GEOLOGY 25 - LECTURE 4B

National Parks of the Cascades: *Crater Lake NP, Lassen Volcanic NP*

[Textbook Chs. 15, 16 & 1 (p, 5-7, 10-13)

Crater Lake National Park

Located in the Cascades of southern Oregon, Crater Lake became a national park in 1902
Crater Lake, about 5 miles across, reaches a depth of 1950', the deepest lake in North America
- steep walls surrounding the lake average ~1000' above water level
- visually stunning, with forested lands surrounding an aquamarine lake
- entire region is volcanic in origin, with volcanic rocks covered by a veneer of soil and forest; same with the lake: volcanic rocks beneath the water

Crater Lake has a water clarity unmatched by any other lake in N.A., with visibility to depths of 325' (visibility in Lake Tahoe, about 1650' deep, is <100')
The hydrology of Crater Lake is a closed basin, where the amount of water entering the lake is balanced by the loss of water outward. There are no perennial streams that flow into the lake and none that allow water to drain outward from the saucer-shaped depression. Water is added via abundant snowmelt and rainfall directly within the lake basin.
- the boundary of the watershed (drainage basin) of Crater Lake runs along the rim of the cliffs circumscribing the lake
– high rainfall and snowfall in the crater is balanced by evaporation as well as seepage of water through the surrounding rocks that eventually exits as springs along the outer flanks. So the elevation of the lake remains stable.
- the input of sediment as well as the supply of nutrients (like phosphorus and nitrogen) that algae need to grow is very low due to the lack of inflowing streams. So the water stays exceptionally clear.

Crater Lake should technically be called "Caldera Lake" since it's not a single simple crater, but rather an enormous collapsed **caldera** left behind after a cataclysmic eruption about **7700 years ago**.
- a **crater** is a near-circular vent in a volcano created during eruptions, whereas a **caldera** is typically a much larger depression that forms by the catastrophic vertical collapse of the volcanic crest to form a basin.

The volcano that existed prior to the caldera eruption is called **Mt. Mazama**, a **stratovolcano** similar to most other Cascades volcanoes, that rose to an estimated elevation of ~12,000'
- Mazama began growing ~420,000 years ago, based on the radiometric age of the oldest rocks composing the volcano. Over the intervening years prior to the eruption of 7700 years ago, episodes of volcanic growth alternated with episodes of erosional decay. Ice Age glaciers carved at the flanks of Mazama, wearing away the volcanic rocks comprising its bulk.
- the walls of Crater Lake reveal the interior anatomy of Mazama and permit geologists to reconstruct its growth and evolution prior to its eruption of 7700 years ago
- geologists from the USGS and universities mapped the various volcanic units comprising the region, collected samples for geochemical analysis, and dated the samples using radiometric methods

Caldera eruption of Mt. Mazama

The climactic **caldera eruption** of Mt. Mazama occurred about 7700 years ago (~5700 BCE)
The event began with an explosive pyroclastic eruption from the crest of Mazama, powered by pent-up gas pressure released from the magma chamber. The sound must have been deafening to the few thousand Native Americans in the area.
- the ash was blown to the east and northeast by prevailing winds, with much of the debris falling back to earth and blanketing a huge area in ash over the next few days as a **pyroclastic fall**
- the eruption might have lasted for a few days to maybe a few weeks, or it may have occurred episodically over a few months
- so much ash and gas was blasted out of the summit crater on Mazama that a large portion of the underlying magma chamber was emptied. The upper summit of the volcanic cone was now unsupported from beneath – fractures formed in the shape of concentric rings around the summit and eventually the entire upper cone collapsed as a chaotic pile of blocks back into the volcano's center, forming the caldera.

Within a few hundred years after the main eruption, remnant lava oozed out onto the caldera floor and cinders were blown out of a small vent, constructing a cinder cone that would become Wizard Island (more below)
- as the caldera cooled with time, rain and snowmelt accumulated in the basin, eventually filling it to today's level of about 6200' elevation

The cinder cone of Wizard Island rises 800' above lake level and contains a crater 90' deep at the crest

A **cinder cone** is a steep-sided, symmetrical landform composed of sand-sized volcanic particles formed as magma explodes into the air then rapidly cools, falling back onto the cone as angular, pebble-sized fragments called **cinder**. Lava flows may emerge laterally from the base of the cone since the strength of the cinder pile is not great enough to support the internal flow of molten rock. (we'll talk more about cinder cones when we visit Lassen Volcanic NP)

