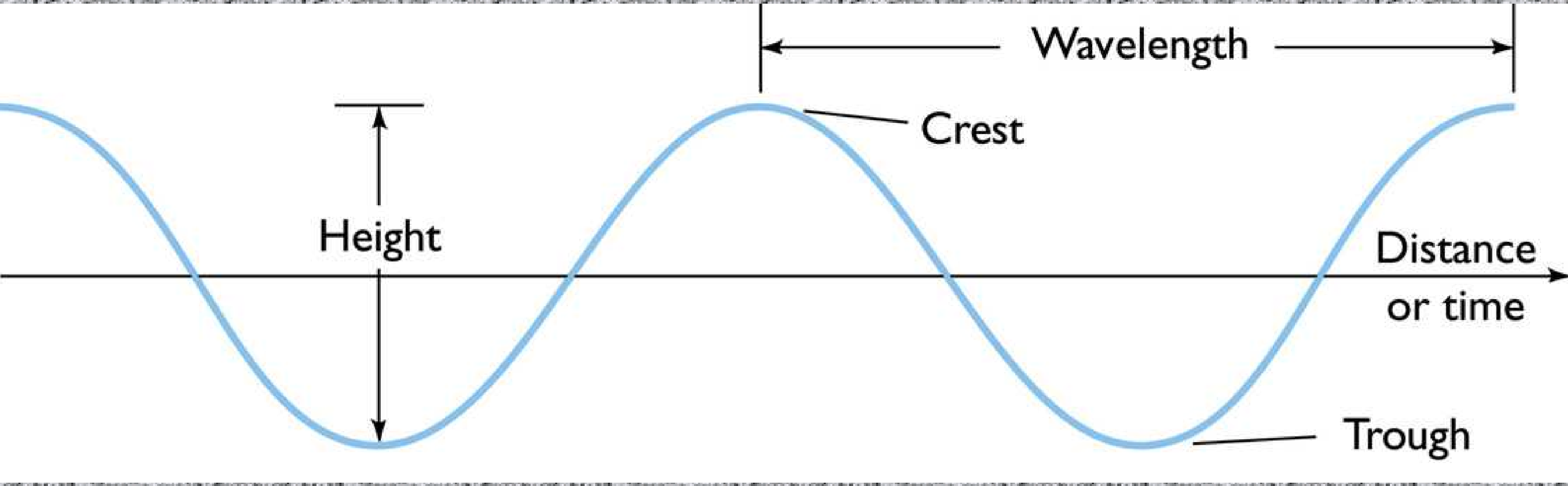
Waves

Parts of a wave:

height (H) wavelength (L, or λ)



amplitude (H/2) crest trough

Wave as an oscillation

Waves are energy

The energy moves through the water as a wave form

The water particles move in circles (orbits) as the wave passes

REALLY important point related to tsunamis:

The longer the wavelength, the faster the wave

C = 1.25 * sqrt (wavelength)

Wave speeds

Deep-water wind waves

Maximum values:

Period	20 seconds
Wavelength	600 meters
Speed	110 kilometers per hour (70 mph)

*Seismic sea waves (**shallow**-water waves)*

Maximum values:

Period	20 minutes (60x wind waves)
Wavelength	200 kilometers (120 miles)
Speed	760 kilometers per hour (470 mph)

Wave speed: Celerity

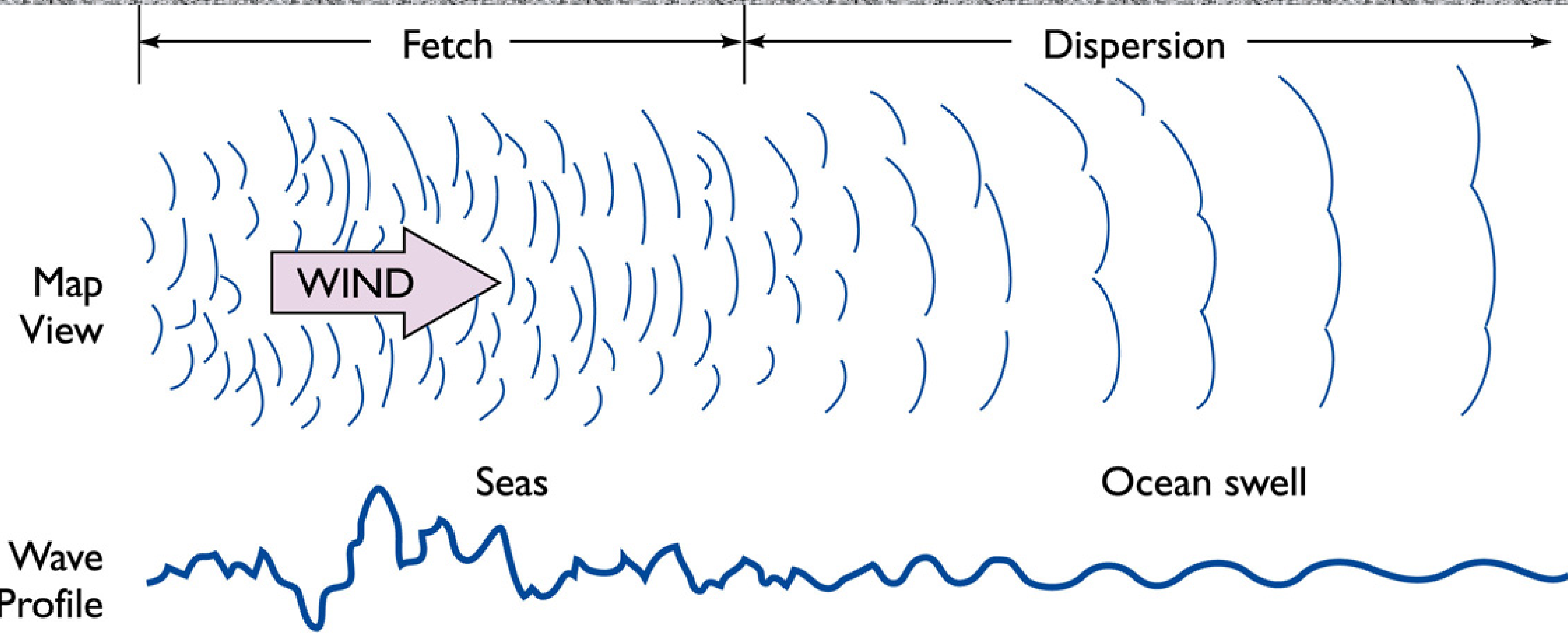
C = L / T (equivalent to R = D / T)

For surface waves in water, ***the longer the wavelength, the faster the celerity***

Wave dispersion, away from a storm center

Wave dispersion away from a storm

Long wavelength waves move out ahead



(a) DEEP-WATER WAVE TRANSFORMATIONS

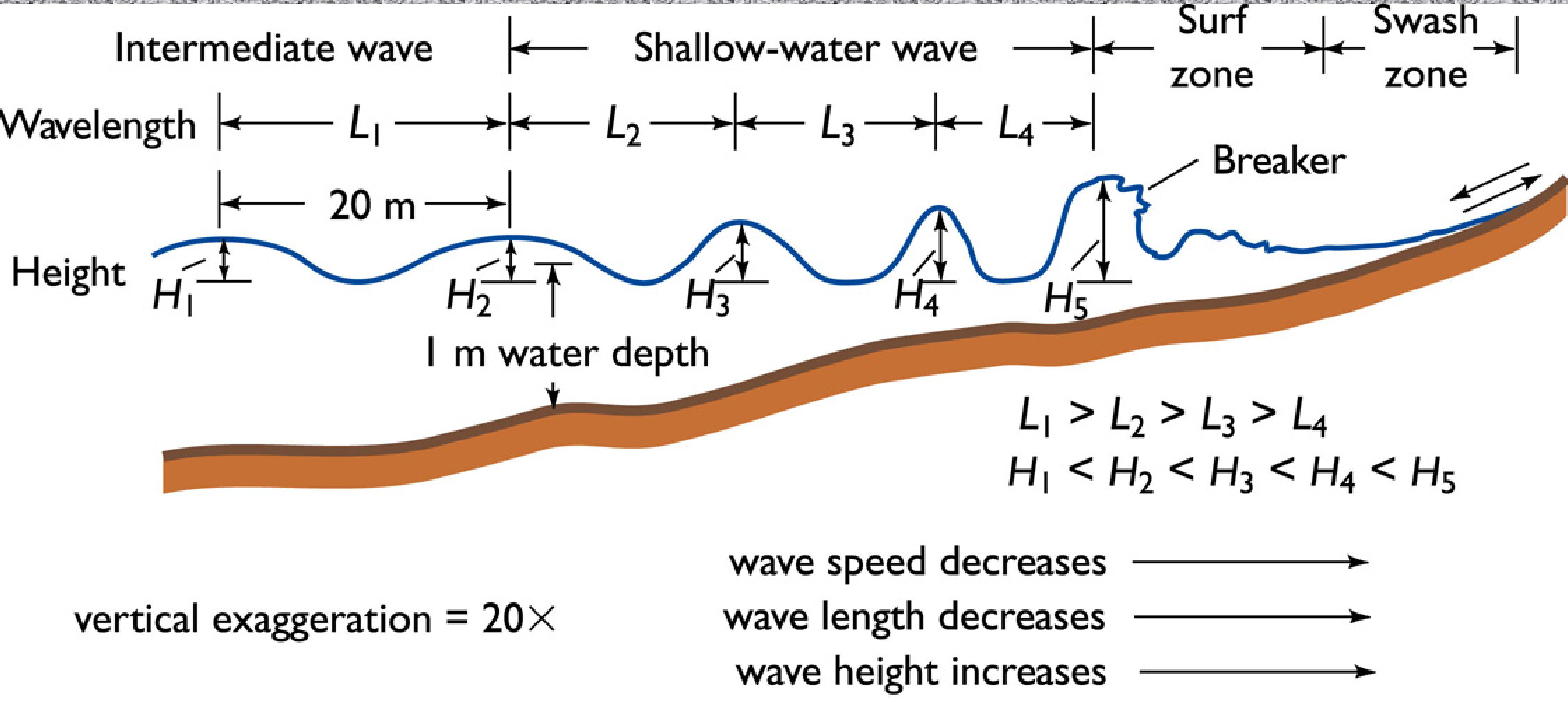
Waves in shallow water

Energy is lost from the wave because of friction with the bottom

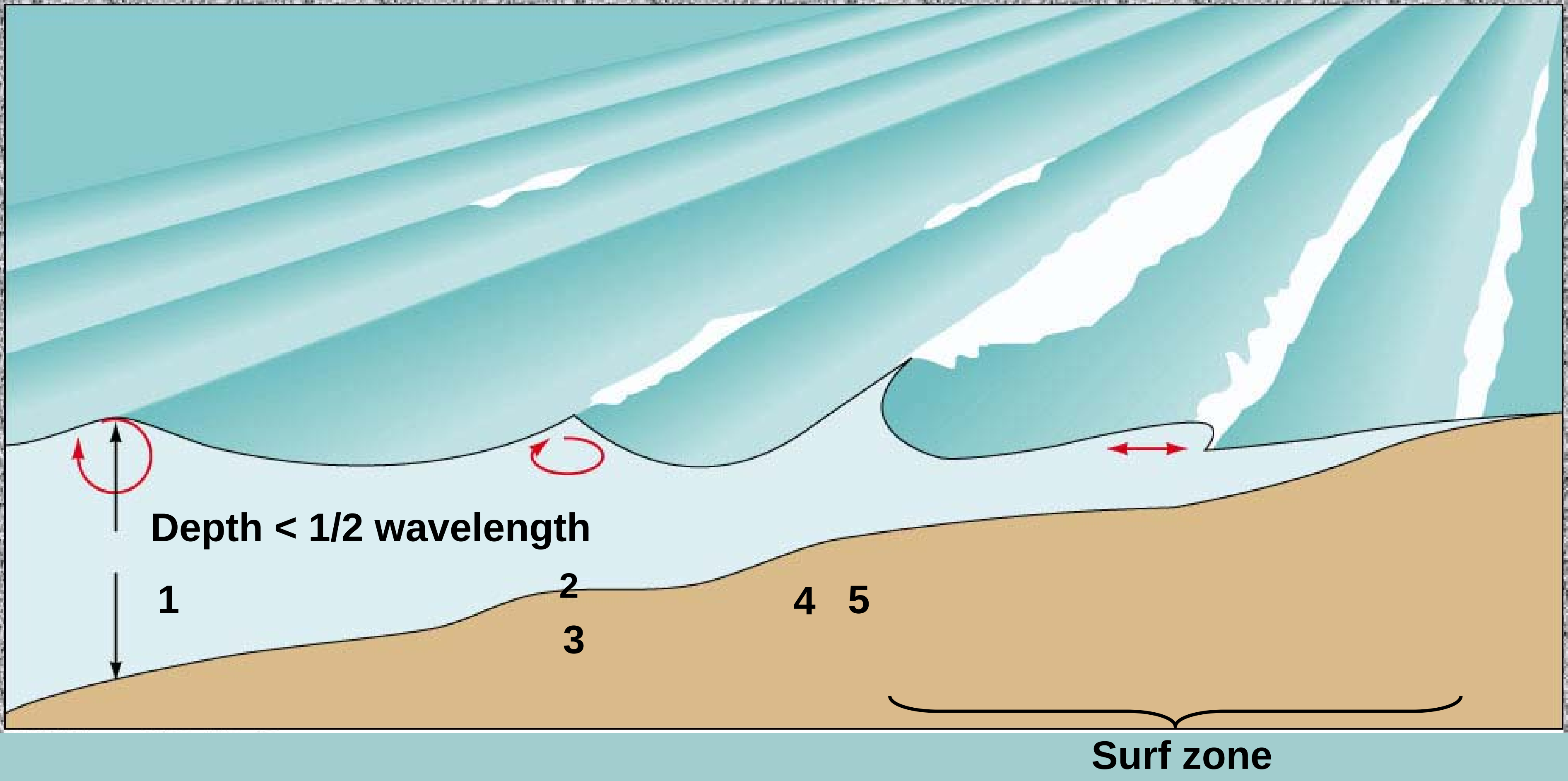
As a wave moves into shallow water:

- speed decreases
- wavelength decreases
- height increases

Waves in shallow water



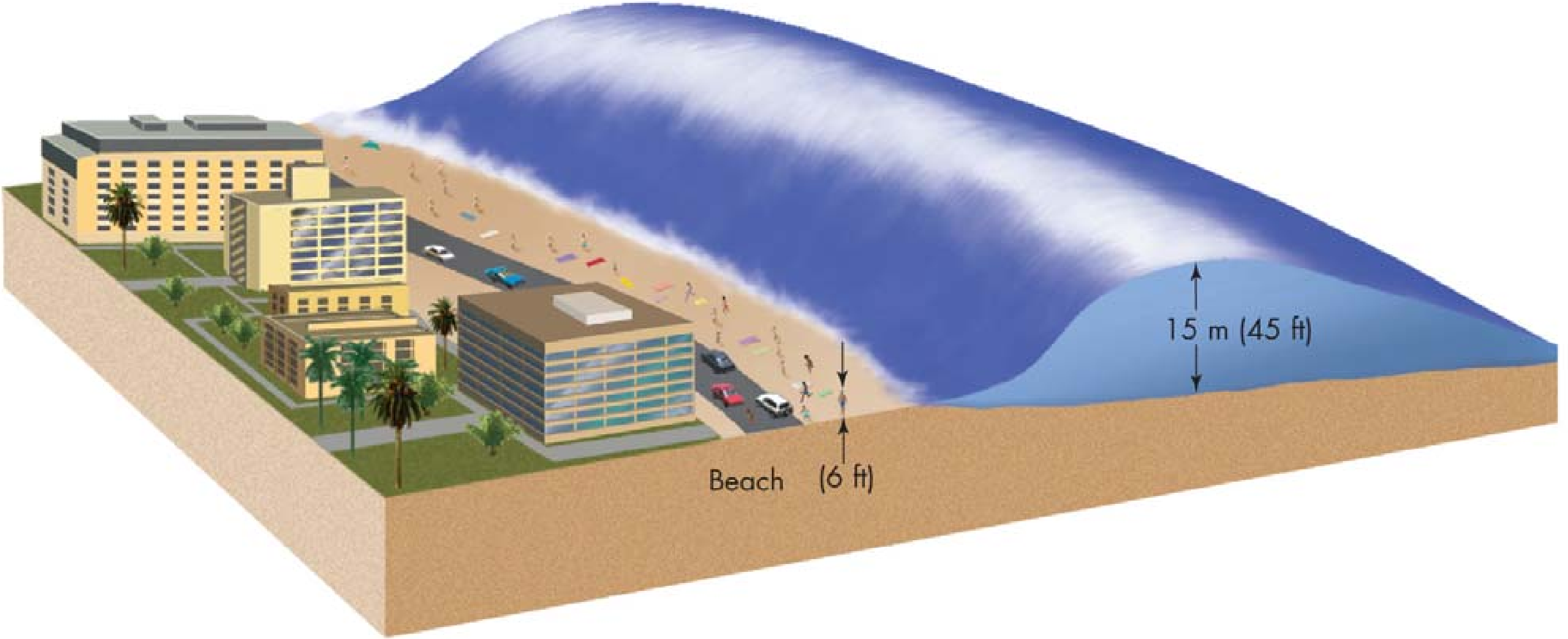
(b) SHALLOW-WATER WAVES IN PROFILE



Depth < 1/2 wavelength
1
2
3
4
5
Surf zone

Surging wave

Scale of a tsunami



Tsunami

Tsunami is Japanese for “harbor wave”

Caused by the vertical displacement of ocean water

Triggered by:

- Large earthquakes that move the sea floor
- Underwater landslides
- Volcano flank collapse
- Submarine volcanic explosion
- Asteroids

