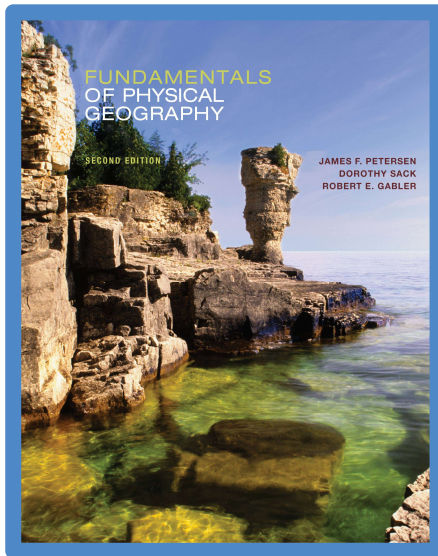


Fundamentals of Physical Geography 2e

Coastal Processes and Landforms

17



- ⌘ Peterson
- ⌘ Sack
- ⌘ Gabler

Introduction

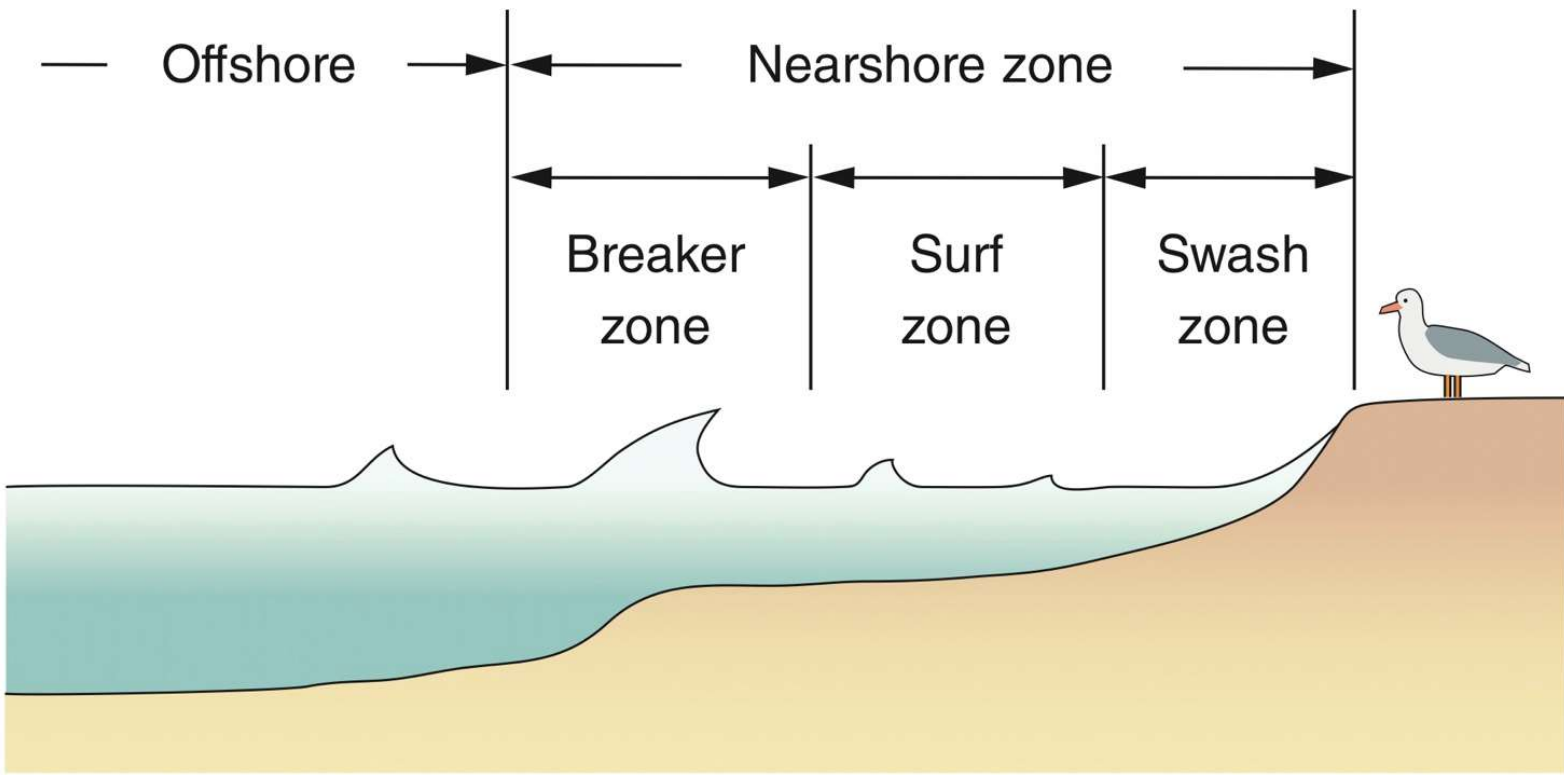
- Earth's one ocean
 - Atlantic, Pacific, Indian, and Arctic Oceans
 - 71% of Earth's surface
- Earth's coastlines
 - Biologically and geomorphically diverse
- What natural hazards are associated with coastal zones?
- Environmental problems due to:
 - Urban development, high population, etc.

The Coastal Zone

- Standing body of water
- Shoreline: fluctuates
 - Long-term changes: tectonic movements and amount of water
- Sea level
 - Ocean shoreline's average position
- Coastal zone
 - General region of interaction between the land and the ocean or lake

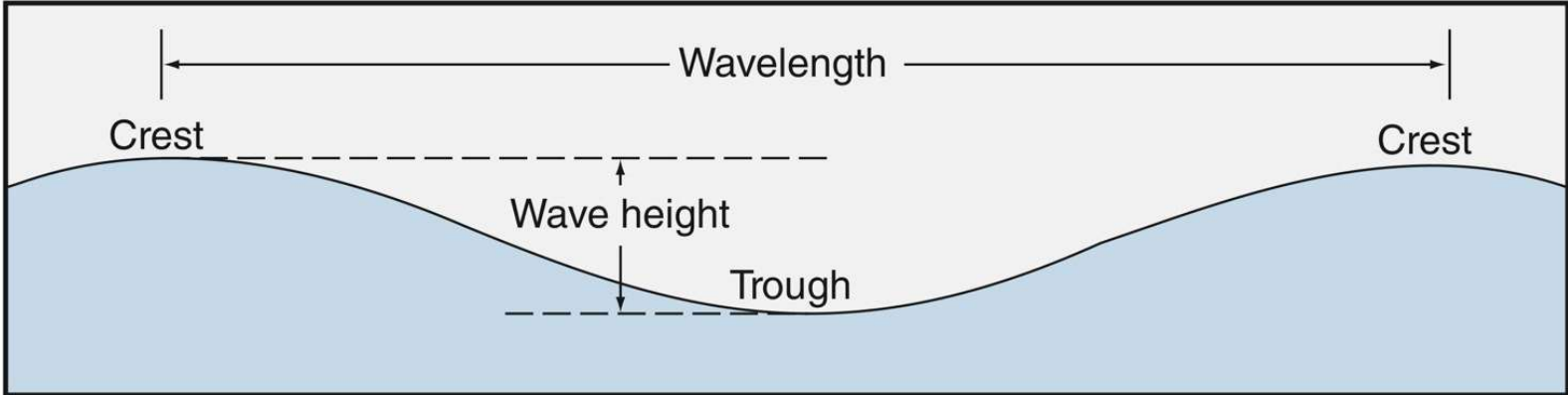
The Coastal Zone (cont'd.)

