Mountain/Desert Field Trip Orientation

What to Bring

- Layered clothing
  - Cool to cold morning and evening
  - Warm mid day
  - Sturdy walking shoes
    - No sandals or high heels
- Sleeping bag, pad and optional tent
  - Water bottle, Flash light, sunscreen, personal toiletries, medications
- Field book, pencils, eraser, ruler, observation skills
  - Record/Discuss important observation & questions at each stop
  - Turned in at end of weekend – no exceptions

Note: today's exercise will get you started on information needed for your field book – bring today's lab questions and answers on Weekend Trip!

Geology Field Stops

PRB Geology Stop 1

- **Sunrise Highway Plutonic rocks of the Western PRB – Granites and gabbros**

PRB Geology Stop 2

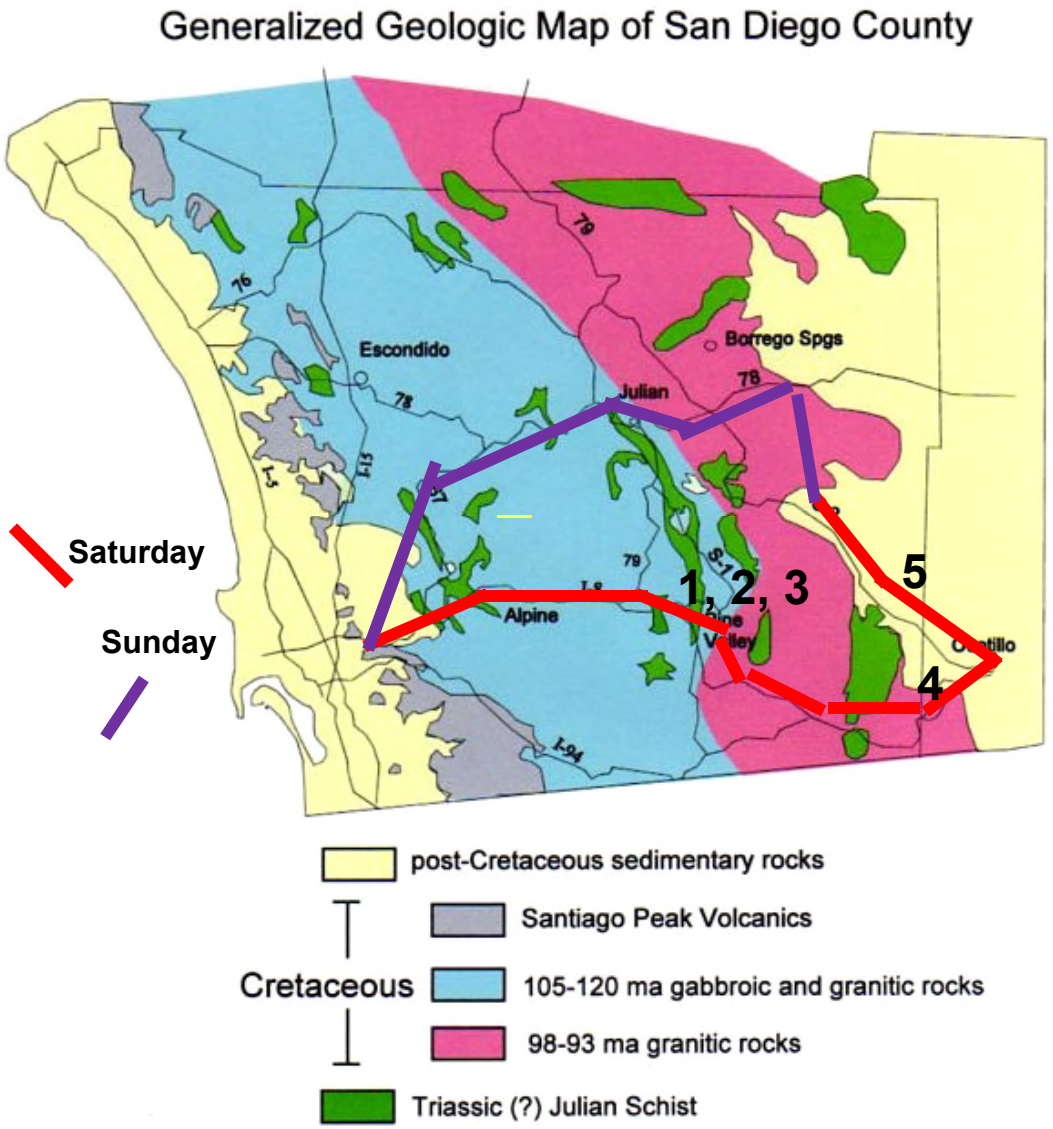
- **Desert Tower- Plutonic rocks of the Eastern PRB – the La Posta pluton; and Salton Trough tectonics**

Desert Geology Stop 1

- ✓ Canyon Sin Nombre – Basement igneous and metamorphic rocks; young sedimentary rock cover; and Elsinore fault zone

Desert Geology Stop 2

- ✓ Anza Borrego Museum Summary, all rock types; mountain and desert landforms; tectonics



Tectonic History of the Western Margin of North America

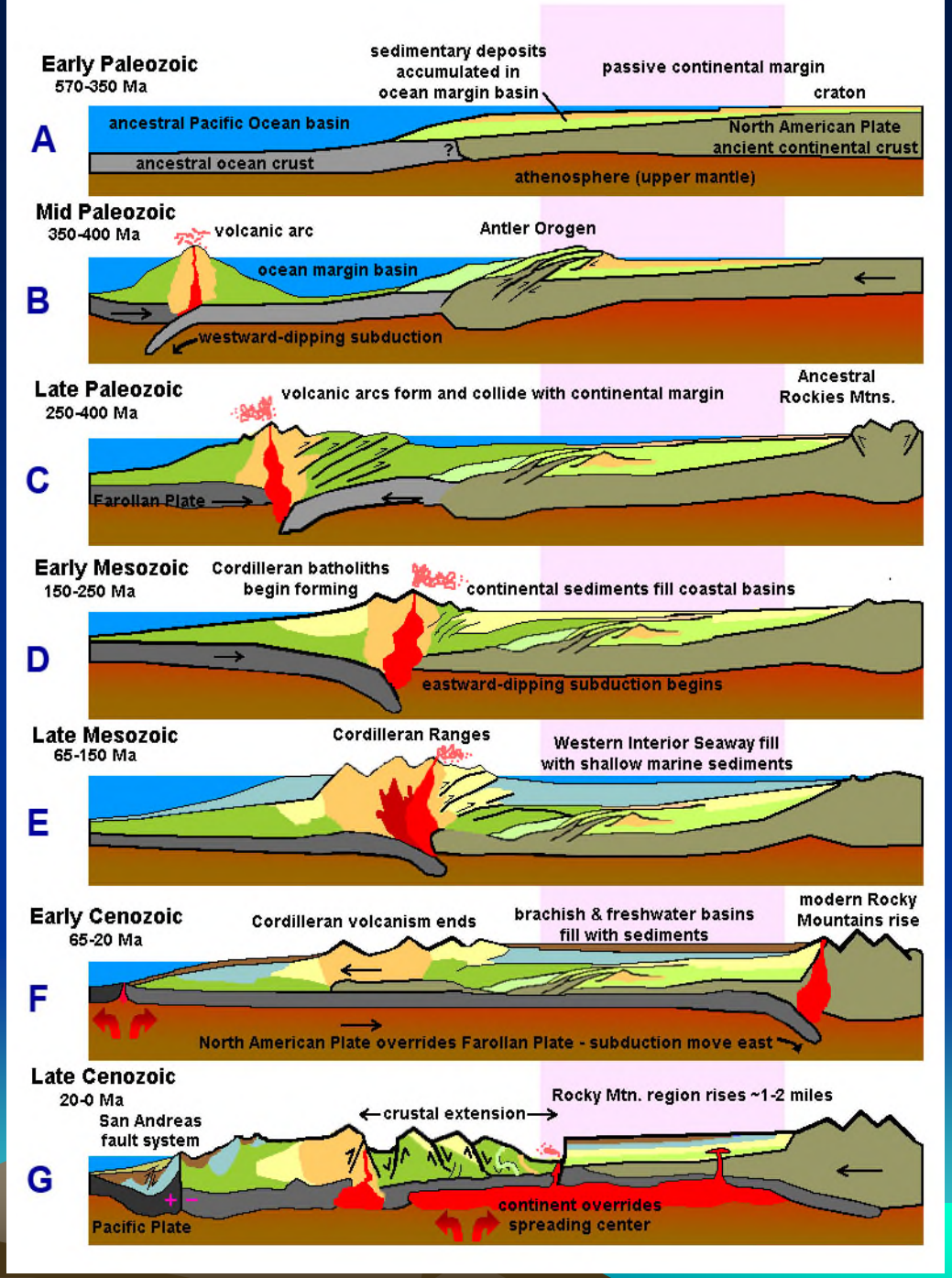
Four Stages of Tectonic Evolution of Southern California

1) Passive Margin (600 - 200ma)

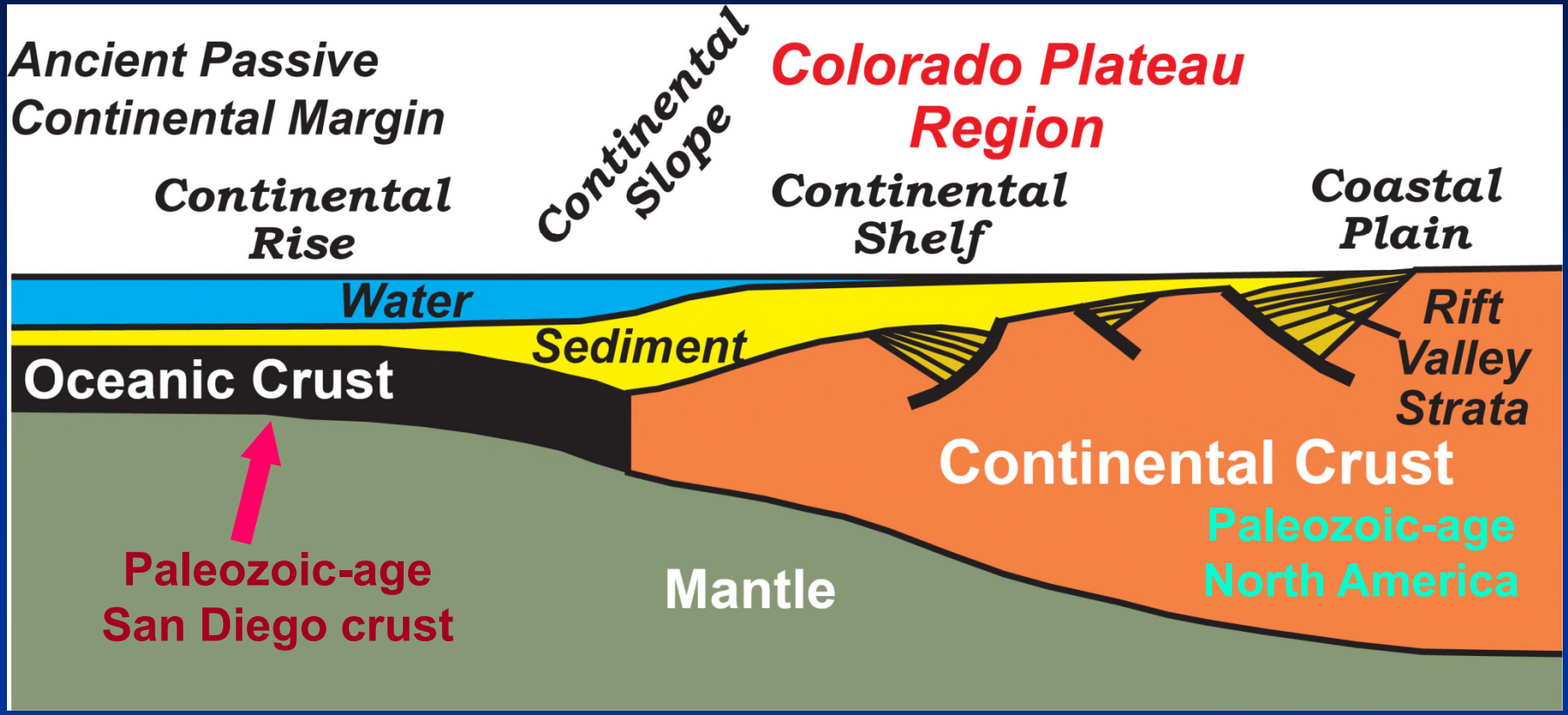
2) Subduction (200 - 30ma)
   - Part 1 – Island magmatic arc
   - Part II – Continental margin magmatic arc