Another category: *Mega tsunami*

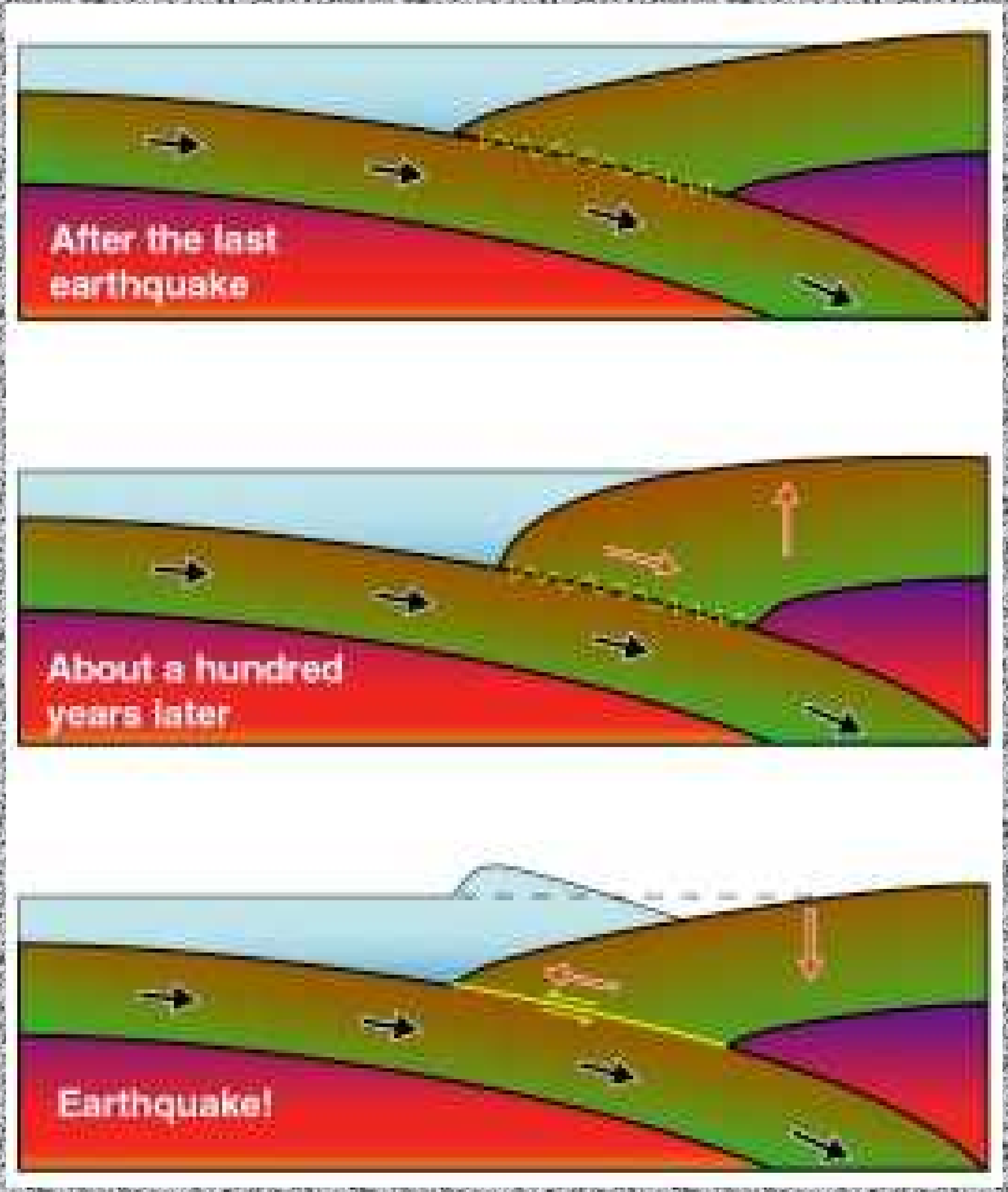
Ways to create a tsunami

Subduction-zone earthquake

larger than M 7-7.5

100 years later stored tension

Fault rupture

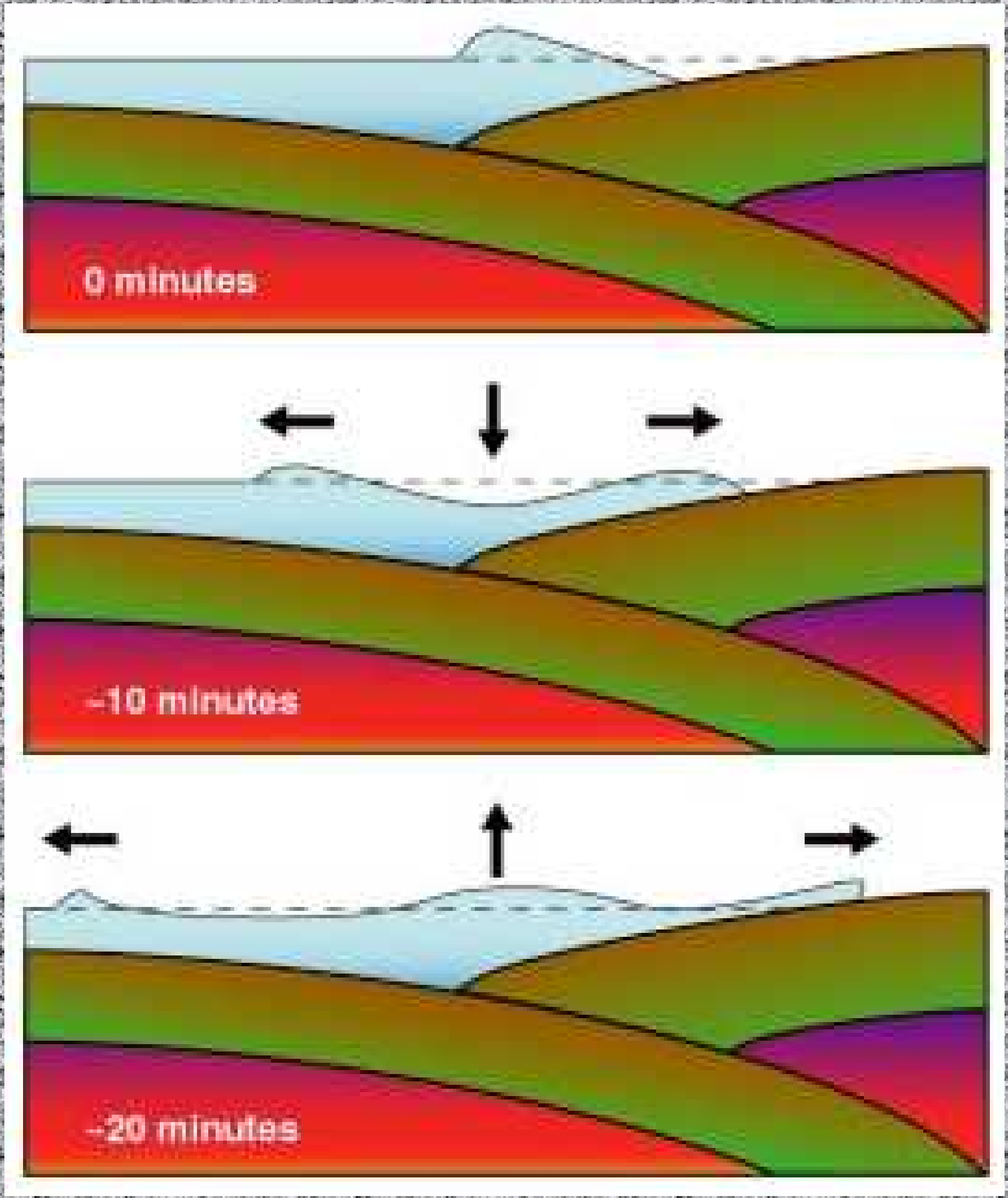


Response after earthquake

0 minutes

10 minutes

20 minutes



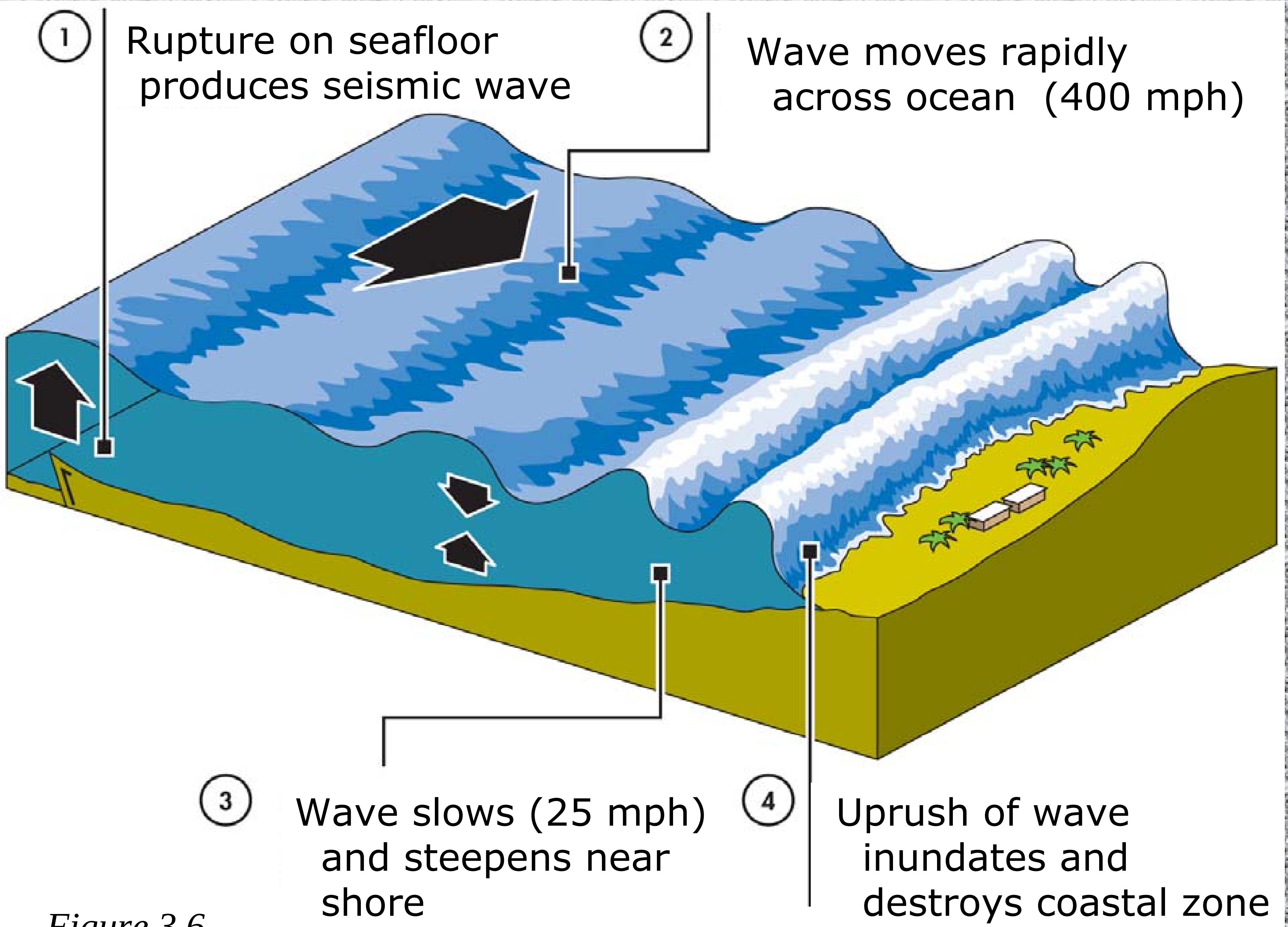
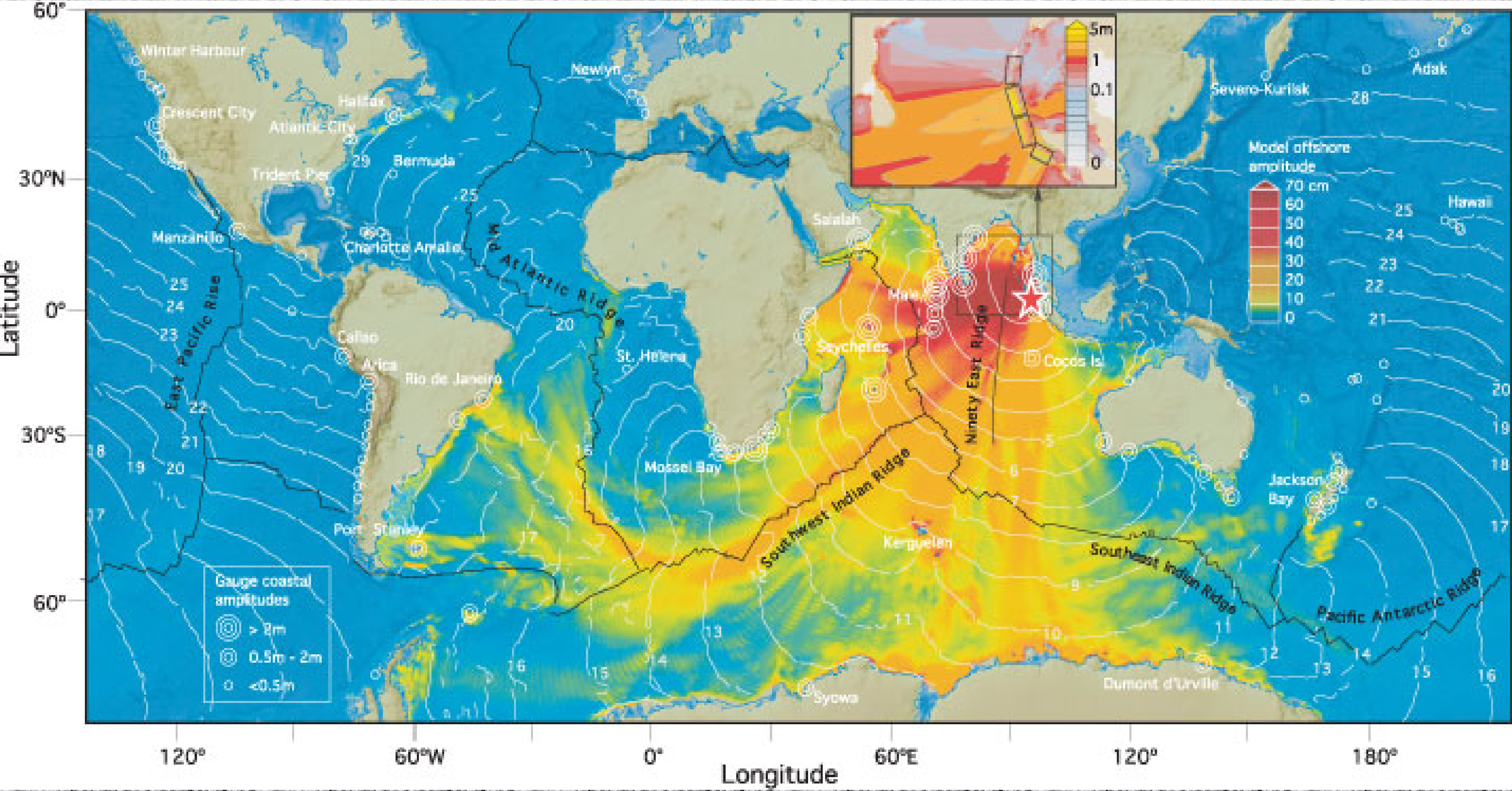

1
Rupture on seafloor produces seismic wave
2
Wave moves rapidly across ocean (400 mph)
3
Wave slows (25 mph) and steepens near shore
4
Uprush of wave inundates and destroys coastal zone

Figure 3.6

Tsunami path through the ocean



Meulaboh, Indonesia

Meulaboh, Indonesia

Meulaboh, Indonesia

Banda Aceh, Indonesia

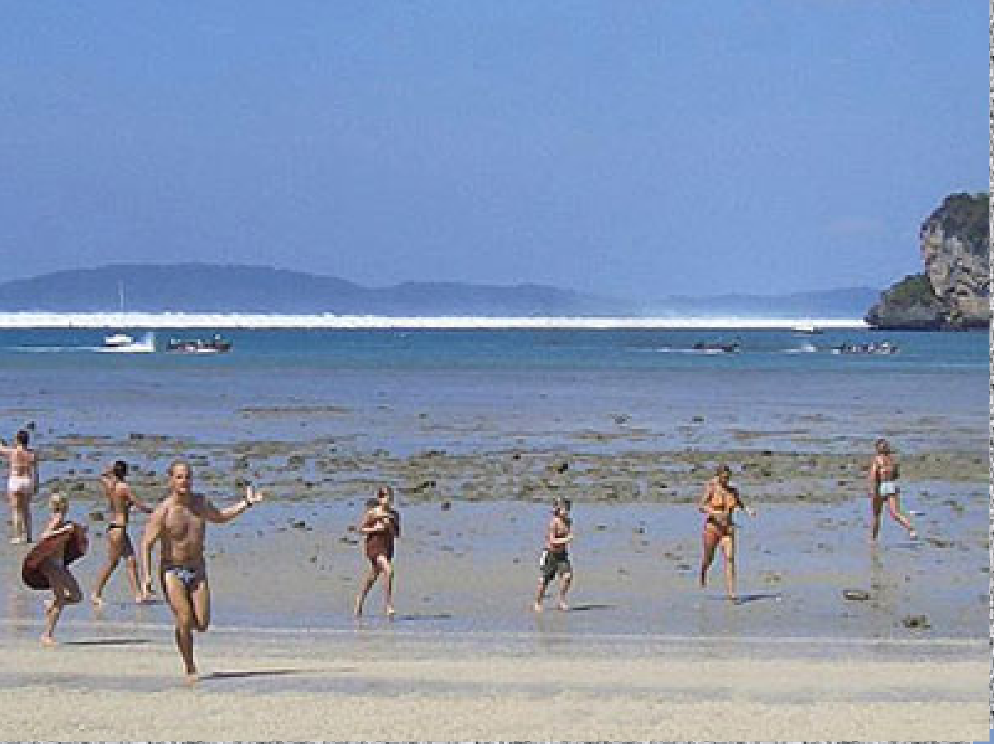
Banda Aceh, Indonesia

Fig. 10-32b, p. 289

(b)

