The Geology of Sculpting Stone

PNW Granite

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Why Should You Care about the Geology of Sculpting Stone?

- Stone makes our chosen art form unique from all others
- Knowing more about the stone will allow you to:
  - Select stone that has a compelling history
  - Marvel at its various elements of grain, color and texture as you work it
  - Consider how your chosen artistic form relates to the science of the stone
  - Weave into your final art work story a geologic component that enhances the interest in the your work by the potential buyer

Outline

- The Stone Defined
  - General Description, Physical/Chemical Properties and Historic Use
  - Specimens (macro and thin section)
  - Specific Occurrences
- Geology
  - Age and Geologic Description
  - Formation Environment and Processes
  - Global Paleogeographic Setting
  - Modern Analogs
- Select Creations
  - Art
  - Architecture

General Description, Physical/Chemical Properties and Historic Use

- PNW granite is a general term used to describe light colored igneous rock occurring in several localities in Washington State and British Columbia
- Historically, two major areas have been quarried for PNW
  - The Coastal Plutonic Belt of British Columbia, Hardy Island area (emplacement age about 120 million years ago)
  - The Snoqualmie Batholith and the Index Pluton (emplacement age of 18 and 35 million years ago respectively)
- Although different in age, both areas are composed of similar uniform light grey Granodiorite associated with Andean-style tectonic environment
- Quarrying began in the early 1900s at both locations
- Hardy Island quarried stone has been used as a foundation stone in Canada and the United States and was used to construct the Victoria Harbor seawall because of its durability and attractive appearance.
- Snoqualmie quarried stone was used extensively through-out the Puget Stone region for major commercial and government buildings

Chemical Composition of Snoqualmie Batholith	
SiO_2	66%
Al_2O_3	17%
FeO	5%
Mg/Ca/Na/K/TiO	12%

Specimens: Macro

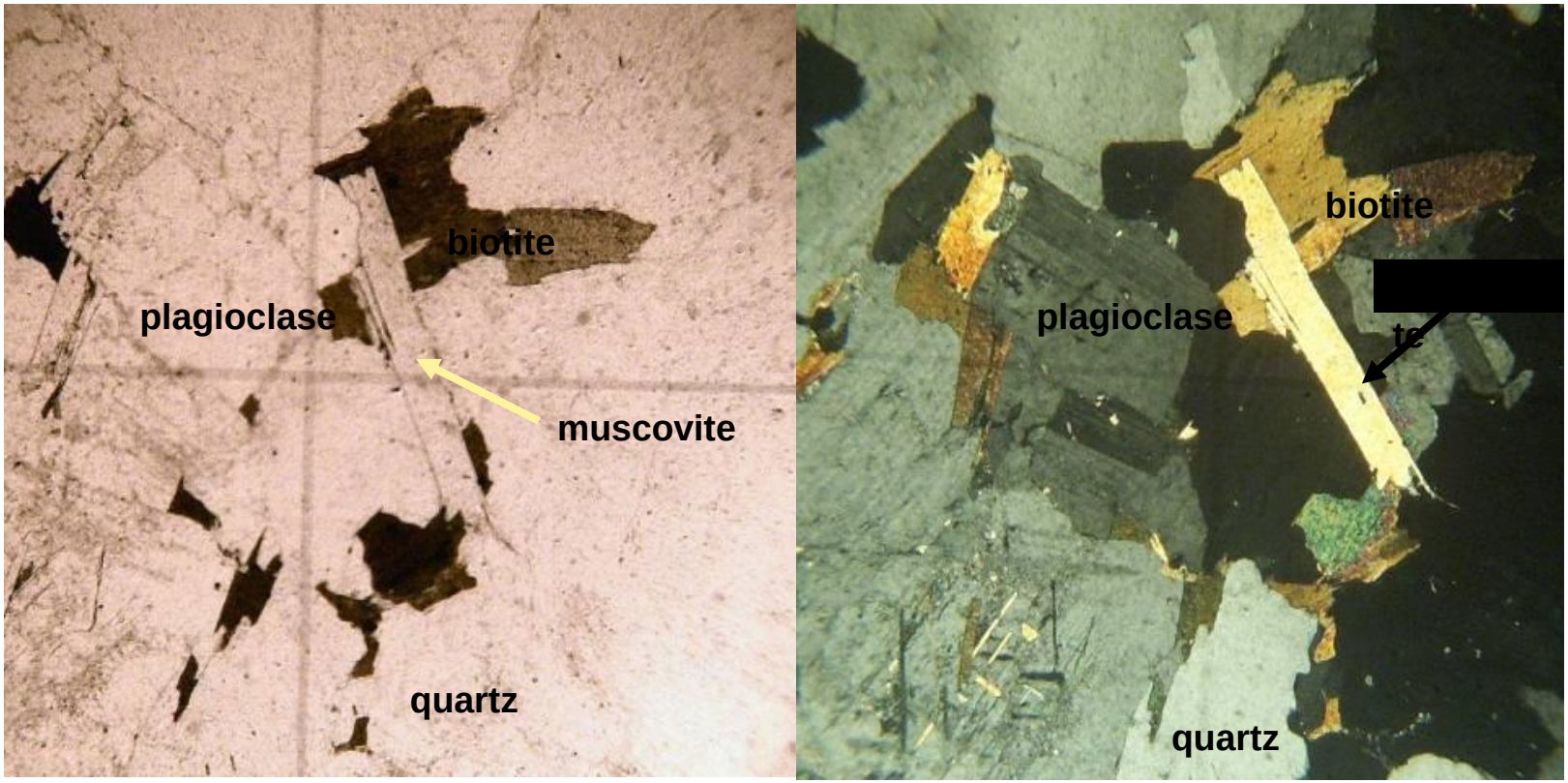
Hardy Island Quarry Worked Outcrop

Index Quarry early 20th century

Hardy Island Prepped Blocks

Skykomish River Field Specimens

Specimens: Thin Sections
(About 20X Magnification)



Plane light **Crossed Polarized Light**

Granite

Note how light and clear it is under PPL and grey/white/black under XPL; main minerals – feldspars (often microcline), quartz, biotite and muscovite

Specific Occurrences

Skykomish River: Index Pluton

History of the Index Quarry

- In 1904 John A. Soderberg (1866-1935), began developing the Index Granite Company, a large quarry along the Great Northern tracks three-quarters of a mile west of town. Seventy men were employed there most of the time, supplying material for construction of prominent buildings in Seattle, Spokane, and Everett, including the State Capitol in Olympia.
- Soderberg's quarry brought workers and stone artisans with their families from as far away as Barre, Vermont. Photos show intricately carved, highly polished tombstones waiting for shipment.
- In May 1932 the quarry shed with its massive crane burned, leaving unmovable stones inside the building. The shed was never rebuilt and the remaining broken blocks were ground and sold as chicken grit.
- Depression gripped the economy, and failing banks would not finance what had become obsolete technology. A relatively new material, reinforced concrete, was recognized as far cheaper for structural use than quarried granite.

- The Index Quarry is no longer in operation, however many excellent stream specimens can be collected from the Skykomish and Stillaguamish rivers

Marenakous "High Cascade" Granite
From the Crown Lakes Quarry

Specific Occurrences

Hardy Island, B.C.

- The Hardy Island Granite Quarry is about 20 kilometres southeast of Powell River. It is one of the historic Jervis Inlet Quarries
- These quarries provided stone for many of British Columbia's notable buildings in the early part of the last century, producing a classic grey, "salt and pepper" granite, which Parks (1917), in his survey of the Building Stones of Canada, referred to as "the best in BC".
- Products of the stone from the Hardy Island Quarry include the lions in front of the old Vancouver Courthouse, and the Ogden Point breakwater.
- The stone at the Hardy Island quarry splits with unusual facility along both the rift and the grain (the primary and secondary splitting directions). This quality, together with the favorable joint orientation and spacing, allows the stone to be quarried easily.
- Over half the stone produced by the quarry is exported to the United States, either as blocks or as split products.