- Swash
 - Thin sheet of water rushing toward the shoreline
 - Backwash: return flow



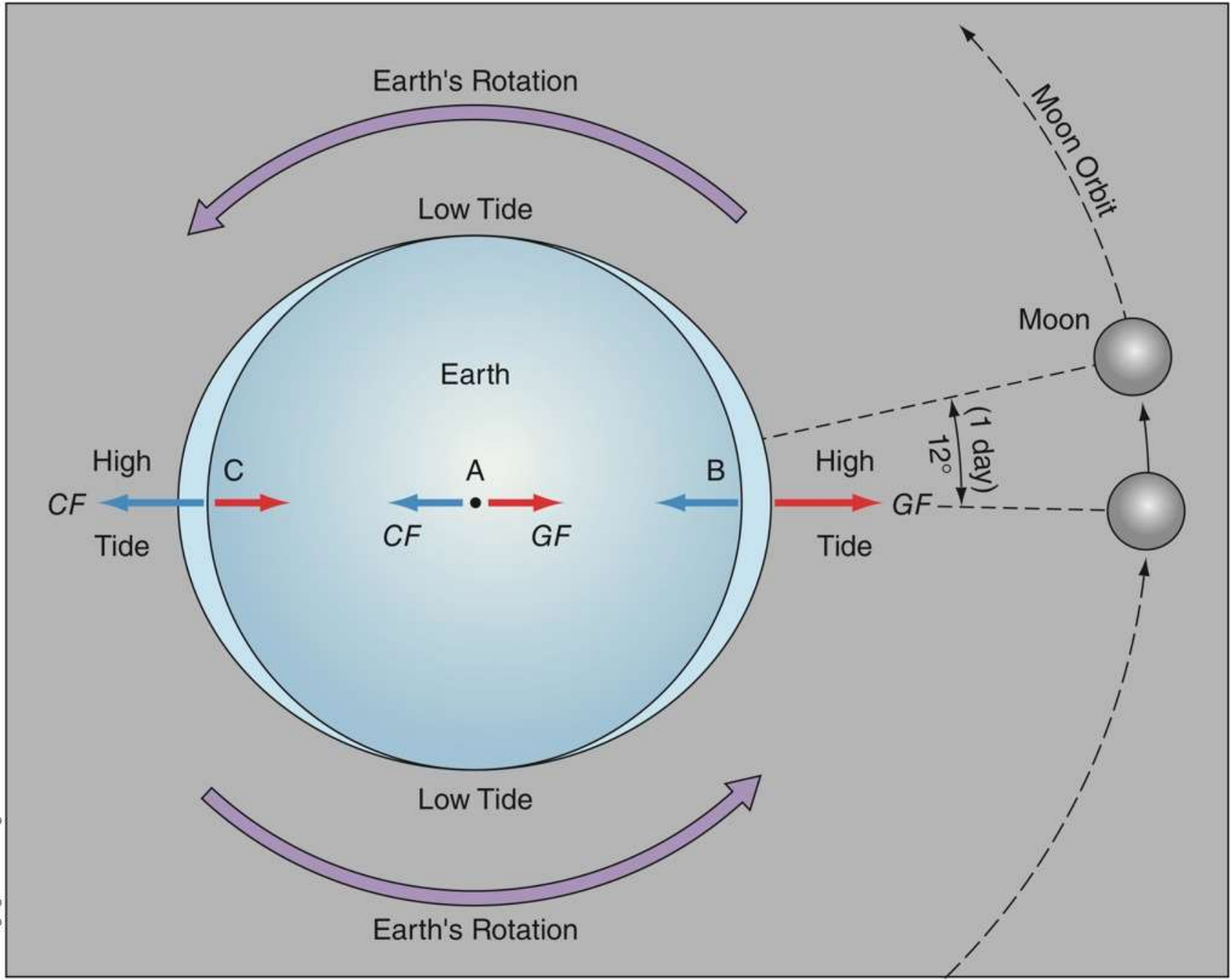
Origin and Nature of Waves

- **Waves**
 - Traveling, repeating forms (wave crests and troughs)
 - Wave height
 - Wavelength
 - Wave steepness
 - Wave period
 - Principal geomorphic agent
 - Responsible for coastal landforms



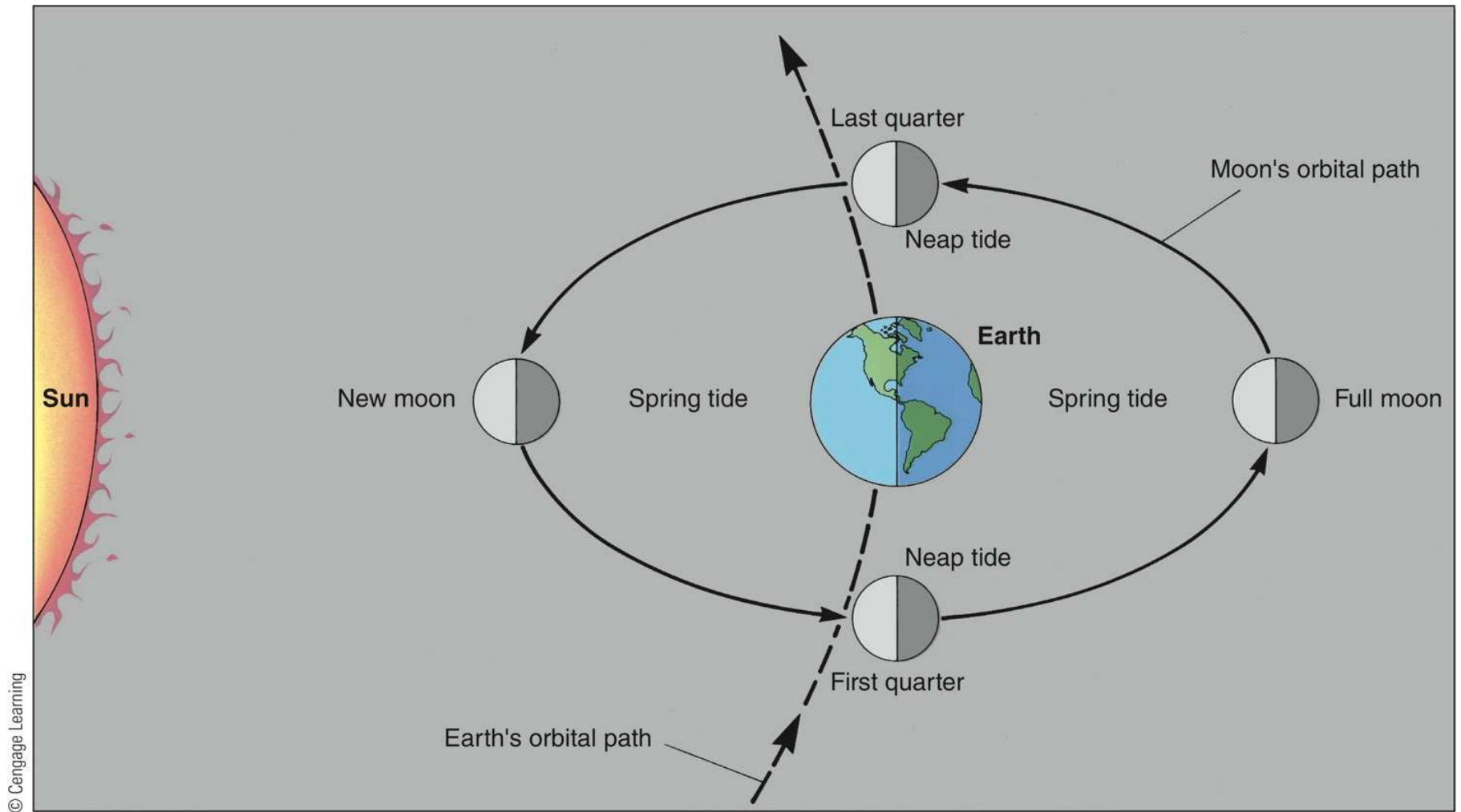
Origin and Nature of Waves (cont'd.)