c

Fig. 10-32c, p. 289



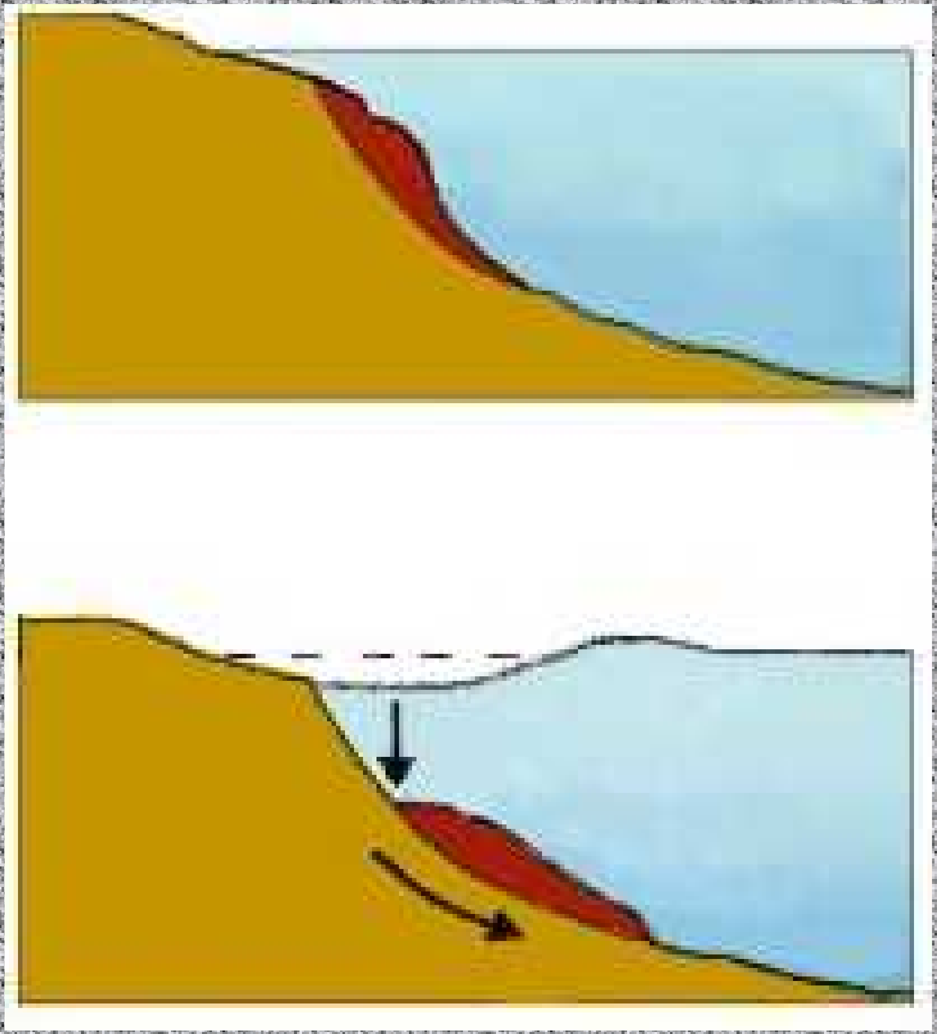
Kata Noi receding wave

Water receding from shoreline

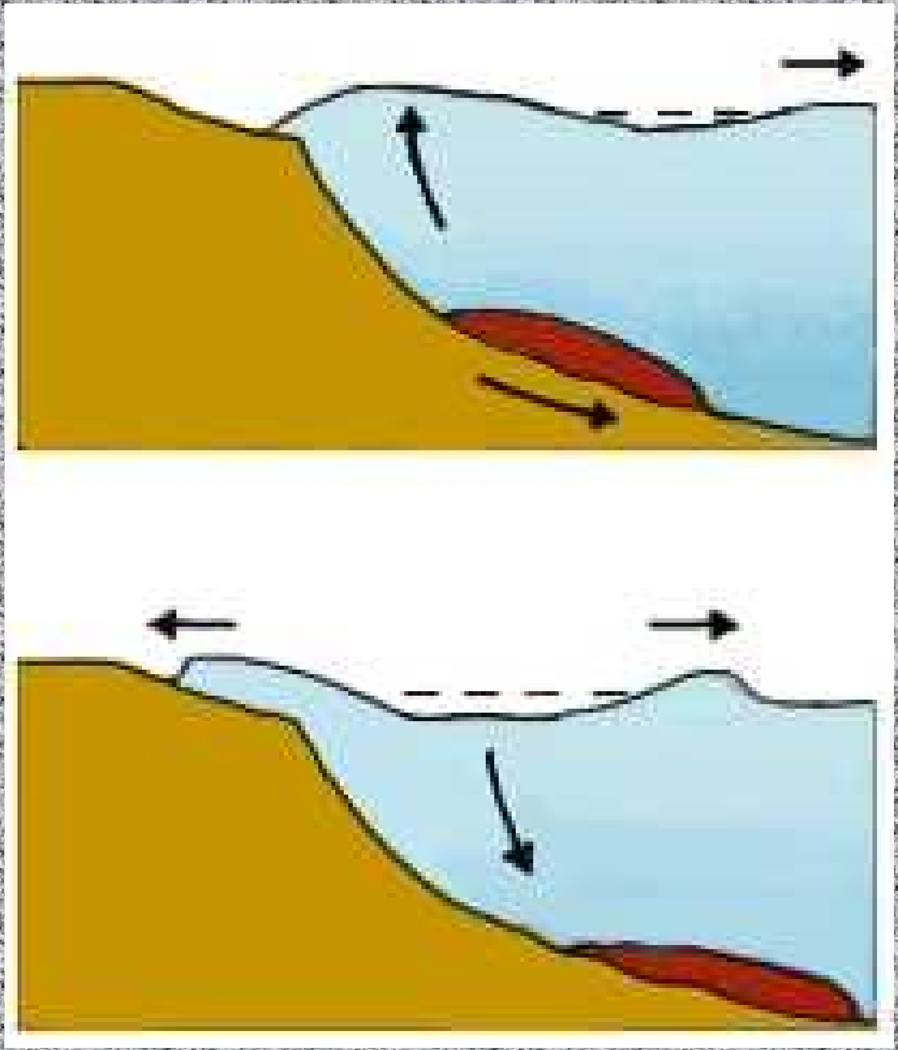
Water receding from shoreline

Ways to create a tsunami

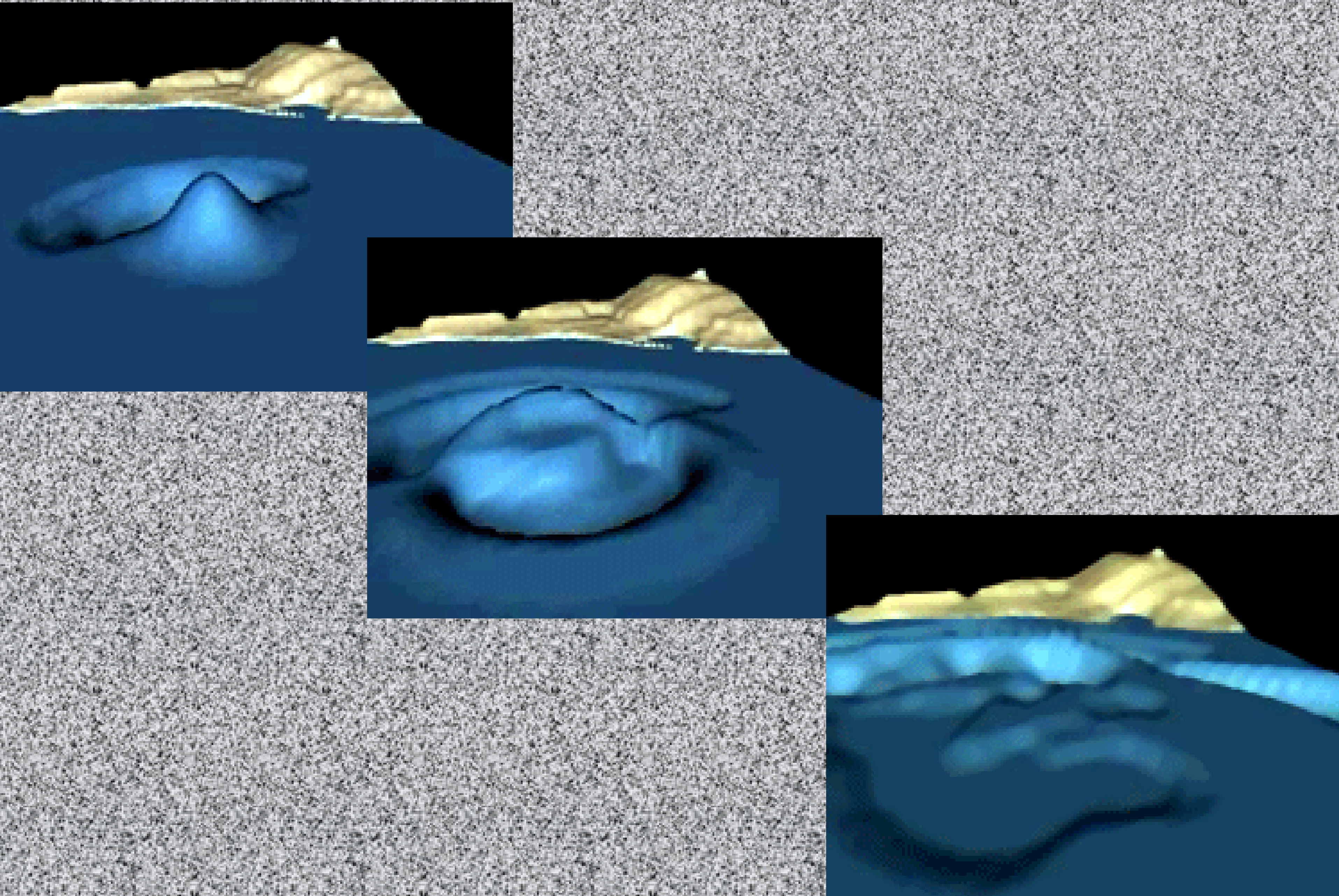
Submarine landslide on edge of slope



Submarine landslide



Simulation of landslide-induced wave



Minimizing the Tsunami Hazard

Detection and warning

- Monitor earthquake zones
- Tsunami warning system
  - Seismographs to detect earthquakes
  - Tidal gauges to determine sea level changes
  - Buoy sensors to detect tsunami in open ocean

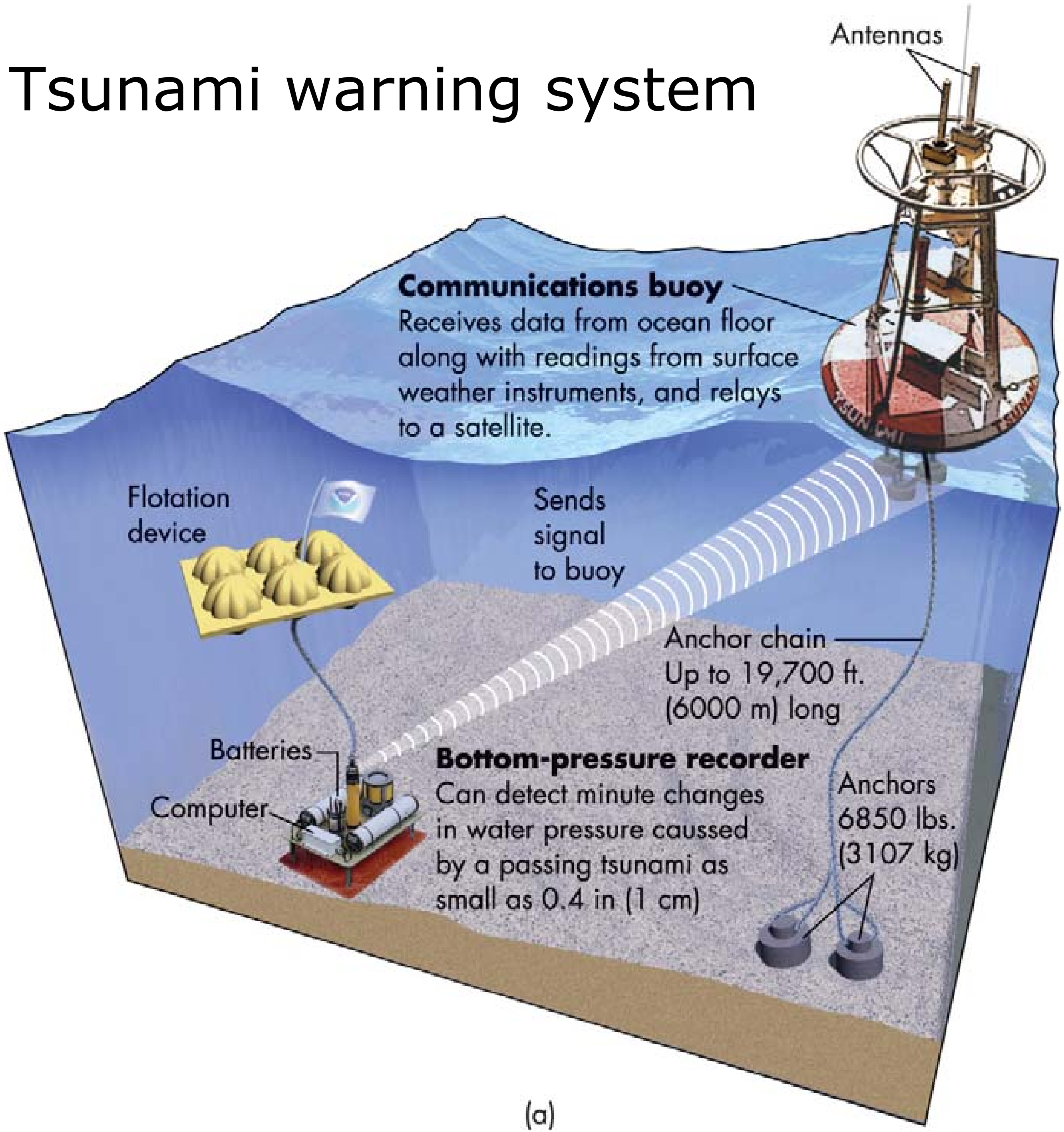
Structural control

- Building codes for susceptible coastline areas

Run-up maps

- Show the height to which water is likely to rise

Tsunami warning system



(a)

Tsunami run-up map

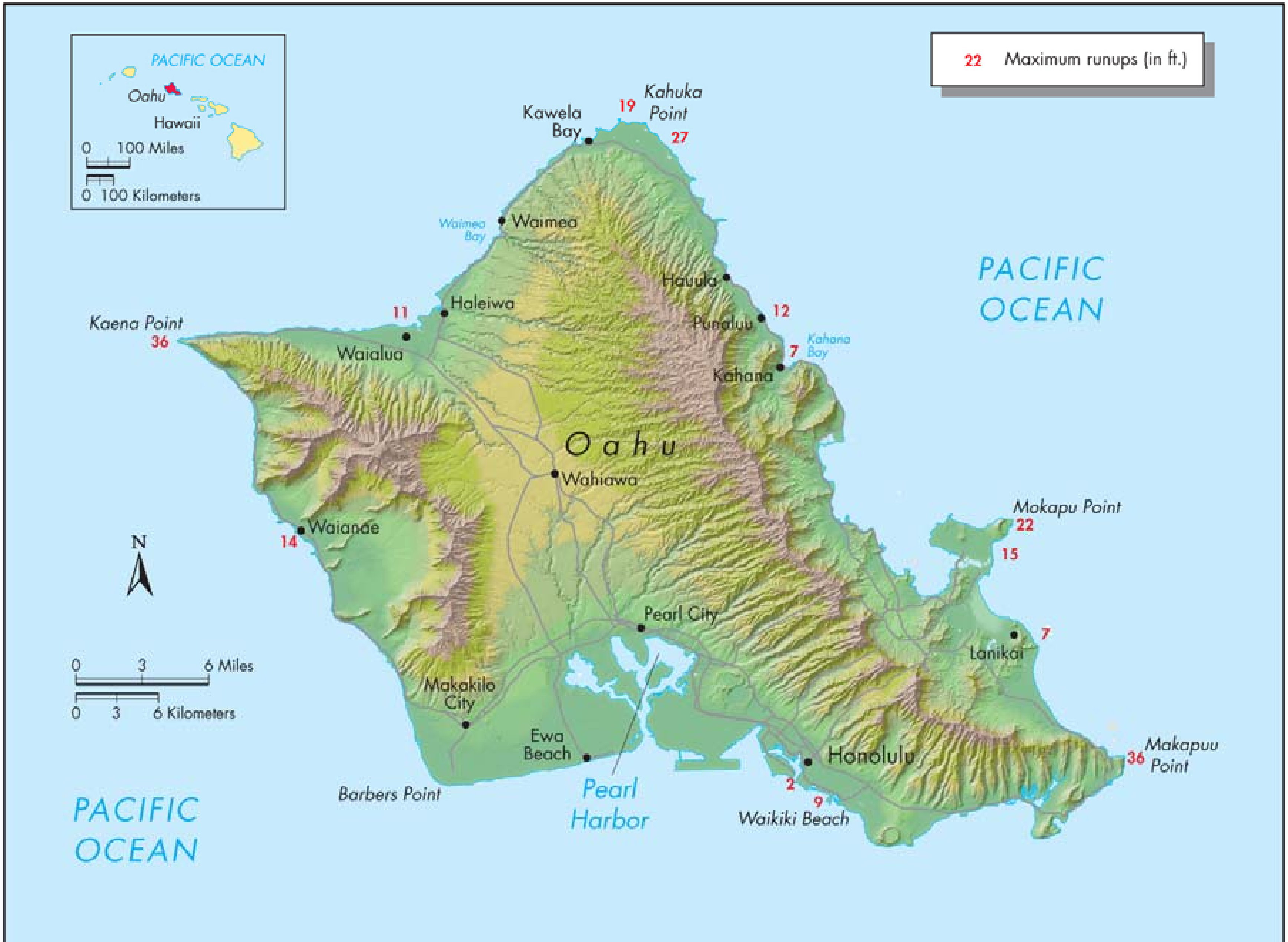
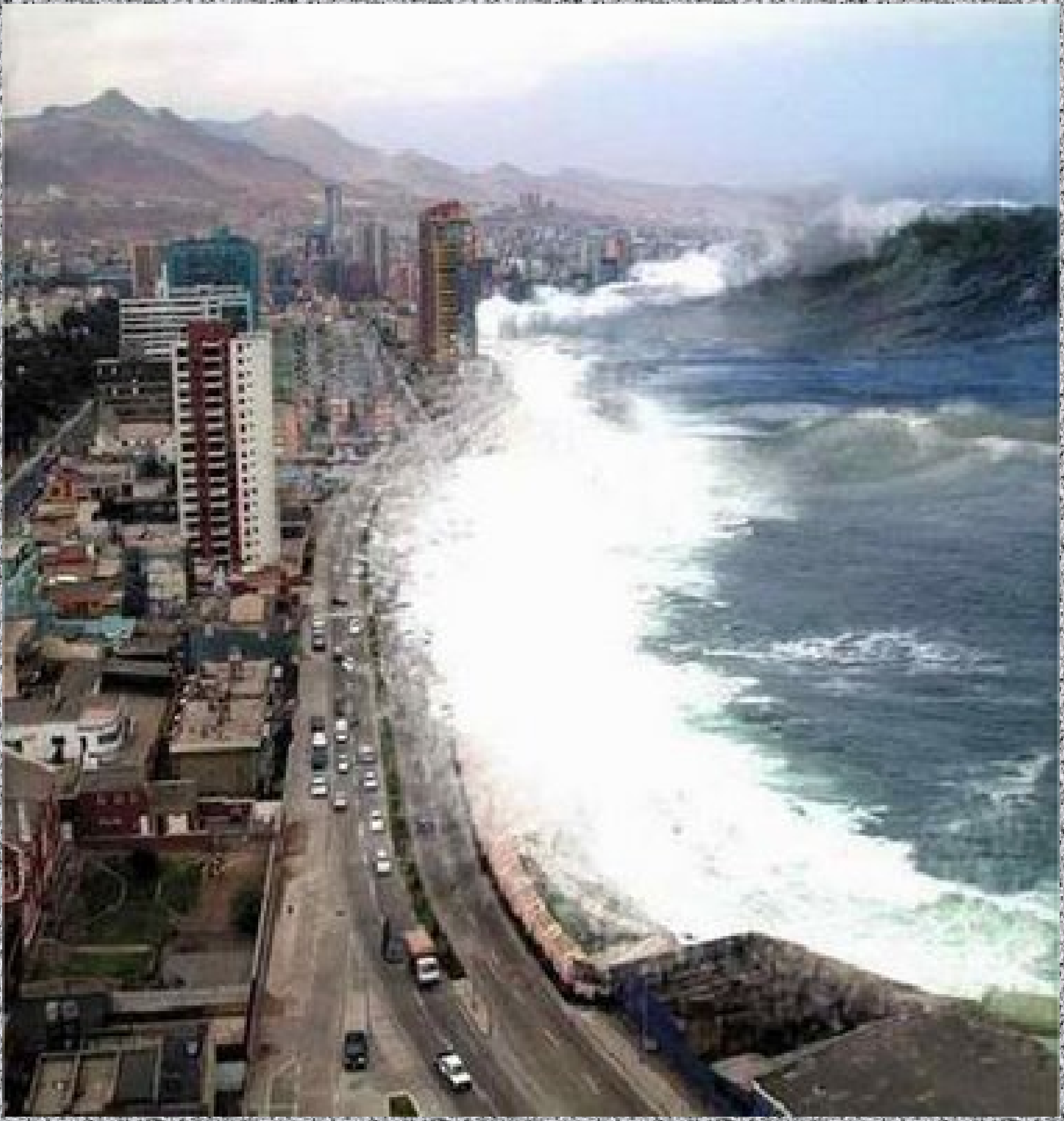


