

# The Dynamic Landscape of Oregon's Coast: A Tale of Beauty and the Beast

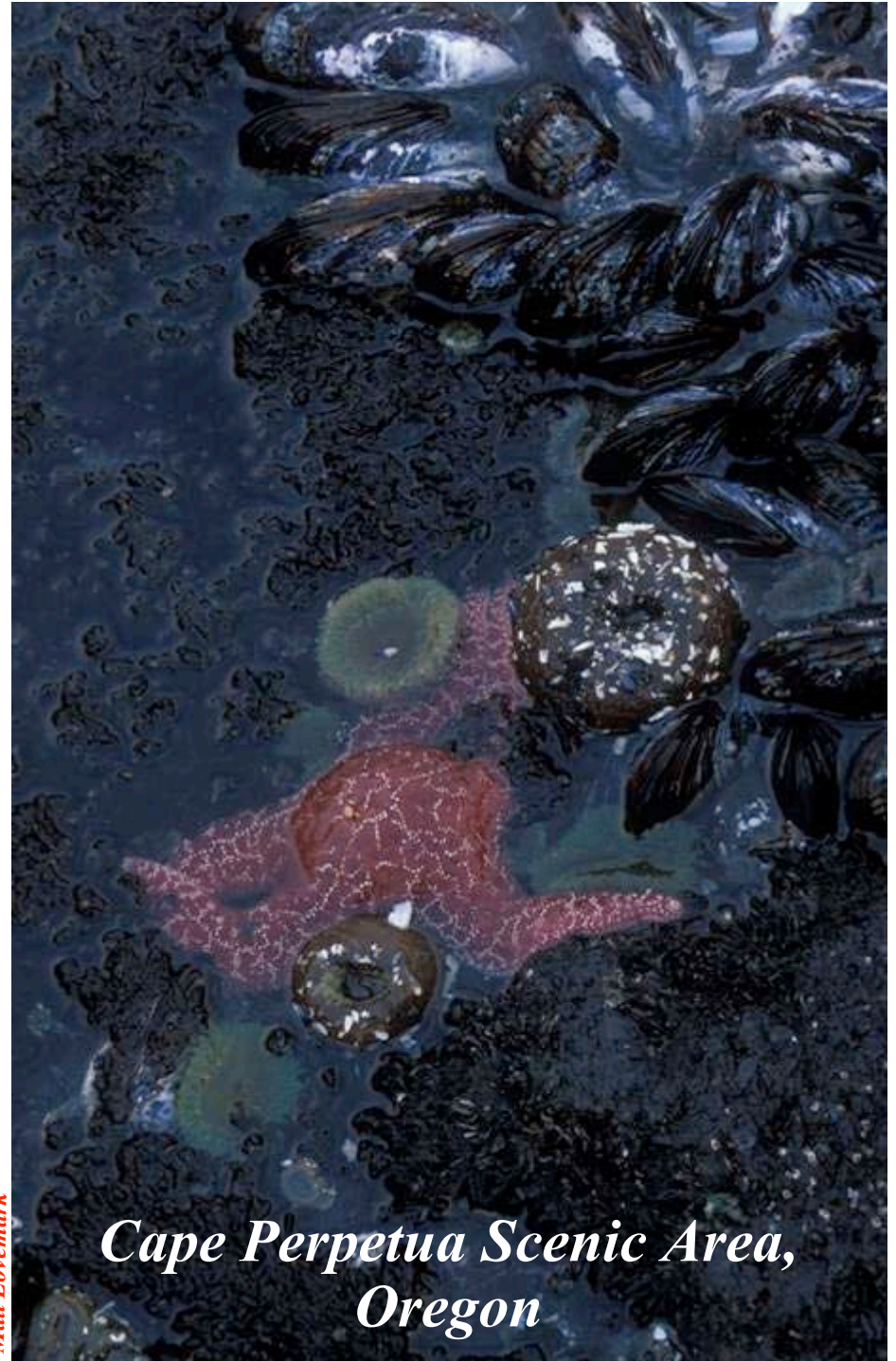
**Bob Lillie**

Professor of Geology  
Certified Interpretive Trainer  
Oregon State University

*Oregon Coast Region of the  
Oregon Master Naturalist Program*

*Unit 9: Geology of the Oregon Coast*

*Cape Perpetua Scenic Area, Oregon  
February 26, 2011*



Matt Lovemark

*Cape Perpetua Scenic Area,  
Oregon*



# Goal and Objectives for Coastal Master Naturalist Geology Training

- **Goal:** To provide Oregon Master Naturalists with an overview of Oregon Coast geology and appreciation of the Coast's geologic stories and processes.
- **Master Naturalists will be able to:**
  1. Explain how the Oregon Coast Range formed.
  2. Discuss geological hazards of the Oregon Coast.
  3. Incorporate the Coast's geological landscape and processes into interpretive programs focused on biology, ecology, and human history.



# Agenda

## Oregon Coast Region of the Oregon Master Naturalist Program

### Unit 9: Geology of the Oregon Coast

Cape Perpetua Scenic Area  
Feb. 26, 2011

#### Morning:

- 9:00 - Plate Tectonics and Landscape Formation
- 10:00 - Ongoing Coastal Processes
- 11:00 - Coastal Geological Hazards
- 12:00 - Lunch at Visitor Center (bring own)

#### Afternoon:

- 12:30 - Hike "Trail of the Restless Waters"
  - Brainstorm: Geology observations and connections
- 3:00 - Interpretive Methods
- 4:00 - Developing Themes for Oregon Coast Geology
- 5:00 - Adjourn



# Topics

## Oregon Coast Region of the Oregon Master Naturalist Program

### Unit 9: Geology of the Oregon Coast

#### 1. Plate Tectonics and Landscape Formation:

Building Oregon

Cascadia Subduction Zone

Columbia Plateau Basalt

#### 2. Ongoing Coastal Processes:

Dynamic Duo: Uplift and Erosion

Coastal Headlands

#### 3. Coastal Geological Hazards:

Earthquakes

Tsunamis

Landslides

#### 4. Interpretive Methods:

Presenting Coastal Geology to  
Coastal Audiences



Robert J. Lillie

*Marine Gardens  
Newport, Oregon*



# **1. Plate Tectonics**

## **1. Plate Tectonics and Landscape Formation:**

**Building Oregon**

**Cascadia Subduction Zone**

**Columbia Plateau Basalt**

## **2. Ongoing Coastal Processes:**

**Dynamic Duo: Uplift and Erosion**

**Coastal Headlands**

## **3. Coastal Geological Hazards:**

**Earthquakes**

**Tsunamis**

**Landslides**

## **4. Interpretive Methods:**

**Presenting Coastal Geology to Coastal Audiences**

# **The Dynamic Landscape of Oregon's Coast: A Tale of Beauty and the Beast**

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***Oregon Coast Region of the Oregon Master Naturalist Program***

***Unit 9: Geology of the Oregon Coast***

***Cape Perpetua Scenic Area, Oregon***

***February 26, 2011***

**Marine Gardens, Newport, Oregon**

**Robert J. Lillie**



## Beauty and the Beast

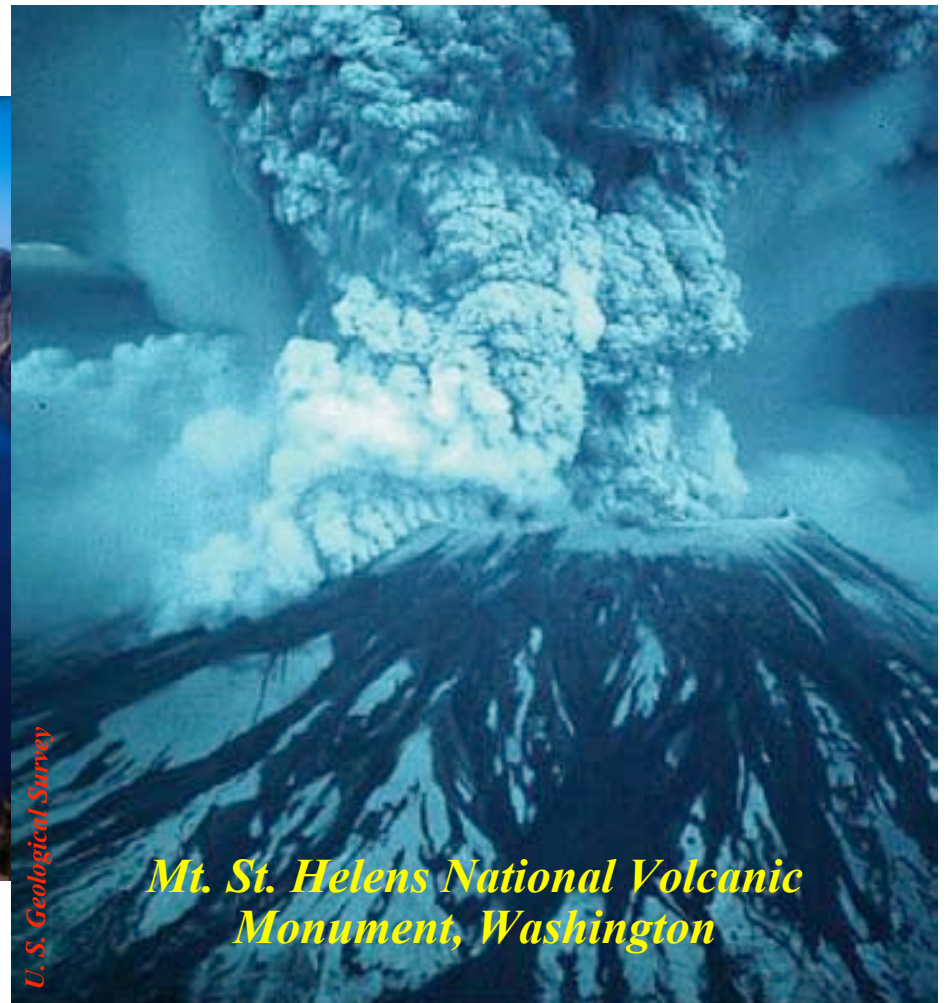


*“The same geological processes that threaten our lives with earthquakes, tsunamis and volcanic eruptions also nourish our spirits by creating the inspiring mountains, valleys, and coastlines of the Pacific Northwest.”*



*Robert J. Lillie*

*Crater Lake National Park, Oregon*

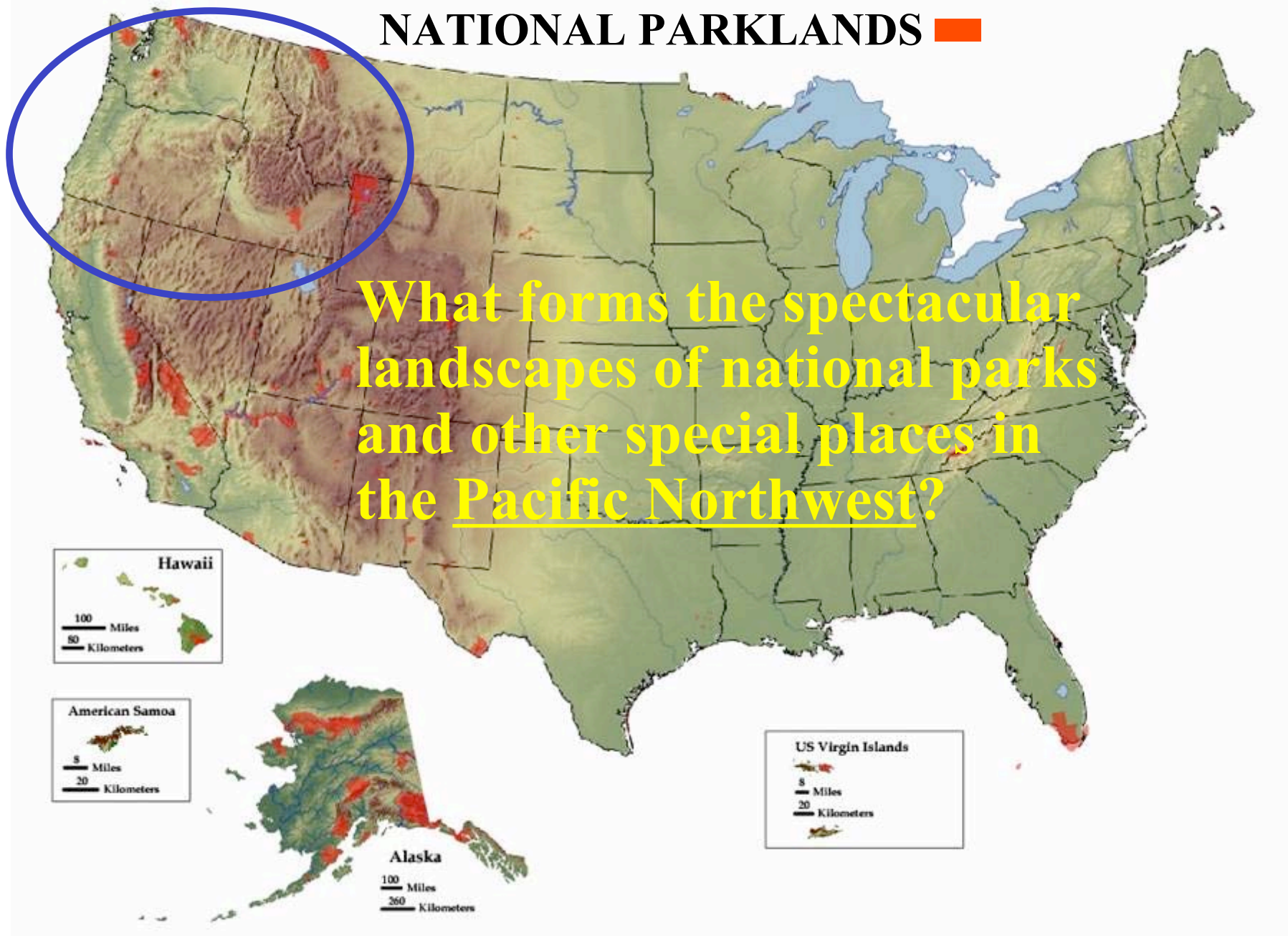


*U. S. Geological Survey*

*Mt. St. Helens National Volcanic Monument, Washington*

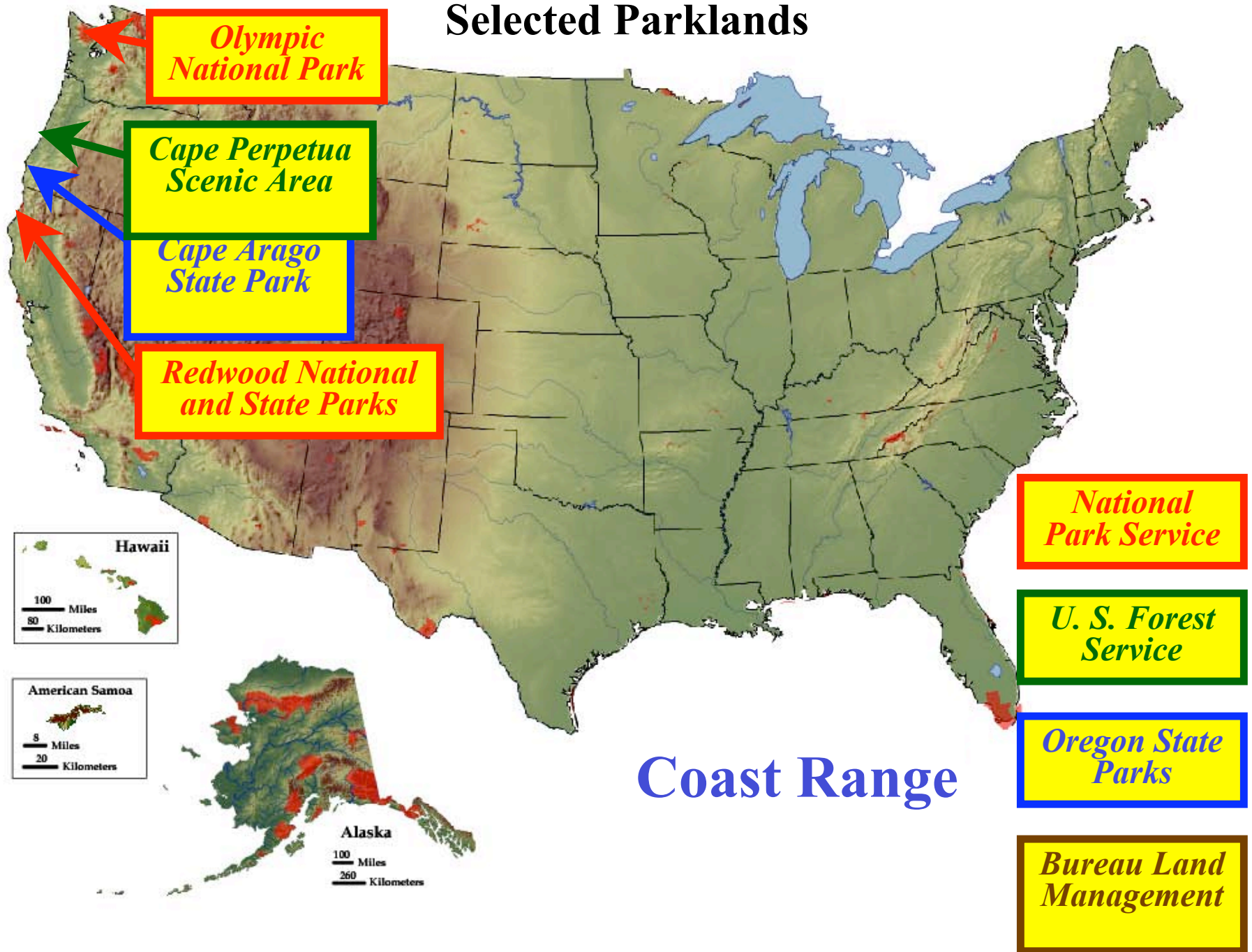


# NATIONAL PARKLANDS



What forms the spectacular landscapes of national parks and other special places in the Pacific Northwest?