3) Extension (30 -10ma)

4) Transform (10ma - today)



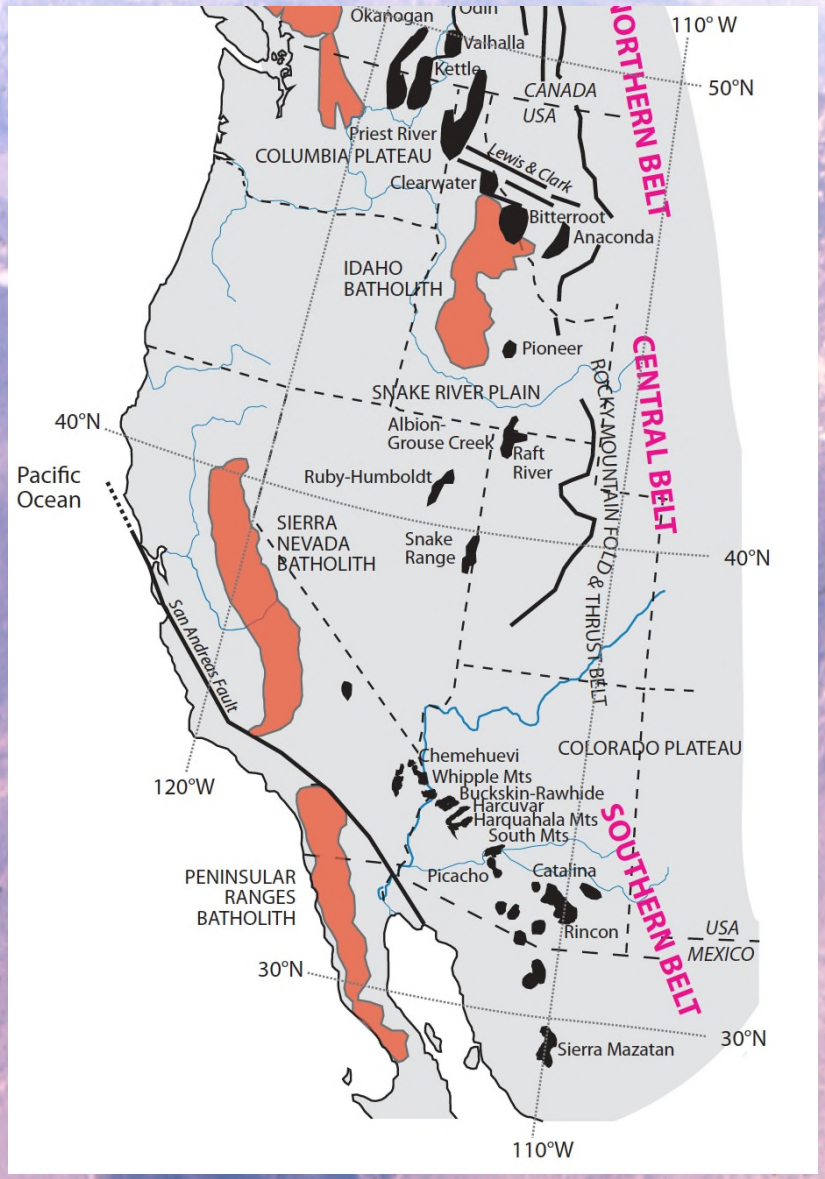
Passive Margin Stage



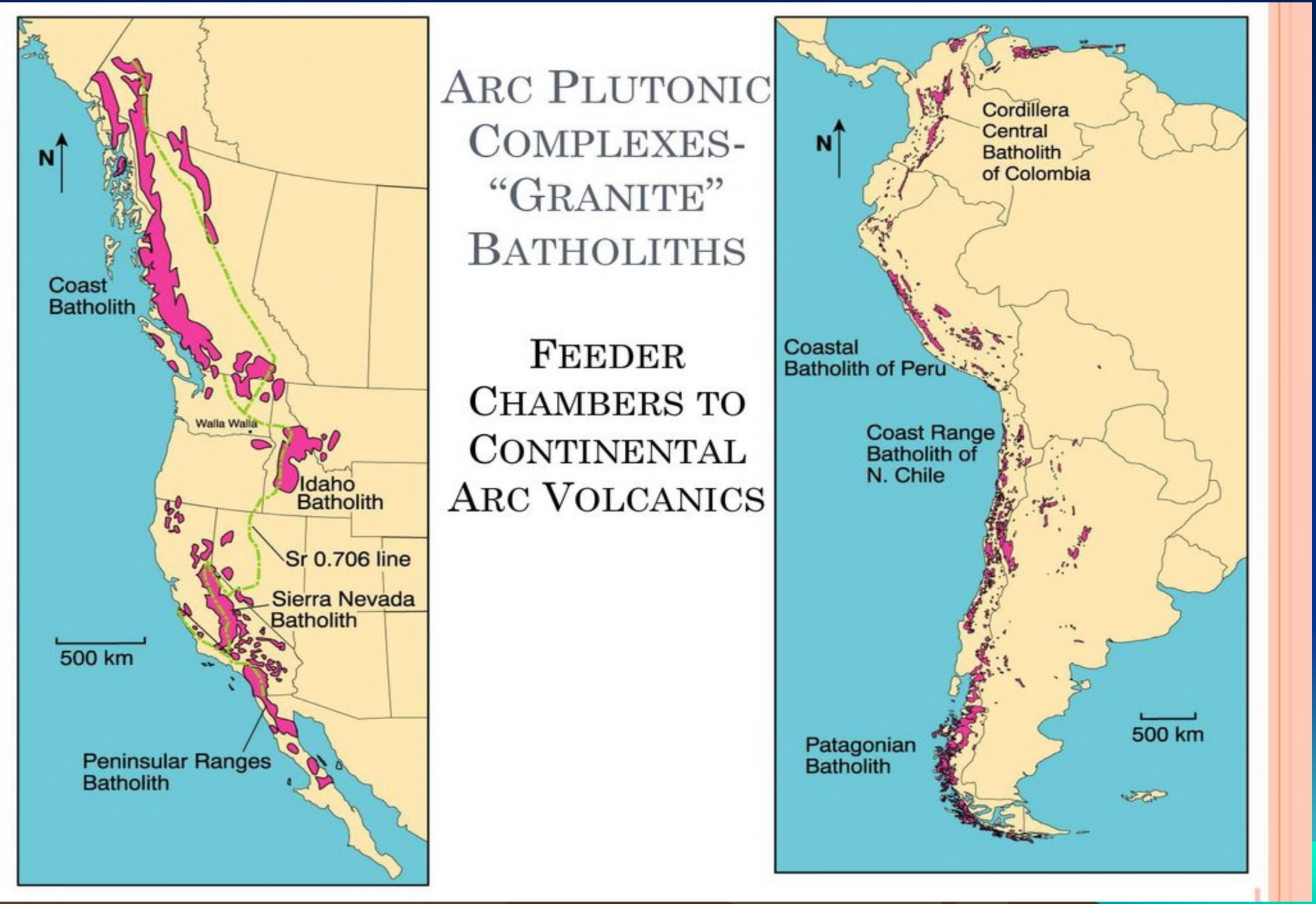
San Diego was originally a part of the thin, deep-sea, basaltic oceanic crust that fringed the western edge of North American continent during the Paleozoic era between 600 and 200 million years ago. This would be the site of future subduction

The Peninsular Range Batholith:

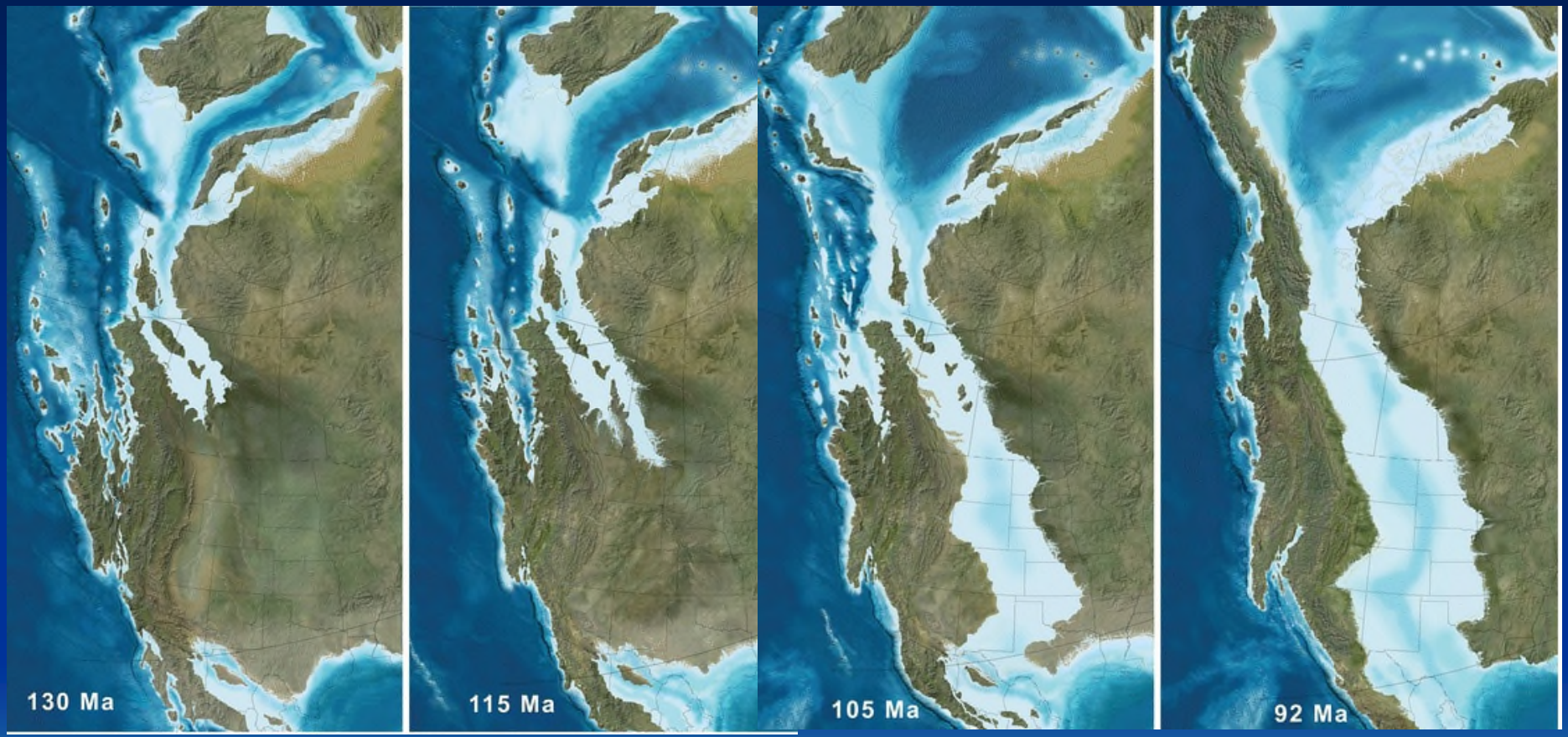
A Mesozoic-age Plutonic-Metamorphic Complex



