Chapter 13
Mesozoic Events
Mesozoic Era

• Mesozoic Era = 251 to 65.5 million years ago.

• Name Mesozoic means "middle life"

• Mesozoic Era consists of three periods:
  – **Triassic** - Oldest. Lasted about 51 million years
  – **Jurassic** - Lasted about 55 million years
  – **Cretaceous** - Youngest. Lasted about 80 million years
Mesozoic Era

- Mesozoic began after the extinction of Paleozoic organisms.
- Mesozoic rocks contain the remains of organisms that are more advanced than those of Paleozoic, but not as modern as those living today.
- Two new vertebrate classes appeared: birds and mammals.
- Mesozoic lasted approximately 186 million years, and ended with an extinction event in which the dinosaurs met their demise.
At the beginning of Mesozoic, continents were assembled into a supercontinent, **Pangea**.

**Pangea** formed during Late Paleozoic by the collision and joining of the continents to form a single landmass surrounded by a vast ocean.
In the equatorial area to the east, between Africa and Europe, and between India and Asia, was an embayment called the **Tethys Sea**.

The climate became arid; **evaporites** (E) were deposited.
The Breakup of Pangea

• Pangea began to break up during Mesozoic.

• The northern continents were called Laurasia and the southern continents were called Gondwana.

• As North America and Europe separated, they were called Laurentia and Baltica.
The Breakup of Pangea
The breakup occurred in four stages:

Stage 1:

- **Rifting** and **volcanism** along normal faults during Triassic, resulting in the separation of North America (Laurasia) from Gondwanaland.
- **Normal faulting** in eastern North America, accompanied by the **intrusion** of dikes and lava flows.
- **Atlantic Ocean opened** and widened through the **extrusion** of oceanic basalts.
The continents did not split along the places that marked their previous edges.

The old suture (or "seam") between North America and Africa lies in southern Georgia.

When Africa pulled away, it left a sliver of the African continent attached to the southeastern U.S.
The Breakup of Pangea

Stage 2:

- Rifting and separation of Africa, India, and Antarctica.
- Large volumes of basalt were extruded.
Stage 3:

- The Atlantic rift extended northward.
- Eurasia moved to the south, partially closing the Tethys Sea.
- South America began to split from Africa by Late Jurassic, and completely separated by Late Cretaceous.
- Australia remained connected with Antarctica.
- India was moving northward toward Asia.
- Greenland began to separate from Europe (Baltica), but remained attached to North America (Laurentia).
Stage 4:

- After Mesozoic, the breakup of Pangea continued.
- North America (Laurentia) separated from Eurasia (Baltica) along the North Atlantic rift.
- Antarctica and Australia separated about 45 m.y. ago.

The total time for the fragmentation of Pangea was about 150 m.y.
Triassic of Eastern North America

- During Triassic in eastern North America, the Appalachian Mountain ranges were much higher than they are today.
- The mountains were eroding at the beginning of Mesozoic.
- Coarse clastic sediments from the mountains filled basins between the mountains during Early and Middle Triassic.
- The Appalachians were reduced by erosion throughout Triassic, Jurassic and Cretaceous.
Triassic Paleogeography
Triassic of Eastern North America

• During Late Triassic and Early Jurassic, North America experienced **tensional stress** and **rifting**.

• **Fault-bounded rift basins** developed in eastern North America, extending from Nova Scotia in the north to Georgia in the south.
Newark Supergroup

The fault-bounded basins filled with Upper Triassic and Lower Jurassic sediments eroded from the Appalachians, and basaltic lava flows and diabase intrusions (sills and dikes). These rocks comprise the Newark Supergroup.
Four stages of Triassic history of the Connecticut Valley

1. Erosion of mountains
2. Low plain
3. Sediment deposition, lava flows, and intrusions in fault-bounded basin
4. Post-depositional faults
Newark Sediment Deposition

The sediment in the Newark basins was deposited in continental (non-marine) sedimentary environments such as:

- Alluvial fans
- Rivers and floodplains (alluvial)
- Lakes (lacustrine)
- Deserts (aeolian or eolian)
Newark Sediment Deposition

- The sedimentary rocks are primarily red arkosic sandstone, siltstones, and shales.
- Dinosaur bones and tracks are present locally.
- Some of the lake deposits are black and gray shales with the remains of fish, aquatic reptiles, and freshwater invertebrates.
Newark Supergroup
Sedimentary Rocks
Palisades Sill

- The Palisades along the western shore of the Hudson River are created by the exposed diabase sill, about 190 million years old.
Several belts of sedimentary deposition were present in western North America during Mesozoic:

1. A western belt of volcanic rocks and graywackes associated with volcanic island arcs
2. An eastern belt of shallow marine sandstones and limestones closer to the mainland
3. And farther eastward, non-marine, continental red beds deposited on the low alluvial plains
During Middle Triassic, the seas regressed in the U.S. (although they still covered parts of Canada), and the former seafloor was subject to erosion, forming an unconformity.
Upper Triassic to Jurassic continental deposits (fluvial, lacustrine, and aeolian) overlie the unconformity.