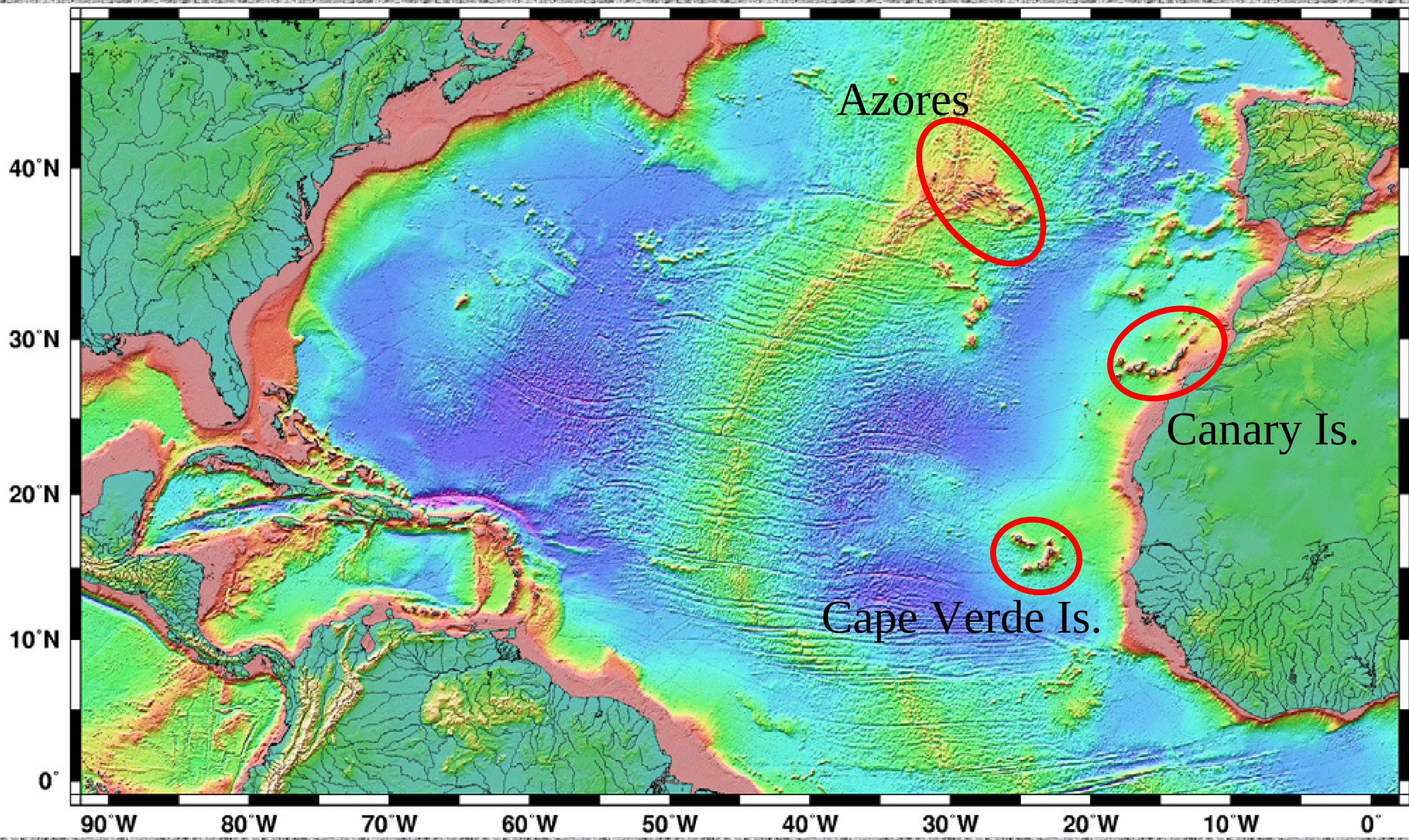
Fig. 10-36b, p. 292

Mega tsunami

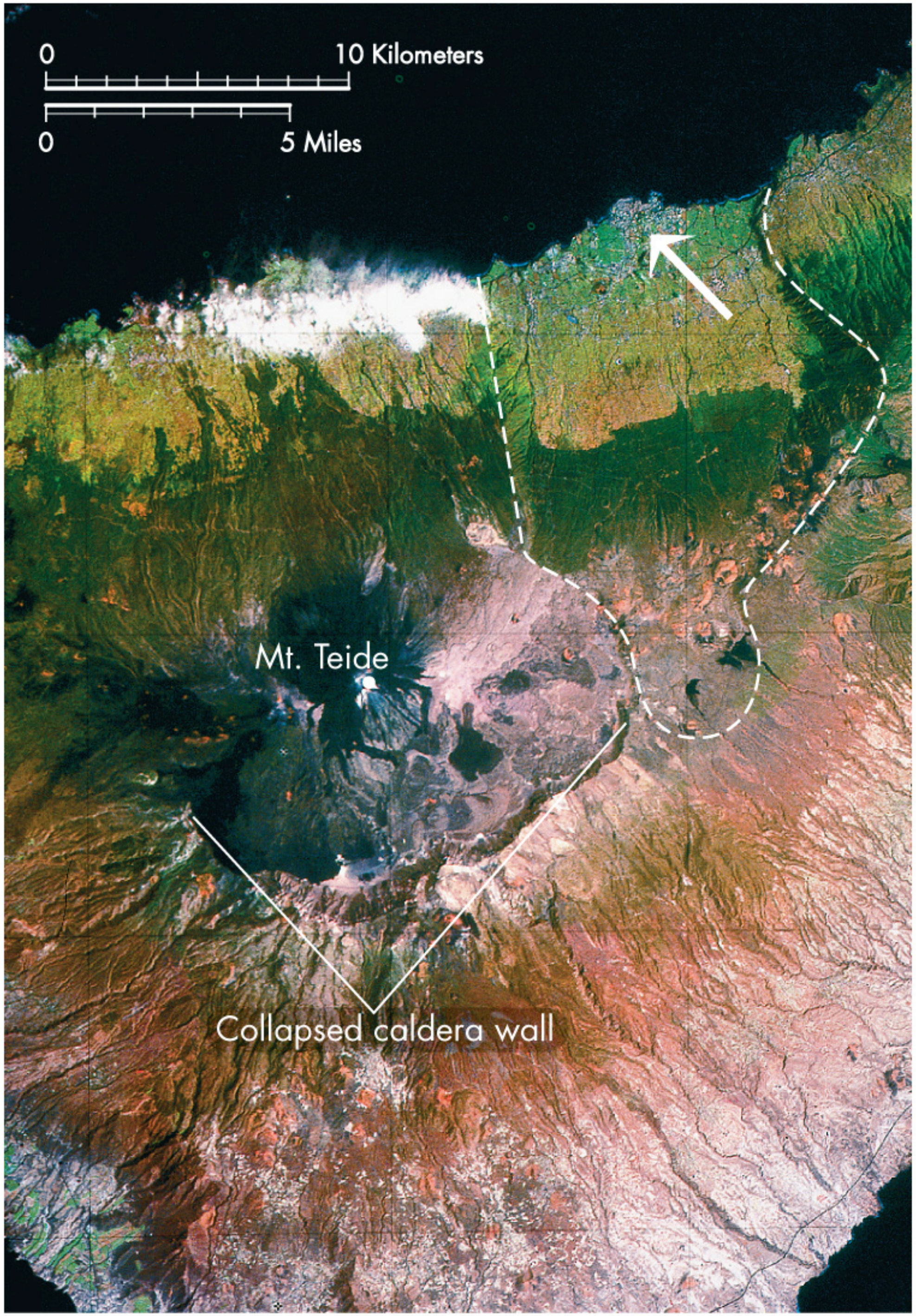


Mega tsunami

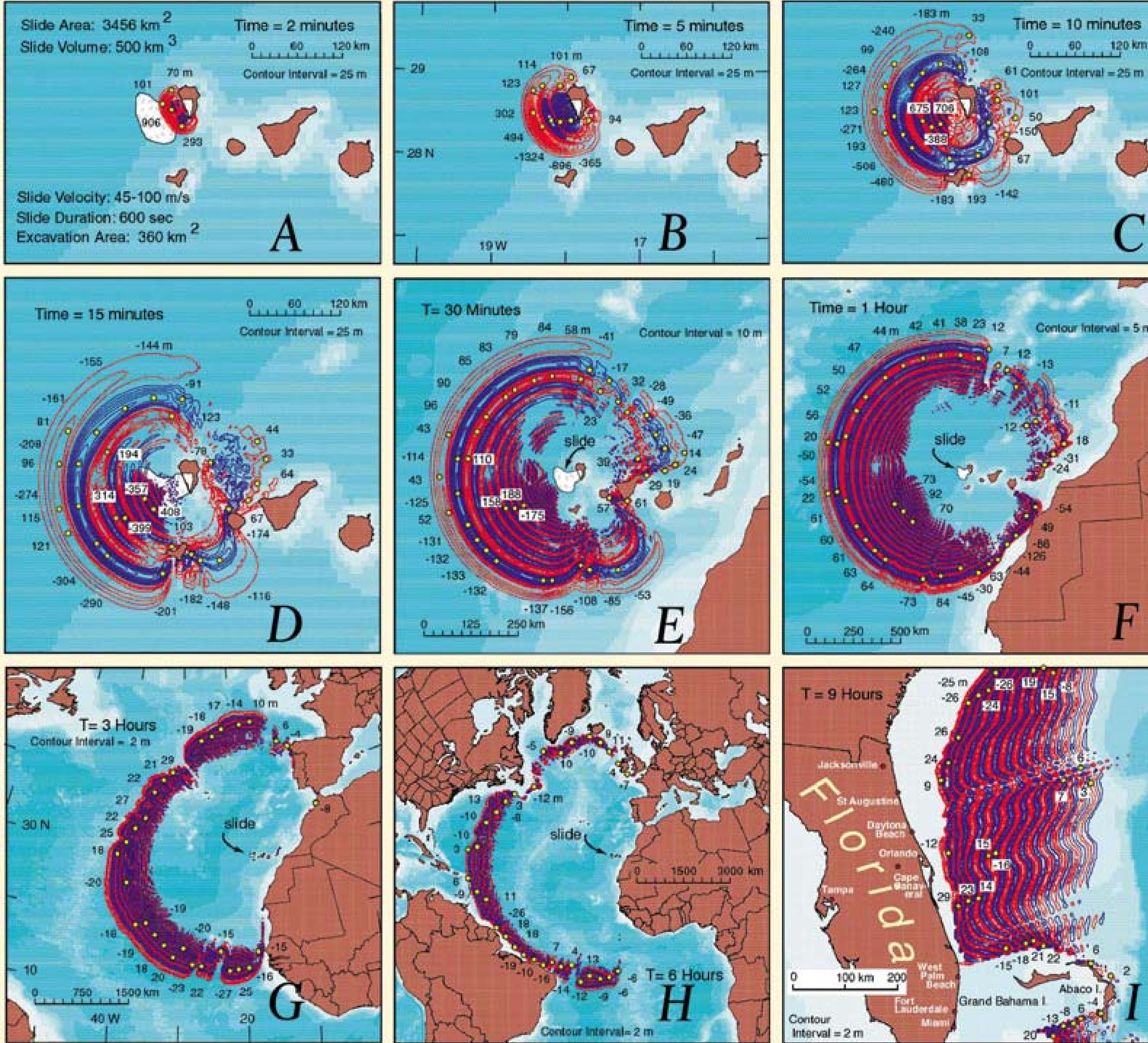
North Atlantic Ocean



Tenerife, Canary Islands

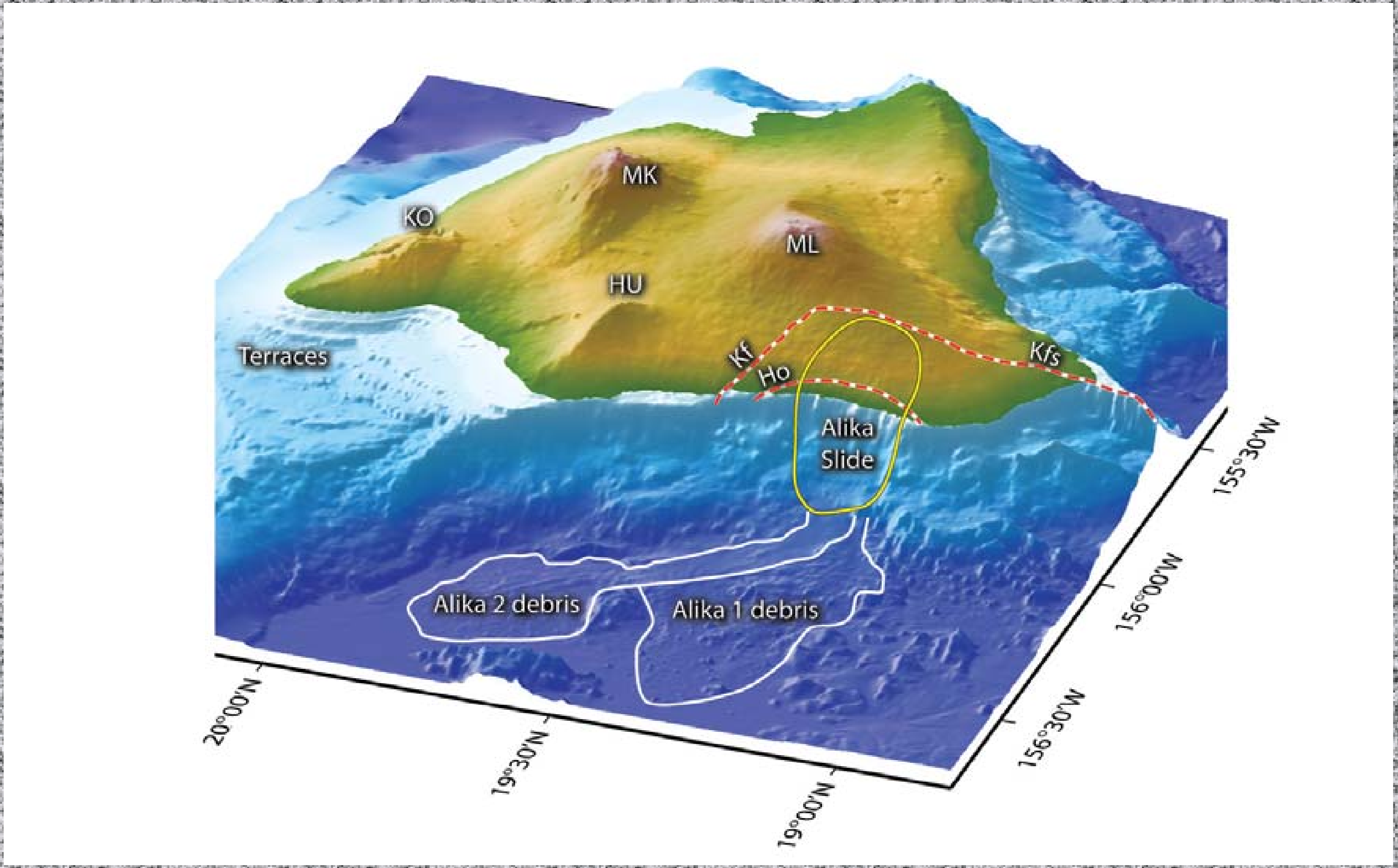


Orotova landslide



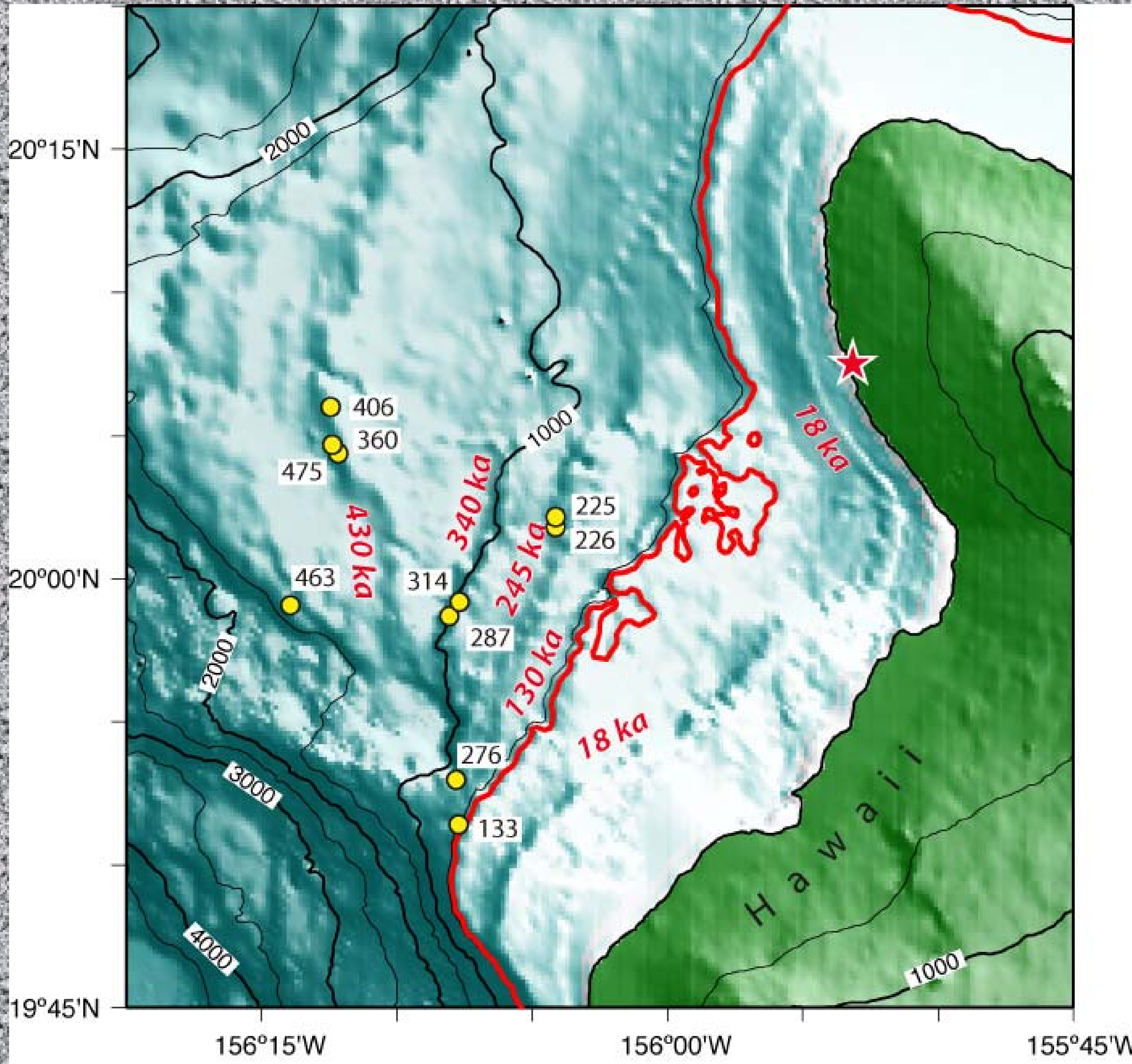
Slide Area: 3456 km 2
Slide Volume: 500 km 3
Time = 2 minutes
0 60 120 km
Contour Interval = 25 m
Slide Velocity: 45-100 m/s
Slide Duration: 600 sec
Excavation Area: 360 km 2
A
Time = 5 minutes
Contour Interval = 25 m
29
28 N
19 W
17
B
Time = 10 minutes
Contour Interval = 25 m
C
Time = 15 minutes
Contour Interval = 25 m
D
T= 30 Minutes
Contour Interval = 10 m
slide
0 125 250 km
E
Time = 1 Hour
Contour Interval = 5 m
slide
0 250 500 km
F
T= 3 Hours
Contour Interval = 2 m
30 N
slide
10
0 750 1500 km
40 W
20
G
slide
0 1500 3000 km
T= 6 Hours
Contour Interval= 2 m
H
T = 9 Hours
Jacksonville
St Augustine
Daytona Beach
Orlando
Cape Canaveral
Tampa
Florida
West Palm Beach
Fort Lauderdale
Miami
Grand Bahama I.
Abaco I.
0 100 km 200
Contour Interval = 2 m
I

Alika submarine landslide



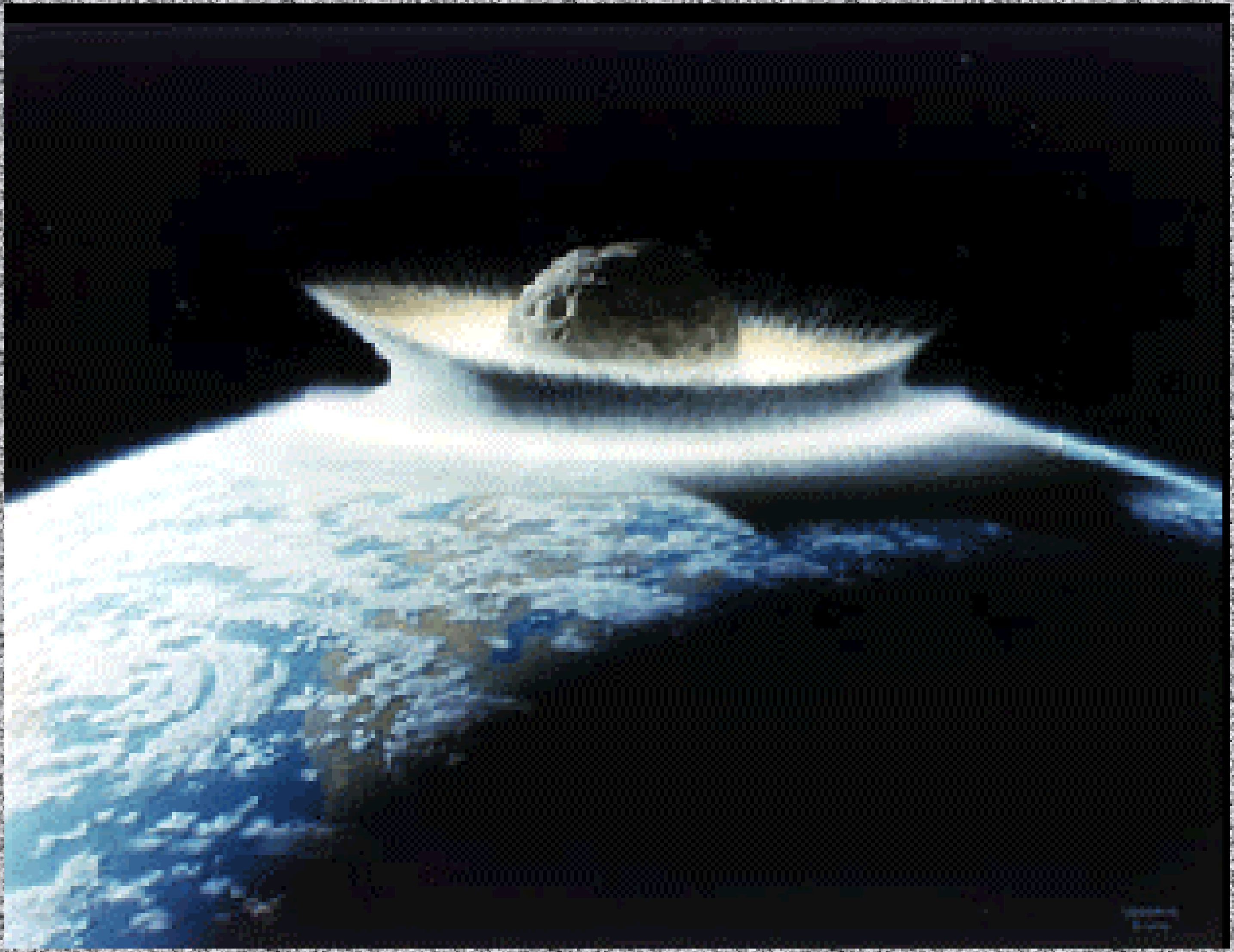
Alika submarine landslide

At least
60 m
of run-up



Drop

Asteroid impact



Volcanoes

Volcanoes occur in what tectonic settings?