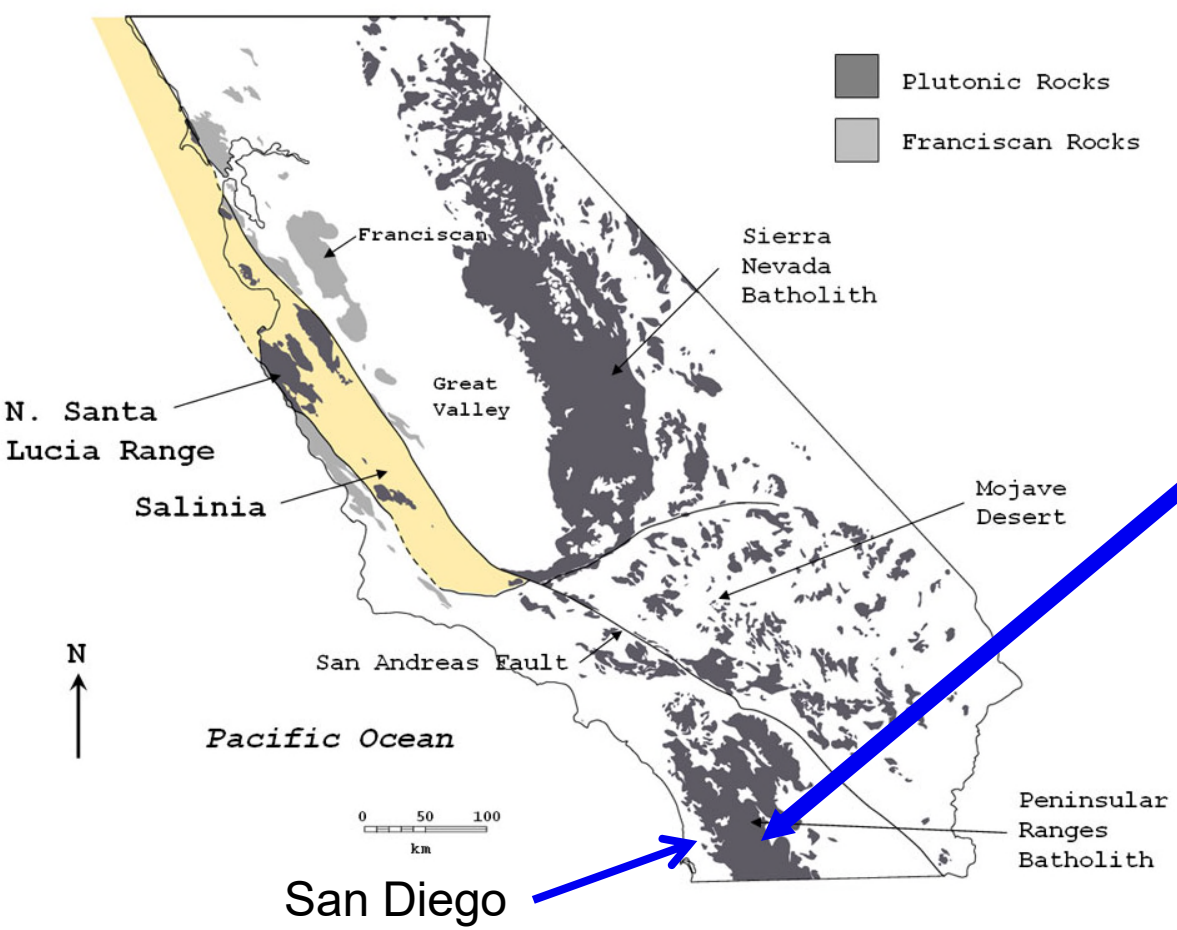
Cordilleran Batholiths of the Americas Roots of Subduction-Zone Volcanic Arcs



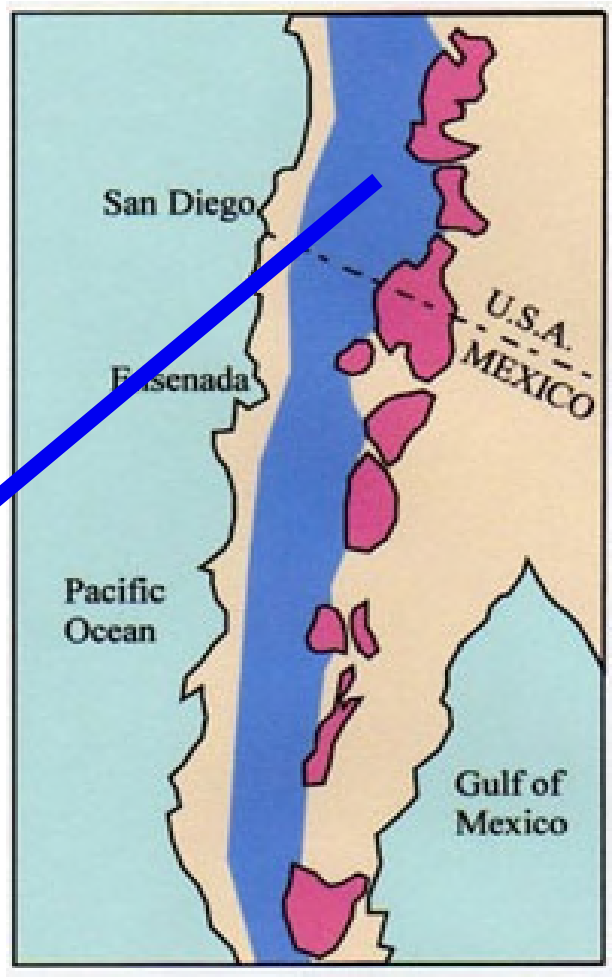
Tectonic History of the Western Margin of North America



Location of Peninsular Ranges Batholith (PRB)



Map of California

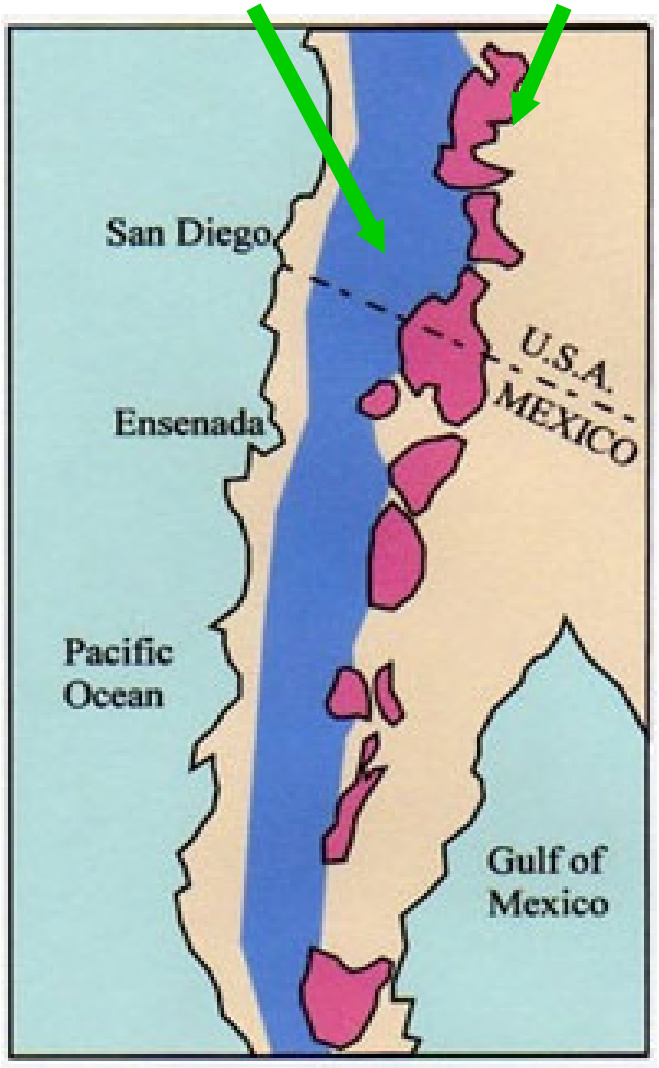


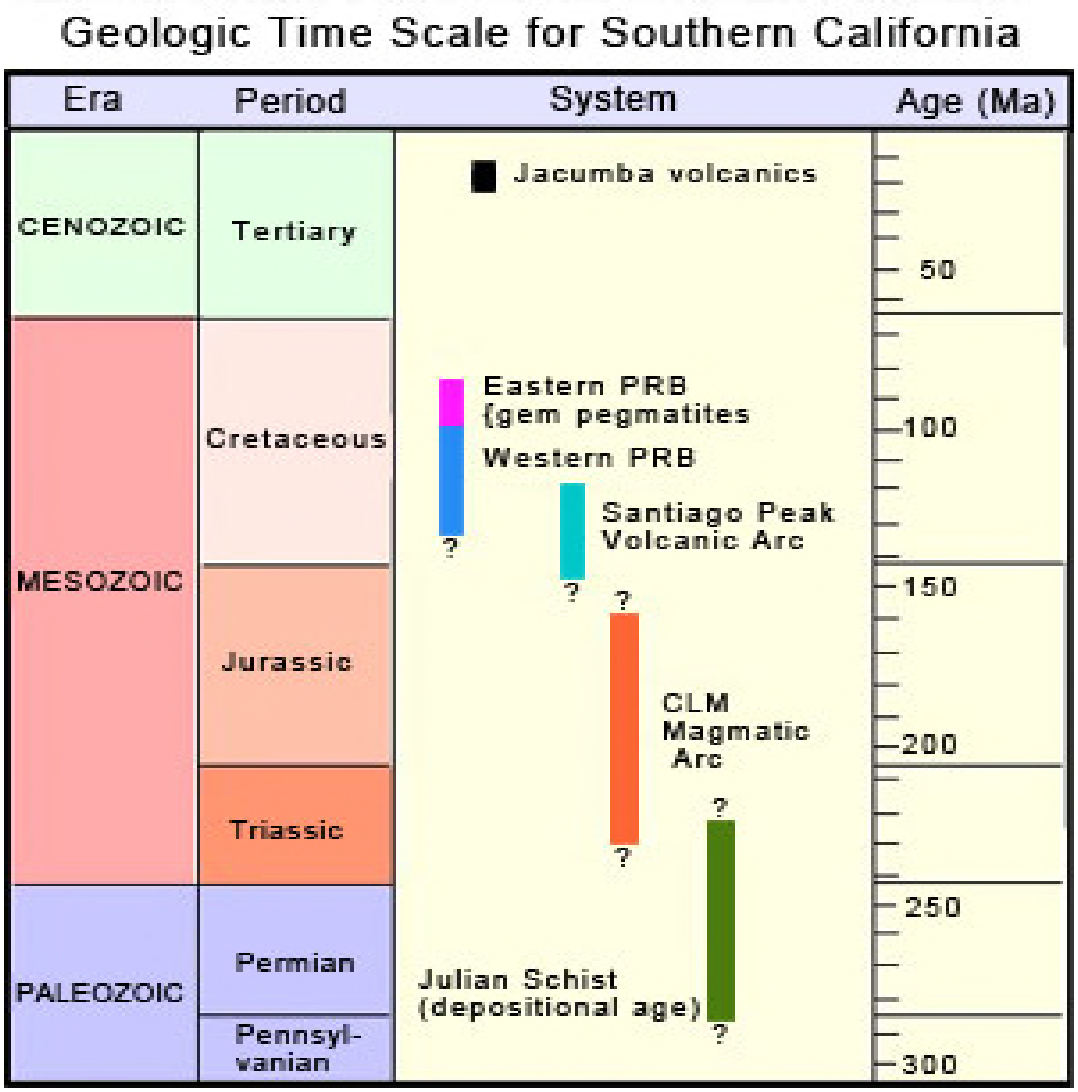
Western and Eastern PBR

Peninsular Ranges Batholith (PRB)

Divided into Two Longitudinal Plutonic Zones:

Western and Eastern



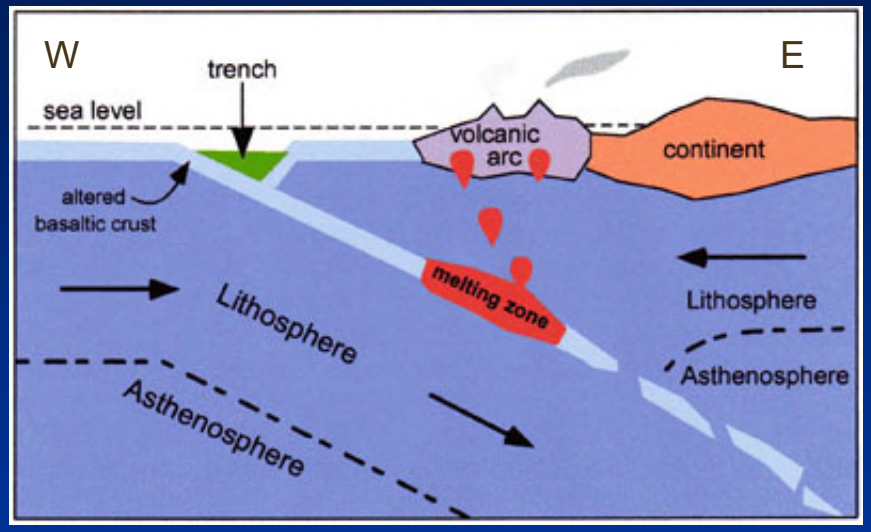


Age Differences

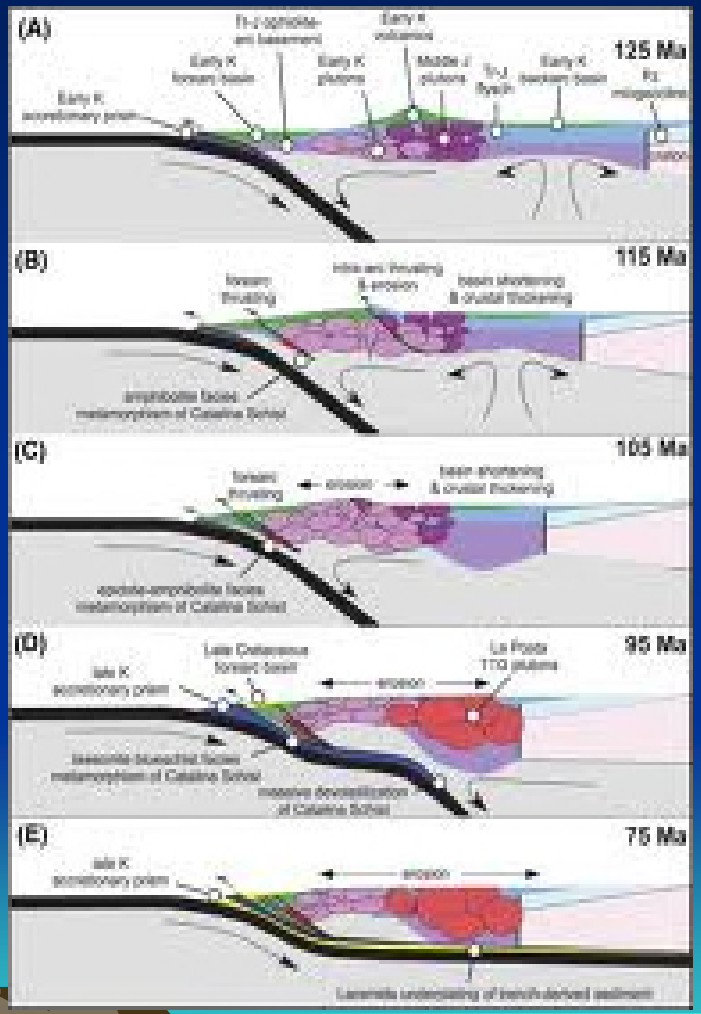
Peninsular Range Batholith - Cretaceous Subduction

Two Periods of PRB-forming Subduction

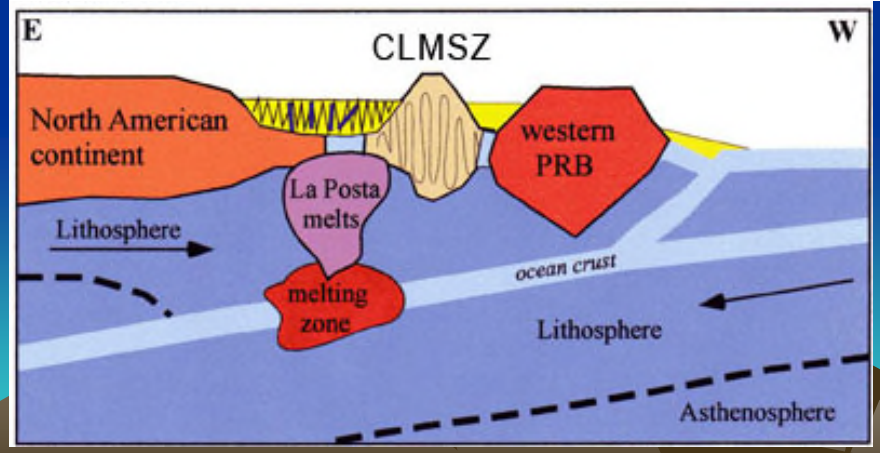
Older Western Fringing Island Arc - (A) through (C)



140-100 Ma



Younger Eastern Continental Margin Arc - (D)

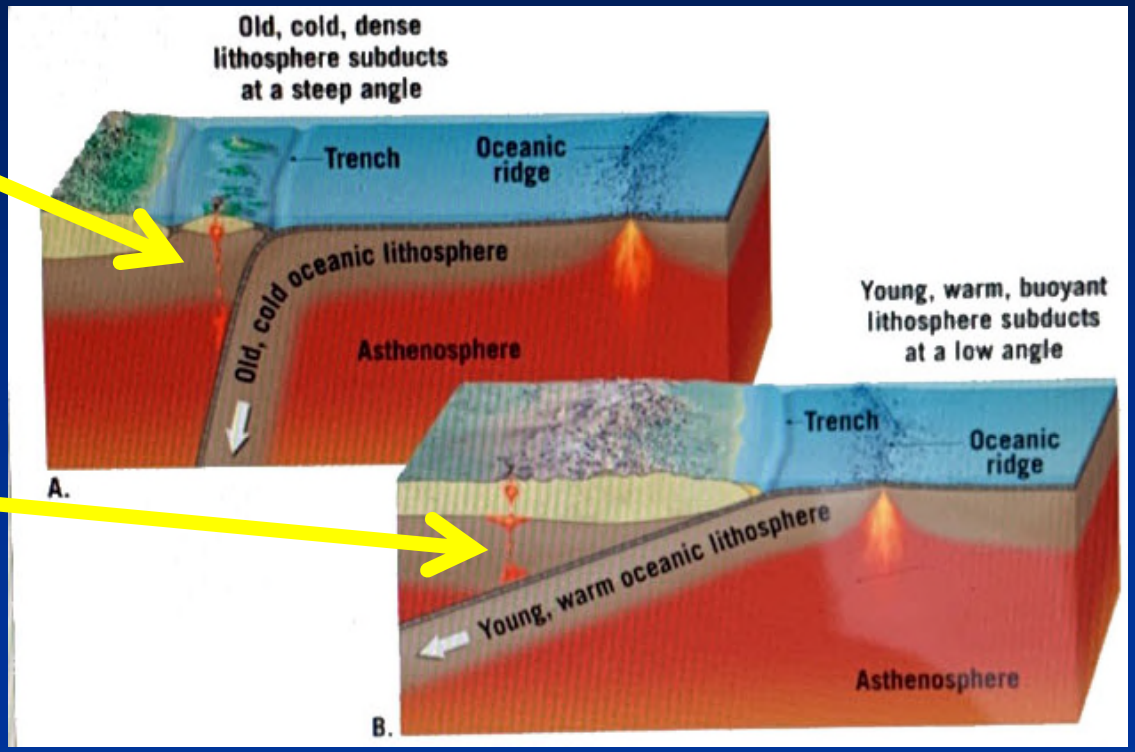


100-80 Ma

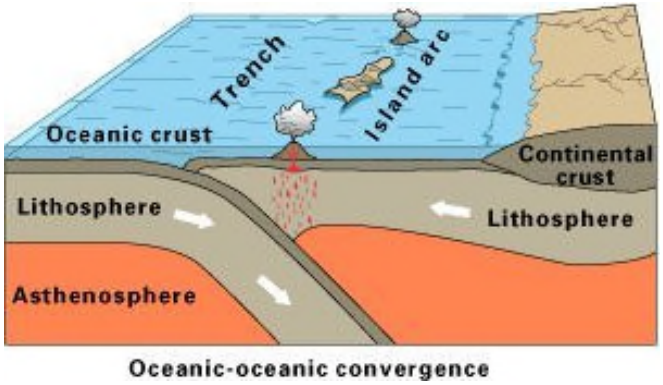
Evolution of the PRB Subduction System: A Shallowing of Subduction Angle

The older island arc (western zone of PRB) had a steep subduction angle

The younger continental margin arc (eastern zone of PRB) had a more gradual subduction angle



The Western Plutonic Zone of the PRB



Oceanic-oceanic convergence

Western Zone Characteristics:

Tectonic Setting: *Fringing Island Arc – oceanic-oceanic subduction system close to edge of Western NA continent (west of Sonora, Mex)*

Plutonic Rock Types: *Tonalite, Diorite, Granodiorite and Granite; Lots of gabbro; Most rocks contain magnetite*

Ages: *140 to 100 Million Years*

Type of Host Crust for Emplacement:

Oceanic crust

Depth of Pluton Emplacement:

1 to 8 km depth

Western PRB Petrology:

Felsic/Silicic, Intermediate, and Mafic Plutonic and Volcanic

Granite

Granodiorite

Tonalite

Diorite

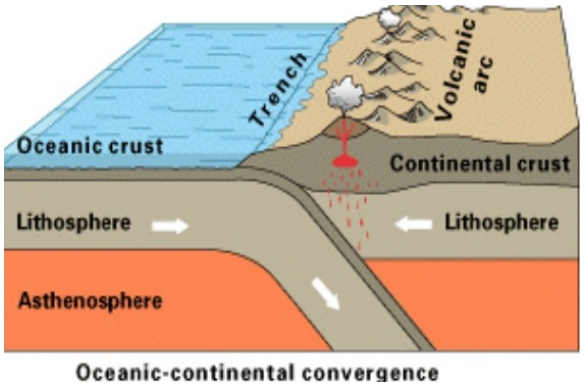
Gabbro

Most Common Petrology = Tonalite composition:

Lots of plagioclase (50%) and quartz (25%) ; a little K-spar (5%); with accessory mafic minerals of hornblende and/or biotite (20%)

Western PRB rocks contain magnetite

The Eastern Zone of the PRB



Oceanic-continental convergence

Eastern Zone Characteristics:

Tectonic Setting: *Continental Margin Arc – oceanic-continental subduction system in edge of Western NA continent*

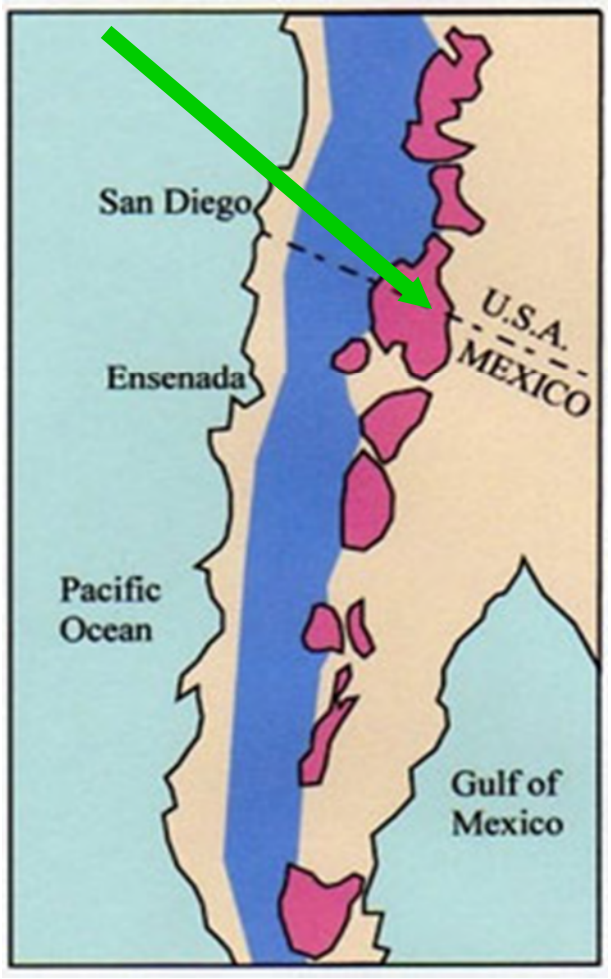
Rock Types: *Tonalite, Granodiorite and Granite; Little to no gabbro; No magnetite*

Ages: *100 to 80 Million Years*

Type of Host Crust for Emplacement:

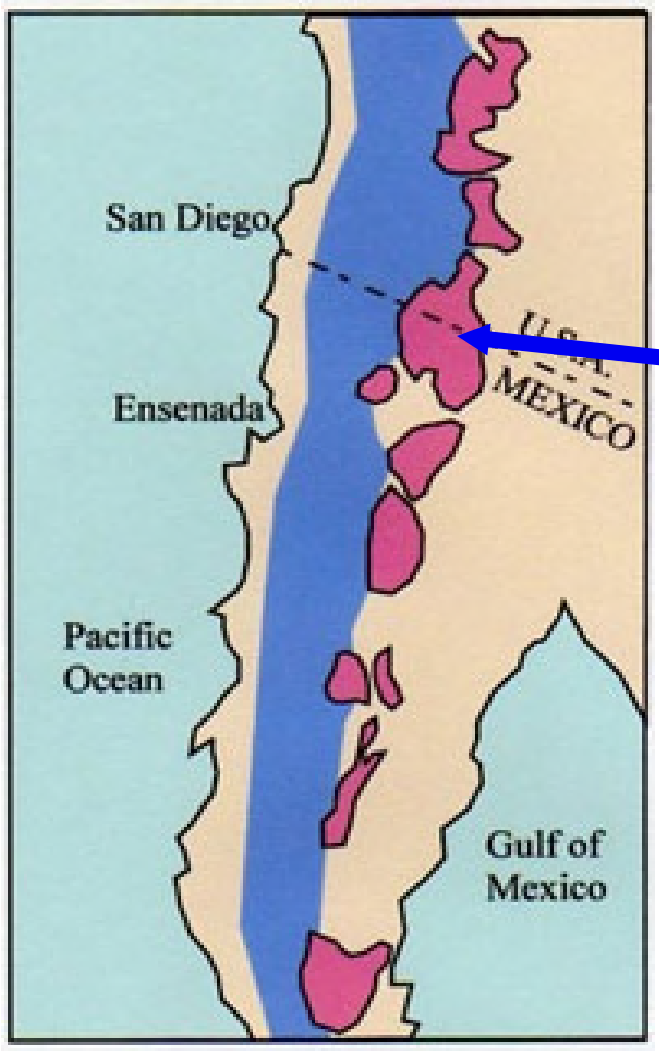
Marginal continental crust

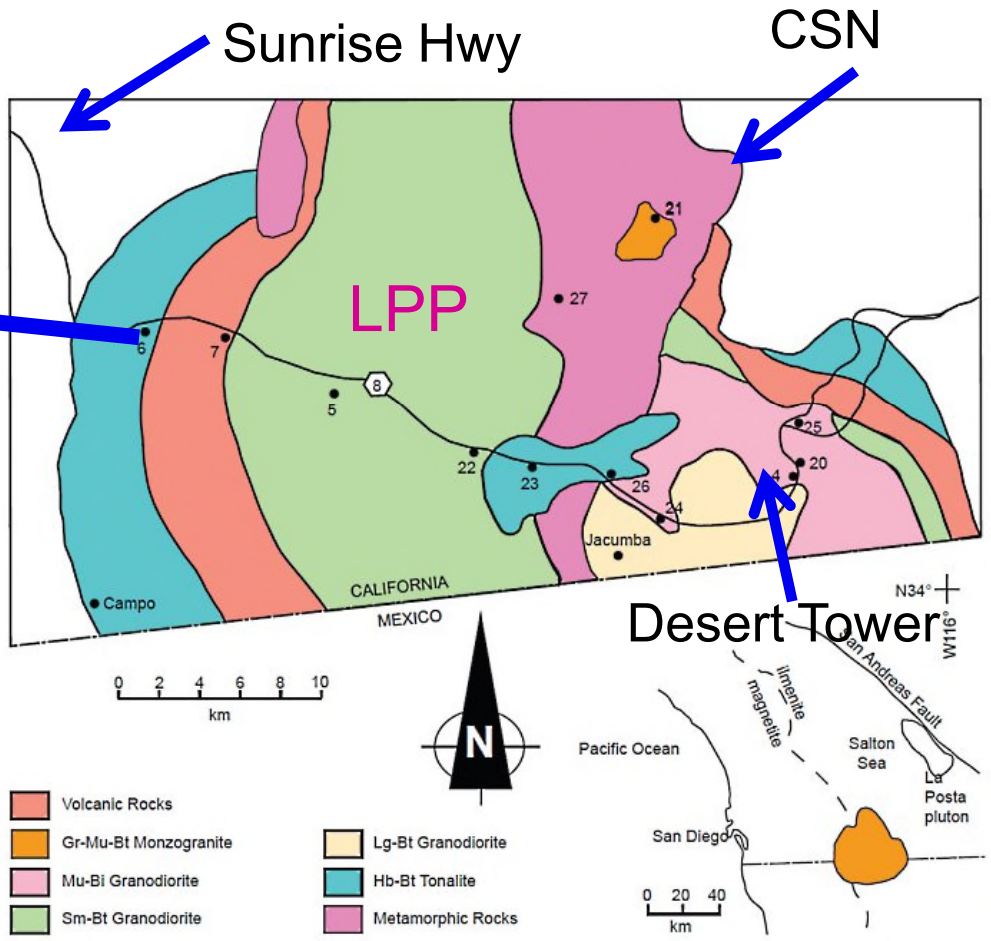
Depth of Pluton Emplacement: *6 to 18 km depth*



La Post Pluton – Eastern Zone Pluton

Extremely Large, Zoned, Granodiorite Body





Eastern PRB Petrology:

Felsic/Silicic, Intermediate, and Mafic Plutonic and Volcanic

Granite

Granodiorite

Tonalite

Most Common Petrology = Granodiorite composition:

Lots of plagioclase (45%) and quartz (30%) ; a little K-spar (15%); with accessory mafic minerals of biotite with hornblende or muscovite (10%)

Eastern PRB rocks do not contain magnetite

Pre-Batholithic Metamorphic Rocks of the PRB

Meta Rock Types:
1) Schist, 2) Quartzite, 3) Gneiss, 4) Marble, and 5) Amphibolite

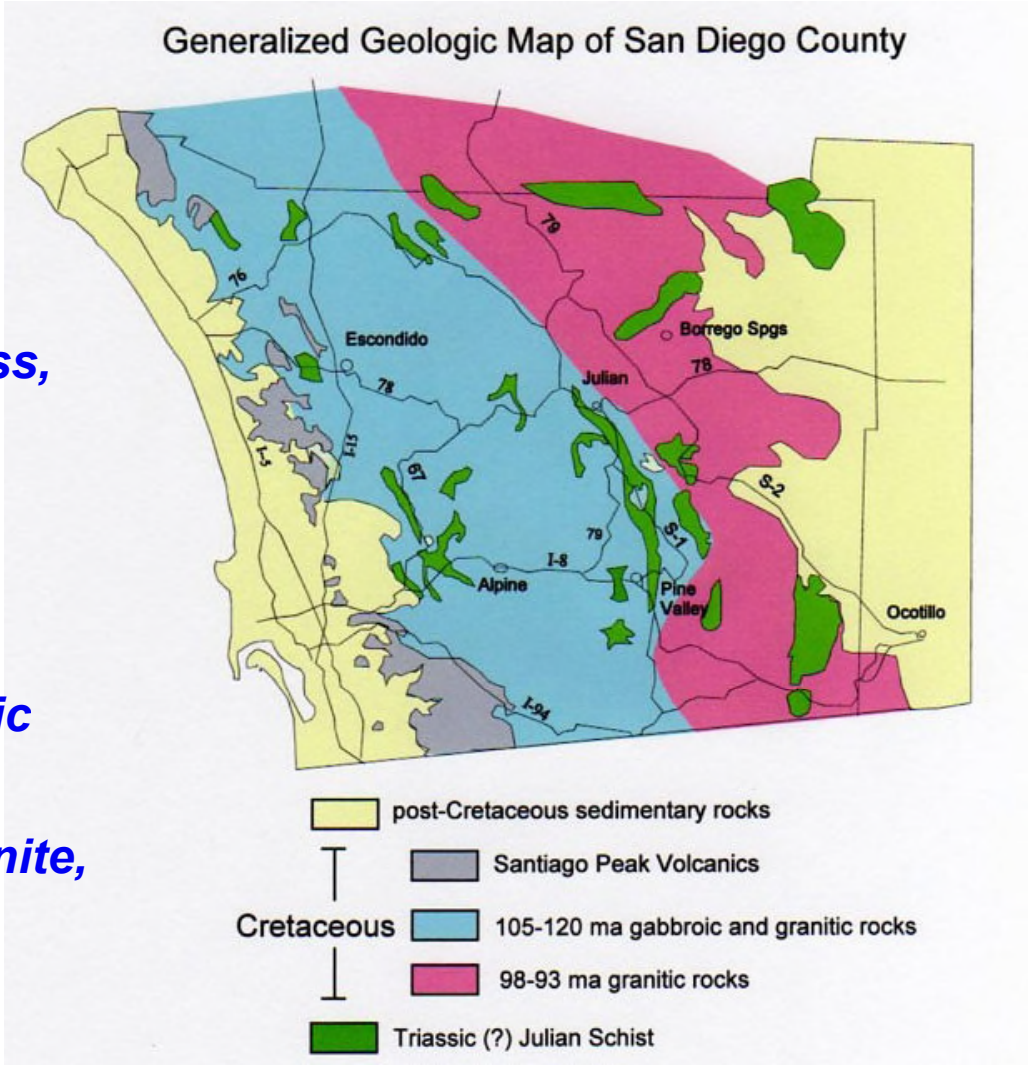
Ages of Metamorphism:
120 to 90 Ma

Types of Metamorphism:
Regional, Contact and Dynamic

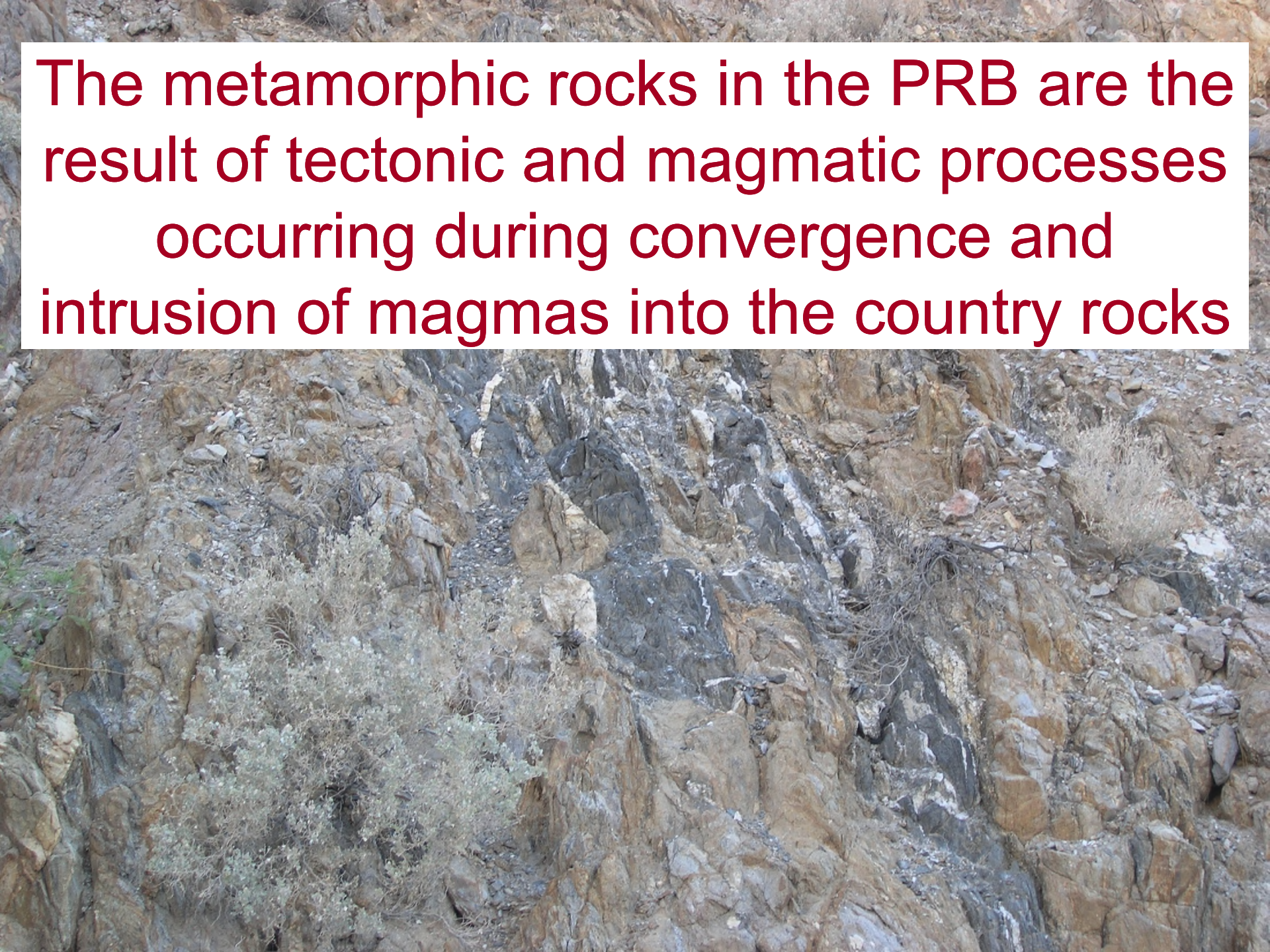
Meta Parent Rock Types:
1) Shale, 2) Sandstone, 3) Granite, 4) Limestone, and 5) Basalt

