The Geology of Sculpting Stone

Columbia River Basalt

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Outline

- The Stone Defined
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  - Specimens (macro and thin section)
  - Specific Occurrences
- Geology
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General Description, Physical/Chemical Properties and Historic Use

- Columbia River Basalt (CRB) Group is the name given to a series of dark volcanic rocks which flooded SE Washington and adjacent parts of Idaho and Oregon from about 17.5 to 6 million years ago.
- CRB ranges from 0, at the edge of the Columbia Basin, to over 6000 feet thick at its center
- Generally chemically homogeneous, CRB is dark brown to black which weathers to a medium brown rough rind. Unlike most basalts, CRB overall has a high percentage of quartz with its main component, the Grande Ronde member close to an andesite . In addition, it is contains dark minerals (e.g. hornblende, proxenes, biotite, olivine, magnetite) and some feldspars. It is of medium density and has a tendency to fracture conchondially
- CRB has been locally used since the 1800s and is most commonly crushed for use as aggregate in industrial/ construction projects. It is also used as dimension stone for walls, tiling and occasionally veneers. Artistically, CRB is used for monuments and sculpture, often in some modified columnar form

Chemical Composition of CRB*

SiO_2	53.84%
Al_2O_3	14.37
FeO	11.37
MgO	5.25
CaO	8.97
Na_2O	2.92
K_2O	1.10
TiO_2	1.75
P_2O_5	0.23
MnO	0.19

***Grande Ronde Member**

Specimens: Macro

Outcrop

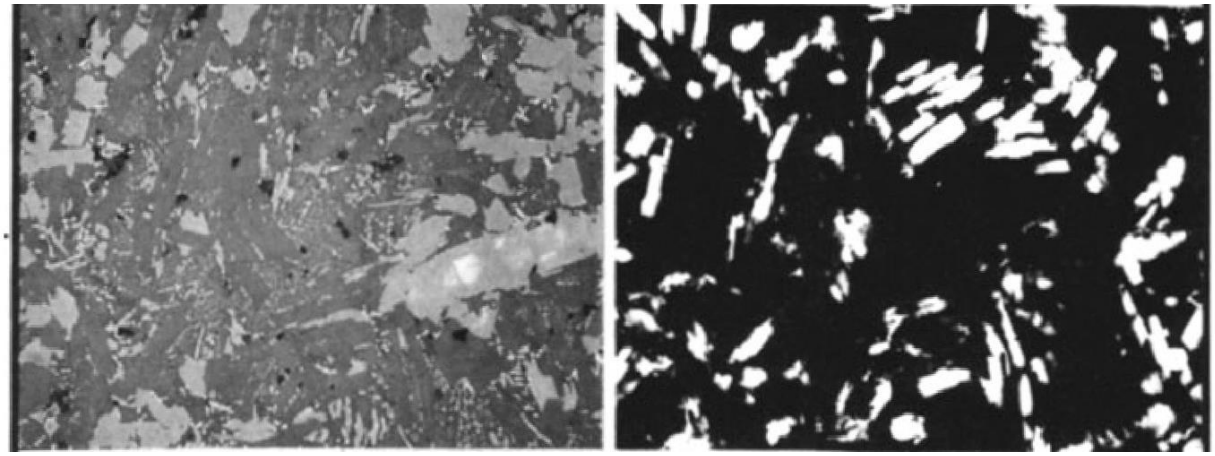
Hand Specimen

Prepped Slabs

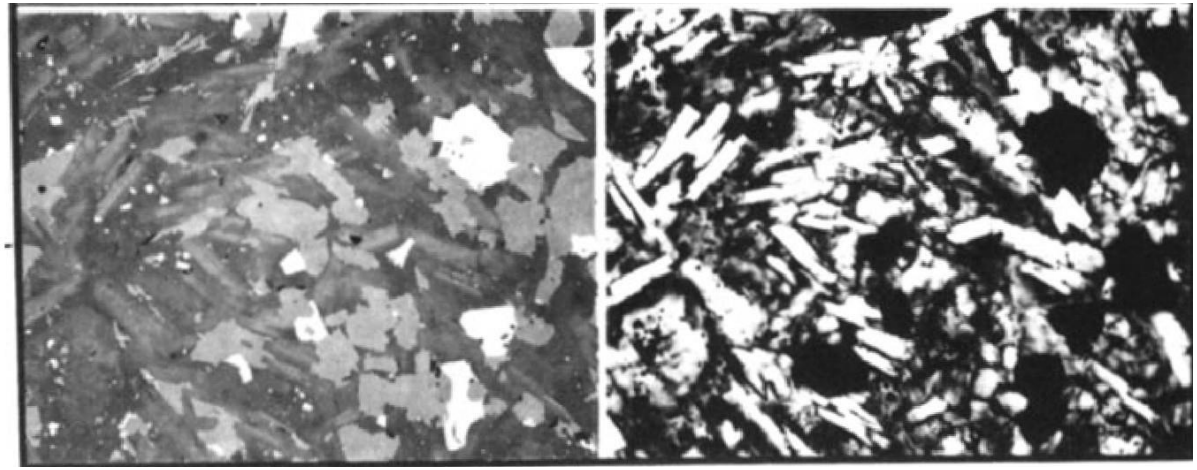
Quarried Columns

Specimens: Thin Sections

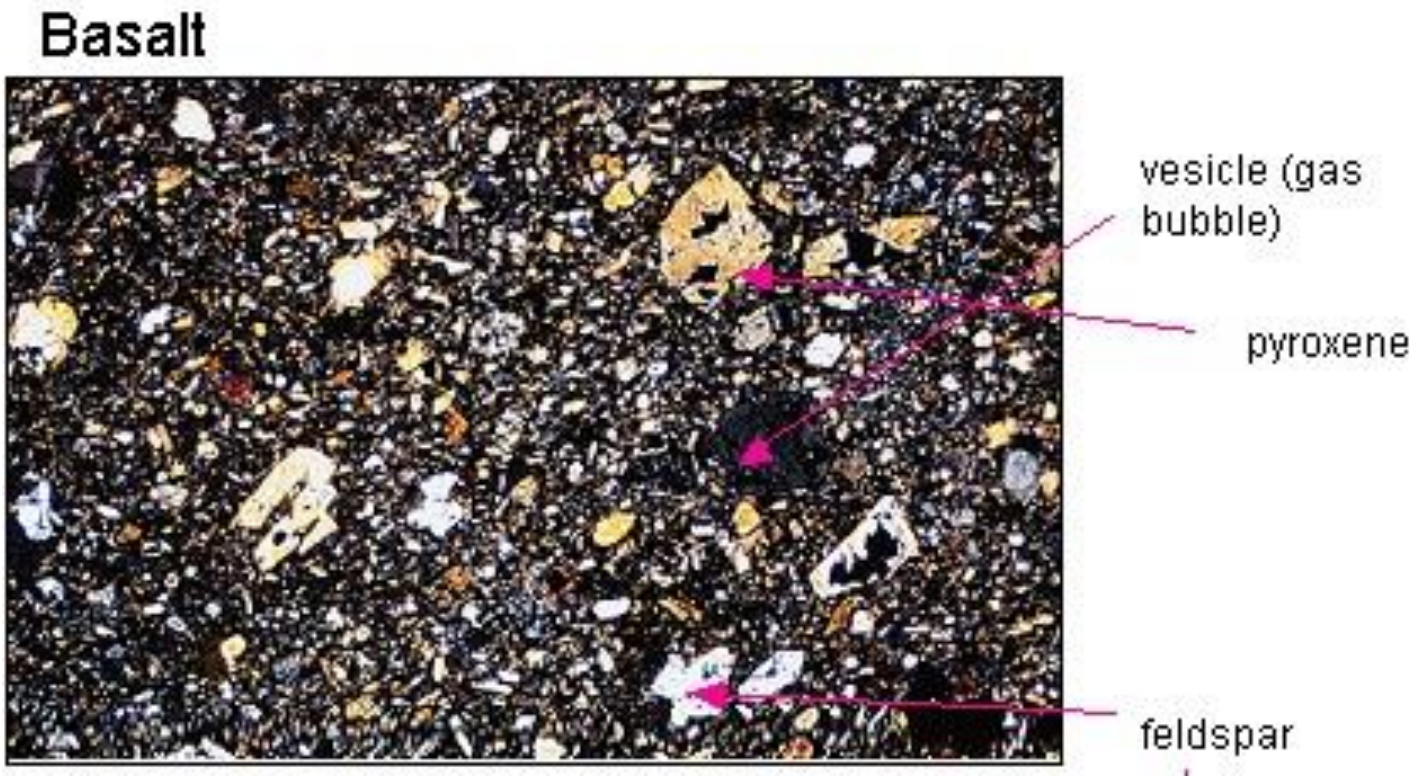
ENTABLATURE (towards flow top)



