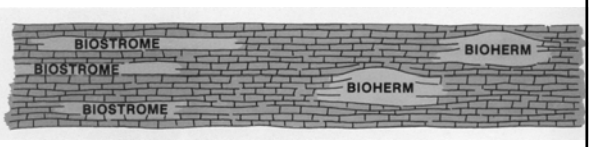
Carbonate Buildups

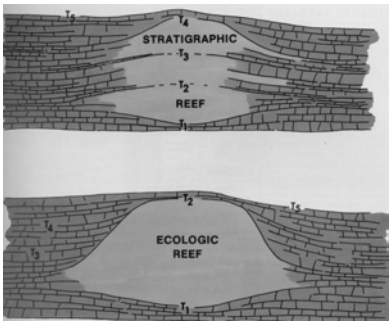
Mounds: **"Biogenic mounds"**

- **Microbial***
  - **Stromatolites/thrombolites, calcimicrobes, mud**
- **Skeletal***
  - **Organisms control trapping**
  - **Small "reef builders", calcareous algae, bryozoa, spiculate sponges, brachiopods, rudist bivalves**
- **Mud**
  - **Inorganic accumulation with some fossils**

Carbonate Buildups

- **Bioherm:**
  - **Lens-shaped reef or mound**
- **Biostrome:**
  - **Tabular body**
- **Carbonate buildup**
  - **No compositional, size or shape connotation**





"Stratigraphic reef": stacked mounds, never had much relief

"Ecologic reef": *Was* a topographic feature

Facies/Processes

- **Core facies**
  - **Massive, unbedded carbonate, with or without skeletons**
- **Flank/forereef facies**
  - **Bedded carbonate sand and conglomerate of *in situ* or derived material**
  - **Dips and thins away from core**
- **Interreef/open platform facies**
  - **Subtidal deposits (carbonate/clastic) unrelated to reef growth**

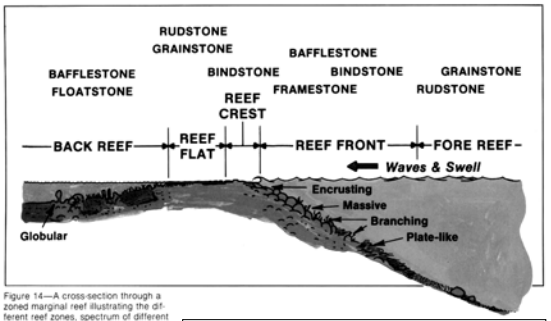
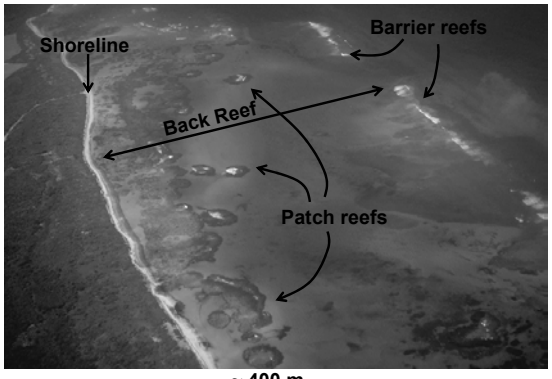


Figure 14—A cross-section through a zoned marginal reef illustrating the different reef zones, spectrum of different limestones produced in each zone, and environment of different reef-building organisms. In many modern reefs, the reef crest is occupied by the massive branching coral *Acropora palmata*, a situation that is rare in the fossil record (after James, 1979, with permission of Geol. Assoc. Canada).