Mazama ash fell across a huge area, reaching southern Canada, northern California, and as far east as Yellowstone. This volcanic hazard is called a **pyroclastic fall**, where winds transport ash downwind until it eventually settles out across the landscape.
- Mazama ash layer is several hundred feet thick near the park, thinning to a few inches at its distal edge a few hundred miles to the northeast
- the ash kills much of the vegetation beneath by cutting off access to sunlight and the effects cascade up the food chain. The animals that depend on the vegetation die of starvation.
- about 12 cubic miles of pyroclastic material were erupted during this single event. (for comparison, ~ 0.5 cubic miles of pyroclastic debris was erupted from Mt. St. Helens in 1980)

What is the possibility of a future eruption at Crater Lake? An eruption of the magnitude of the climactic event 7700 years ago is very unlikely anytime in the near future. It's been loosely estimated that it takes about 20,000 years for magma to replenish the chamber a kilometer or

two beneath the lake, so there are several millennia yet to go before another catastrophic eruption is expected.

Great hikes in Crater Lake NP: https://westcoastwayfarers.com/best-crater-lake-hikes/

Lassen Volcanic National Park

Southernmost volcano of the Cascade Range, Lassen Volcanic NP is located near the northern margin of the Sierra Nevada
- Lassen Peak is the volcano that forms the centerpiece of the park and is located due east of the southern margin of the Cascadia subduction zone
- Lassen Peak is 10,457' high, established as a NP in 1916

Lassen Peak forms the world's largest **volcanic lava dome** – characterized by a massive, rounded plug of rock that oozed up as thick, pasty lava through a vent, eventually solidifying as a rounded mass near its origin. (Lassen Peak is not a stratovolcano, unlike the rest of the Cascades volcanoes.)
- (a "vent" is a general term for a location on the surface where lava or ash has erupted. Vents could be a crater at the top of a volcano, a fissure running along the flank of a volcano, or a crater-like opening along the flank of a volcano)
- the current dome of Lassen Peak arose only about 27,000 years ago

The Lassen volcanic dome grew from the core outward – new lava flows near the central crater pushed older lava flows to the side, building steep-sided, rubbly flanks.
- so volcanic domes like Lassen are oldest on the flanks and youngest toward the interior of the dome
- the modern appearance of Lassen Peak was smoothed and modified by alpine glaciers that left a veneer of rubble on the surface after the ice had melted
- even though no glaciers exist in the park today, the effects of Ice Age alpine glaciation are widely exhibited throughout the park. (more on Ice Age glaciation when we get to the Sierra Nevada).

Lassen Peak originated about 27,000 years ago from a volcanic vent north of an ancestral precursor volcano that geologists call **Brokeoff stratovolcano**
Brokeoff went extinct after its last major eruption ~400,000 years ago. It's been eroding ever since, mostly due to glaciers scraping away at it. The natural volcanic "plumbing system" beneath Brokeoff shut down, with a subterranean connection diverted to the north to feed magma to Lassen Peak beginning around 27,000 years ago.

Repeated eruptions from Brokeoff depleted the magma of gases. By the time the lava oozed out of a lateral vent to create the volcanic dome of Lassen Peak, the lava was thick and sticky, empty of gas pressure.
- the "thick and sticky" lava oozed out of the summit craters, pushing the older lava rock laterally and building the structure of the Lassen volcanic dome outward over time
- Lassen Peak also erupts in small pyroclastic explosions of volcanic ash and larger blocks of rock blown out from the crater

Recent eruptions at Lassen . . . .

Lassen lay dormant for about 26,000 years till it re-awoke to erupt episodically from 1914-1921
- during that long dormant phase, gased accumulated within the magma chamber below the volcano, increasing its explosive potential
- the eruptions of 1914-1921 included pyroclastic falls, pyroclastic flows, and lava flows

The largest eruption at Lassen Peak was a pyroclastic eruption in 1915, blasting a column of volcanic ash 9 km into the atmosphere and creating a **pyroclastic fall** that was blown downwind all the way to central Nevada. (see earlier notes for Crater Lake on pyroclastic falls)
- no one died, only local property damage
- a volcano that erupts this recently in time is considered "active" and capable of another eruption in the future (how long in the future is uncertain)

As the upward thrust of gas pressure began to dissipate, the eruption column partially collapsed under its own weight, generating a **pyroclastic flow** that scoured the northeast flank

pyroclastic flows – consist of masses of ash, hot poisonous gases, and blocky debris that flows rapidly (up to 90-100 mph) down the slopes of the volcano, often following stream channels
- temperatures may reach 1500°F
- destroys all vegetation and animal life in its path, even scouring and ripping up much of the surface soil
- may extend for tens of miles beyond its source, driven by a cushion of hot gases trapped below the flow and its own momentum, before eventually settling out as an ash deposit