- Origination of waves affecting coastal zones
 - Tides
 - Tsunamis
 - Wind waves
- Tides
 - Major cause of tides
 - Gravitational pull: moon and sun (lesser extent)
 - Force produced by motion of Earth-moon system



Origin and Nature of Waves (cont'd.)

- Tides
 - High tide
 - Low tide
 - Tidal range
 - Difference in sea level between high tide and low tide
 - What are the positions of the Earth, moon, and sun when spring tide occurs? When neap tide occurs?
 - Tidal day: 24 hours and 50 minutes



How many spring tides and neap tides occur each month?

Origin and Nature of Waves (cont'd.)

- Tidal patterns occur daily
 - Semidiurnal
 - Two high and two low tides
 - Diurnal
 - One high and one low tide
 - Mixed tide
 - Two high tides (unequal heights) and two low tides (unequal heights)

Origin and Nature of Waves (cont'd.)

- Tidal ranges
 - Microtidal: less than two meters
 - Mesotidal: between two and four meters
 - Macrotidal: greater than four meters
- Tidal range varies due to:
 - Shape of the coastline
 - Water depth
 - Access to the open ocean
 - Submarine topography, etc.



© 2003, Province of New Brunswick, all rights reserved.

(a)



Robert D. H. Warren/Communications New Brunswick.
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(b)

Why does the Bay of Fundy have such a great tidal range?

Origin and Nature of Waves (cont'd.)

- Tsunamis
 - Long-wavelength waves form when large volume of water displaced upward or downward by:
 - Earthquake
 - Volcanic eruption
 - Landslide
 - Natural hazard
 - Tremendous destruction and loss of life



U.S. Air Force photo/Tech. Sgt. DeNoris A. Mickle

Origin and Nature of Waves (cont'd.)

- Wind waves

- Most waves on the surface of standing bodies of water are created by the wind
- Frictional drag and pressure differences cause irregularities in the water surface
- Can travel thousands of kilometers
- Sea
 - Steep, choppy, chaotic waves in a storm
- Swell
 - Gentler waves

Origin and Nature of Waves (cont'd.)

- Three factors determine height of wind waves
 - Wind velocity
 - Duration of the wind
 - Fetch
- How is the position of water particles changed after the passage of each wave?

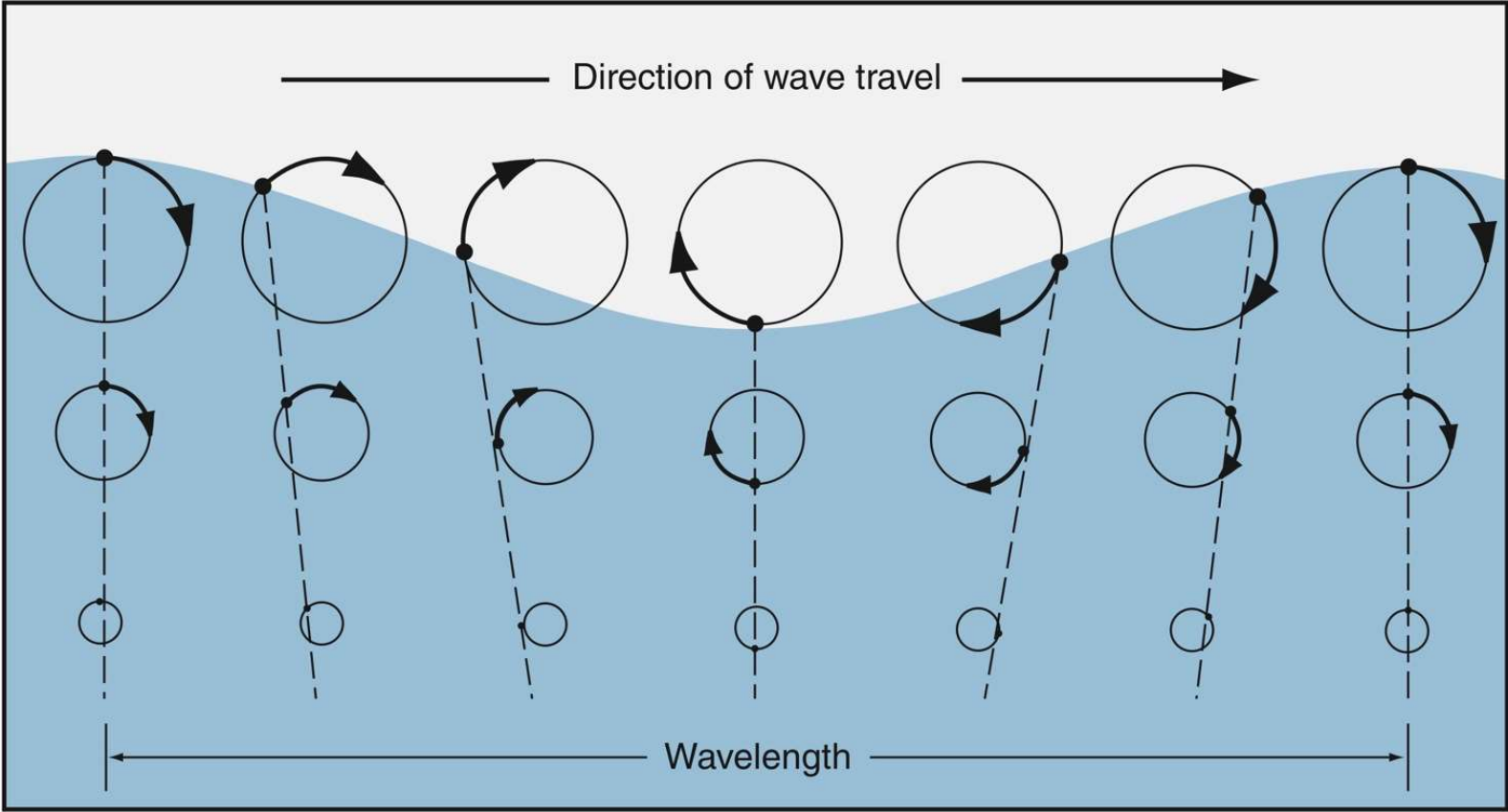
Origin and Nature of Waves (cont'd.)