COLONNADE (towards flow bottom)



Specimens: Thin Sections



Specimens: Thin Sections

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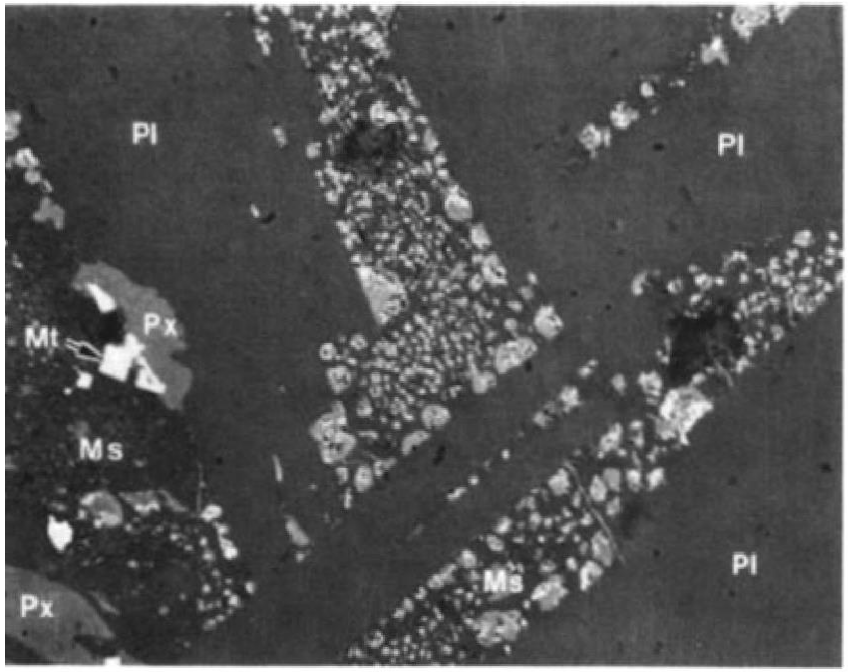
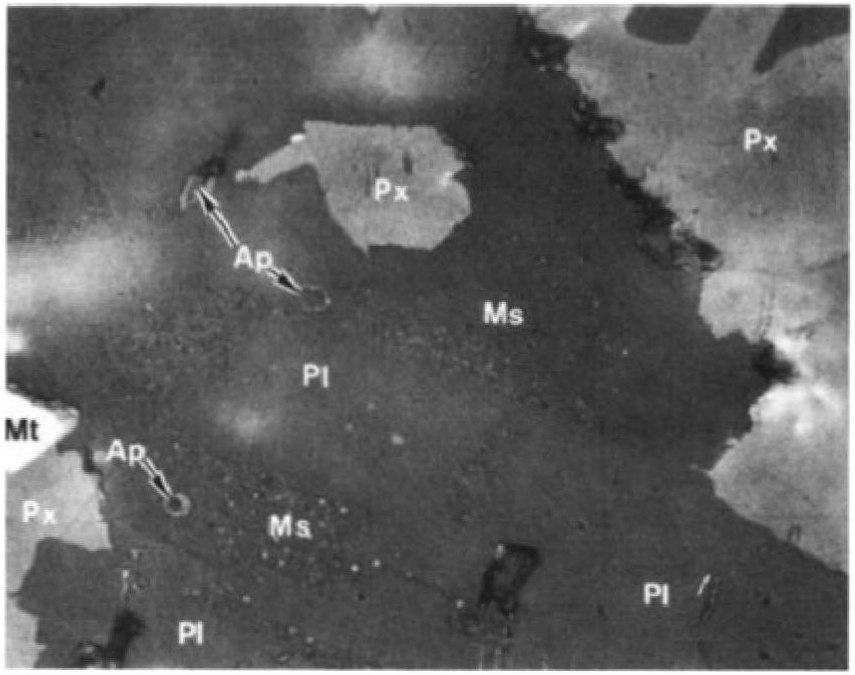