Narrow rimmed shelf - Bahamas

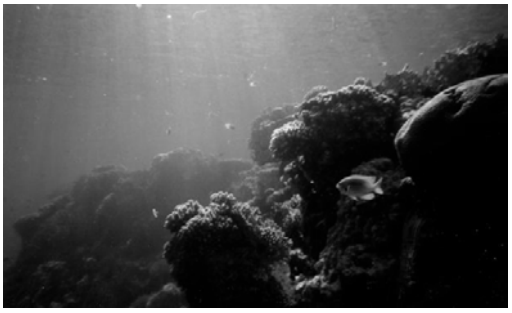


~ 400 m

Barrier Reef – corals - Bahamas

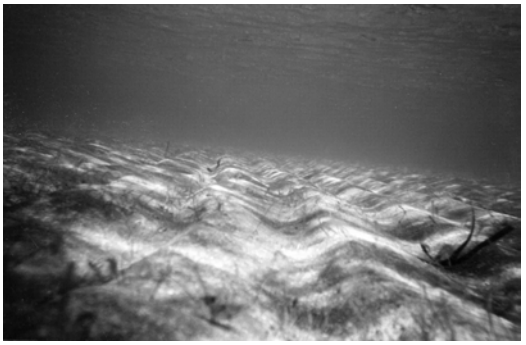
Reef front – Red Sea

Reef front – Red Sea



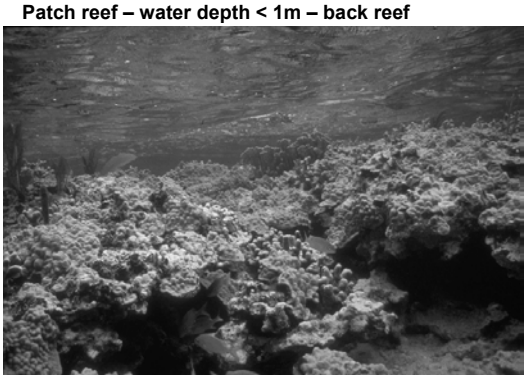
Reef crest – Red Sea

Back Reef – Red Sea

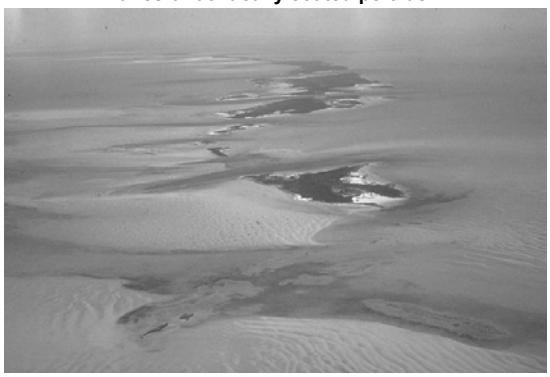


Grass-stabilized open shelf sediment – back reef

Patch reef – water depth < 1m – back reef



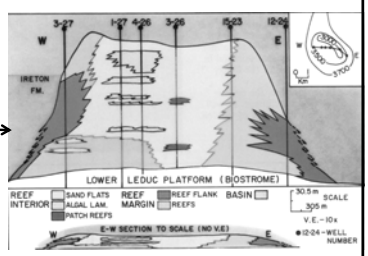
Dunes of oolitically coated peloids



Cross-bedded Pleistocene grainstones

Sabkha

Leduc Formation
Upper Devonian



Permian Reef Complex – West Texas

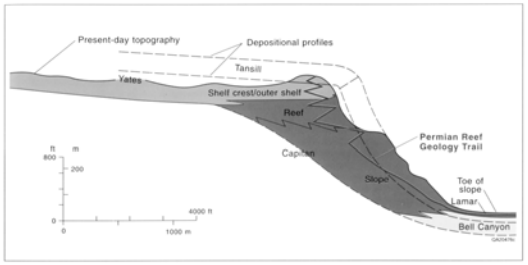
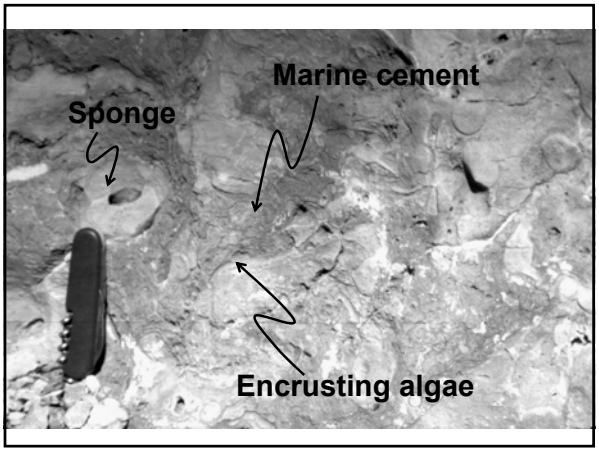
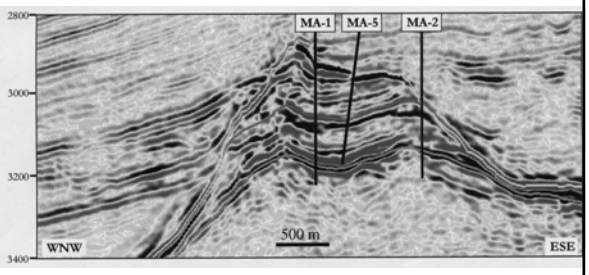
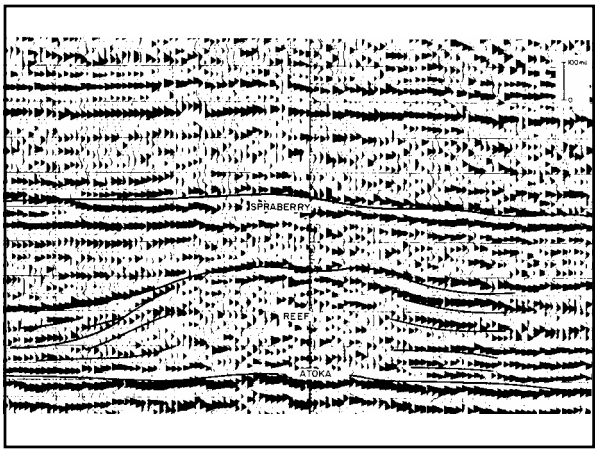
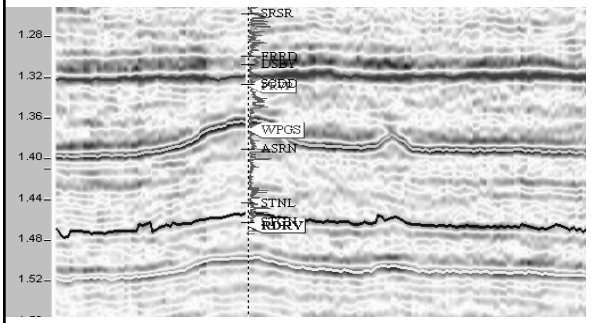