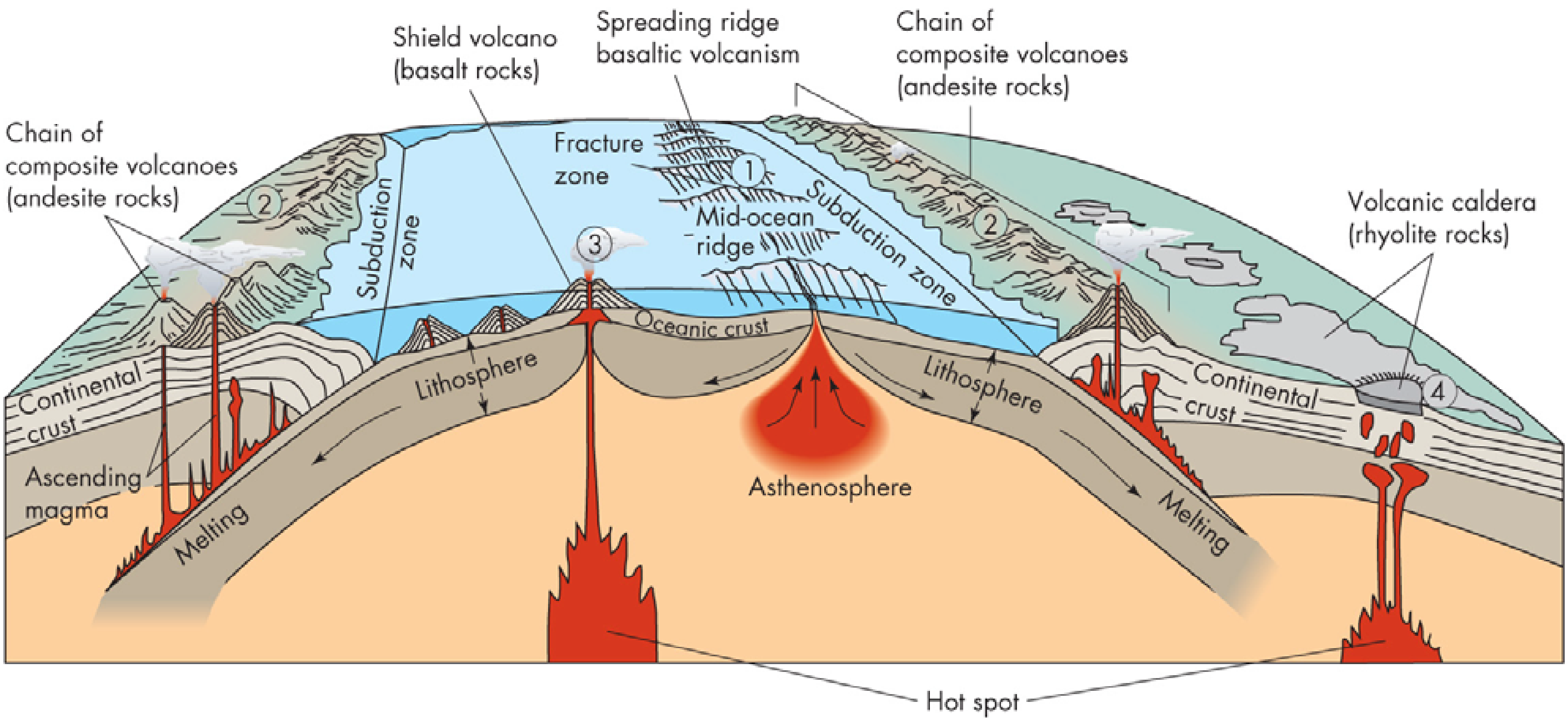
Subduction zones (convergent margins)
- Volcanic island arcs
- Coastal mountain ranges
  - *Difference?*

Hot spots
- Oceanic crust
- Continental crust *Examples?*

Continental rifting zones
- *Example?*

Mid-ocean ridge
- *Is this a problem to people anywhere?*

Tectonic settings for volcanoes



Subduction zones

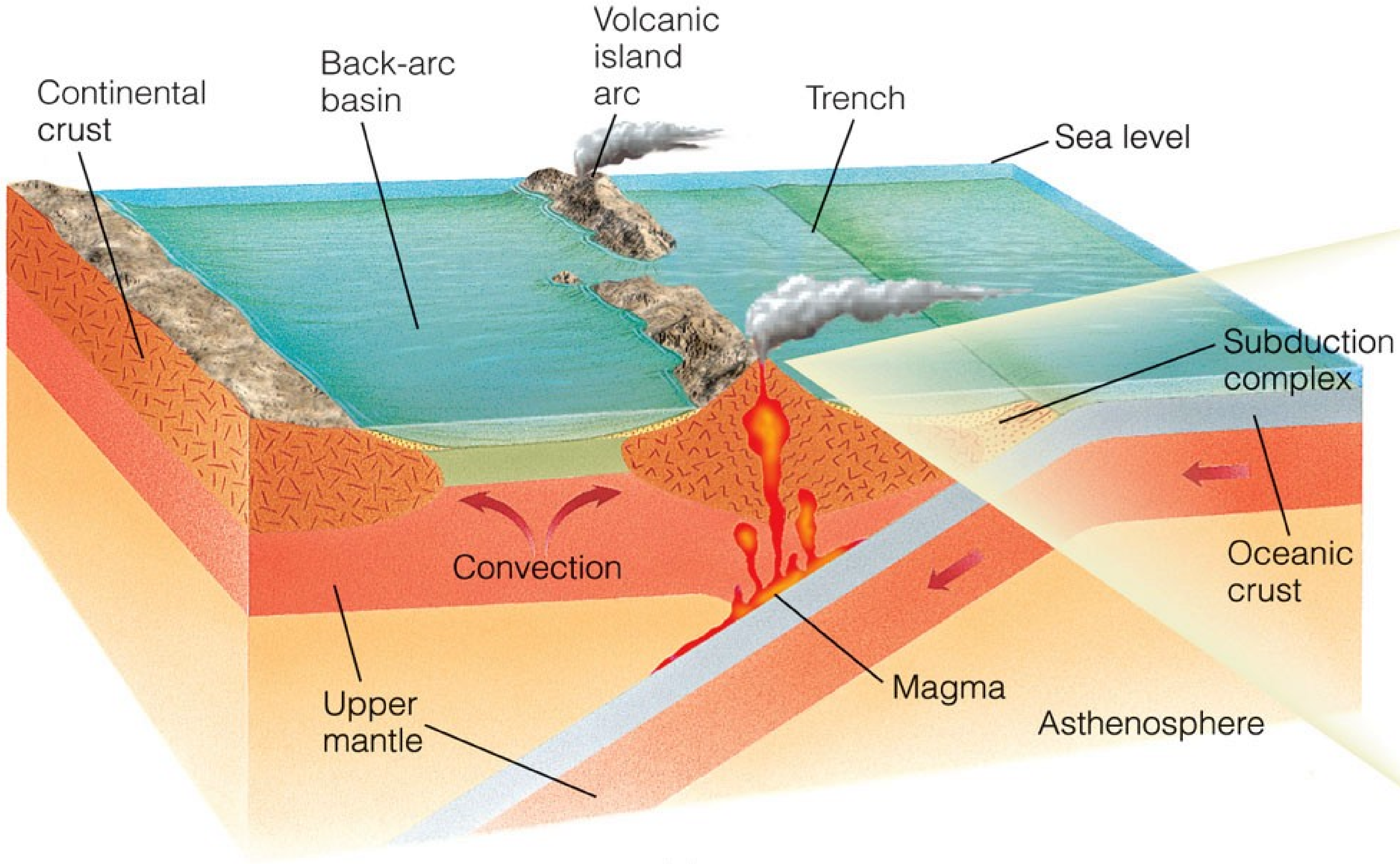
Mid-ocean ridge

Hot spots

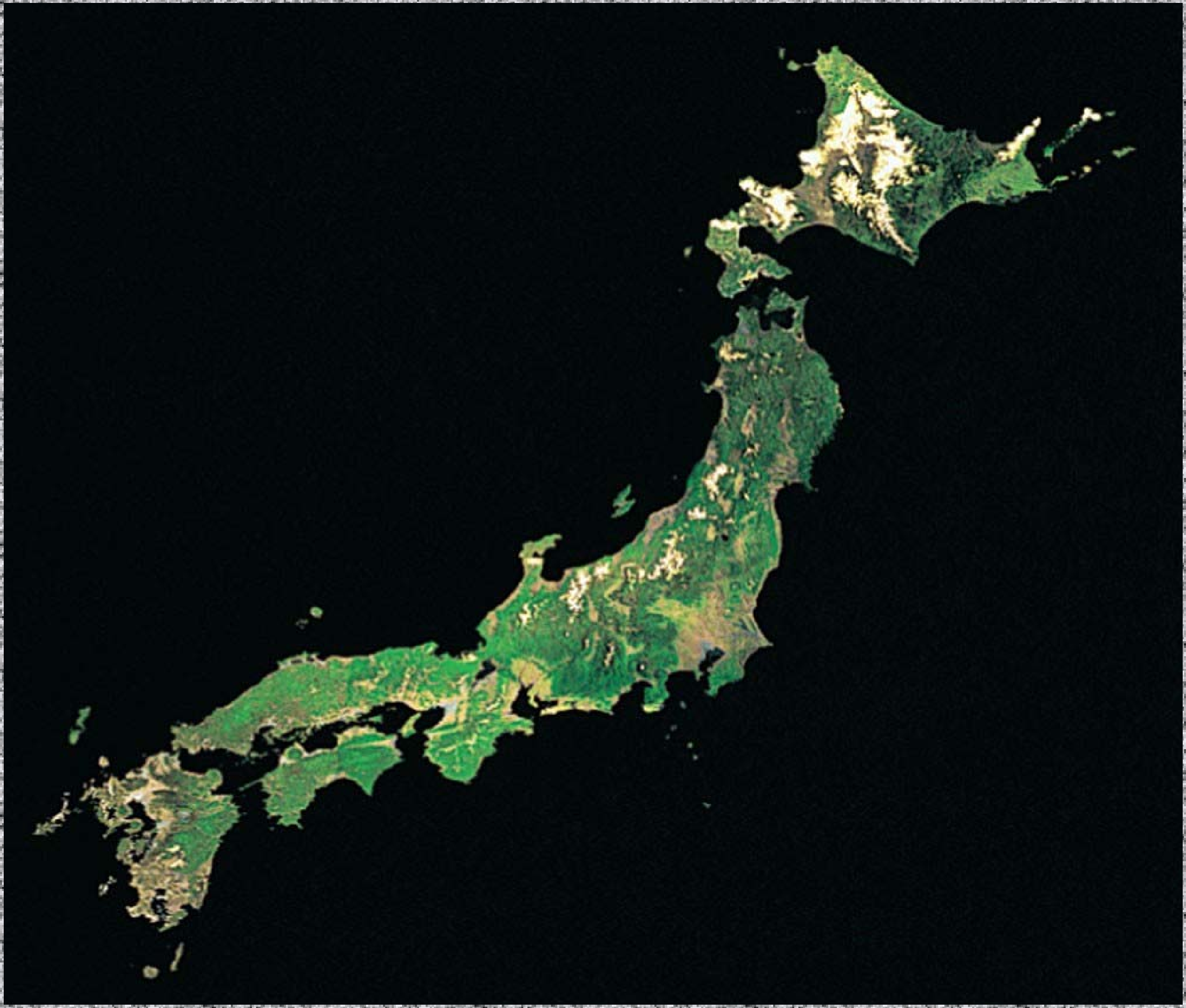
Continental rifting

Where, geographically, are most of the volcanoes?

Volcanic island arc An example is….



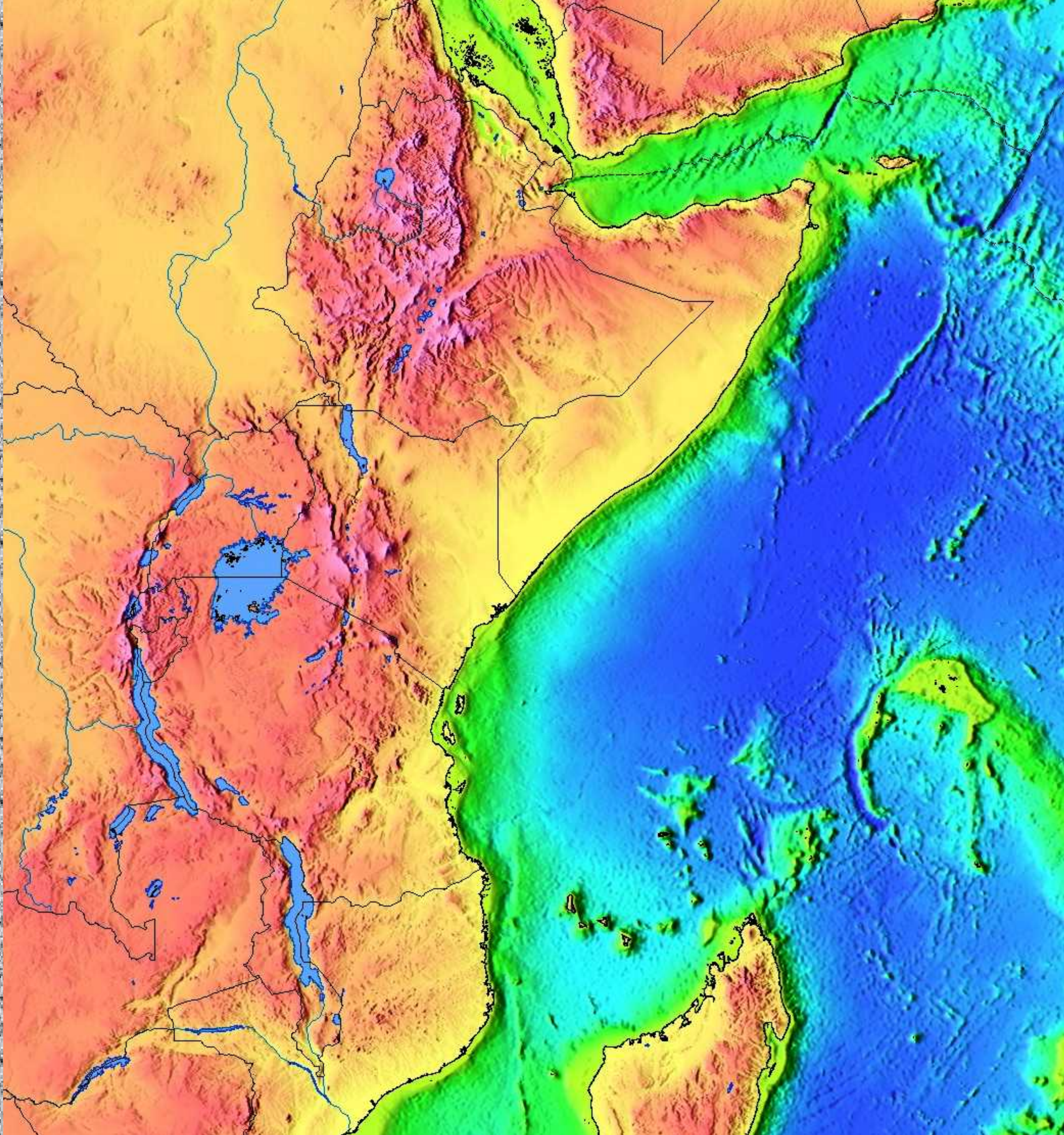
Volcanic island arc – Japan



Where?

What feature?

Name of a famous volcano?