# Selected Parklands





# *Olympic National Park, Washington*



*Cape Perpetua Scenic Area, Oregon*

Ken Bennick





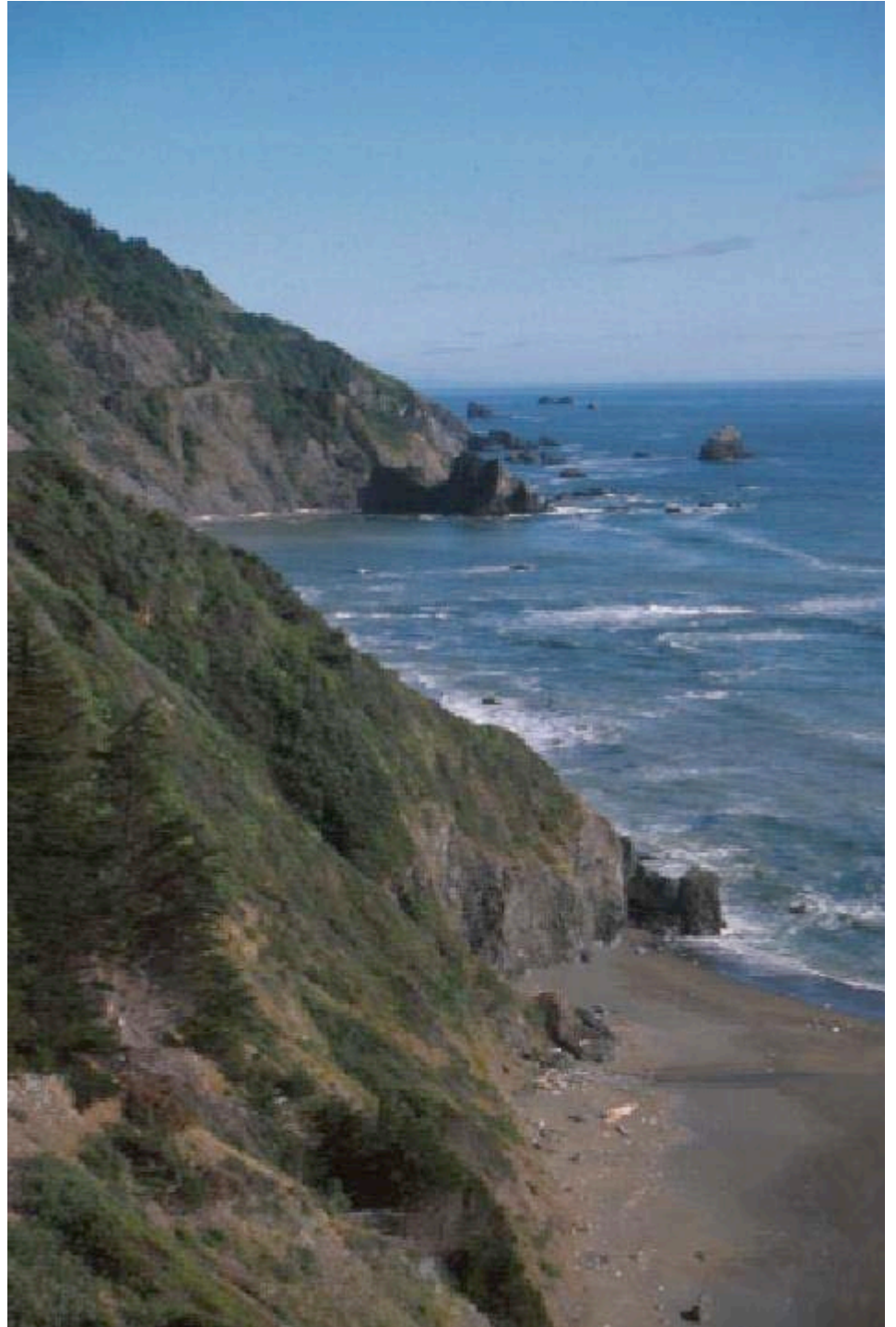
# *Cape Arago State Park, Oregon*



Mark Ebnik

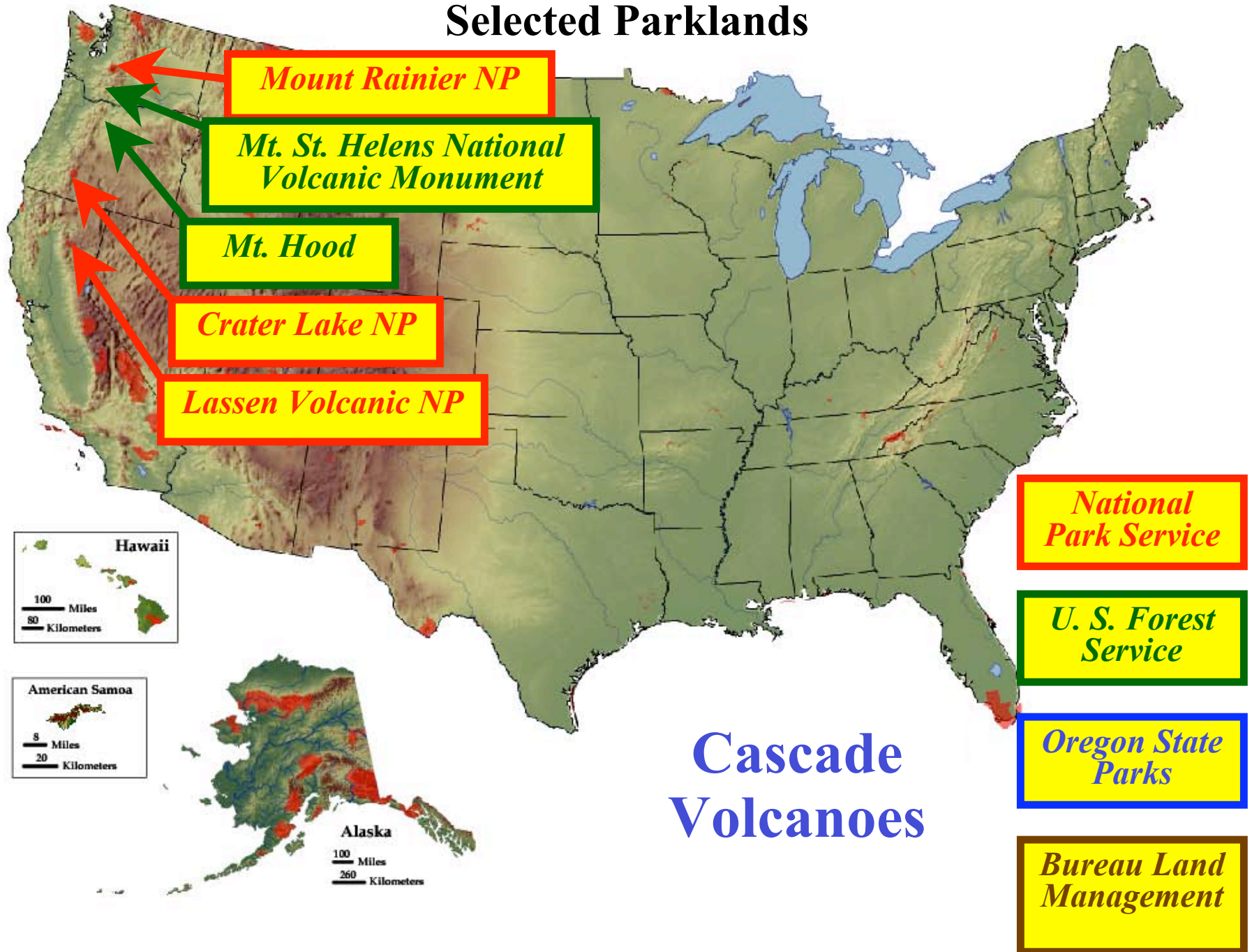
*Redwood National and  
State Parks, California*

*Robert J. Lillie*



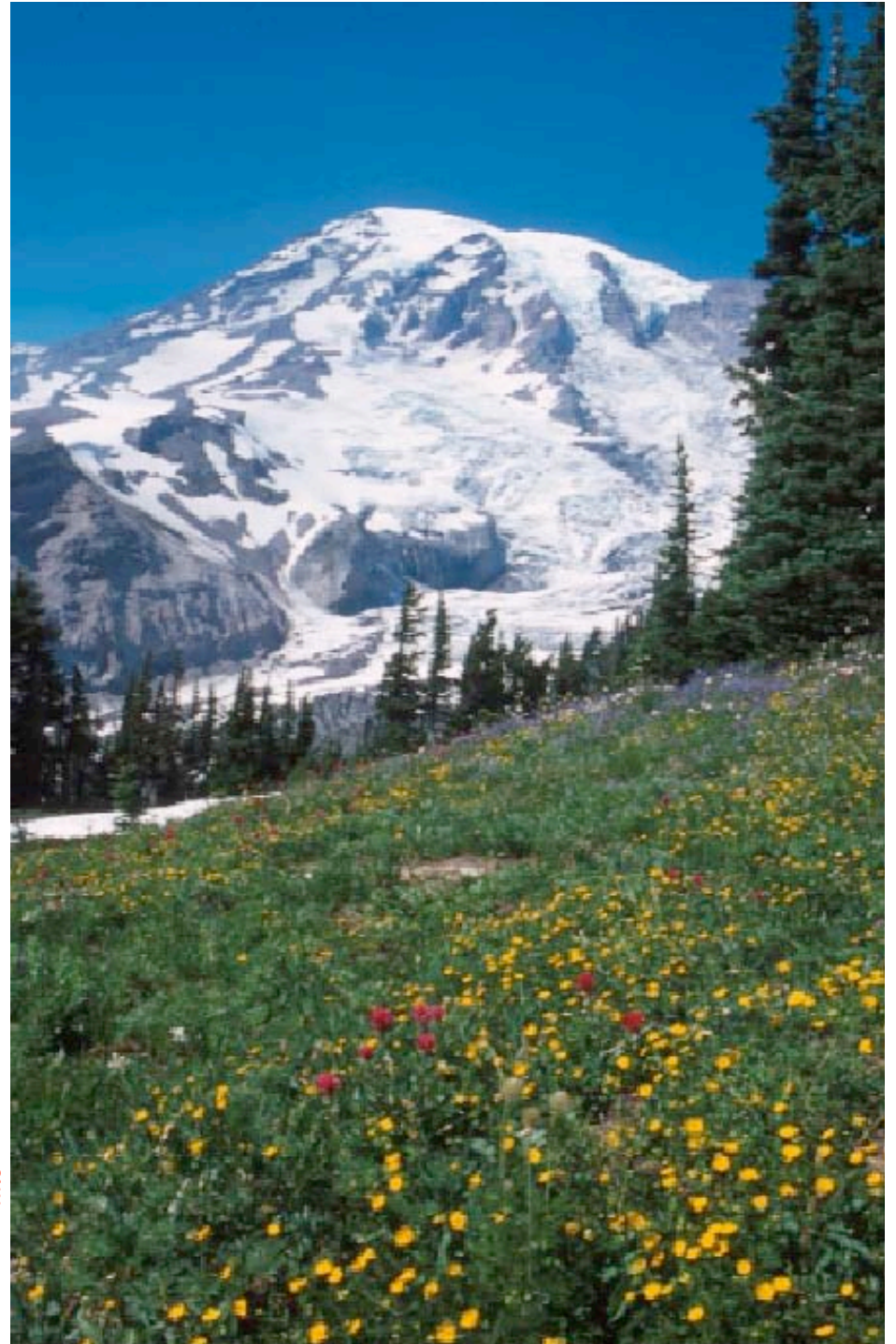


# Selected Parklands





*Mount Rainier  
National Park,  
Washington*



*Robert J. Lillie*



*Mt. St. Helens National Volcanic Monument, Washington*



*Mt. Hood National Forest, Oregon*



*Robert J. Lillie*



# *Crater Lake National Park, Oregon*



*Robert J. Little*

# *Lassen Volcanic National Park, California*



*Naaman C. Horn*





*Beauty*

*and*



*The Beast*

*Coastal Ranges*

*Cascade Volcanoes*

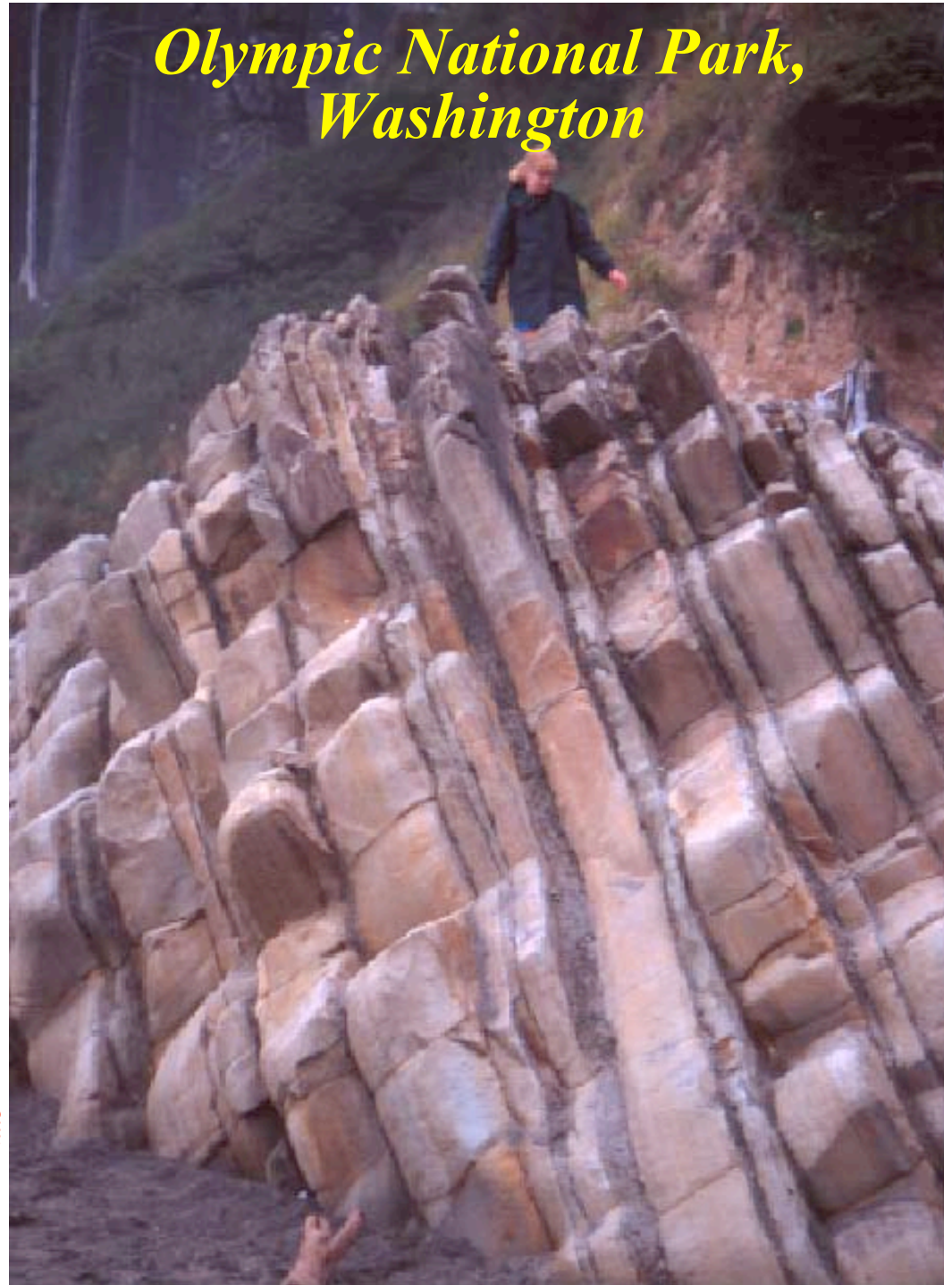
*Why are there Two Parallel Mountain Ranges in the Pacific Northwest?*

**National Park Lands in the Pacific Northwest**



# Coastal Ranges

*Layers Lifted out of  
the Sea*

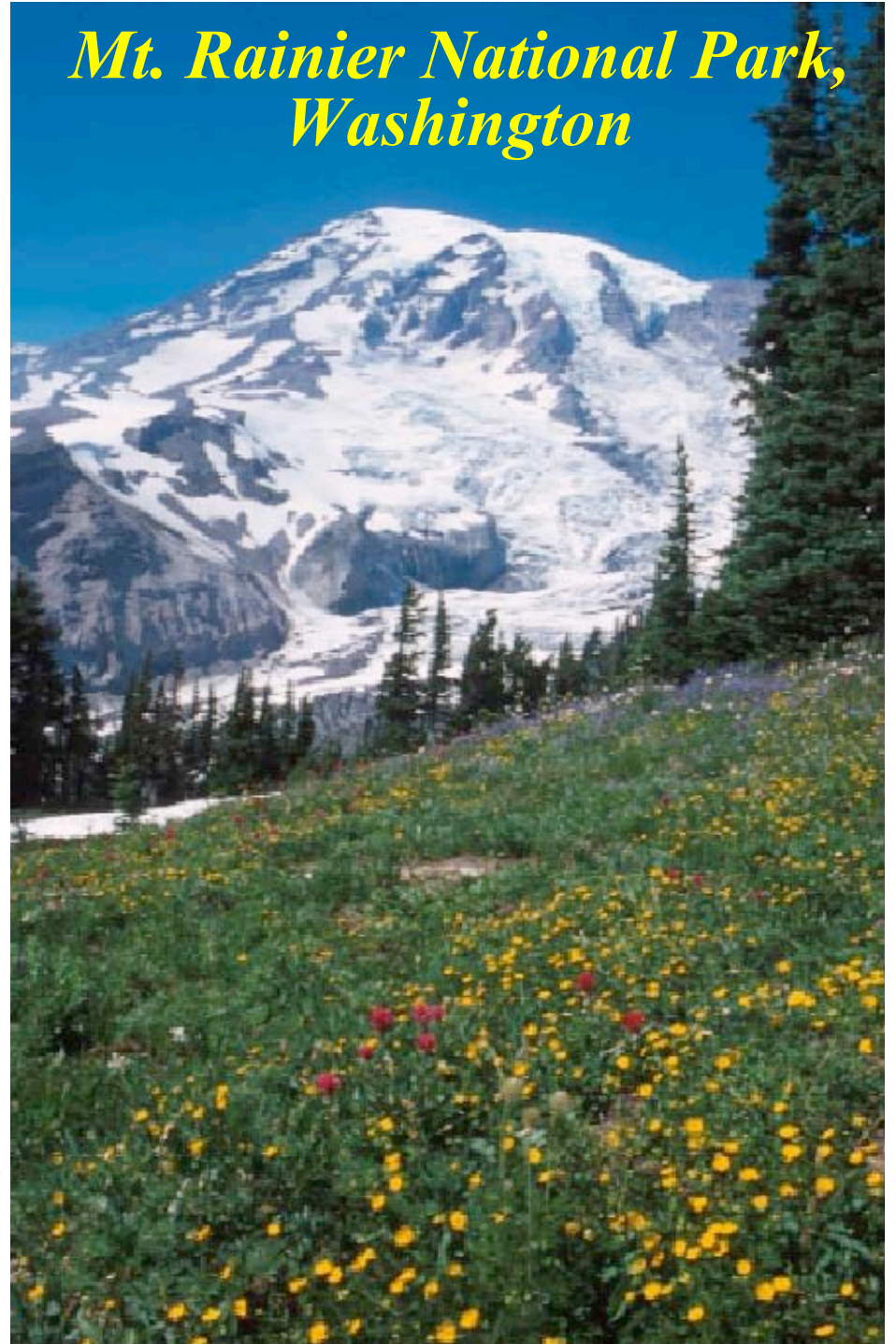




# Cascade Mountains

*Steep, Explosive  
Volcanoes*

*Mt. Rainier National Park,  
Washington*



*Robert J. Lillie*

# NATIONAL PARKLANDS

Plate tectonics is about reading the landscape and making connections:

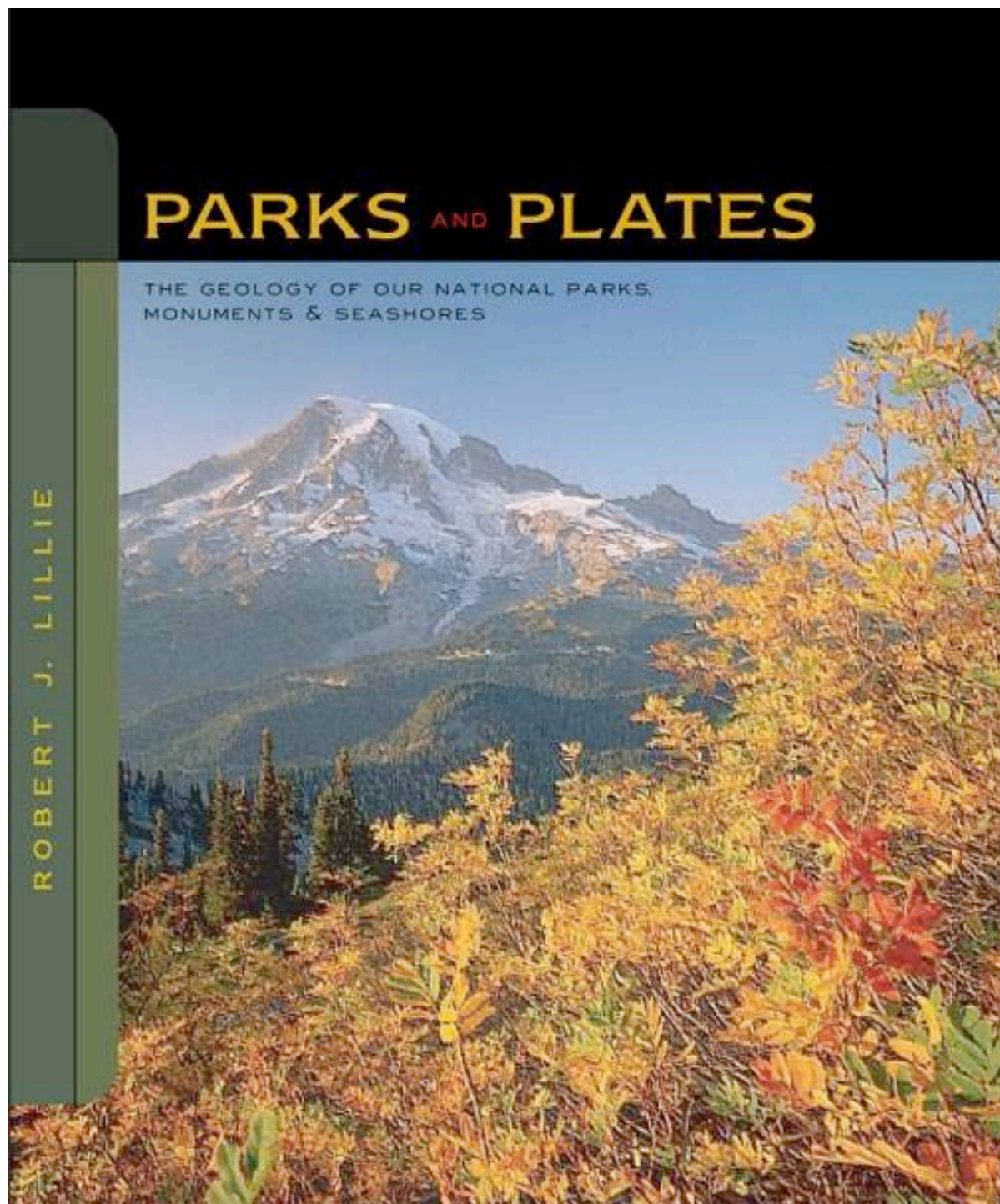
- Why are landscapes similar?
- Why are they different?
- What we see happening today can help us understand what happened in the past .....