Age of Parent Rocks:
400 to 100 Ma

Tectonic Provenence of Parent Rocks:
Continental margin and fringing ocean seafloor



Pre-batholithic-protolith metamorphic rocks shown in green on map


The metamorphic rocks in the PRB are the result of tectonic and magmatic processes occurring during convergence and intrusion of magmas into the country rocks

Metamorphic Basement Rocks of the PRB

Foliated, Amphibolite-grade, Meta-sedimentary and -igneous

Gneiss

Mudstone or granite protolith

Schist

Mudstone protolith

Quartzite

Quartz sandstone protolith

Marble

Limestone protolith

Amphibolite

Basalt or gabbro protolith

Most Common Petrology = Schist - Granitic composition: *Lots of feldspar and (50%) and quartz (35%); with appreciable amounts of mica (biotite and muscovite) (15%) +/- garnet*

Protoliths consisted of continentally-derived sediments and pelagic sediments along edge of continent lying on oceanic crust

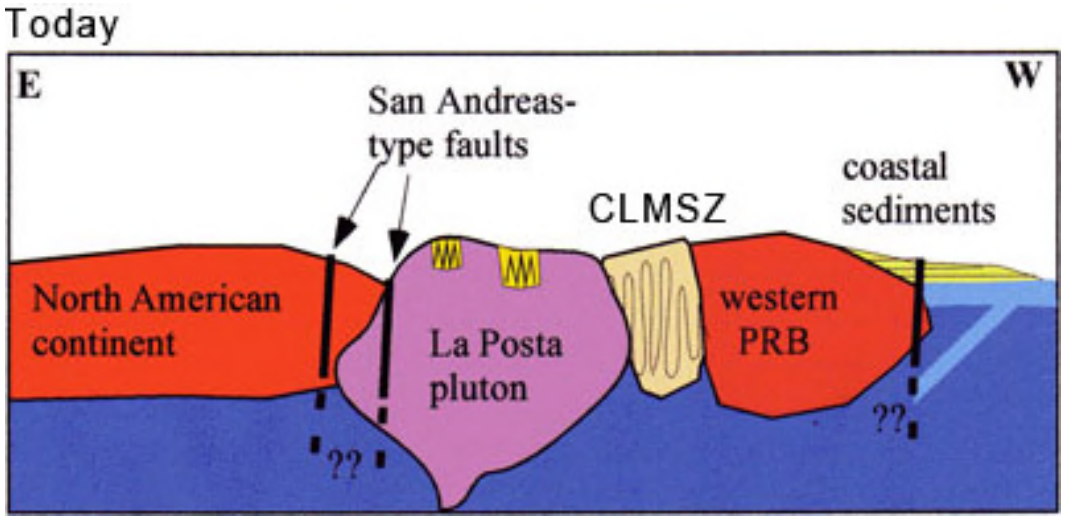
Peninsular Range Batholith Post-Subduction Stages

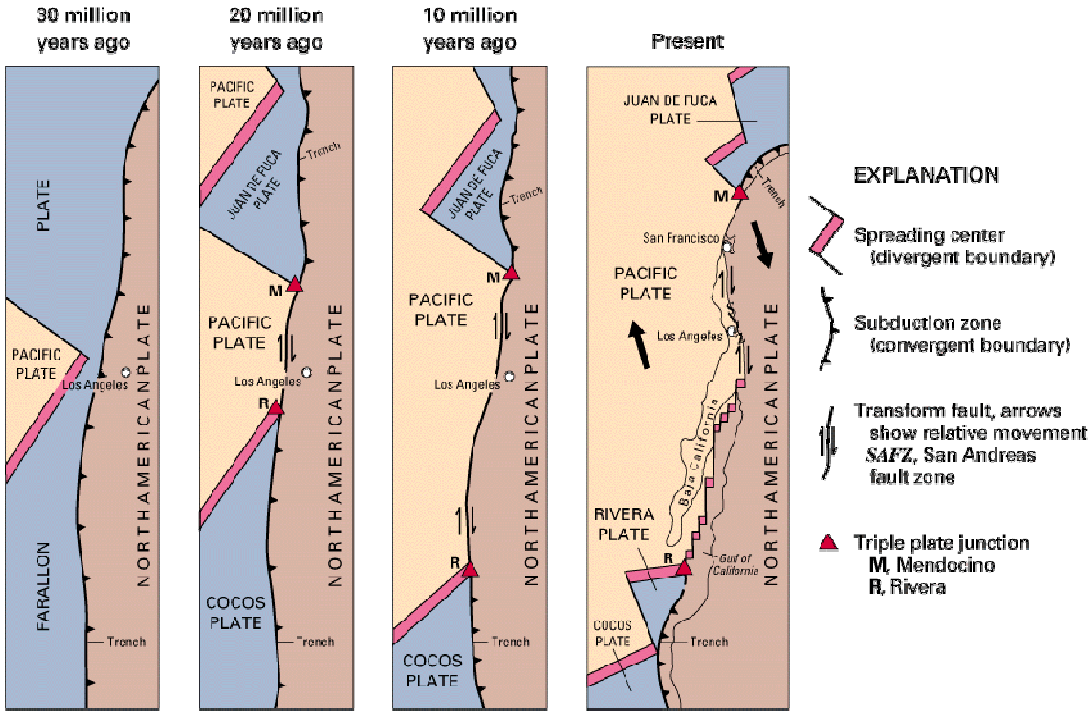
1) Extensional Period – 30-10 Ma

- Docking of offshore seafloor spreading zone (mid-ocean ridge) with subduction zone
- Farallon plate completed subducted beneath NA plate
- Convergence replaced with divergence = crustal extension and thinning (detachment faults)

2) Transform Period – 10-0 Ma

- Reorganization of plates: New Pacific and NA plate boundary is a right-lateral transform system
- Originally along edge of continent, transforms jumps inland around 6 ma to form SAF



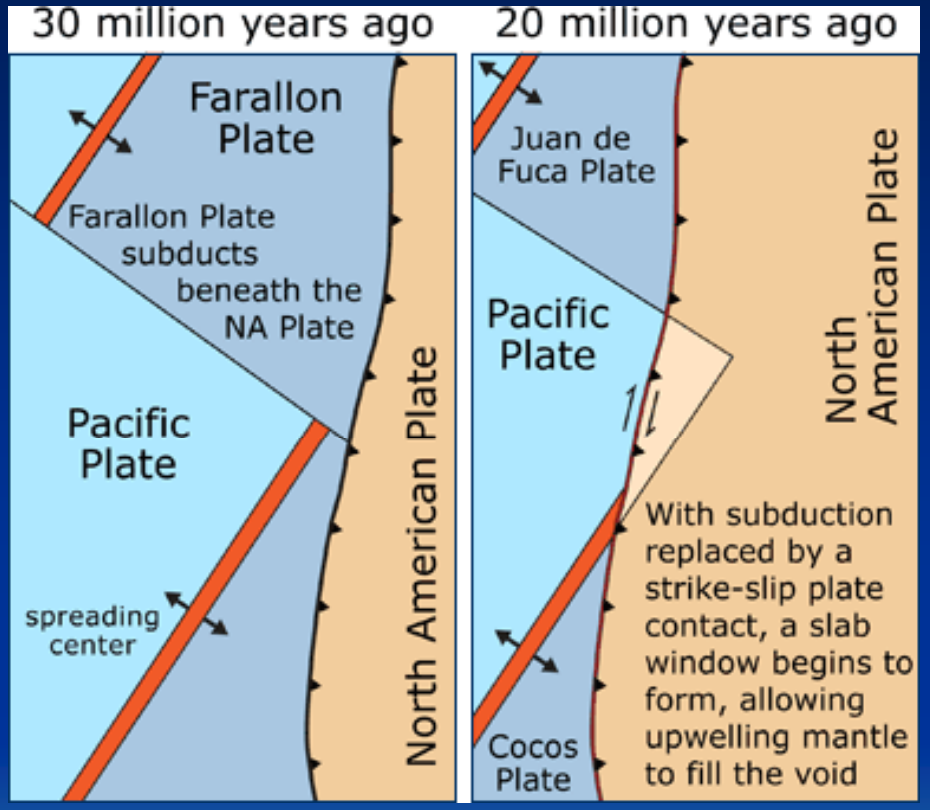


The End of Subduction:

Pacific Plate Meets North American Plate

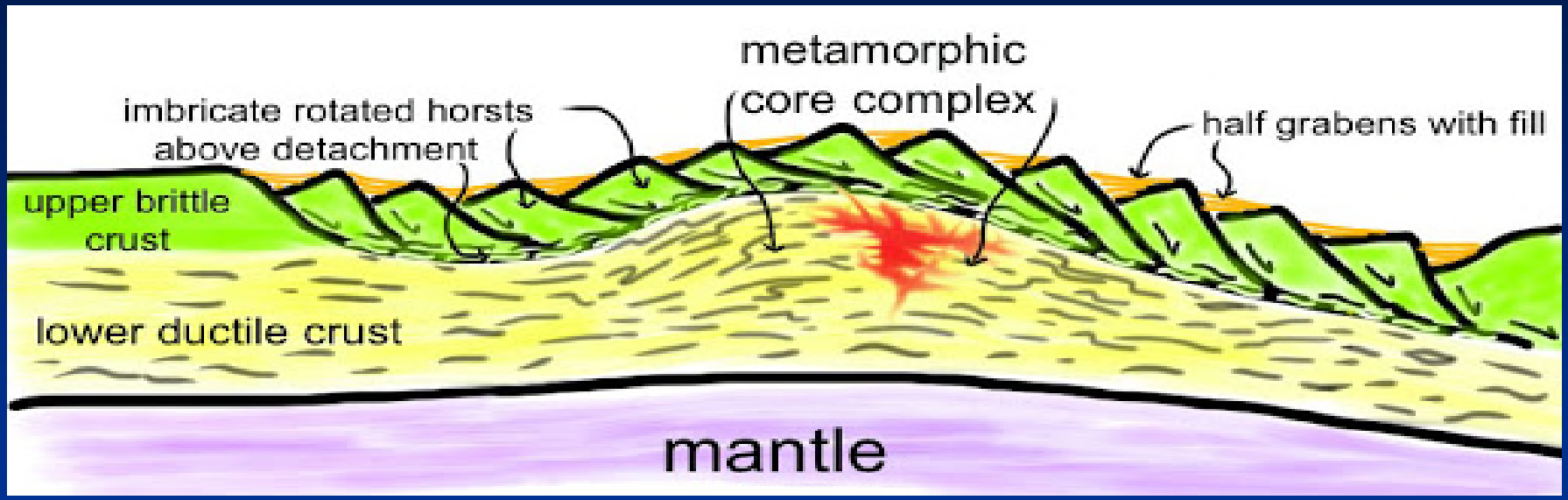
The spreading center between the Farallon plate (spreading eastward) and the Pacific plate (spreading westward) migrated eastward over time

When the spreading center encountered the North American Plate around 25 million years ago, subduction ceased and convergence changed to divergence and transform.



This marked the onset of the extensional stage for Southern California and the development of detachment faults, and dawn of the San Andreas fault system

Stage 3: Extension and Detachment Faulting



Western Edge of North America During the Miocene Epoch

Tensional stresses between the Pacific and North American plates during the Miocene caused the western edge of North America to stretch (lengthen and thin) westward and eastward.

