

GEOLOGY OF WESTERN WASHINGTON

For The Mountaineers

Grace Sherwood Winer, MSc.



Geological Processes

- ◆ Plate tectonics
 - ◆ Mountain building
 - ◆ Exotic terranes
 - ◆ Volcanoes
 - ◆ Glaciers



Mount St Helens

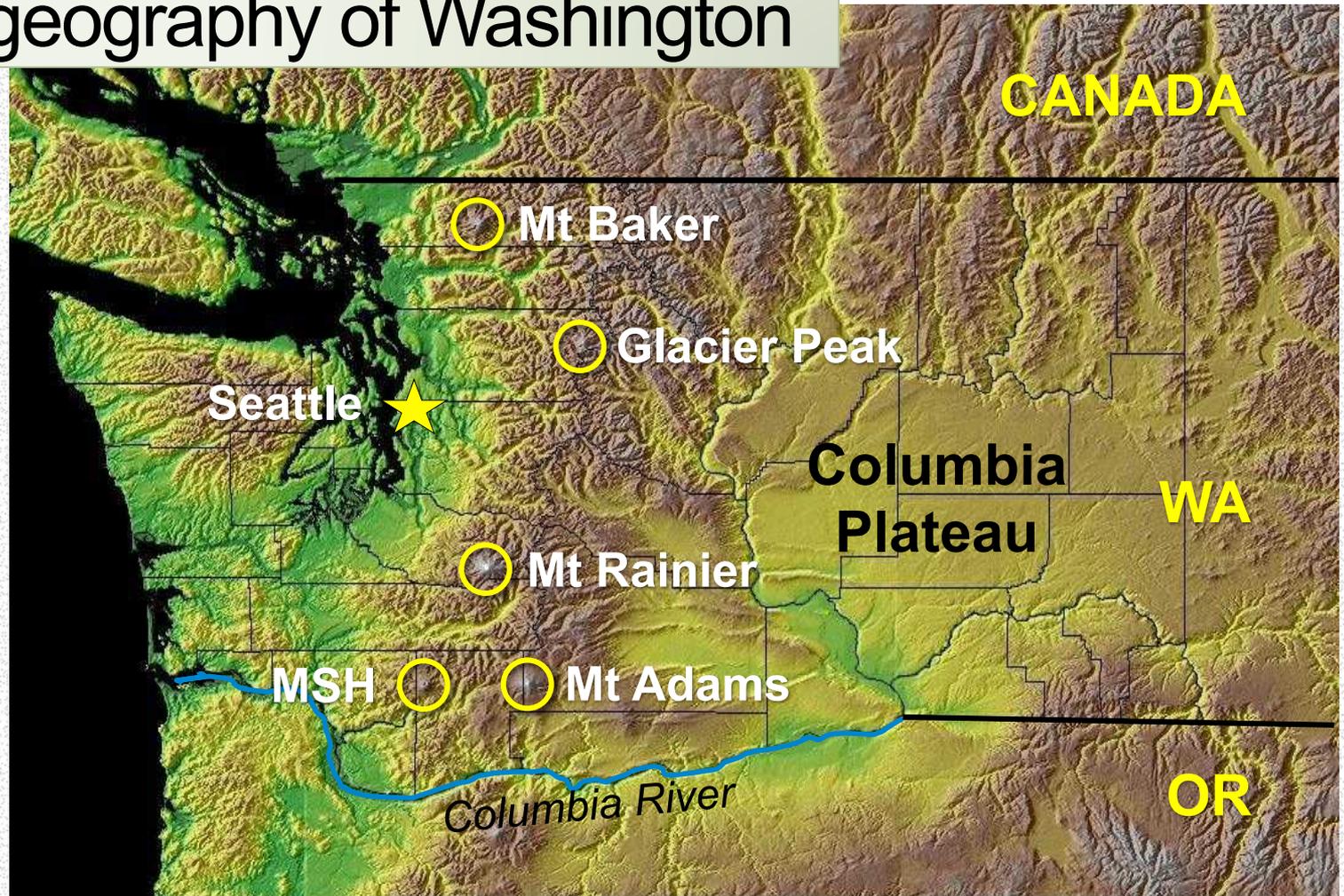
Geological Processes

- ◆ Plate tectonics
 - ◆ Mountain building
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 - ◆ Glaciers
- ◆ Columbia Plateau
 - ◆ Columbia River Basalts
 - ◆ Ice Age Floods



Mount St Helens

Physical geography of Washington



Lithosphere: the rigid outer shell of the earth

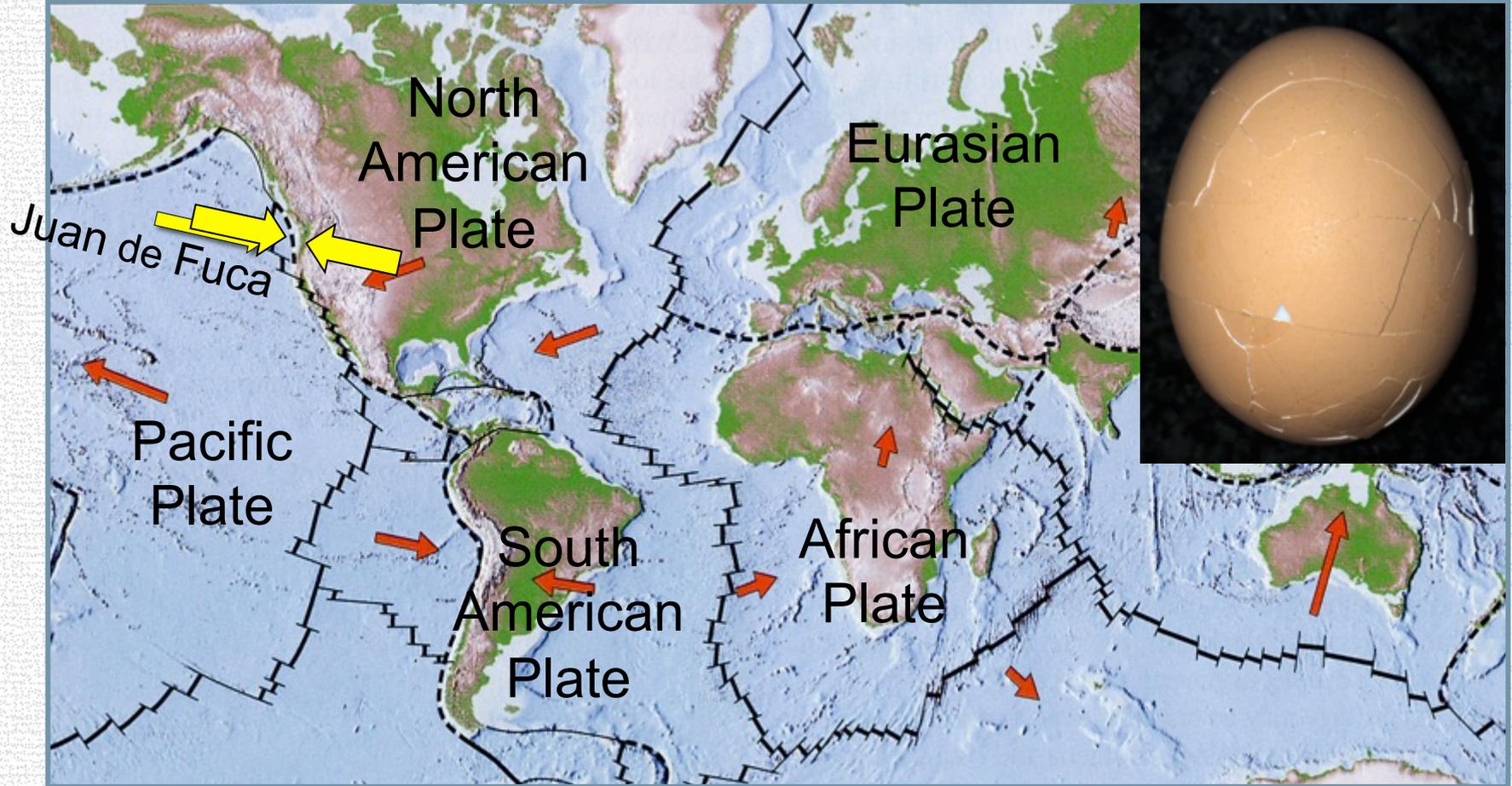
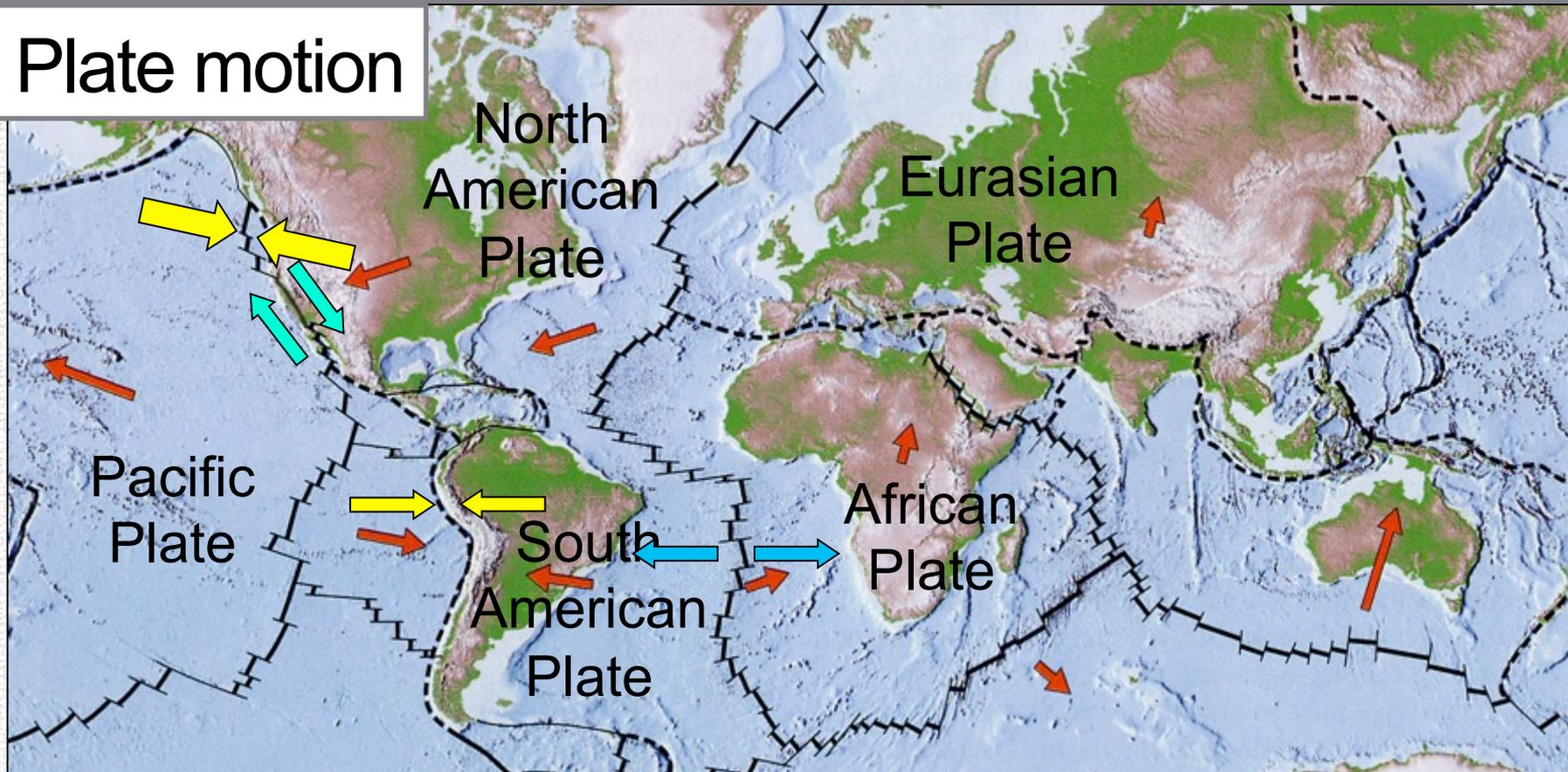