- Deep-water waves

- Travel through water depth (d) greater than or equal to half the wavelength (L)

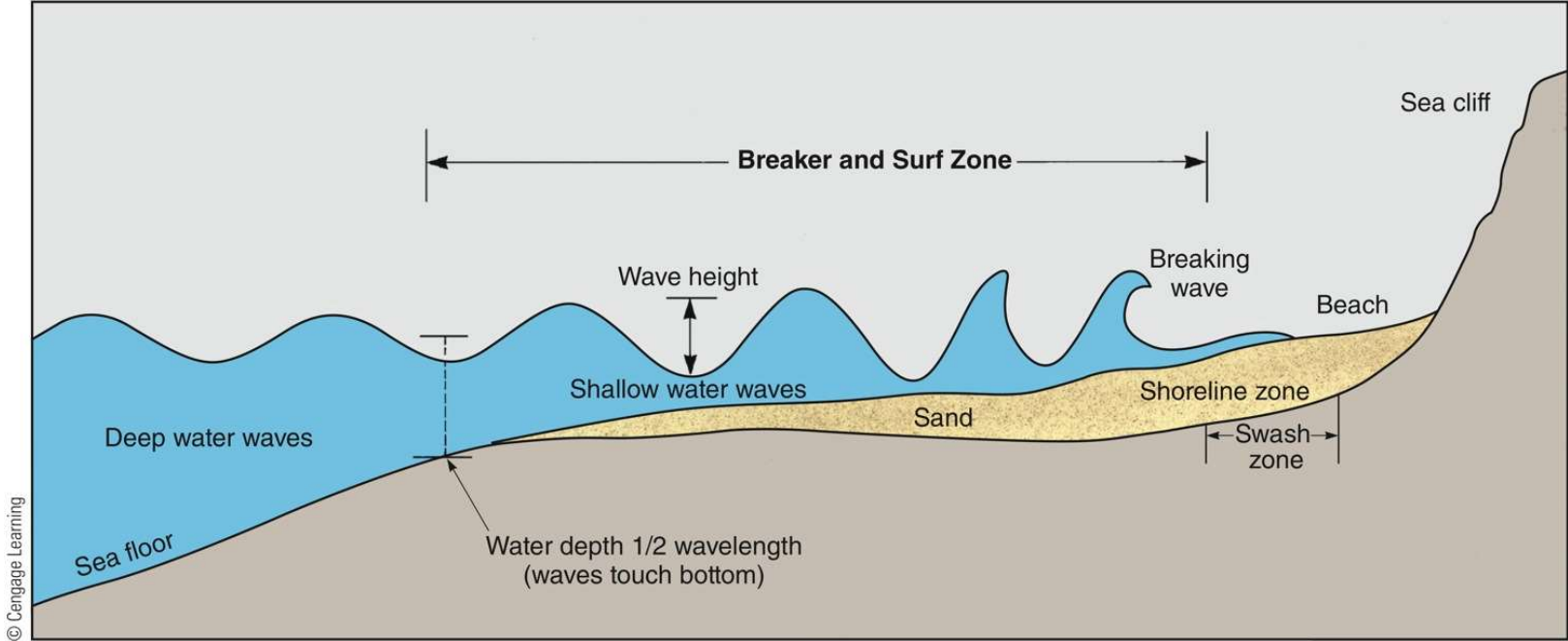
$$d \geq L/2$$

- Wave base: $L/2$



Waves in Shallow Water

- Wave breaking
 - Wave enters shallow water ($d < L/2$)
 - Friction with the bed: wave decreases in velocity and wavelength; height increases; steepness increases ($S = H/L$)
 - What is the maximum steepness ratio at which the wave breaks?
 - Rip currents
 - Relatively narrow zones of strong offshore-flowing water



City of Miami Beach, Florida, Public Safety Division



Why are these currents a hazard to swimmers?

Waves in Shallow Water (cont'd.)

- Tsunami forecasts and warnings
 - Tsunami: most dangerous type of wave affecting coastal areas
 - Speed across the open ocean: related to ocean depth
 - Pacific Ocean: up to 500 mph
 - Tsunami moves into shallow water
 - Speed decreases; height increases
 - Danger can last several hours