## Landscapes of national parks due to processes:

- At plate boundaries
  1. Where they pull apart (divergent)
  2. Where they crash together (convergent)
  3. Where they slide past one another (transform)
- And at hotspots



# *PLATE TECTONICS*

- Tectonics:
- From the Greek “tecton”
  - builder
  - “architect”
- The study of large features on Earth’s surface and the processes that form them.



# “PLATE TECTONICS”

- Large features:
  - continents
  - ocean basins
  - mountain ranges
- and processes:
  - earthquakes
  - volcanic eruptions
- due to movement of plates of Earth's outer shell.





# *Cracked Egg Shell!*





**Divergent** \

**Convergent** ↶  
"Teeth" on  
Overriding Plate

**Transform** \

# Plate Boundaries

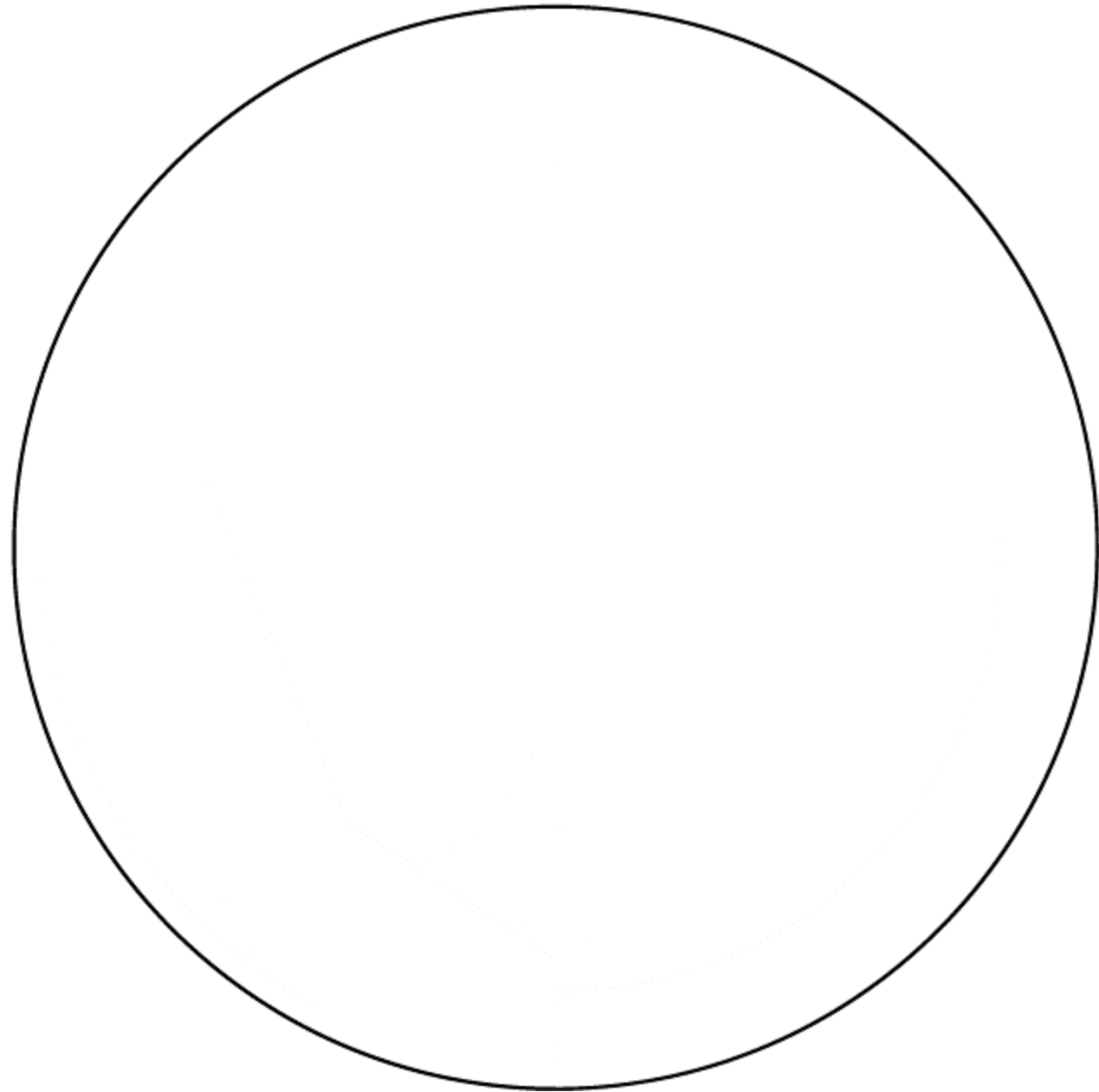


# The Whole Earth and Plate Tectonics

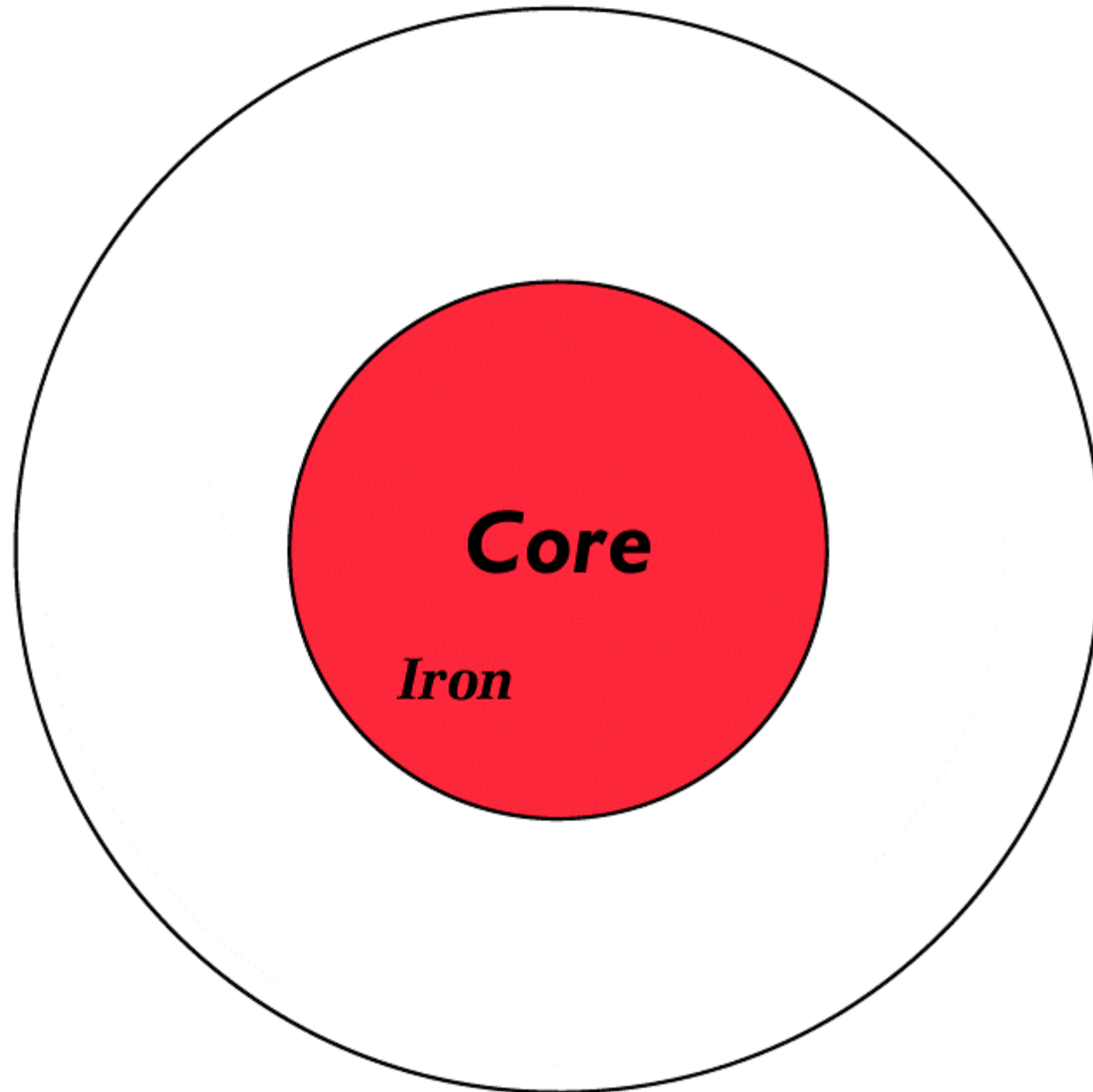
We need to understand  
what goes on inside the  
Earth.



# Classical Divisions of the Earth (Chemical Composition)

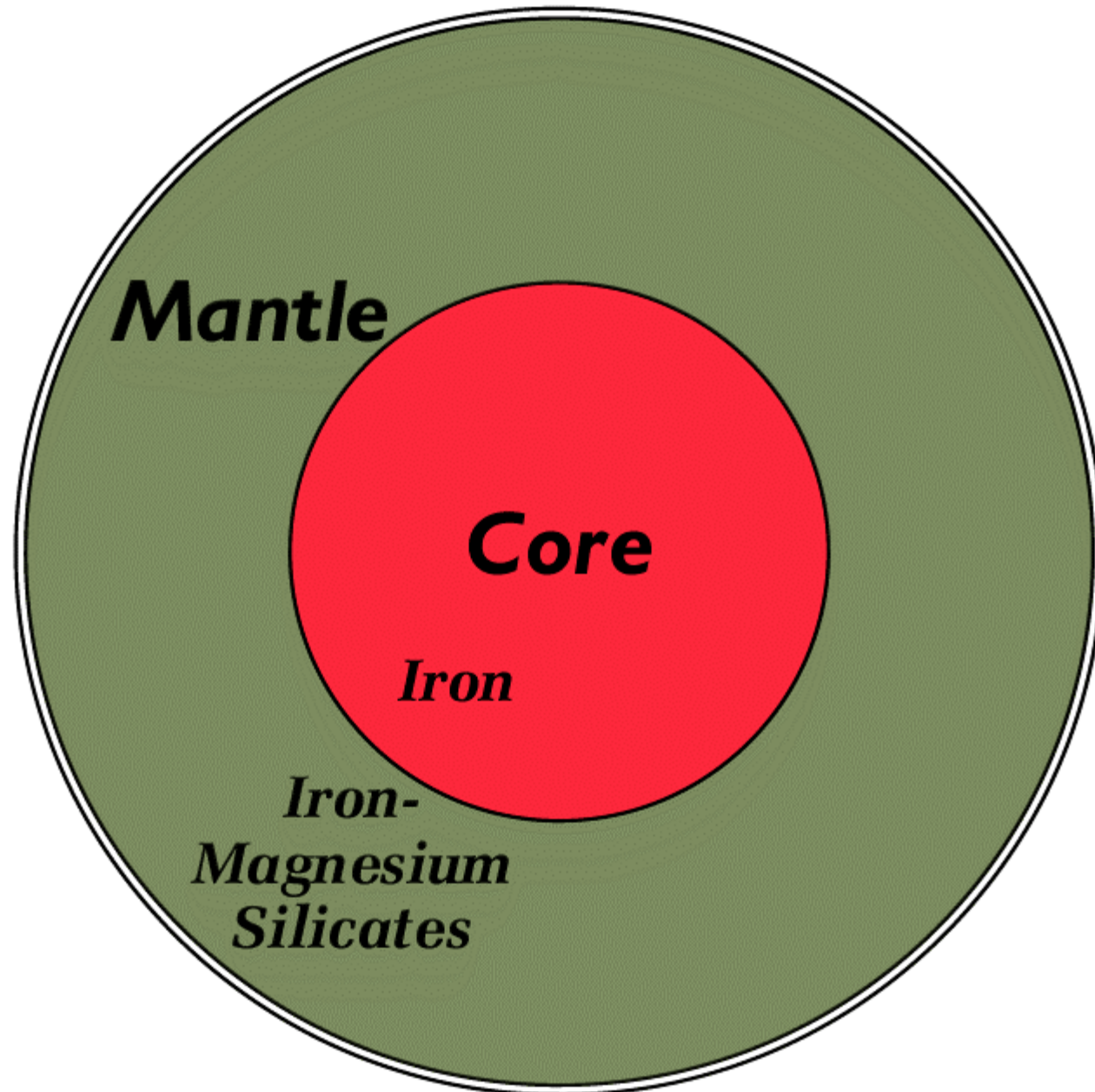


# Classical Divisions of the Earth (Chemical Composition)

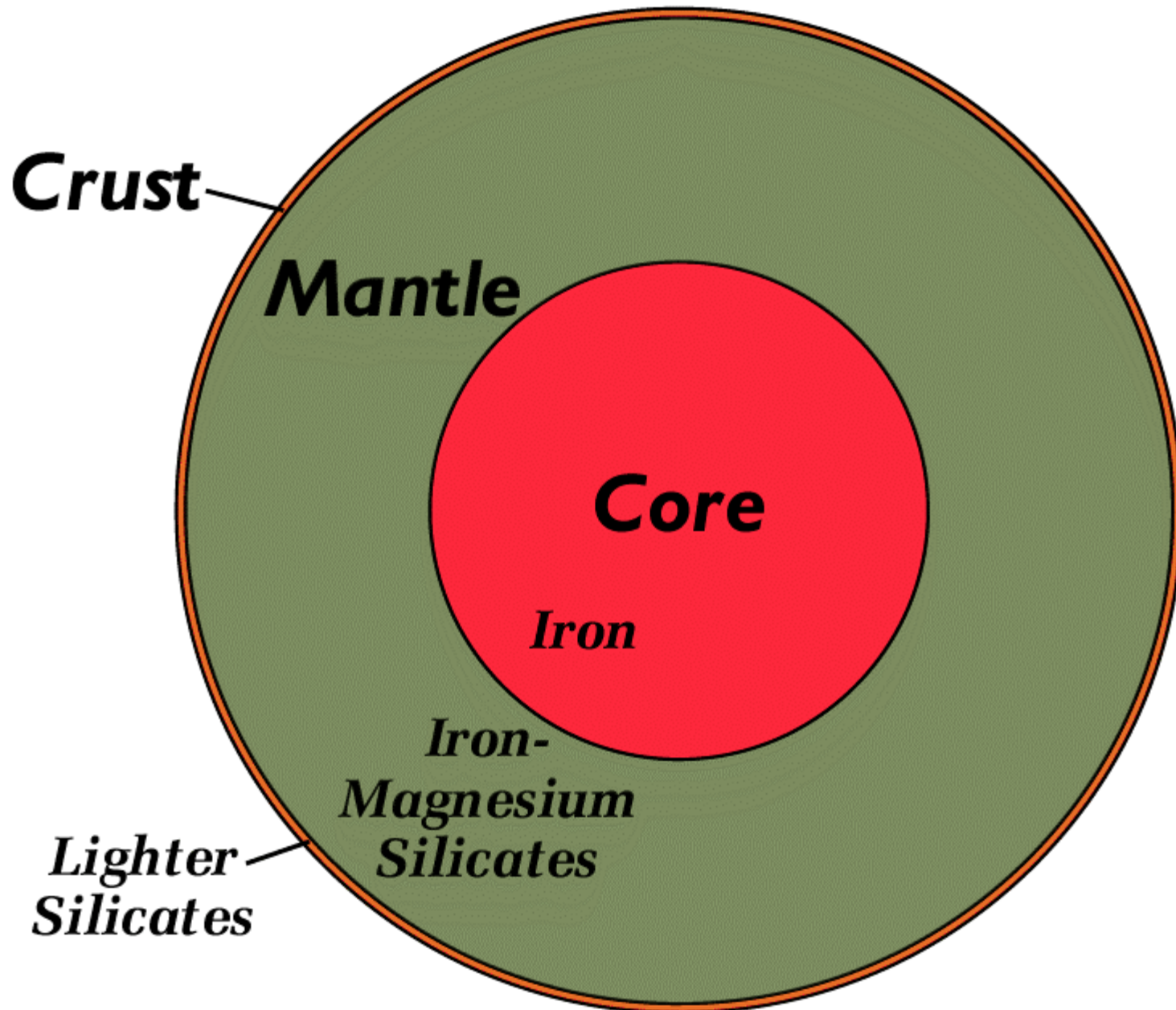




# Classical Divisions of the Earth (Chemical Composition)



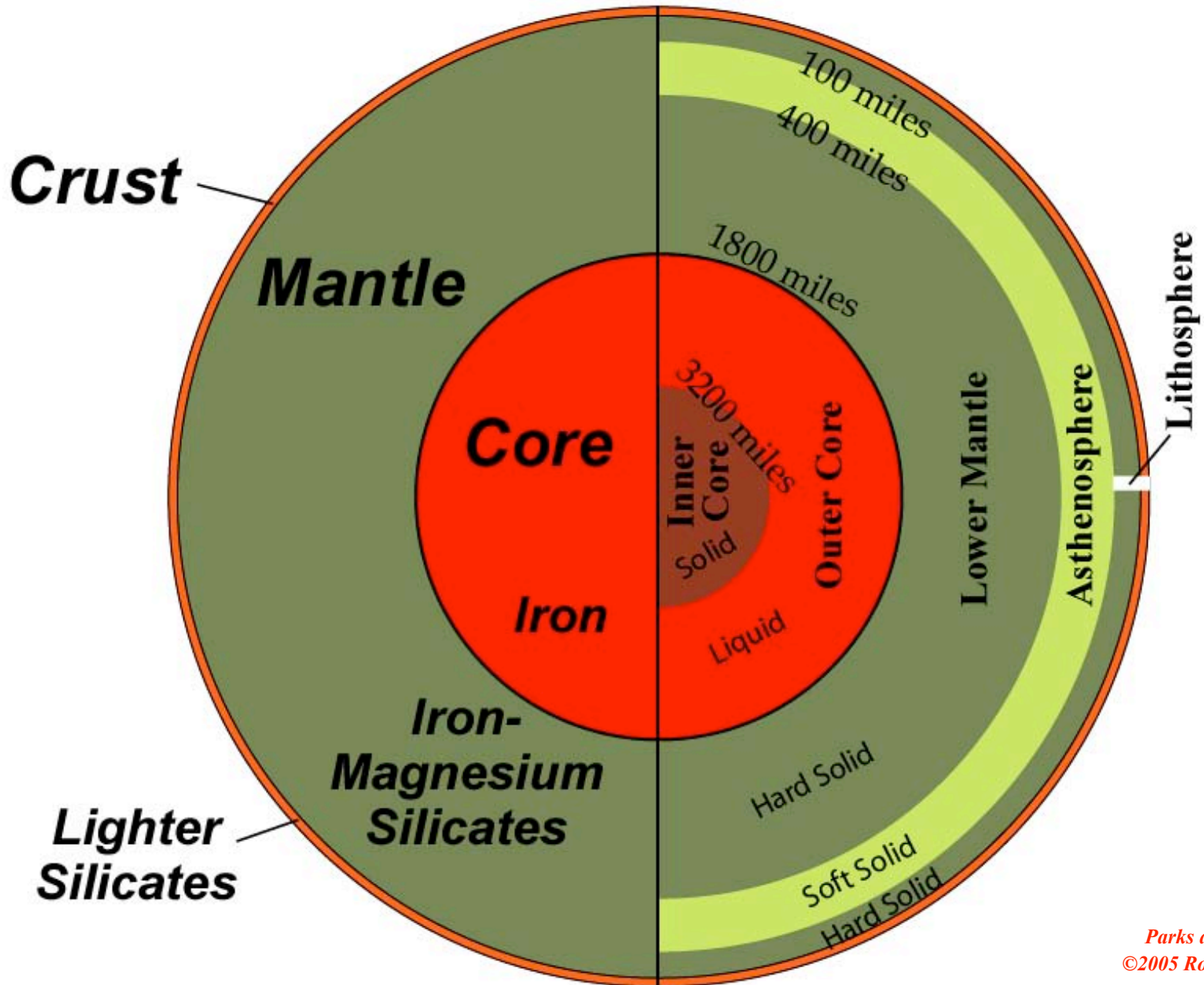
# Classical Divisions of the Earth (Chemical Composition)



