Depositional Environments
Lec. 10 Carbonate platforms

DSRG

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Carbonate platform

Figure 10.2 El Capitan and Guadalupe Peak, West Texas, USA, composed of ~400 m of massive Permian fore-reef dolomite and limestone overlying gentle slopes of basinal sandstone.

Outline

1. Carbonate platform
2. Shoal rimmed platform
3. Open platform
4. Ramp platform
5.

Carbonate platform

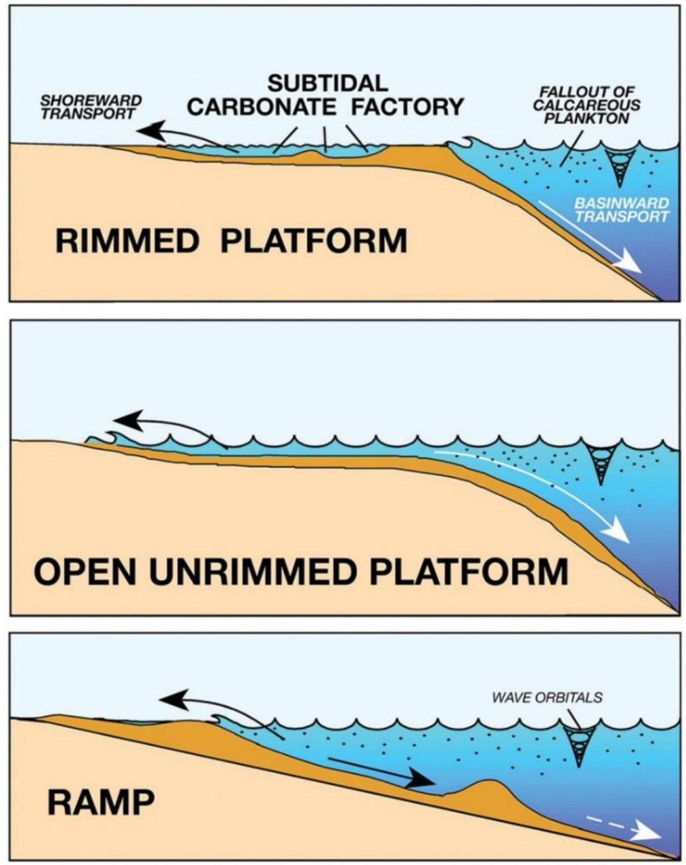


Figure 10.1 Sketch of the general attributes of a rimmed platform with highly differentiated facies, an open unrimmed platform where high-energy conditions prevail across the shallow seafloor creating a wide subtidal facies, and a ramp over which storms sweep into shallow waters. Most complex facies are located on the narrow inner part of the structure. Source: Adapted from James et al. (2010). Reproduced with permission of the Geological Association of Canada.

Shoal rimmed platform

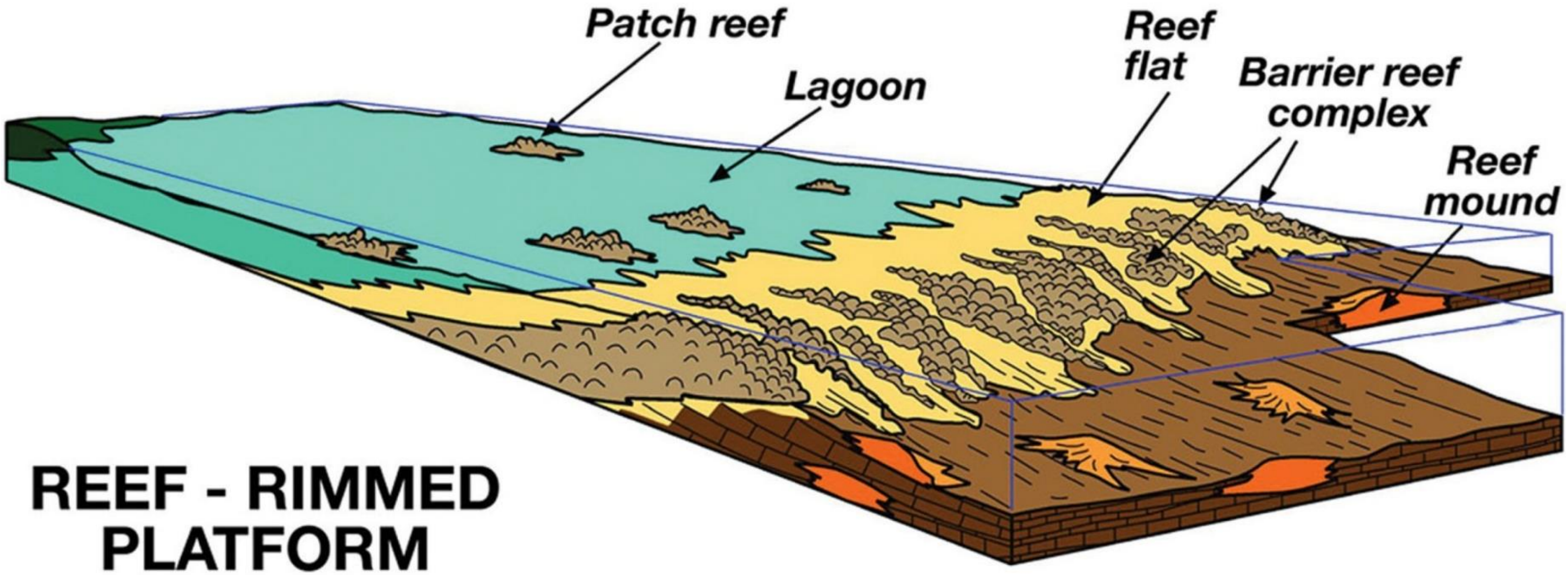


Figure 10.3 An isometric sketch of facies on a reef-rimmed platform. Source: James (1983). Reproduced with permission of the American Association of Petroleum Geologists.

Shoal rimmed platform

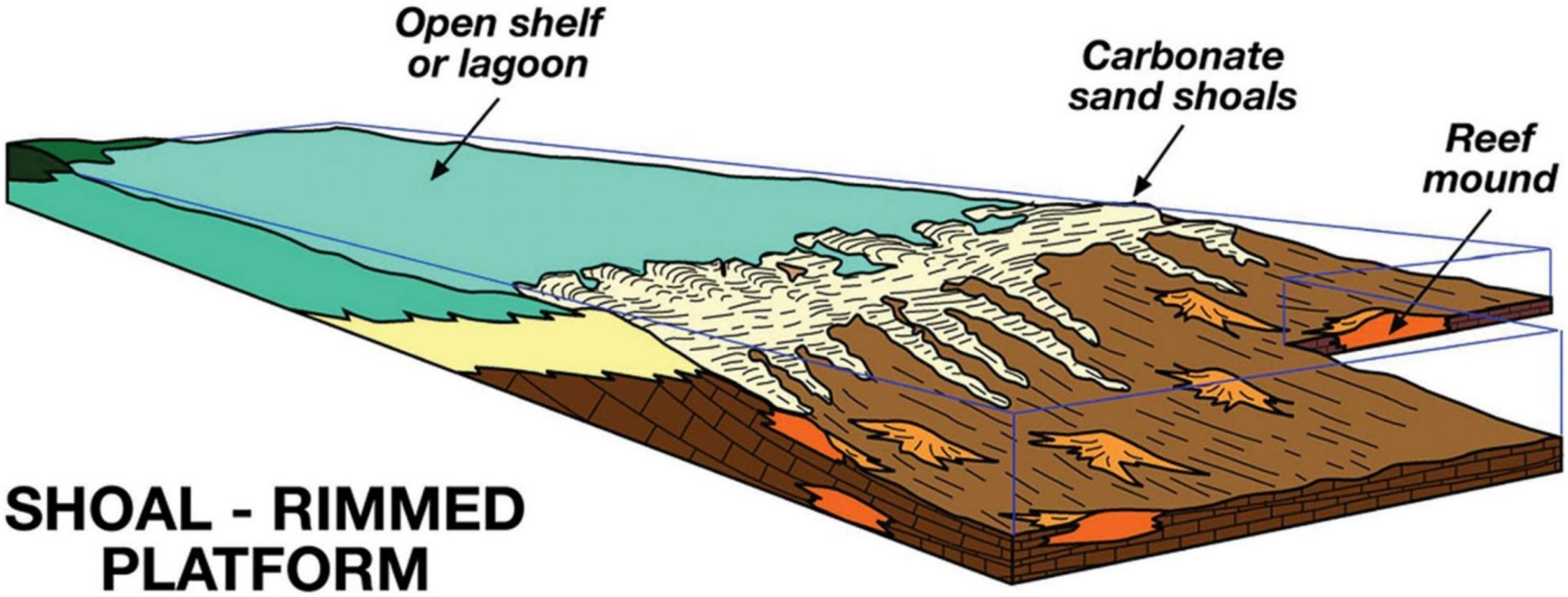
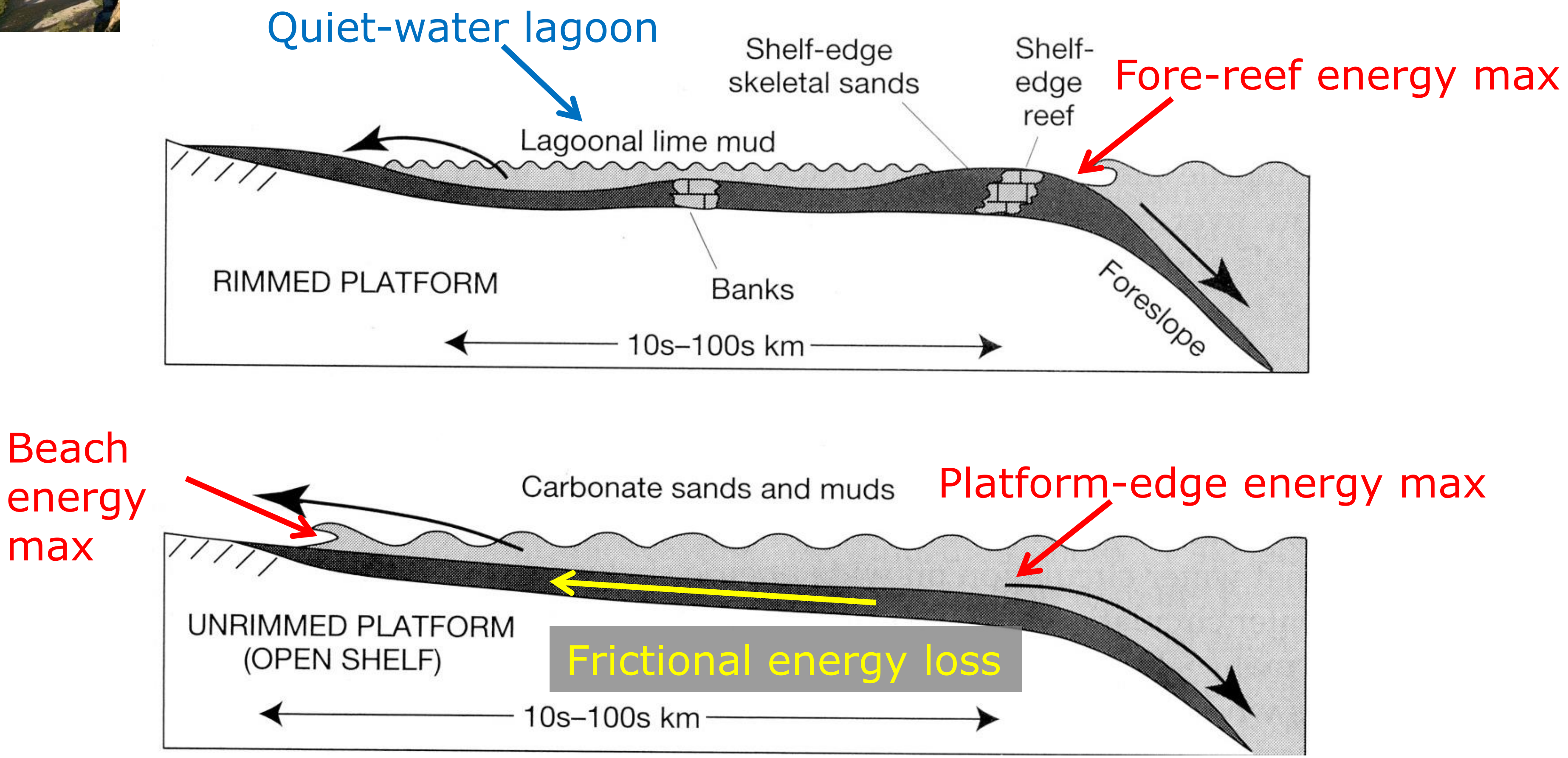