FIGURE 7. Diagrammatic sketch of the north wall of McKittrick Canyon showing the stratigraphy, depositional environments, present-day erosional profile, and general location of the Permian Reef Geology Trail.



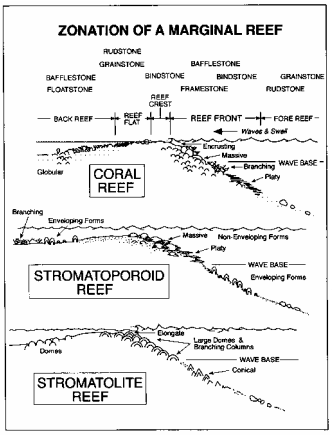






Buildups Through the Ages

- Reef-building organisms have changed through time
- Sedimentological roles of reef-building organisms haven't changed



Cenozoic

Siluro-Devonian

Early Proterozoic

Sequence Stratigraphy

- Carbonate systems are similar to clastic systems, but:
  1. Carbonate production is commonly greater than rate of creation of accommodation (relative sea level rise). During highstands carbonate produced on platform tops can be shed into adjacent deep water "highstand shedding"

Sequence Stratigraphy

- Carbonate systems are similar to clastic systems, but:
  2. Carbonate platforms accumulate at/near sea level, therefore they are excellent indicators for interpreting changes in relative sea level.