The Physical Science Perspective

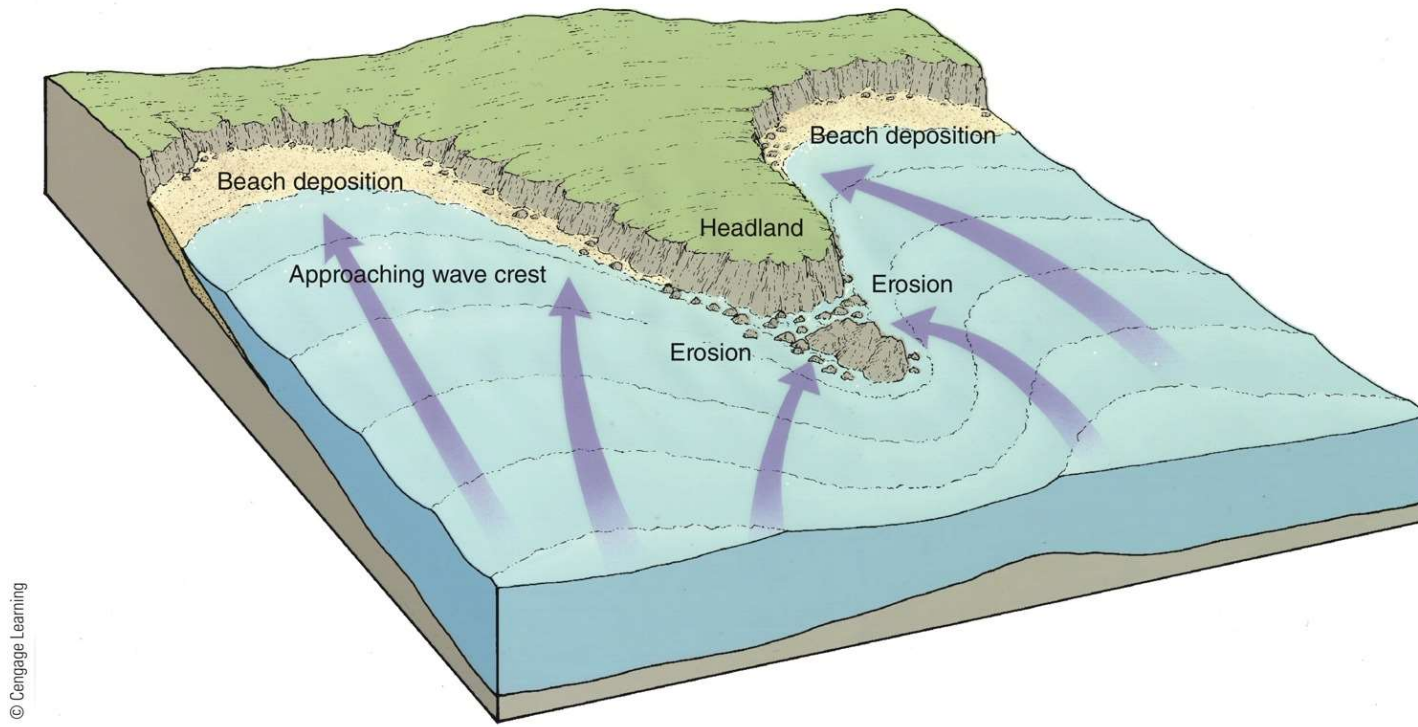
Waves in Shallow Water (cont'd.)

- Tsunami forecasts and warnings
 - Detecting a tsunami, determining its speed and direction, and tracking its progress
 - Critical for saving lives
- U.S. National Oceanic and Atmospheric Administration (NOAA)
 - Part of an international tsunami monitoring network

The Physical Science Perspective

Waves in Shallow Water (cont'd.)

- Wave refraction
 - Bending of a wave in map view as it approaches a shoreline
 - Part of a wave encounters shallow water before other parts
 - Not all waves refract completely before they break
- Littoral drifting
 - Sediment transportation in the coastal zone



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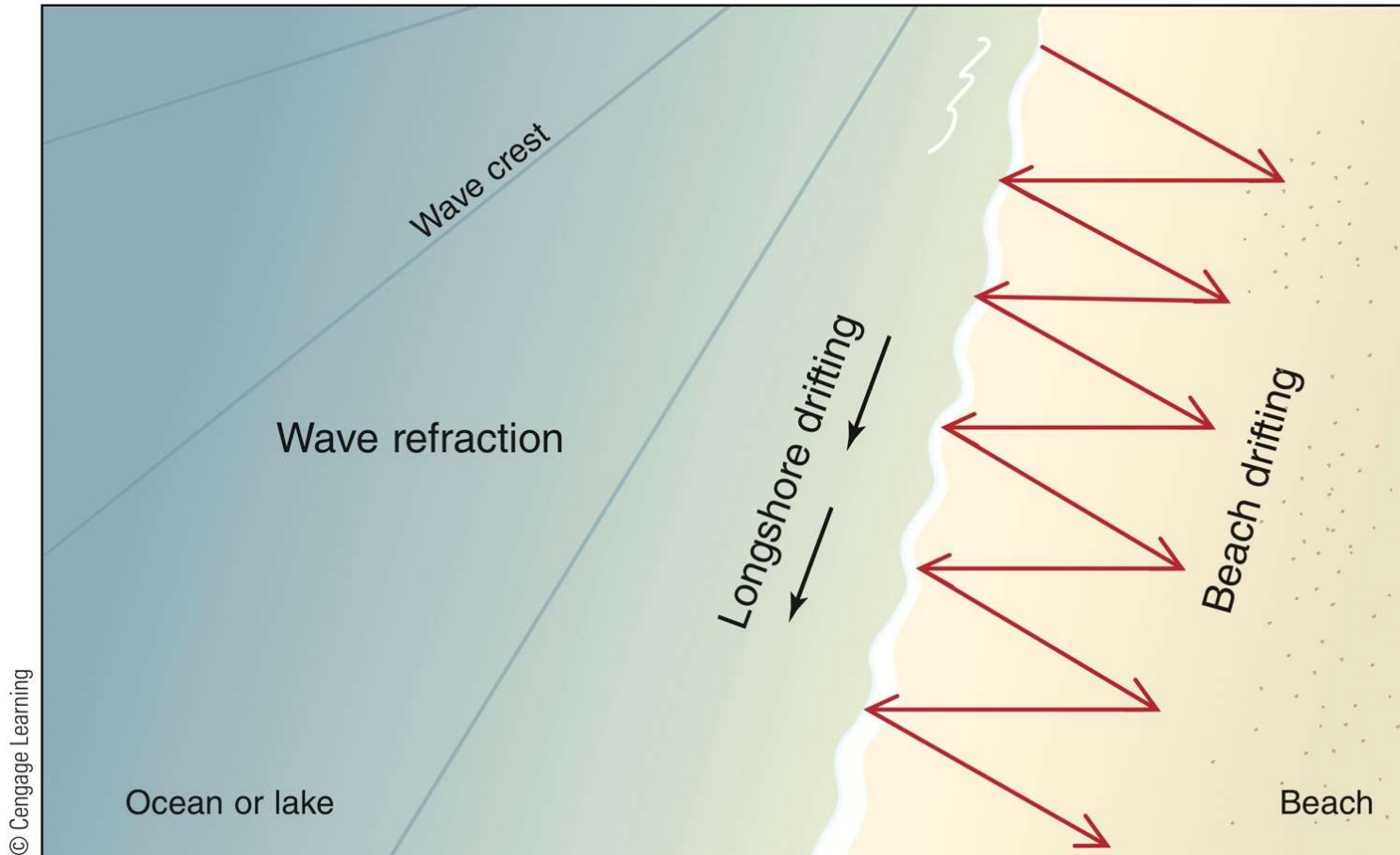
How will the shape of this coastline change over a long period of time?

USGS



Waves in Shallow Water (cont'd.)

- Beach drifting
 - Zigzag-like transportation of sediment in the swash zone
- Longshore current
 - Flows parallel to shoreline near the breaker zone
 - Longshore drifting



Why is the backwash perpendicular to the trend of the shoreline when the swash is at an angle to it?

