GEOLOGY 25 - LECTURE 7C

National Parks of the Basin and Range: *Grand Teton NP*

Textbook Ch. 25

Grand Teton National Park

The Teton Range viewed from the east is one of the most spectacular vistas in America.
- geographically it resides within the central Rocky Mountain province, but geologically it's a basin-and-range type of "**tilted fault block**" mountain range. We might say that it's a slice of the Basin-and-Range superimposed on the margin of the Rocky Mountains.
- located in northwestern Wyoming, just south of Yellowstone NP
- established as a national park in 1929
- NP includes the Teton Range, about 45 miles long, and the adjacent valley to the east, Jackson Hole (a flat-floored basin to the east filled with sediment and Jackson Lake)
- drained by the Snake River
- "Hole" is a term used by the fur-trapping mountain men in the 1830s to describe a high elevation valley surrounded by mountains.

The **Snake River** originates in the Yellowstone country then flows south through Jackson Hole, then westerly into Idaho where it meanders through the Snake River plain. The river turns north and marks the boundary with Oregon, before it ultimately merges with the Columbia River in Washington. So snowmelt and rainfall that originates in Grand Teton national park eventually flows westward into the Pacific Ocean drainage.

The highest peak in the range, Grand Teton, reaches 13,770' in elevation while the very flat valley floor of Jackson Hole rests around 6000' - so over 7000' of **relief** (i.e., elevation difference) between the valley floor and the highest peaks.
- change in relief occurs over a relatively short distance, so the slopes of the eastern Teton front are extremely steep. The western front facing Idaho is less steep because of the westerly tilt of the **tilted fault-block** Teton Range.

Rocks of the Grand Tetons

The rocks that dominate the core of the Tetons are **Precambrian** age (2.5 to 2.8 **billion** years old) and are primarily composed of **gneiss**, a metamorphic rock that formed by intense pressures and temperatures acting on older sedimentary and igneous rocks during an ancient phase of mountain-building in the Teton region.
- these are some of the oldest rocks in the national park system
- remember that **metamorphism** is the transformation of minerals composing a rock into a different set of minerals under conditions of very high temperatures and pressures
- metamorphism of the rocks composing the Tetons likely occurred during a Precambrian phase of mountain-building. These older rocks were later intruded by granitic magma, and both were intruded even later by different magma that pushed into cracks deep underground.
- these rocks are old 'basement,' now lifted up to >13,000' in elevation (about a billion years older than the basement rocks of the lower Grand Canyon) (essentially, the PC metamorphic rocks formed within an ancient PC mountain range are re-exposed today in the modern Teton Range)

- Paleozoic sedimentary rocks overlie the Precambrian rocks of the Teton Range along the western flank of the range, tilted downward toward Idaho to the west. These rocks are the northern equivalents to the Paleozoic rocks we saw in the Grand Canyon and they record the same transgressions and regressions of the shoreline across western North America. (the tilting occurred as the mountains were being uplifted, as described just below.)

Uplift of the Teton Range

The Tetons and adjacent Jackson Hole were formed by **extensional tectonics** (related to Basin and Range extension) that uplifted the Tetons and tilted them toward the west while down-dropping Jackson Hole

- the Tetons and adjacent Jackson Hole are separated by the **Teton Fault**, a 45-mile long, steeply dipping **normal fault** that extends north-south along the base of the Teton Range
- the range is asymmetric, steeper near the Teton fault and gently tilted westward toward Idaho to the west
- offset along the Teton Fault, earthquake-by-earthquake, has raised the old Precambrian rocks up to form the highest peaks of the range while tilting the overlying Paleozoic sedimentary rocks downward to the west
- uplift of the modern Tetons began only about **5 million years ago** and the Teton fault is considered active today even though it has been seismically quiet over the recent past (i.e., the Tetons are still undergoing uplift)

The rocks that compose the basin fill of Jackson Hole are mostly Cenozoic and consist of a variety of sedimentary rocks (conglomerates, sandstones, shales) eroded from the rising mountain range as well as volcanic rocks related to Yellowstone volcanism.

- the rocks filling Jackson Hole are about 9 km (>30,000') in thickness and record the rapid uplift of the adjacent range and their equally rapid erosion
- in essence, the rocks filling Jackson Hole are the accumulated debris shed off of the Tetons as the range was uplifted and the basin downfaulted (so the Cenozoic rocks of the basin are younger than about 5 m.y., the beginning of uplift and erosion)

The Teton fault has repeatedly and violently broken the earth, producing a few thousand magnitude 7.0-7.5 earthquakes during the past 5 m.y.