Figure 10.4 An isometric sketch of facies on an ooid or skeletal sand shoal-rimmed platform. Source: James (1983). Reproduced with permission of the American Association of Petroleum Geologists.

Shoal rimmed platform

- Where is the energy maximum?

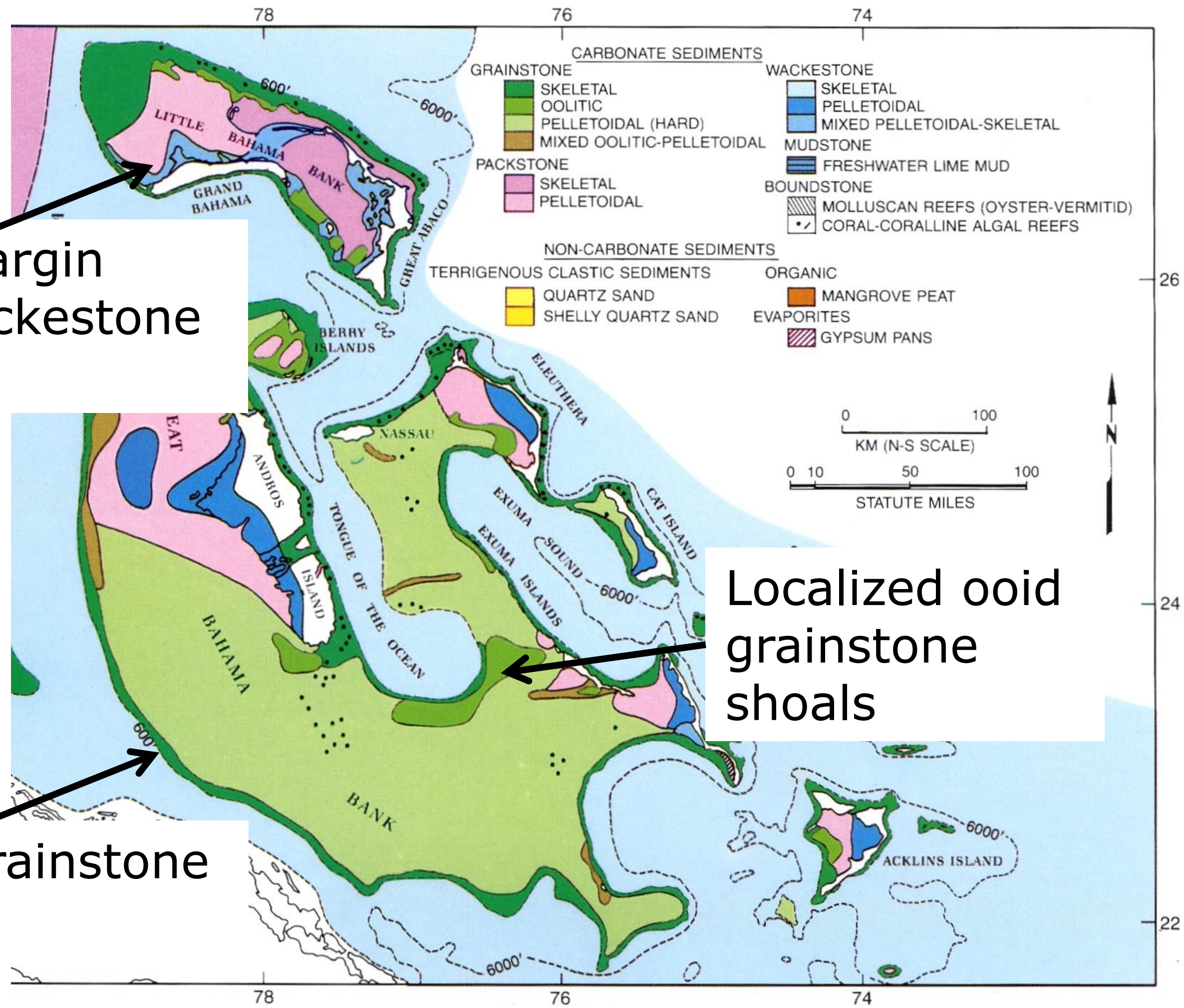


Shoal rimmed platform

Grainstone margin
Packstone/wackestone interior

Localized ooid grainstone shoals

Skeletal grainstone margin



Shoal rimmed platform

Slope Facies

- Deposits form via a variety of sediment gravity-flow processes that result in a suite of calciturbidites and calcareous debrites interbedded with finely laminated to burrowed muds

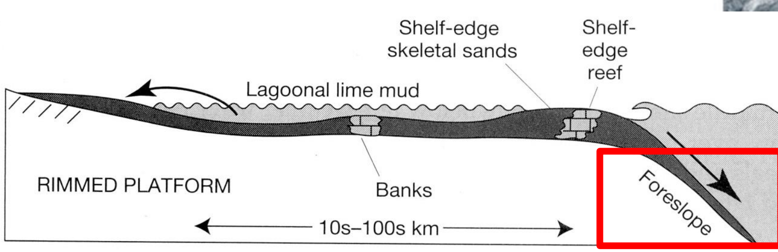
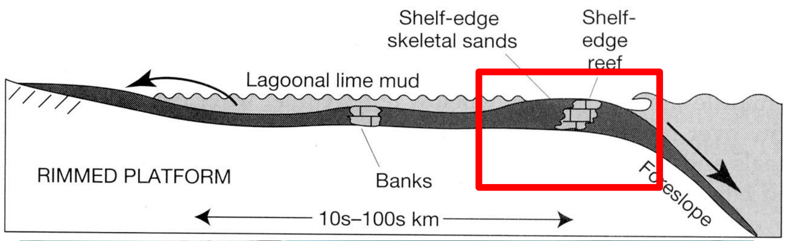
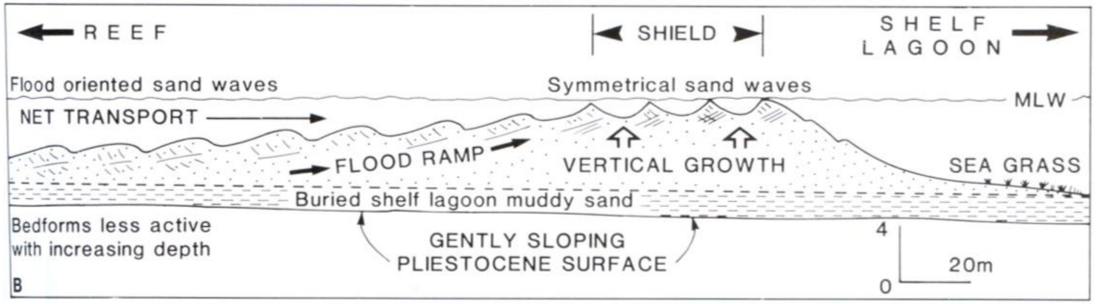


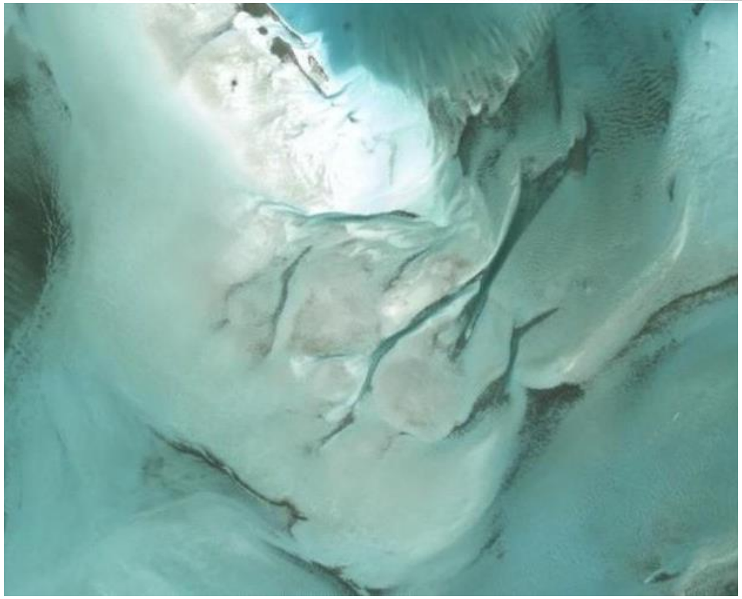
Figure 10.12 Cambro-Ordovician slope deposits in western Newfoundland, Canada, comprising ribbon limestones at left and a massive debrite with white platform margin blocks above. Note person (circled) for scale.