Jurassic
- Navajo Sandstone
- Kayenta Formation
- Wingate Sandstone

Triassic
- Chinle Formation or Group
- Shinarump Conglomerate
- Moenkopi Formation
Petrified Forest

- Petrified Forest National Park in Arizona has fossilized logs of trees in the Triassic Chinle Formation.
- The silica required for silicification of the wood was derived from the dissolution of volcanic ash.
• The rocks of the Painted Desert in Arizona are also from the Triassic Chinle Formation.

• Zion National Park in southwestern Utah is known for the cross-bedded sandstones exposed in Zion Canyon. These belong to the Navajo Sandstone. The other units mentioned above are also exposed there.
Jurassic History of North America

- In North America during Jurassic, the Appalachians were smaller in size and extent than they were during Triassic.
- Non-marine sediments were deposited east of the Appalachians in the area that is now on the continental shelf.
- In western North America, shallow seas flooded the craton, and sandy and shaley sediments were deposited.
Jurassic Paleogeography
Evaporites in the Gulf of Mexico

- Evaporites were deposited during Late Triassic and Jurassic in the Gulf of Mexico area.
- Great evaporating basin in which seawater from the Atlantic Ocean was concentrated.
- Thick beds of gypsum and salt, more than 1000 m thick, were deposited, indicating an arid climate.
Salt Domes

- One of the thick salt beds, called the Louann Salt, formed salt domes in the Gulf of Mexico area.

- Salt has a low density and flows plastically when compressed under 1000’s of m of sediment.

- Salt flows upward through the overlying sediments, forming structures that resemble intrusions, and causing the sediment above them to arch upward into a dome shape.
Salt Domes
Salt Domes

- Salt domes are important economically because oil and natural gas float on water and tend to move upward into the up-arched sediments, where they become trapped.
- Salt domes are major oil and gas traps.
Jurassic of Western North America

- In the western U.S., the seas transgressed and regressed during Jurassic.
- Limestones and evaporites were deposited in shallow seas.
The Navajo Sandstone (Upper Triassic – Lower Jurassic) has large-scale cross-bedding, indicating that it was deposited by the wind, probably in a coastal dune environment.
During Middle Jurassic, west-central North America was flooded by a broad seaway, called the Sundance Sea.

The bones of marine reptiles are found in the sandstones and siltstones of the Sundance Formation, deposited in the Sundance Sea.
Dinosaurs in the Morrison Formation

• After the Sundance Sea regressed, it left behind a vast swampy plain with meandering rivers.

• The deposits of these rivers and floodplains comprise the Jurassic Morrison Formation, which covers a large area in the west.

• The bones of more than 70 species of dinosaurs have been found in the Morrison Formation.
Cretaceous History of North America

• Cretaceous was a time of high sea level and vast epicontinental seas.
• The most prominent feature in North America during Cretaceous, was the shallow epicontinental sea that flooded much of the western interior of the continent, from the Gulf of Mexico to the Arctic Ocean, as well as the Atlantic and Gulf Coastal Plains.
Cretaceous Paleogeography
Cretaceous Chalk

- **Chalk**, a white, fine-grained variety of limestone composed of microscopic shells (called *coccoliths*) of golden-brown algae, was deposited in many places around the world during Cretaceous.

- The word *Cretaceous* is derived from the Latin word for chalk, *creta*.
Atlantic Coastal Plain

• The Atlantic Coastal Plain began to subside (or sink) early during Cretaceous.
• Marine and deltaic sediments accumulated, gradually building a wedge of sediments that thickened seaward.
• Most Cretaceous sediment in this area was deposited on the present-day continental shelf.
Atlantic Coastal Plain
Rudist Reefs

- Extensive carbonate reefs grew in the warm tropical seas of Cretaceous.
- A prominent reef-building invertebrate was a bivalve mollusc called a rudist.
- Cretaceous rudist reefs have high porosity and permeability, and are well-known sites of oil and natural gas accumulation.
In western North America, a range of high mountains formed as a result of orogenies that had begun during Jurassic.

As the mountains eroded, thick sequences of sediments (up to 15,000 m or 9 mi thick) accumulated in adjacent rapidly subsiding basins.