COLONNADE

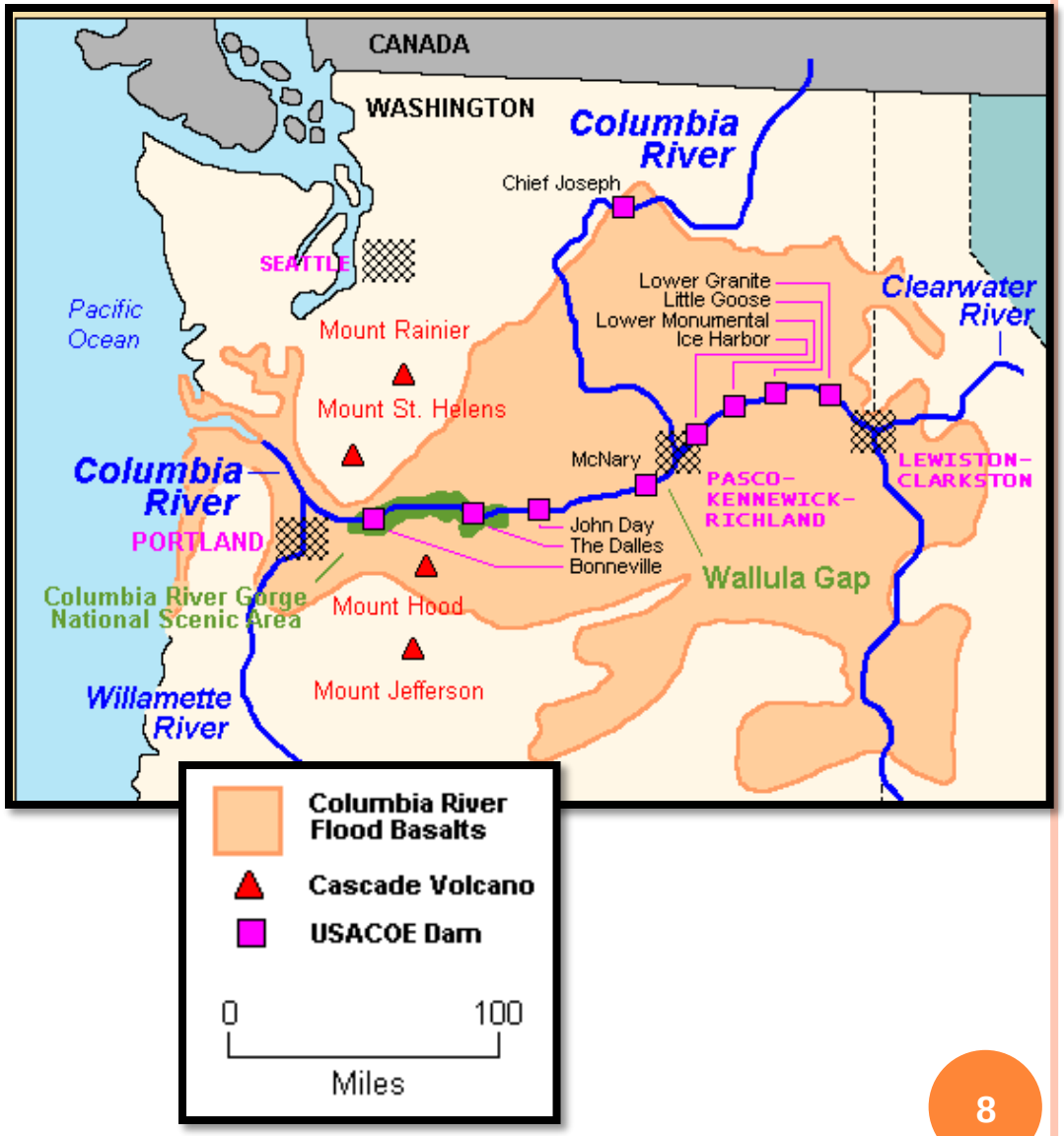


1.1 mm

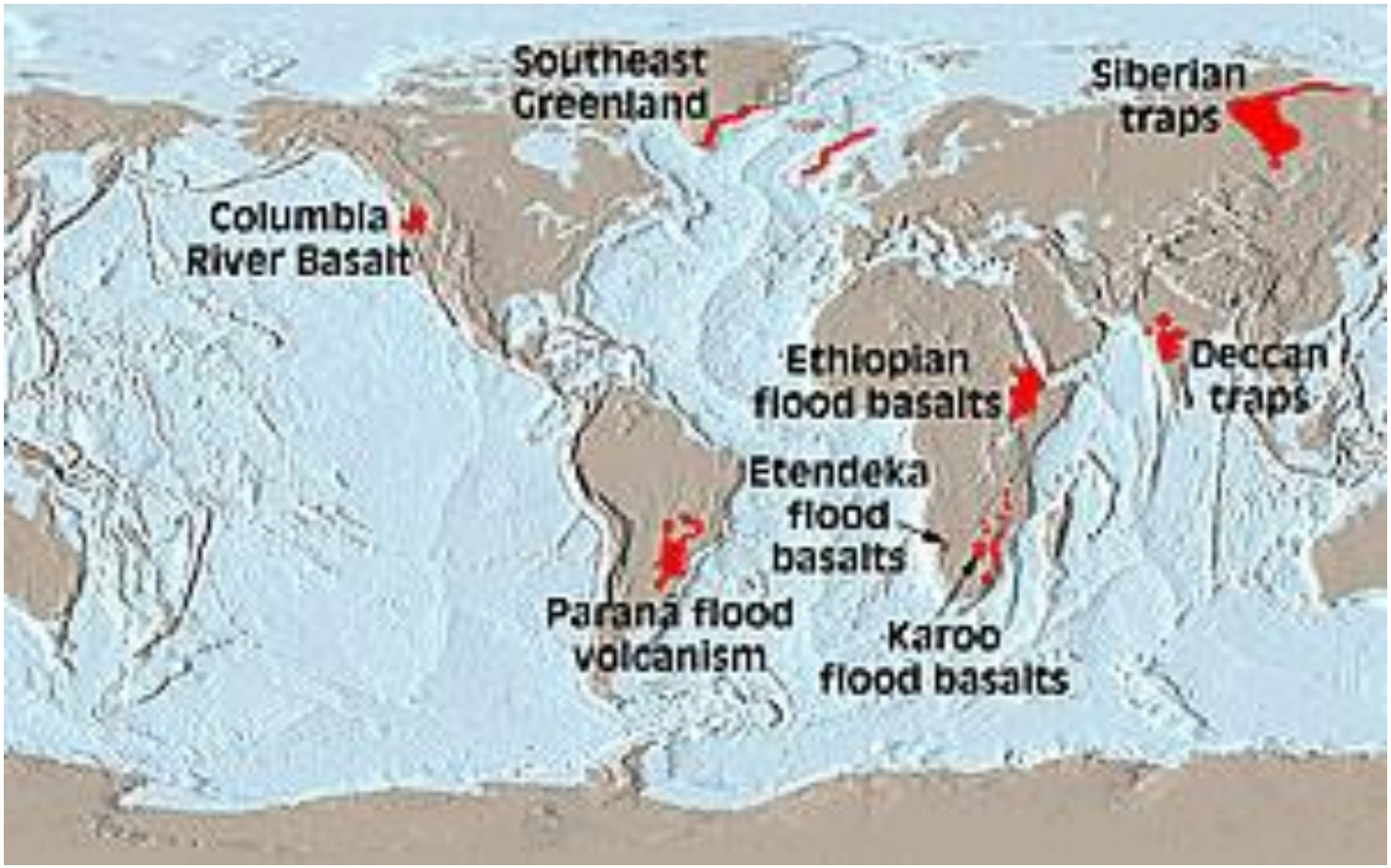
Light colored grains, titaniferous magnetite (Mt); medium-gray grains, pyroxene (Px); dark laths, plagioclase (Pl); interstitial areas, glass plus inclusions of aphanitic groundmass (Ms)

Specific Occurrences

- The CRB occupies about 63,000 square miles of the Pacific Northwest. It is one of the largest basaltic lava floods in earth's history
- During a period 10 to 15 million years multiple flows of CRB occurred, eventually accumulating to a maximum thickness of more than 6,000 feet
- Over 300 high-volume individual lava flows have been identified, along with countless smaller flows. Numerous linear vents, some over 90 miles long, show where lava erupted near the eastern edge of the Columbia River Basalts
- As the CRB accumulated, the earths crust slowly sank under the weight of the basalt and into the space left by the rising lava. The subsidence of the crust produced a large, slightly depressed lava plain now known as the Columbia Basin (Plateau).