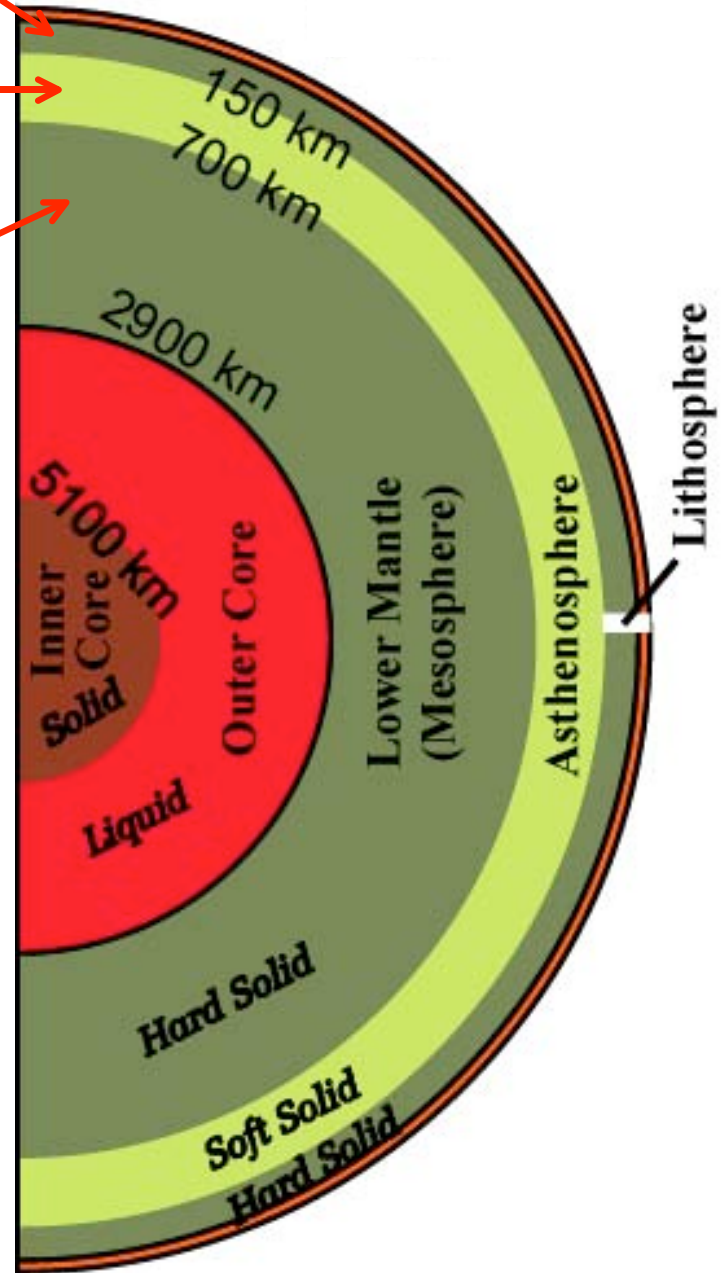


**Classical  
(Chemical Composition)**

**Modern  
(Physical State)**



**Oreo<sup>®</sup>  
Cookie**





# *Oreo<sup>®</sup> Cookie*

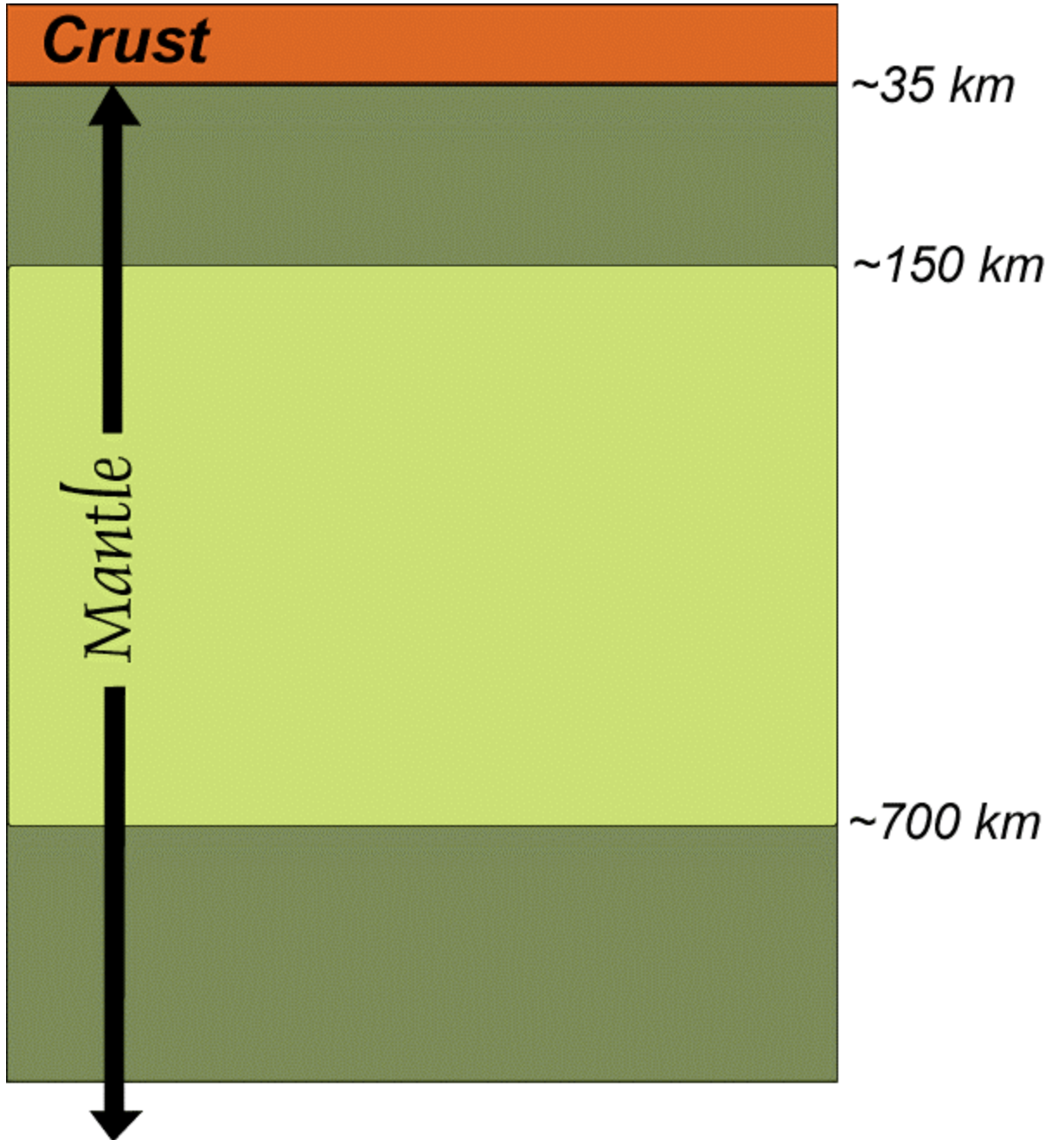
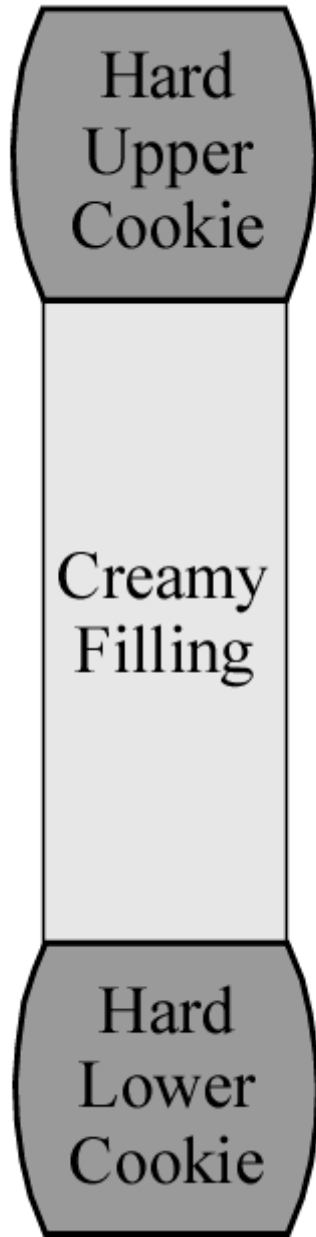


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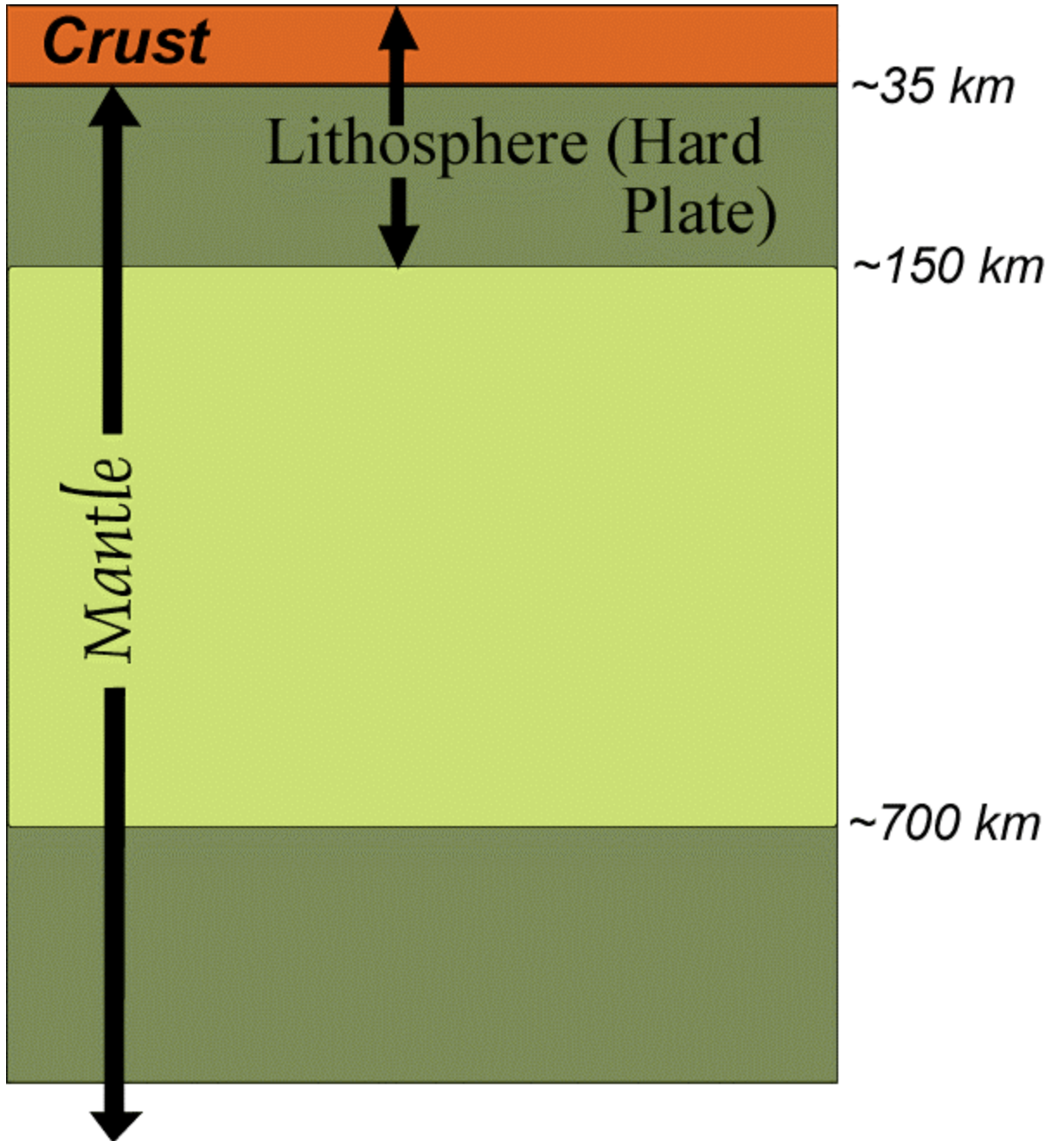




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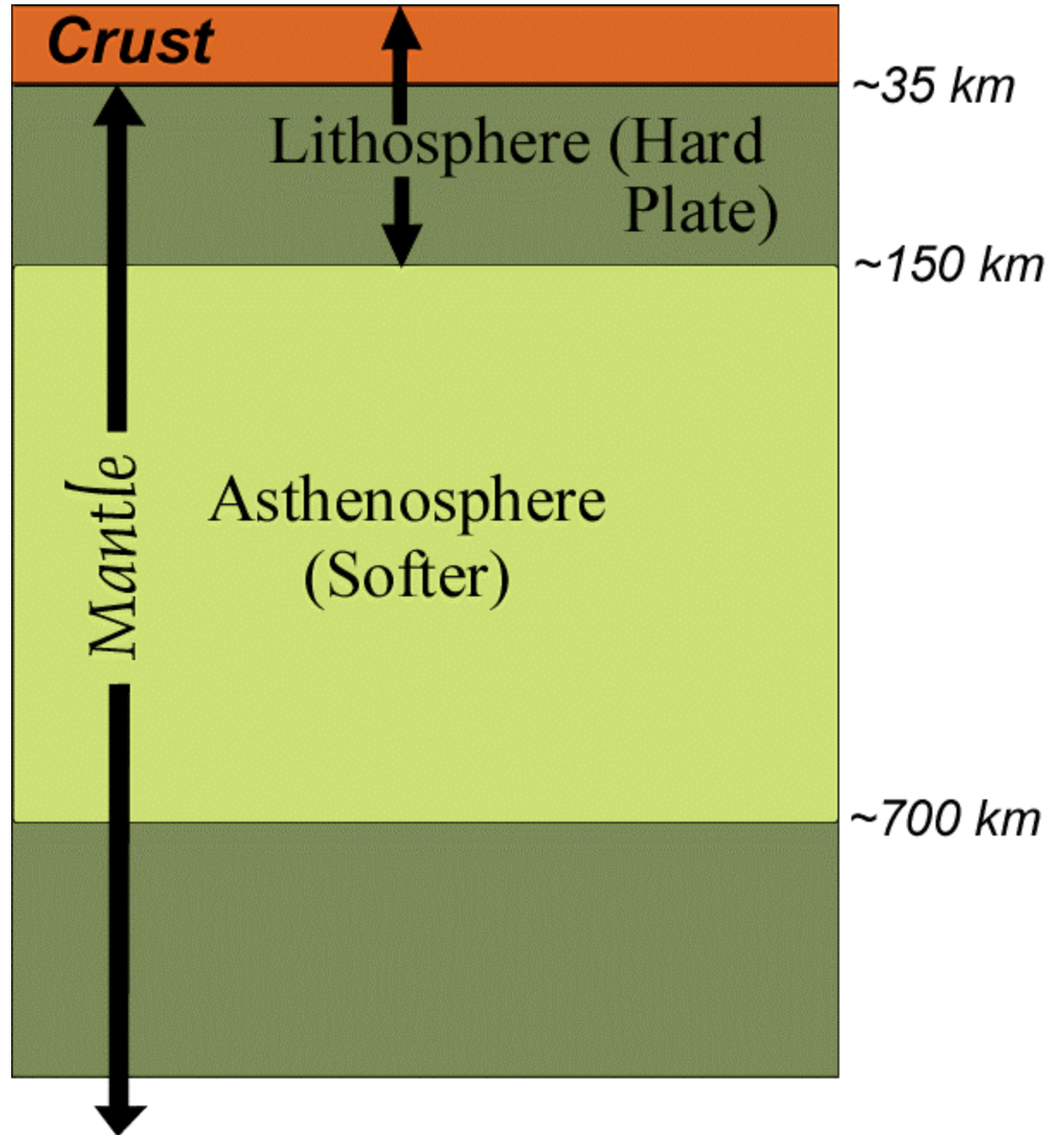


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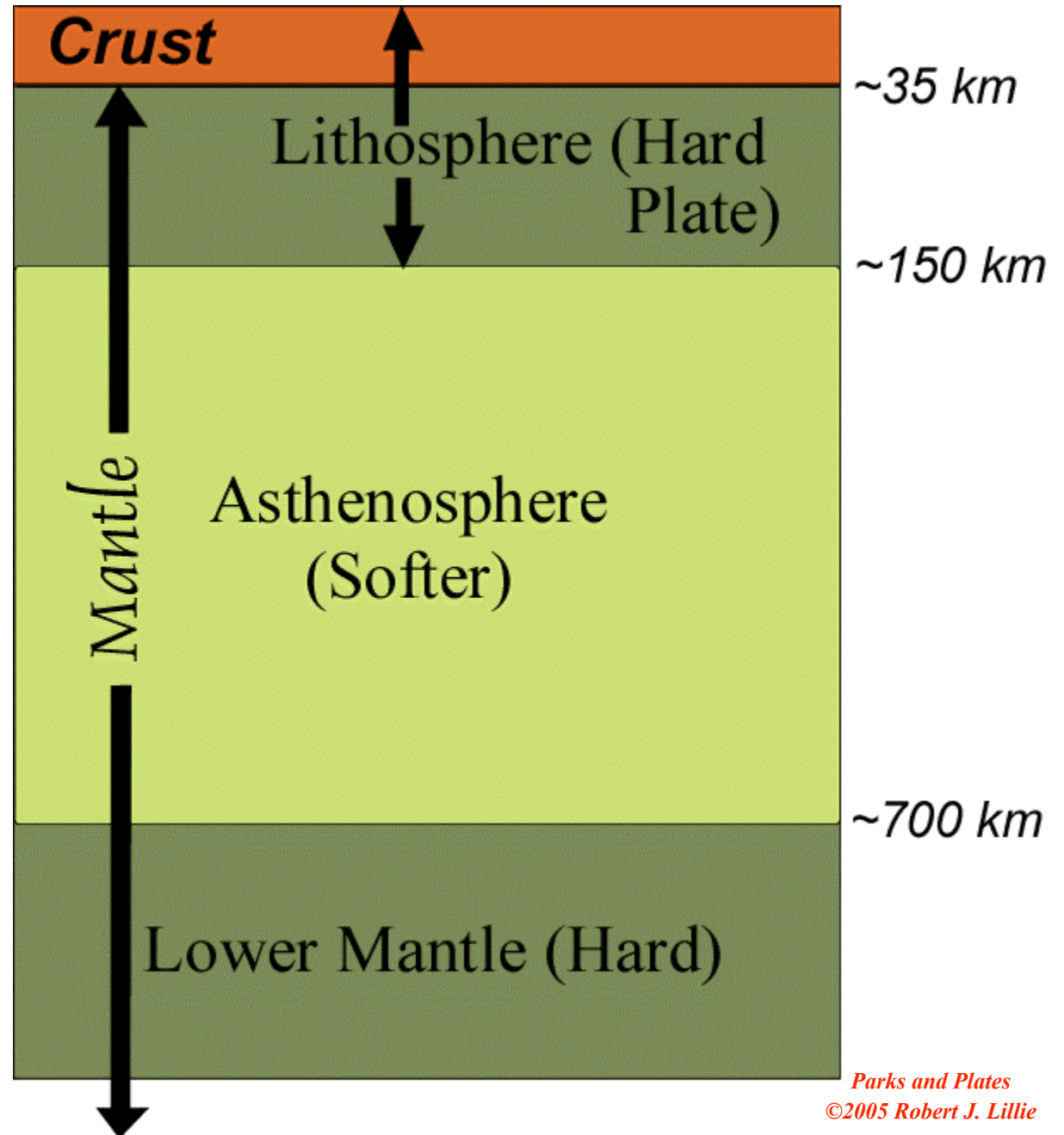




# *Oreo<sup>®</sup> Cookie*



# Oreo<sup>®</sup> Cookie







*Robert J. Lillie*

*Pucks and Plates  
©2005 Robert J. Lillie*

# Oreo<sup>®</sup> Psycho-Personality Test

[www.superkids.com/aweb/pages/humor/050199.sht](http://www.superkids.com/aweb/pages/humor/050199.sht)

Psychologists have discovered that the manner in which people eat Oreo<sup>®</sup> cookies provides great insight into their personalities. Choose which method best describes your favorite method of eating Oreos:

1. The whole thing at once.
2. One bite at a time.
3. Slow and methodical nibbles examining the results of each bite afterwards.
4. In little feverous nibbles.
5. Dunked in some liquid (milk, coffee .....
6. Twisted apart, the inside, then the cookie.
7. Twisted apart, the inside, and toss the cookie.
8. Just the cookie, not the inside.
9. I just like to lick them, not eat them.
10. I don't have a favorite way because I don't like Oreos.