Mt Kilimanjaro

Mantle plumes and continental rifting

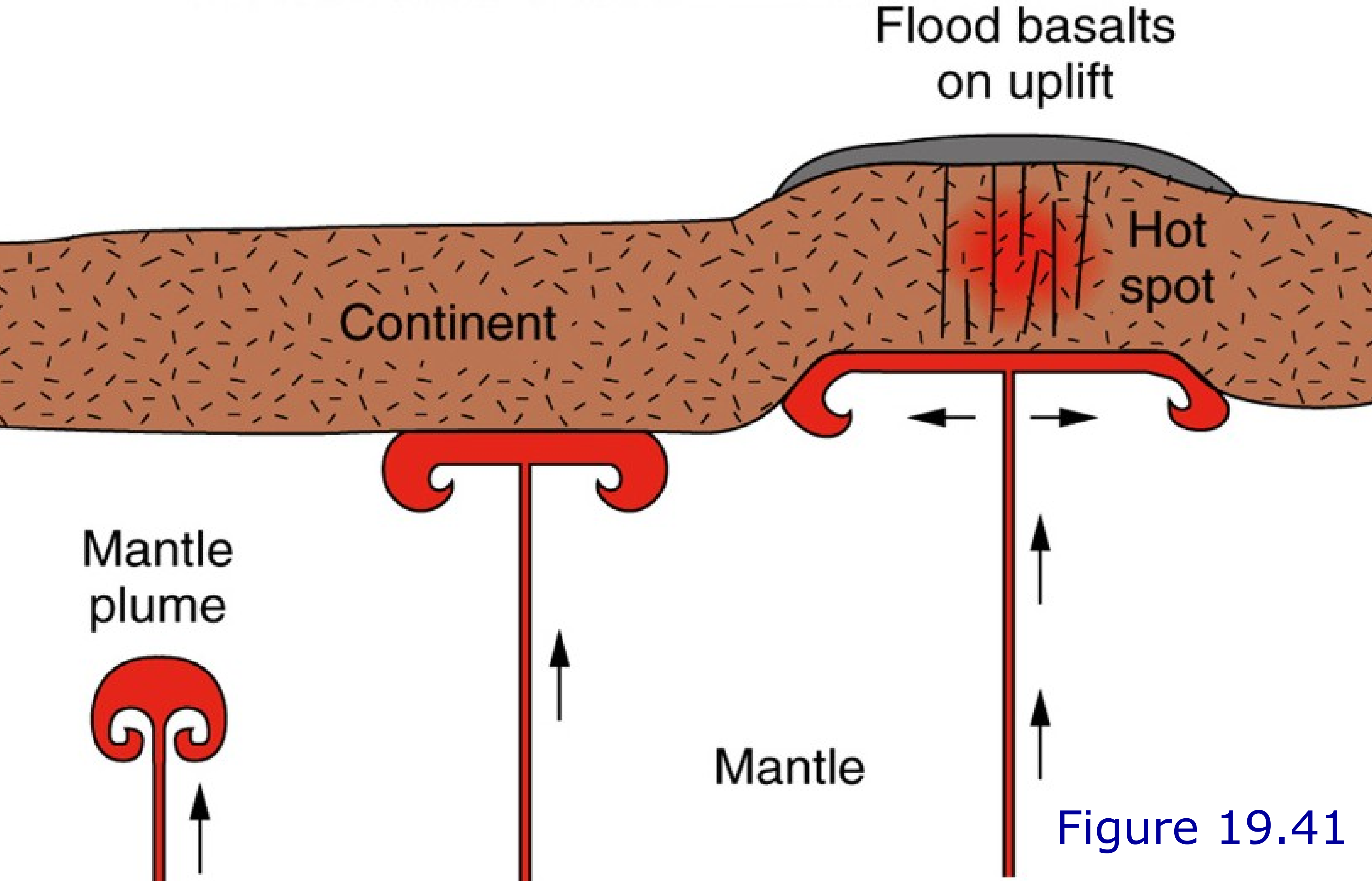
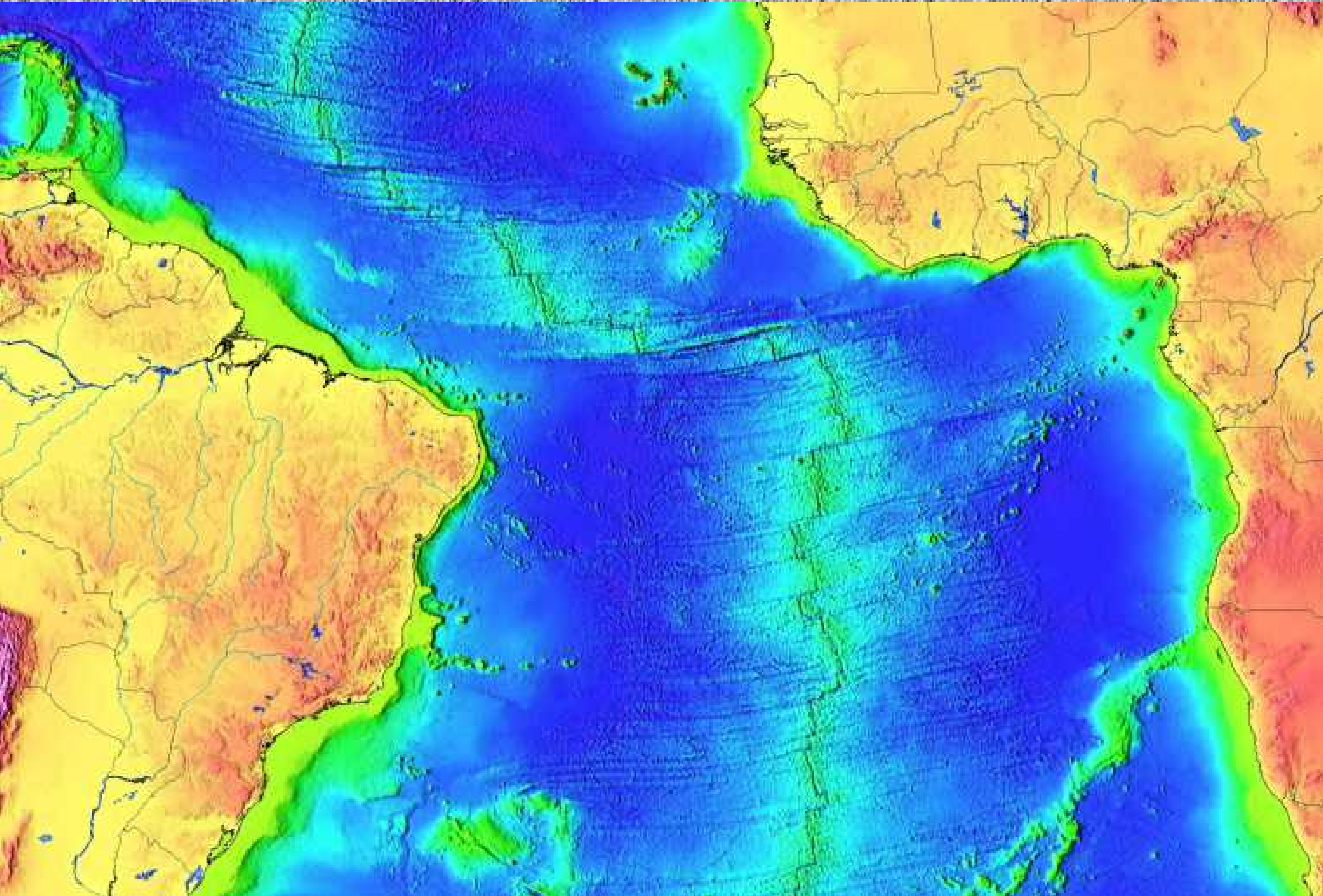
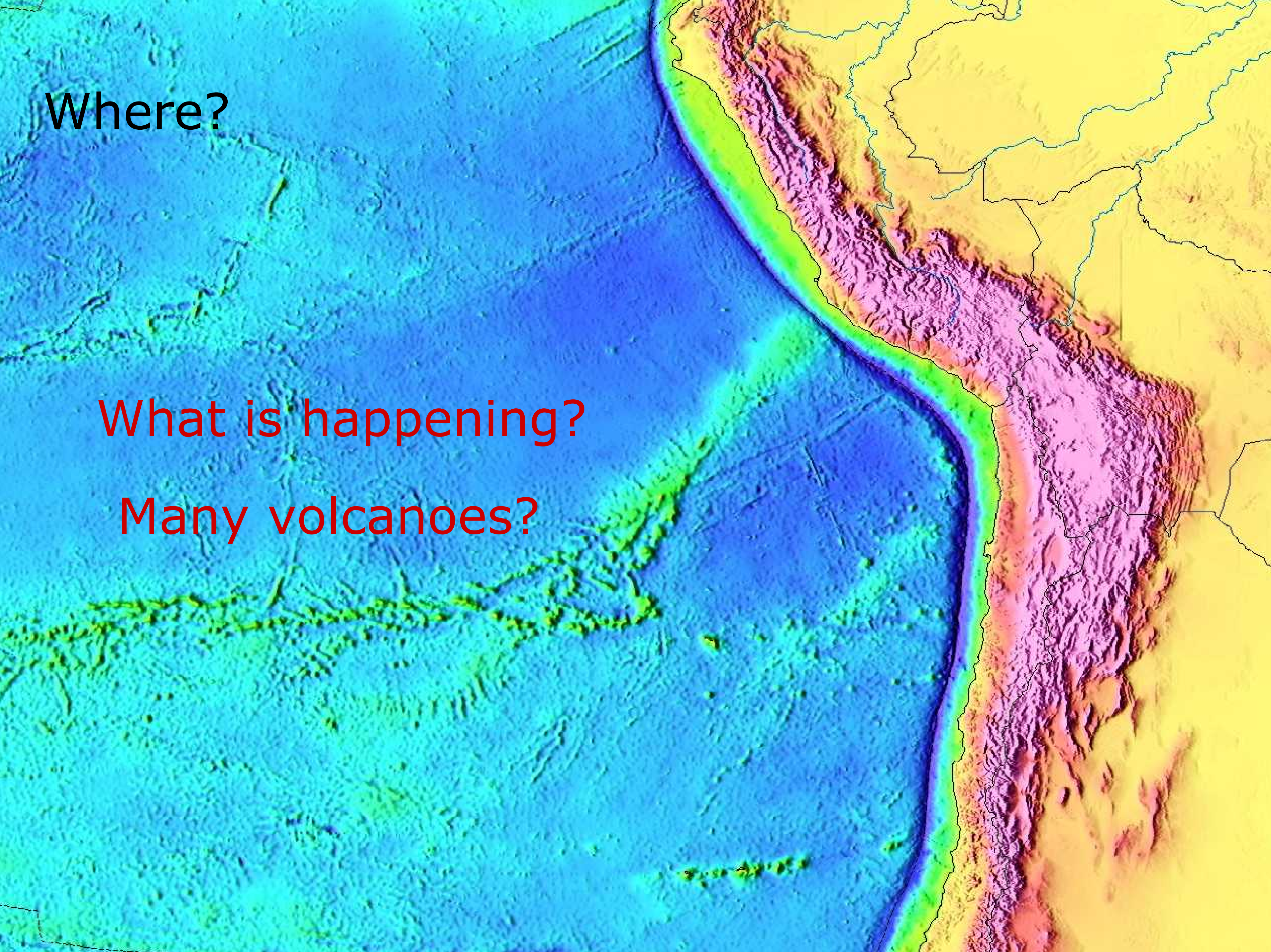


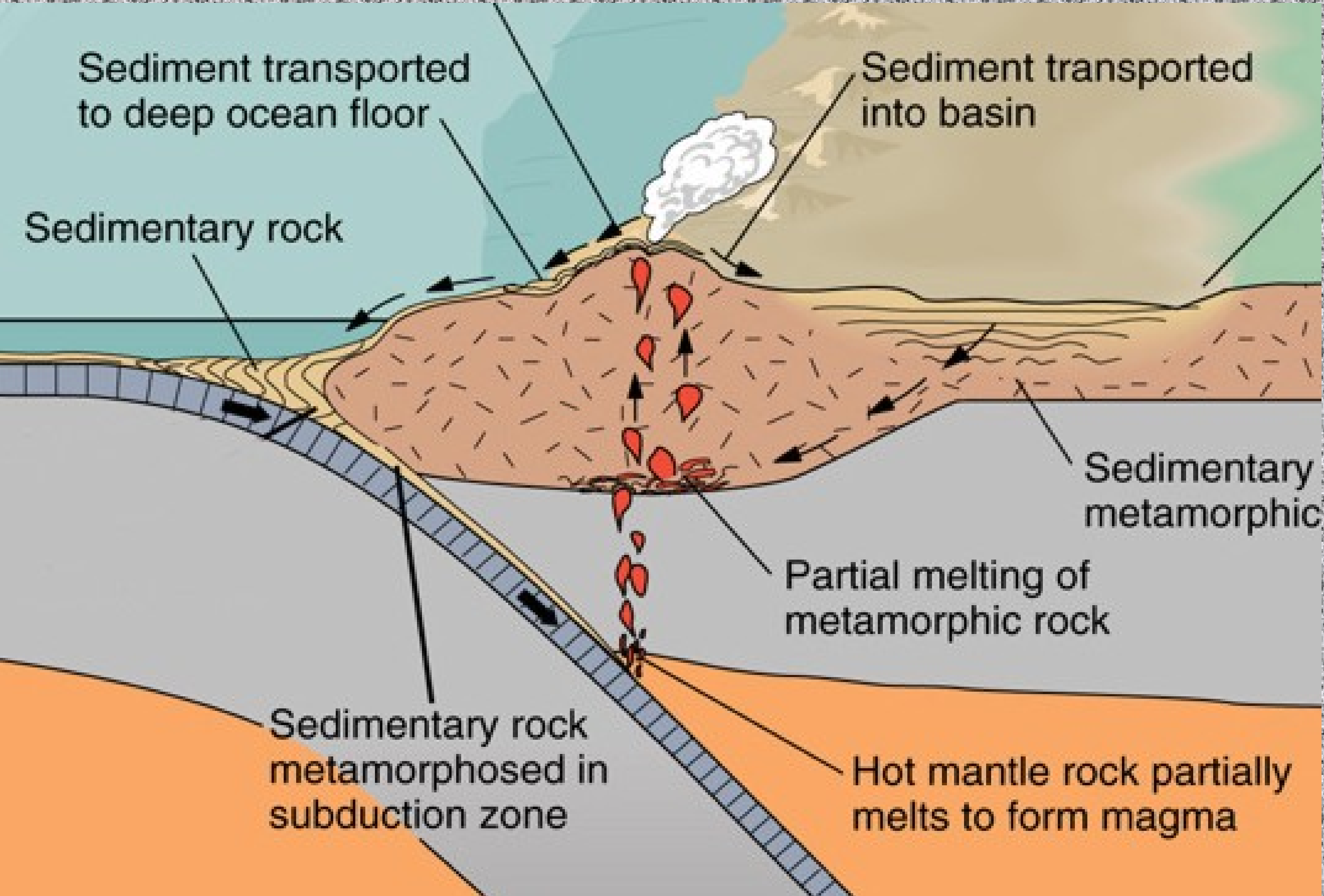
Figure 19.41

Which ocean?   Many active volcanoes?




Where?
What is happening?
Many volcanoes?

Subduction zone processes



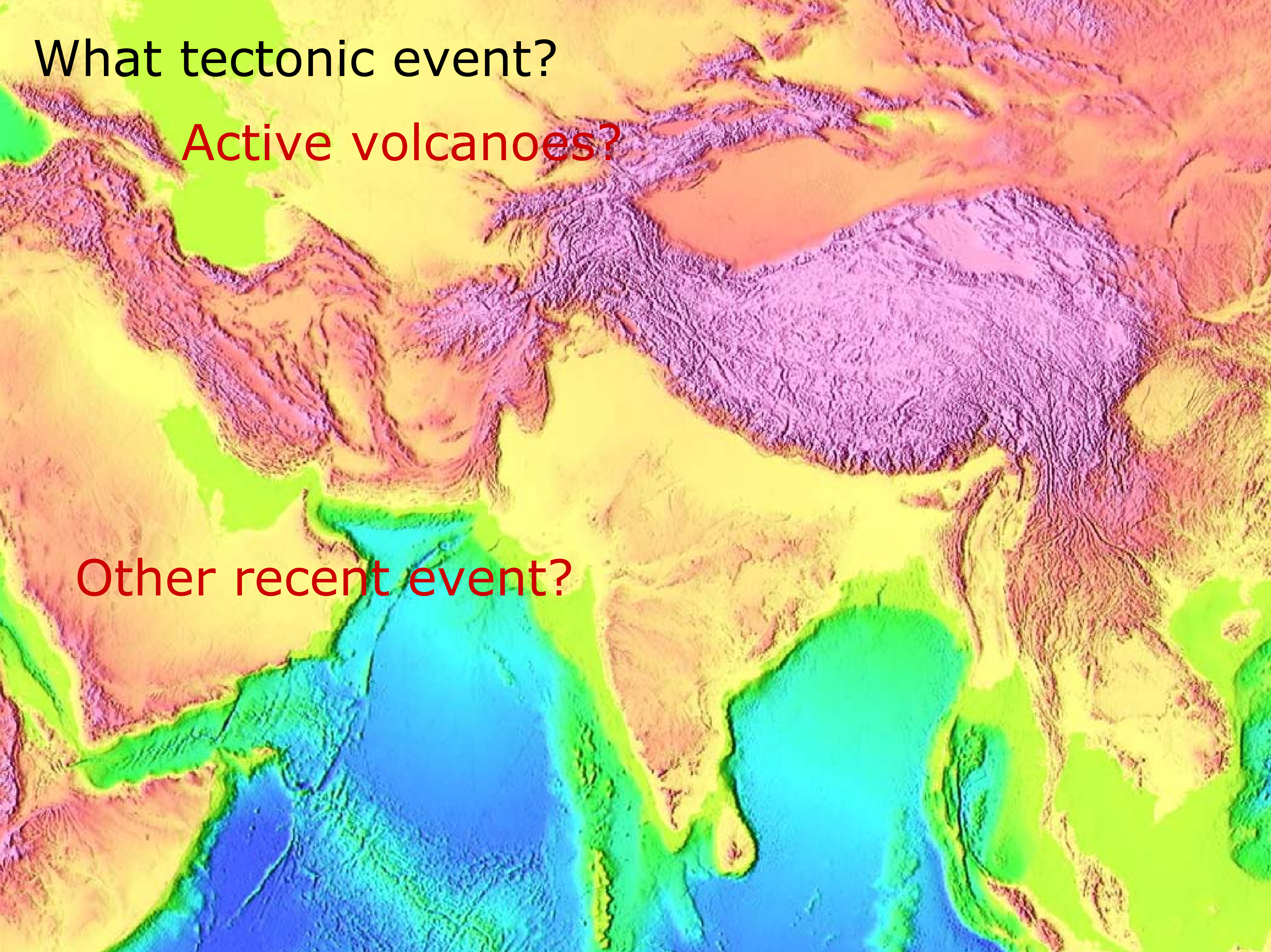
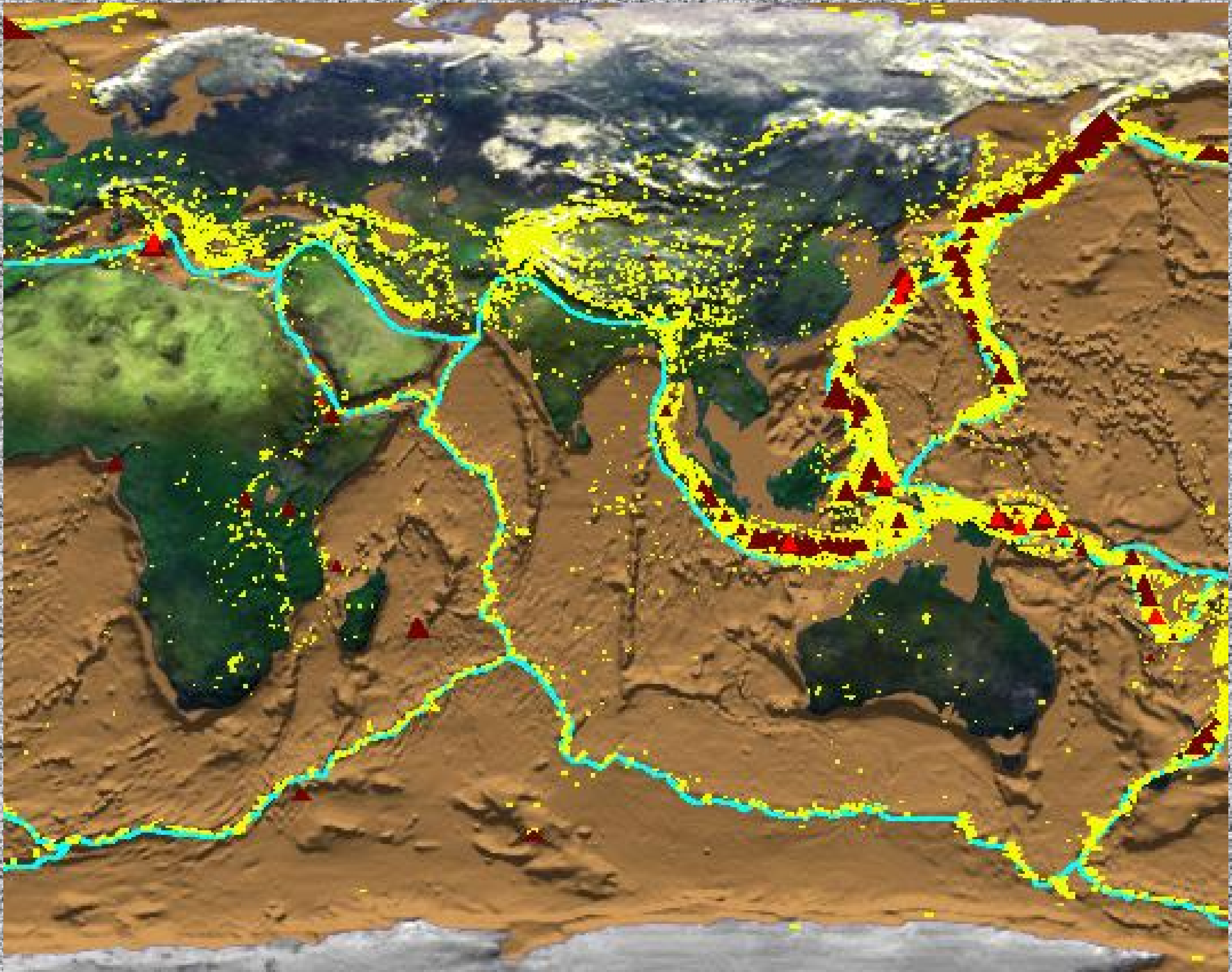

What tectonic event?
Active volcanoes?
Other recent event?

Plate boundaries, volcanoes, & earthquakes

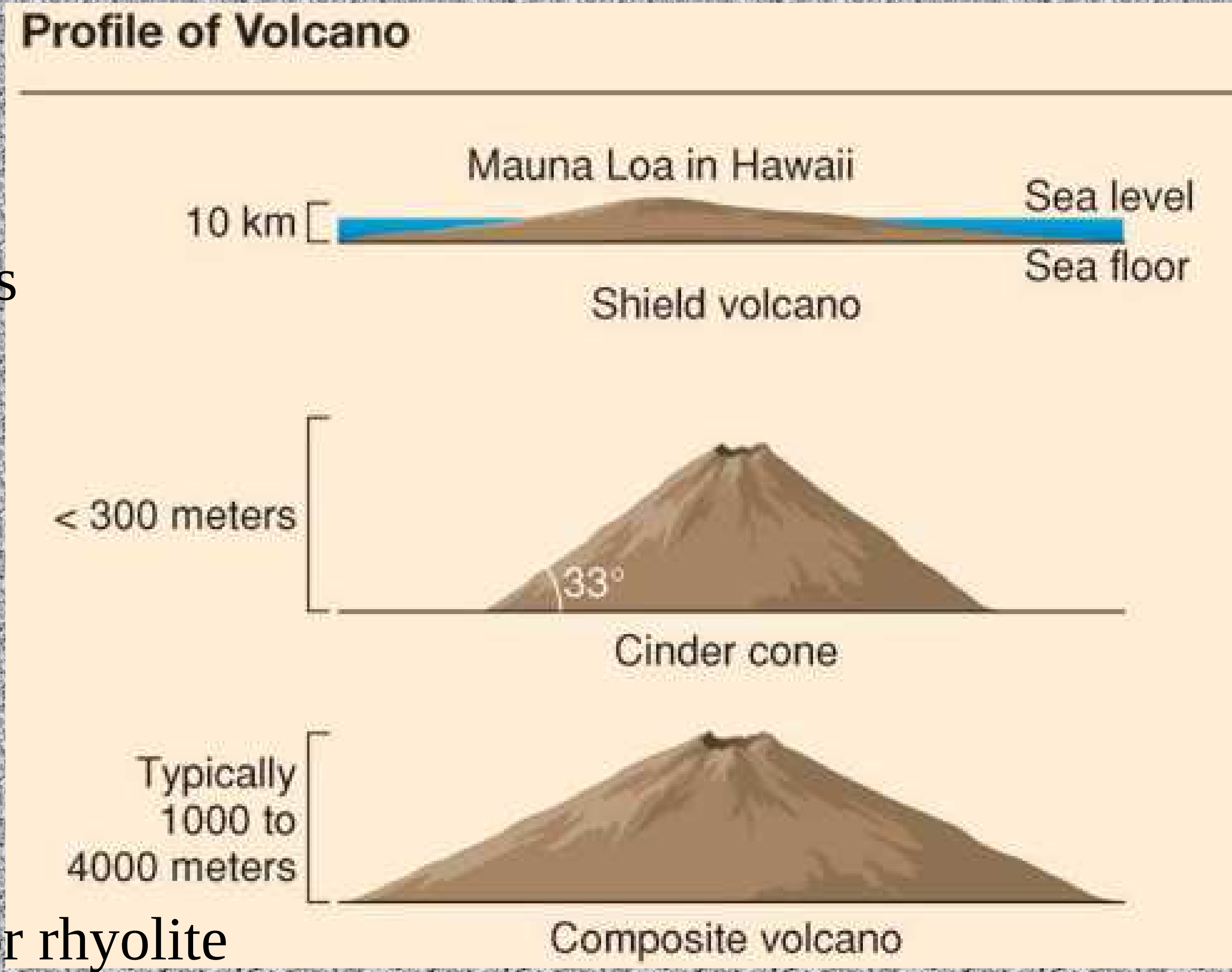


Types of volcanoes

Shield
basalt flows

Cinder
coarse ash

Composite
layered
Andesite or rhyolite



Which volcanoes flow?