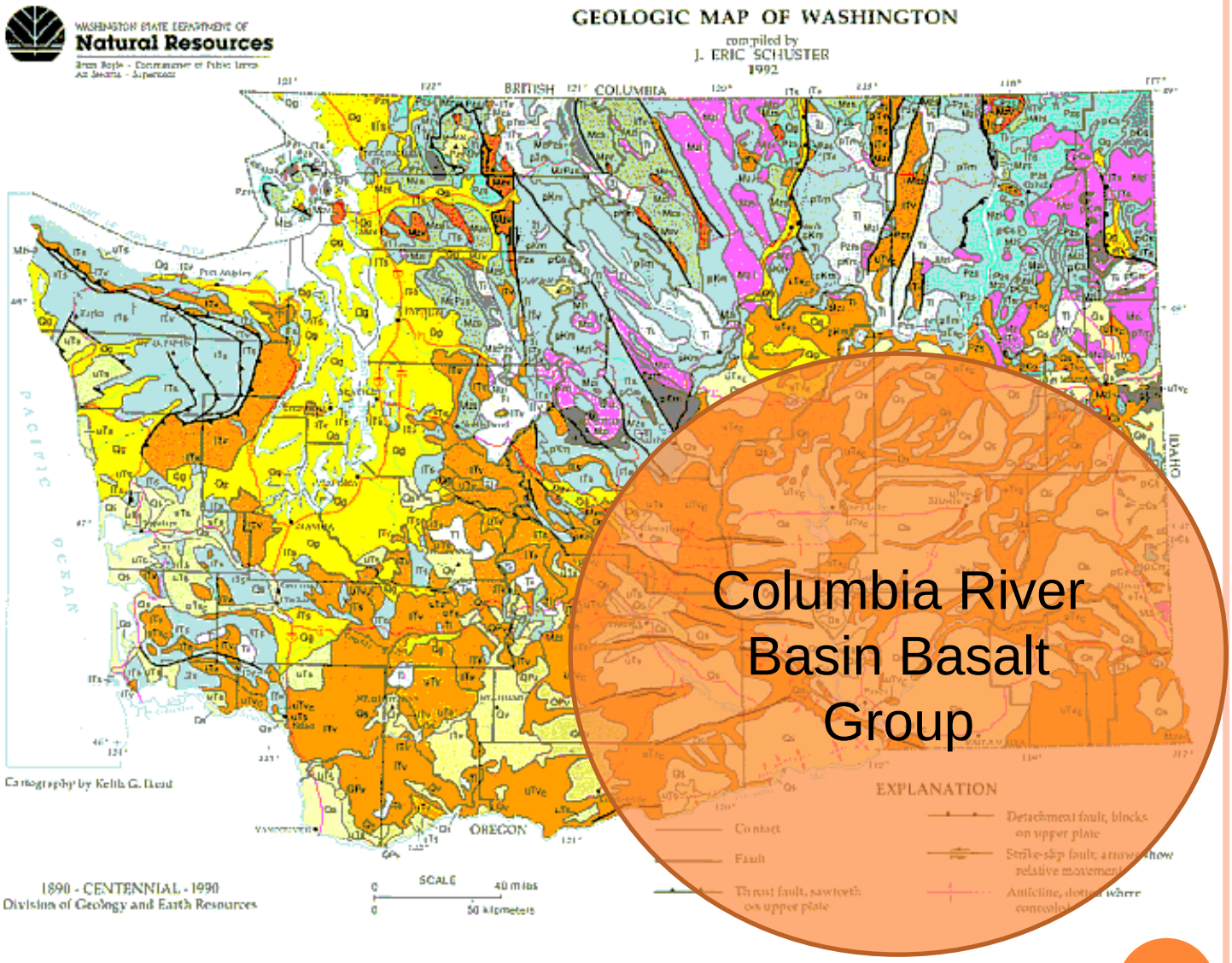


Specific Occurrences



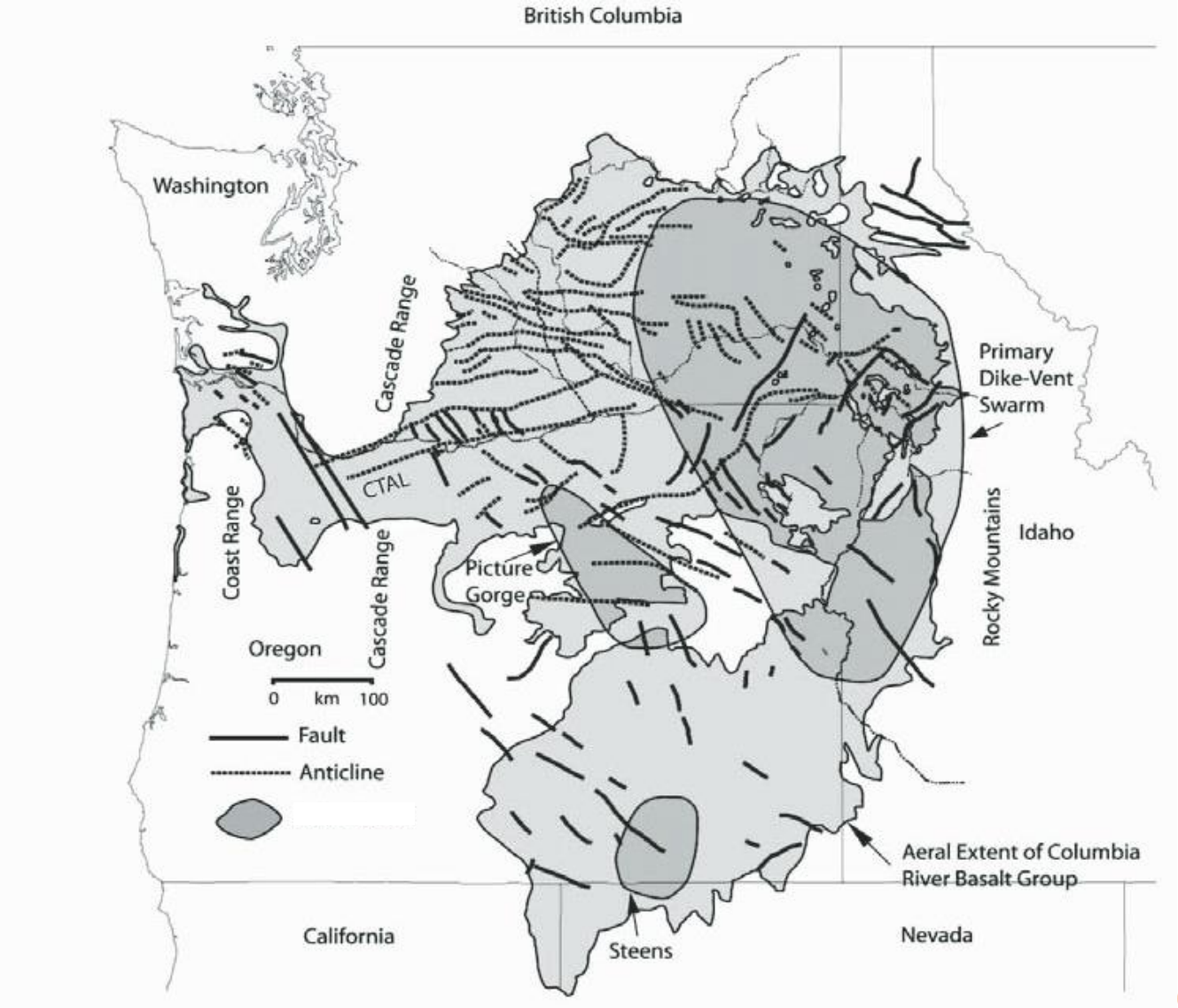
Specific Occurrences

The CRB basin and its subsequent erosion dominates the SE corner of Washington state



Specific Occurrences

The overall CRBG distribution is now recognized to cover a much larger area.



Specific Occurrences: CRBG thickness

Isopach map of the CRBG shows that it is over 10000 feet thick in the center of the Columbis River Basin. Thicknesses have been determined by field and borehole stratigraphic sections.

Age and Geologic Description

Stratigraphic Subdivision of Columbia River Basalt Group (CRBG)

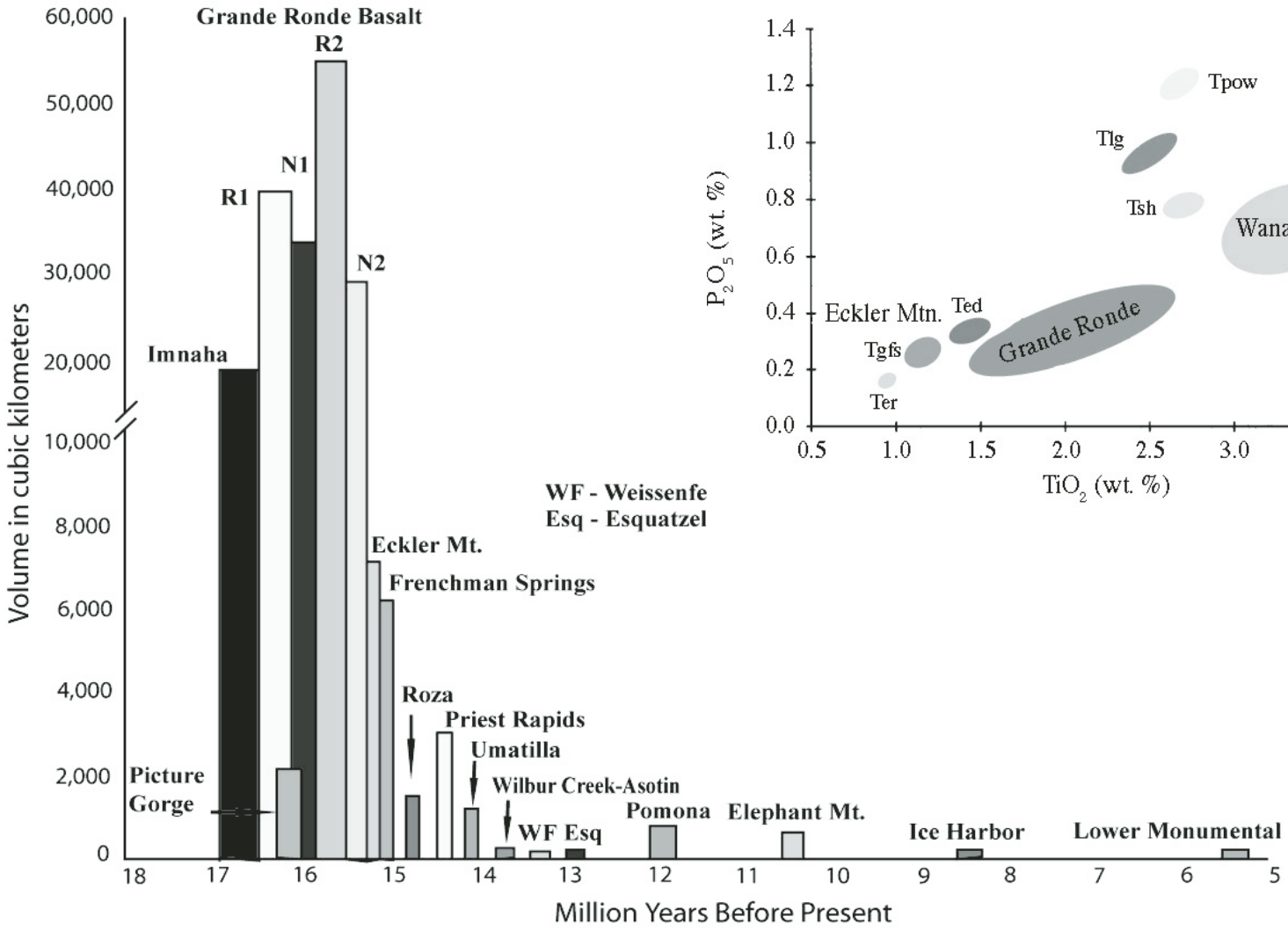
SERIES		GROUP	SUB-GROUP	FORMATION (Age, Volume, % of CRBG)	MEMBER	MAG*
Miocene	Upper	Columbia River Basalt Group	Yakima Basalt SubGroup	Saddle Mountain Basalt (14–6 Ma, 2,400 km3 volume, 1.5% of CRBG)	Lower Monumental Member	N
					Ice Harbor Member	N,R
					Buford Member	R
					Elephant Mountain Member	R,T
					Pomona Member	R
					Esquatzel Member	N
					Weissenfels Ridge Member	N
					Asotin Member	N
					Wilbur Creek Member	N
					Umatilla Member	N
	Middle			Wanapum Basalt (15.5–14.5 Ma, 10,800 km3 volume, 6.0& of CRBG)	Priest Rapids Member	R3
					Roza Member	T,R
					Frenchman Springs Member	N2
					Eckler Mountain Member	N2
	Lower			Grande Ronde Basalt (17–15.5 Ma, 151,700 km3, 87%)		N2
						R2
				Picture Gorge Basalt		N1
						R1
				Imnaha Basalt (17.5–17 Ma, 9,500 km3 volume, 5.5% of CRBG)		R1
						T
						N0
						R0