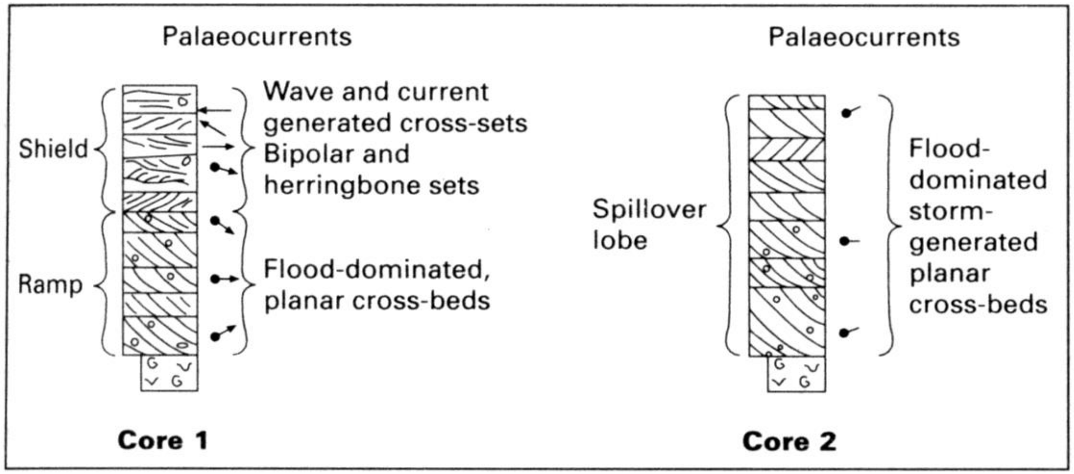
Rimmed platform

- **Rim Facies**
- Platform-margin shoals of ooid or skeletal grainstone
- Spillover sediment transport in windward direction









Shoal rimmed Platform

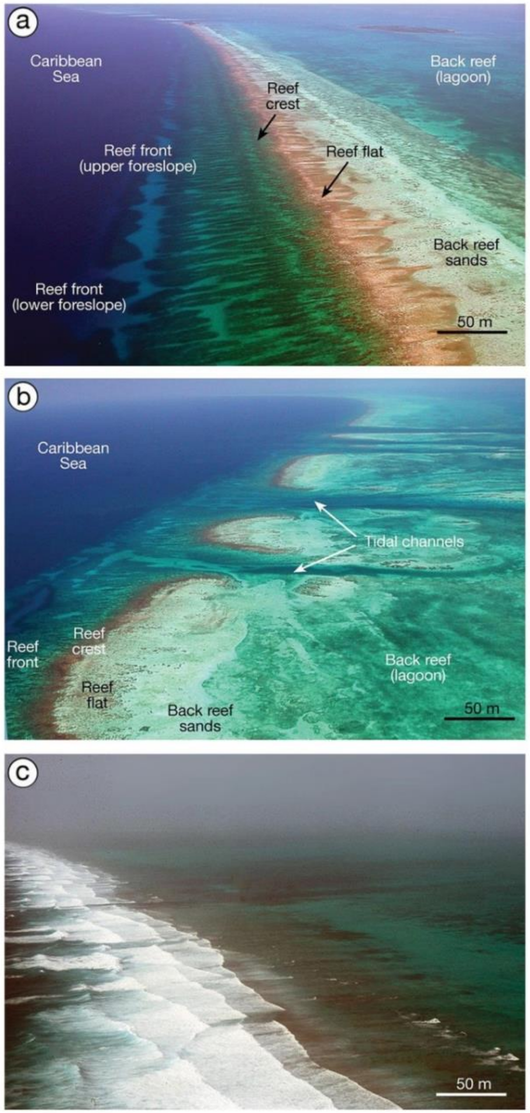
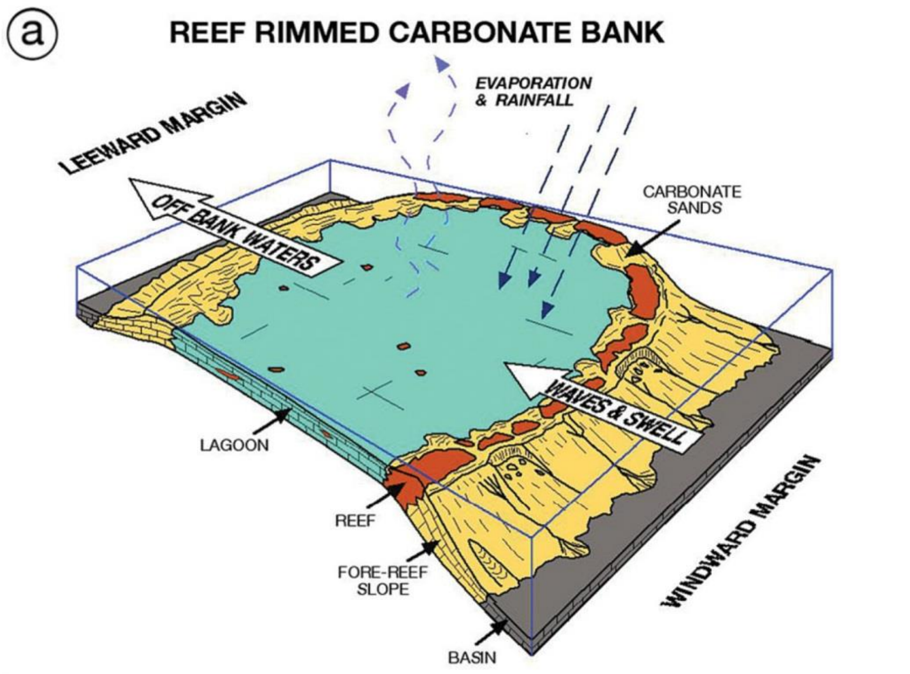


Figure 10.5 (a) A platform rimmed by continuous coral reef growth along the continental margin of Belize, looking south on an exceptionally calm day, with various facies named. Scale bar 50 m. (b) As for (a), rimmed by a segmented coral reef. Photographs by W. Martindale. Reproduced with permission. (c) The same barrier reef on a stormy day, where all of the wave energy is absorbed by the reef rim leaving the lagoon behind largely unaffected and tranquil.

Shoal rimmed platform



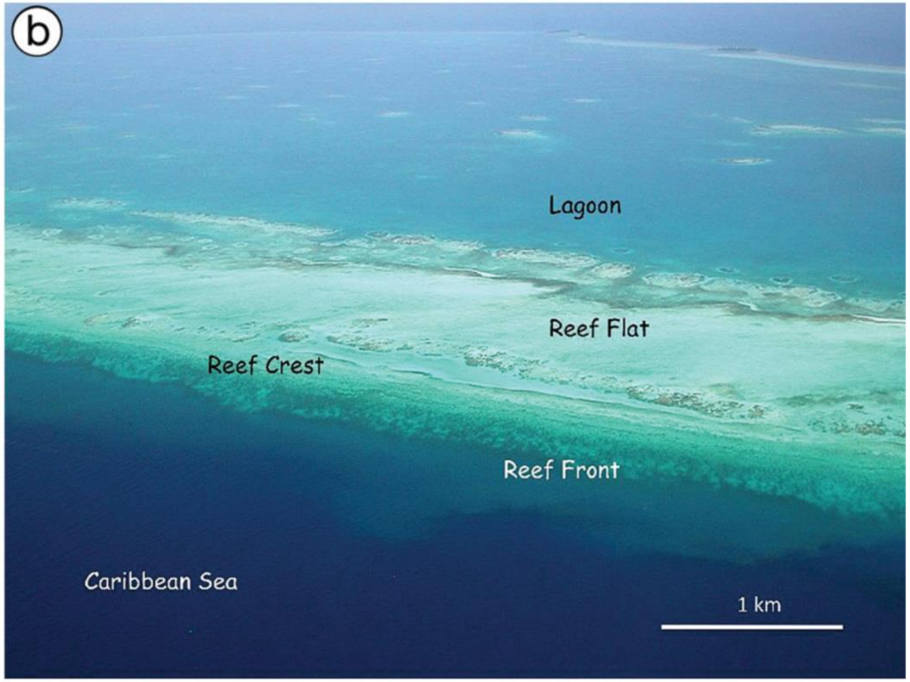


Figure 10.6 (a) An isometric diagram of a carbonate bank with well-developed reefs on the windward side and a poorly developed rim on the leeward side, due to saline and nutrient-rich waters formed in the lagoon by rainfall and evaporation. Source: Adapted from Hanford and Loucks (1993). Reproduced with permission of the American Association of Petroleum Geologists. (b) An aerial view of the leeward margin of Glovers Atoll, Belize with a poorly developed reef (compare to Figure 10.5a, b) that is leeward facing and swept by somewhat nutrient-rich warm and saline waters. Photograph by W. Martindale. Reproduced with permission.

Shoal rimmed platform

Lagoonal Facies

- can be divided into inner and outer shelf lagoons.

- Muddy sediments and scattered algae, but few corals, typically characterize the inner lagoon where *Thalassia* seagrass banks are extensive. Mangroves commonly grow along the coastal boundary of this zone. Patch reefs and skeletal sands formed from skeletons of the resident calcareous algae, and invertebrates typify the outer lagoon.

