LATE JURASSIC TO LATE CRETACEOUS

Reading:
GNAM volume G3, Chapter 5

Topics
• Eastern and central Cordillera
• Western Cordillera

Eastern and Central Cordillera
• Cordilleran fold and thrust belt
• Foreland basin
• Hinterland

Plate Interior
• Foreland Deformation
  – Foreland fold and thrust belt and related basin system
• Foreland Basin Deposits
  – Aeolian deposits (Navajo ss.) followed by marine incursion (Morison Fm.)

Three Deformation Belts
• Lunning Fencemaker Thrust (Nevada)
• Sevier Belt
• Hinterland Belt (Willow Creek Allochthon)

Foreland Basin Deposits
• Fluvial Morrison Formation with conglomerate wedges
• Deposited on top of earlier aeolian deposits of Navajo ss.
• Represents erosion from a western orogenic highland onto an extensive eastern foreland basin
Fold And Thrust Belt

- Geometry and Displacements
- Timing of Thrusts

Geometry and Displacements
- Proterozoic and Paleozoic geocline
- East vergent
- Thin-skinned
- E limit is Wasatch line or hinge line
- Shortening is about 50%
- Basal decollement
  - Steps down section from E to W
- Cretaceous to Precambrian sediments

Timing of Thrusts
- 100 Ma to 50 Ma (older in the west)
- Classic stacked shingle structure
  - Structurally oldest faults are highest
  - Carried eastward piggy back on younger faults

Foreland Thrust Belt

Foreland Basin

- Interpretation
- Early Jurassic
- Late Jurassic

Interpretation
- Began in late Jurassic
- Culminated in Cretaceous
- Extended from S Nevada into Canada
- Asymmetric
  - Thickest near uplift
  - Feathered toward the east
  - Up to 10 km thick
Interpretation
• Basin responded to crustal loading
  – Loading caused by thrusting
  – Deposition occurred in the basins
• Broadly distributed flexure
  – Elastic deformation
  – Low to moderate thermal gradients

Early Jurassic
• Vast epeiric seaway

• Shallow marine and sub aerial deposits
  – Derived from the continental interior

Late Jurassic
• Non-marine deposits spread eastward
  – Shale, sandstone, and conglomerate
• Epeiric sea retreated
  – Northward into Canada
  – Southward into Mexico
• Swamp deposits spread eastward
  – Form an alluvial plain

Hinterland
• Thrust systems rooted in the west
• Metamorphic core complexes
  – Late Jurassic and early Cretaceous age
  – Located in the western thrust belt
• 90 to 100 Ma plutons
  – Coextensive with the Sevier thrust belt
Upper Jurassic to Upper Cretaceous

- Bisbee Group
- McCoy Mountain Formation

Middle Jurassic-Late Cretaceous

Transtensional Disruption

- Bisbee Basin
  - Rift Sediments (Glance Conglomerate, 2 Km)
- McCoy Basin
  - Volcaniclastic Rocks (3 Km)
- Sinistral Faults (Sonora)
- Independence Dike Swarm (Rift Related)

Bisbee Group

- Southern Arizona and SW New Mexico
- Deposits are 3 Km thick
- Basal conglomerates
- Overlain by volcanics (150 Ma)
- Overlain by shallow marine/non-marine sediments
- Related to failed rift & opening of the Gulf of Mexico

McCoy Mountain Formation

- Deposits are 7 km thick
- Deformed and metamorphosed
- Lower quartzose to volcaniclastic section
- Overlain by upper Cretaceous arkoses

Western Cordillera

- Structural tectonic groups
- Sierra Nevada Batholith
  - Roots of the magmatic arc
- Great valley sequence
  - Sedimentary fill of the forearc basin
- Franciscan complex
  - Subduction complex
  - Deformed and metamorphosed ocean floor, trench, and continental slope materials
Western Belt Map

- Sierra Nevada batholith
- Great Valley Group
- Franciscan Fm.

Sierra Nevada Batholith

- Plutons
- Framework Rocks

Plutons

- Upper Jurassic to Cretaceous age
- Main batholith
- Scattered stocks & plutons
- Amalgam of plutons & comagmatic suites
- Region displaced ~ 200 km westward
  - Post emplacement extension in the Great Basin

Framework Rocks

- Generally strike northwards
- Southern part
  - Cordilleran miogeocline
  - Precambrian and Paleozoic strata
- Northern part
  - Subduction complexes
  - Paleozoic arc-related terranes

Framework Rocks

- Mojave area
  - Precambrian basement
- Klamath complex basement
  - Overlapping nappes of back arc terranes
- Nevada
  - Accreted arc terranes
  - Continental shelf sediments

Ages in Sierra Nevada

- U-Th are the best ages
- K-Ar dates represent cooling ages
- Sierra Nevada ages are younger eastward
  - Western part has 150 Ma to 130 Ma plutons
  - Western foothills mafic belt is at 130-115 Ma
  - Eastern part is 110-80 ma
Ages of Other Plutons