Coastal Erosion

- Resulting landforms
 - Sea cliffs (lake cliffs)
 - In what way does the formation of a notch lead to more efficient erosion by abrasion?
 - Cobble beach
 - Sea caves
 - Sea arches
 - Sea stack
 - Abrasion platform

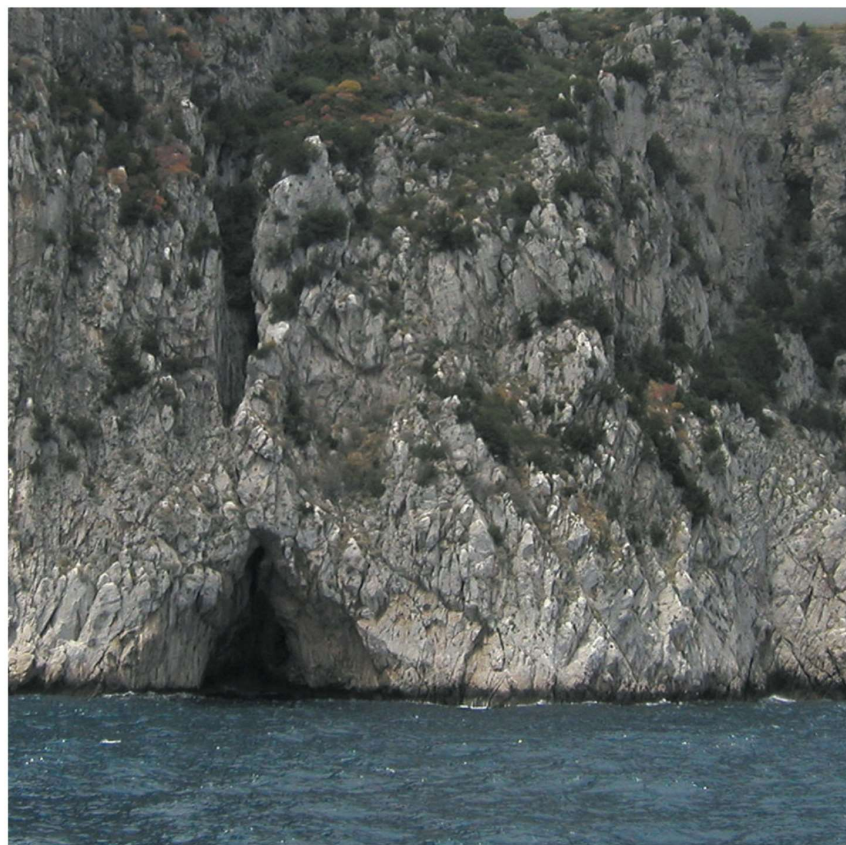
Coastal Erosion

- Resulting landforms
 - Marine terraces
- Rates of coastal erosion
 - Controlled by interaction between wave energy and rock type
 - Accelerated by:
 - High-energy events (e.g., storms or tsunamis)
 - Human actions (e.g., disrupting vegetation)



D. Sack

(a)



J. Petersen

(b)



(c)



(d)

Robert Cameron/Getty Images



(e)

What other coastal erosional landforms do you see in photo (e)?

Coastal Deposition

- Significant accumulation of sediments along coasts
 - Low wave energy relative to the amount or size of sediment
- Three principal sources of coastal sediment
 - Streams: deposited in a delta or estuary
 - Coastal cliff erosion
 - Offshore sources

Coastal Deposition (cont'd.)

- Beach: most common coastal depositional landform
 - Various grain sizes and mineral types: sandy beach, cobble beach, boulder beach, white sand, etc.
 - Longshore bar
- Splits
- Tombolo

University of Washington Libraries, Special Collections, John Shelton Collection, KC10045-1/2.



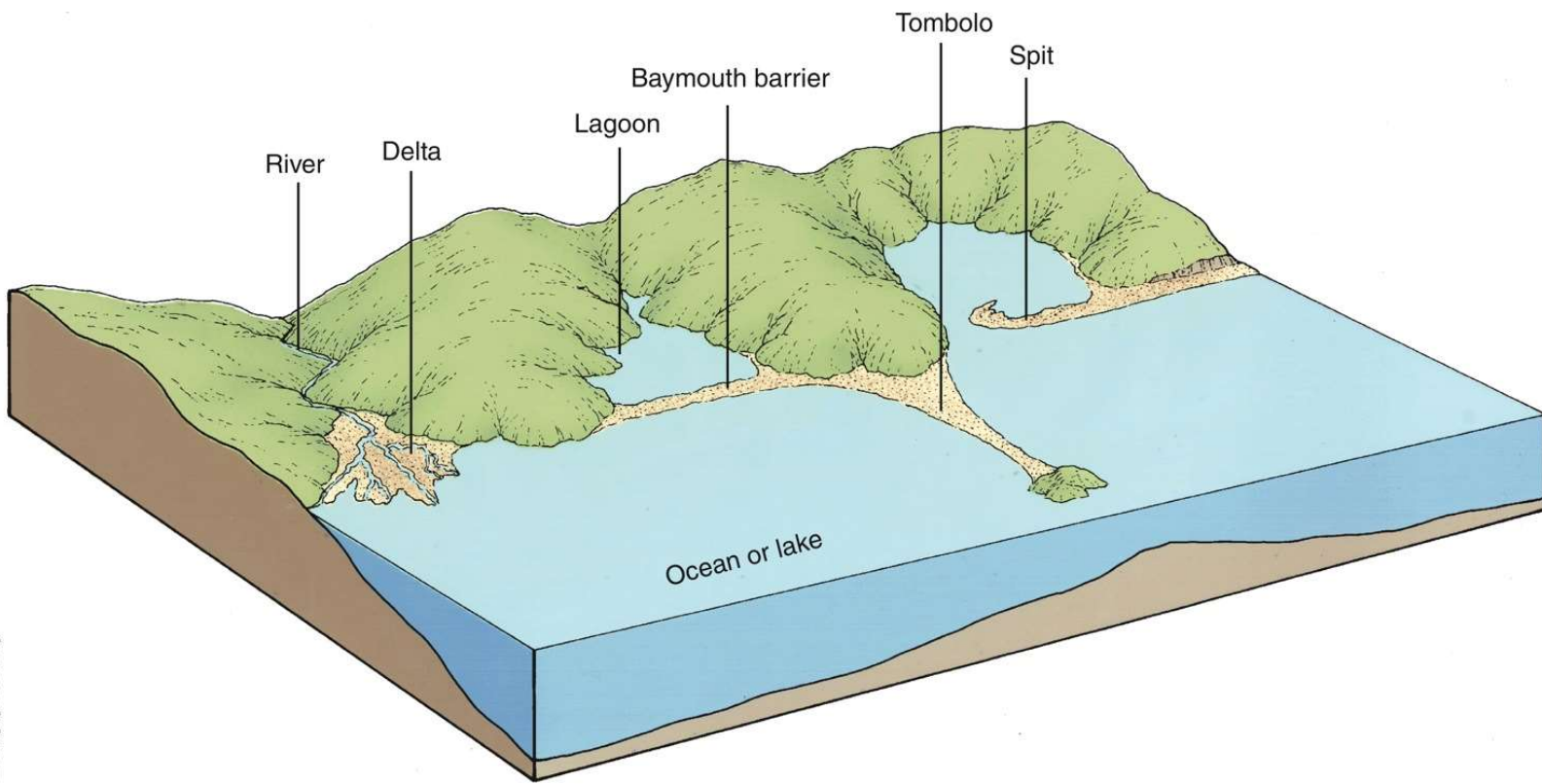
(a)

University of Washington Libraries, Special Collections, John Shelton Collection, KC19589x



(b)

What attribute of waves represents the amount of energy they have?