An overhead view of the Hardy Island Granite Quarry in the Jervis Inlet south of Powell River, B.C.

1915 Hardy Island Quarry Crew

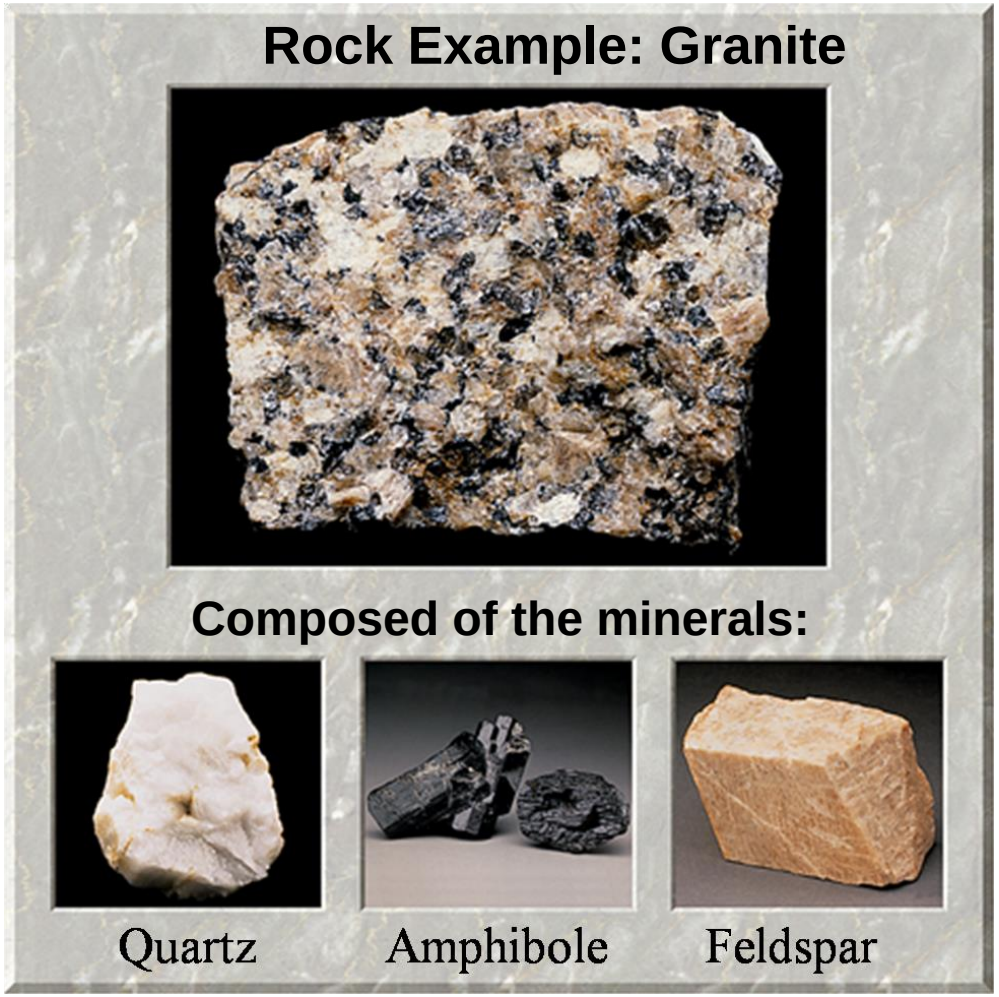
Barge being loaded with large granite blocks

Age and Geologic Description

There are three types of rock:

- **Sedimentary:** A rock formed from the accumulation and consolidation of sediment, usually in layered deposits. (e.g. sandstone)
- **Metaphoric:** A rock formed by the alteration of the minerals, textures and/or composition of another rock caused by exposure to heat, pressure and/or chemical actions. (e.g. quartzite)
- **Igneous:** A rock formed by the crystallization of magma (intrusive, e.g. granite) or lava (extrusive)