- Mojave Desert: 100-75 Ma
- NW Nevada: 105-80 Ma
- Klamath Mountains: 150-130 Ma
- Idaho Batholith: 95-75 Ma

Petrology

- Lower Cretaceous Plutons: More Mafic Than Late Cretaceous
- Older Plutons Are Tonalites
- Concentric Zoning
- Sheared and Foliated Outer Contacts
- Dominant Composition Is Granodiorite

Eastward Trends

- Increasing SiO₂
- Increasing K₂O
- Sr isotope ratios reflect basement
  - Accreted arc sequences in east
  - Cratonic assemblages in west

Volcanism

- Andalucite in contact metamorphic rx
  - Indicate shallow (<10 km) depths of intrusion
- Roof pendants
  - Preserve sub aerial volcanic rocks
  - Ritter range pendant caldera complex

Deformation

- Volcanic complexes strongly deformed
  - Synkinematic folding
- Deformation and metamorphism
  - Affected a hinterland
  - Softened by plutonism

Origin

- Magmatic arc formed at a convergent plate boundary
- Comparable to the subvolcanic zones of active convergent margins
  - Andean type volcanism
- Nearly continuous record of convergence
  - Entire western coast of North America
Great Valley Group

- Terrigenous clastic sequence
  - Sandstone, mudstone, and conglomerate
- Overlies diverse basement terranes
- Sierra foothills
  - Eastward thinning sedimentary wedge
  - Rests upon:
    - Mafic, intermediate, and felsic plutonic rocks
    - Low-grade metamorphic rocks

Coast Range

- Jurassic ophiolites
- Overlying sedimentary and volcanic rocks
- Marks the extinction of the late Jurassic magmatic arc and related ophiolites
- Inception of a new forearc basin and magmatic arc
- Represented by Great Valley Group & Sierra Nevada Batholith

Asymmetric Syncline

- NW trend
- Coast Ranges - 15 km section
- Diablo Range - 8-10 km section
- Folding can't explain distribution & structure
- Perhaps faulting or erosion are involved
- Some may be strike-slip (left lateral)

Sedimentology and Petrology

- Proportion of lithic clasts decrease upward while feldspar increases
- Temporally changing provenance
- Late Jurassic
  - Supracrustal rocks were the main source
  - Includes some ophiolites
- Cretaceous
  - Volcanic arc to the east provided clasts
- Represents progressive unroofing of plutonic system
Paleogeography

• Accumulated in a forearc or outer-arc basin
• Sierra Nevada magmatic arc to the east
• Similar to modern Sunda-Java forearc basin
• Sedimentation outlasted the magmatic arc

The Franciscan Complex

• Lithologically Heterogeneous
• Three Main Packages

Initial Franciscan Deposits

• Local Deposition Began in Late Jurassic
• Washington (Pickett Peak Fm)
  – Basalt, Argillite, Clastics
• South Oregon (Otter Point Complex)
  – Volcaniclastics, Basalts, Submarine Pyroclastics

Lithologically Heterogeneous

• Clastic sediments, basalt, chert, and metamorphic rocks
• Late Jurassic to Paleocene age
• Separated from the GVS by faults
• Noted for blueschist and eclogite
• Highly deformed (chaotic) and faulted

Three Main Packages within the Franciscan

• Eastern Belt
• Central Belt
• Coastal Belt

Eastern Belt

• East-dipping thrust sheets with blueschists
• Protoliths of sandstone, mudstone, and basalt
• Radiometric age is difficult to determine
Central Belt

- Mélange with outliers of eastern belt rocks
- Many units are laterally displaced
- Small exotic blocks
  - High-grade metamorphic rocks
  - Includes blueschists and eclogites
  - High P, low T
- Fragments of deeply-buried oceanic crust
- Fragments of tropical limestones

Coastal Belt

- Sandstone-mudstone turbidites
- Imbricate, east-dipping thrusts
- Boundary with the GVS
  - Partly Neogene low-angle normal faults
  - Indicates extension

Origin

- Franciscan was material scraped off a subducted "pacific" plate slab
- Developed during the late Jurassic to Cretaceous
- Remaining questions
  - How were deep parts of the subducted slab brought to the surface?
  - What was the mechanisms for the large lateral displacements?

Tectonic Models for Franciscan

- Oblique plate convergence
- Fragments of an oceanic arc traveled thousands of km on top of subducted plates

Displaced Terranes

- The Sierra Nevada and Great Valley Group
  - Formed in their present location along the edge of the north American Plate
- Parts of underlying Franciscan Complex
  - Likewise formed in place
- Many rock units to the west
  - Were transported northward &
  - Emplaced in the latest Cretaceous or Tertiary
Displaced Terranes of California

- Salinian composite terrane (E of SNFZ)
- Sur-Opispo composite terrane (W)
- Tujunga terrane (San Gabriel Mts.)
  - Pelona-Orocopia Schists
- Cretaceous Plutons

Composite Terranes of Washington

- San Juan nappe terrane
- Skagit metamorphic terrane
- Methow-Payson sequence
- Okanogan Highlands

Review - Triassic to Jurassic