Plate motion



 Direction & velocity, 5 cm/yr

 Divergent

 Convergent

 Transform

Tectonics of Western Washington

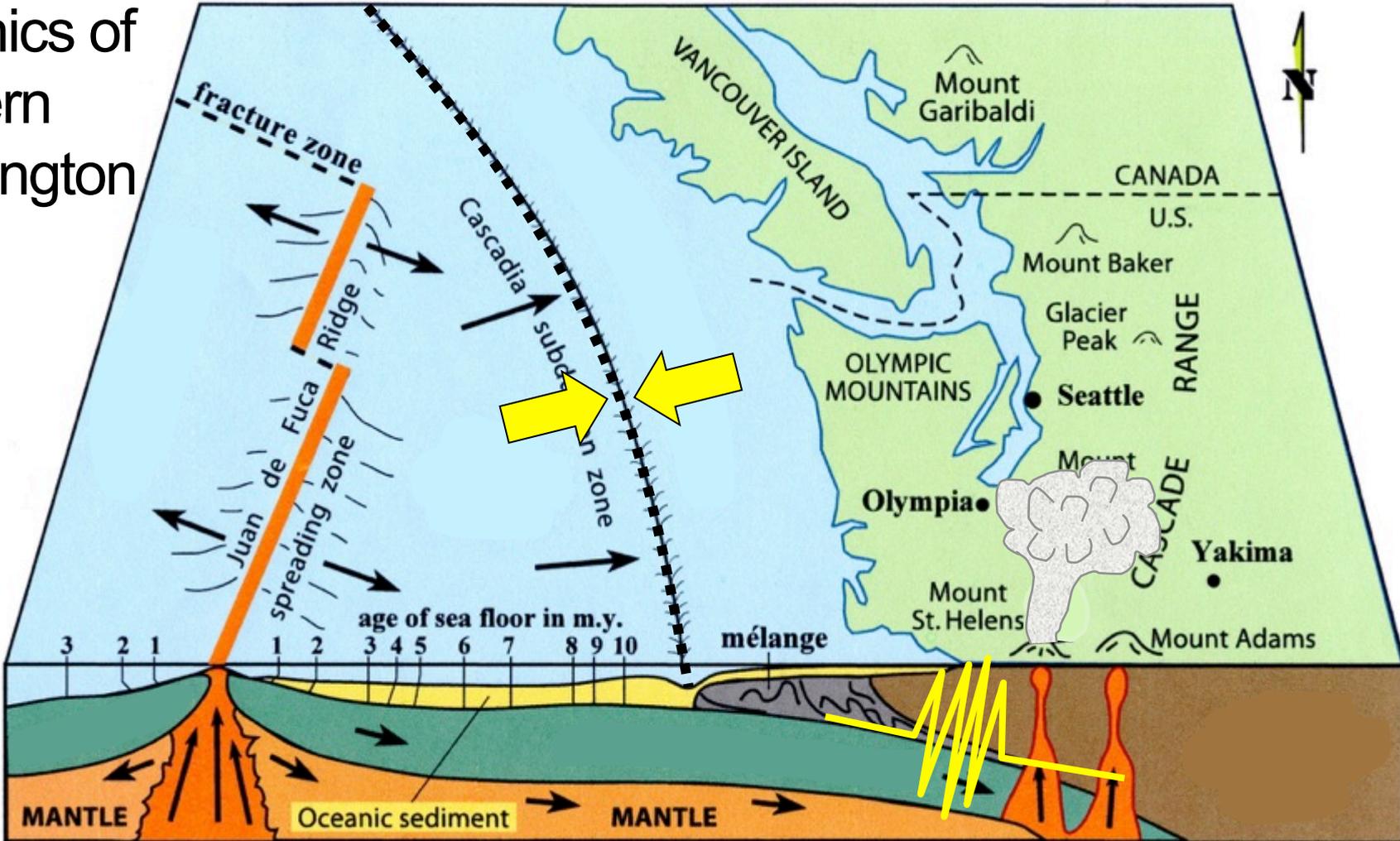


Figure after Norman and Roloff, 2004

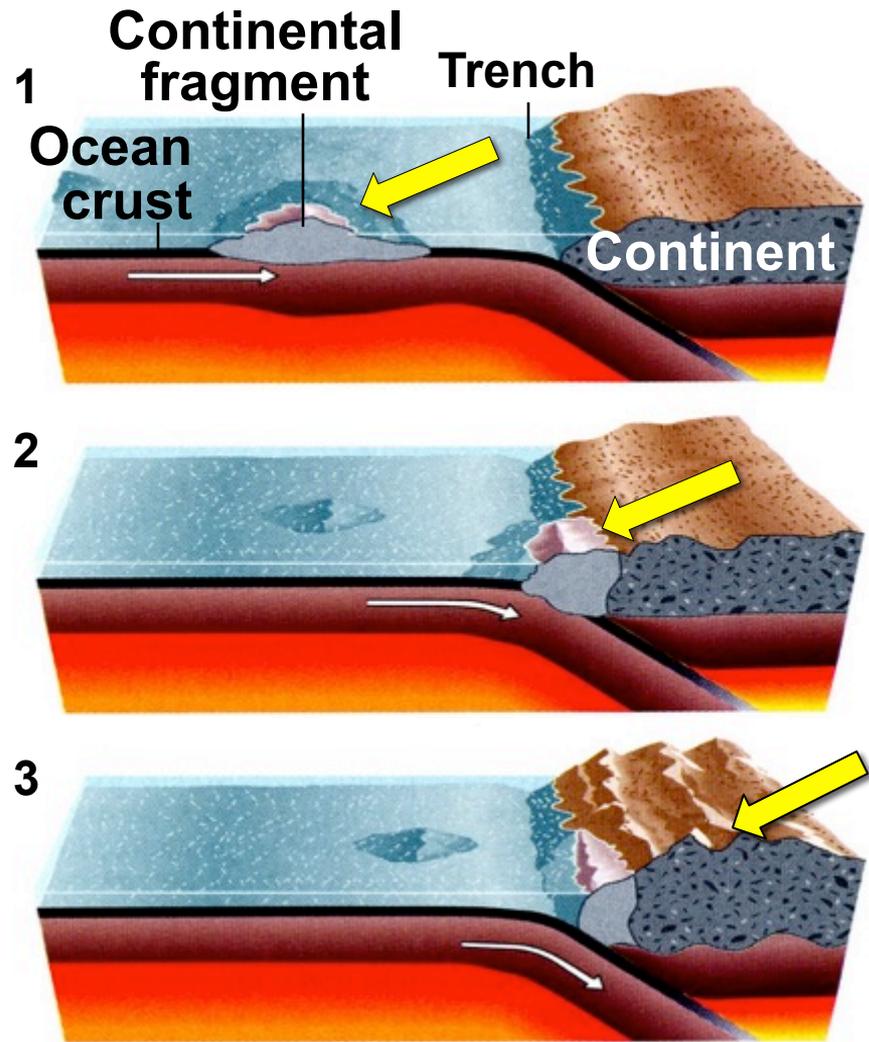
Terrane accretion

1. A continental fragment is carried toward the trench of a subduction zone

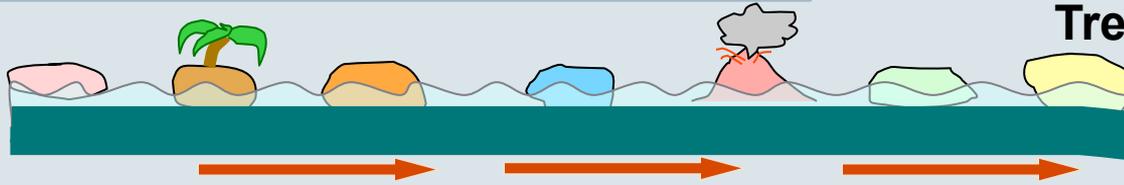
2. It is not subducted, but is welded onto the overriding plate in process called *docking*

3. Compression causes shortening & builds mountains

A terrane is a discrete and different piece of land

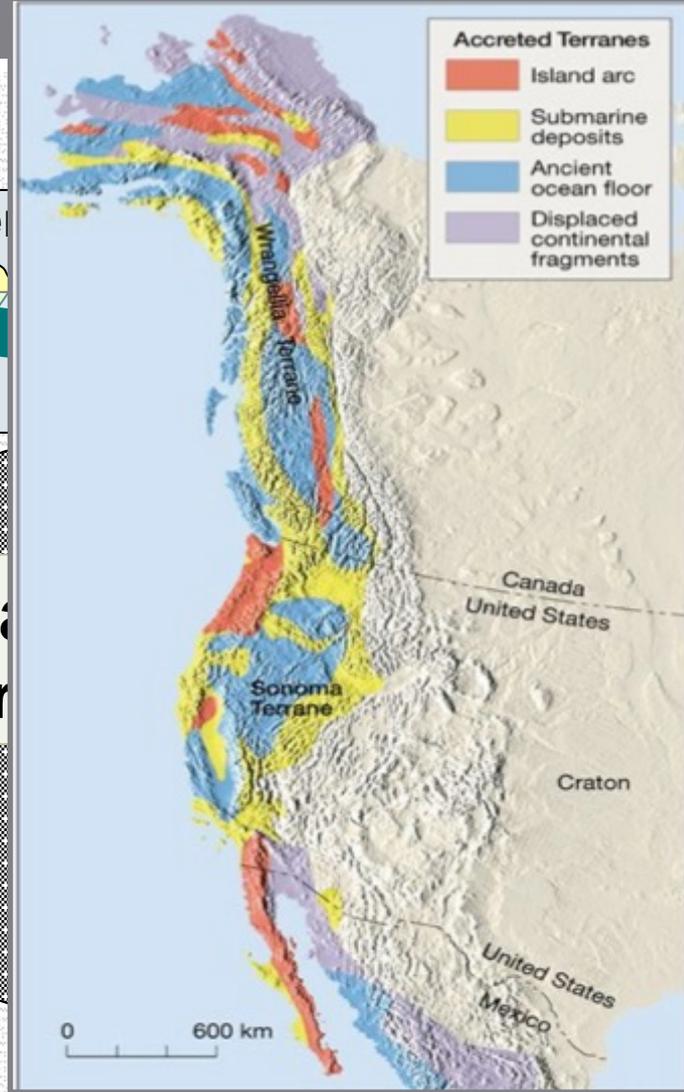
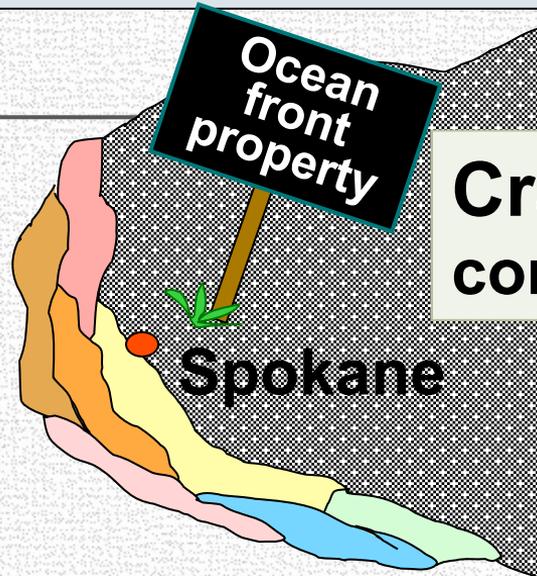


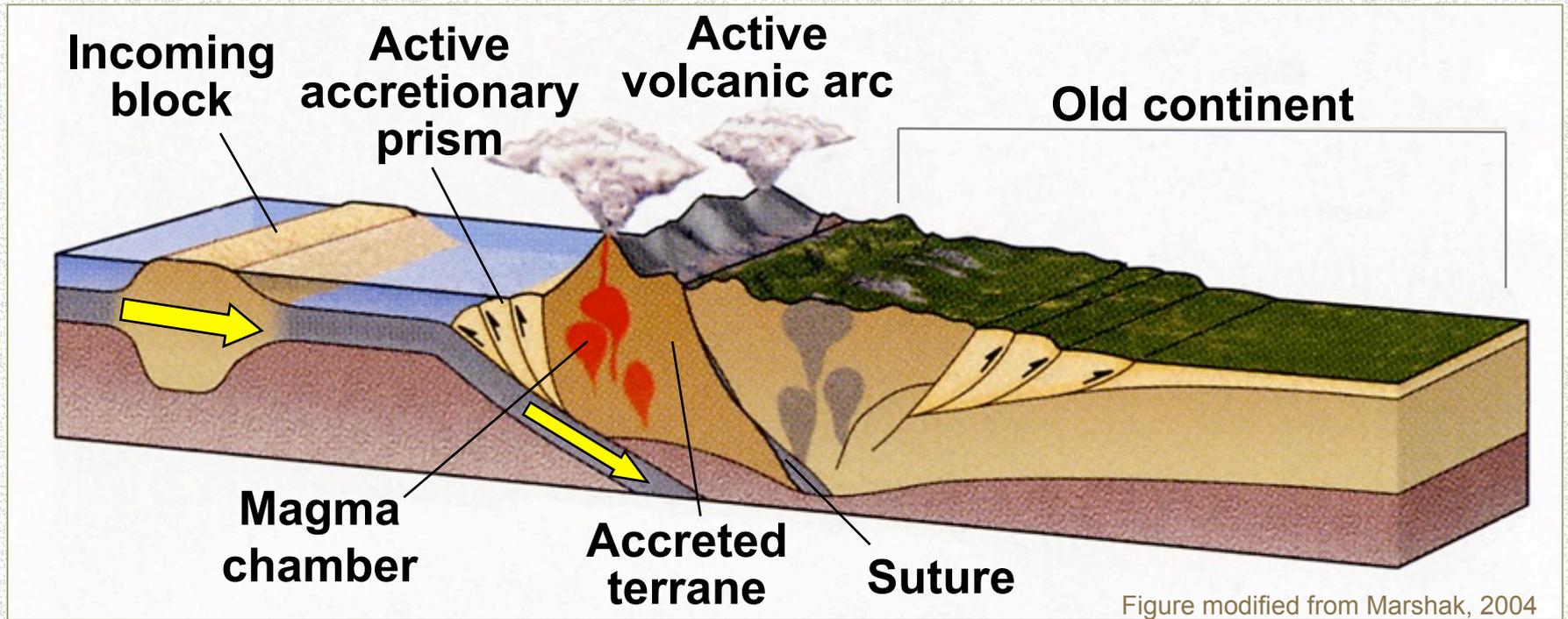
Terrane accretion



Accreted terranes:

island arcs and continental blocks added on to the margin of a continent





At convergent margins mountain building is related to:

Accretion

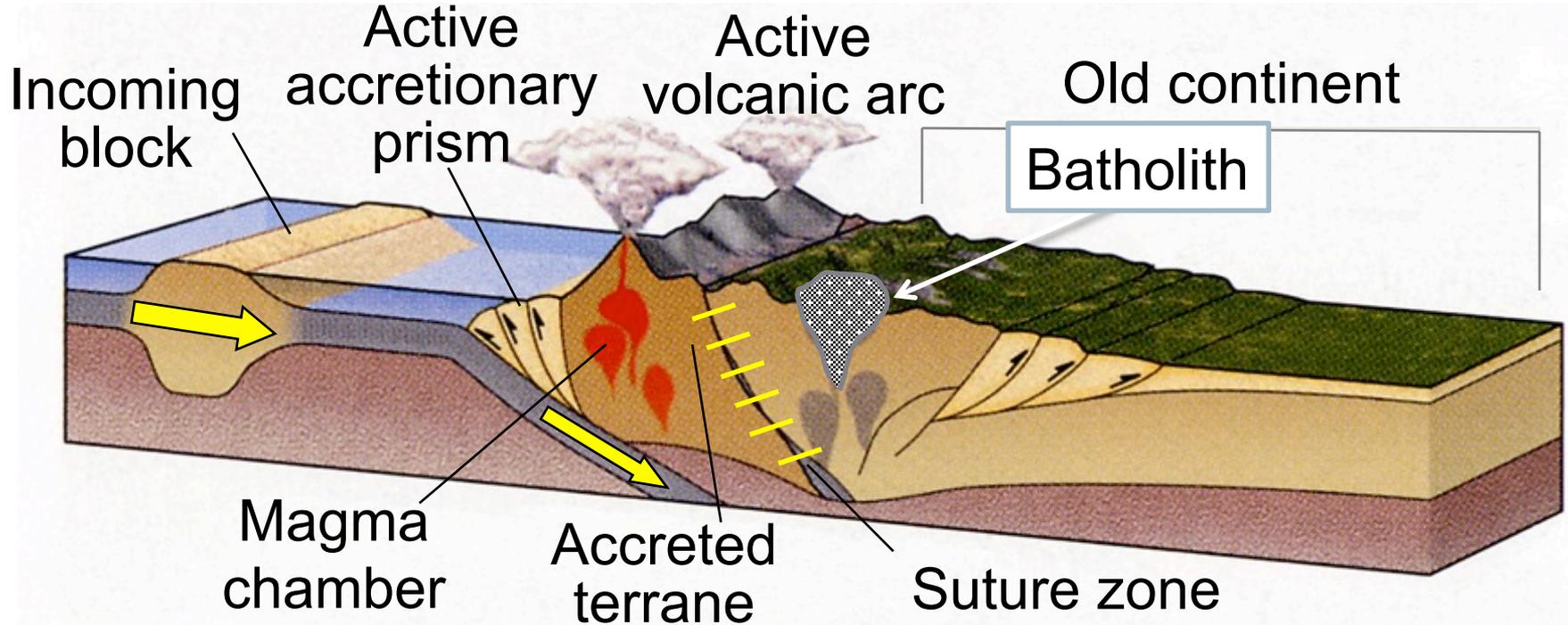
Compression

Crustal shortening

Volcanism

The making of a batholith

Mt Stuart batholith intruded about 90 Ma





Mount Stuart:
A mountain carved
from a batholith

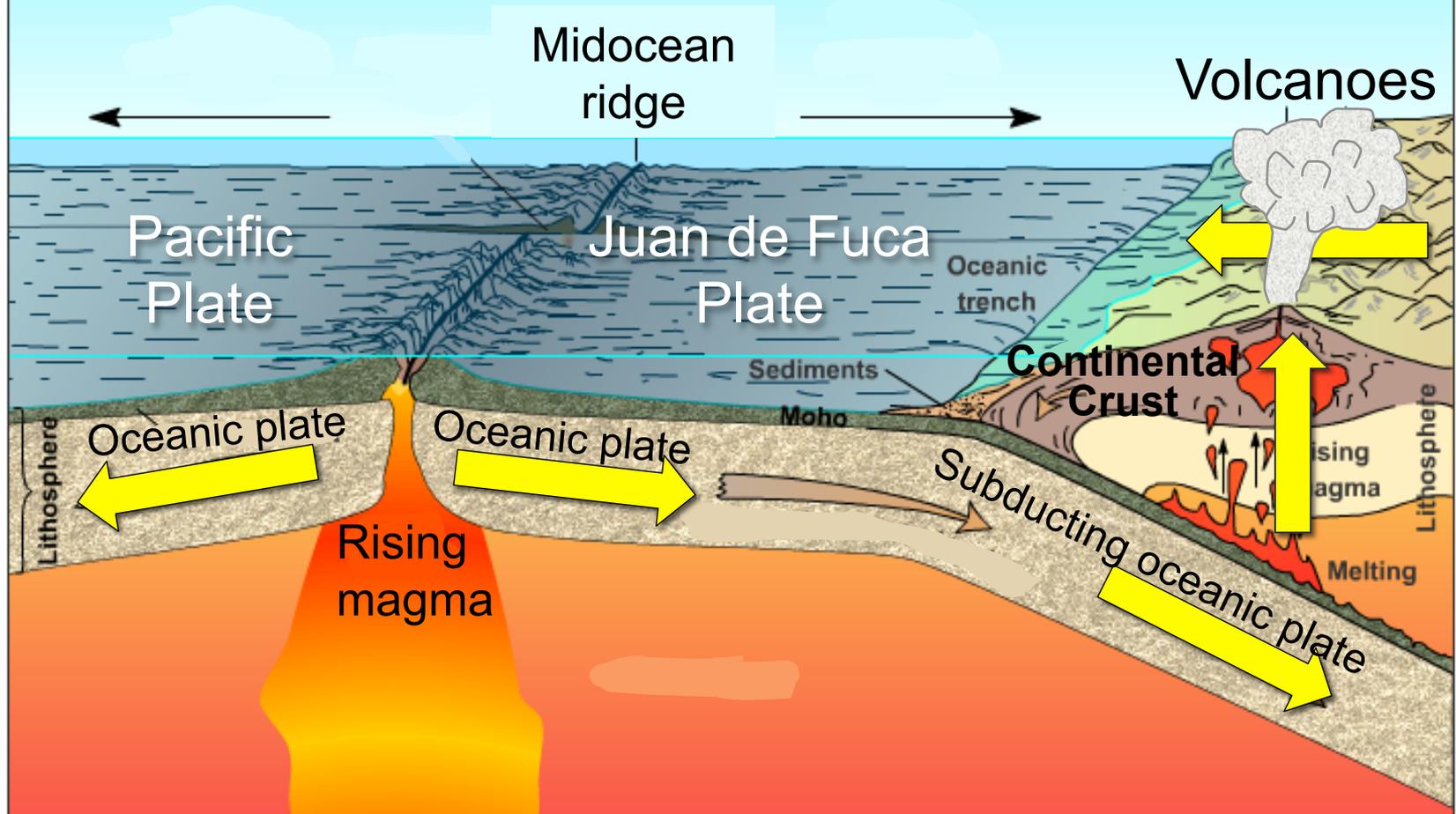
Batholith: A
large igneous
intrusion

A batholith carved by ice



Photo by Steph Abegg

Cascadia subduction zone

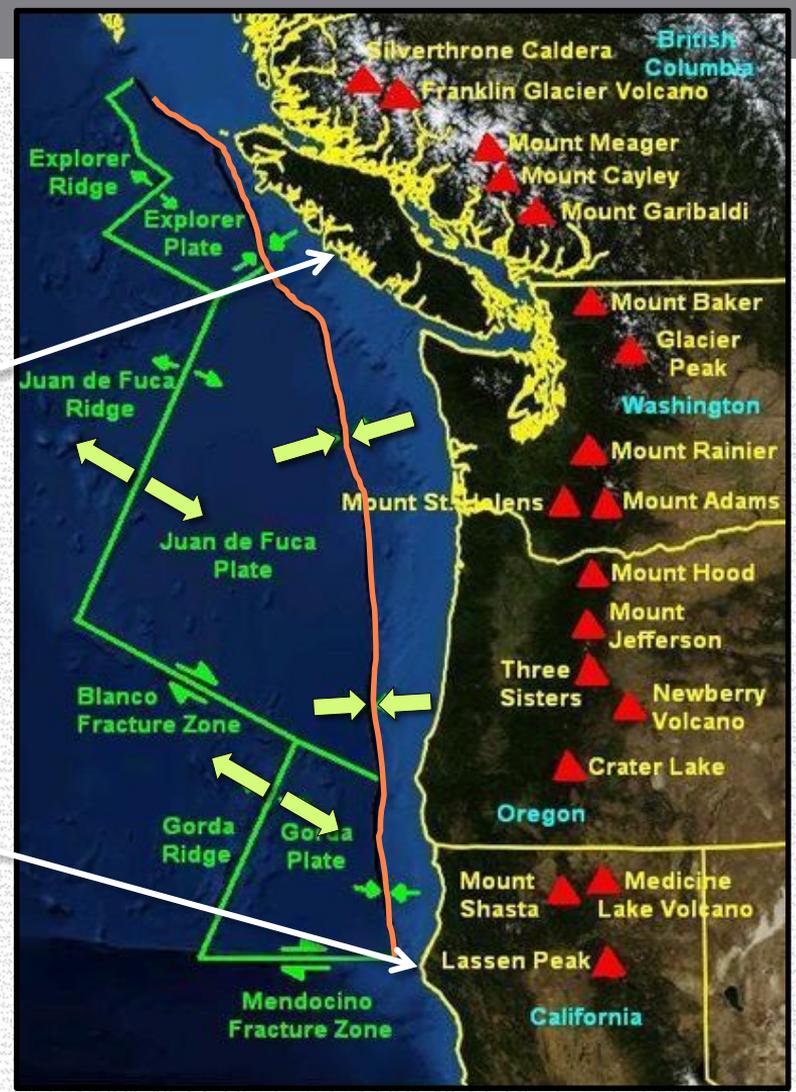


Cascadia Subduction Zone: A 1000 km “megathrust” fault

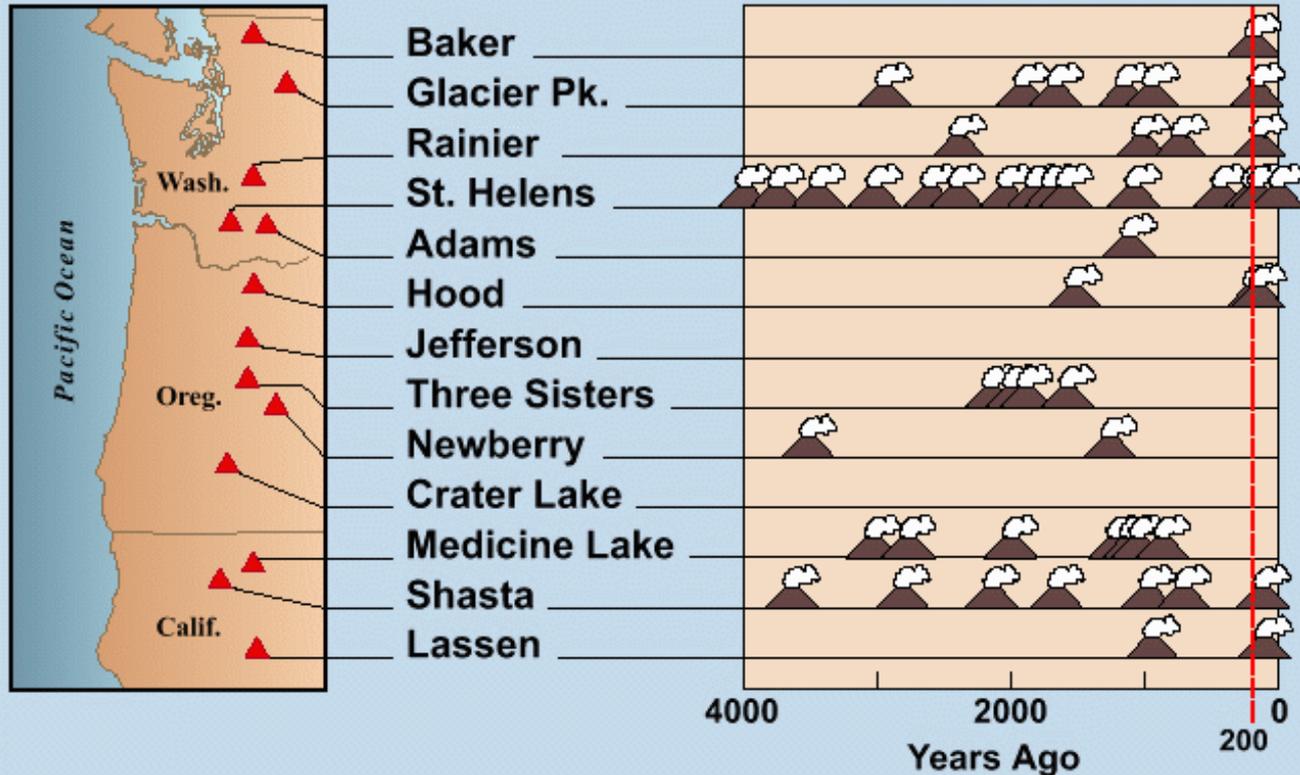
Vancouver Island

A convergent plate boundary

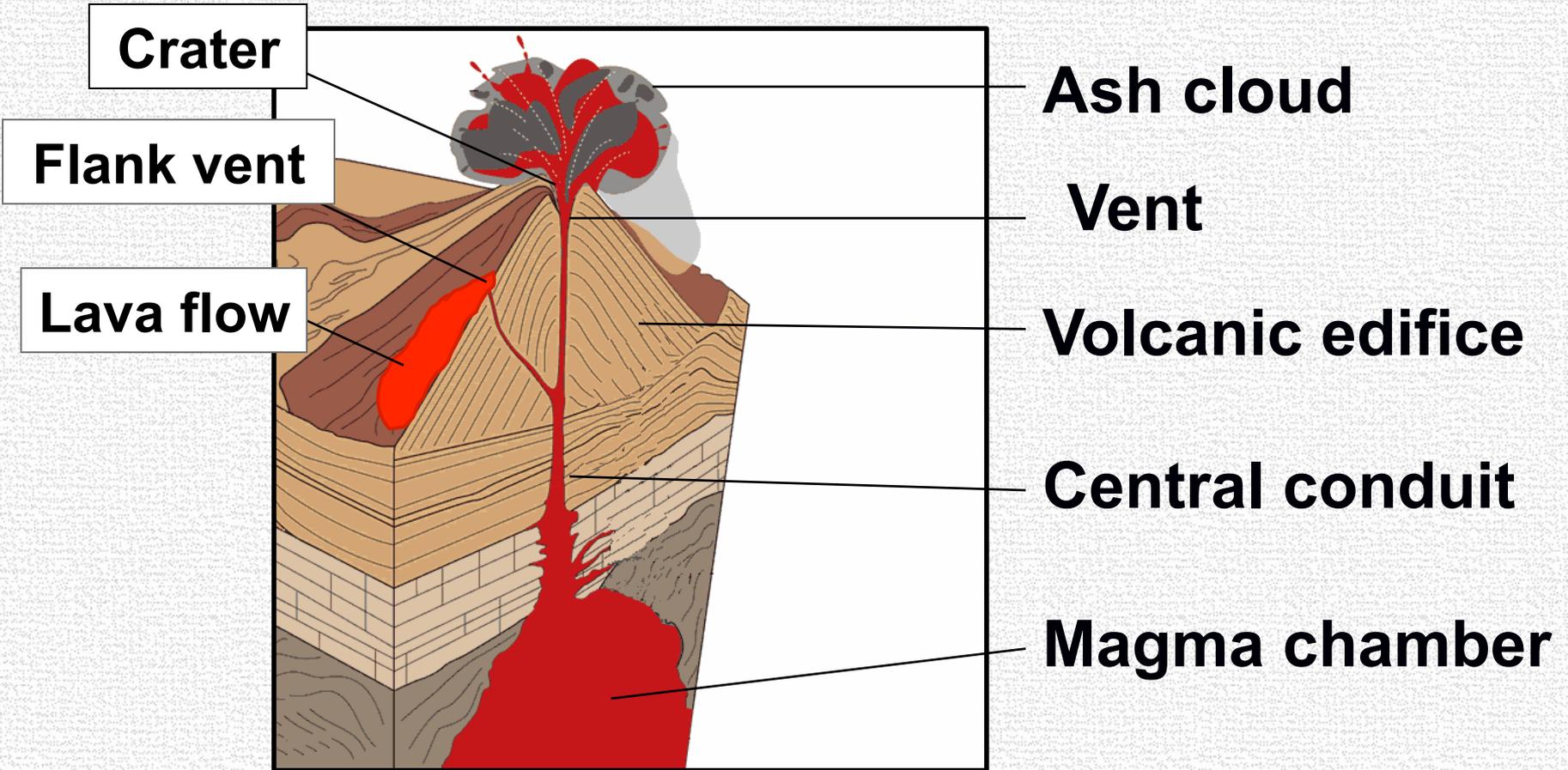
Cape Mendocino



Cascade eruptions during the past 4,000 years



Anatomy of a volcano



Stratovolcanoes (Composite cones)