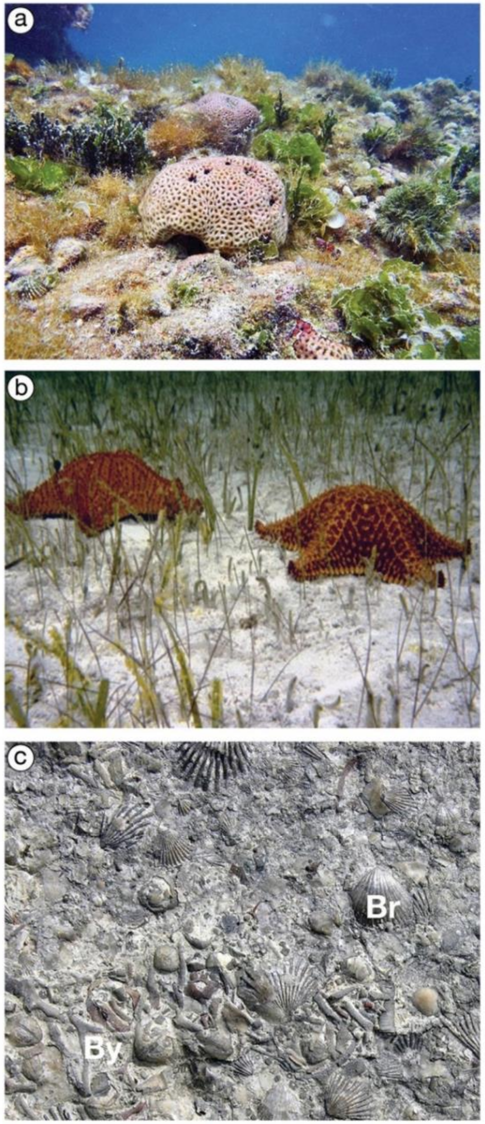


Figure 10.7 (a) A shallow subtidal lagoon community of corals and green algae in ~1 m of water, Harrington Sound, Bermuda. Image width 30 cm. (b) A shallow subtidal shelf facies in ~2 m of water with sparse seagrass and echinoids, Belize. Image width 20 cm image. Photographs by W. Martindale. Reproduced with permission. (c) A shallow Paleozoic subtidal facies of brachiopods (Br) and stick-like bryozoans (By) in an Upper Ordovician limestone, Anticosti Island, Québec, Canada. Image width 15 cm.

Beach Facies (Beaches are common peritidal deposits)

- The deposits are characterized *by* gentle seaward-dipping (5–15°) large-scale planar accretion beds. The *foreshore* portion is typified by alternating coarse- and fine-grained laminations, local inverse-graded laminations, and vertical burrows formed by mollusks, worms, and crustaceans

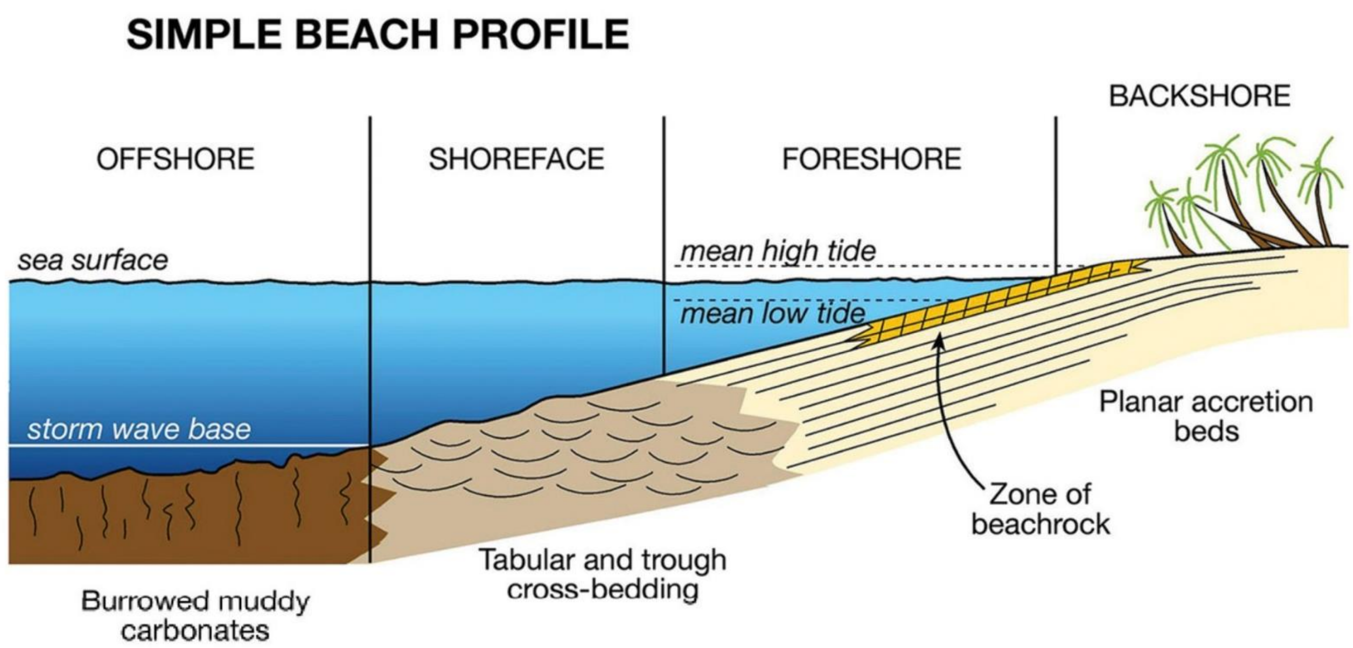
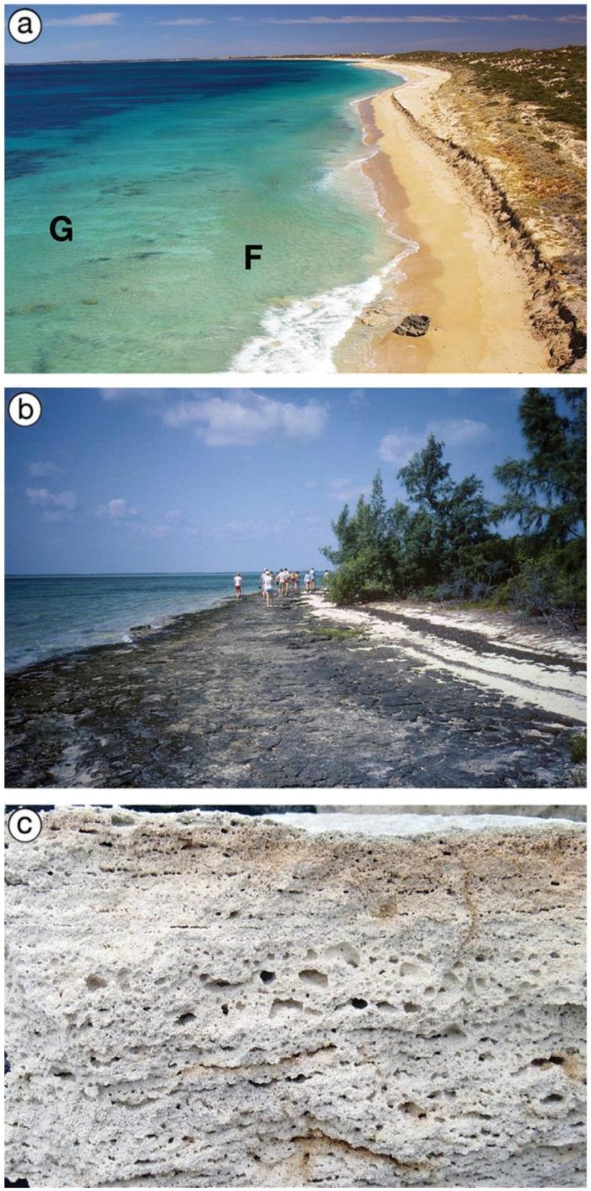


Figure 10.9 A sketch illustrating the different zones on a typical carbonate beach.

Shoal rimmed platform



Ooid sand shoals, consisting of particles generated as tidal currents sweep back and forth across the shallow subtidal and intertidal sand bodies, accumulate rapidly to form segmented barriers along the edge of the platform.

Figure 10.10 (a) A long carbonate beach with shallow foreshore (F) and offshore grassbed (G), southern Yorke Peninsula, Australia. Foreground image width 30 m. (b) Dark beachrock on a small island in the Bahamas (people for scale in background). (c) Keystone vugs (large holes) in a Holocene beach outcrop, Bahamas. Image width 8 cm. Photograph by W. Martindale. Reproduced with permission.

Muddy Peritidal Facies

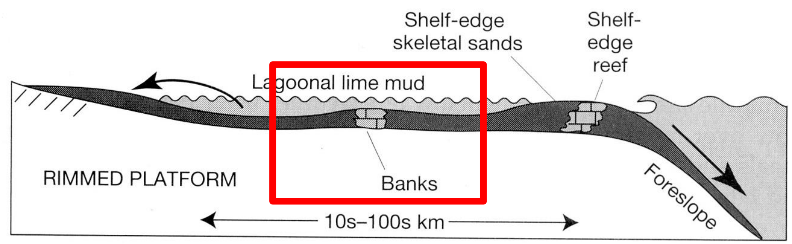
- fine-grained sediment production and landward transport on warm-water rimmed platforms