Basaltic lava flows easily

Where could this be?

Which volcanoes explode?

- Rhyolitic and andesitic lavas tend to explode
  - water & gasses under pressure, viscous magma

Granite – Diorite – Gabbro

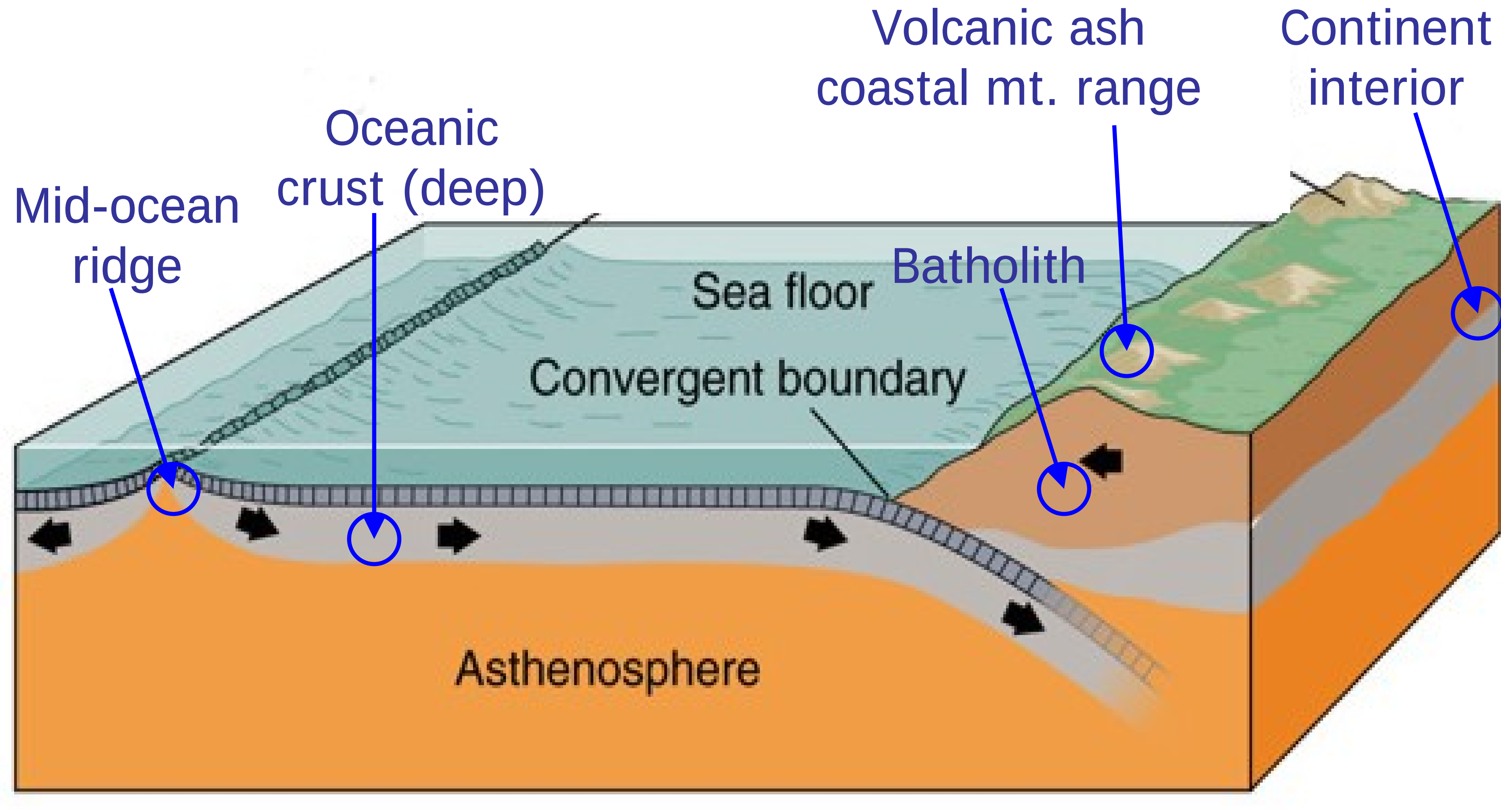
The EXTRUSIVE equivalent igneous rocks?

Rhyolite Andesite Basalt

Composition and Texture

Magma type	Coarse grained	Fine grained
Mafic (from mantle)	Gabbro	Basalt
Intermediate (mixture)	Diorite	Andesite
Felsic (continents)	Granite	Rhyolite

Tectonics & types of igneous rocks



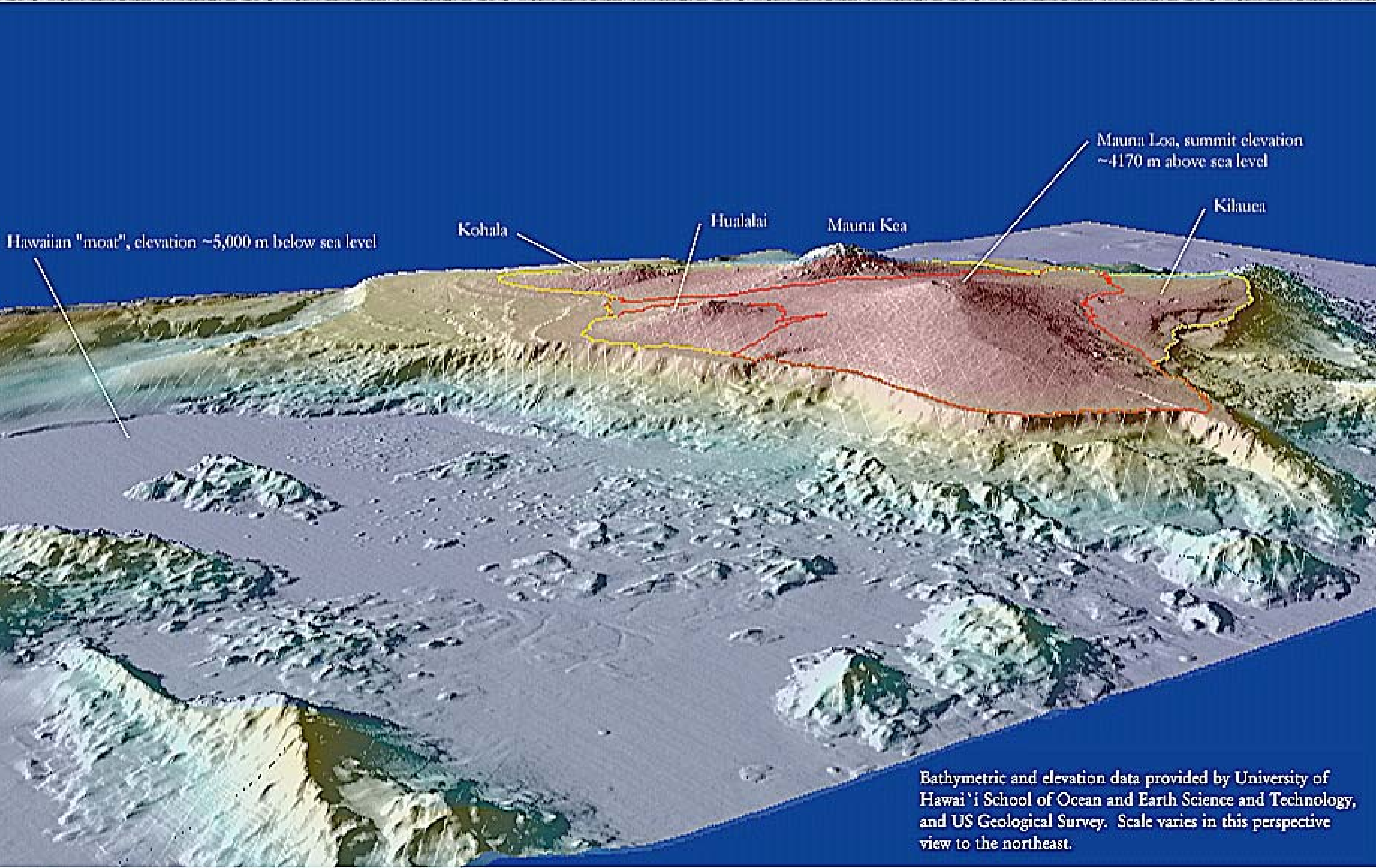
Which volcano is more likely to erupt explosively?

Think about the tectonic setting of each, and the type of magma

Mt. Fuji, Japan

Mauna Loa, Hawaii

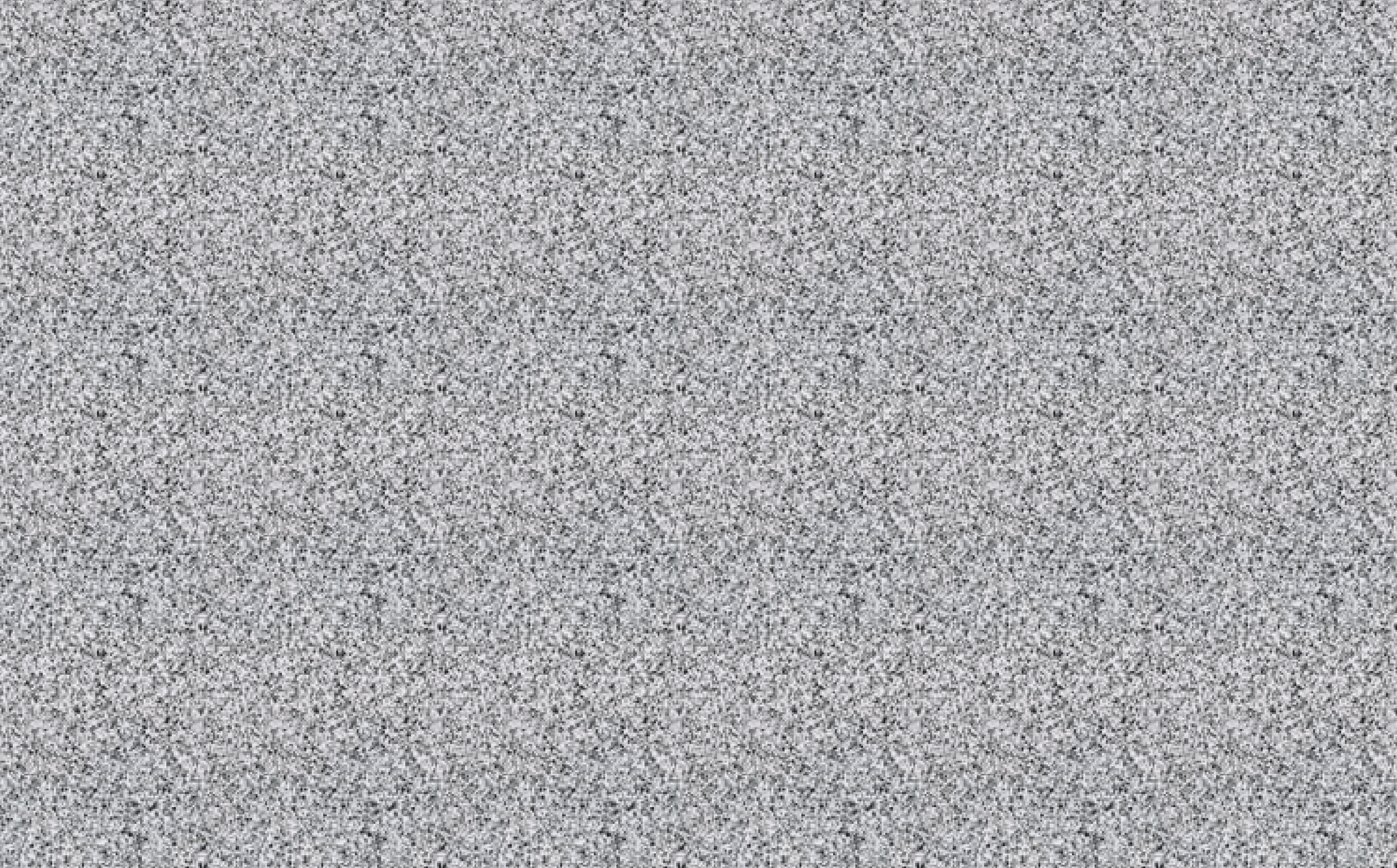
View of the Big Island of Hawaii



Mauna Loa, Hawaii


Mt. Fuji, Japan

Geography: Where on North America are most of the active volcanoes?

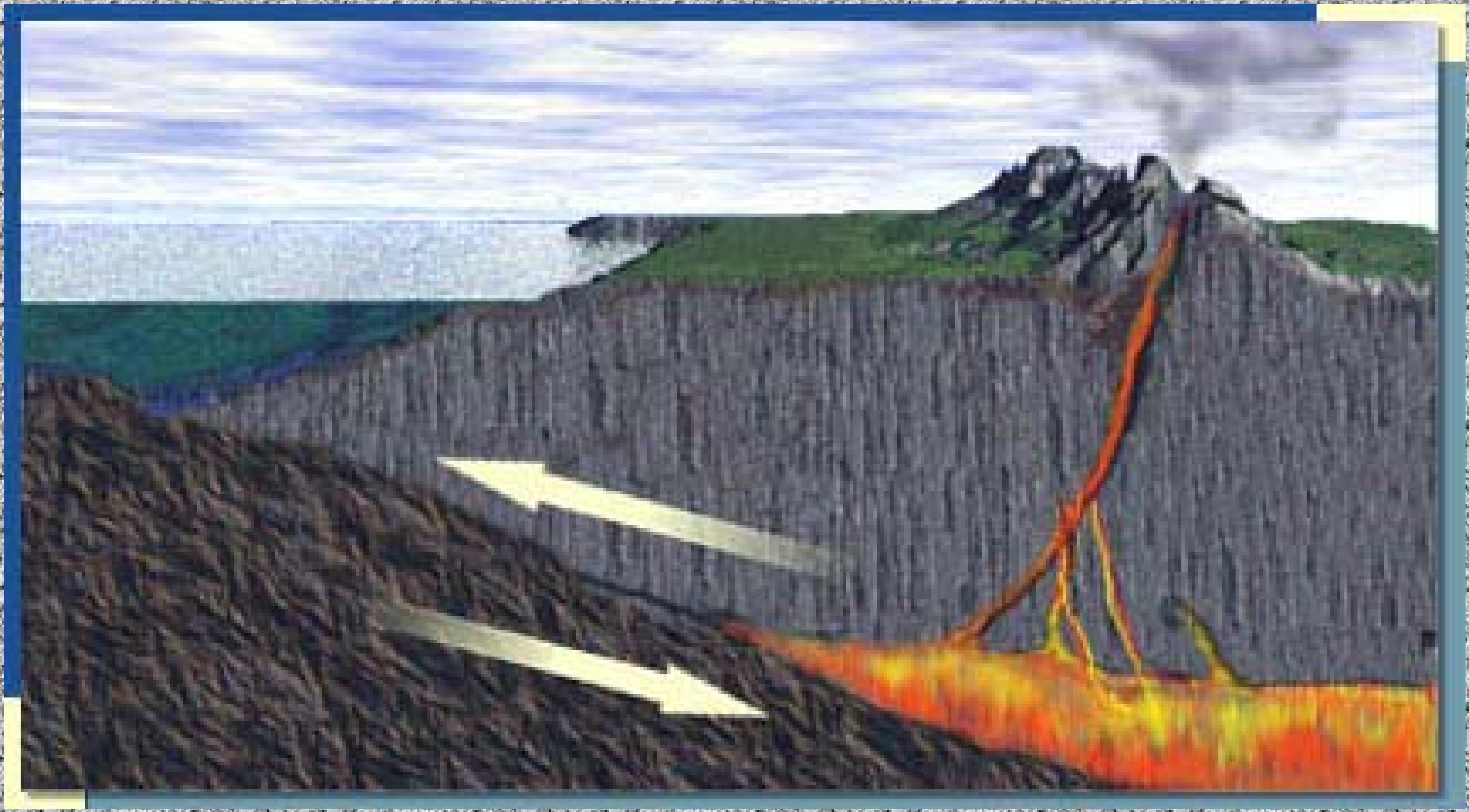


Cascades volcanoes of the Pacific Northwest

Subduction of Juan de Fuca plate

Volcanoes produced by subduction

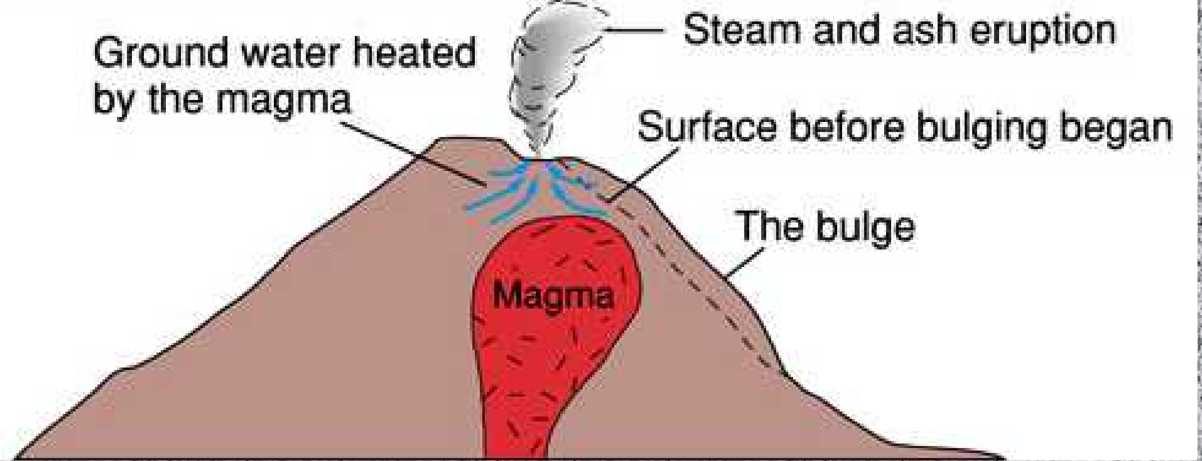
Juan de Fuca plate is young, hot, low density