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How is a tombolo different from a spit?

Coastal Deposition (cont'd.)

- Barrier beaches all have lagoons
 - Three common kinds
 - Barrier split
 - Baymouth barrier
 - Barrier islands: gulf coasts of the United states, e.g., Padre Island (Texas)



NASA

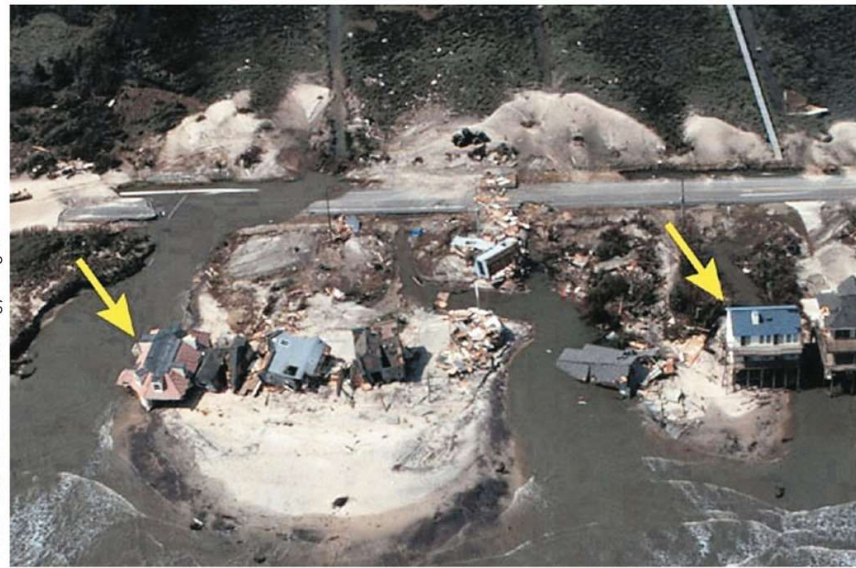
What feature separates a barrier island from the mainland?

USGS Coastal & Marine Geology Program



(a)

USGS Coastal & Marine Geology Program



(b)

How can this type of damage be prevented in the future?

Coastal Deposition (cont'd.)

- Beach systems
 - Equilibrium: input and output of sediment are in balance
 - What is the negative impact of a groin?
 - Damming rivers decreases sediment supply
 - Beaches become narrower and lose ability to protect coastal region against storm

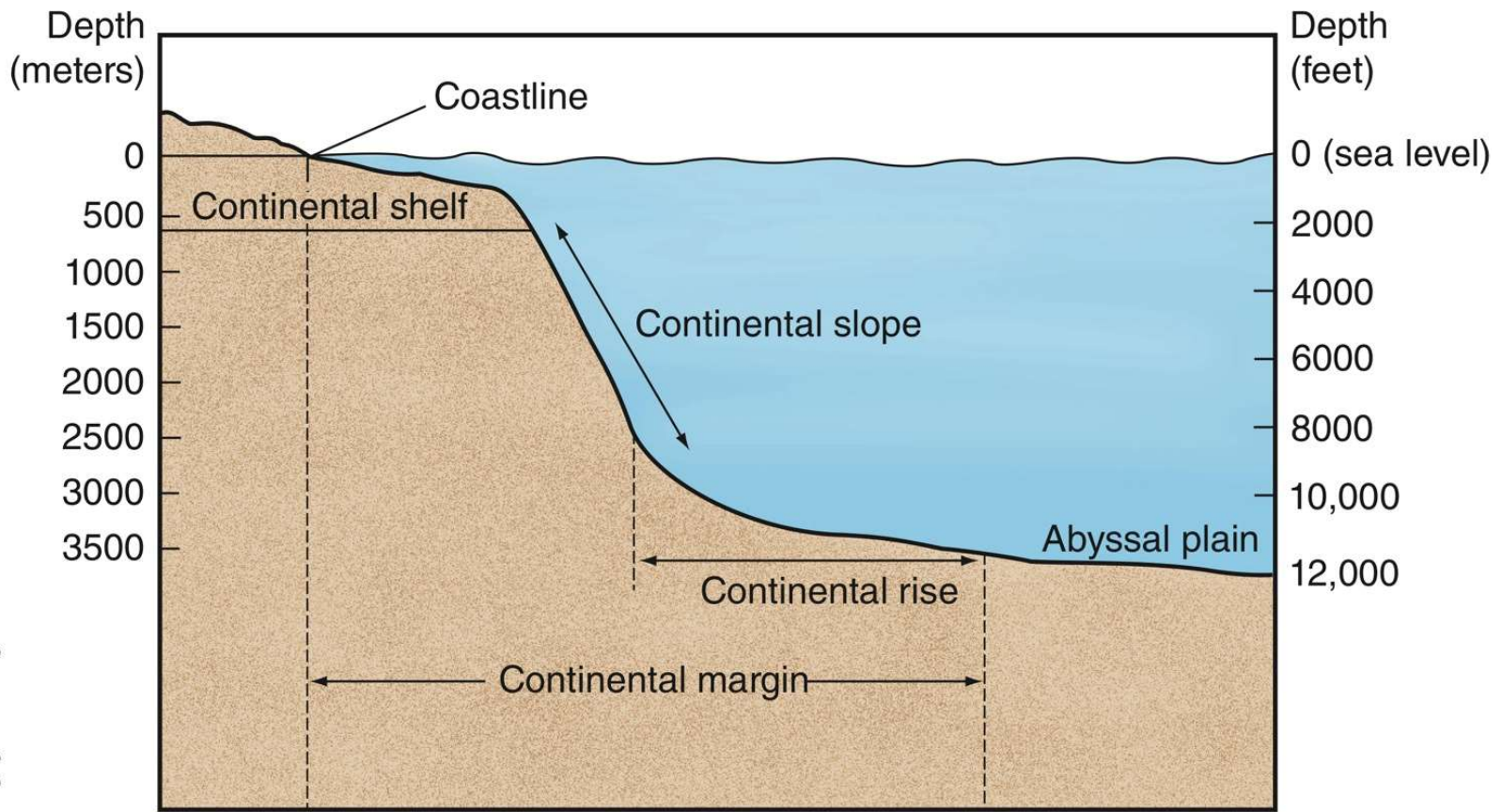
USGS



How do you think the stretch of coast beyond the last groin would be affected by these structures?

