General Tectonic History of San Diego Region

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Four Tectonic Stages

Stage #1 - Passive margin (400 to 200 Ma)

- ✓ **Started as garden-variety oceanic seafloor adjacent to (fringing) the western edge of North American and facing a divergent plate boundary**
- ✓ **Classified as "Atlantic-type" ocean margin.**
- ✓ **Continental-derived slope and rise deposits shed on top of this ocean crust, along with oceanic-based pelagic sediment too.**
- ✓ **The oceanic crust and the overlying sediment apron was caught up in several episodes of intense metamorphism related to the following subduction stage, where intense compression-related tectonic forces (folding and faulting) and subduction-generated magmatism turned the passive margin rocks into medium to high-grade metamorphic rocks (termed the pre-batholithic metamorphic assemblage of rocks)**

Stage #2 - Subduction (200 to 30 Ma)

- ✓ **Started when the ancient oceanic Farallon plate began subducting beneath the fringing oceanic crust.**
- ✓ **Subduction stage is divided into three unique periods:**
  - **Early period (200 Ma to 100 Ma) -- Created the Western Zone of PRB**
    - **Development of fringing island arc**

- **Classified as "Japan-type" ocean margin.**
- **Relatively steep subduction angle.**
- **Presence of a narrow oceanic "back-arc" between volcanic arc and continental margin.**
- **Generated wide range of metaluminous magmas that formed a wide compositional range (mafic to silicic) of plutonic and volcanic rocks.**

- **Middle period (100 Ma to 80 Ma) -- Low-angle subduction under the margin of western North America (created the Eastern Zone of PRB)**
  - **Development of continental margin arc**
  - **Classified as "Andean-type" ocean margin.**
  - **Relatively lower angle of subduction with high rate of oblique subduction, compared to earlier western zone subduction.**
  - **Corresponds to accelerated opening of North Atlantic Ocean basin**
  - **Collapse of the narrow oceanic "back-arc" with synchronous intrusion of very large silicic magma bodies between western PRB and edge of the continental crust.**
  - **Generated huge batches of metaluminous to paraluminous magmas that formed a narrow compositional range (tonalite to granite) of plutonic rocks.**
  - **Formation of relatively few, but extremely large, round-shaped diapiric intrusions, termed "La-Posta type" plutons**
- **Late period (80 Ma to 30 Ma) -- Transition from low-angle subduction to near-zero-angle, non-magmatic, flat subduction (created the Laramide orogeny far to the east of San Diego)**
  - **Spreading center migrates close to western margin of North America**

- **Subduction of extremely warm/buoyant ocean crust (including oceanic plateau crust?) causes subduction angle to flatten to near zero**
- **The flat-subducting slab essentially becomes a new "duplexed" bottom layer to continental lithosphere, thus thickening, hydrating, and insulating the crust.**
- **Magmatism completely ceases across entire arc region; but compressional tectonics increases - all the way to the Rockies**
- **Laramide and Sevier orogenies occur - lots of crustal thickening and shortening, with formation of extensive fold and thrust belts across western US**
- **Coincides with development of a ductile, high-angle, compressional shear zone along the eastern side of the PRB - called the Eastern Peninsular Ranges Mylonite Zone (EPRMZ)**

Stage #3 - Extensional/Detachment Faulting (30 Ma to 10 Ma): Beginning of a Transform Boundary - The Early Transtensional Period

- ✓ **Started when the ancient oceanic spreading center (mid-ocean ridge "MOR") separating the Pacific plate (west) and Farallon plate (east) encountered the subduction boundary of western North America**
  - **The point of contact of the MOR was actually a ridge-ridge-transform triple boundary; this occurred at the latitude of what is now Los Angeles, CA.**
  - **The newly-created plate boundary between the Pacific and North American plate was a extensional-type of transform boundary.**

- ✓ **Synchronous with docking of spreading center was the initiation and progressive delaminating of the flat subduction slab (the "duplexed" under-layer) from underneath western North America**
- ✓ **Inflow of sub-continental asthenosphere between slab and western North American lithosphere (as the result of the slab delamination) caused the rapid heating and softening of the high-standing overlying NA lithosphere**
- ✓ **Combined of the docking MOR and the slab delamination was the gravitational collapse of the volcanic margin arcs and Sevier and Laramide orogenic crustal welts.**
  - **Progressive series of low-angle detachment fault zones developed across Nevada and the desert Southwest as the gravitationally unstable crust was thinned and lengthened.**
- ✓ **Inflow of sub-continental asthenosphere between slab and western North American lithosphere also causing widespread explosive bimodal (basaltic-silicic) volcanism, due to the partial melting of the hydrated lithopshere.**
  - **Simultaneous to the detachment faulting was abundant volcanism, especially during Miocene time.**
- ✓ **Peninsular Ranges batholith, and crust to the east of it, was greatly extended by detachment faulting, and intruded by Miocene magmas (climaxing around 20 Ma).**
  - **Eastern Peninsular Ranges - Salton Trough Detachment zone formed**
    - **Developed along the eastern side of the eastern-zone plutons along a NW-SE trend**
    - **Formed in response to the newly-established regional extensional tectonic regime**

- **Detachment faulting is the expression of the collapse of the over-thickened margin arc crust due to gravitational instability.**
- **Detachment faults are low angle, with faults dipping towards the east (upper block sliding eastward off of lower block)**
- **Exhumed mid-crustal level rocks.**
- **Created a "graben-and-horst" or "basin-and-range" style topography**
- **Massive amounts of locally derived sediments were shed off the exhumed, elevated crustal blocks (ranges) and deposited into the subsided, dropped-down crustal blocks (basins).**

Stage #4 Transform (10 to Present) - The Modern-day Transform System

- ✓ **Started when the Pacific and North American plate motion reorganized, causing the plate boundary between the ocean Pacific plate and continental North American plate to jump into the edge of the North American plate**
- ✓ **The modern-day San Andreas Fault system began (about 3 MA), and is lengthening as times goes on.**
- ✓ **San Andreas fault motion caused the opening of the Gulf of California, and the northward translation of the coastal Central and Southern California, along with Baja California**
- ✓ **The San Andreas Fault Zone (SAFZ) slices up Southern California into a set of NW-SE trending crustal blocks bounded by right-lateral strike-slip faults**
  - **Major right-lateral strike-slip faults across latitude of San Diego (from east to west) include the San Andreas, San Jacinto, Elsinore, and Rose Canyon Faults.**
  - **Salton Trough lies between the San Andreas fault (east side) and San Jacinto fault (west side)**

- ✓ **Southern end of the Salton Trough marks the northern end of the Gulf of California seafloor spreading, and transition to true transform motion of the SAFZ.**
- ✓ **The SAFZ has deformed the Peninsular Ranges batholith, and crust to the east of it (Salton Trough region) by right-lateral, and clock-wise rotation of inter-fault crustal blocks**
  - **Batholith has become extended and offset, as a set of en-echelon crustal blocks**
  - **The older detachment fault system has also been deformed.**
- ✓ **Bends in the right-lateral strike-slip faults causes either compressional (left-bends) or tensional (right bends) between the two fault blocks, where the bend occurs.**
  - **Right bends create topographic low spots (depressions and basins)**
  - **Left-bends create topographic high spots (mountains and ridges)**