- during each quake, Jackson Hole dropped downward and the Teton Range rose upward by about 2-3 m, sometimes less, sometimes more.
- sediments eroded from the mountains fill the sinking valley to keep it relatively flat.
- a near-vertical **fault scarp** along the base of the Tetons is the surface exposure of the planar face of the Teton fault created during earthquakes over the past few thousand years. (a fault scarp is simply the surface expression of the fault plane where it breaks the surface, typically as a steep cliff-face)
- in time, the fault scarp erodes and the adjacent basin fills with sediment derived from the nearby mountains
- the time span between major earthquakes on the Teton fault is difficult to determine accurately, but a reasonable calculation is once every few thousand years.
- the last earthquake with a magnitude >7.0 on the Teton fault occurred between 4800 and 7100 years ago.

- geologists think the fault is temporarily locked and wouldn't be surprised to see another major earthquake on the Teton fault today. It's been rupturing with regularity for the past 5 m.y., so there's no reason to think that it won't rupture for the next 5 m.y.

Glacial Modification of Grand Teton NP

The jagged, serrated profile of the Teton Range was created by glacial action during the recent Ice Ages of the last 2.6 m.y.

During the **Last Glacial Maximum** ~20,000 years ago, a huge **ice cap** was centered over the Yellowstone Plateau to the north of the Tetons. The ice cap was over 1 kilometer thick and sent lobes outward in all directions toward lower elevations. One of these lobes extended southward across what is today Jackson Hole and reached a thickness of about 2000'.

- the peaks of the Tetons poked up above the ice like rocky islands. Alpine glaciers carved their way downslope across the Tetons, eventually merging with the lobe of the Yellowstone ice cap flowing south.
- alpine glaciers modified old stream valleys into the U-shaped valleys we see today.
- alpine glaciers descended from the peaks toward the surrounding ice sheet, carving amphitheater-like **cirques**, **U-shaped mountain valleys**, **hanging valleys**, and **arêtes**,

Glaciers transport enormous amounts of sedimentary debris within the body of the ice as well as on the top of the glacier. Glaciers also push along eroded material in front and along the sides as they ponderously flow downslope.

- when the glacier reaches its maximum extent and starts to melt, it releases this debris along its sides and toe, forming a curving ridge of unconsolidated material of all sizes. This ridge of rocky debris is called a **moraine**.
- moraines that mark the peak extent of the glacier's downslope movement are called '**terminal moraines**.'

Terminal moraines act as natural dams that trap glacial meltwater in the depression between the moraine and the receding glacier.

Jenny Lake is one of a string of lakes that formed in a similar fashion along the base of the Tetons.

- several of the modern lakes aligned along the base of the range in Jackson Hole exist due to morainal ridges along their eastern flanks left behind as alpine glaciers receded back up toward higher elevations during warmer interglacial phases
- each of the lakes was impounded behind the natural dams formed by terminal moraines and are fed by snowmelt from mountain streams
- many smaller lakes are currently being filled in with sediment and are well on their way to becoming meadows.

Today there are nine small active glaciers tucked away in the shadows of the highest peaks. These glaciers are **not** the remnants of the huge Ice Age glaciers that receded over the past 20,000 years or so. The small glaciers of the Tetons, and the glaciers of many other national parks, are the remains of glaciers that grew during the **Little Ice Age** that occurred between the years 1350 and 1850. This global cold phase lasted for a few centuries and its glacial vestiges are still with us today.

Grand Teton national park is one of those iconic places that we associate with the American West. Be sure to visit it soon to see very old rocks and very young mountains.

Best hikes in Grand Teton NP
https://www.earthtrekkers.com/best-day-hikes-grand-teton/

A few websites with relevant material if you're not using the textbook
National Park Service – Geology of Grand Teton NP
https://www.nps.gov/grte/learn/nature/geology.htm
NPS animation of the geologic history of the Grand Teton region
https://www.nps.gov/grte/learn/photosmultimedia/geo_film.htm
Wikipedia – Geology of Grand Teton NP
https://en.wikipedia.org/wiki/Grand_Teton_National_Park