* Magnetic Polarity:
N, normal; R, reversed; T, transitional; subscripts denote magnetostratigraphic units

USGS Topinka, USGS/CVO, 1997, Modified from: Swanson, et al., 1989, AGU Field Trip Guidebook T106

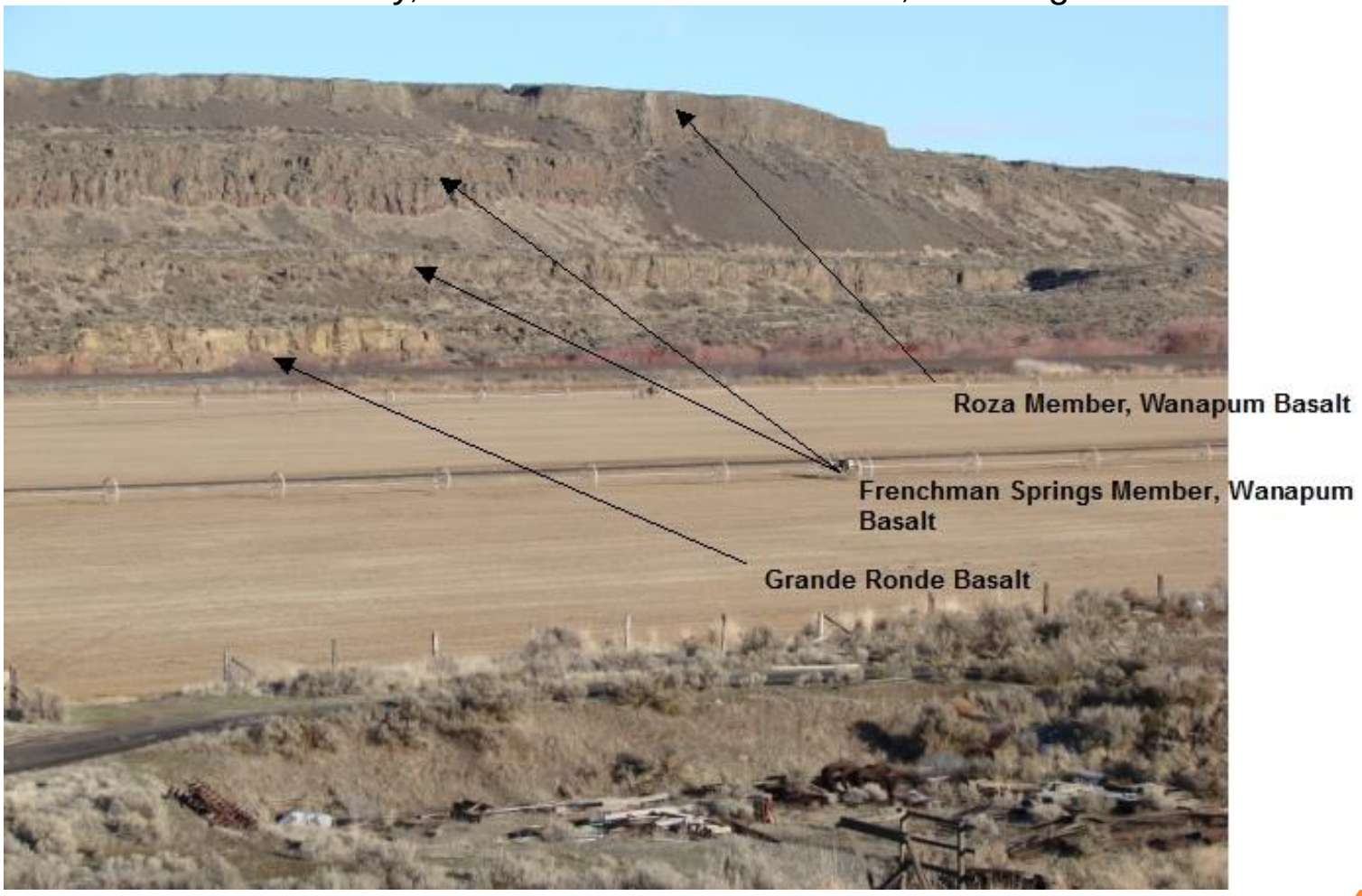
- CRB erupted between 17.5 and 6 million years ago
- Early eruptions (17.5-17 Ma) fed the **Imnaha Basalt**, which is confined to the southeast part of the province
- Most of the group was formed during a 1.5-m.y. period between about 17 and 15.5 Ma, resulting in the **Grande Ronde Basalt** and the greatly subordinate and geographically limited **Picture Gorge Basalt**
- Later eruptions formed the **Wanapum Basalt** (about 15.5-14.5 Ma) and the **Saddle Mountains Basalt** (about 14-6 Ma)
- Relatively little erosion took place between flows, owing to the rapid rate of accumulation, except during Saddle Mountains time
- However, a regionally extensive saprolite (fossil soil) or a sedimentary interbed separates the Grande Ronde and Wanapum in most places; flows just below and above the contact typically are normally magnetized, so that the time represented by the break is most likely less than 100,000 years. In Saddle Mountains time, however, interflow erosion was significant, and most contacts are erosional unconformities.

Age and Geologic Description: temporal Distribution and Differentiation of Basalt Flows