Ash cloud carried
downwind _____

Ash fall _____



Bomb



Block

Crater



Concave

Cotopaxi

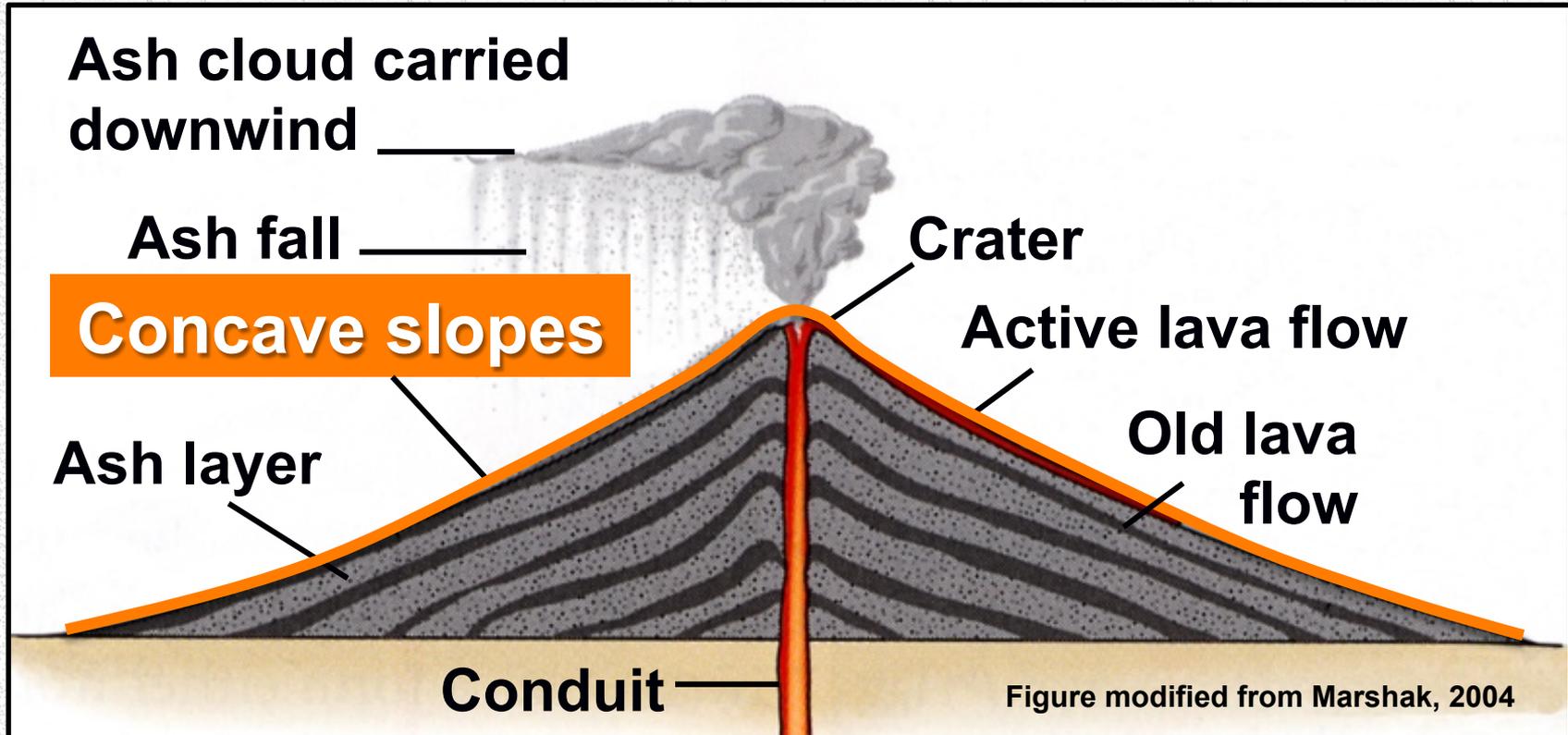
Elevation: 19,347'



Ash layer

Krakatoa Pi

Stratovolcanoes (Composite cones)



Krakatoa

Pinatubo

Fujiyama

Mount St Helens

Cotopaxi

CASCADE VOLCANOES



Mt Hood in morning light

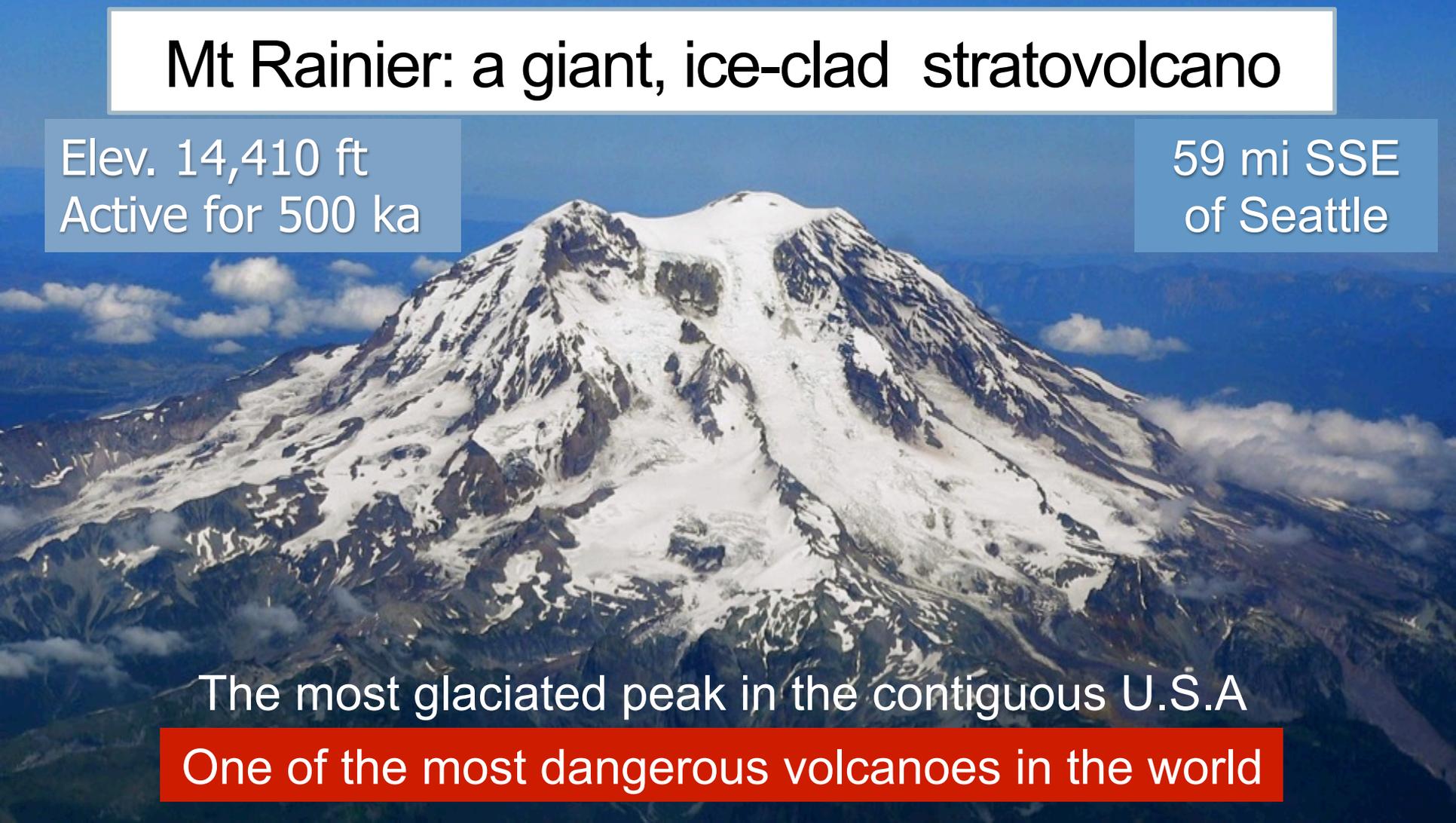
Mt Rainier: a giant, ice-clad stratovolcano

Elev. 14,410 ft
Active for 500 ka

59 mi SSE
of Seattle

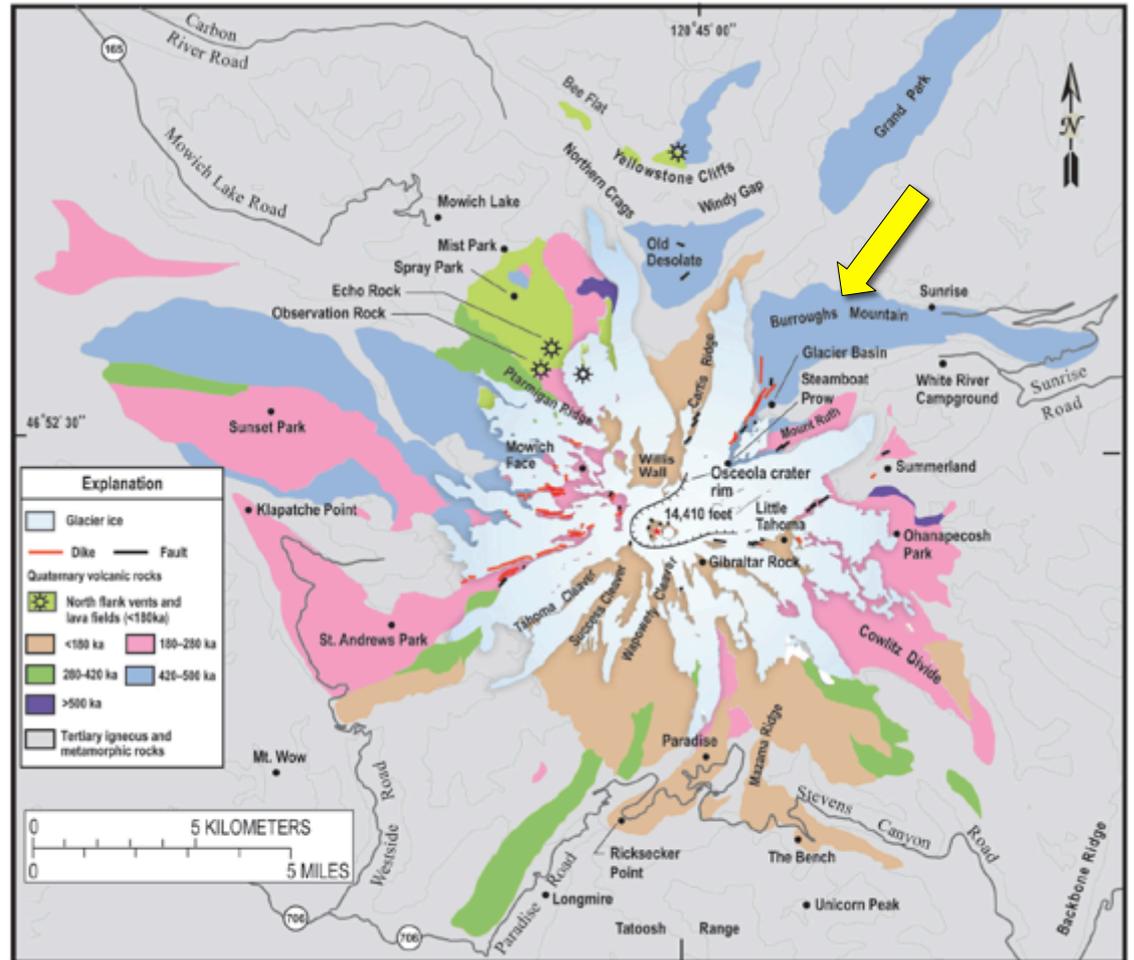
The most glaciated peak in the contiguous U.S.A

One of the most dangerous volcanoes in the world



Simplified geology of Mount Rainier

Burroughs Mtn formed by lava flow 420-500 ka



Mt Rainier as seen from First Burroughs

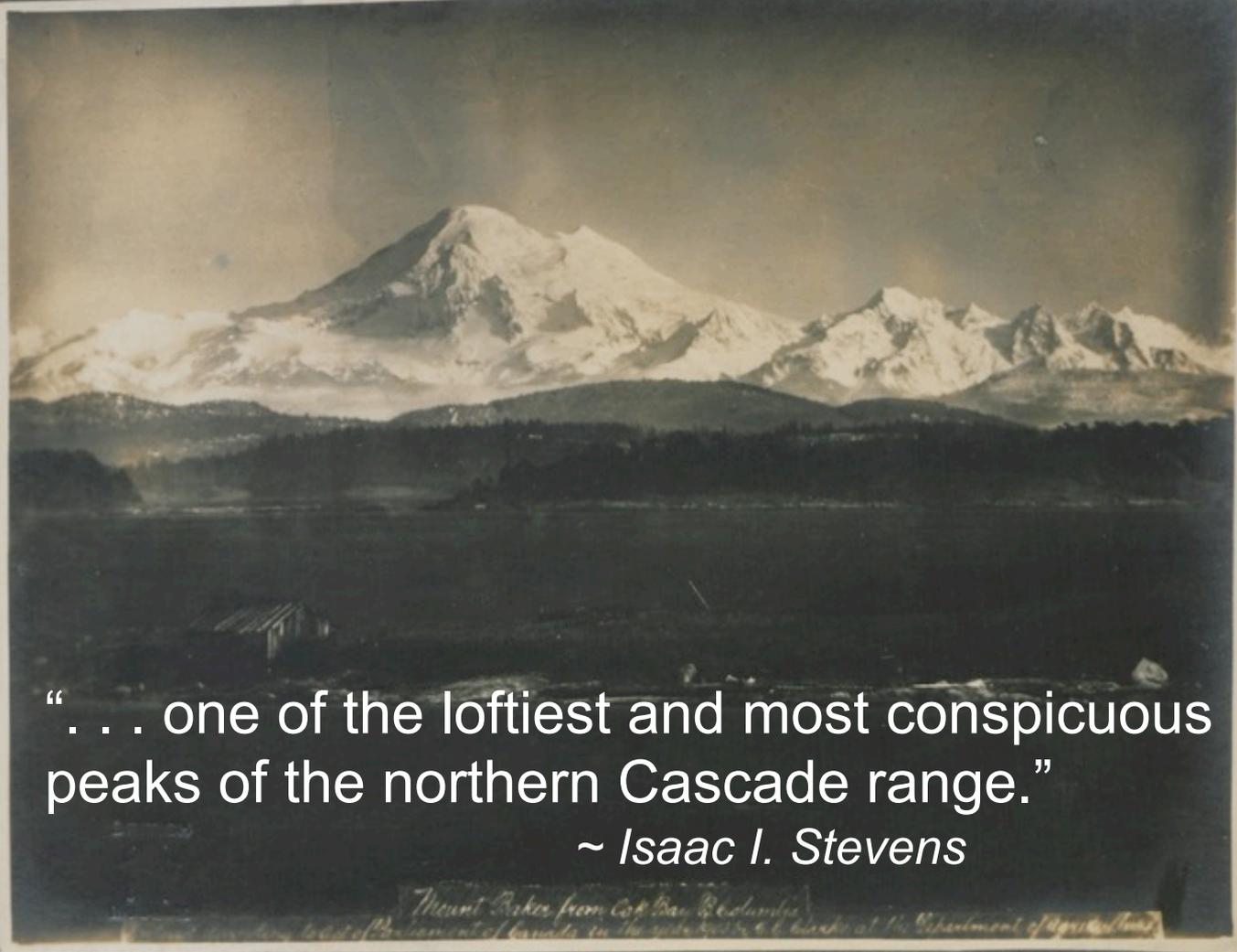
Burroughs Mountain formed of ancient lava flow

Notable for alpine tundra with plants typically seen at much higher latitudes



Mount Baker:
a heavily
glaciated
stratovolcano

- Elev. 10,781 ft
- Age <100 ka
- Nooksack & Skagit rivers



“ . . . one of the loftiest and most conspicuous peaks of the northern Cascade range.”

~ Isaac I. Stevens

Mount Baker from Cape Bar, B. Columbia
the highest of the mountain of Canada in the north-west of the United States at the Department of Agriculture

Glacier Peak

10,541 ft

70 mi NE of Seattle

Chocolate Glacier

A most
dangerous
volcano!