- **PNW granites are Igneous rocks** that can be classified in a number of ways…



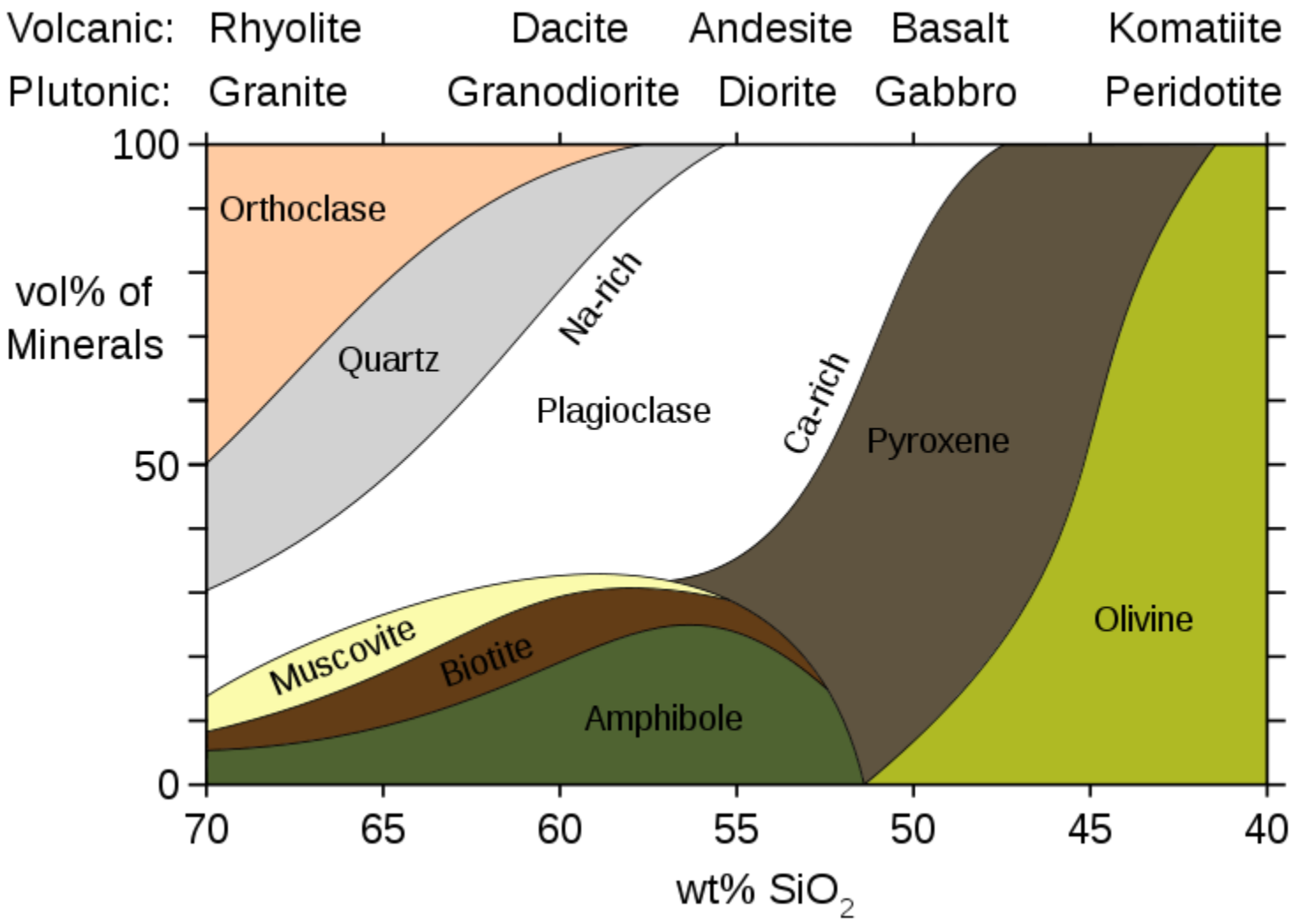
Age and Geologic Description

Igneous Rock classification: Descriptive

	Granitic (felsic)	Andesitic (intermediate)	Basaltic (mafic)	Ultramafic
Dominant Minerals	Quartz Orthoclase (Alkali or K-Feldspar)	Amphibole Plagioclase Feldspar	Pyroxene Plagioclase Feldspar	Olivine Pyroxene
Color	Light-colored < 15% dark minerals	Medium-colored 15 - 40% dark minerals	Dark gray to black > 40% dark minerals	Dark green to black ~100% dark minerals
Coarse-grained (Plutonic/Intrusive)	Granite	Diorite	Gabbro	Peridotite
Fine-grained (Volcanic/Extrusive)	Rhyolite	Andesite	Basalt	Gabbro