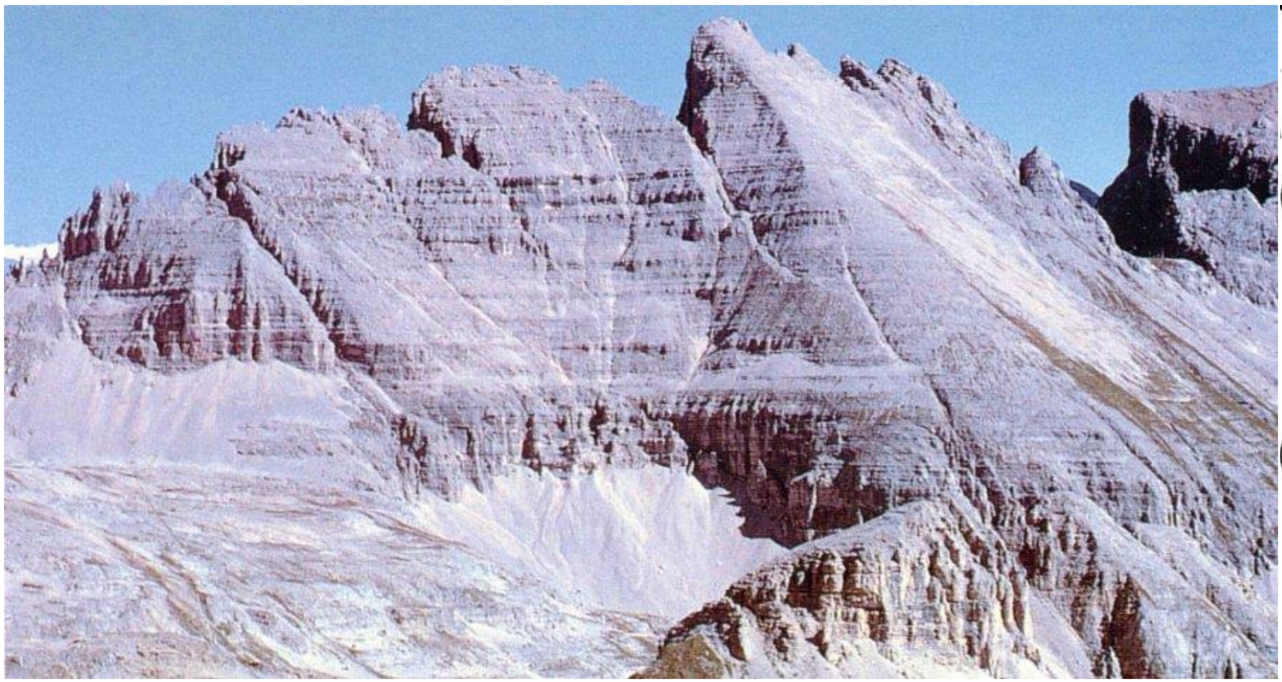
Deposits are replete with microbial mats, a high abundance of low-diversity biota (particularly gastropods), storm deposits, desiccation features, dolomites, and evaporites

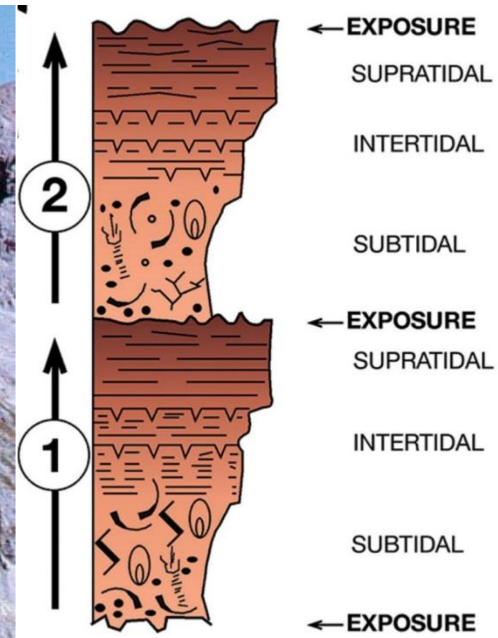
Figure 10.8 A tidal creek winding its way across the muddy tidal flats to the open ocean (left) in the Turks and Caicos Islands, bordered by dark intertidal microbial mats (M) and a wide supratidal zone (S). Image foreground width 80 m.

Shoal rimmed platform

- Characteristic meter-scale cyclicity in platform interior
- Primary relief on surface mantled and infilled by subsequent deposition

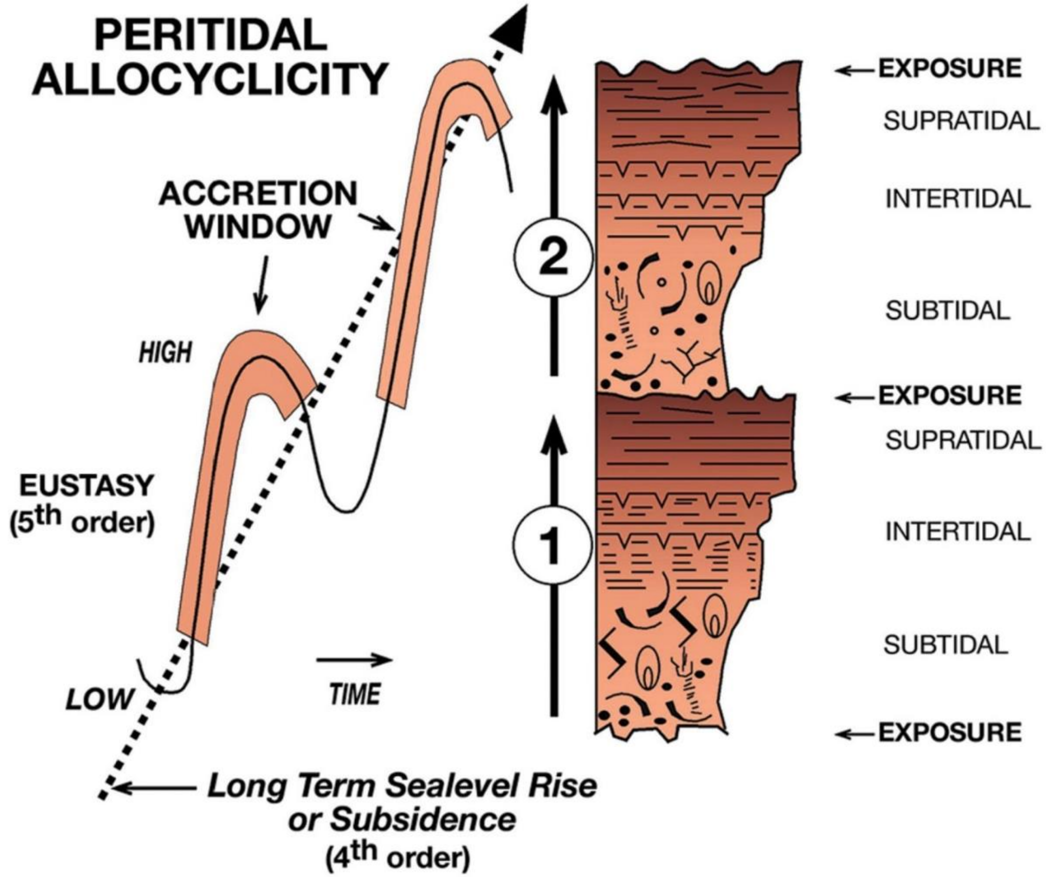






Shoal rimmed platform

- Cycles may be allocyclic, driven by rising base level and creation of accommodation space for sediment accumulation
- Typical carbonate accumulate rates are very high (> base level rise), so rapidly fill accommodation space and shallow upward



Shoal rimmed platform

Aeolinite Facies

- Holocene and Pleistocene marginal marine carbonate sand dunes (aeolianites) occur towards the northern and southern margins of the warm-water carbonate realm where the air is dry.

- Carbonate dunes are best developed where ocean waves sweep unimpeded onshore, mobilizing shallow sands and building beaches in the intertidal zone. Sand is then transported by trade winds to build dunes.

- The deposits are shore-parallel bodies in the form of transverse ridges in which the dunes are predominantly oblique, parabolic, or barchanoid. Large-scale landward-dipping foresets, grainflows, pinstripe laminations, slump scars, animal tracks, and numerous trough cross-beds related to blowouts along windward margins characterize these deposits.

Shoal rimmed platform

Aeolinite Facies

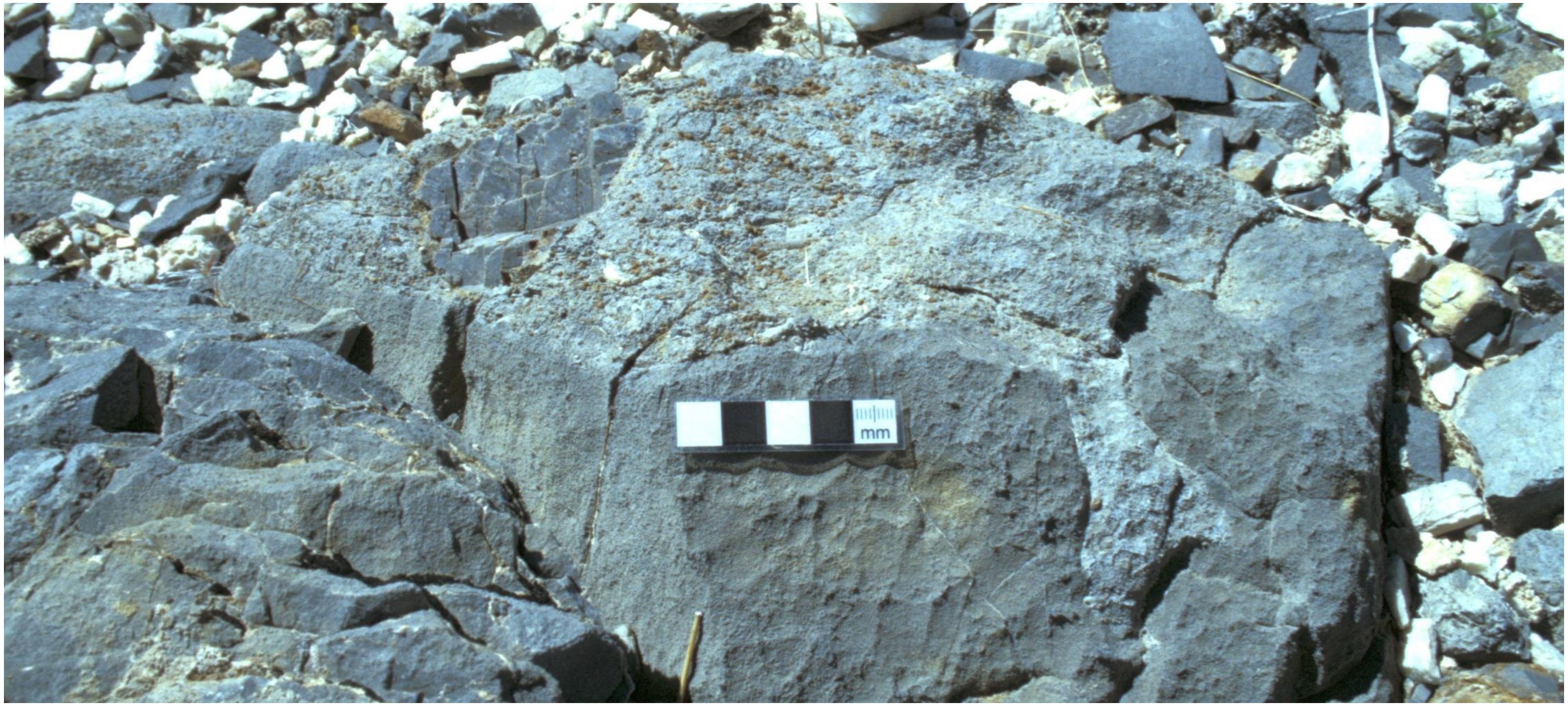
Cliff section of aeolianite ~8 m high along south coast illustrating steep landward-dipping beds (Bermuda)

Eroded trough cross-bedded aeolianites, Castle Island. Cliff is ~8 m high.