Two eruptions 5X bigger
than MSH in 1980



Mount Adams

Elev. 12,281 ft

One of the great
stratovolcanoes
of the world

34 mi. east of
Mount St Helens



Adams False Summit from Lunch Counter



Photo from Bruce Barcklow

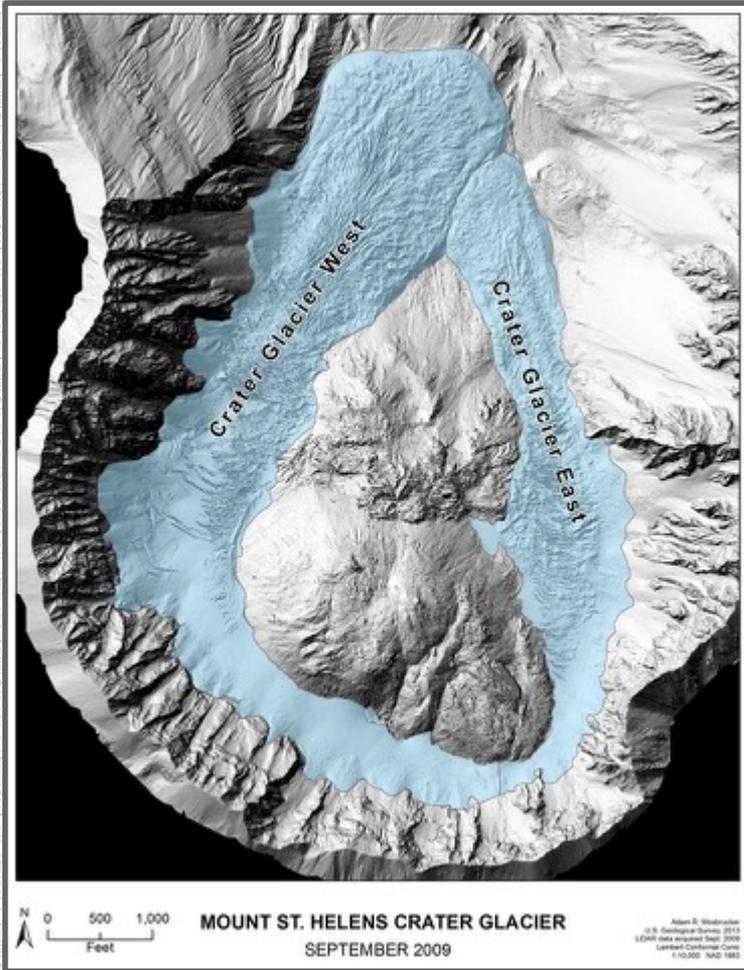
Mount St Helens



Mount St Helens caldera



Crater Glacier, MSH



Requirements for alpine glaciers

- ❖ Low temperatures
- ❖ Sufficient snowfall
- ❖ Slope not too steep
- ❖ Slope protected from wind



Hambrey & Alean, 1994

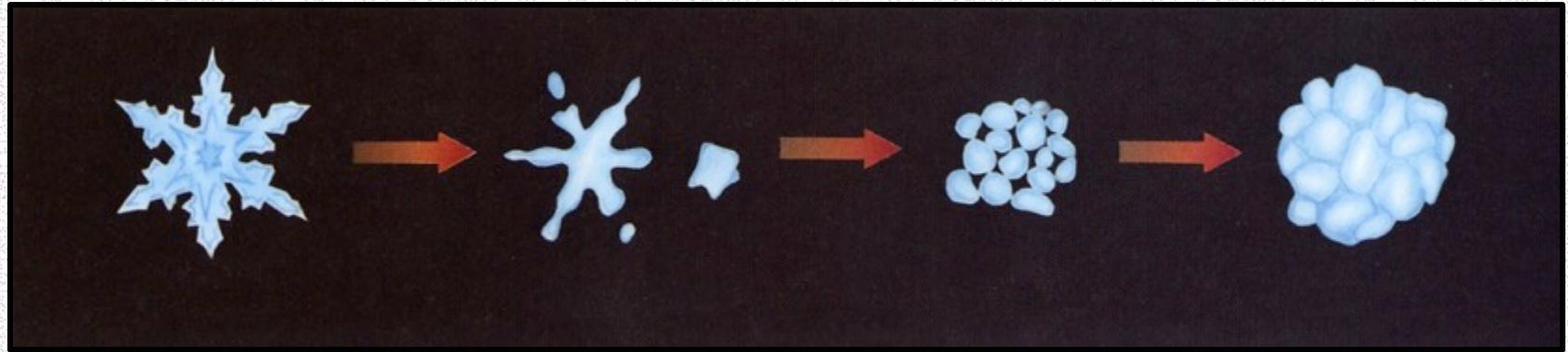
Steps in transformation of snow to glacier ice

Snowflake

Granular snow

Firn

Glacier ice



90% air

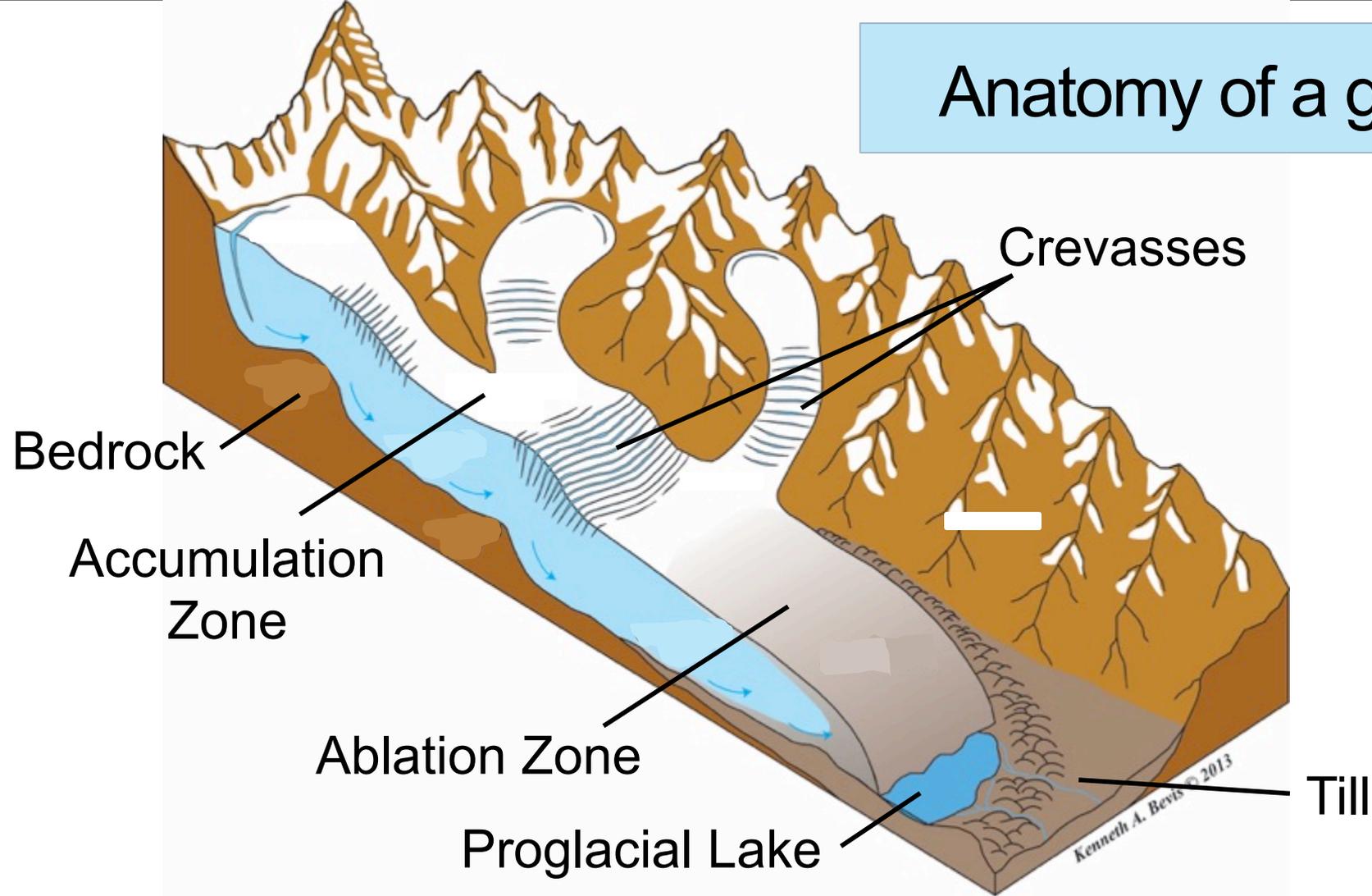
Fresh snow

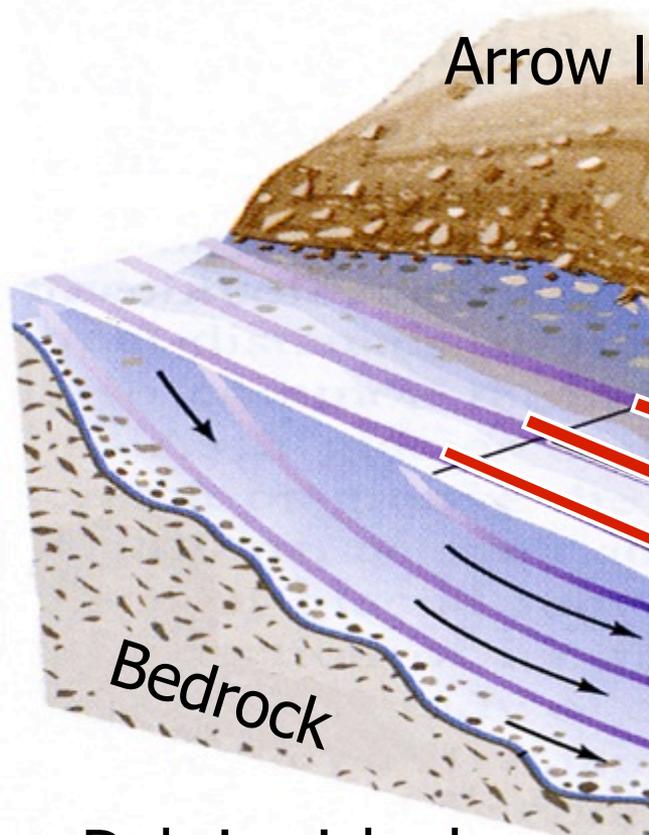
Increasing depth
> 30 m

20% air

5 to 10
years

Anatomy of a glacier





Debris picked up
by the glacier

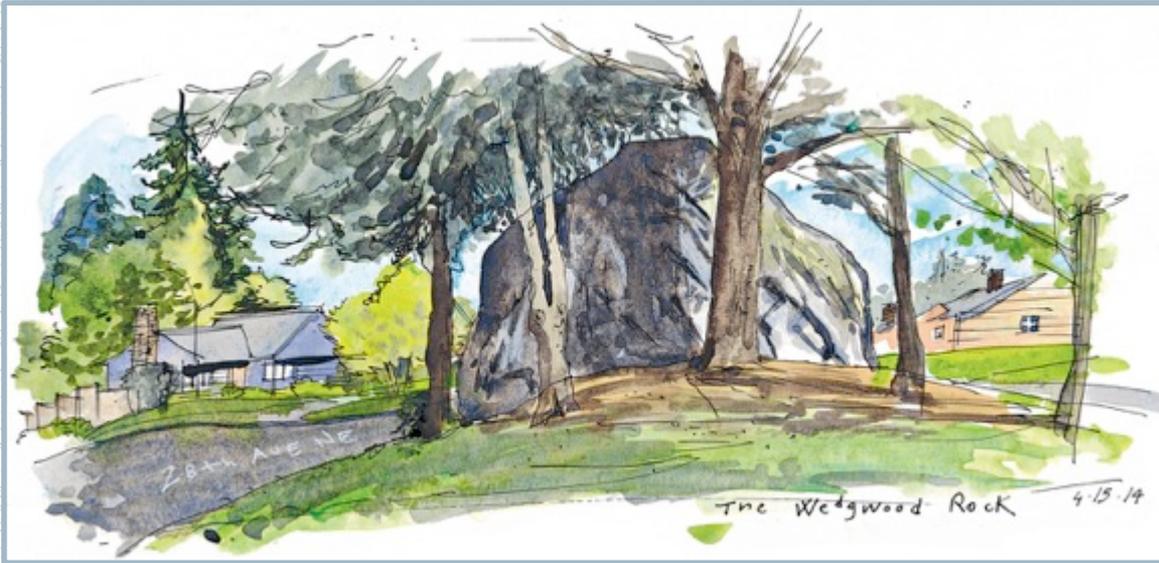
Debris from
valley walls

Modified from Press & Sevier, 2001

Glacial striations
on bedrock



Wedgewood Rock: a glacial erratic

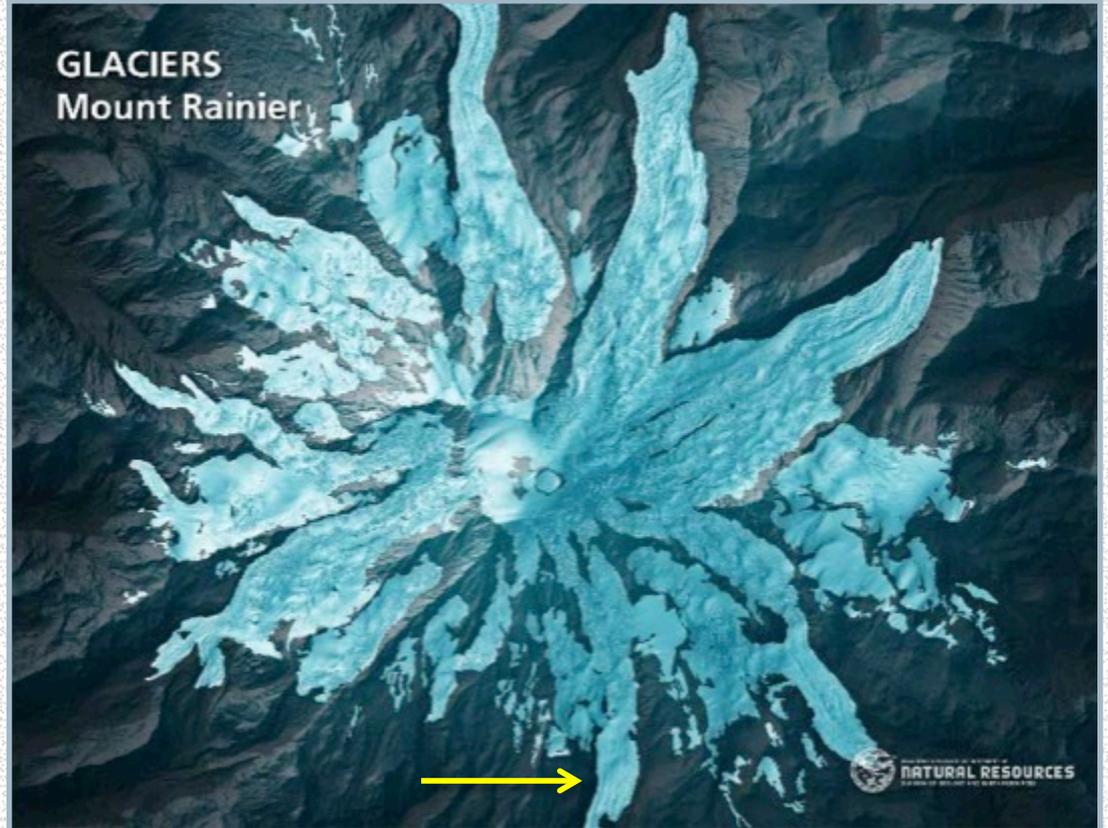


Located at 7200 28th Ave NE in Seattle

- A rock fragment carried by glacial ice and deposited far from its source
- A pebble to a house-sized block

Glaciers: Rivers of Ice

- 25 major glaciers on Mt Rainier
- Essential sources of water
- Support six major river systems