Types of Coasts

- On a global scale, plate tectonics generates two major types:
 - Passive-margin coasts
 - Tectonically quiescent
 - Active-margin coasts
 - Pacific Ring of Fire



(not to scale)

Stockbyte/Getty Images





Where else in the world might you expect active-margin coastlines?

Types of Coasts (cont'd.)

- **Classification on a regional scale**
 - Emergent coastlines
 - Water level has fallen or the land has risen
 - Submergent coastlines
 - Many features of the former shore lie underwater
 - Two special types of submerged coastlines: ria and fjord coasts
 - Some coastlines
 - Features of both emergence and submergence

USGS



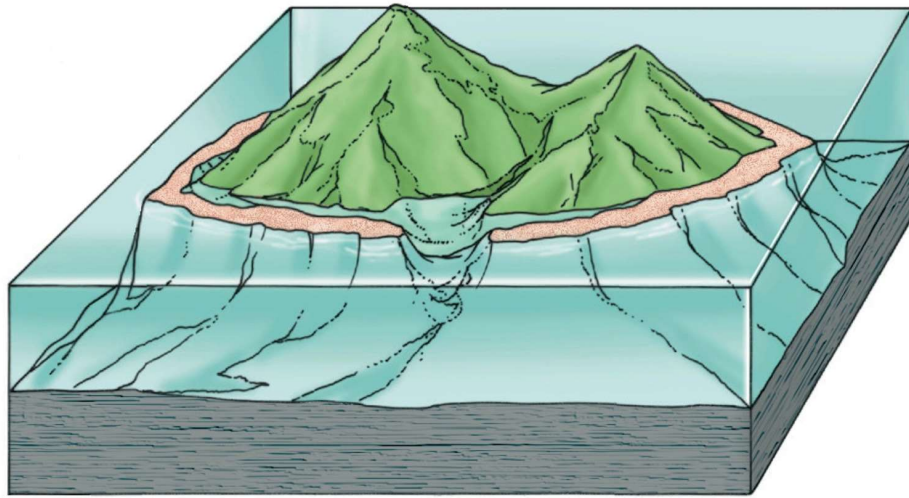
How does a marine terrace differ from an abrasion platform?

Islands and Coral Reefs

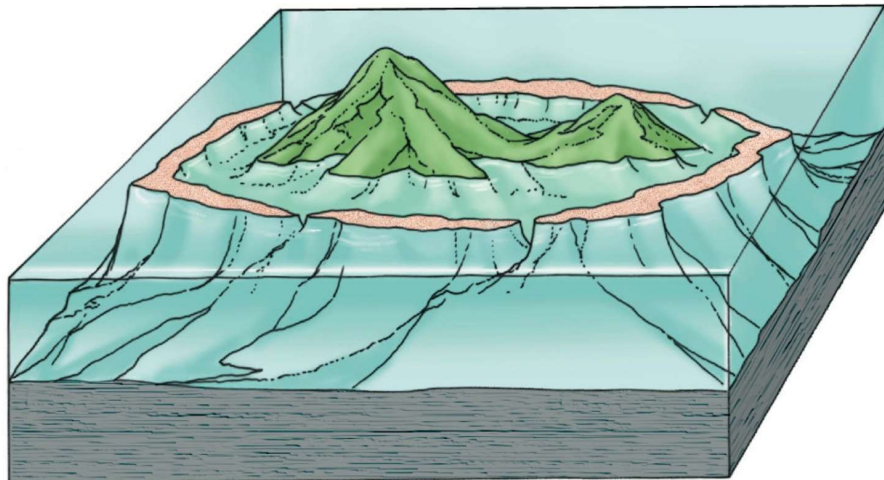
- Three basic types of islands (within the ocean)
 - Continental islands
 - Greenland, New Guinea, Great Britain, etc.
 - Oceanic islands
 - What causes the formation of oceanic islands?
 - Atolls
 - Ring of coral reefs

Islands and Coral Reefs (cont'd.)

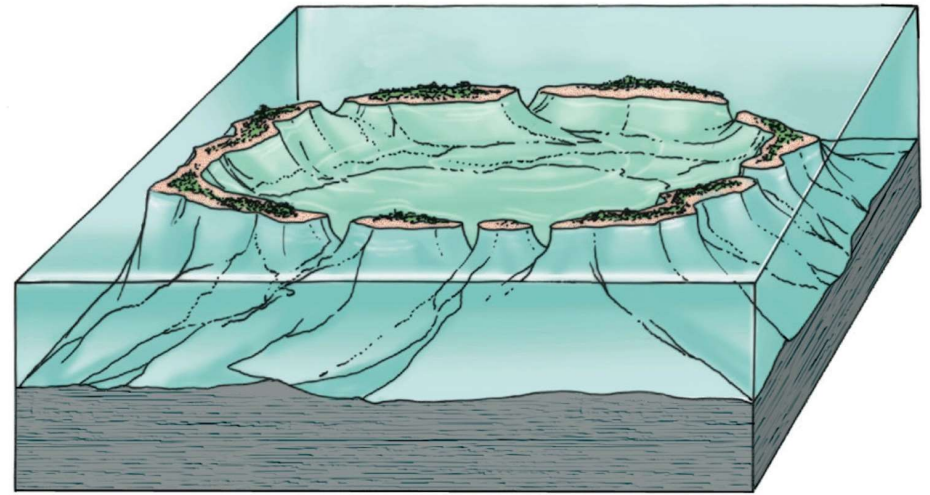
- Coral reefs
 - Shallow, wave-resistant structures
 - Remains of tiny sea animals (calcium carbonate skeletons)
 - What special conditions are required for reef corals to grow?
 - Types of coral reefs
 - Fringing reef
 - Barrier reef
 - Atolls



(a) Fringing reef



(b) Barrier reef



(c) Atoll

Change over Time

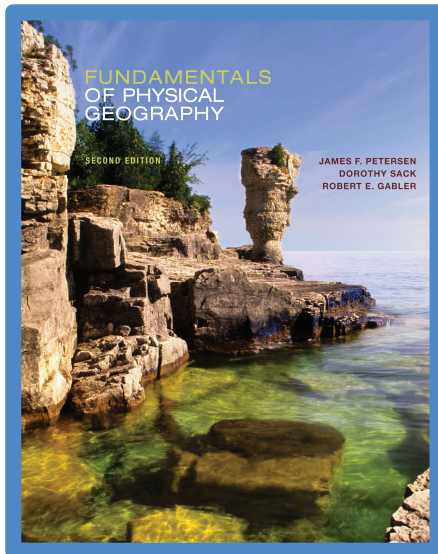
- Importance of:
 - Appreciating the power of coastal processes
 - Recognizing impact of natural and human-induced alteration of coastal zones
- Coastal zones are subject to change
 - Daily changes: waves
 - Over several months: changes due to groins or dams
 - Long-term factors: tectonism and climate

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<end of chapter>



- ⌘ Peterson
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