## **6. Twisted apart, the inside, then the cookie.**

- **You have a highly curious nature.**
- **You take pleasure in breaking things apart to find out how they work, though you're not always able to put them back together, so you destroy all the evidence of your activities.**
- **You deny your involvement when things go wrong.**
- **You are a compulsive liar and exhibit deviant, if not criminal, behavior.**

# Sliding Plate over Asthenosphere







Robert J. Lillie

## *Divergent Plate Boundary*



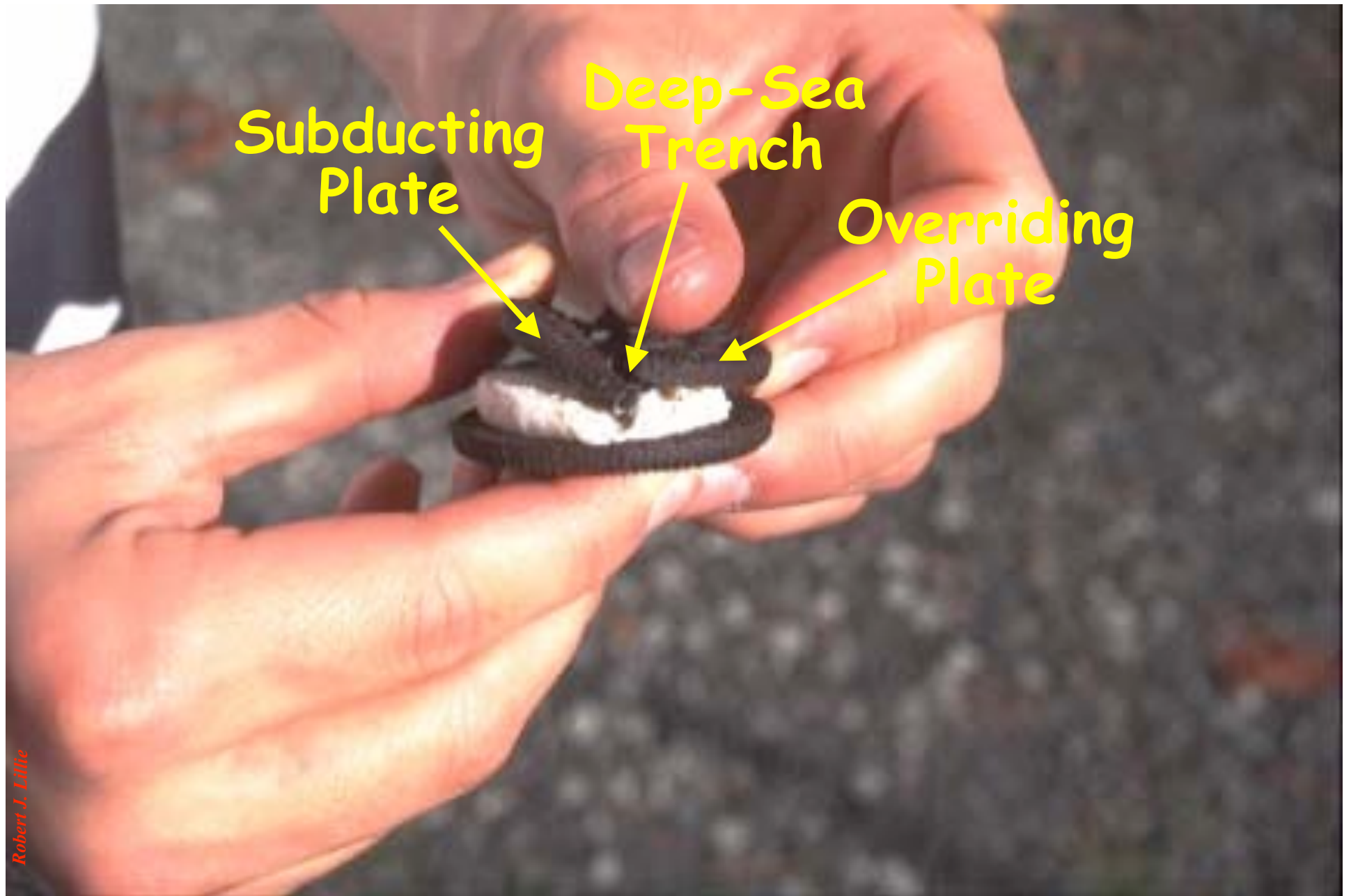


*North  
America*

*Mid-Atlantic Ridge  
(Divergent Plate Boundary)*

*Africa*



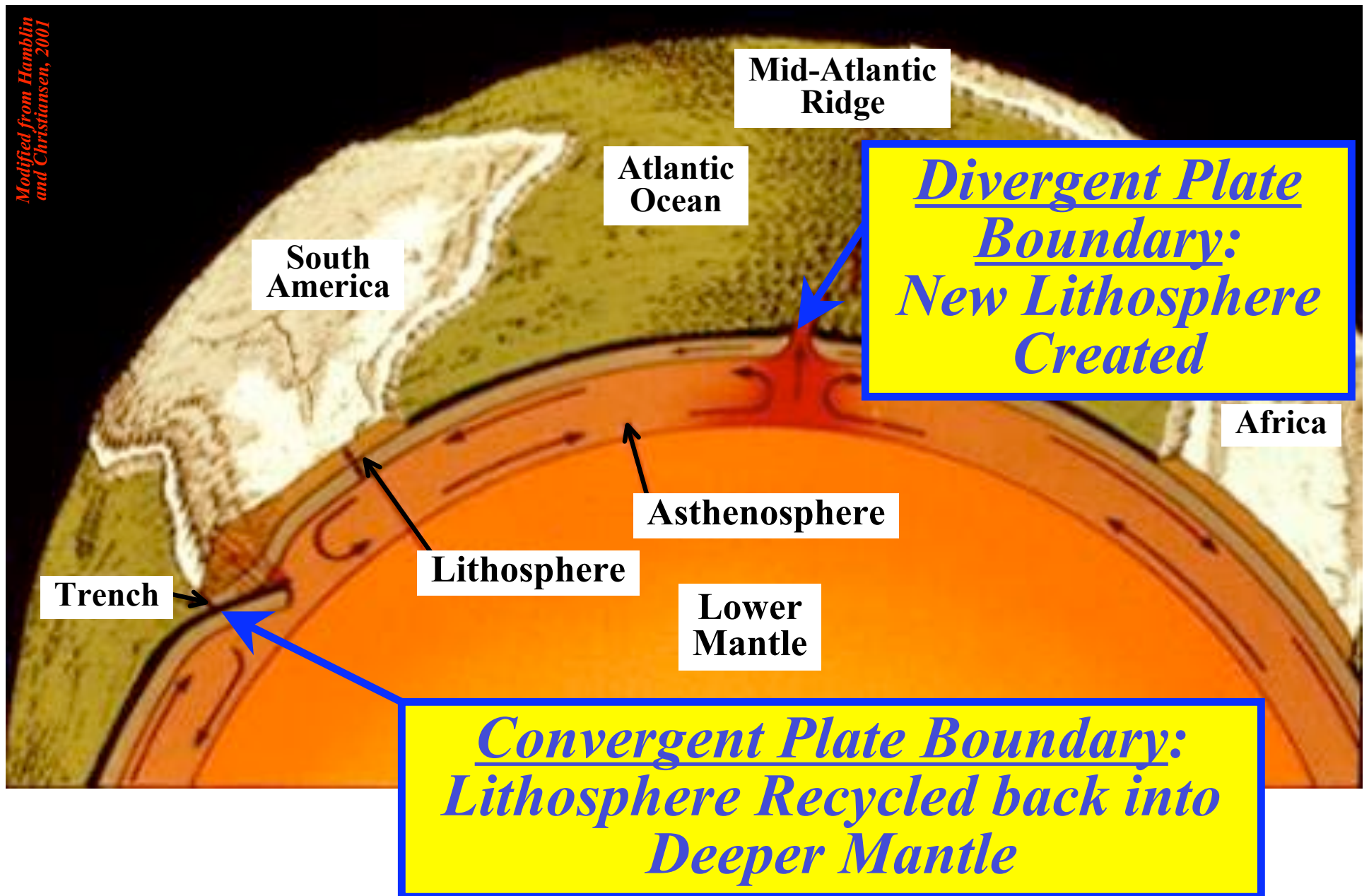


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## *Convergent Plate Boundary*



# Earth is a Giant Recycling Machine!! 😊



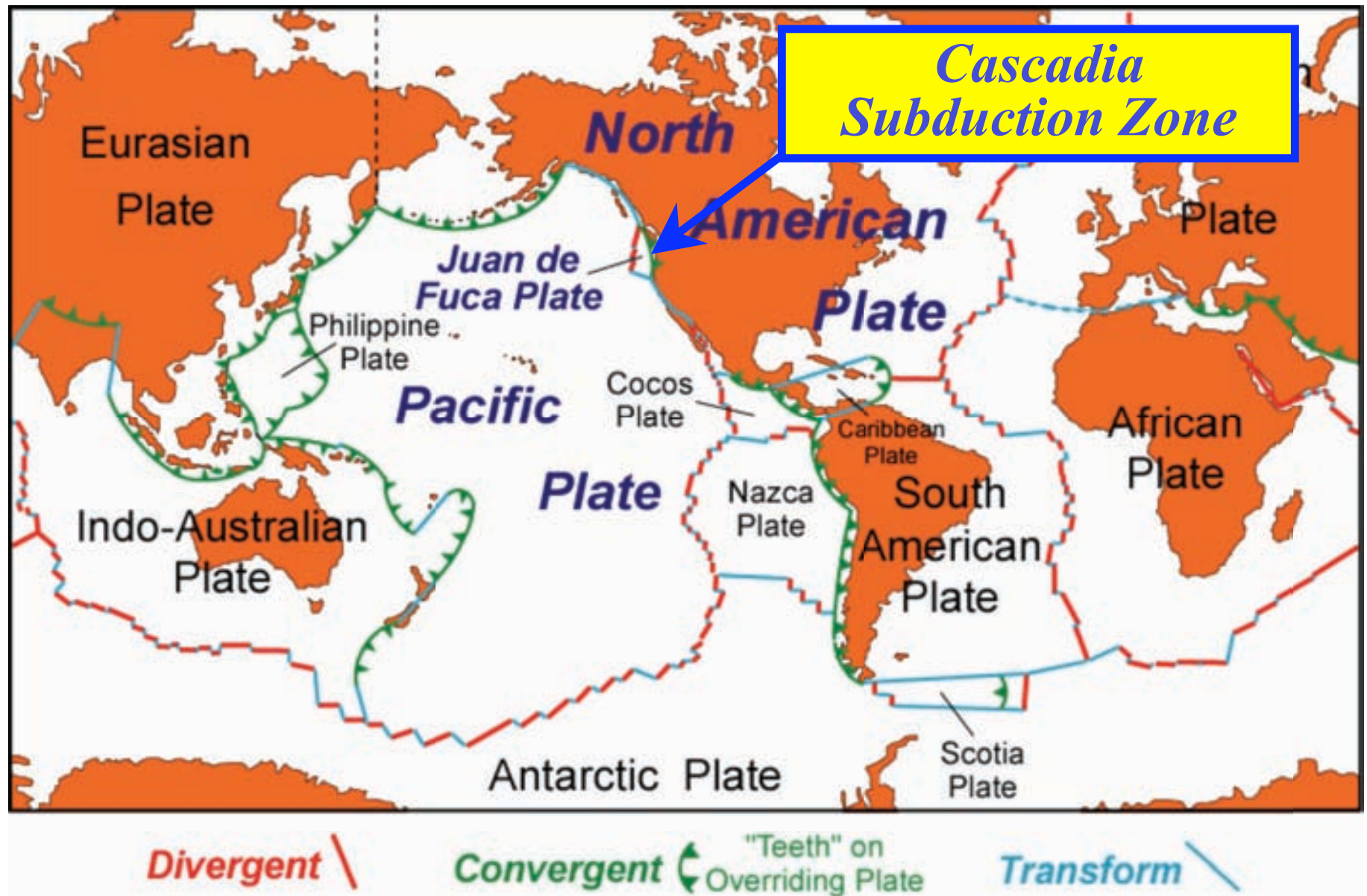
# Andes Mountains, South America



**Osorno volcano near Puerto Montt, Chile**

<http://whatonearth.olehnielsen.dk/volcanoes.asp>

# The Pacific Northwest Coast is a Convergent Plate Boundary







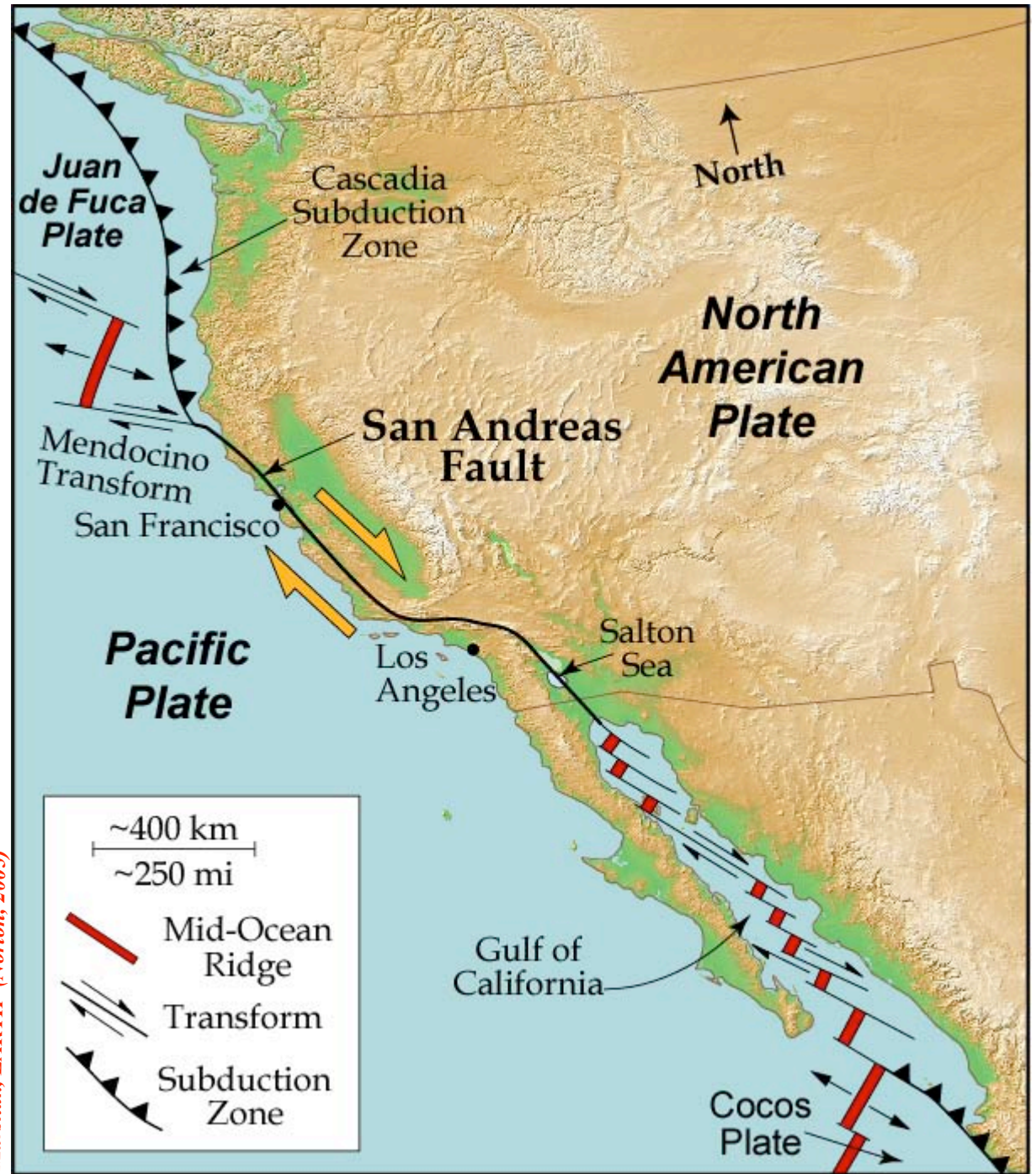
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## *Transform Plate Boundary*

# TRANSFORM PLATE BOUNDARY

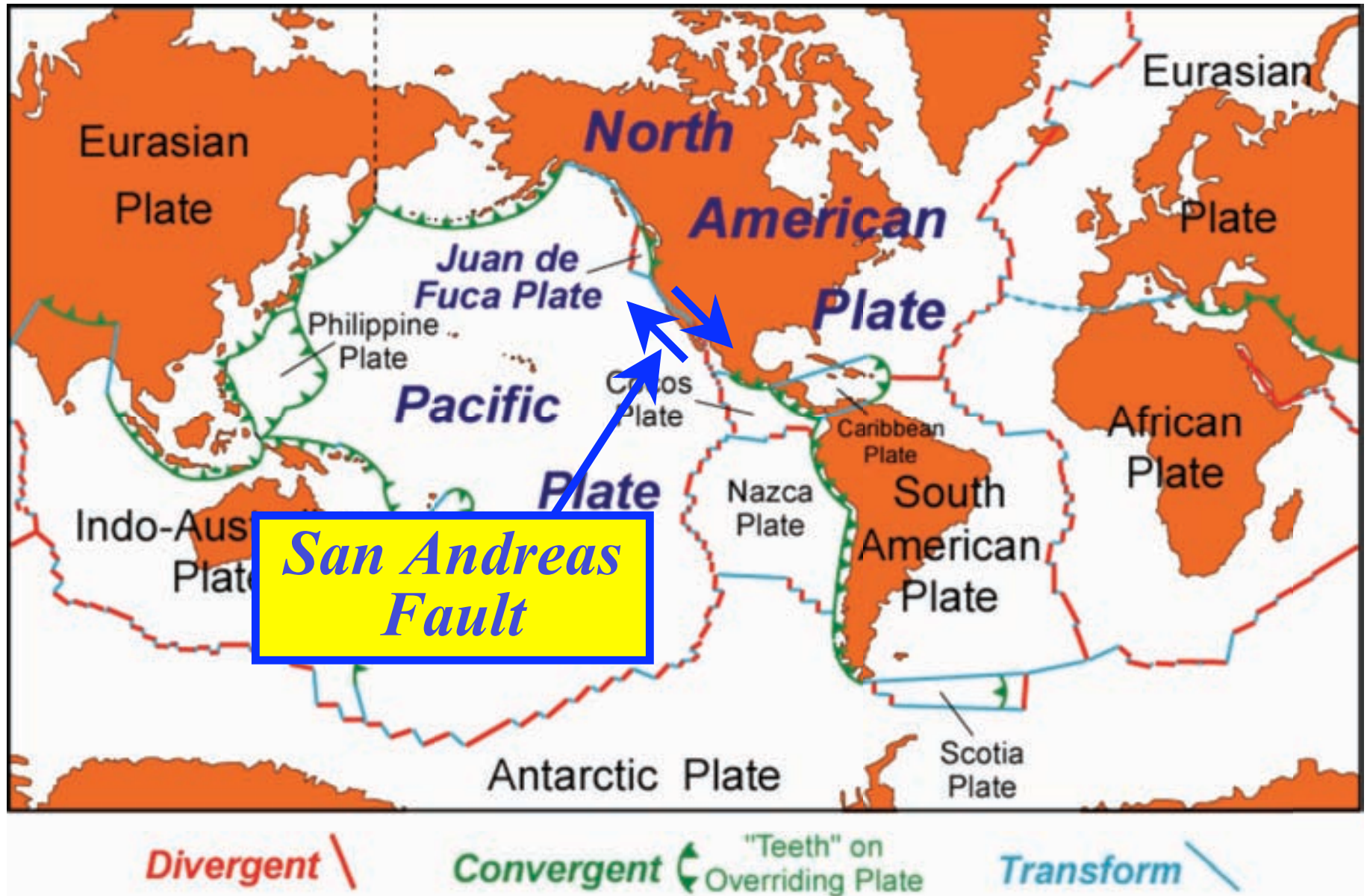
*The Pacific Plate  
moves  
northwestward past  
the North American  
Plate along the San  
Andreas Fault.*

Marshak, EARTH (Norton, 2005)