Nisqually Glacier on Mt Rainier

- Source of Nisqually River
- Thinning
- Retreating



On Mt Baker's Easton Glacier lateral moraine

Note sharp ridge
& very poor
sorting of moraine



Photo from Bruce Barcklow



Bridge on
Route 706

Nisqually River



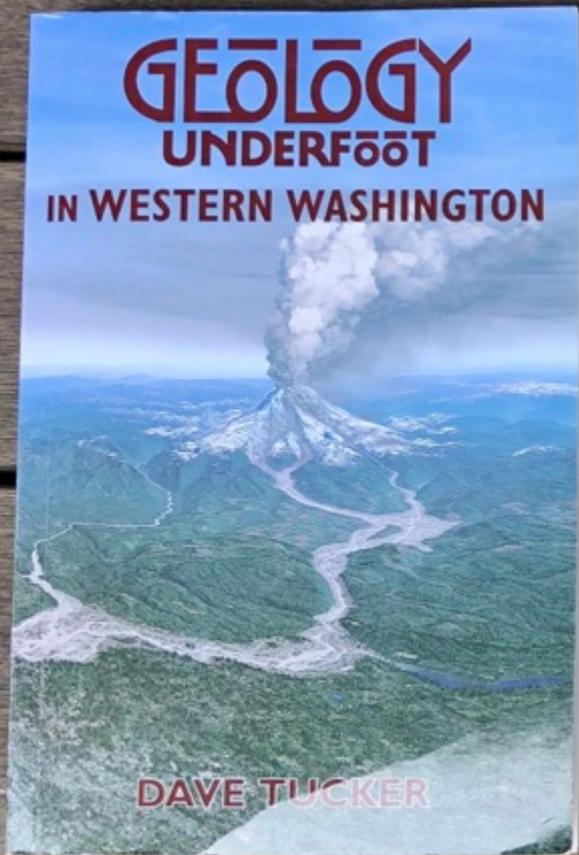
Along the Wonderland Trail

Mount Rainier from Nisqually Wildlife Refuge

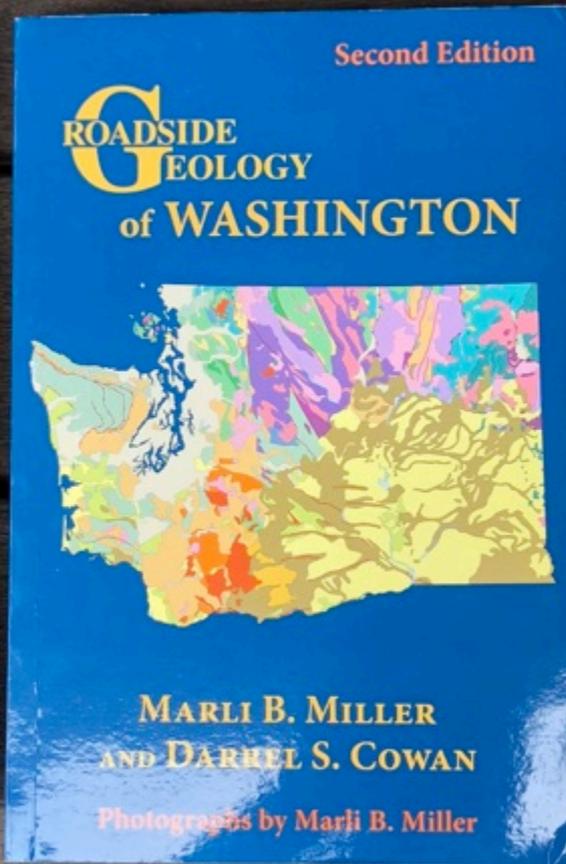


Thank you

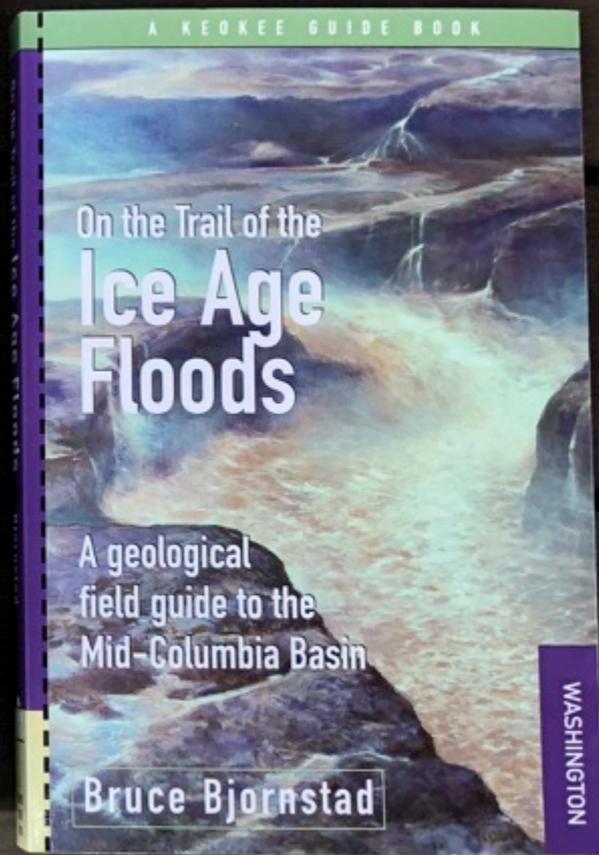




Dave Tucker



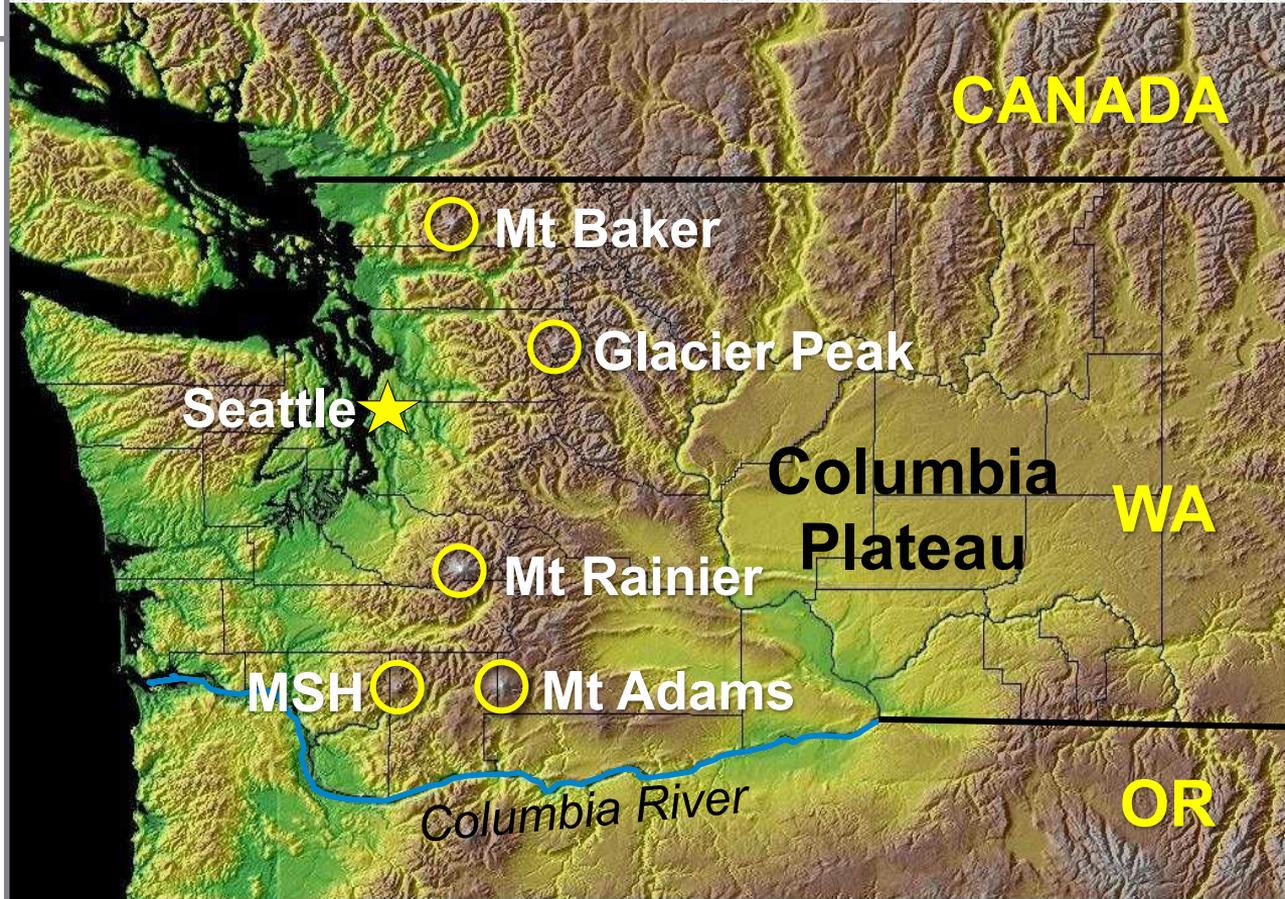
Marli Miller & Darrel Cowan



Bruce Bjornstad

Overview

- ◆ Plate tectonics
 - ◆ Mountain building
 - ◆ Exotic terranes
 - ◆ Volcanoes
 - ◆ Glaciers
- ◆ Columbia Plateau
 - ◆ Columbia River Basalts
 - ◆ Ice Age Floods



Columbia Plateau

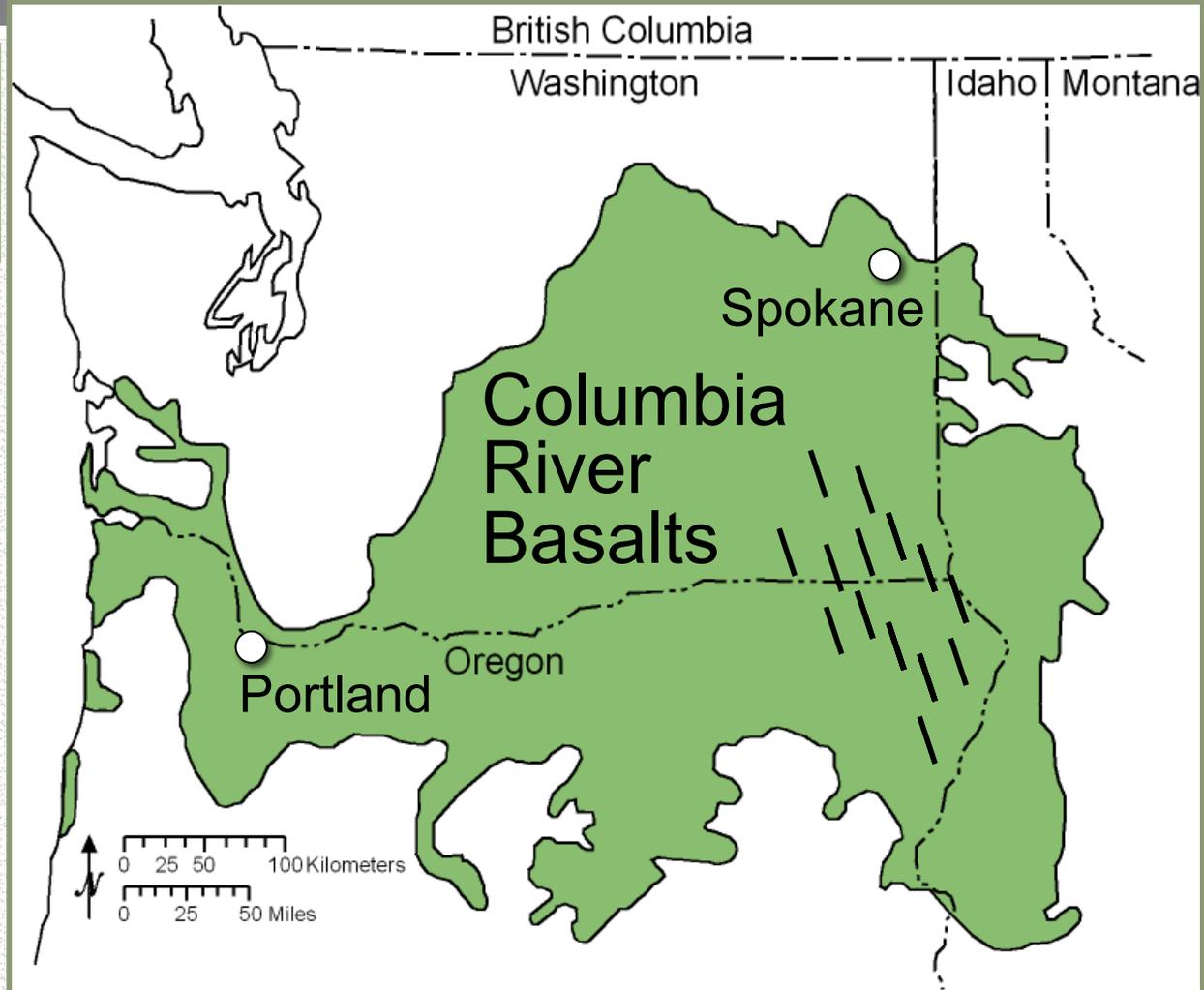
- **Buried by gigantic lava flows**
- **Scoured by Ice Age floods**



Palouse Falls

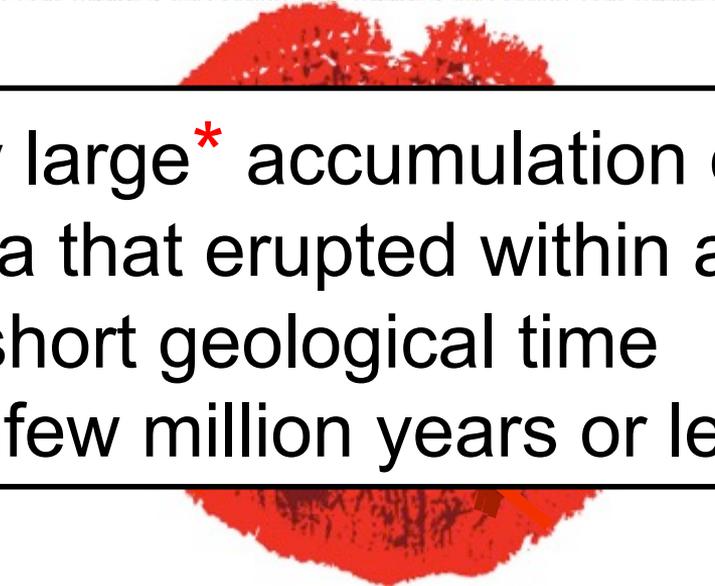
CRBs: Flood Basalts

- Erupted 17-6 Ma
- Some vents over 100 mi long
- 1 million m^3/s
- Land buried and smoothed



You are in a LIP!

Large Igneous Province



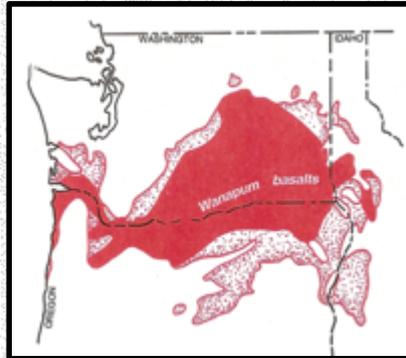
LIP: A very large* accumulation of basaltic lava that erupted within an extremely short geological time interval—a few million years or less.