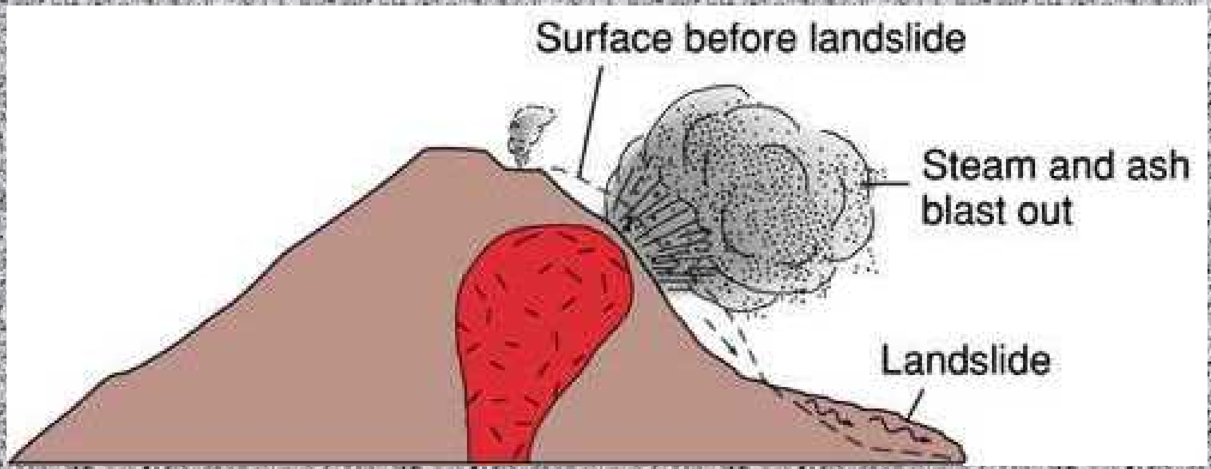


The Cascades, Washington and Oregon

Mount St. Helens before eruption 1980

Mt. St. Helens eruption sequence





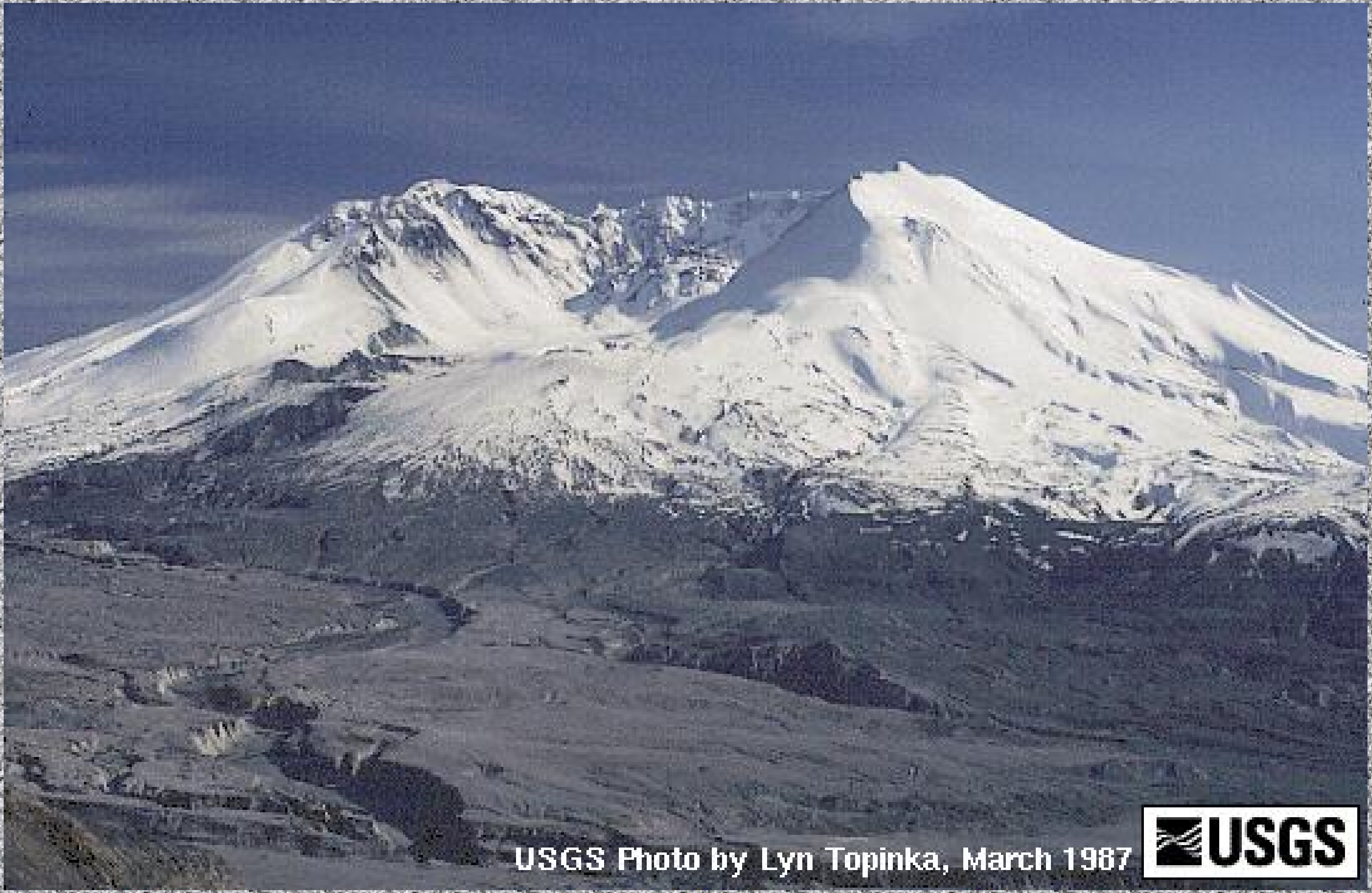
Bulge on NE flank prior to eruption

Initial blast – 500x the Hiroshima bomb

Mount St. Helens

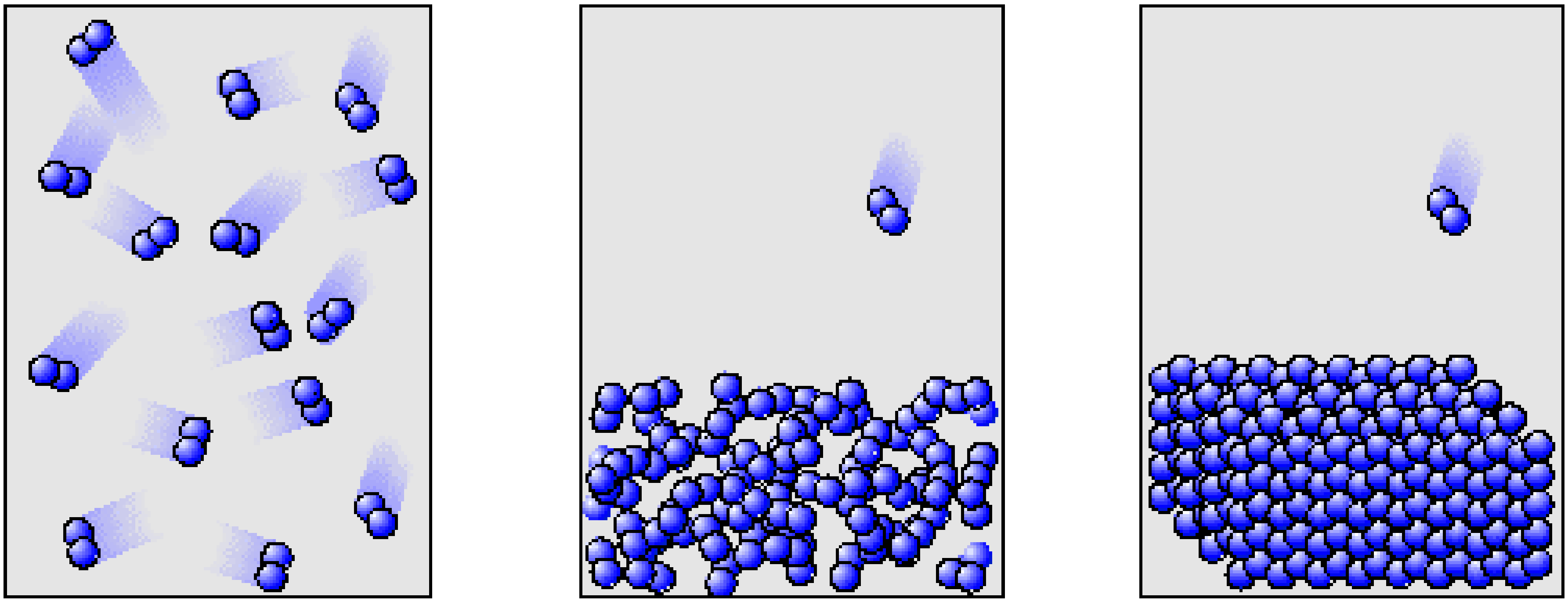
Mount St. Helens

After eruption (7 years later)



States (or Phases) of Matter

GAS LIQUID SOLID



gas
disorder

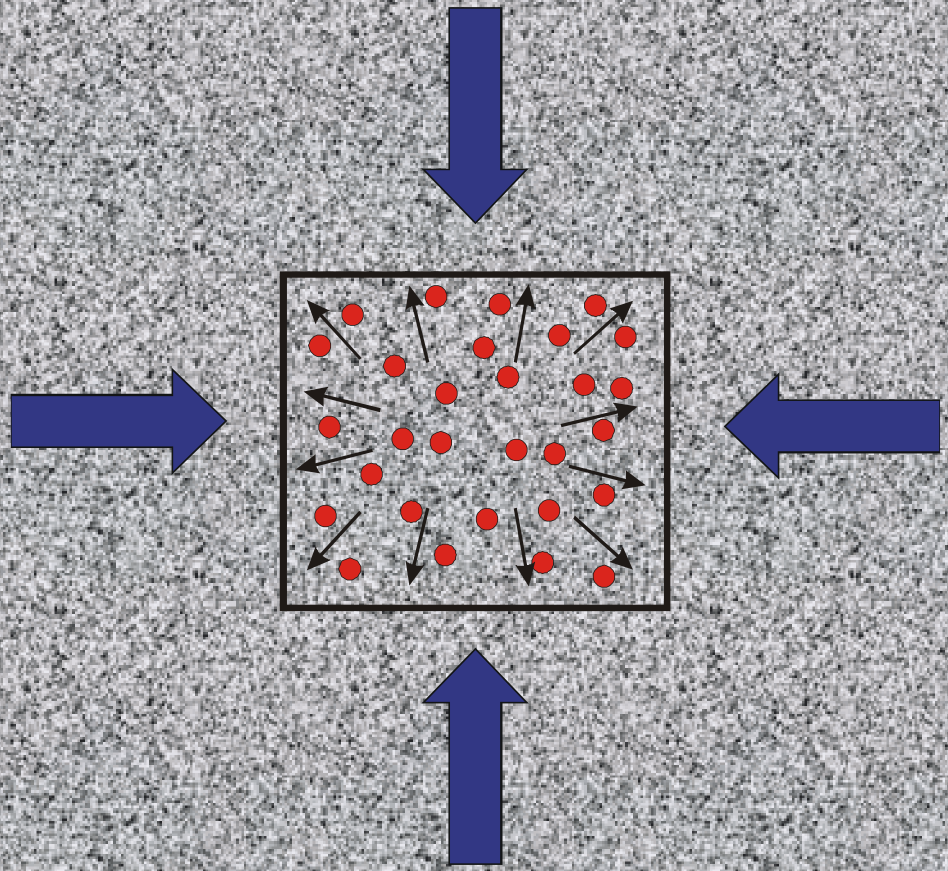
liquid
short range order

solid
long range order

Controls on phase transitions

Phase transitions are controlled by:

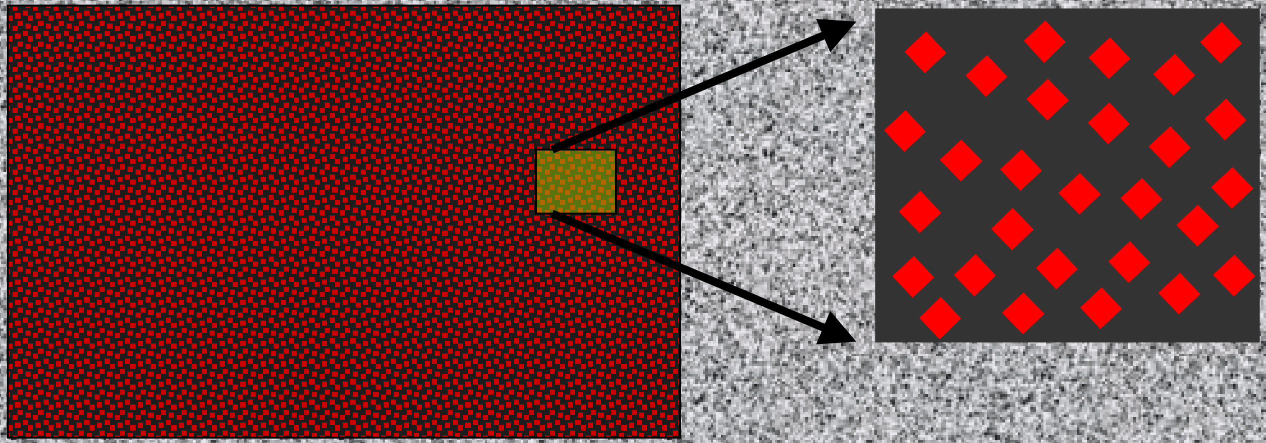
- **heat** (energy available – outward force)
- **pressure** (constraining force)



Phase transitions and rocks

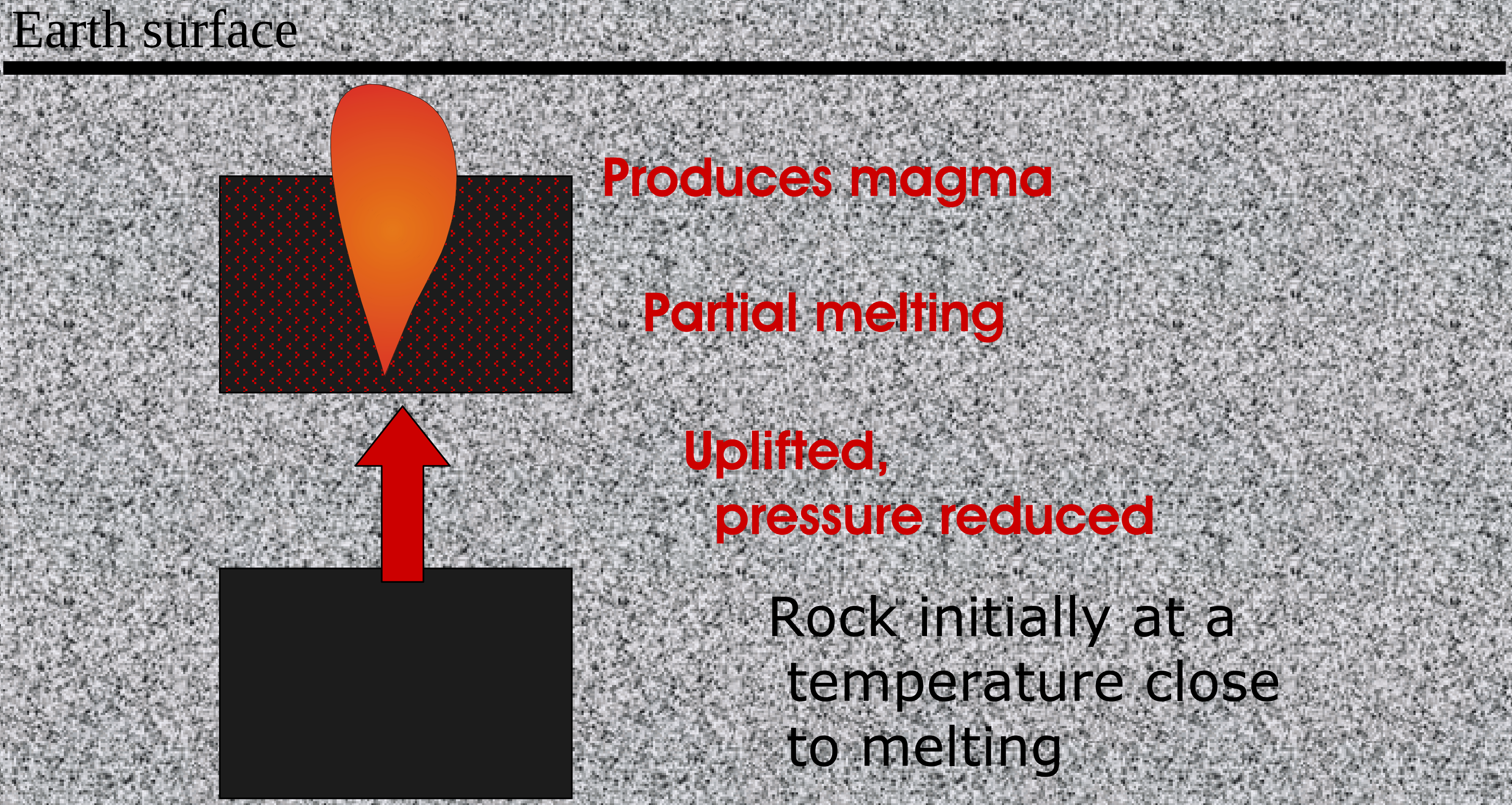
Most rocks are made of more than one mineral.
Each mineral melts at a different temperature.

So, a rock can be ***partially molten*** – with liquid in between solid crystals



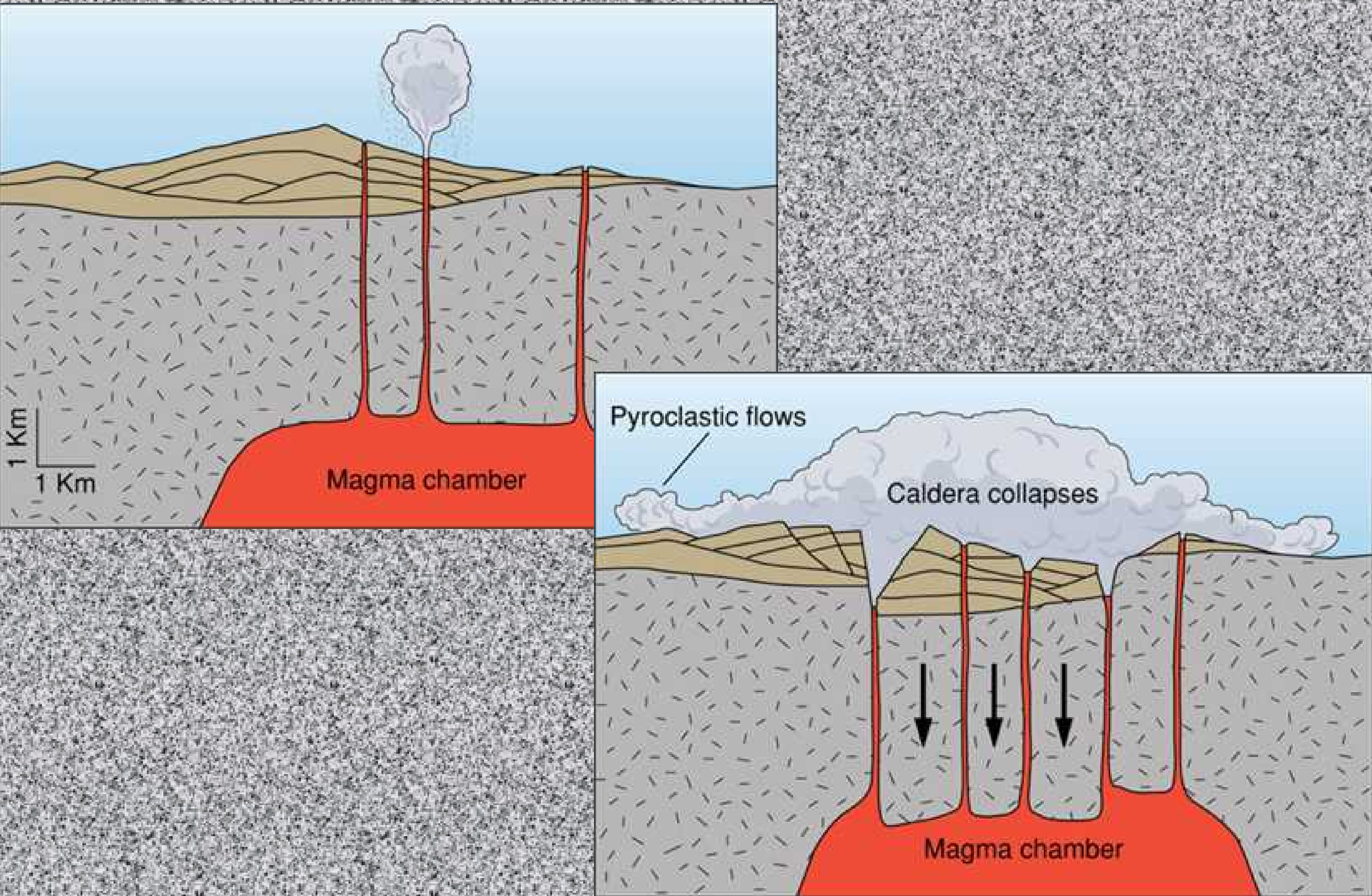
Phase transitions and rocks

Can a rock in the upper mantle melt without an increase in temperature?



What happened here?

Forming a caldera – Crater Lake, Oregon



Forming a caldera