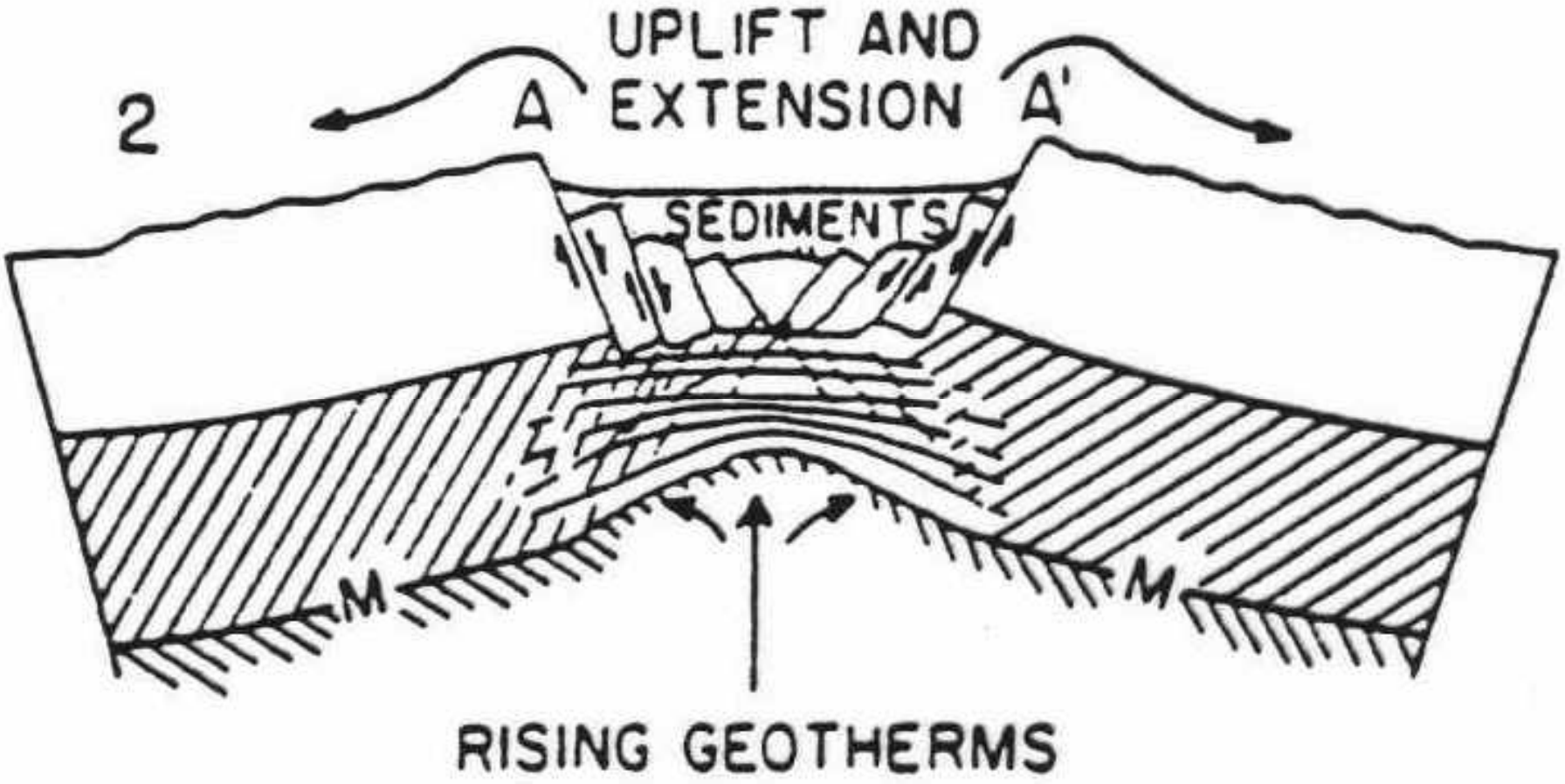
Crustal extension was accomplished by faulting and shearing, which consists of upper-crust (listric) normal faults that are floored by a middle crust detachment fault, which in turn, overyly a lower crust ductile shear zone

Detachment Faulting of Salton Trough

Orange arrows indicate extensional directions of detachment faulting across the Salton Trough region during the Miocene

Cross Section of the Salton Trough:

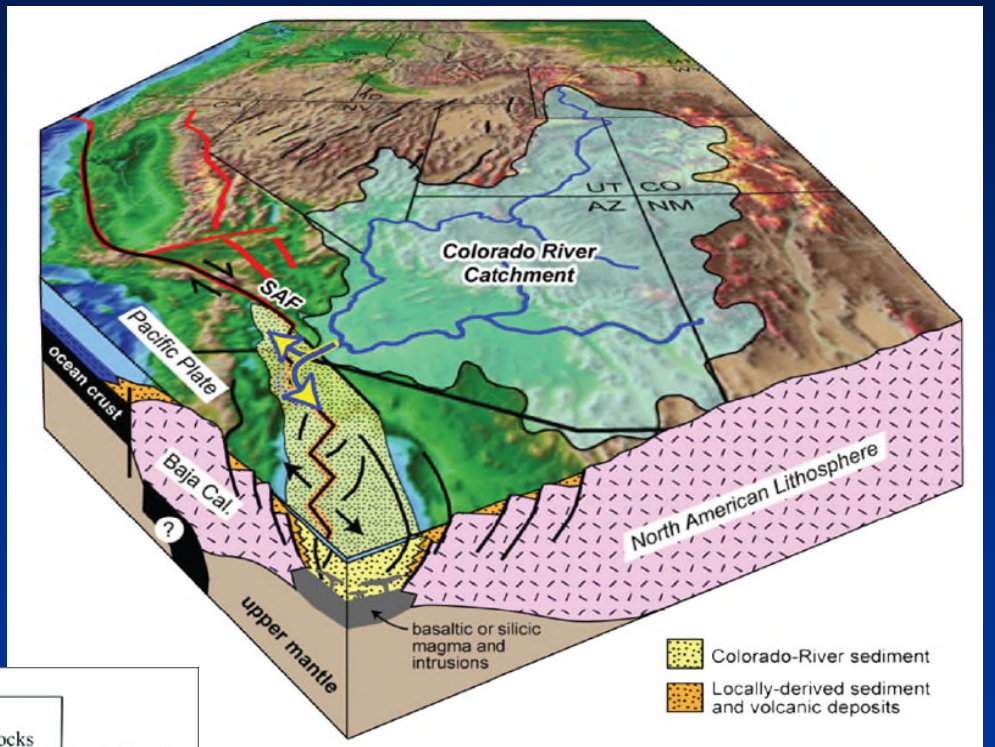
A Buried Insipient Spreading Center

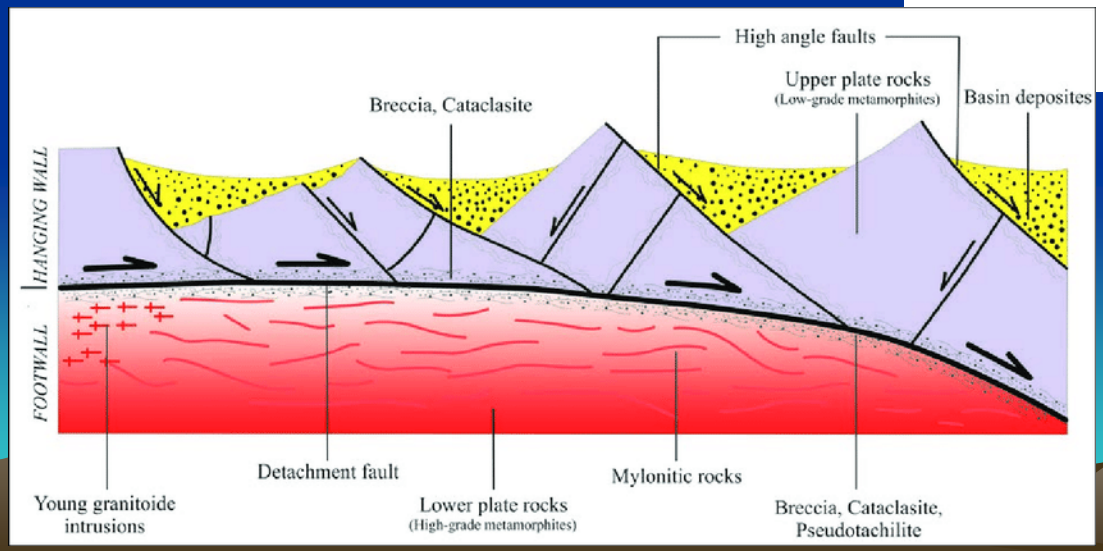


The Salton Trough is a Rift Valley

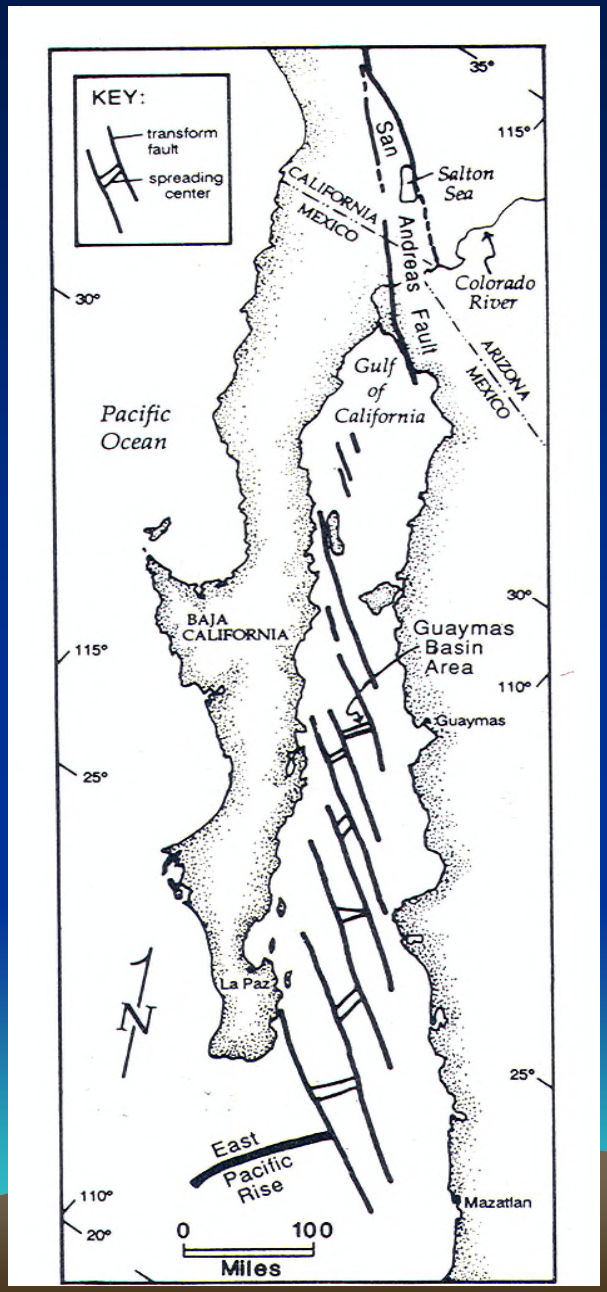
Stage 3: Extension and Detachment Faulting

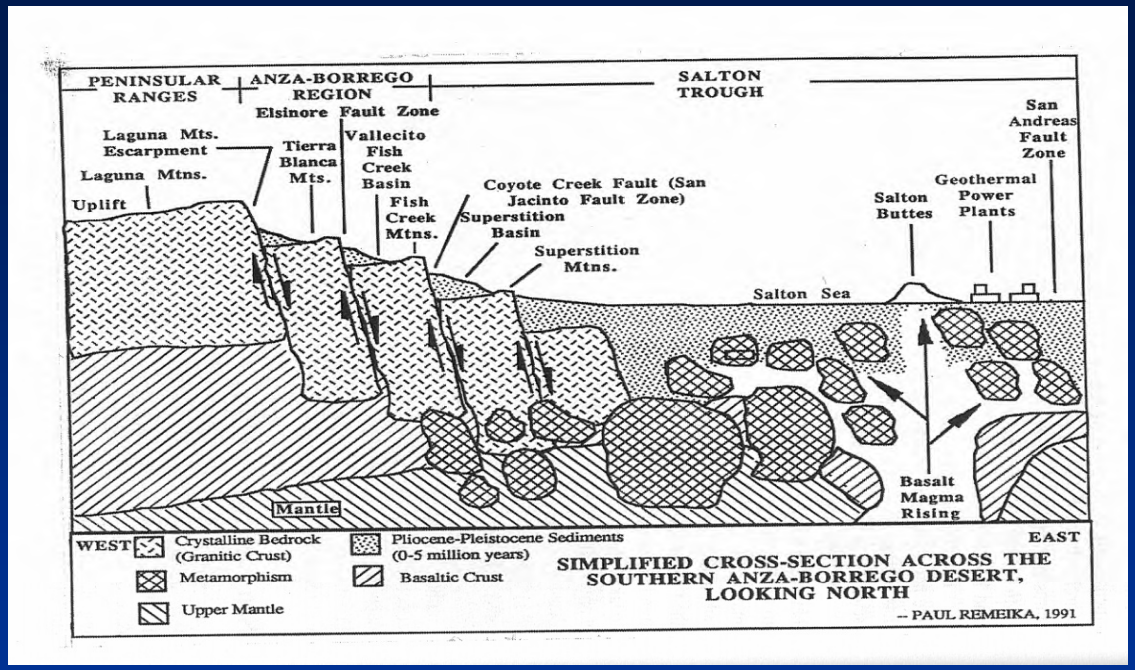
- Detachment Fault System
- Formation of Salton Trough
- Basin & Range Landforms
  Basins = sediments
  Range = PRB
- Extensive Basin Sediment Pile Records Tectonic Events