* Area greater than 100,000 km²

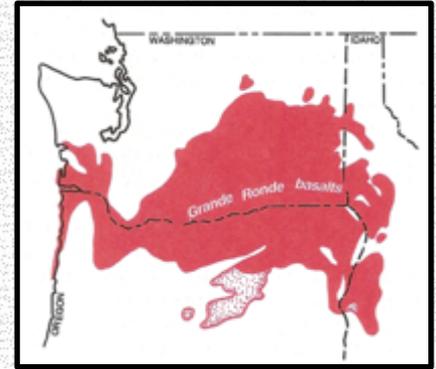
Columbia River Basalts

**Enough lava to bury
all of the continental
United States under
12 m of lava!**

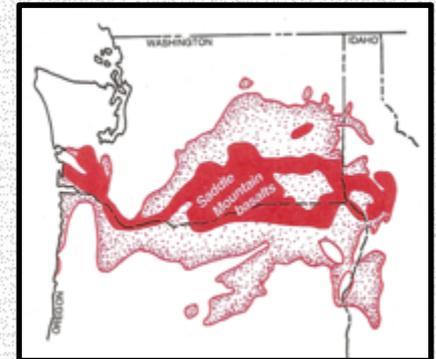
Wanapum
15.5 - 14.5 Ma
10,800 km³
6%



Grande Ronde
17-15.5 Ma
>150,000 km³
87%



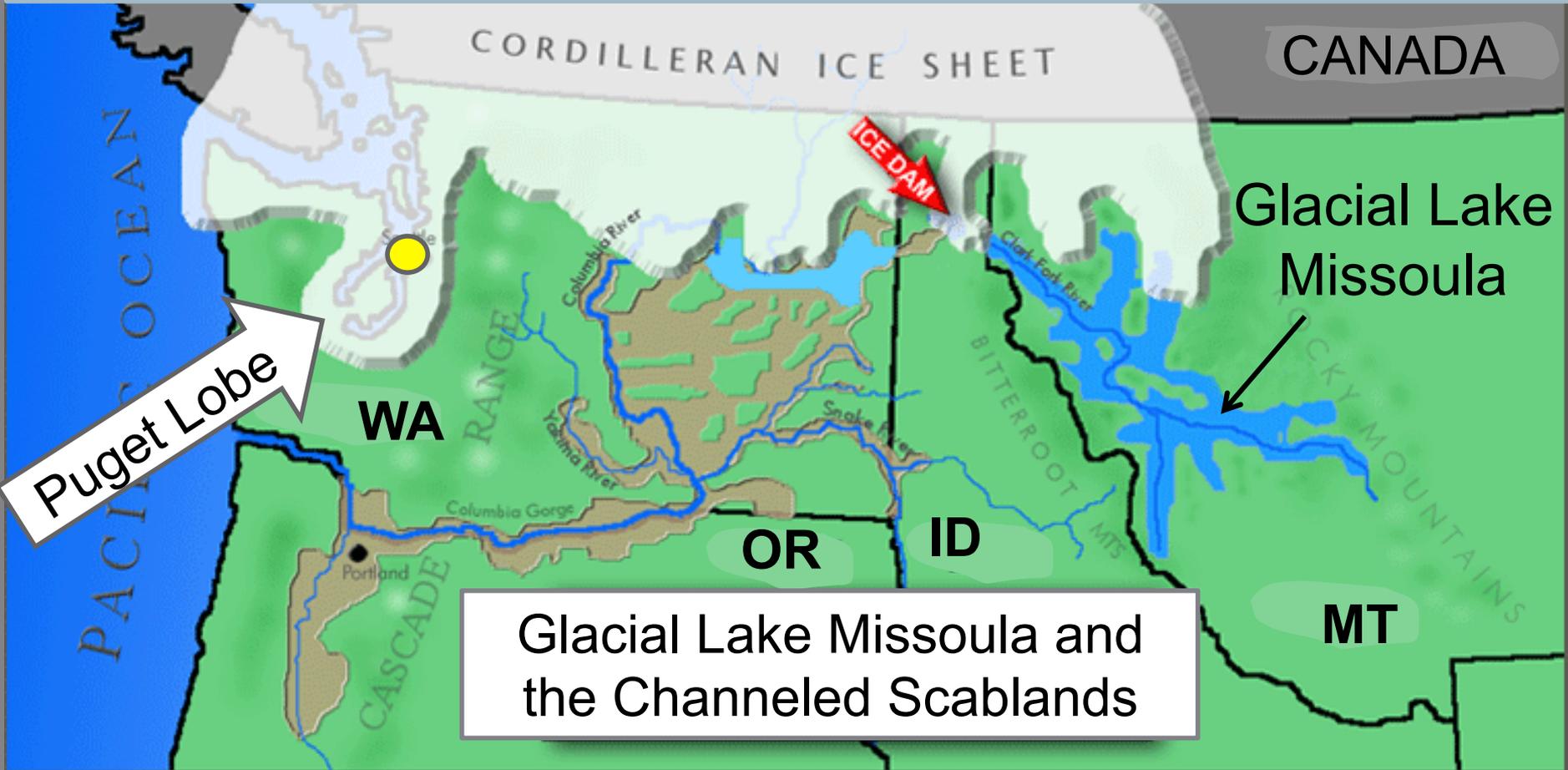
Saddle Mountain
14 - 6 Ma
2,400 km³
1.5%



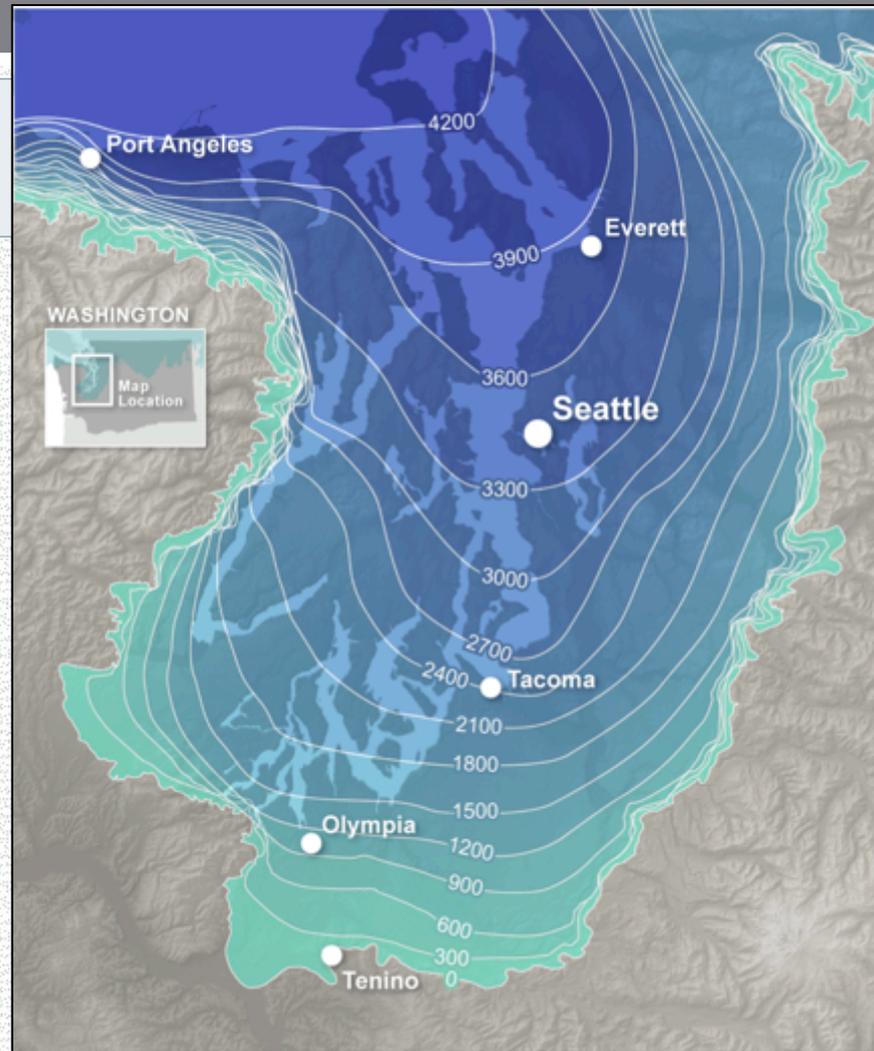
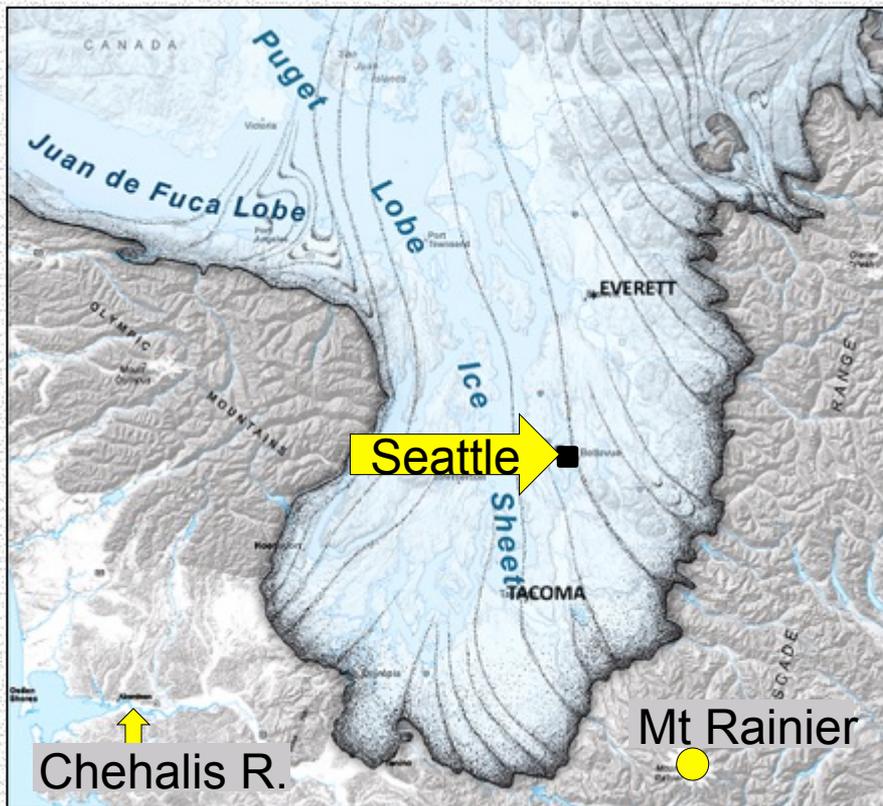
Columbia River Basalt Province: Lava, lava, lava!



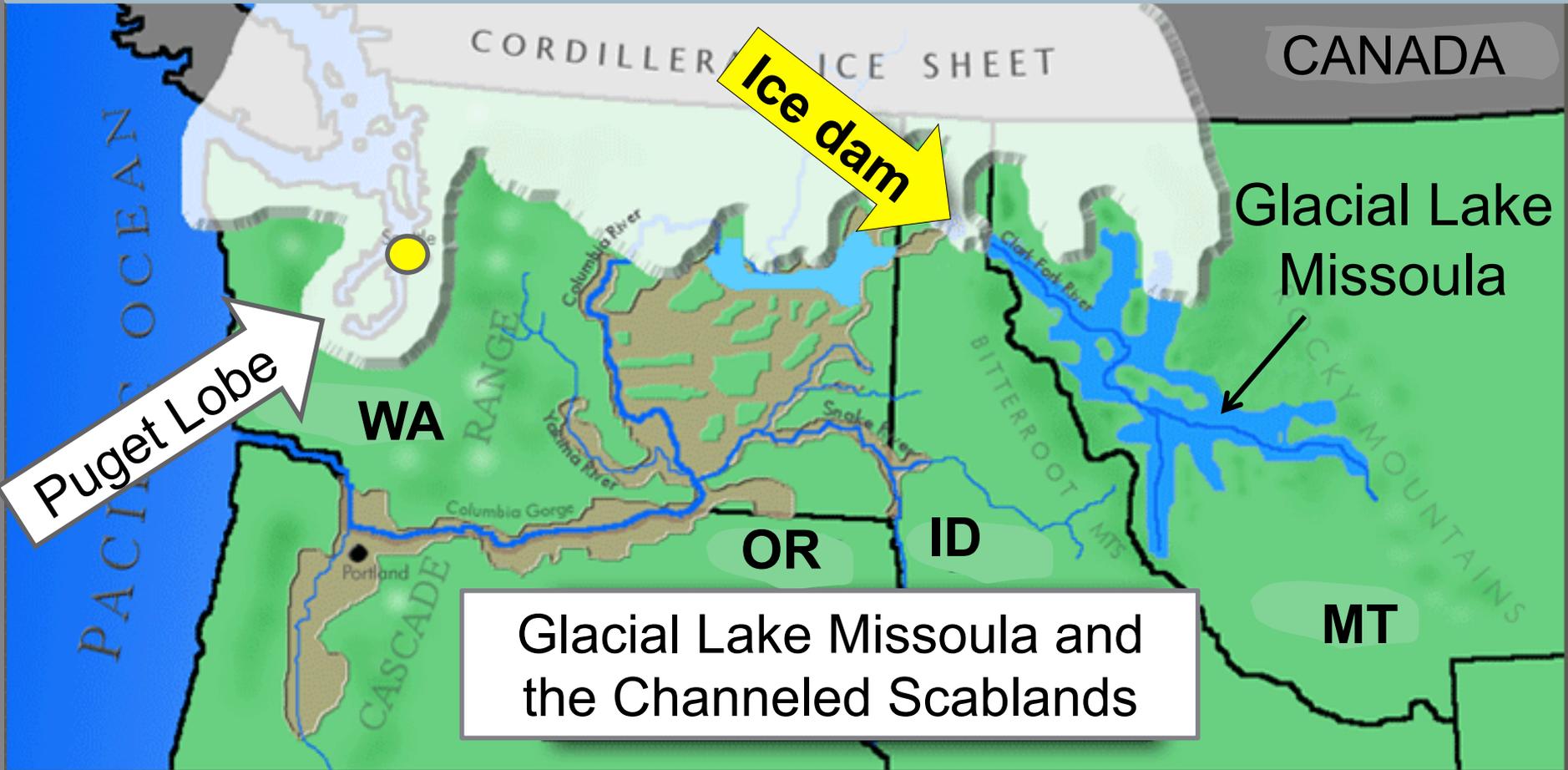
The Cordilleran Ice Sheet crept south



Puget Lobe 19-16 ka



The Cordilleran Ice Sheet crept south



Channeled Scablands



Dry Falls:

- Under 300 feet of water
- 3 miles wide, 400 ft high

Palouse River Canyon

Basalt layers



Umtanum Canyon



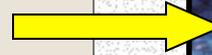
Outcrops of
CRBs



A continuous spectrum . . .