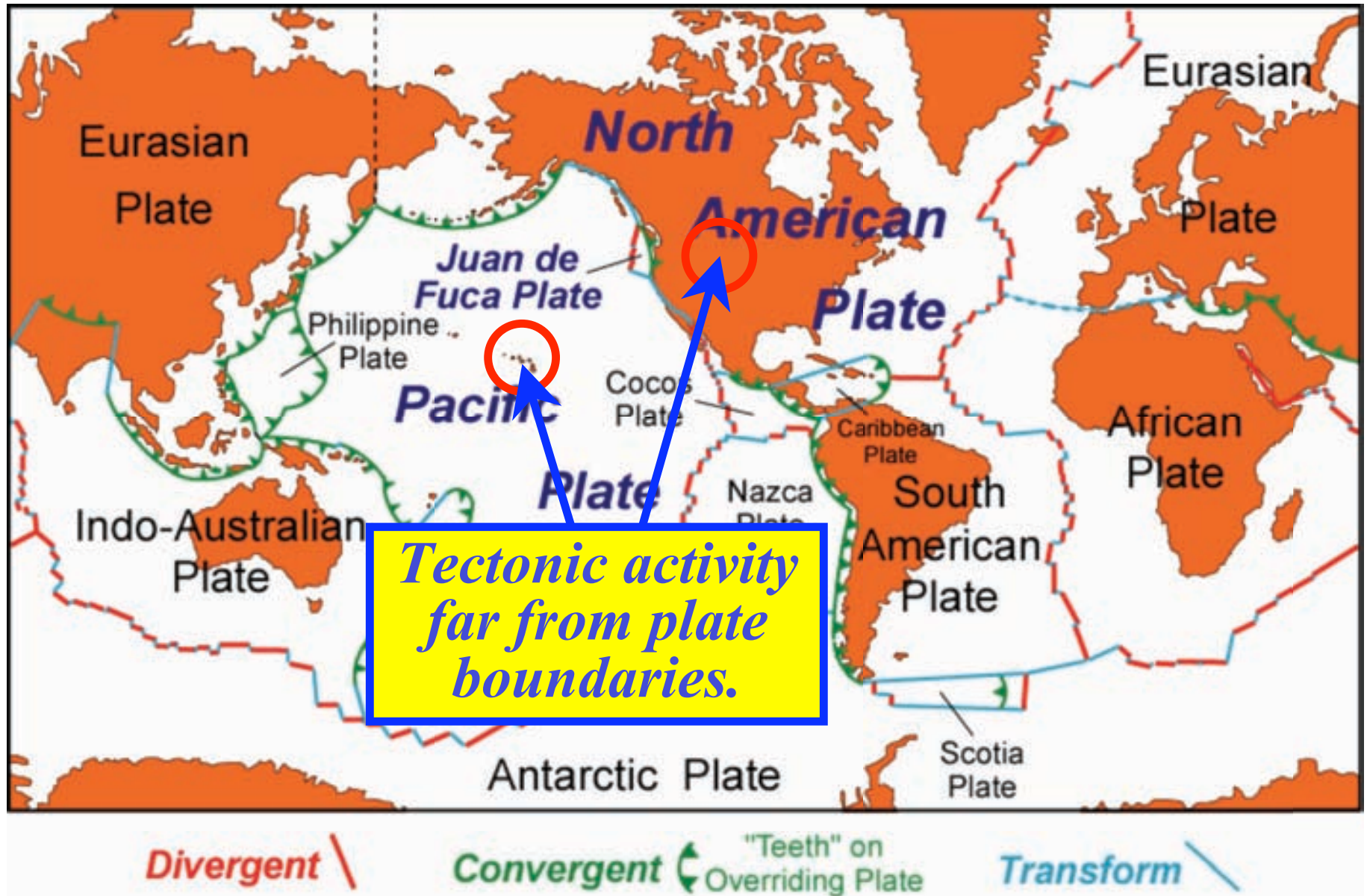


# Western California is a Transform Plate Boundary



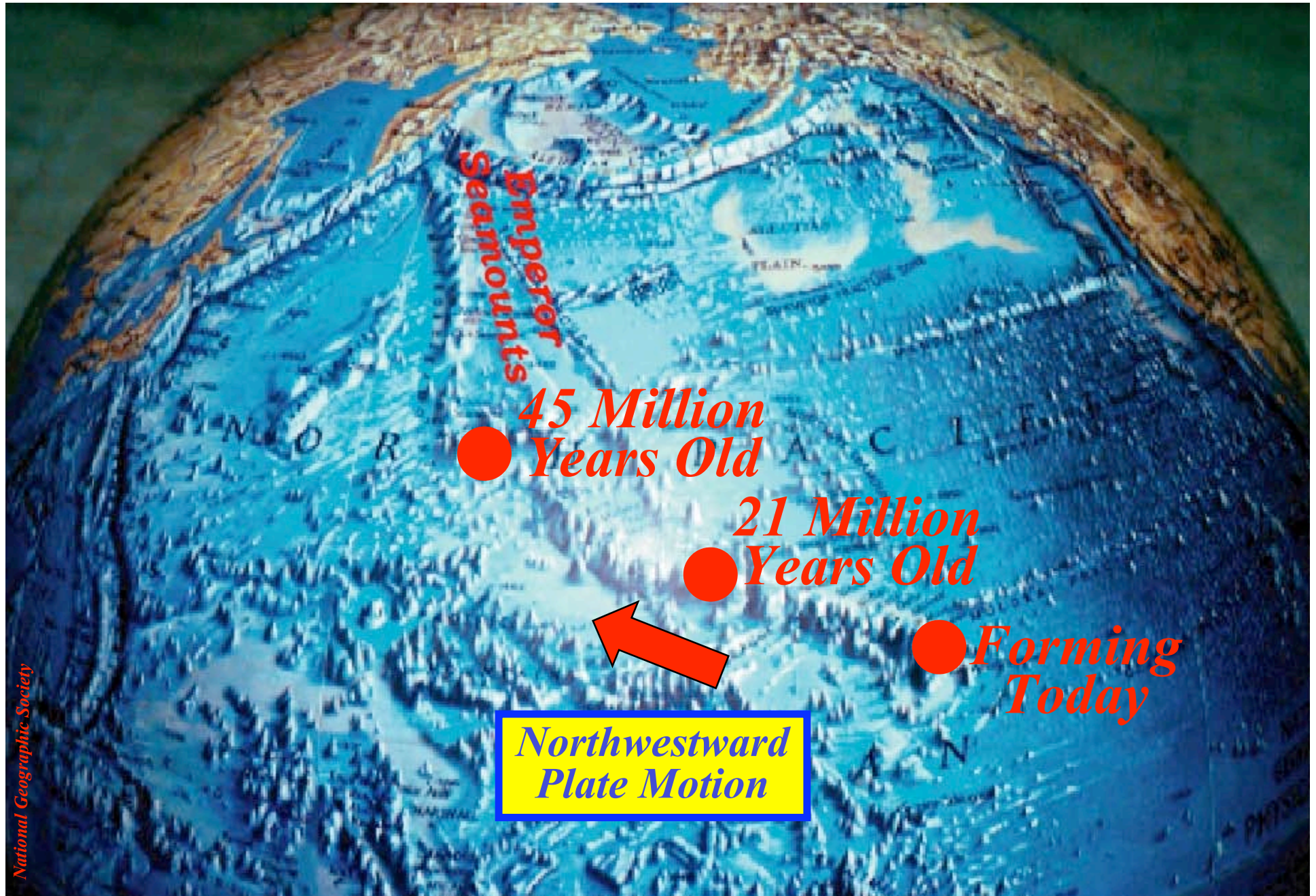


# Hotspots





# *Hawai`i – Emperor Hotspot Track*





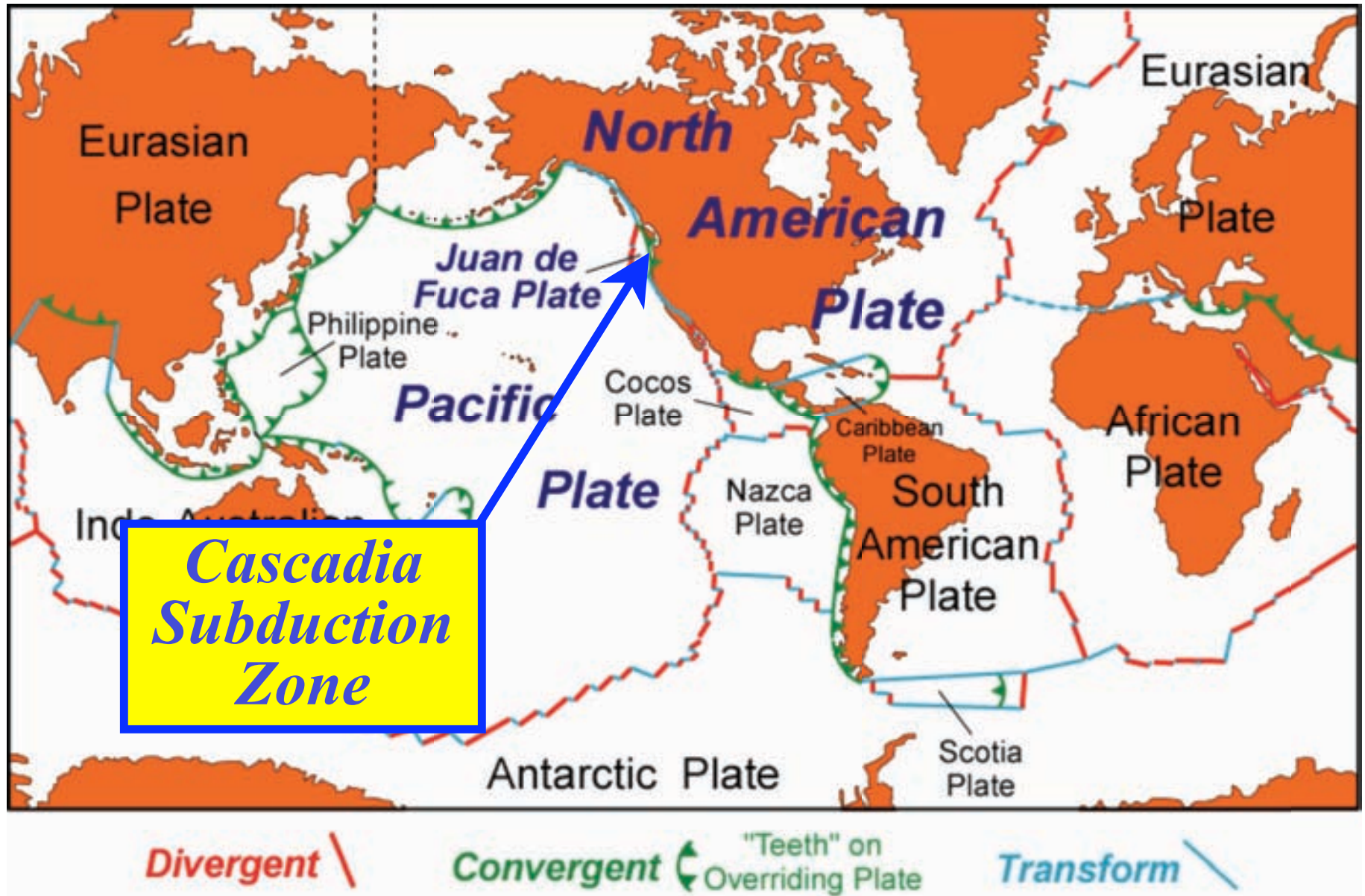


*Robert J. Lillie*

*Hotspot*



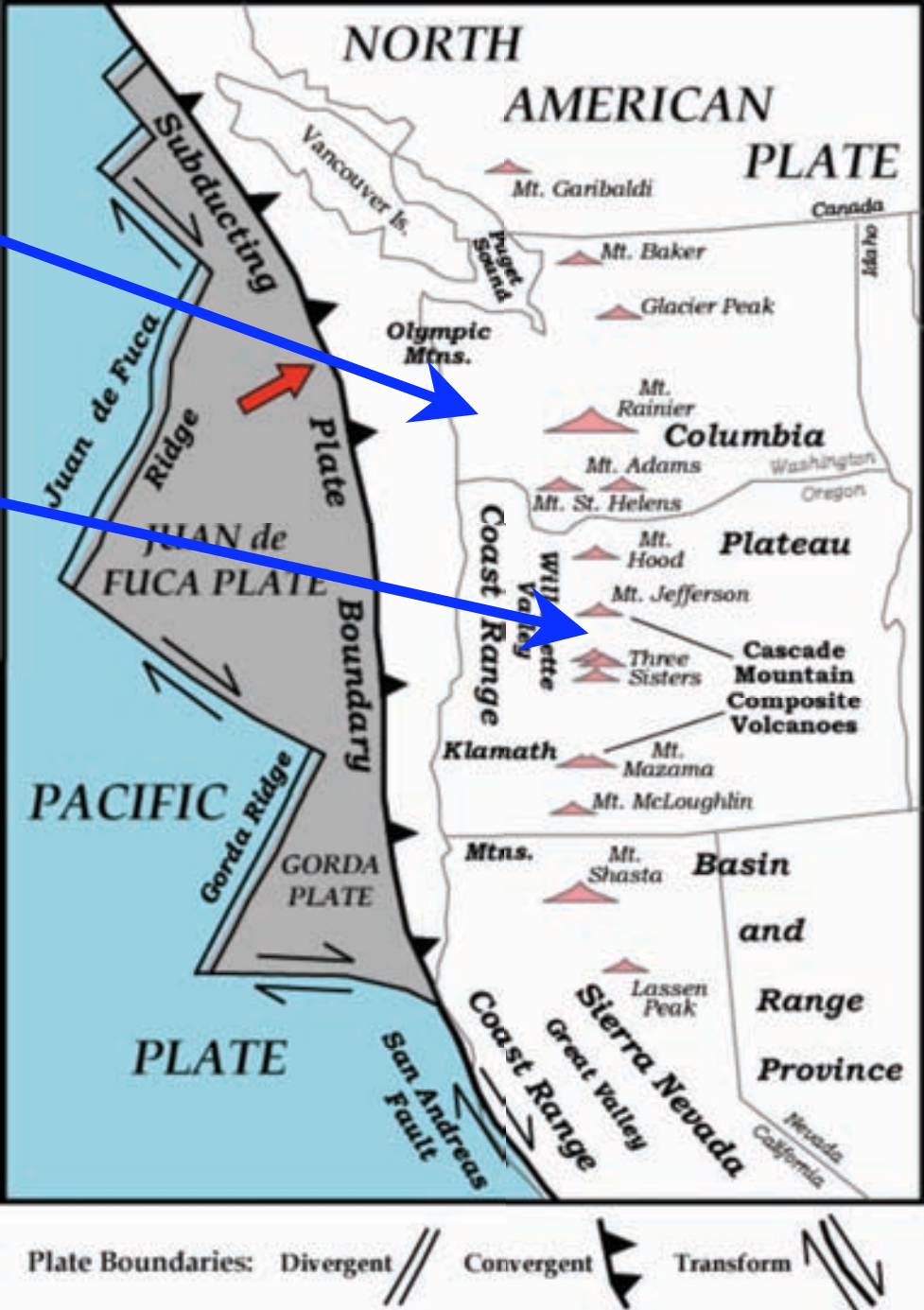
# Subduction Zones rim the Pacific Ocean



*Coastal Ranges*

*Cascade Volcanoes*

*Subduction of the Juan de Fuca Plate forms the Coastal Ranges and Cascade Volcanoes*







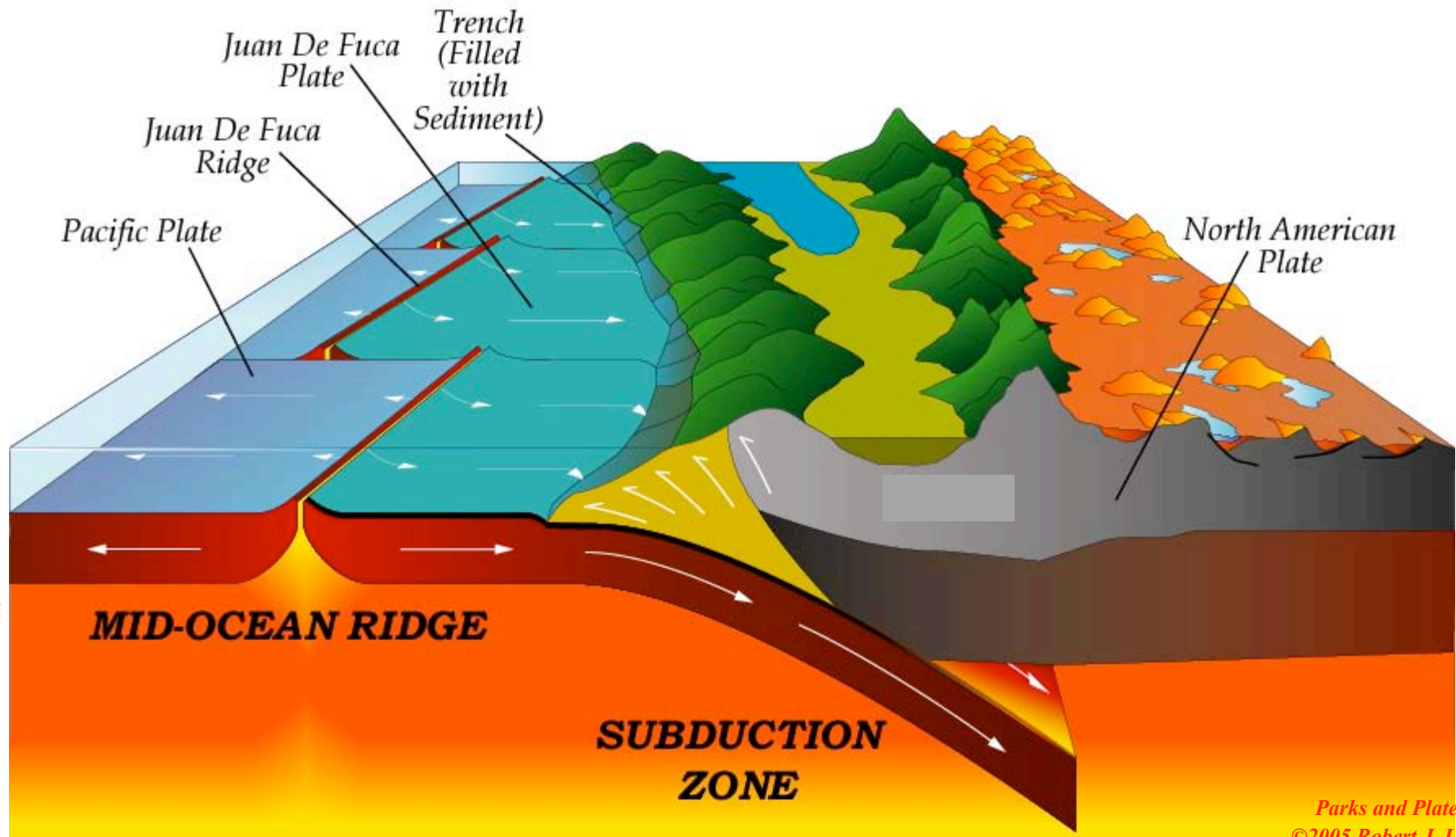
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*Parks and Plates*  
©2005 Robert J. Lillie

## *Plate Tectonics--Subduction Zone*



*Subducting Juan de Fuca Plate forms two parallel mountain ranges in the Pacific Northwest.*

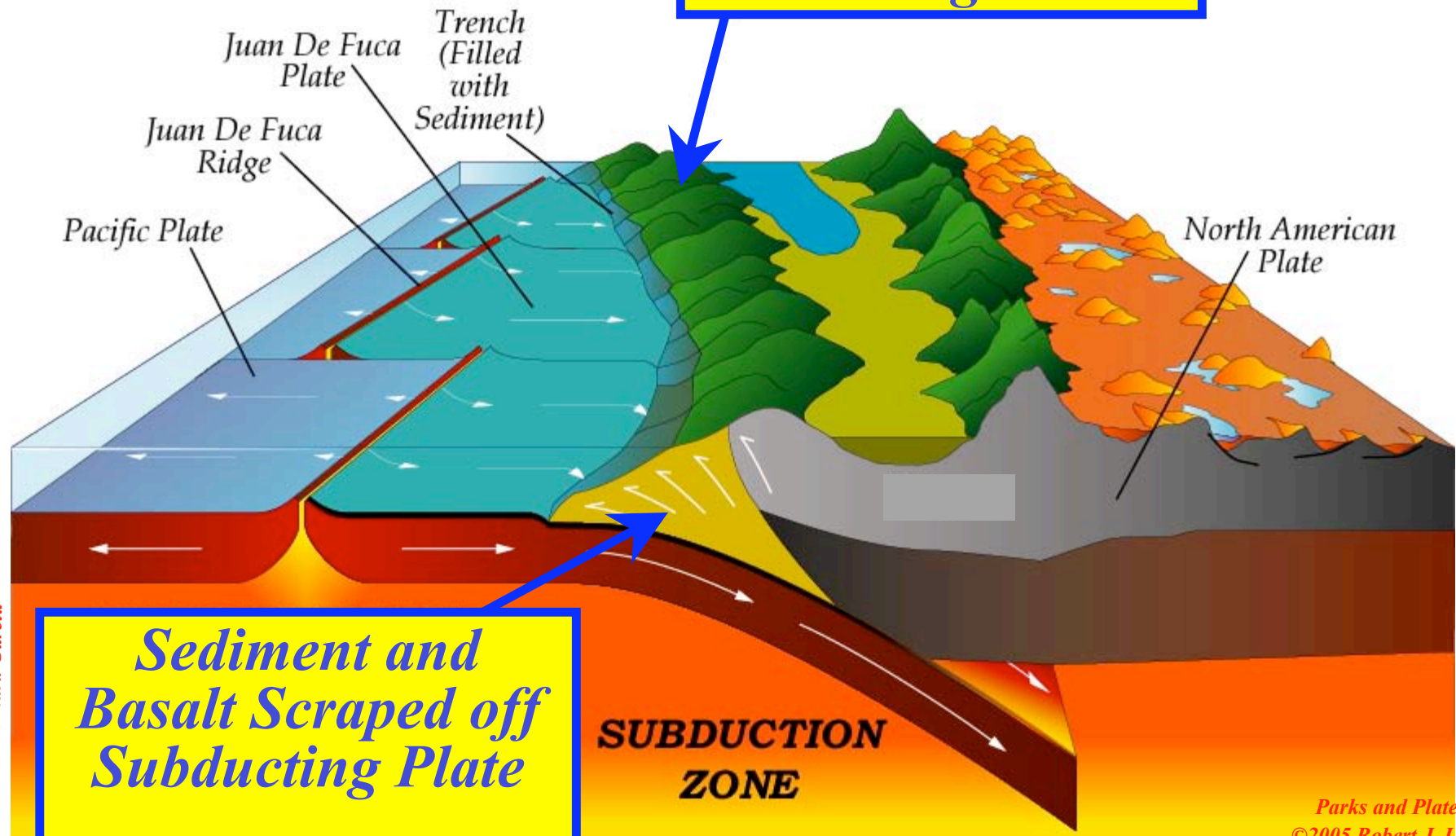


Robert J. Lillie  
Bernard Garcia

*Parks and Plates*  
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*Oceanic sediment and basalt scraped off subducting plate, forming Coastal Mountains.*