The rocks were folded and intruded as a result of continuing tectonic deformation during mid- and Late Cretaceous.
Cretaceous of Western North America

- The sea was east of the mountains, advancing and retreating. The sea flooded the interior lowlands of North America from the Gulf of Mexico to the Arctic in Canada.
- The depositional basin east of the mountains was a foreland basin.
Cretaceous Foreland Basin
Cretaceous Coal

• Coal was deposited in the foreland basin, to the east of the eroding mountain range.

• Cretaceous coal underlies 300,000 km² of the Rocky Mountain region.

• It is mined for fuel and is valued for its low sulfur content.
Dakota Sandstones

• Transgressive-regressive sedimentary cycles mark the advance and retreat of Cretaceous seas.

• The Dakota Group sandstones were deposited by a transgression, and form hogback ridges along the eastern front of the Rocky Mountains.

• In parts of the Great Plains, the Dakota sandstones are an important source of underground water (aquifer).
Volcanic Ash and Bentonites

• A series of volcanoes in western North America deposited ash over an extensive area.

• The volcanic ash is now altered to a soft clay called bentonite.

• These volcanic ash beds are important because they are useful in correlation and serve as time horizons.
Niobrara Limestone

Cretaceous limestones of the Niobrara Formation deposited in the epicontinental sea contain the remains of marine reptiles, flying reptiles, a diving bird, oysters, and other organisms.
Regression of the Cretaceous Sea

The sea withdrew near the end of Cretaceous during the Laramide orogeny, which formed the Rocky Mountains.
Mesozoic Tectonics of Western North America

• Western North America experienced compressional forces as the continent moved westward, overriding the Pacific plate.

• A subduction zone was present along the western margin of North America.

• Uplift of mountains in the Cordillera was related to sea-floor spreading in the Atlantic. Tectonic activity was greatest in western North America when sea floor spreading was most rapid in the Atlantic.
Accretionary Tectonics

• As the Pacific plate was subducted under the North American plate, microcontinents, volcanic island arcs, and other exotic terranes carried on the Pacific plate collided with the North American plate and became attached to it.

• The North American continent grew by the accretion of exotic terranes around its edges.

• The growth of a continent by addition of exotic terranes is called accretionary tectonics.
Map of the larger exotic terranes of western North America.

The rocks in these terranes contain rocks Paleozoic or older.

The pink areas may be displaced areas of the North American continent, but the green areas probably originated as parts of other continents.
Mesozoic Orogeny in Western North America

- Orogenies (or mountain-building events) occurred as the exotic terranes collided with western North America.

- Among these orogenies were the:
  - Sonoma orogeny
  - Nevadan orogeny
  - Sevier orogeny
  - Laramide orogeny
Sonoma Orogeny

- The **Sonoma orogeny**, during Triassic, was the first orogeny in the Cordillera.

- It was caused by the collision of a volcanic arc with western North America.

- Oceanic rocks were **obducted** (thrust on top of continental rocks).
Nevadan Orogeny

• Subduction resulted in eastward-shifting phases of deformation, initially affecting the far western Cordillera, and then proceeding eastward to the margin of the craton. This produced the Nevadan orogeny.

• Graywackes, mudstones, cherts, and volcanics were folded, faulted, and metamorphosed, forming a mélange (meaning "a jumble") in the subduction zone.

• This formed the Franciscan fold belt of California.
Mesozoic Batholiths

- Large bodies of magma, derived from melting of rocks in the subduction zone, were intruded into overlying rocks.
- The magma cooled to form enormous granite batholiths. This occurred during and after the Nevadan orogeny, during Jurassic and Cretaceous.
Mesozoic Batholiths

Examples:

• Sierra Nevada batholith
• Idaho batholith
• Coast Range batholiths
• Baja California batholith
Sevier Orogeny

- A second tectonic phase affected shallow water sedimentary rocks east of the present-day Sierra Nevada mountains.
- Sedimentary rocks were sheared from underlying Precambrian rocks.
- This resulted in the formation of multiple thrust faults stacked upon one another and referred to as imbricate thrusts.
- Thrust faults shortened the crust by more than 100 km (60 mi) in the Nevada-Utah region.
Imbricate Thrusts from the Sevier Orogeny
Cross section showing the spatial relation between the batholiths and the Sevier-type imbricated thrust faults.
Laramide Orogeny

- Deformation shifted eastward toward the craton after intrusion of batholiths, and thrust faulting decreased near the end of Cretaceous.
- Domes, basins, monoclines, anticlines, and high angle reverse faults (which become low angle thrust faults at depth) formed during this orogeny.
- Many of the larger faults were reactivated Precambrian faults.
Rocky Mountains

- The **Rocky Mountains** formed in New Mexico, Colorado, and Wyoming during the **Laramide orogeny**.

- The present-day landscape, however, is the result of Cenozoic erosion and uplift.