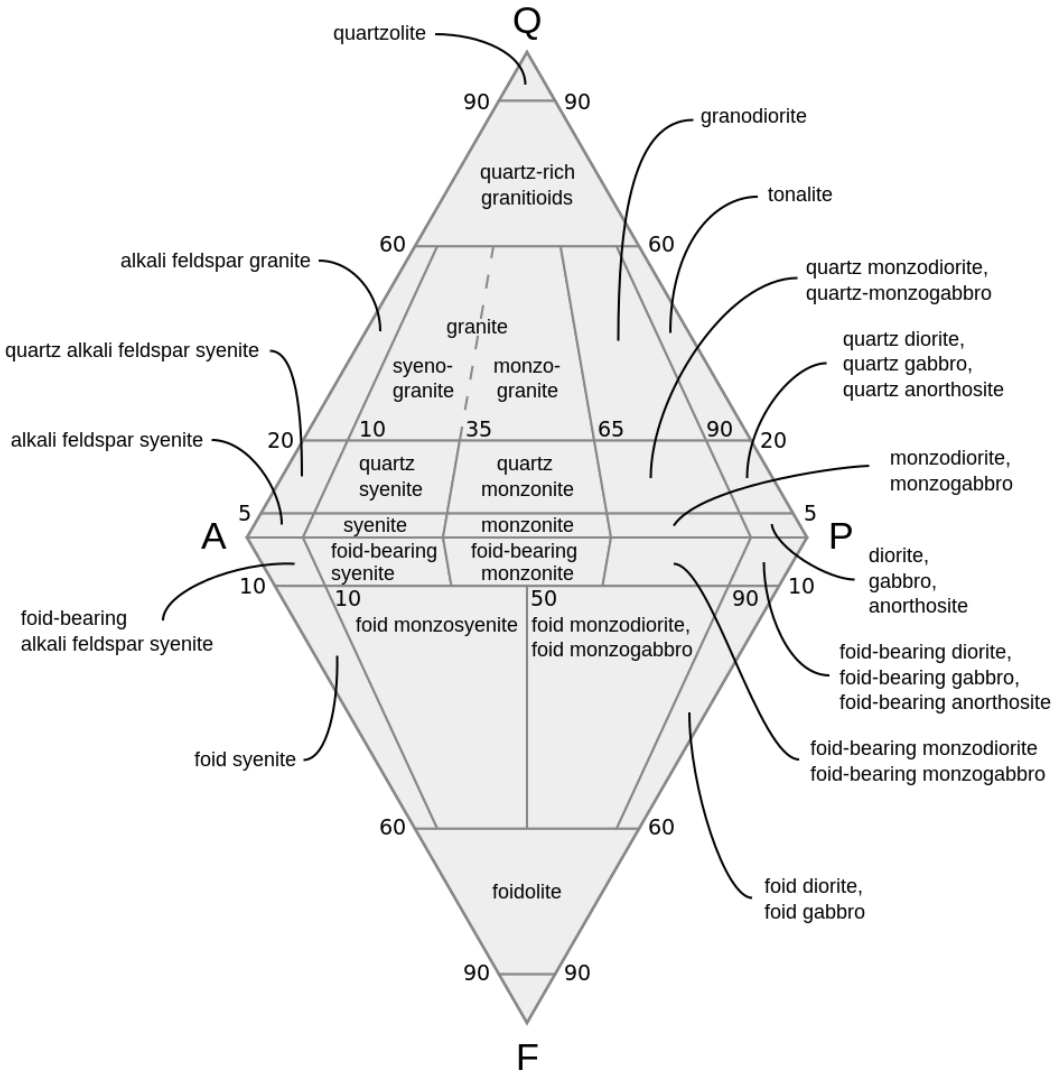
Age and Geologic Description

Igneous Rock classification: Major Components

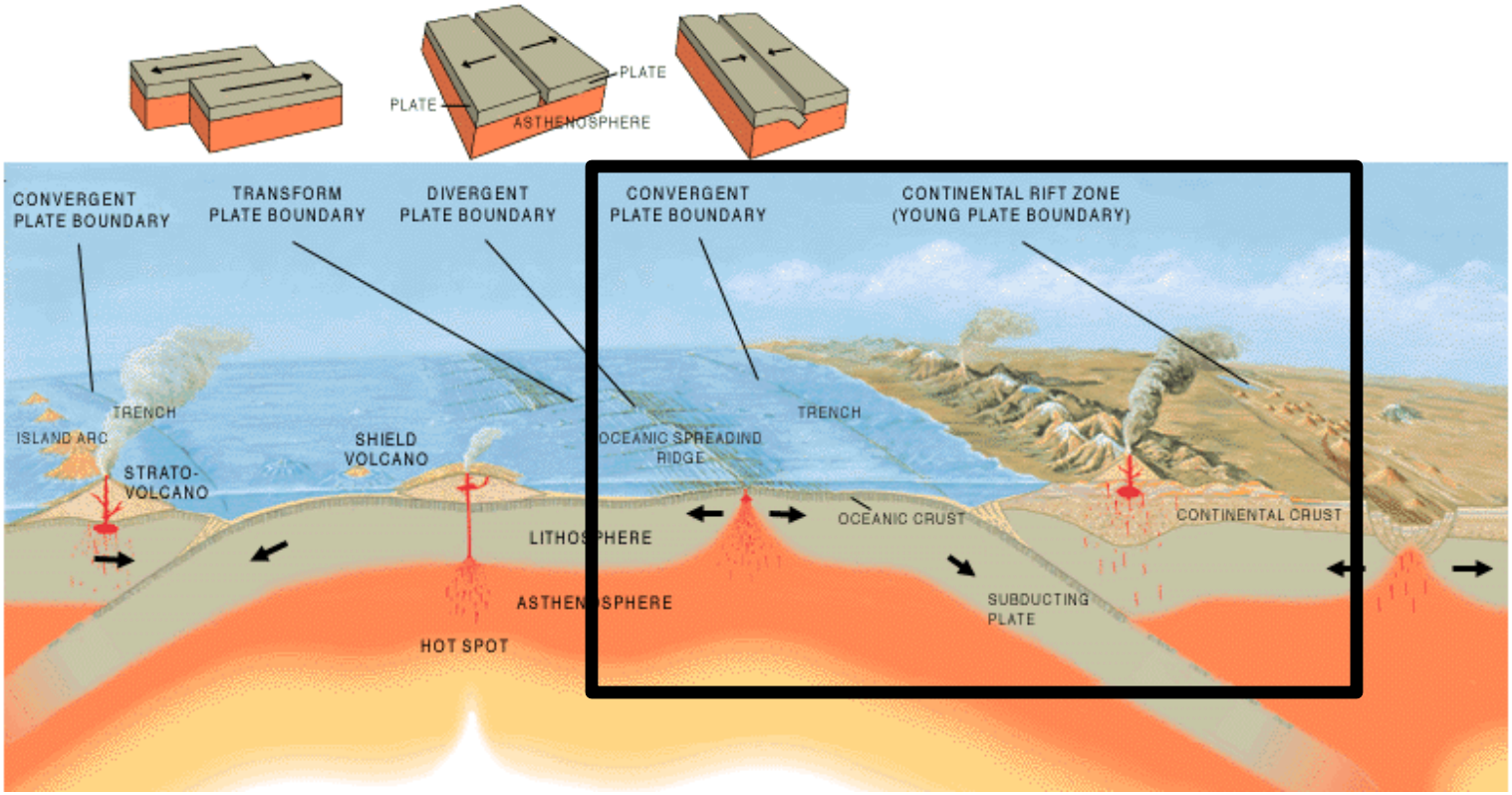


Age and Geologic Description

Igneous Rock classification: Plutonic Subdivisions



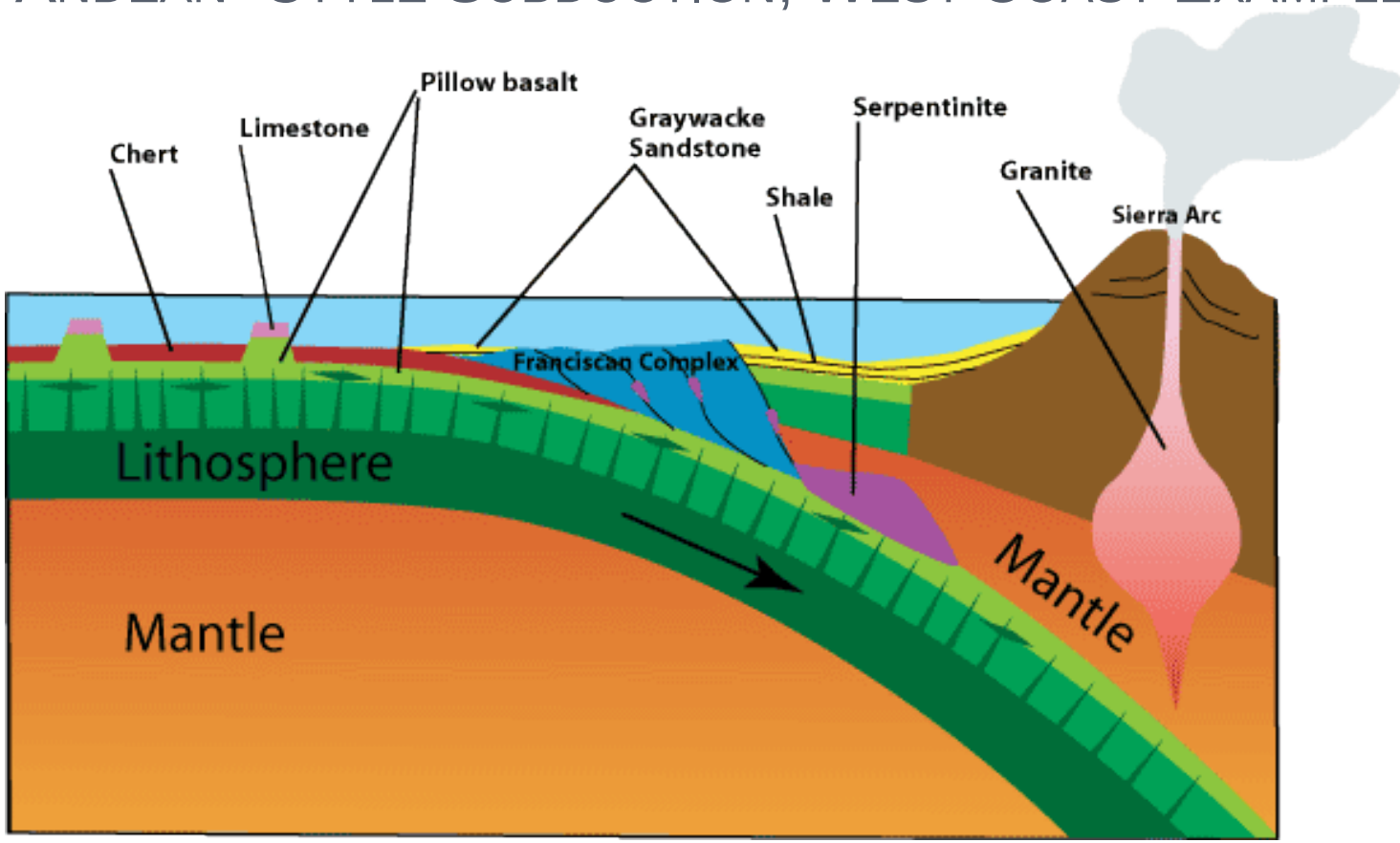
Formation Environment and Processes



- The Lithosphere is made up of relatively thin plates which move slowly about the surface.