Transtension and Formation of Salton Trough





Cenozoic Sedimentary Rocks of the Salton Trough – Basin Sediments

Alluvial Fan Deposits

River Deposits

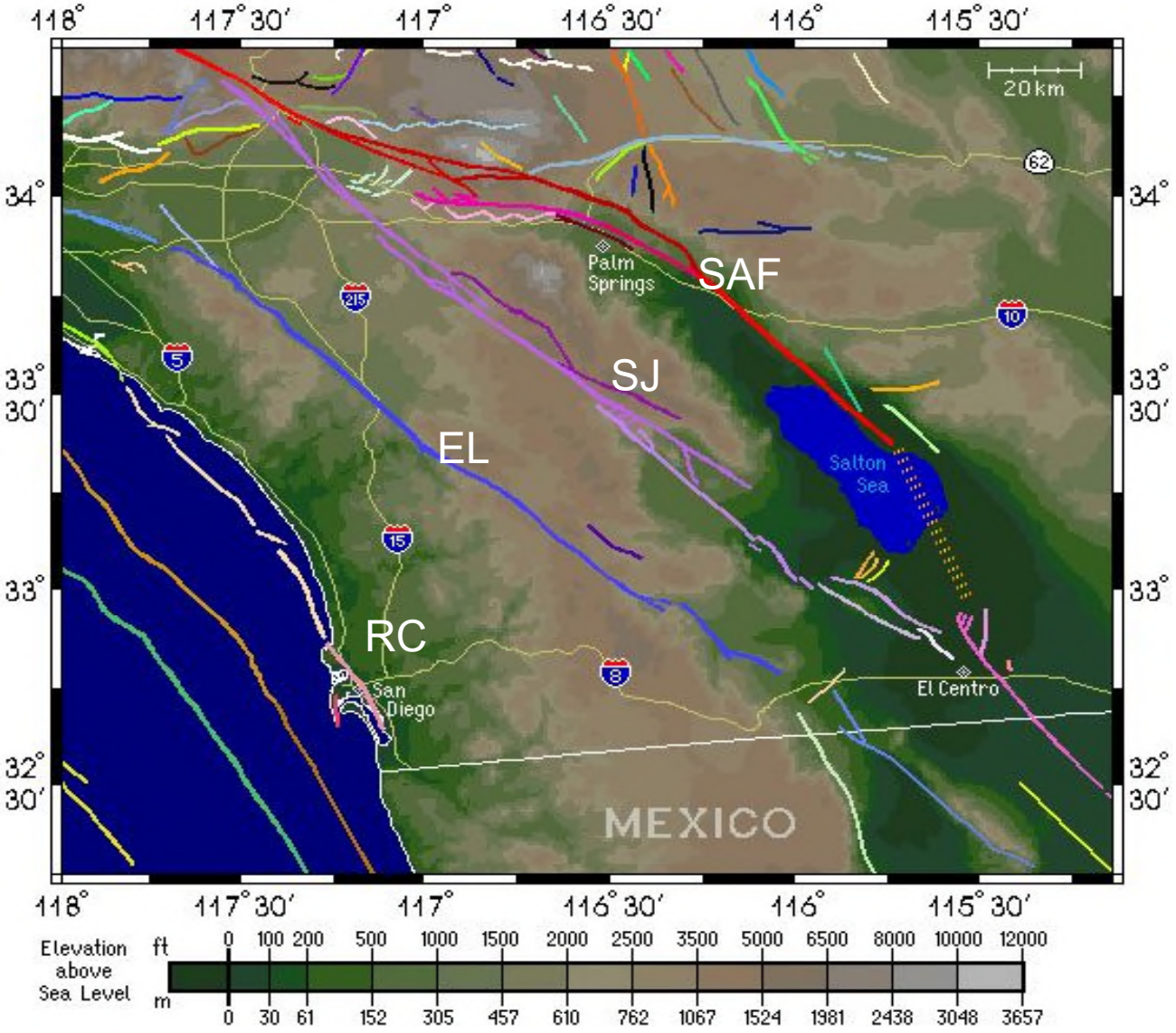
Lakndslide Deposits

Lake Deposits

Stage 4: Continental Transform Faulting

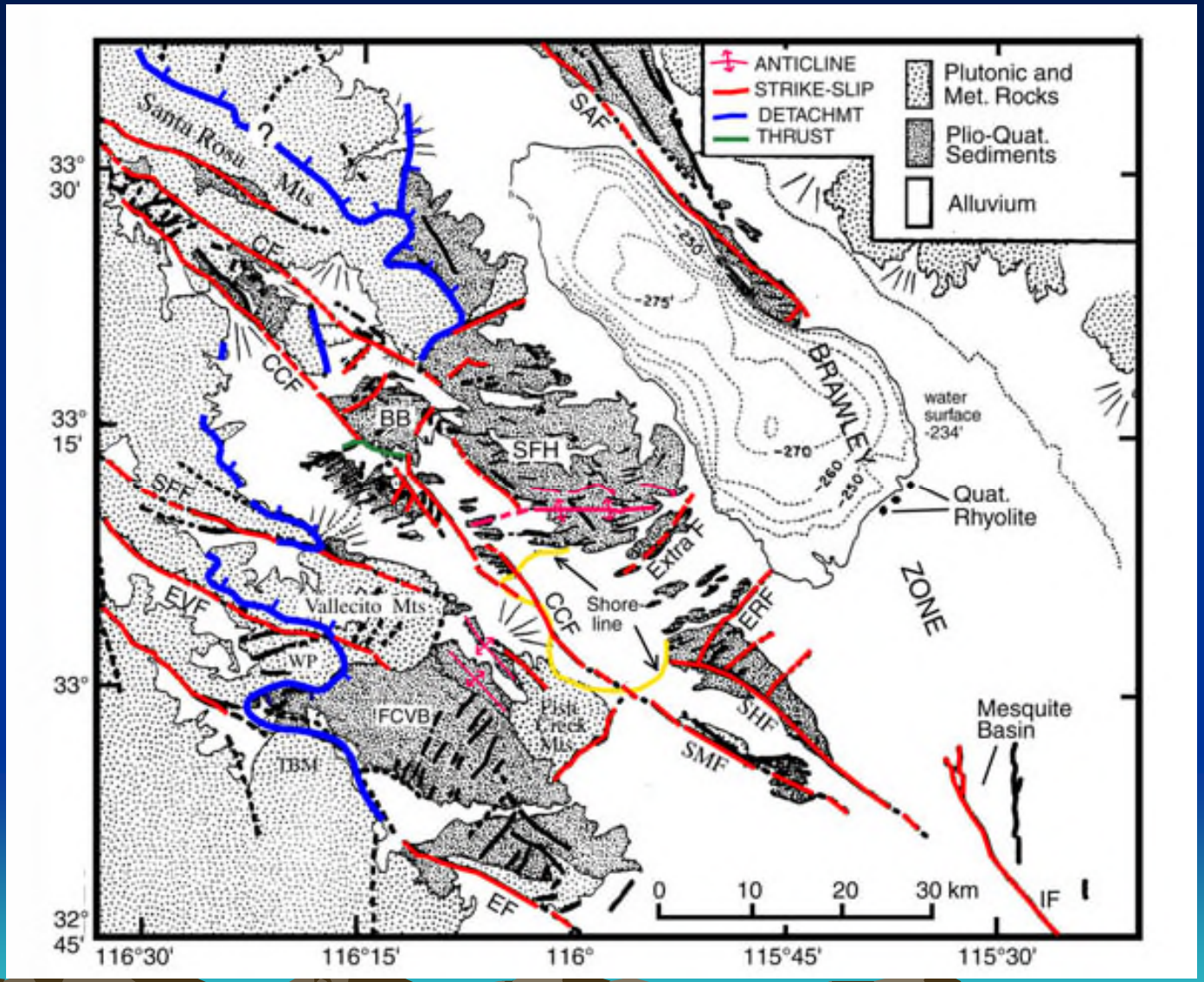
So-Cal Transform Faults from East to West

- San Andreas
- San Jacinto
- Elsinore
- Rose Canyon



The major faults that run through Southern California.

Present-Day Geology of Salton Trough



Most recent transform (right-lateral strike-slip) faulting has broken and offset (complicated) the older detachment faults

Mountain/Desert Landforms

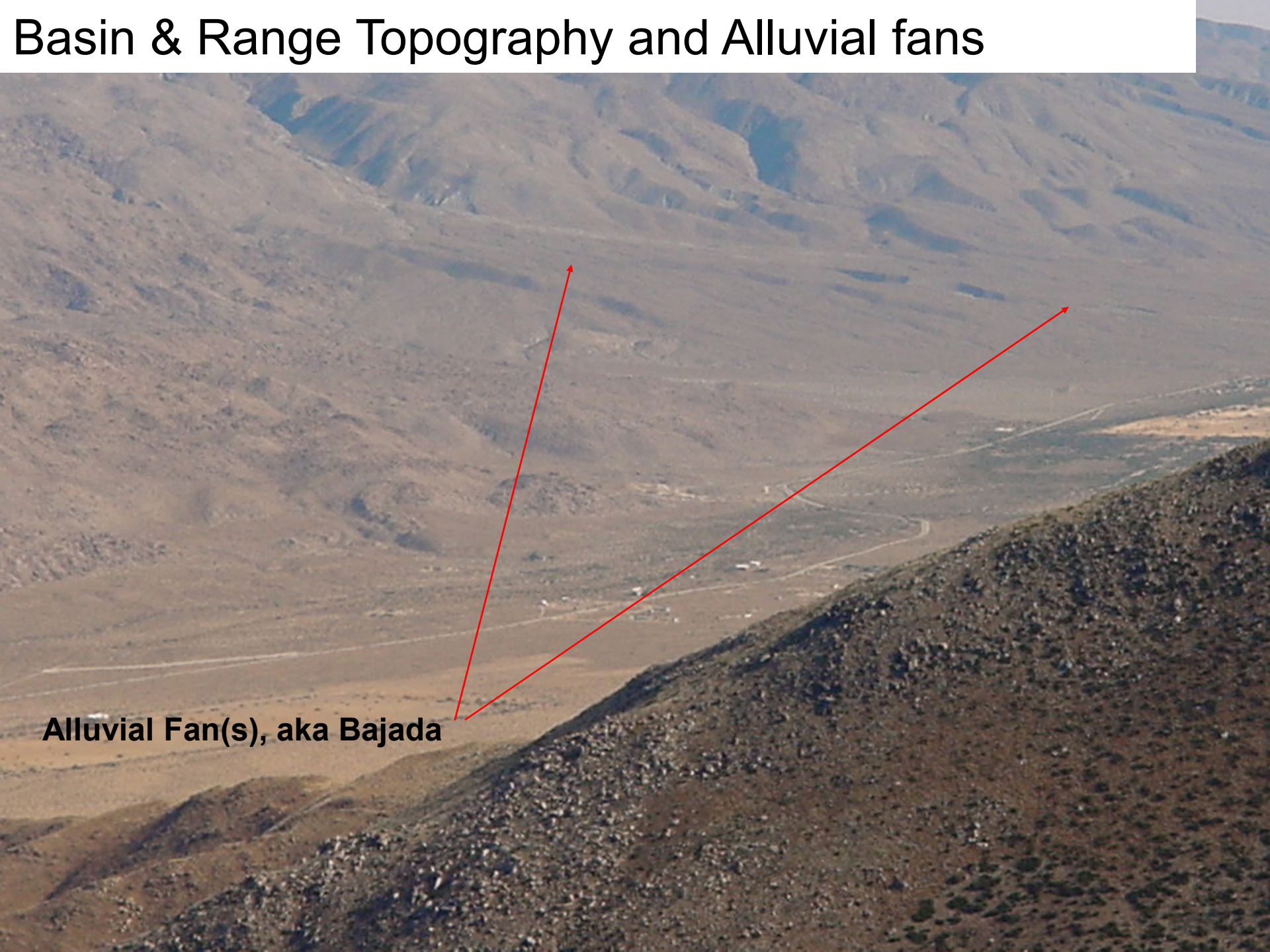
- Stream erosion patterns

  Bedrock Channel - steep, v-shaped

  Alluvial Channels

  - Braided
  - Dendritic
  - Radial
- Fault-controlled features
- Sediments
  - Orientation (STRIKE AND DIP)
  - Age range

Basin & Range Topography and Alluvial fans



A Seismically Active Transform Boundary