*Olympic and other Coastal Mountain Ranges*

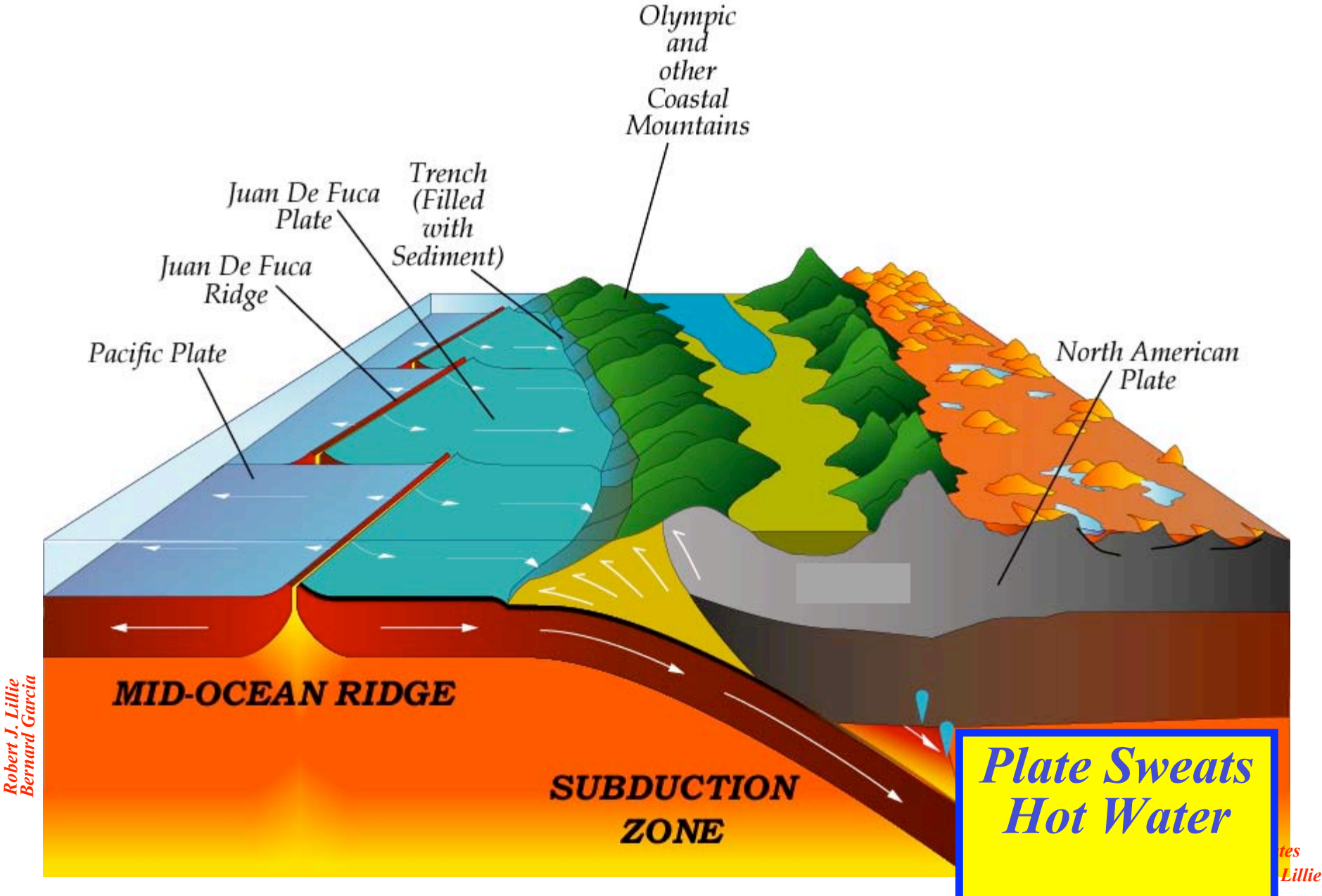


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*Sediment and Basalt Scraped off Subducting Plate*

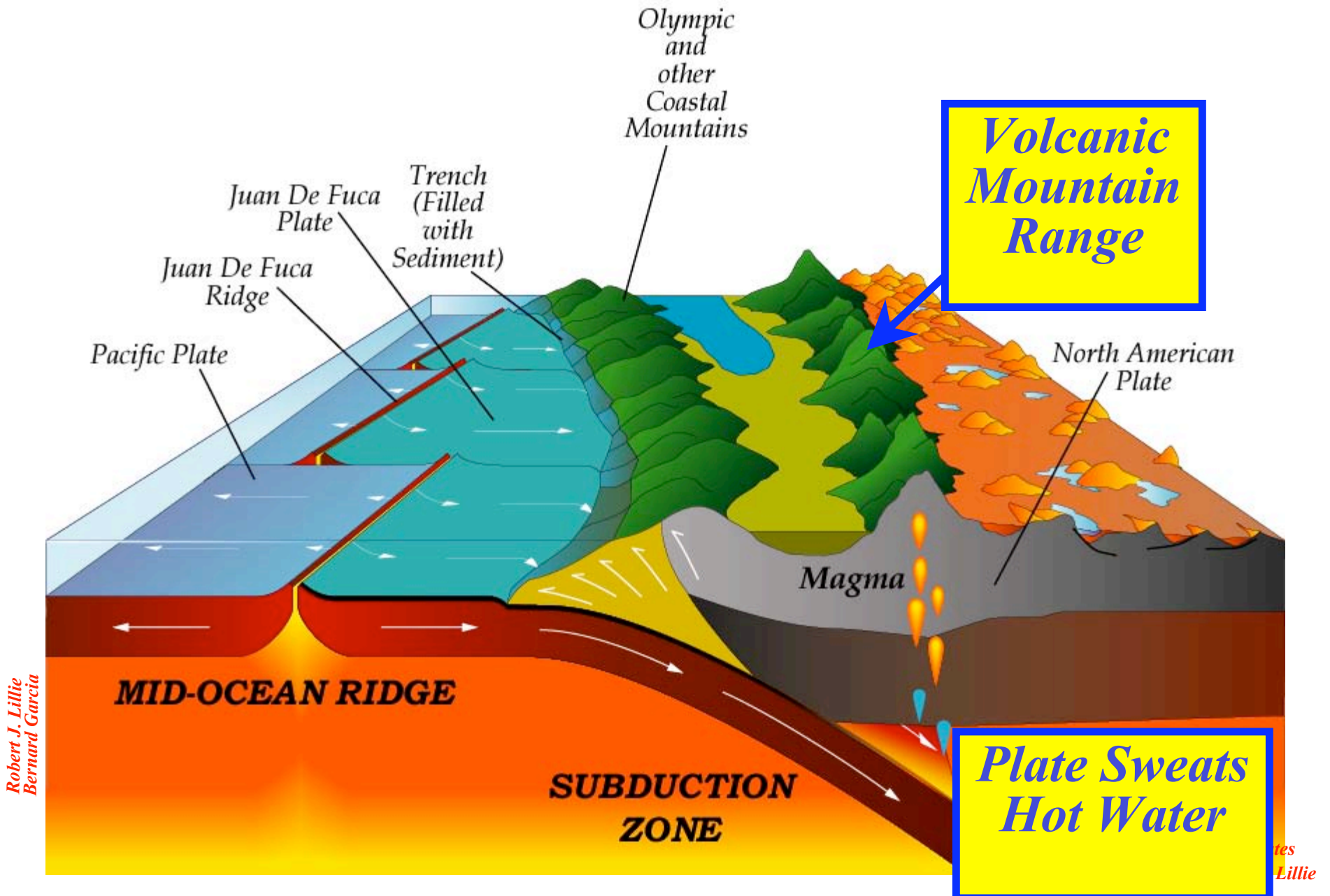
*Parks and Plates  
©2005 Robert J. Lillie*

*Subducting plate dehydrates, forming Cascade Volcanoes.*

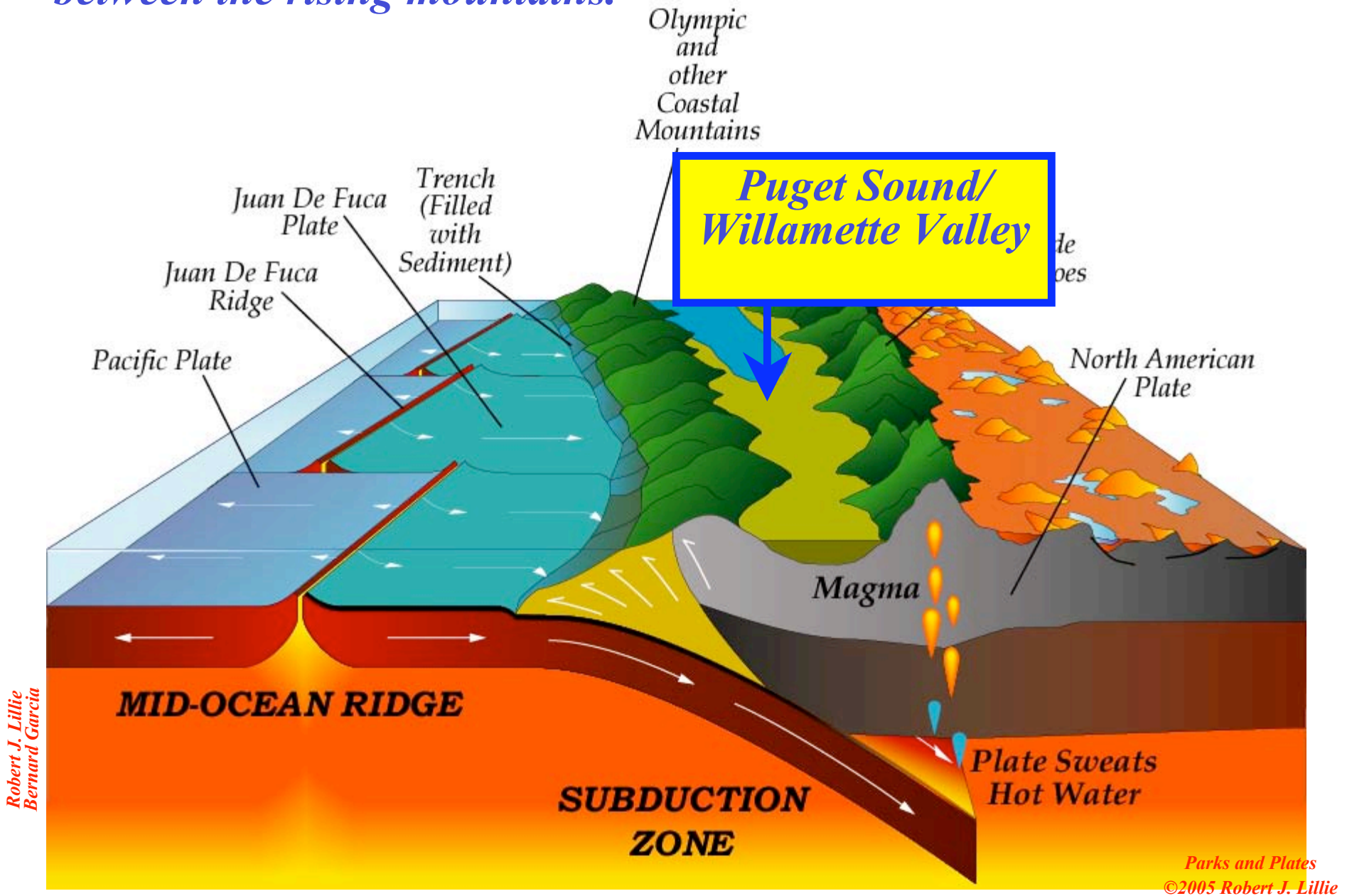




# *Subducting plate dehydrates, forming Cascade Volcanoes.*



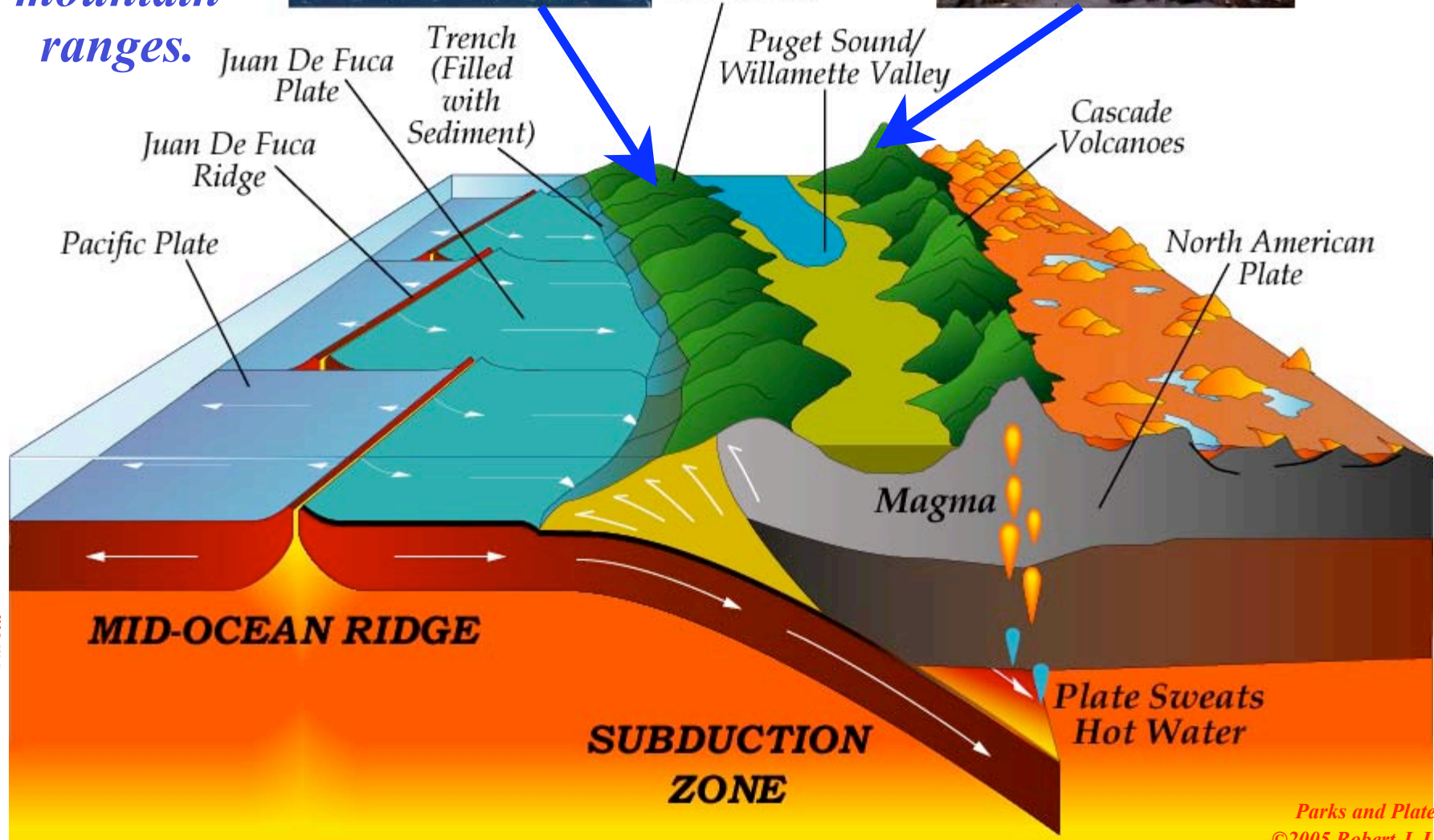
*Puget Sound and the Willamette Valley are low-lying regions between the rising mountains.*



*National Parks represent the two different mountain ranges.*



Olympic and other Coastal Mountains



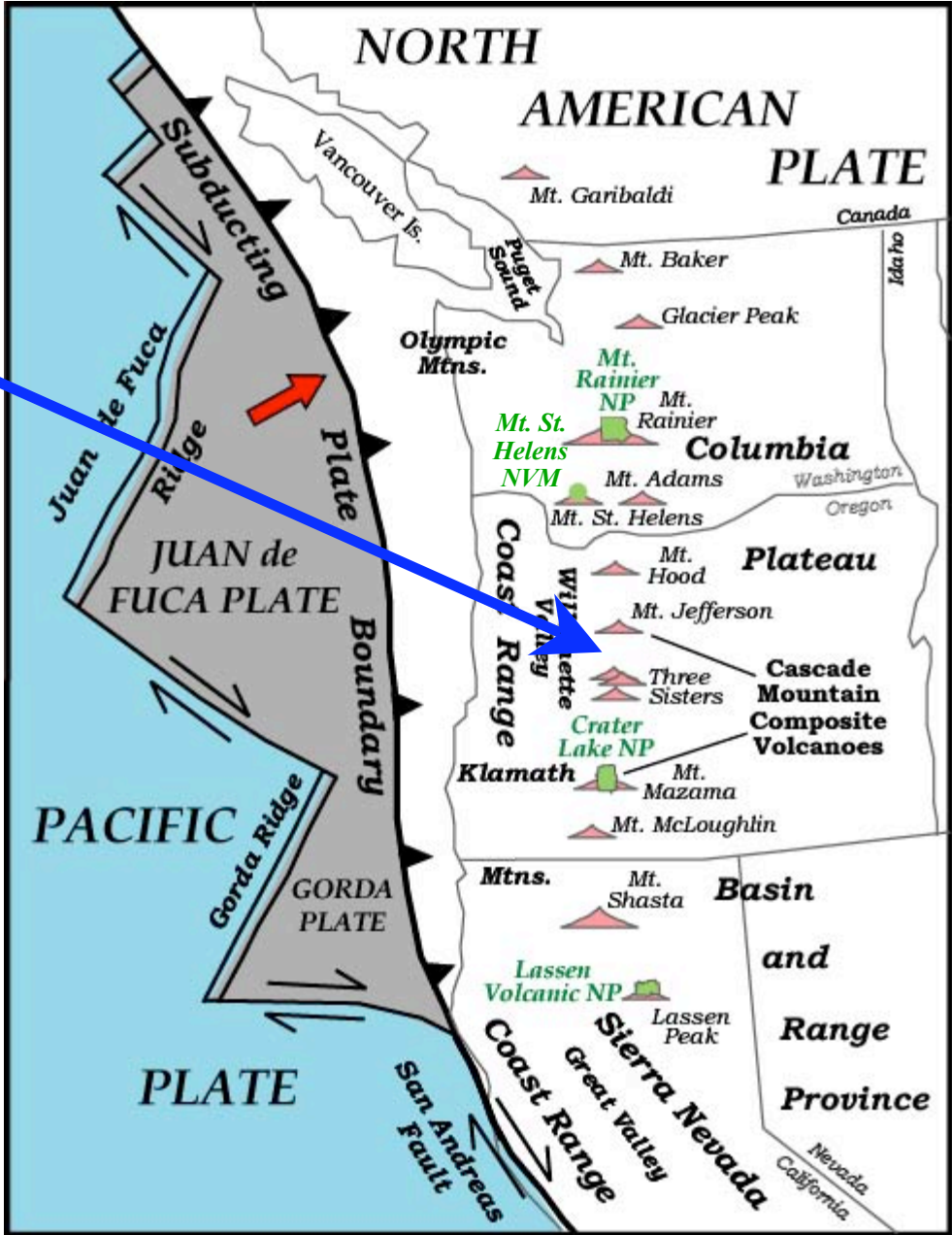
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Bernard Garcia



*Cascade  
Volcanoes*

*Parks in the Cascades  
showcase volcanoes  
formed above the  
sweating plate.*

**National Park Lands in  
Active Volcanic Arc**



# Cascade Mountains, Central Oregon

View looking North





The exhibit was developed by the Oregon Historical Society, in collaboration with the Oregon State University Department of Geosciences, Oregon Department of Geology and Mineral Industries, Oregon Paleo Lands Institute, OSU Hatfield Marine Science Center, Portland State University, and the Oregon Department of Energy.