- These plates interact by converging, diverging or sliding (transform) past one another.
- PNW granites were formed at a convergent boundary where the North American craton collided with the (mostly) oceanic Pacific plates

Subduction Zone Details

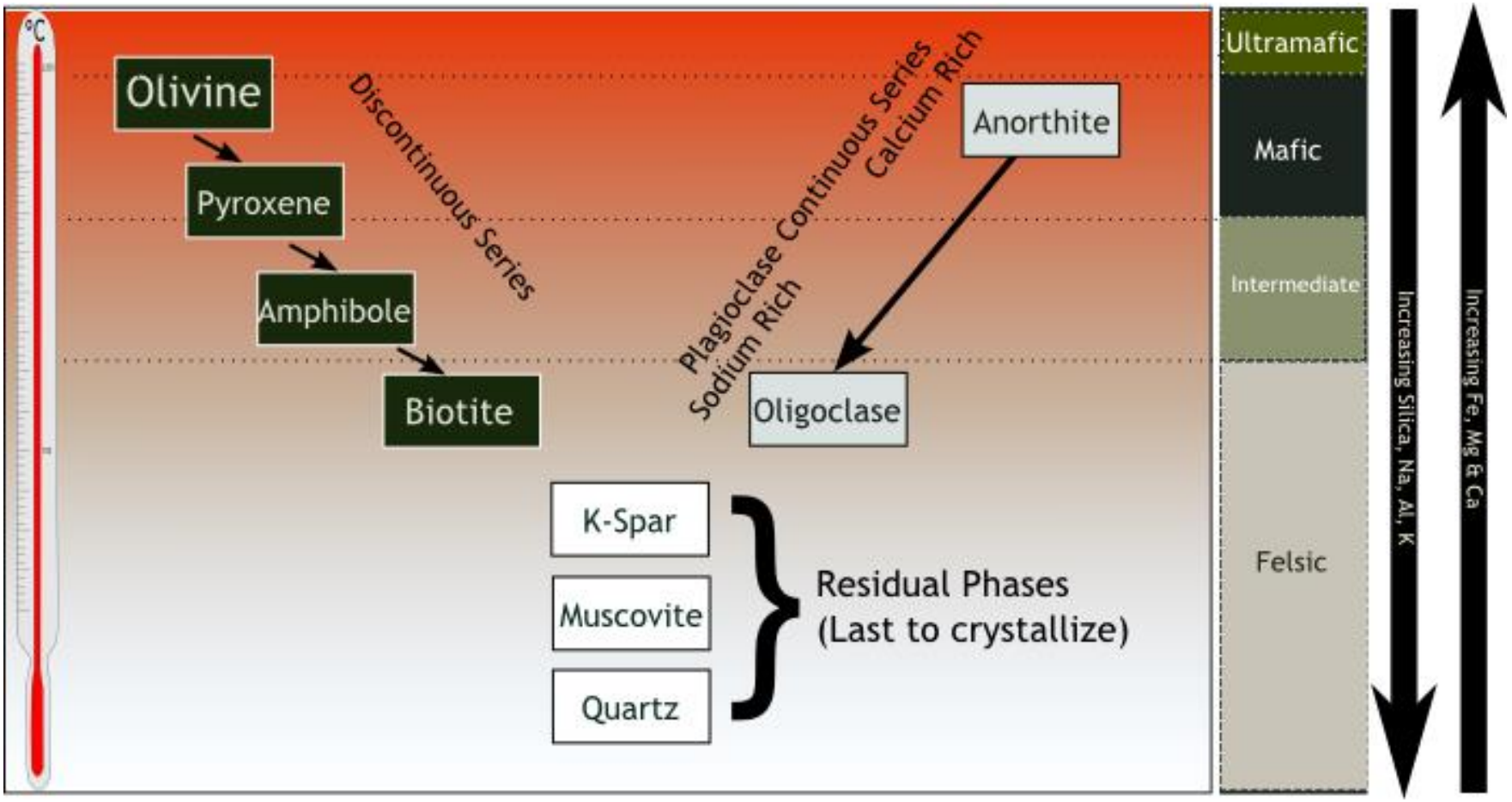
"Andean" Style Subduction, West Coast Example