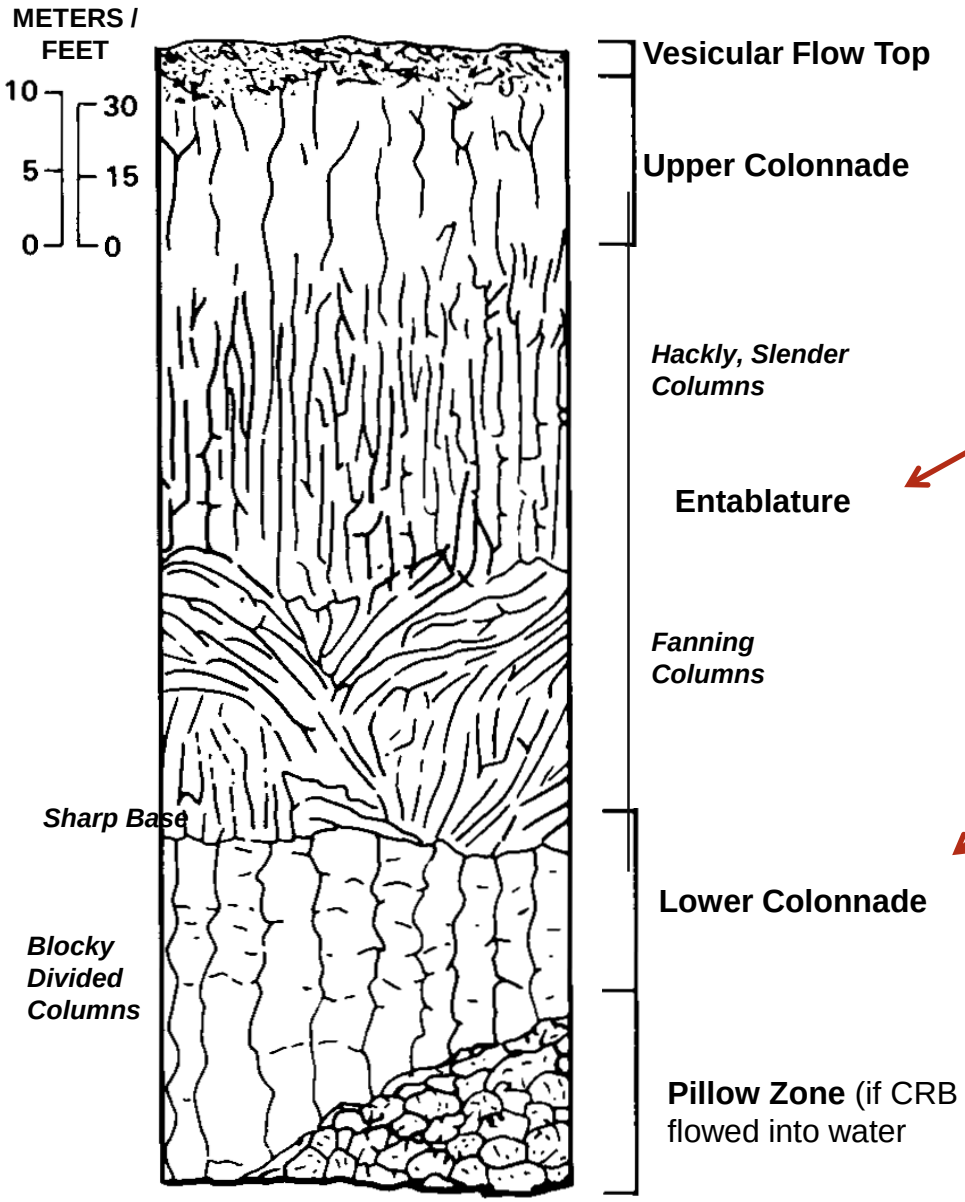
Age and Geologic Description: Sample Outcrops

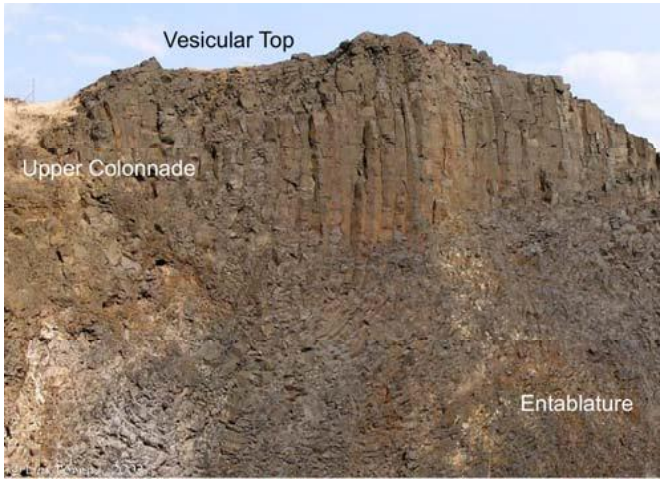
The base of the Wanapum Basalt and the uppermost Grande Ronde Basalt exposed in Crab Creek Coulee near Irby, a few miles west of Odessa, Washington.



Age and Geologic Description: Sample Outcrops

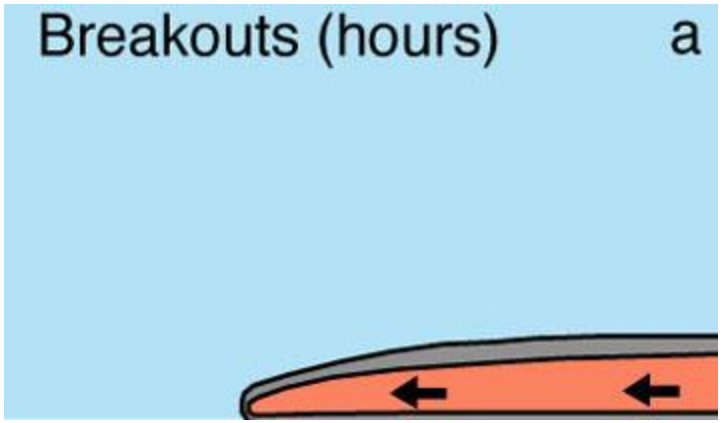
Formation Environment and Processes: CRB Intraflow Structures

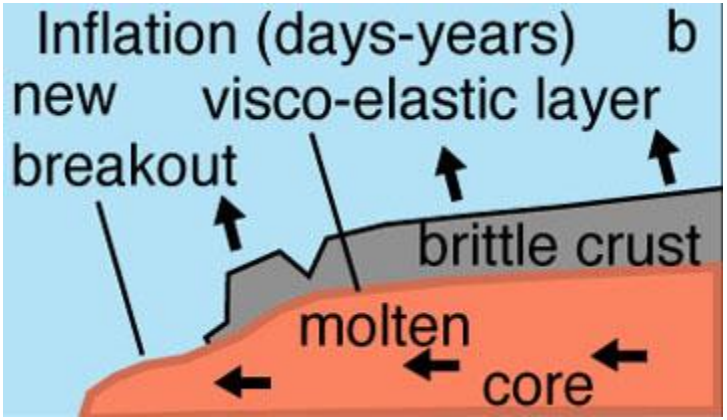


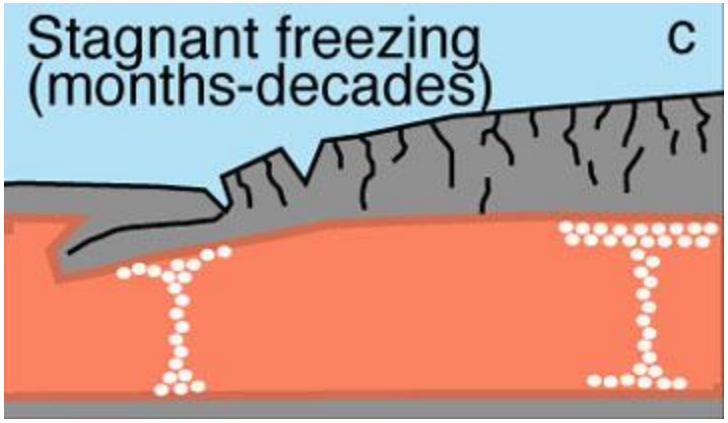


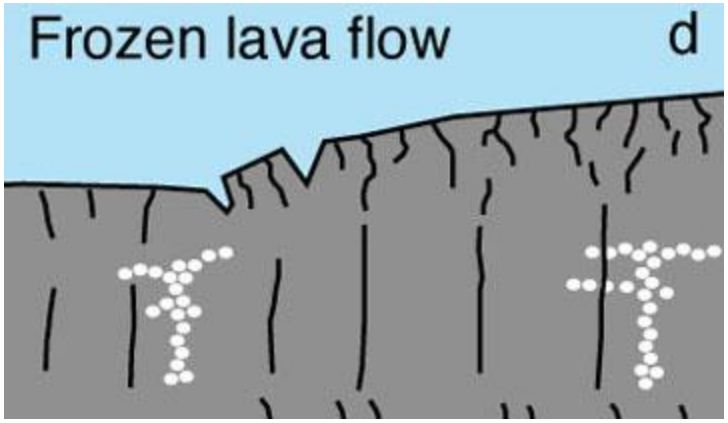
Formation Environment and Processes: CRB Flow Dynamics

- Growth and inflation of lobes of lava by the internal injection of more lava
- Each pulse of new lava creates a thicker flow
- Flows advance by breakouts at the front of the flow