EXHIBIT CONTENT

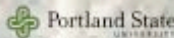
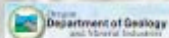
Robert J. Lillie, Jason Kenworthy, and Shan de Silva  
Oregon State University, Department of Geosciences

Ellen Morris Bishop  
Oregon Paleo Lands Institute

James Roddey  
Oregon Department of Geology and Mineral Industries

Nancee Hunter  
Oregon Sea Grant-OSU Hatfield Marine Science Center

Scott Burns  
Portland State University Department of Geology



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Oregon State University College of Science  
Oregon State University Advancement Office

We thank Raven Map and Design for permission to use their digital elevation map of Oregon in various places throughout the exhibit.

Digging  
Deeper

FOR MORE INFORMATION ON THESE TOPICS PLEASE VISIT

[www.ohs.org](http://www.ohs.org)

# OREGON

*150 Years of  
Statehood;  
150 Million Years  
in the Making*

EXHIBIT AT  
OREGON'S STATE CAPITOL  
BUILDING, SALEM  
*Monday - Friday  
8am - 5pm*

## State Capitol Geology Exhibits

- Jan, 2009 - Jan, 2011
- Oregon's Geology and how it relates to natural and cultural history

<http://www.ohs.org/exhibits/traveling-exhibits/oregon-150-years-of-statehood-150-million-years-in-the-making.cfm>

<http://www.oregongeology.org/sub/pub&data/capitol-windows.htm>

<http://oregonstate.edu/leadership/presidentsreport/2008/winter/assembling-oregon>

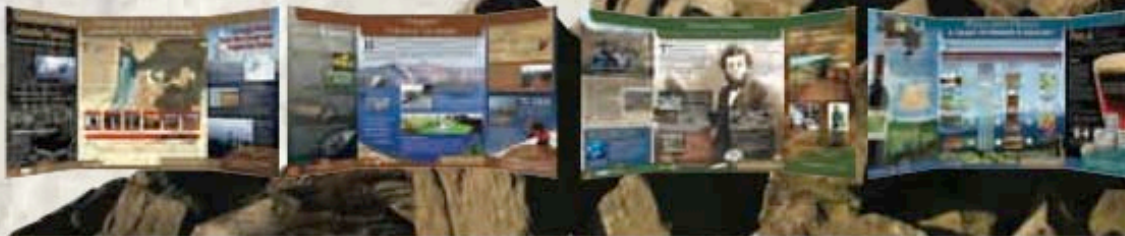


## EXHIBIT AT OREGON'S STATE CAPITOL BUILDING, SALEM

**G**eological processes shape Oregon's landscape and affect our natural and cultural history. The exhibit in the Galleria of the State Capitol building in Salem illustrates how Oregon's spectacular mountains, valleys, and coastlines develop. They show that, like the Capitol, Oregon's geological landscape plays a major role in the state's economy, culture, and history. Oregon celebrates its 150th anniversary in 2009 – and Oregon's landscape has been forming for a million times as long! The most iconic of Oregon's landscapes – Crater Lake, Multnomah Falls, Newberry Crater, Steens Mountain, the Painted Hills, and so much more – display Oregon's geologic splendor.

The exhibit opens in Oregon's sesquicentennial year, 2009, and closes in 2010, at the end of the legislative biennium – taking Oregonians to the next 150 years of statehood and 150 million years of continued landscape development.

TOPIC AND NUMBER	WINDOW TITLE
<b>Assembling Oregon</b>	1 Oregon: 150 Years of Statehood; 150 Million Years in the Making
	2 The Assembly Continues: Cascadia Subduction Zone
	3 Flowing Rock and Water: Columbia Plateau – Columbia Gorge
	4 Oregon Stretches Out: Basin and Range Province
<b>Volcanoes of Oregon</b>	5 Oregon's Volcanic Wonderland
	6 Oregon's Volcanic Heritage
	7 Taking the Pulse of Oregon's Volcanoes
	8 Oregon's Natural Volcanic Laboratory
<b>Geological Resources</b>	9 Oregon's Foundation: Rocks and Minerals
	10 Thomas Condon: Establishing a Foundation for Oregon's Geoscientists Today
	11 Oregon's Fossils: Citizens of the Past
	12 Oregon's Energy Future
<b>Geology and People</b>	13 Oregon on Shaky Ground: Earthquakes and Landslides
	14 Oregon's Tsunami Hazard Zone
	15 Changing Climate: Oregon's 55 Million Year Record
	16 Pints and Pinots: A Toast to Oregon Geology!



# State Capitol Geology Exhibits

- Jan, 2009 - Jan, 2011
- Oregon's Geology and how it relates to natural and cultural history

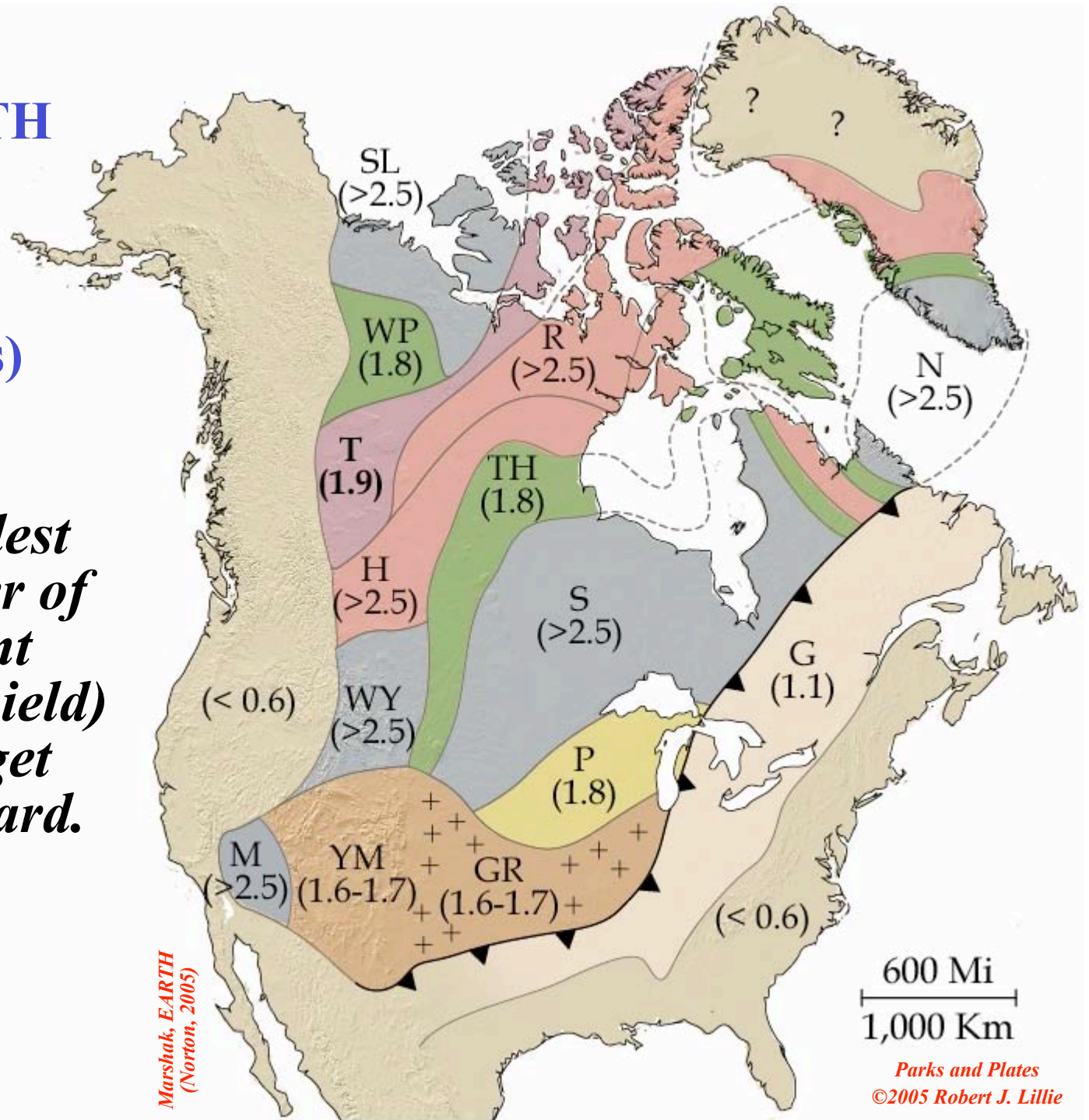
<http://www.ohs.org/exhibits/traveling-exhibits/oregon-150-years-of-statehood-150-million-years-in-the-making.cfm>

<http://www.oregongeology.org/sub/pub&data/capitol-windows.htm>

<http://oregonstate.edu/leadership/presidentsreport/2008/winter/assembling-oregon>

# AGE OF NORTH AMERICAN BASEMENT ROCKS (Billions Years)

*Rocks are oldest near the center of the continent (continental shield) and tend to get younger outward.*

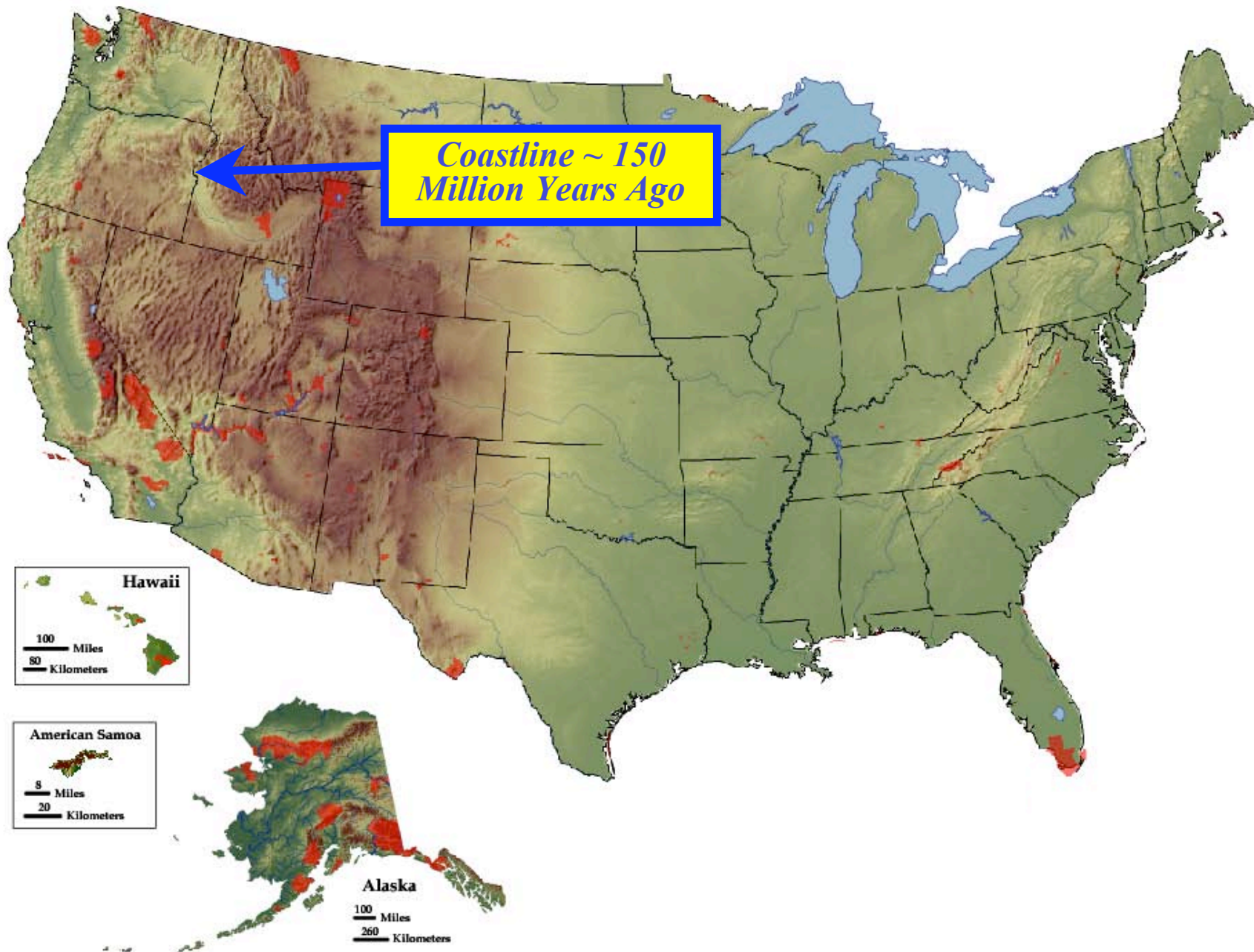


Marshak, EARTH  
(Norton, 2005)

600 Mi  
1,000 Km

Parks and Plates  
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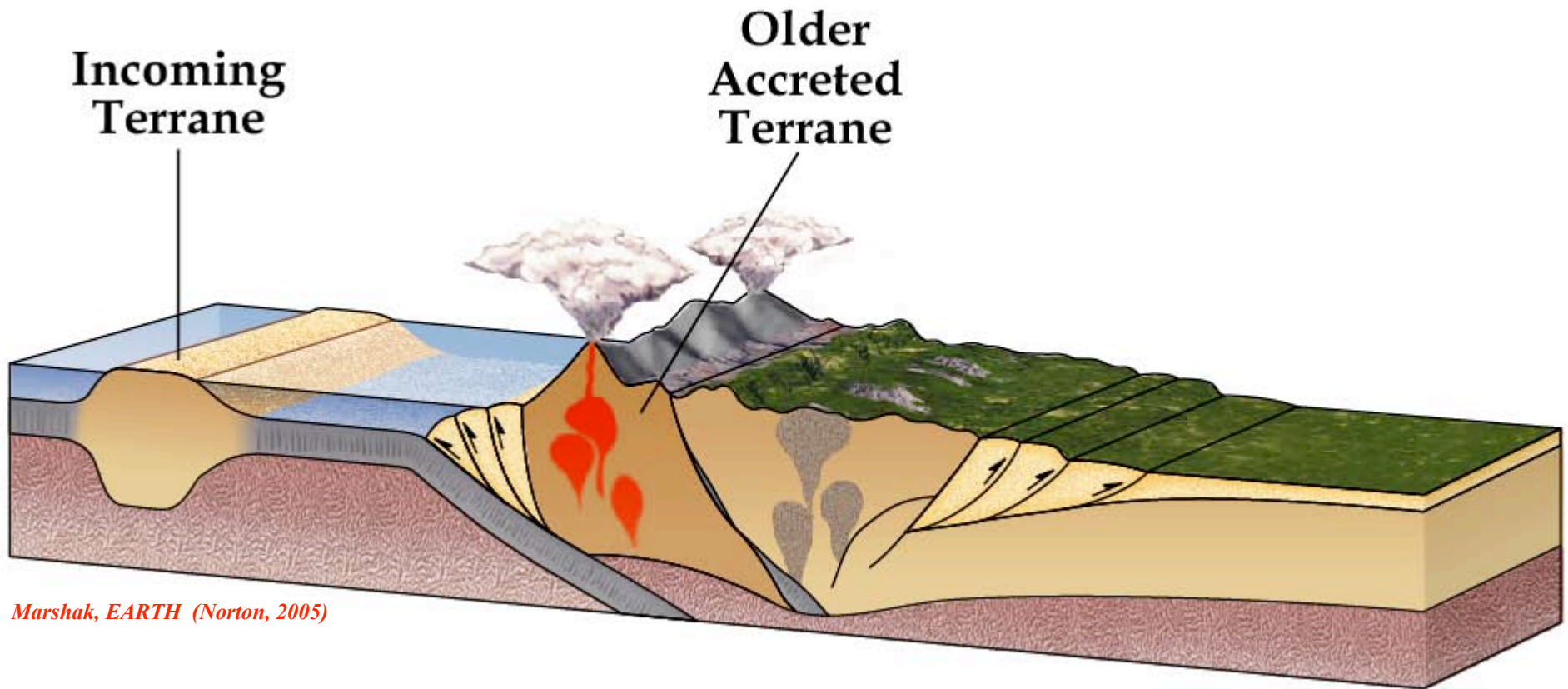






# Terrane Accretion

*A TERRANE consists of crust that is too thick and buoyant to subduct. The continent grows outward as terranes come crashing in.*



*Marshak, EARTH (Norton, 2005)*

# Safeway Terrane Accretion ☺

**Forth  
Terrane**

**Third Terrane**

**Second  
Terrane**

**Ocean  
Plate**

**First Terrane**

**North American  
Plate**



**Second  
Terrane**

**First Terrane**



**Ocean Plate**





Ocean Plate



**Third Terrane**



**Ocean Plate**

*Robert J. Lillie*





**Fourth  
Terrane**



**Ocean Plate**





Ocean Plate

Fourth Terrane

Third Terrane

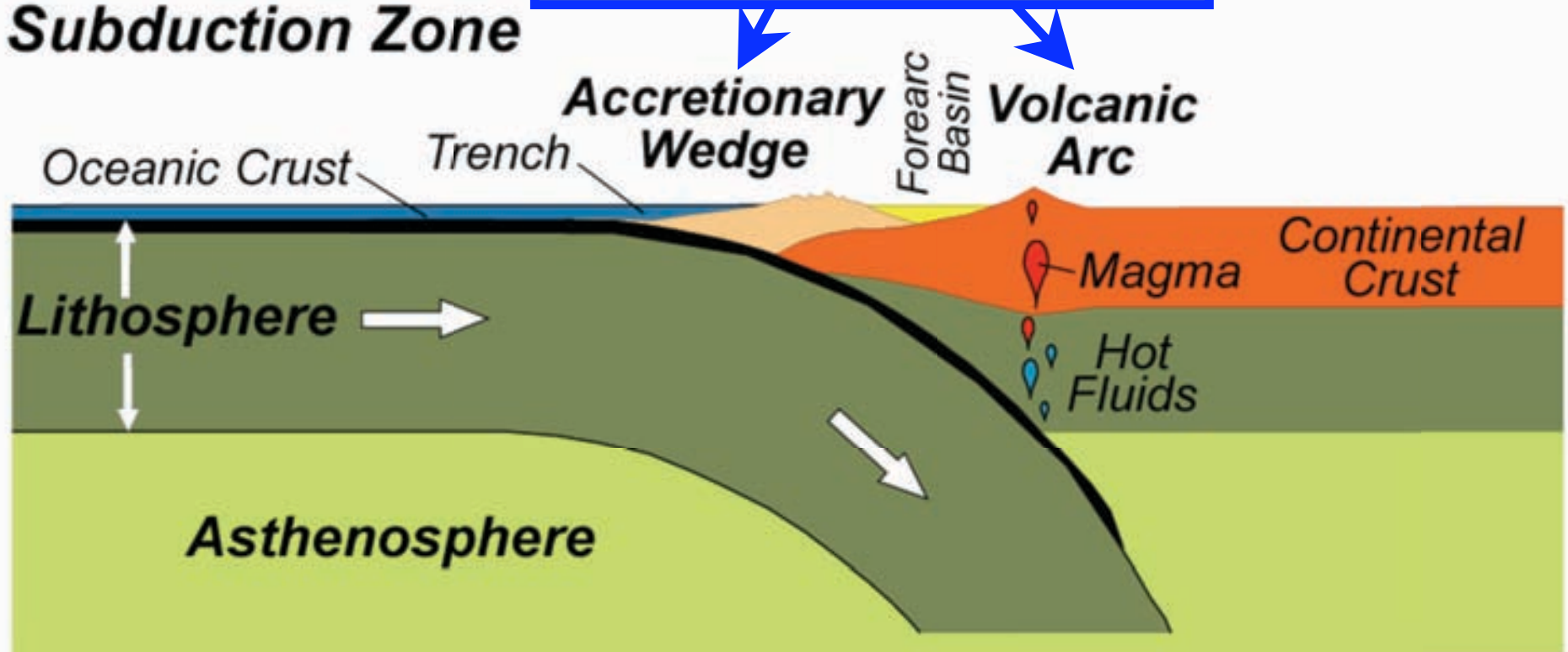
Second Terrane

First Terrane

North American Plate

# *Two Parallel Mountain Ranges*

## **Subduction Zone**







**Basalt Lava Flows**

- **Manufactured in Ocean Realm**
- **About 35 million years ago**

***Cape Perpetua Scenic Area, Oregon***