Sediments are scraped off the top of the subducting plate and melted as the plate descended rising up through the North American continental crust to form granitic plutons and associated volcanoes

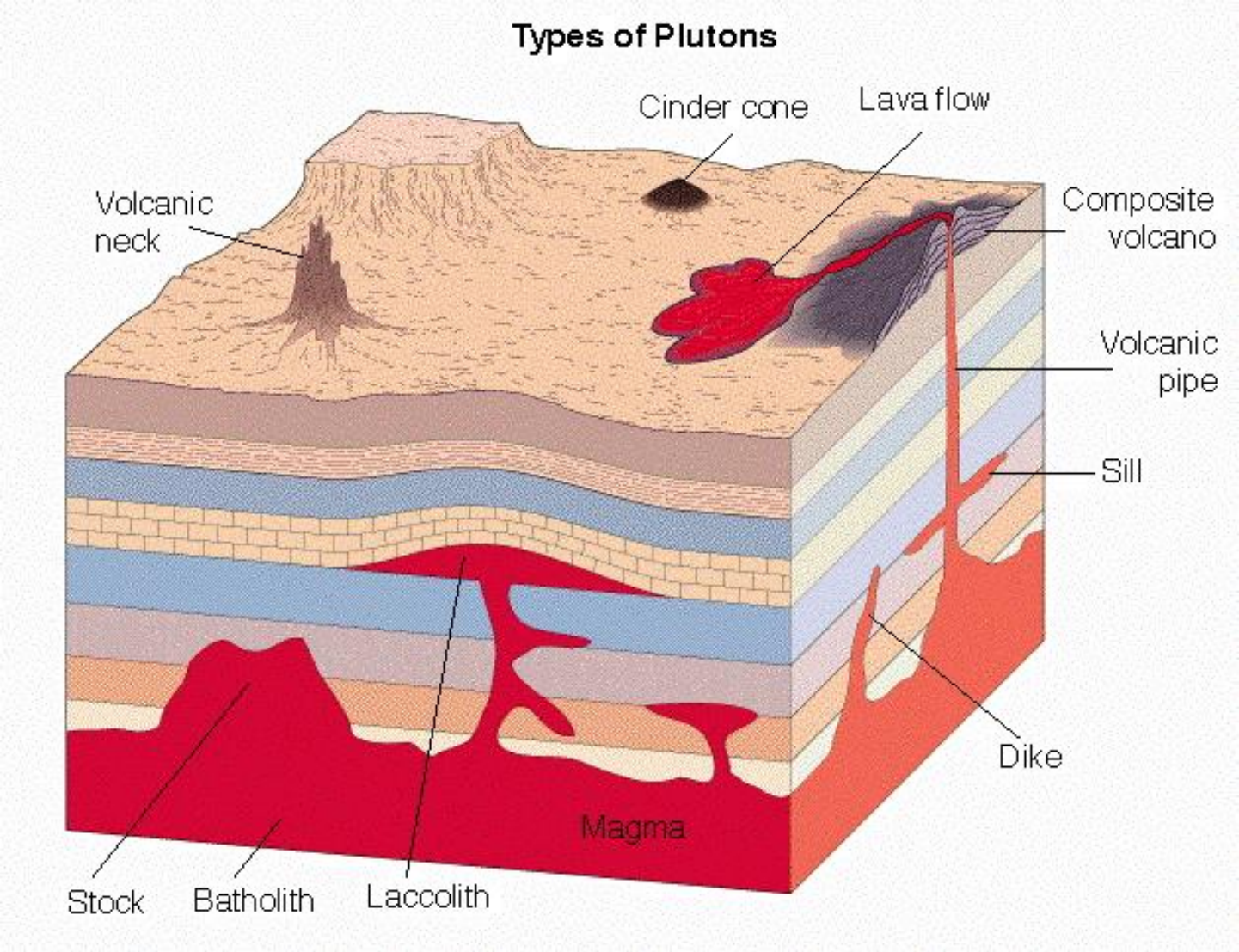
How a Pluton Crystalizes

Bowen Reaction Series



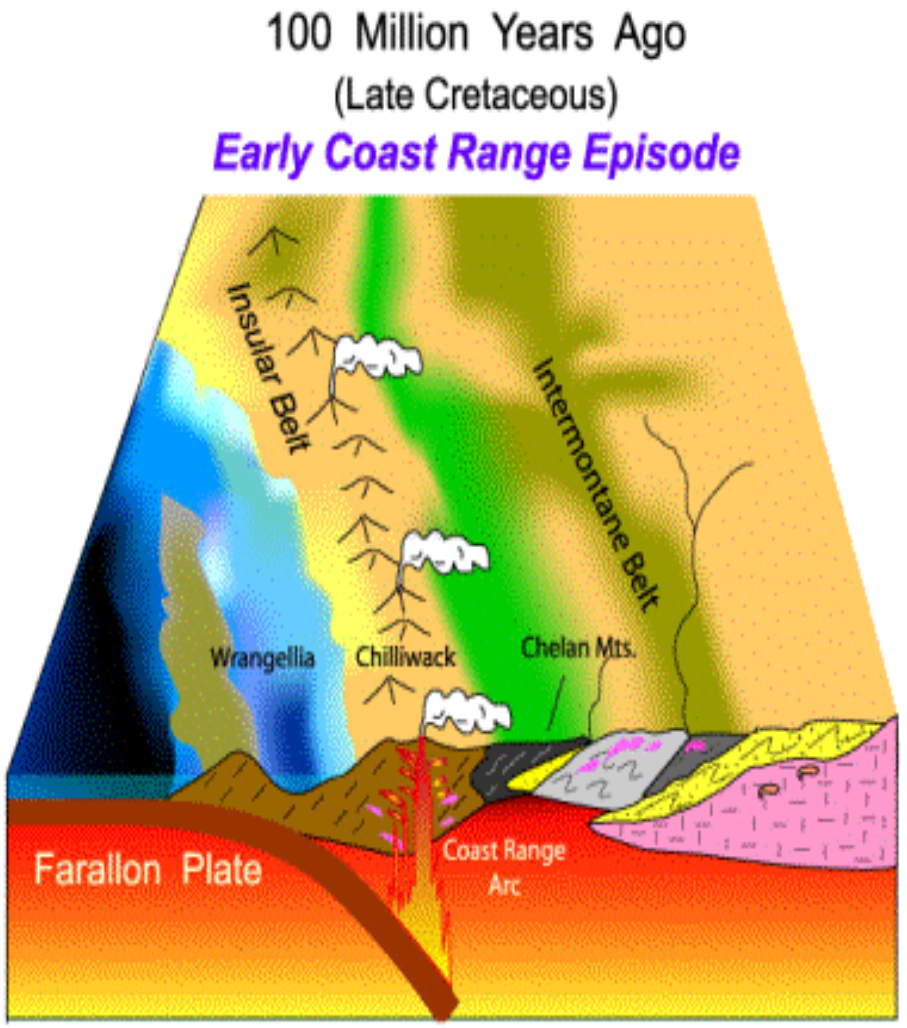
Formation Environment and Processes

Intrusion Geometry of Plutons



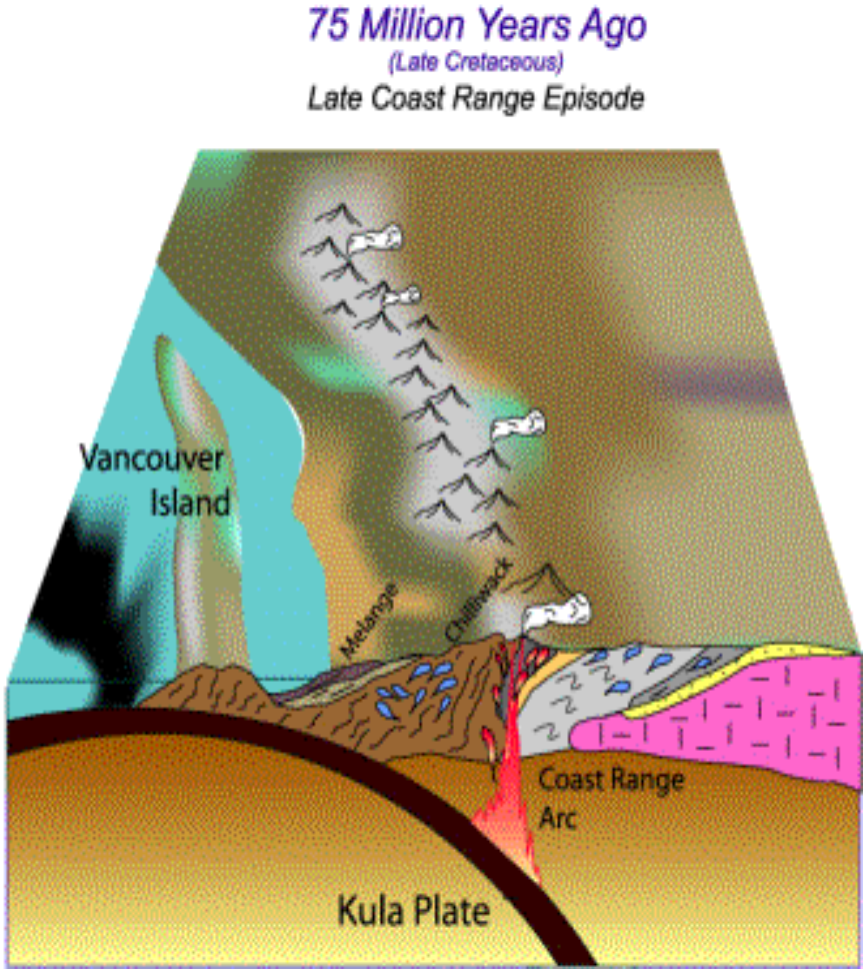
THE COAST RANGE EPISODE: (115 TO 57 MILLION YEARS AGO)

- The Coast Range began with the Insular Volcanic Islands colliding with the Pacific NW and the associated subduction zone ceasing
- Subduction continued on the western Farallon Plate with molten rock rising upward through the accreted Insular Belt forming another stitching belt, the Coast Range plutonic arc, which ranges from Washington to Alaska
- To the west, yet another exotic land mass “Wrangellia” approached
- Controversy still exists about whether significant elements of the emplaced landmasses came from much further south (the “Baja to B.C.” hypothesis)



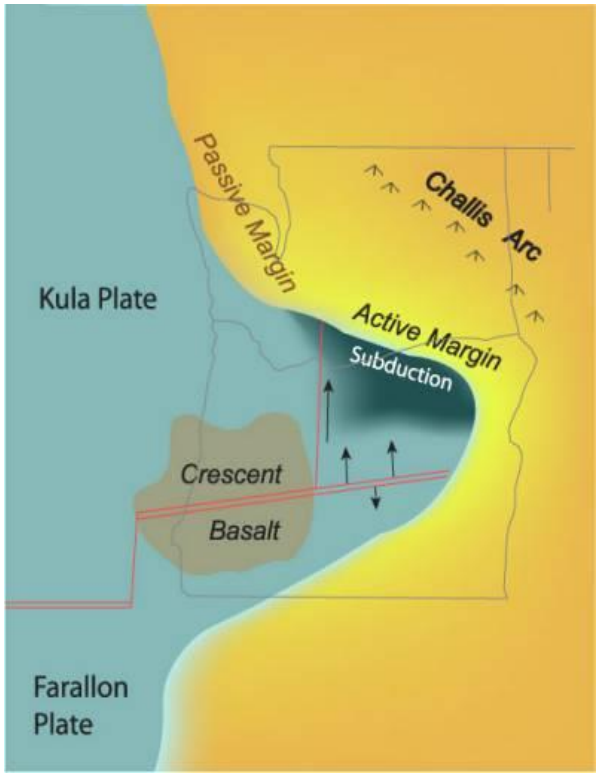
THE COAST RANGE EPISODE: (115 TO 57 MILLION YEARS AGO)

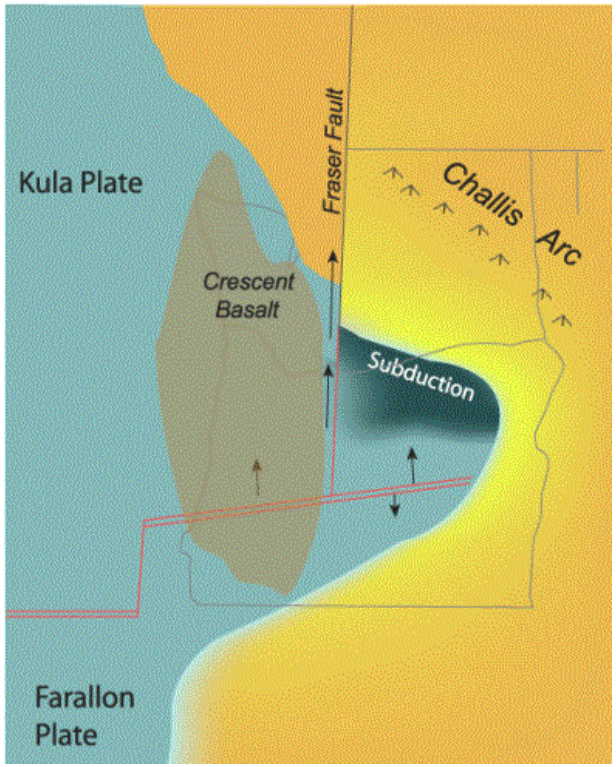
- Coast Range arc plutonic activity continued into the late Cretaceous
- Sediments began to be shed off the emerging Coast Range arc mountains and from a Wrangellian land mass we now know as Vancouver Island
- The Farallon Plate fragmented into two major pieces with the north Pacific section being renamed the Kula plate
- The emplacement of the Intermontaine and Coast Range terranes had created a large embayment south of Washington State
- An west-east trending spreading center developed between these pieces and subducting sediments were scraped off the descending plate creating the Melange belt of SW Washington