Shoal rimmed platform

Supratidal flat Facies

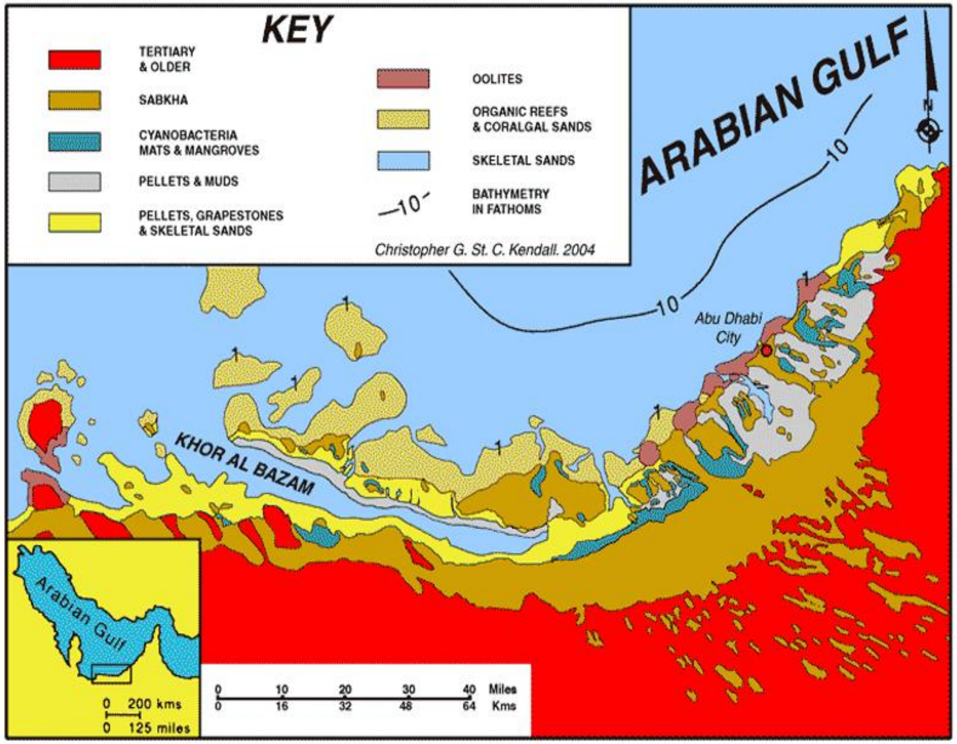
- Exposure (karst) surface (Carboniferous, Nevada)
- Primary relief on surface mantled and infilled by subsequent deposition



Open platform

- These platforms lack a raised rim and so large ocean waves and swells can easily sweep across the whole shelf or bank. They are most prominent today in cool-water heterozoan settings where the waters are too cold to allow reefs or ooid sands to develop.
- No rim, no muddy open lagoon and the platform is characterized by grainy facies throughout, including beaches and aeolianites. These coarse sediments can be ooids or biofragments with microbialites in some tropical systems.
- The large amounts of sediment that are transported off the platform generate thick prograding clinoforms of predominantly neritic origin.

Ramp platform



Ramp platform

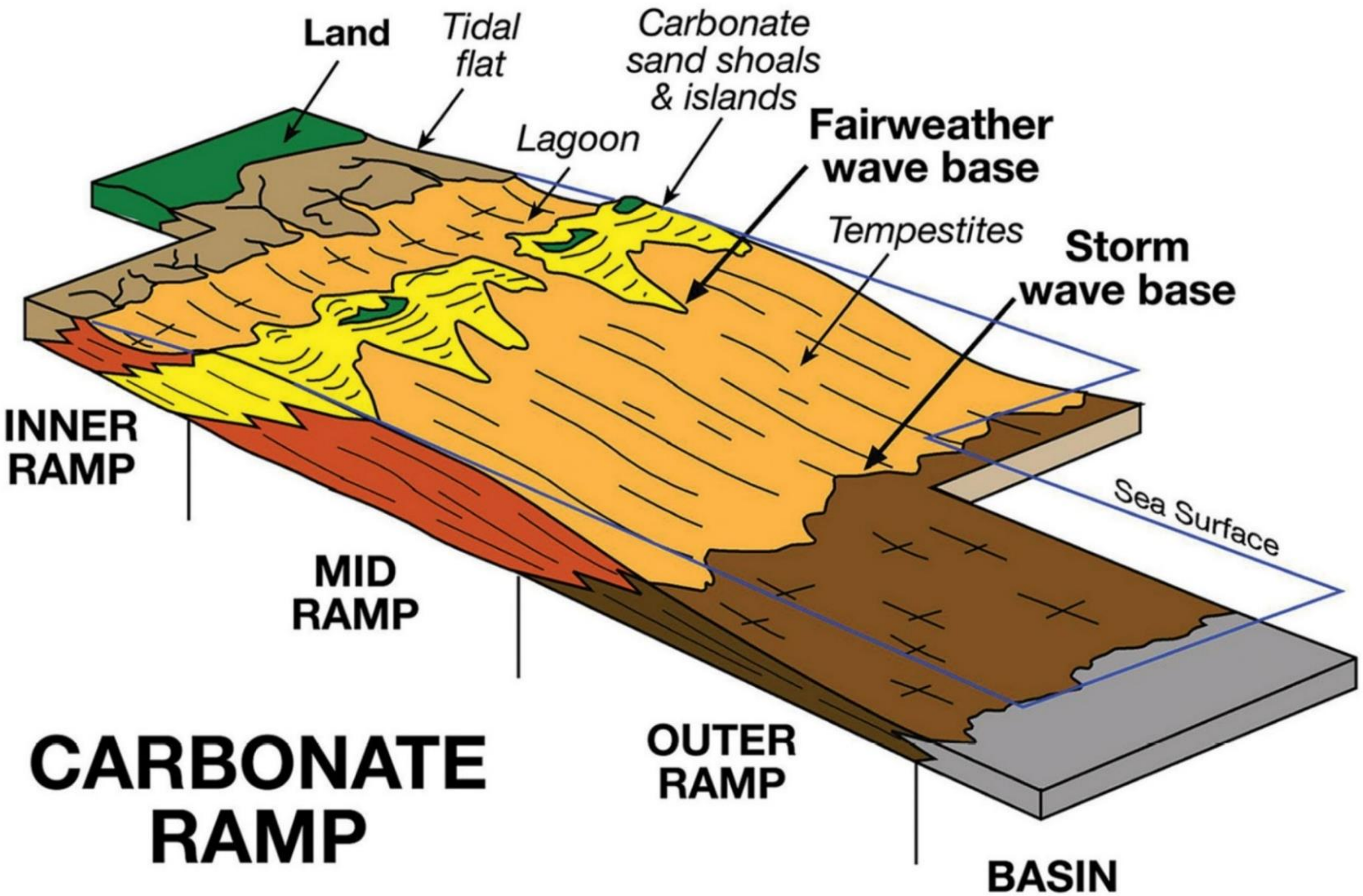
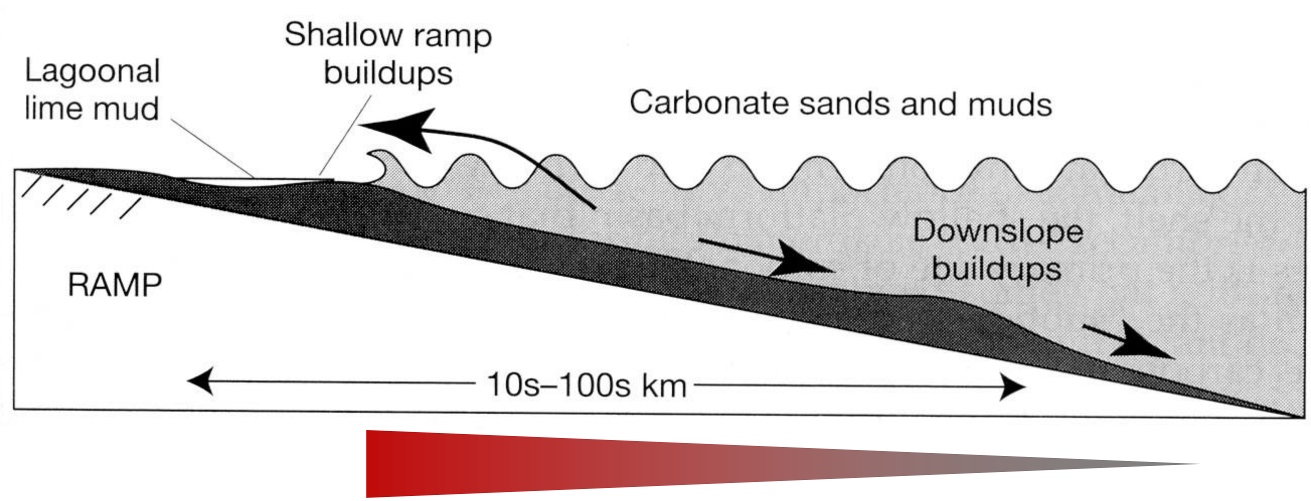


Figure 10.13 Isometric diagram of a carbonate ramp illustrating the major facies and location of the separate sectors, as defined by fair-weather wave base and storm wave base.