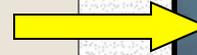
▣ **Effusive** eruptions

■ **lava flows**



▣ **Explosive** eruptions

■ **Lava explodes** from vent



***Pyroclast* =
“fire broken”**

Fire, Ice and Astonishing Floods of the Columbia Plateau

- Buried by gigantic lava flows
- Scoured by Ice Age floods



Palouse Falls

Tectonics & accretion on a continental margin

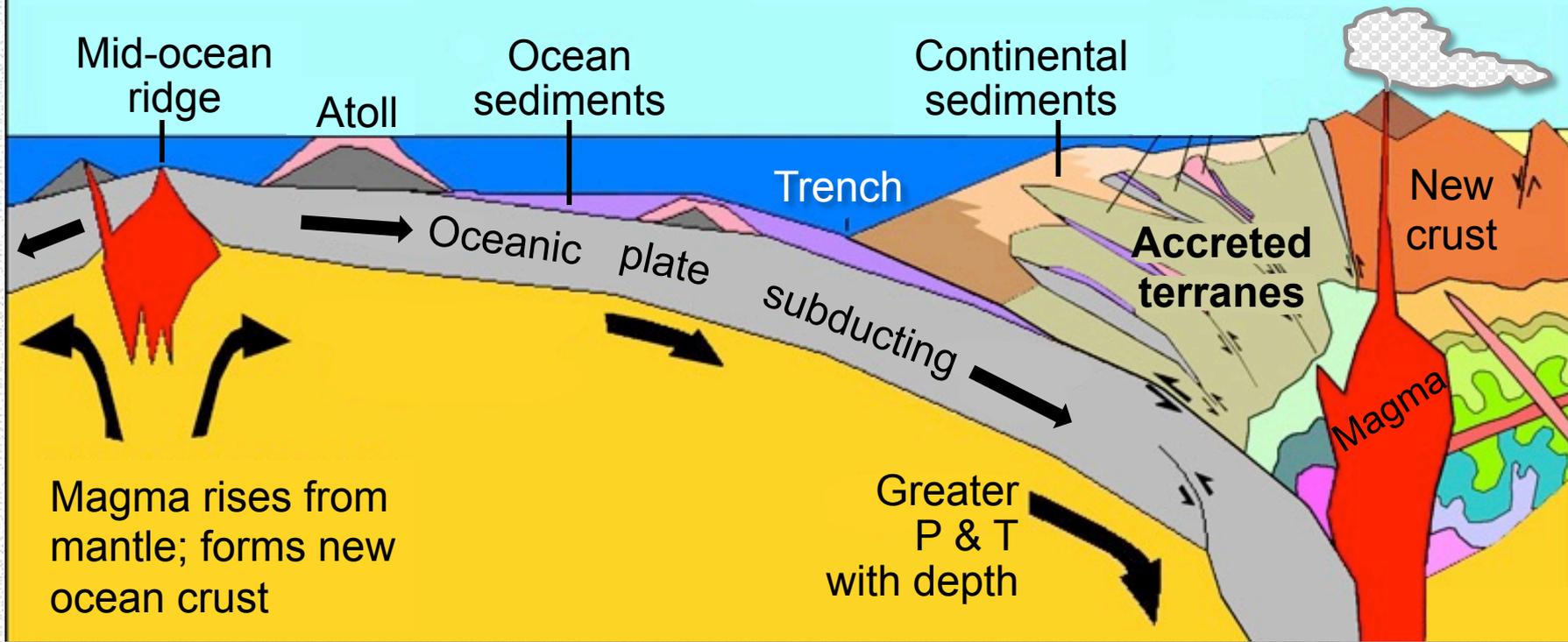
Divergent boundary

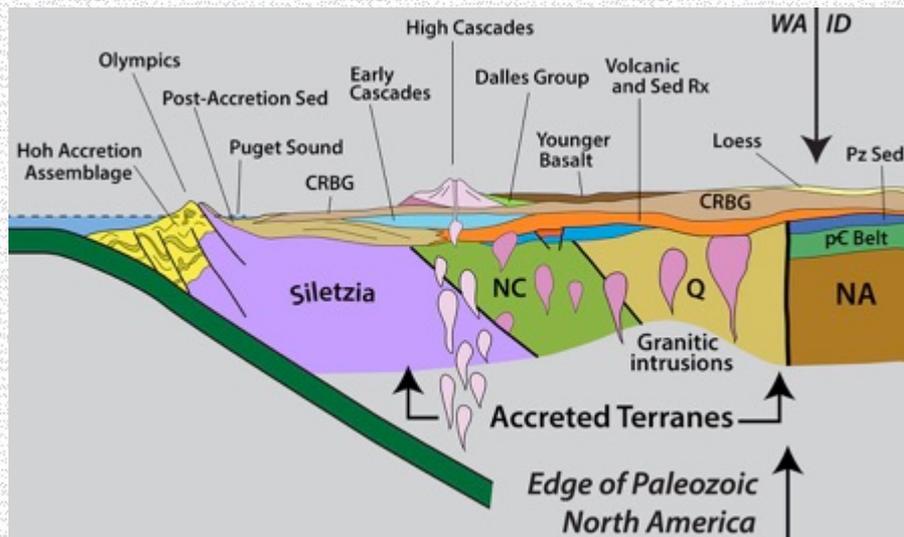
Convergent boundary

Spreading center

Subduction zone

Volcanic arc

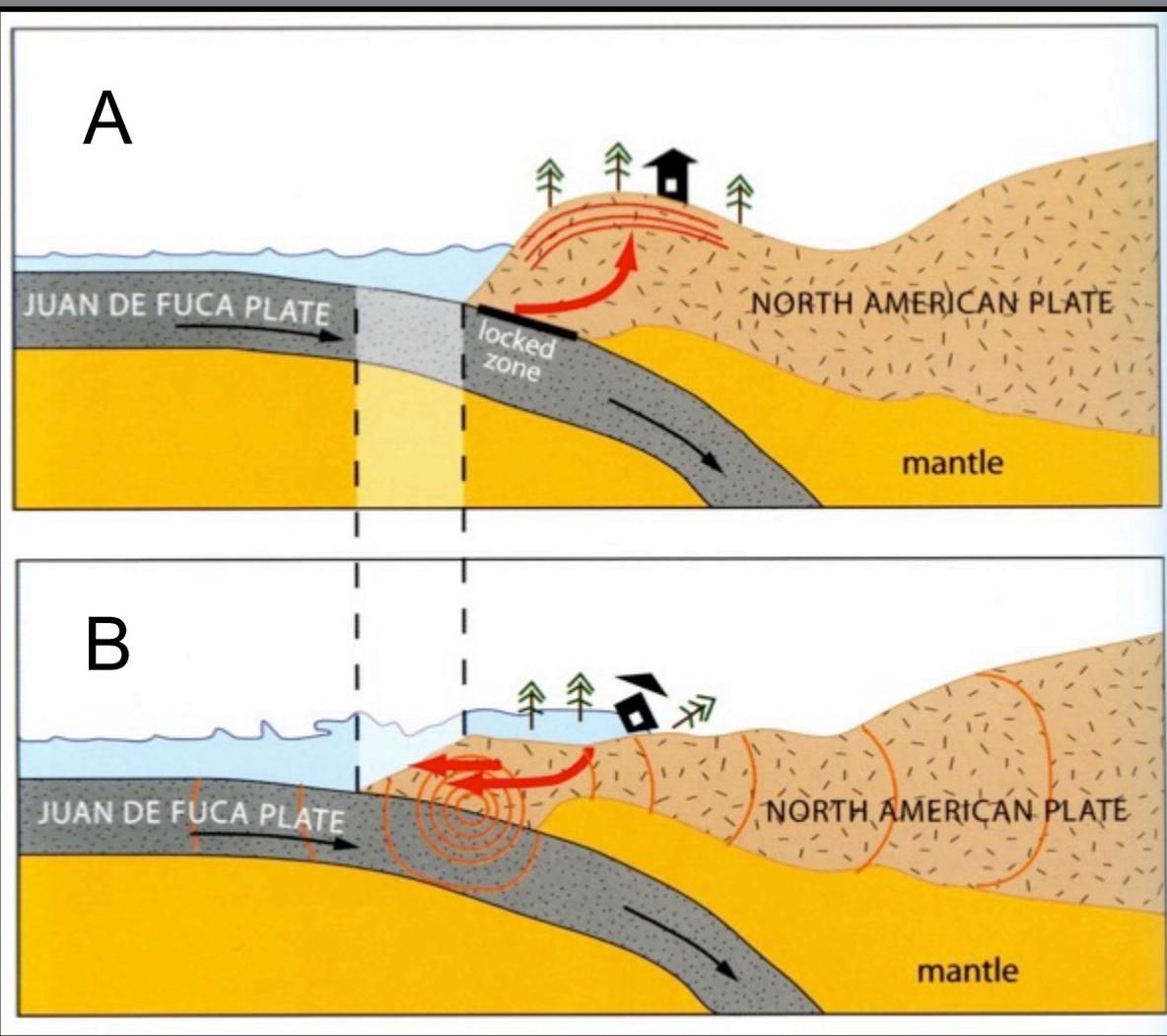




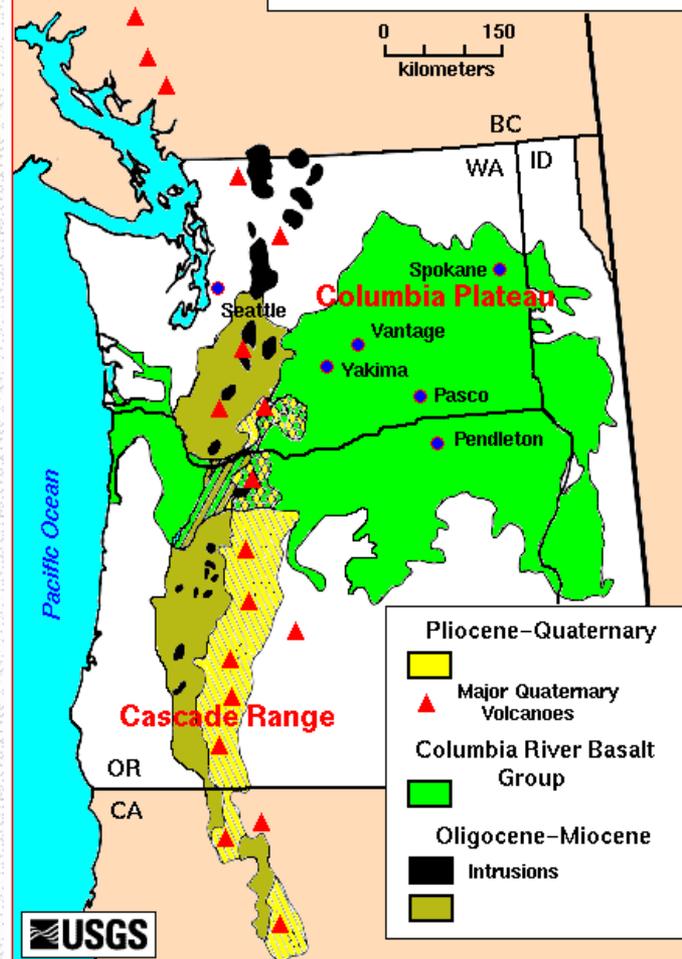
- A. As the eastward-moving Juan de Fuca Plate is subducted beneath the westward-moving North American Plate, friction creates a locked zone between the two plates.
- The massive continental plate, resistant to reverse motion, deforms upward to accommodate the stress.
- B. Eventually the locked zone ruptures and generates an earthquake, partially or entirely relaxing the uplifted area and allowing the leading edge of the continental plate to rebound westward.
- The vertical dashed lines represent this rebound.
- In general, the greater the area that is unlocked, the greater the EQ (modified from Hyndman et al. 1996)

Subduction of the Juan de Fuca Plate beneath the North American Plate

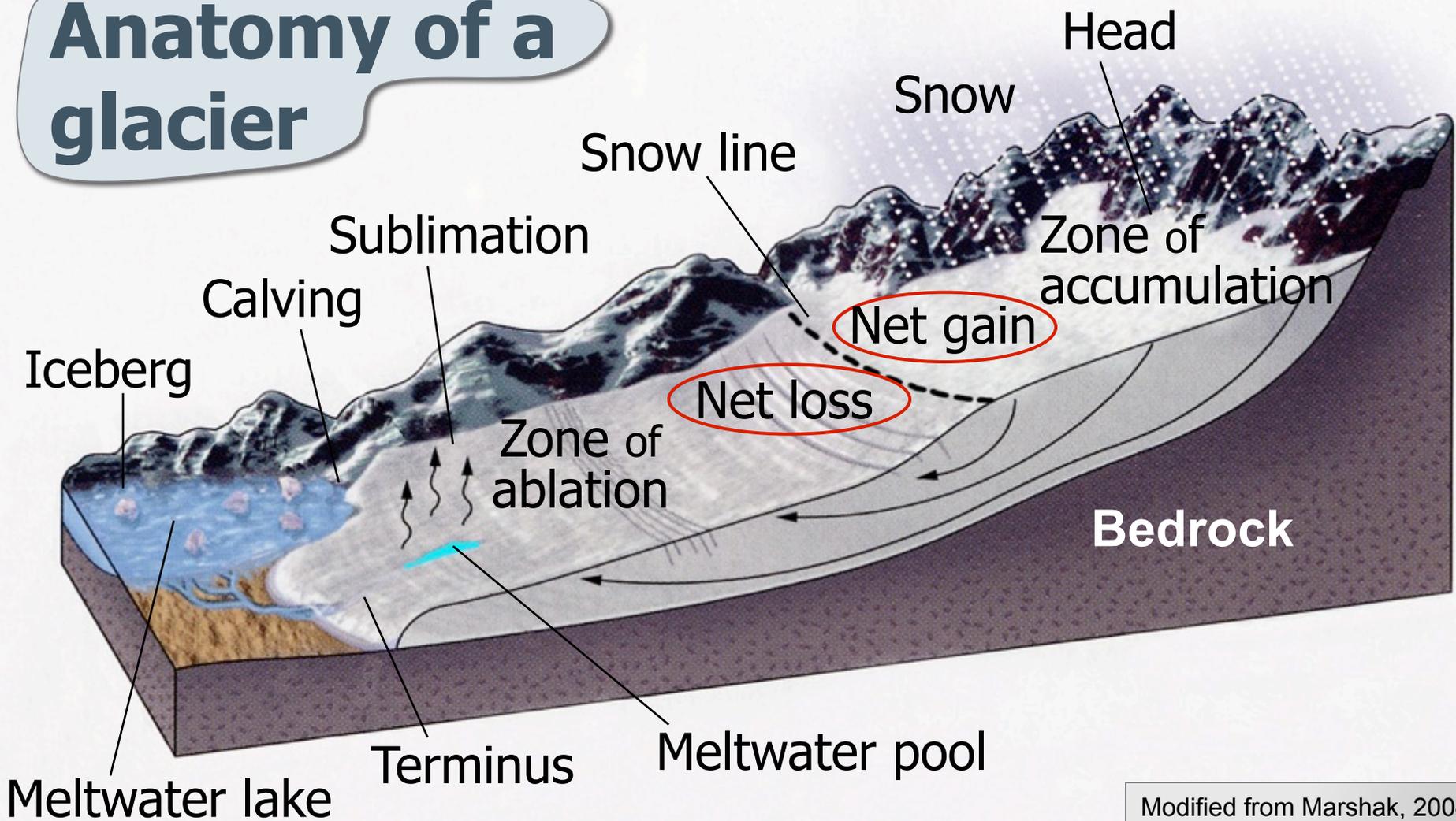
- A. Compression and uplift occurs between EQs
- B. Extension and subsidence occurs after an EQ



Pacific Northwest Volcanics



Anatomy of a glacier





Palouse River Canyon

Cut into basalt
layers by Ice
Age Floods