THE CHALLIS EPISODE: (57 TO 37 MILLION YEARS AGO)

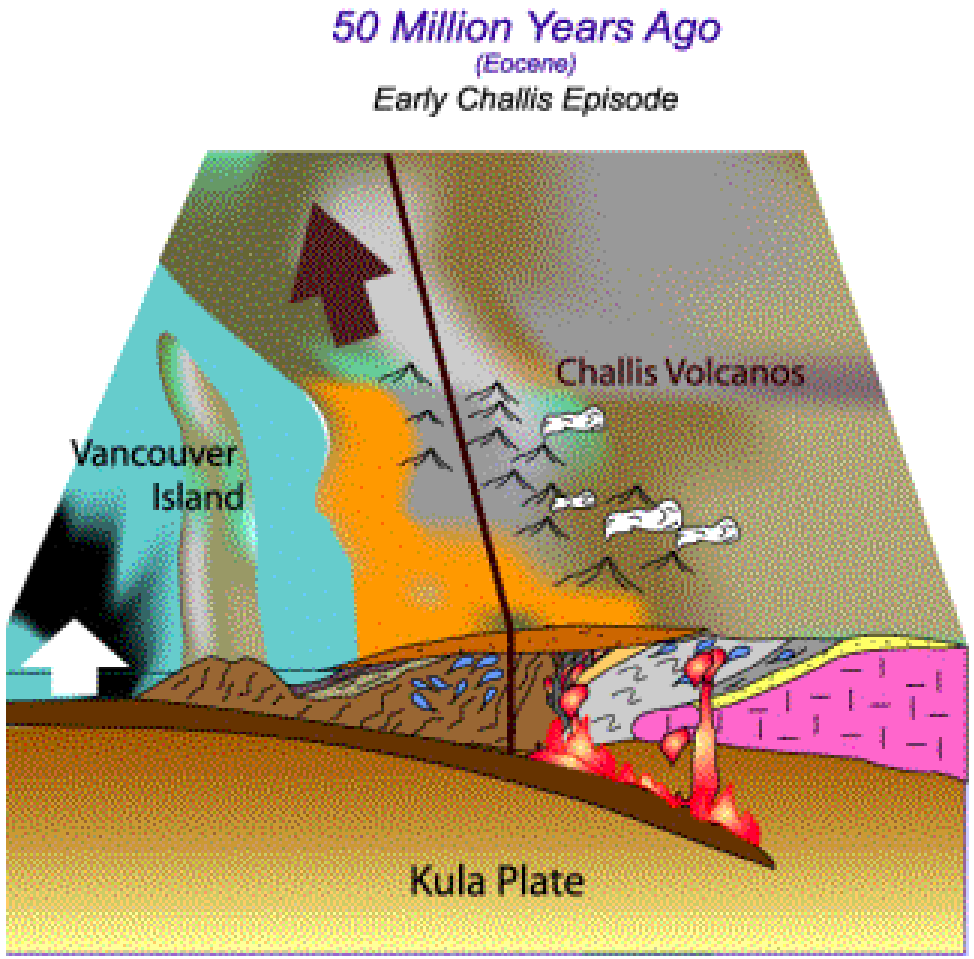
- The Challis Episode is a complex and controversial chapter in Pacific Northwest geologic history
- The west-east trending spreading center which started during the Coastal range perios remained active
- Northeastern subduction created a new plutonic arc; the Challis Arc, while transform faulting to the west moved large amounts of basalts' which accumulated at the spreading center, north along the Fraser (i.e. Straight Creek) fault





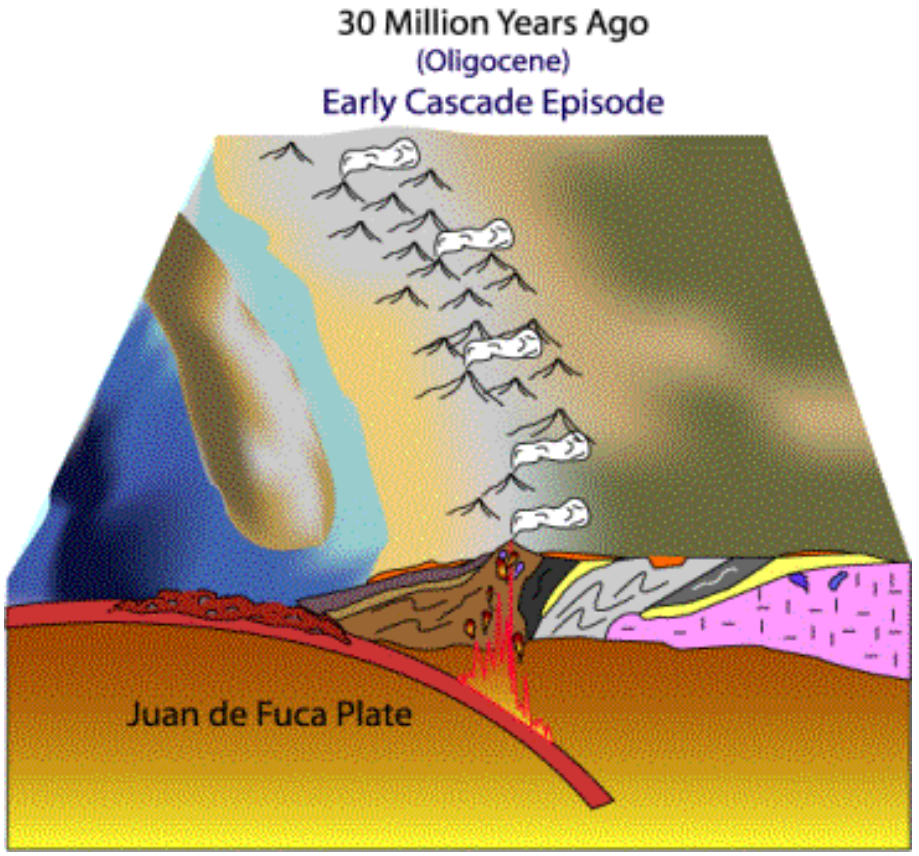
THE CHALLIS EPISODE: (57 TO 37 MILLION YEARS AGO)

- Large regions of the Pacific Northwest were compressed during the development of Challis chain of volcanoes running diagonally across Washington and Idaho
- Thick sections of nonmarine sediment were deposited in rapidly subsiding “pull-apart” basins (in the region shown in orange)
- Late in this period, a large piece of ocean floor which contained the Crescent basalts overlain by marine sediment was uplifted and partially forced beneath the edge of the continent. This terrane makes up the core of the Olympic Peninsula



THE CASCADE EPISODE: (37 MILLION YEARS AGO TO PRESENT)