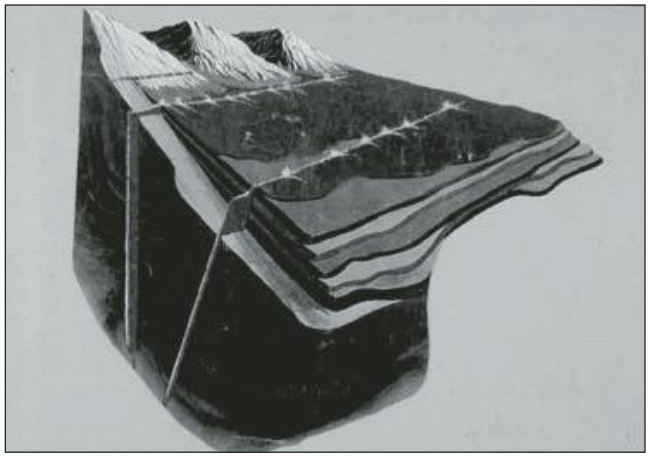


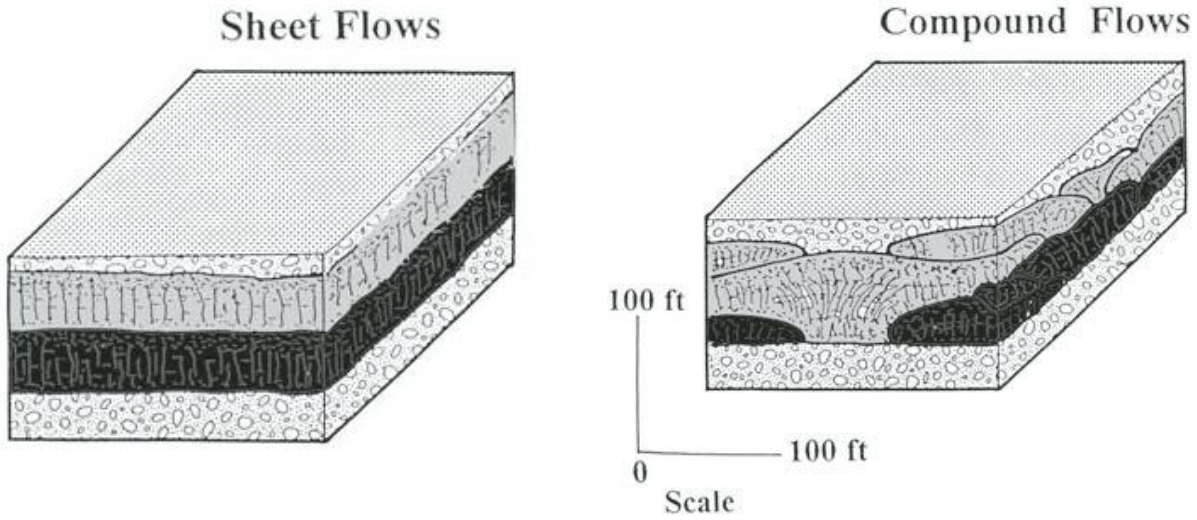




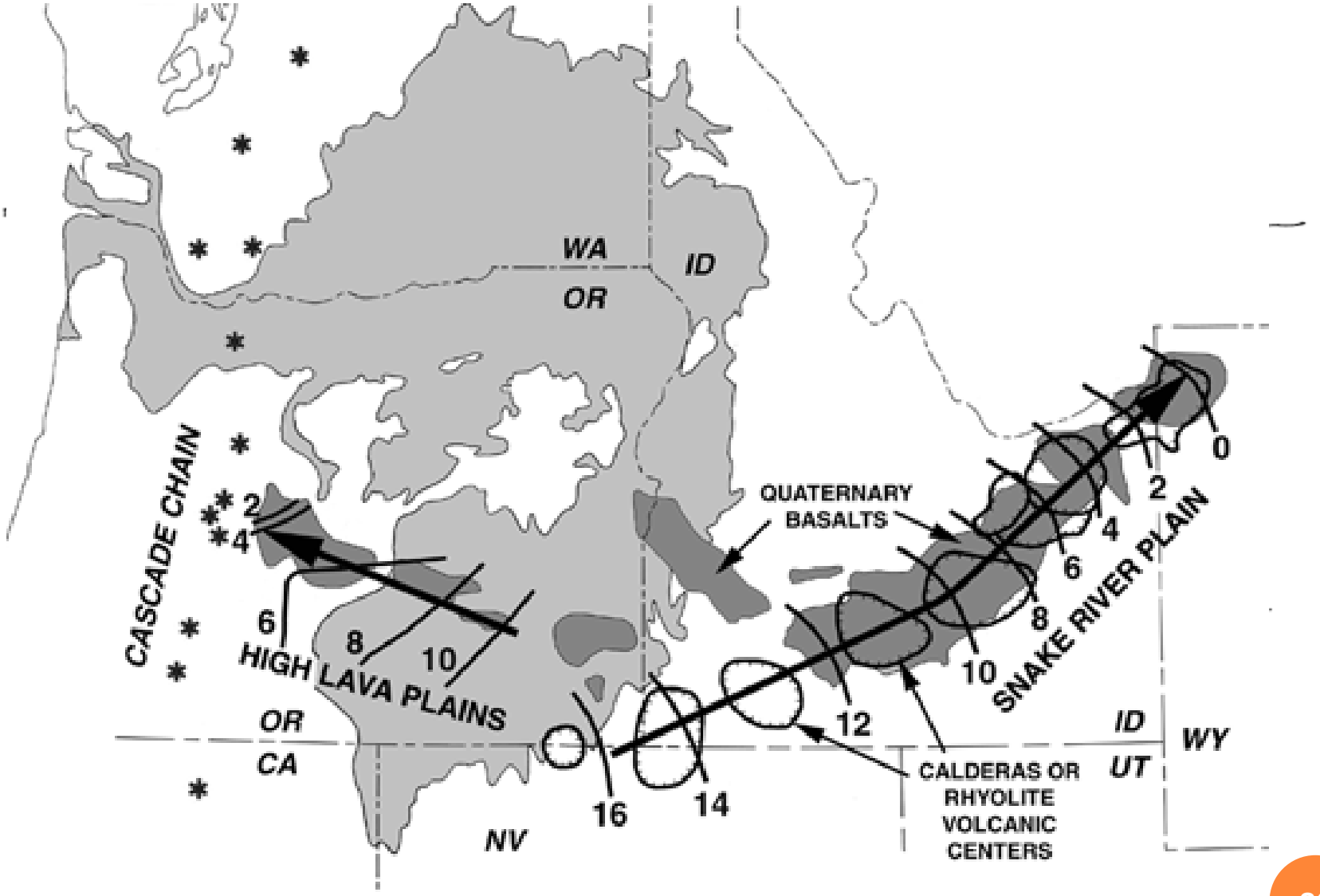
Sheet Flow vs Compound Flow

CRBG sheet flow volcanics have a different internal makeup and component distribution than conventional point source compound flows