Sequence Stratigraphy

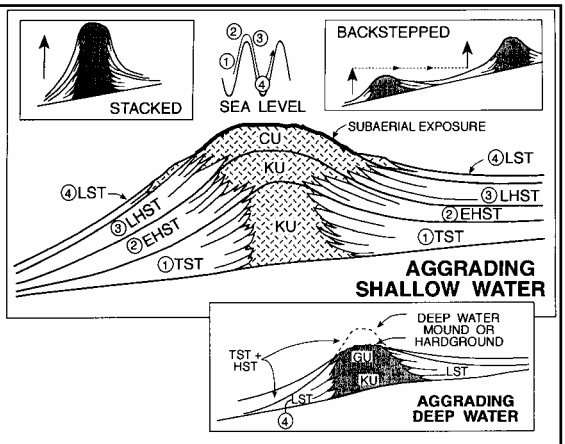
- Carbonate systems are similar to clastic systems, but:
  3. Aggradational margins more common in carbonate systems: keep-up response to relative sea level rise. Clastics tend to backstep.

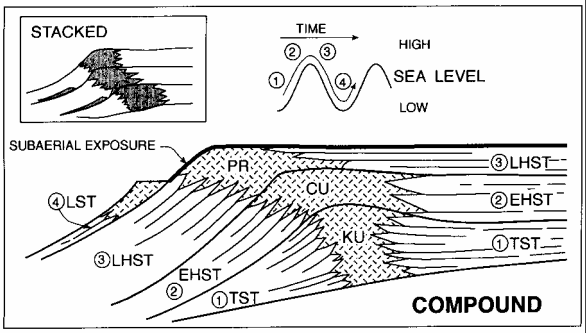
Sequence Stratigraphy

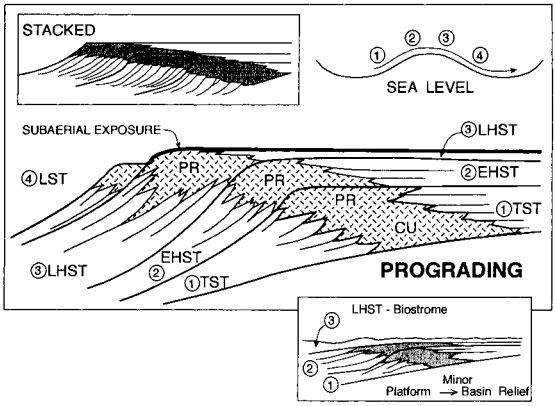
- Carbonate systems are similar to clastic systems, but:
  4. "Drowning unconformity" can be produced by (rapid) increase in water depth – shuts down carbonate factory. Surface may be onlapped and downlapped by other sediments (e.g., deepwater clastics). Recognizable in outcrop/core ("abrupt deepening") and seismic data (resembles a sequence boundary)

Sequence Stratigraphy

- **Carbonate systems are similar to clastic systems, but:**
  5. **Platforms exposed during lowstand, but chemically eroded carbonates do not generate much carbonate debris for resedimentation as submarine fans on basin floor**







Summary

- **Carbonates represent *in situ* generation of sediment**
  - **Climate**
  - **Oceanography**
  - **Tectonics**
  - **Sediment Supply**
  - **Organism Biology**
- **"Carbonate factory" – shallow, illuminated seafloor, low (no) siliciclastic supply**

Summary

- **Different types of carbonate platforms**
  - **Shelves, banks, ramps**
  - **Rimmed or unrimmed**
- **Platform morphology affects wave energy dissipation/facies distribution**
- **Vertical successions commonly show shoaling upward trends**
  - **Some like clastic shelf/shoreline systems**
  - **Not always "coarsening upward"**
  - **Many types of successions possible**

Summary

- Various types of "carbonate buildups"
  - Reefs
  - Mounds
  - Bioherms
  - Biostromes
- 3 different sub-environments:
  - Reef core
  - Reef flank
  - Inter-reef

Summary

- Nature of reef-building organisms has changed through time
  - Stromatoporids, corals, sponges, bivalves, etc.
- Sedimentological role of reef-building organisms has not changed

Summary

- Sequence stratigraphic character of carbonate systems has similarities/differences with clastic systems