Ramp platform

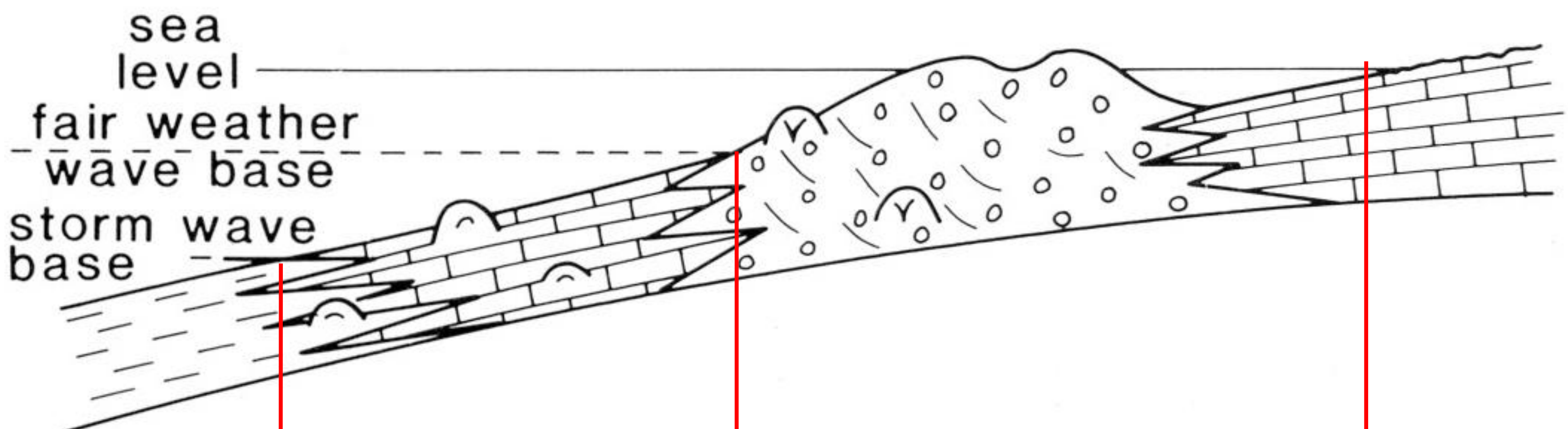
Carbonate Ramps consistent shallow gradient from shoreline to basin (some may be distally steepened), somewhat analogous to siliciclastic shelf



Highest Energy

Lowest Energy

Ramp platform



Deep ramp	Mid ramp	Inner ramp	Peritidal
Offshore	**Deep Subtidal**	**Shallow Subtidal**	

Offshore	Offshore-Transition	Shoreface

Siliciclastic Equivalents

Ramp platform

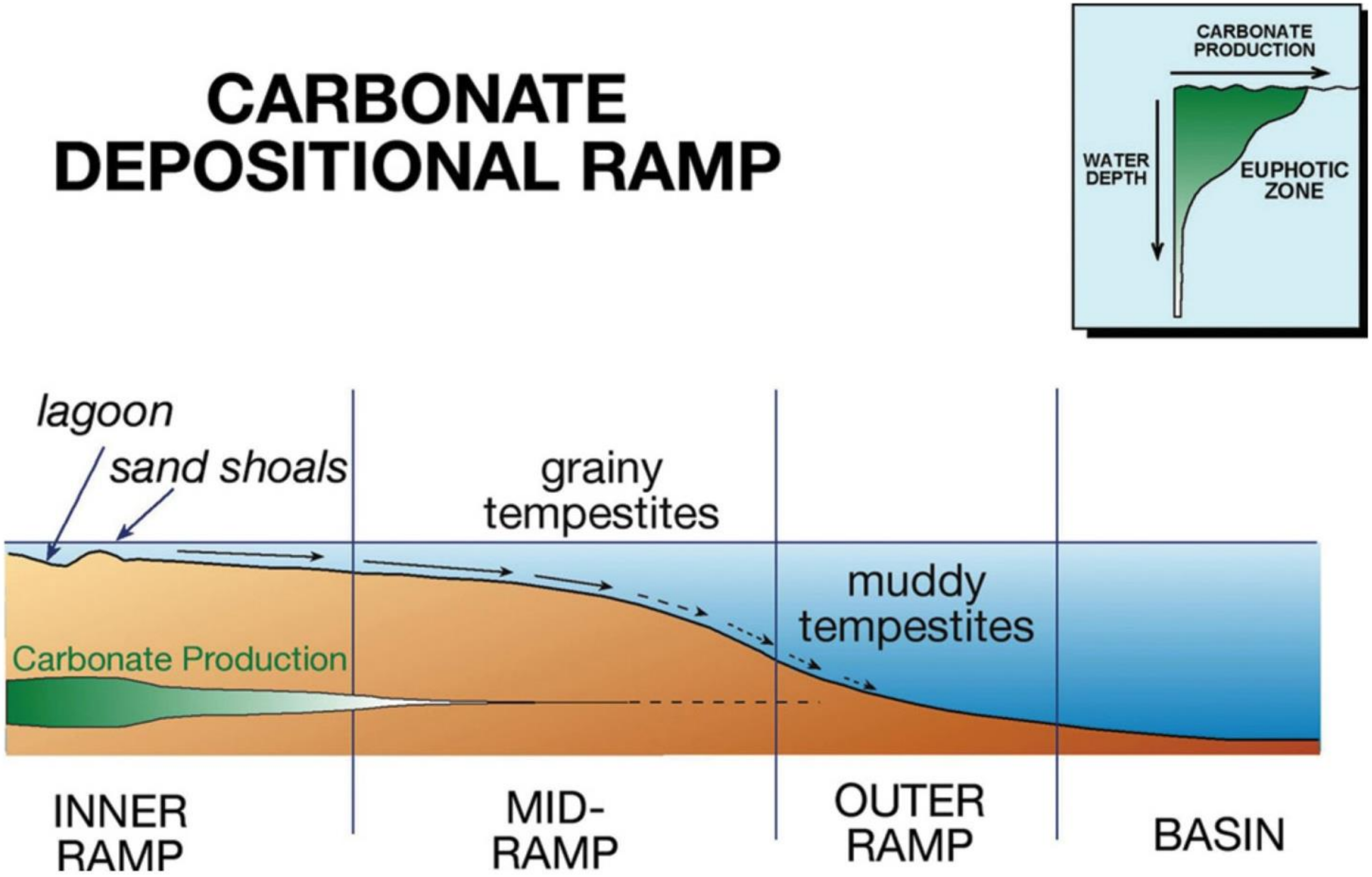
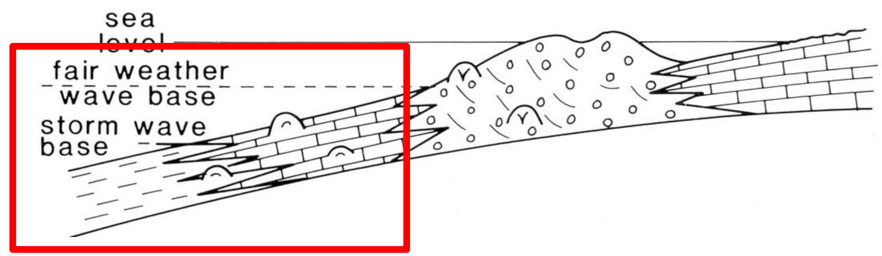


Figure 10.14 Cross-section of a carbonate ramp indicating the importance of the carbonate factory and location of different tempestites.

Ramp platform

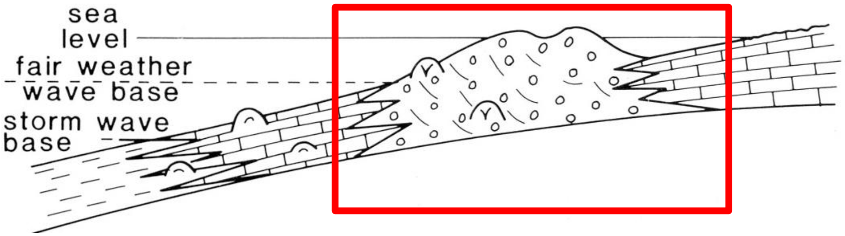
Outer Ramp Facies

- Thin packstone “tempestites” in lime mudstone (or siliciclastic mud)
- May be normally graded or contain HCS; gutter casts/sole marks on base



Ramp platform

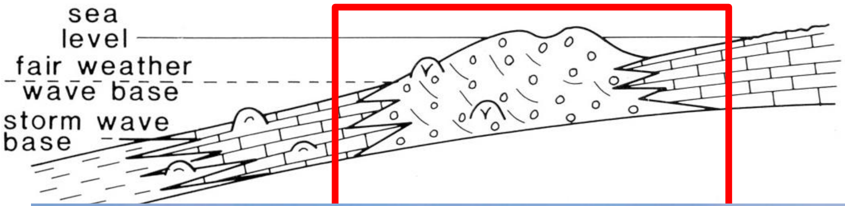
- Shoals (ooids or skeletal) are much more common than in clastic settings
- Large subaqueous dunes, generating large-scale cross-bedding



Ramp platform

Middle Ramp Facies

- Other sedimentary structures and facies may be similar to siliciclastics (wave ripples, SCS, low-angle parallel beach laminations, etc.)