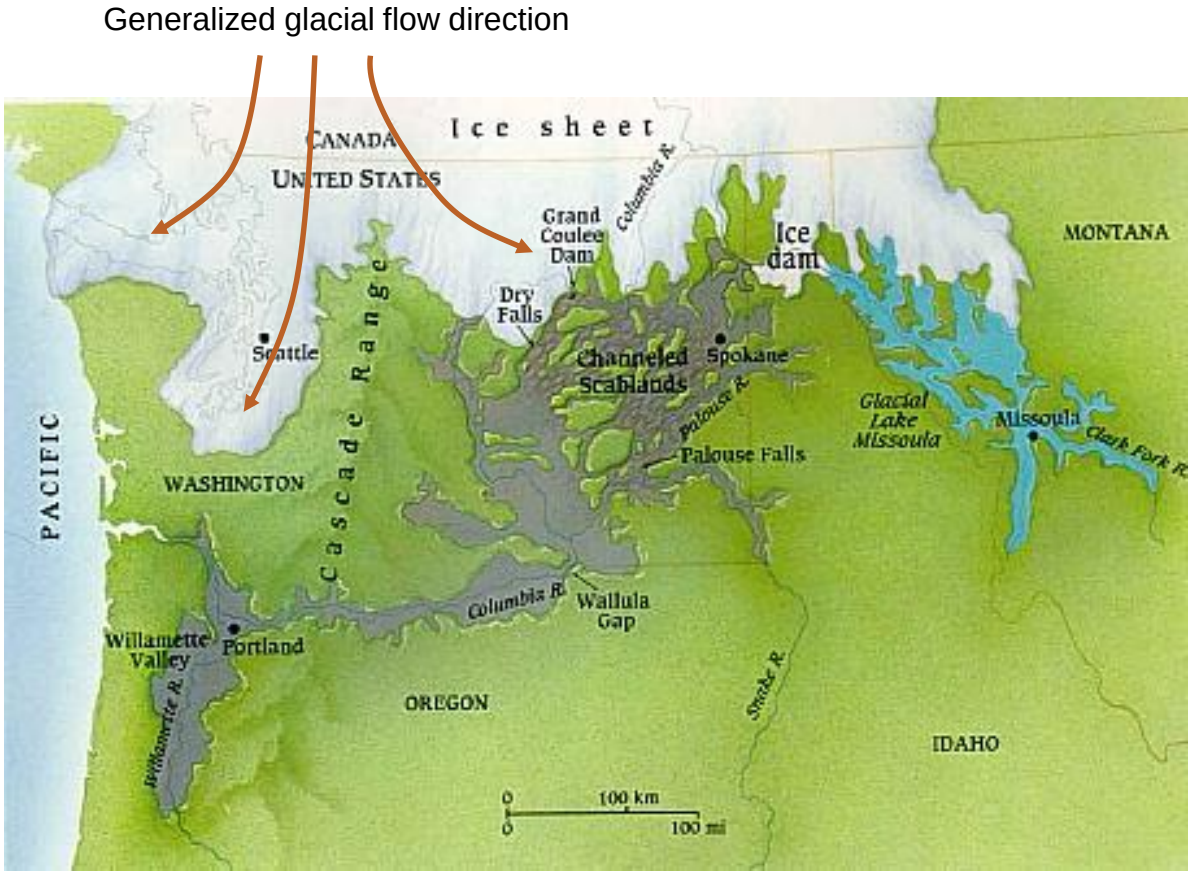
- The Cascade Episode began with a remaining fragment of the Kula plate (named the Juan de Fuca Plate) subducting underneath the western edge of the continent
- A new chain of plutonic bodies and volcanoes were developed; the Cascade Arc
- This ancestral Cascade mountain arc formed in approximately the same north-south location of our present day Cascade range



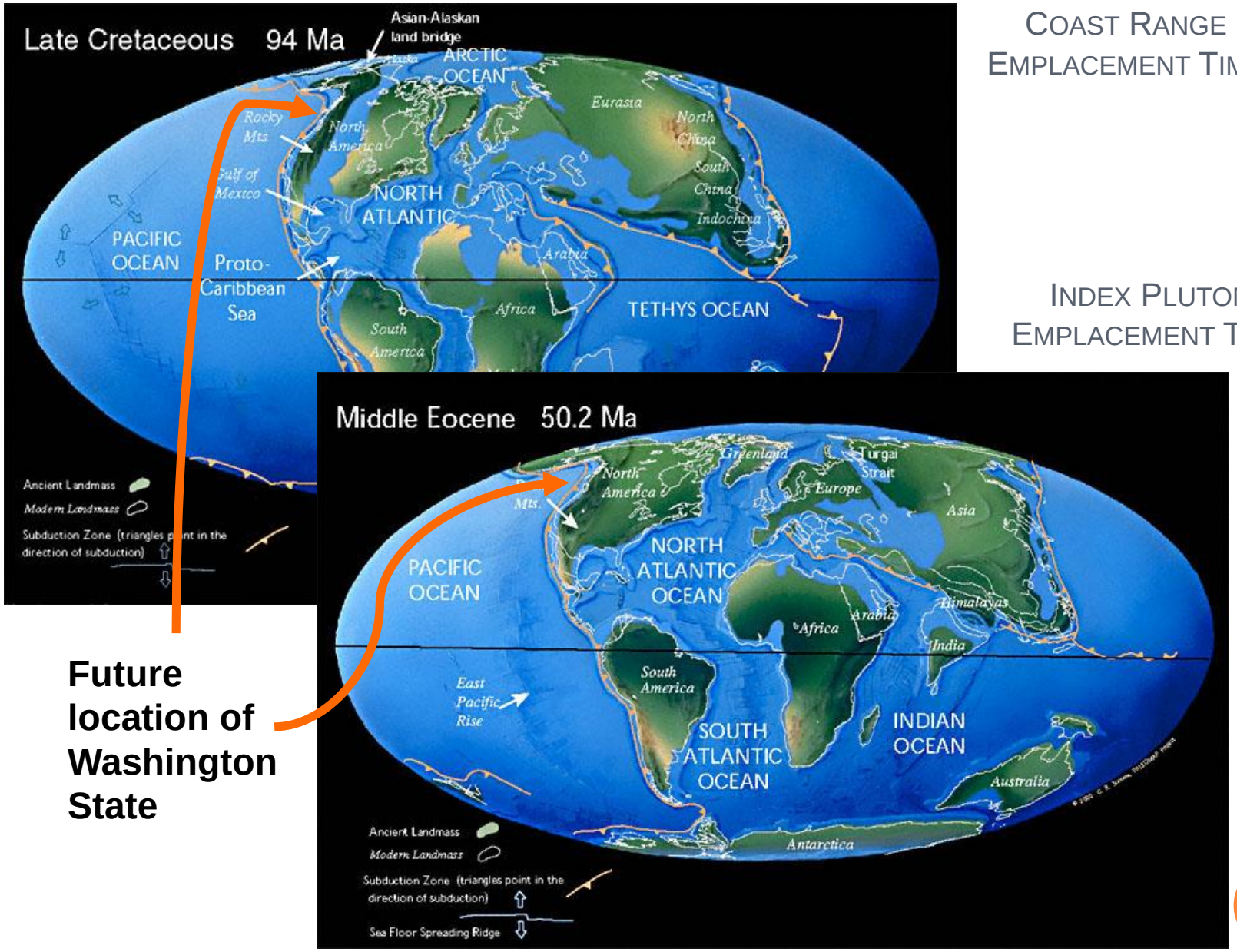
THE GREAT ICE AGES OF THE PLEISTOCENE

- The past two million years have seen periodic episodes of continental glaciation
- These continental glaciers flowing down from the mountains of British Columbia picked and a brought with them large boulders
- When the glaciers melted they dropped these boulders, called “erratics”
- Many of these erratics were from the granitic coastal mountains and can be found on the surface throughout the Puget Sound lowlands

Glacial Ice Sheet Coverage about 12,000 years ago



Global Paleographic Setting



Future location of Washington State

Coast Range Emplacement Time

Index Pluton Emplacement Time

Modern Analogs

Present Day Cascadia

Art

Tracy Powell

Sue Taves

Pasha Stinson

Verena Schwippert

Architecture

Lion's Gate Bridge Footings Vancouver B.C.

Vancouver Art Gallery carved lions

Smith Tower, Seattle

Washington State Capital, Olympia