GEOLOGY 25 - LECTURE 7A

National Parks of the Basin and Range: Basin & Range Province

Textbook Ch. 23

Basin and Range Province

Basin and Range (B/R) extends N-S from eastern Oregon into Mexico, and E-W from the eastern front of the Sierra Nevada, across Nevada, to the western escarpment of the Wasatch Range (western edge of Colorado Plateau) in Utah.

The B/R consists of a swarm of hundreds of north-south-trending elongate mountain **ranges** alternating with broad elongate valleys (aka "**basins**").

- many of the basins lie 4000-7000' above sea level, with some ranges reaching over 13,000'
- basins tend to be relatively flat; mountains are linear and steep

Great Basin National Park is located in eastern Nevada near the border with Utah.

- You can drive to 10,000' and camp; hike to see bristlecone pine trees, among the oldest in the world; climb to the top of 13,000' Wheeler Peak on a well-maintained trail; explore a cave filled with stalactites and stalagmites; experience scenic views across the B/R that extend for hundreds of miles; and see countless stars in the clear night skies.
- located just off Route 50 (the "Loneliest Highway in America") that crosses Nevada east to west

Within the northern B/R *geologic* province is a *hydrologic* drainage basin called the **Great Basin,** characterized by **internal drainage**.

- internal drainage simply means that rivers and streams don't connect with larger rivers that eventually drain into the oceans.
- streams and rivers in the Great Basin flow into temporary lakes and "sinks" that grow and shrink with weather patterns. Examples include the Great Salt Lake of Utah and Mono Lake of eastern California.
- examples of rivers that drain internally into the Great Basin include the Humboldt in Nevada, the Sevier in Utah, the Amargosa near Death Valley, the Mojave in California, and the Truckee River that drains Lake Tahoe
- the largest river within the Great Basin is that of the Humboldt River, which flows east to west for 330 miles across Nevada. The Humboldt ends by simply disappearing via seepage and evaporation in the Humboldt Sink.
- many basins in the province have salt-encrusted dry lakebeds called **playas** spanning the lowest areas, evaporative remnants of what were once salty lakes that existed during wetter climates.
- as the land stretched across the broad Basin & Range (a geologic province), the central region sagged to form a vast area of internal drainage: the Great Basin (a hydrologic province)

Although the term 'Great Basin' suggests a bowl-like plain surrounded by high rims, the region is no less mountainous than any other part of the Basin & Range geologic province.

- during major glacial phases of the Ice Ages, the climate of the Great Basin was wetter and huge lakes occupied many of the basins – visited by mammoths, camels, wooly rhinos, cave bears, saber-toothed cats, and ancestors of horses
- the Great Salt Lake of Utah is a small remnant of a much larger Ice Age lake called Lake Bonneville

How do basins and ranges form in the B/R province?

Basin & Range Province originated due to **extensional forces** that have pulled apart the area, mostly over the past **16 m.y.** or so.

Extension is essentially "stretching" where tectonic stresses are directed away from each other

- recall that compressional tectonic stress generates **thrust faults**, like those that formed during the Laramide orogeny (80 to 40 m.y.)
- extensional stress, in contrast, generates **normal faults** due to crustal stretching (like the normal fault system along the eastern edge of the Sierra Nevada)

The direction of extension in the B/R is basically E-W, which pulls apart the brittle upper crust into N-S trending basins and ranges.

- the total amount of extension in the B/R is difficult to determine, but careful mapping and analysis suggests that the distance between Reno and Salt Lake City has doubled since before stretching began.

Extension of any rigid crustal block results in **normal faulting** where the block on one side of the fault drops downward relative to the upthrown block on the other side *(see Sierra Nevada notes)*

- with each fault rupture and consequent **earthquake**, the downthrown block slides and rotates – the end result is that, within individual fault blocks, the 'up-rotated' part of the block forms a mountain range while the 'down-rotated' part of the block forms an adjacent basin
- so a "**tilted fault-block**" may contain both an uplifted mountain range as well as a downdropped basin (the Sierra Nevada are a 'tilted fault-block' mountain range)

As the fault block tilts and rotates, rocks that were buried deep beneath the surface are lifted upward with each earthquake, exposing them to view along the faulted side of the range

- the ranges tend to be asymmetric, with steep escarpments along the faulted side (where the older previously buried rocks are exposed), and broad gently sloping opposite sides that merge with the flat basin floor
- the steep escarpments are the actual fault plane, modified by weathering and erosion
- the down-rotated basins act as catchments for several thousand meters of sediment eroded from the adjacent ranges (i.e., basins trap thick wedges of younger sediment eroded from the older rocks in the surrounding ranges)

At times, faulting and uplift may dominate and jagged ranges tower over the adjacent basin floors. But if uplift slows for whatever reason, then the ranges erode and the sediment is deposited within the surrounding basins. Ranges may become rounded and buried in their own sedimentary debris. (This latter case is why the Mojave Desert part of the Basin & Range has such subdued topography.)

What is the tectonic reason for extension in the Basin and Range?

Throughout the B&R, heat pours out of the crust at rates that average 50% higher than typical for the rest of the Earth – this implies that hot rock of the mantle is relatively close beneath the thinned and extended crust of the B&R

- one tectonic model suggests that the Farallon plate, which was relatively flat during the Laramide orogeny, slowly steepened after ~40 m.y.a. so that by ~16 m.y.a. sufficient depths were reached to permit partial melting of rock and heating of the underlying mantle. Hot mantle rock (and some magma) appears to be buoyantly rising directly underneath the Basin & Range, flexing the overlying crust upward and causing extension. The buoyant mass of hot mantle generates the high heat flow and high elevations.

Evidence for this model is provided by abundant late Cenozoic **volcanic rocks** that range in age from about 16 m.y. to very recent (a few hundred years old) throughout the Basin and Range. It would not surprise geologists if a small volcanic eruption occurred today in the B/R.

- the very common occurrence of **hot springs** throughout the Basin and Range are further evidence for high heat flow throughout the region (groundwater gets heated by hot rock a few km beneath the surface then rises back up along joints or faults to flow onto the surface as a hot spring)

The B/R province is still undergoing active extension, as marked by countless small **earthquakes** punctuated by occasional bigger jolts

- when an earthquake occurs in the B&R, a normal fault has ruptured, accompanied by the abrupt uplift of a range and associated downdropping of the adjacent basin

A website with relevant material if you're not using the textbook

Wikipedia – Basin and Range Province

https://en.wikipedia.org/wiki/Basin_and_Range_Province

Internships with the National Park Service

https://www.nps.gov/subjects/youthprograms/jobs-and-internships.htm

Not sure if this program still exists under the current administration.