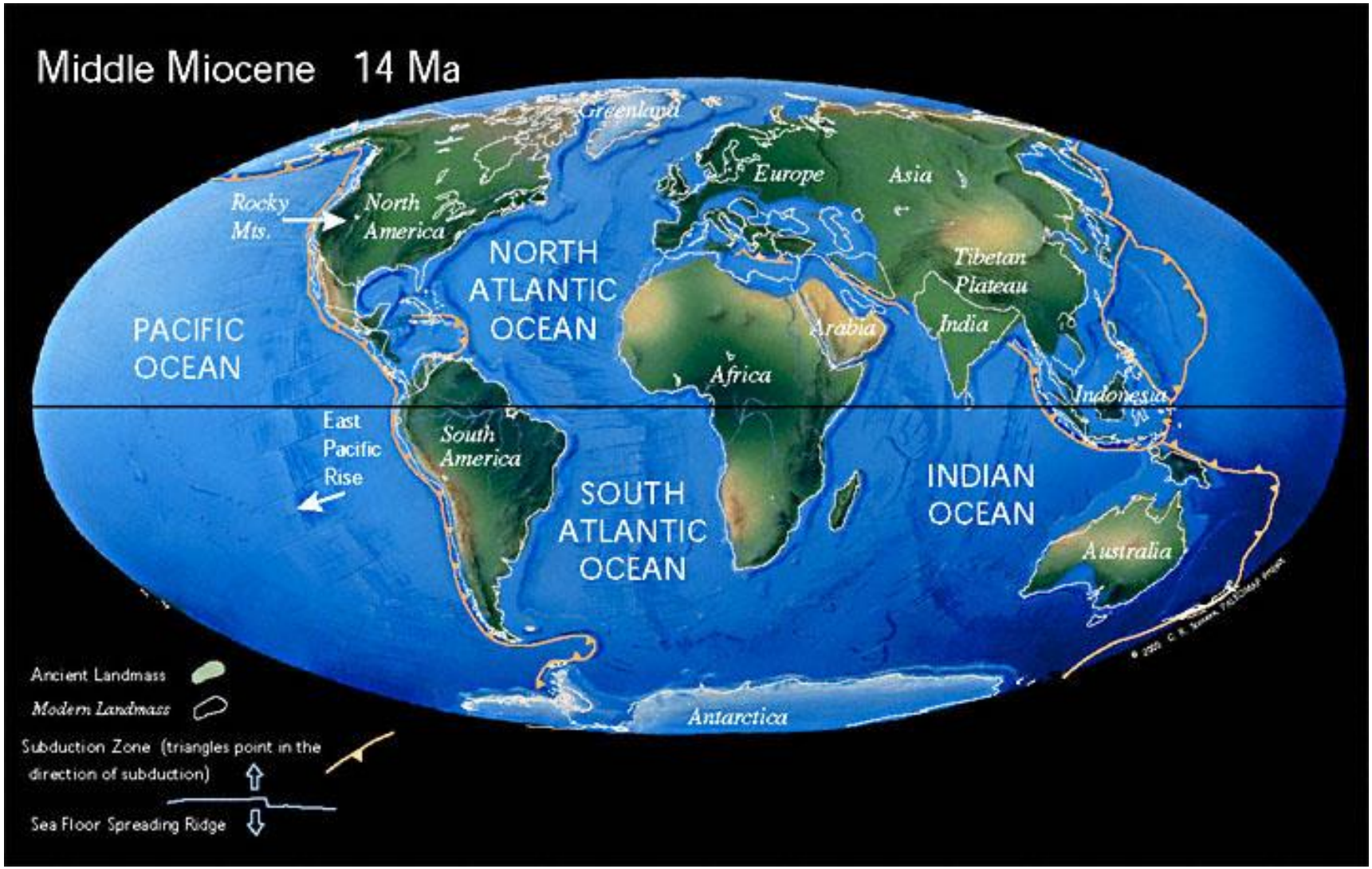




Formation Environment and Processes: CRB Creation - Current Ideas



Global Paleographic Setting

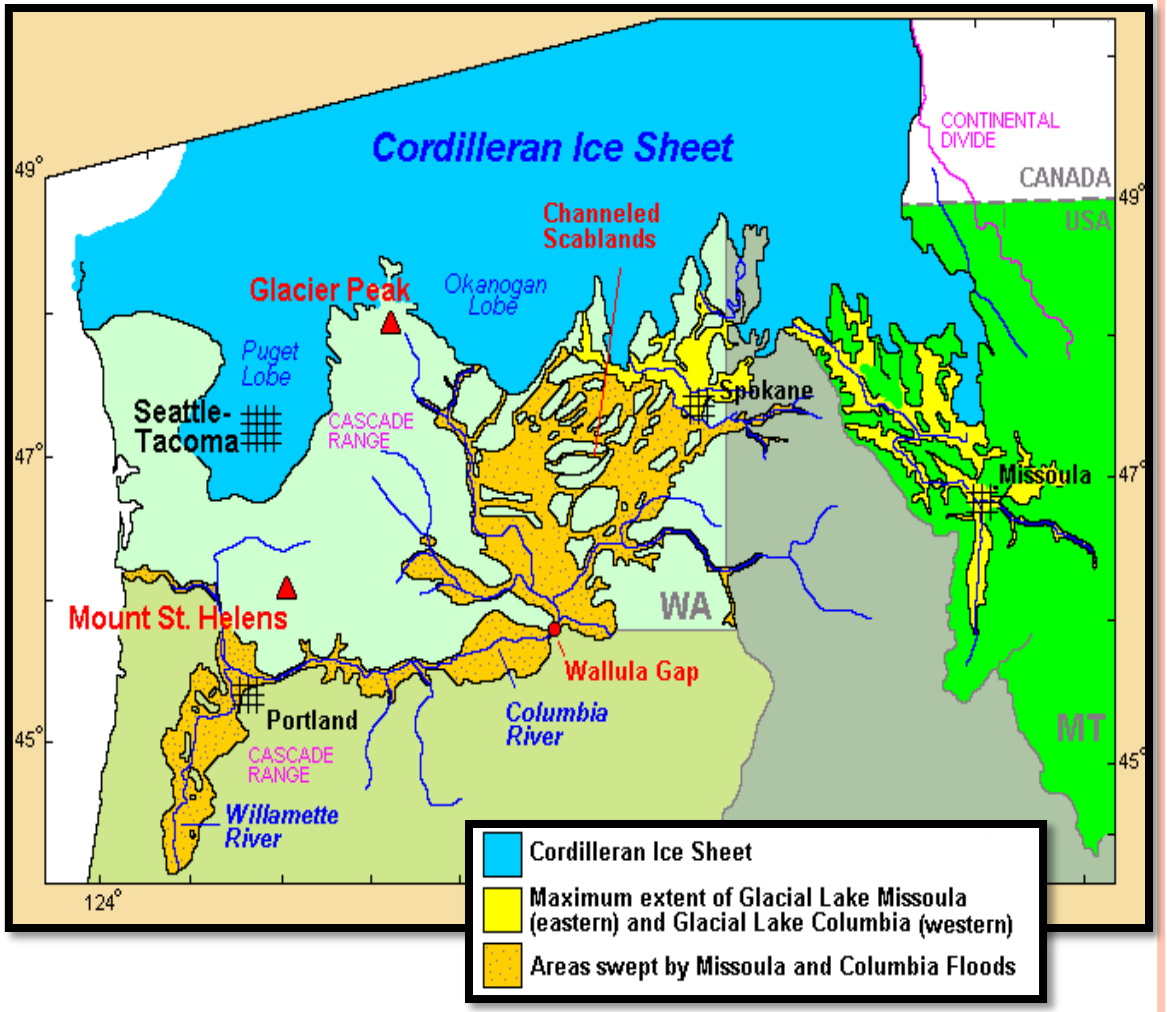



CRB

Global Paleographic Setting: Into the Plio-Pliestocene

Lake Missoula Floods:

- Plio-Pleistocene glacial and associated erosional activity created much of the current landscape of the CRB basin
- Massive flooding tied to the cyclical build-up and collapse of Lake Missoula gouged deep channels, “coulees”, across the CRB as the flood water surged west following the ancestral Columbia river path to the sea
- The floods flowed at 10 times the combined rates of all the rivers of the world with flood approaching 65 miles per hour
- Flooding repeatedly occurred for approximately 2,500 years



Dry Falls

Drumheller Channels near Othello, Washington

Frenchman Coulee

Modern Analogs

- No exact modern analogs to the scale and tectonic locations of the CRB are active today
- However, active shield volcanoes and some current rifting zones may generally reflect the CRB's depositional environment

Krafla, Iceland

Mount Etna, Sicily

Kīlauea, Hawaii

Modern Analogs

- These flows, like the CRB, have low viscosity demonstrating rapid fluid flow

Art

Galileo 2020 Basalt
Goldleaf
Tom Small

Middle Columbia River region, Pile Driver, pre-19th century, carved basalt, 10½" x 7" 3½".

“Opening to Grace"
36" high
Basalt
Sabah Al-Dhaher

Architecture

Harnish Boat House 1929
Lake Oswego

First Congregation Church, Portland

Columbia River Basin

- Underlying the 100,000 square miles (259 000 square kilometers) of the Columbia Basin are deposits of lava (mainly basalt) interbedded with sedimentary rock nearly 10,000 feet (3050 meters) thick. The dry river canyons and scablands (extensively eroded basalt surfaces) were carved by glacial meltwaters.
- An important agricultural and grazing area, the basin is also a major source of hydroelectric power
- The river alters its course to the west because of numerous lava beds, turns again to the south, where it is entrenched in a narrow valley through the central plateau region, and joins the Snake River south of Richland near Lake Wallula.