Later events after the 1915 pyroclastic eruption were smaller, dissipating over the next few years.
- a series of summit craters developed in the dome
- the total volume of material ejected during the 1915 eruption of Lassen Peak was about 0.007 mi^3, a very small amount relative to the 1980 eruption of Mount St. Helens, which emitted about 0.5 mi^3 or the eruption of Mt. Mazama that erupted 12 mi^3 of pyroclastic debris
- volcanic rocks formed in this eruption are the youngest in California

Cinder cones & lava flows

Cinder cone volcanoes are common in Lassen Volcanic National Park, but the youngest is the appropriately named **Cinder Cone** in the northeast corner of the park. Erupted in the year 1666, the cone looks young and fresh. (the age of Cinder Cone was determined from radiocarbon dating of carbonized trees trapped in the cinders)
- the cone volcano itself is a symmetric accumulation of countless pebble-sized particles of 'cinders,' formed as lava was propelled outward from a central vent by moderate gas pressures.
- this style of volcanism is called a **Strombolian eruption**, named after the Italian volcanic island that has been continuously active for the past two millennia. Particles of cinder are formed as droplets of incandescent lava cool and solidify as they come in contact with the atmosphere during eruption.
- it's probable that Cinder Cone, like many cinder cones, was formed over only a few months of volcanic activity. Native Americans likely watched it grow.

The loose pile of particles composing a cinder cone tends to be structurally weak, so lava flows may erupt from the lower flanks of the cone rather than from the unstable summit crater.
- one lava flow from Cinder Cone blocked a creek to form Snag Lake, whereas another lava flow spilled into Butte Lake

Hydrothermal features

Hydrothermal ("hot water") features are commonly formed from vents in the ground surface that emanate hot water or gases.
- the most varied hydrothermal area in Lassen is Bumpass Hell, but many others dot the landscape
- the light-colored ground surface around the hot springs is composed of clay- and silica-rich minerals formed by the in-place alteration of volcanic rock by hot, acidic fluids percolating through the ground
- **hot springs** commonly form colorful pools where the water temperatures may be greater than 90°C (~200°F)
- **fumaroles** are vents in the surface from which steam and gases are emitted. Big Boiler, a fumarole in the Bumpass Hell area, has temperatures measured as high as 161°C (322°F), among the hottest in the world.

The hydrothermal system at Lassen reflects the interaction of snowmelt and rainwater with magmatic heat.
- water from the surface filters downward through cracks in the rock until it encounters hot rock surrounding a magma body (perhaps 5-8 km in depth)
- the heated water rises buoyantly through natural fractures and pipes where decreasing pressures allow vapor to be emitted within fumaroles. In other places, the hot water emerges as hot springs
- as the water rises through the body of rock toward the surface, it dissolves sulfur and other elements from the rock, making the water slightly acidic. These corrosive waters alter solid rock to colorful clay minerals, giving hydrothermal areas their strange light coloration.

The active hydrothermal areas within the boundaries of Brokeoff Volcano today - such as Sulphur Works, Bumpass Hell, and Hot Springs Valley - are surface expressions of the network of fractures that connect with the magma chamber at depth. When you drive the main park road through the southwest corner of the park and stop intermittently to visit the hydrothermal areas, you are traversing the deeply eroded interior of Brokeoff Volcano.

There is no reason to think that Lassen Peak will not erupt again sometime in the near future. The entire Lassen region is designated as a "high threat" by the U.S. Geological Survey due to the active magma chamber beneath the surface, the recent volcanism at Lassen Peak, the seasonal presence of park visitors, and the proximity of human-made structures.

When you visit Lassen, be sure to climb the trail to the top of the peak. It's about 2000' up over 2.5 miles. It's not every day that you get a chance to climb a volcano.

Great hikes in Lassen Volcanic NP: https://ourwanders.com/8-best-hikes-lassen-volcanic-california/

Be sure to download Tour de Volcanoes from Files in Canvas and plan a volcanoes road trip with friends or family.

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

National Park Service – Geology of Crater Lake NP
https://www.nps.gov/crla/learn/nature/geologyresources.htm

Wikipedia – Geology of Crater Lake NP
http://en.wikipedia.org/wiki/Crater_Lake_National_Park

National Park Service – Geology of Lassen Volcanic NP
https://www.nps.gov/lavo/learn/nature/naturalfeaturesandecosystems.htm

Earth magazine – Geology of Lassen Volcanic NP
https://www.earthmagazine.org/article/travels-geology-lassen-volcanic-national-park-volcanic-wonderland

Wikipedia – Geology of Lassen Volcanic NP
https://en.wikipedia.org/wiki/Geology_of_the_Lassen_volcanic_area