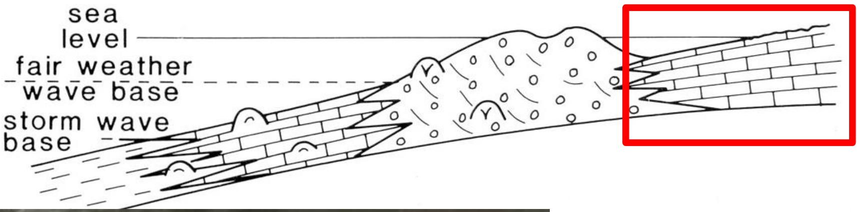


Swaley cross-stratification (SCS)

Beach deposits
Low-angle beds with hardgrounds

Ramp platform

Inner Ramp Facies

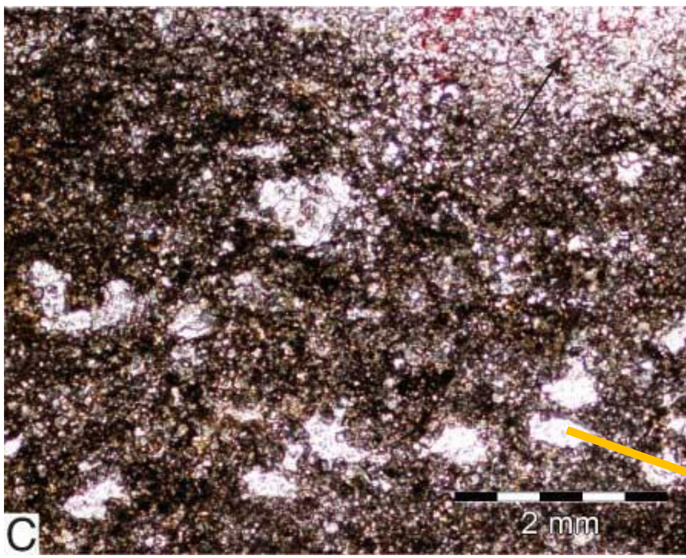


Ramp platform

Inner Ramp Facies

- Typical facies: light gray or light brown limestone/dolostone with

Crinkly or wavy lamination from microbial mats



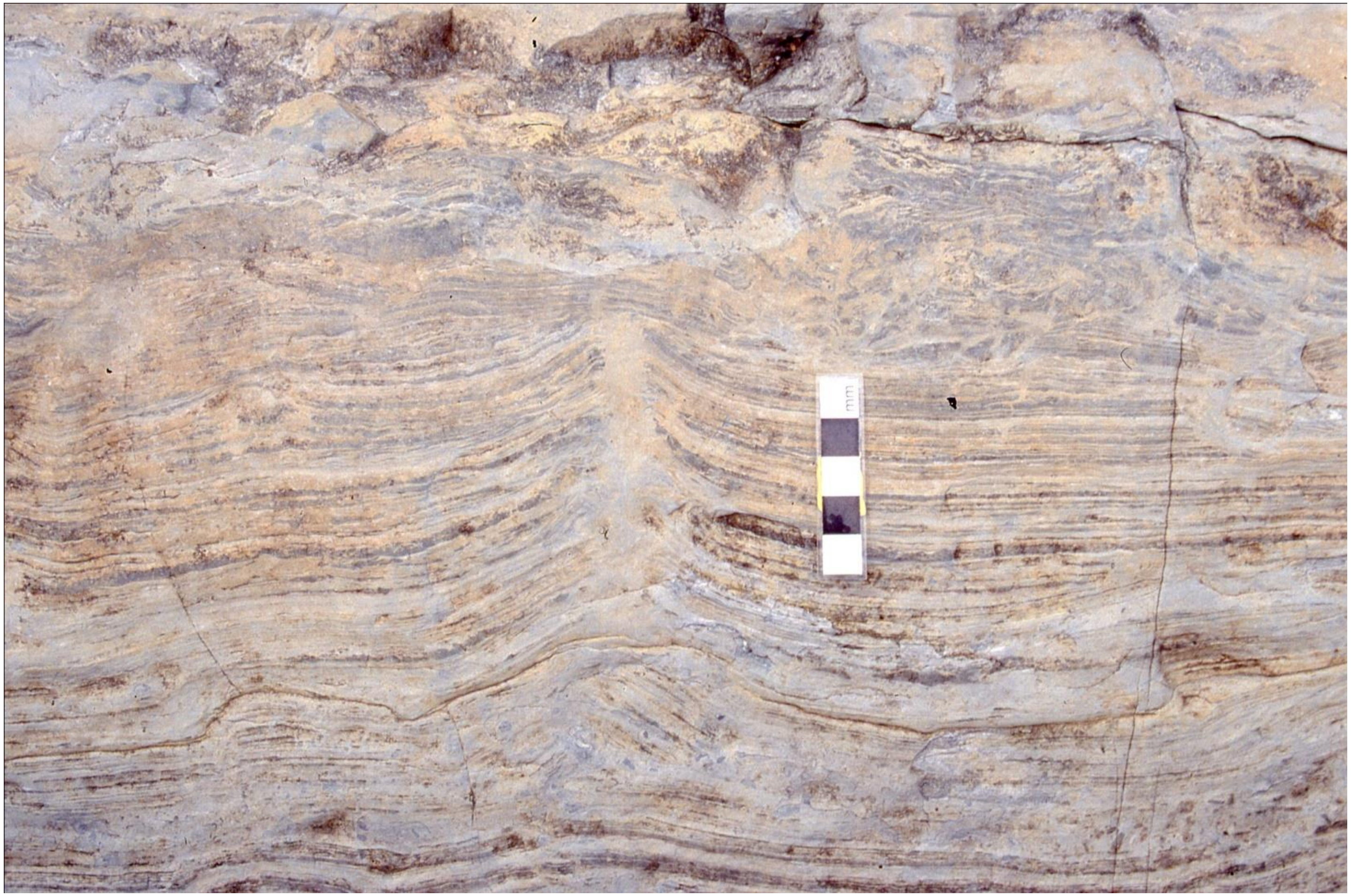
Fenestrae: mm-sized voids (sometimes filled by calcite spar) formed by trapped gas bubbles or beneath microbial mats

Ramp platform

Frontispiece Desiccation cracks in peritidal dolomite, Lower Ordovician, Newfoundland, Canada, hammer scale 15 cm long.

Ramp platform

- <u>Tepee Structures</u> in high intertidal/supratidal zone



Ramp platform

- Continued cycles of desiccation disrupt tepees, forming <u>flat pebble conglomerates</u>

Ramp platform

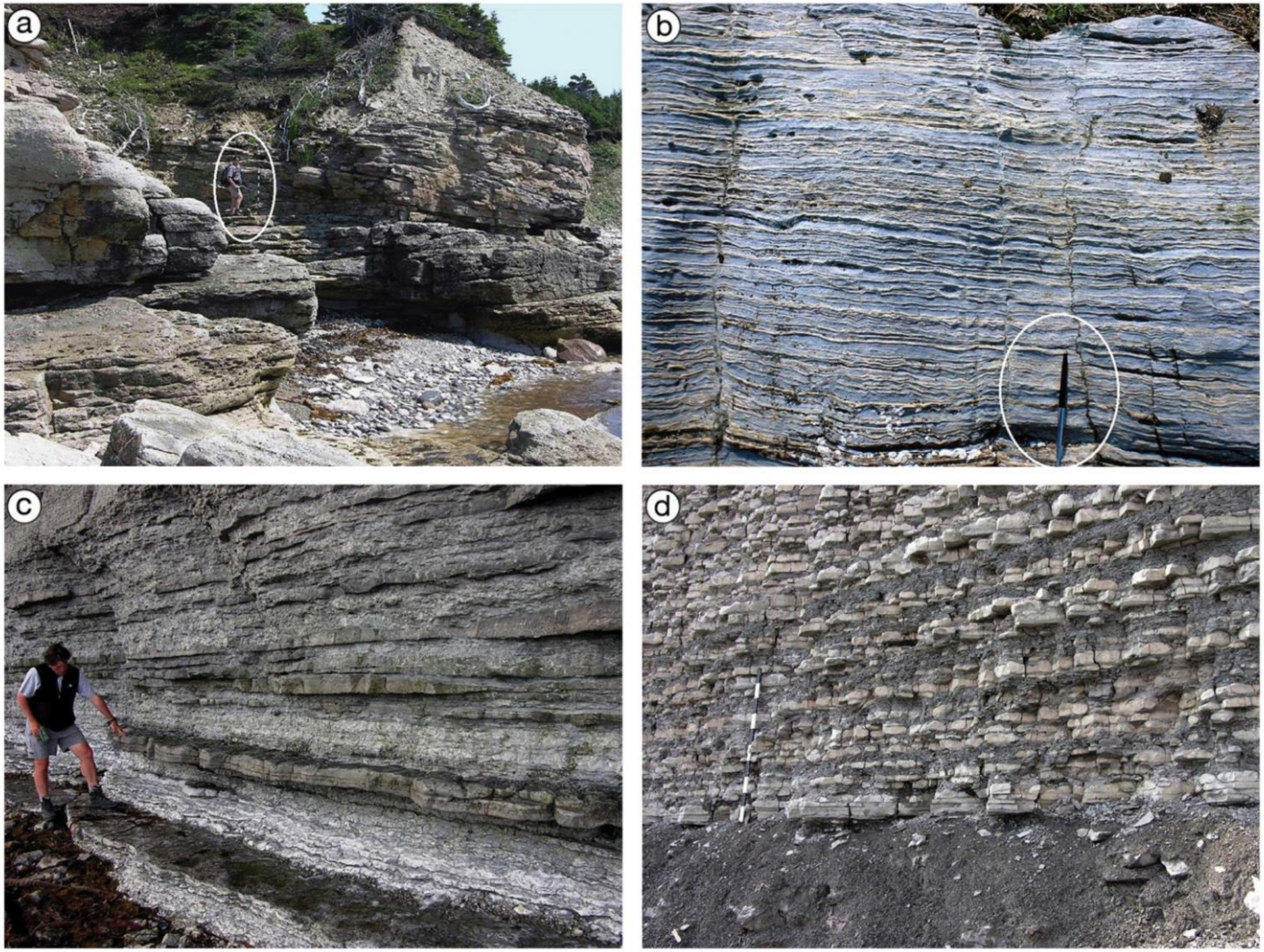


Figure 10.15 (a) Cross-bedded nearshore inner-ramp crinoidal limestones, Upper Ordovician, Anticosti Island, Québec, Canada. Note person (circled) for scale. (b) Finely interlaminated limestone and dolostone, lagoonal facies, Middle Ordovician Maryland, USA. Note 10 cm long pen for scale. (c) Thinly bedded lenticular tempestites of the mid ramp, person scale, Upper Ordovician, Anticosti Island, Québec, Canada. Note person for scale. (d) Thinly interbedded muddy tempestites and shales, Upper Ordovician, Anticosti Island, Québec, Canada. Scale bar: 10 cm increments.

Thank You !

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