

Final paper of Geology G188
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The glacier of Yosemite National Park

Abstract: Domes, waterfalls, U shape valleys and cliff can be widely seen in Yosemite National Park. These landforms are all created by glaciation, especially the Wisconsin glaciation. (Kiver and Harris) Domes such as the Lembert Dome and Half Dome are strongly influenced by plucking and abrasion. (Wikipedia website) The U shape valleys and cliff such as El Capitan is also carved by glaciers. (Wikipedia website) Thus, Yosemite National Park is the masterpiece of glaciation.

1. Yosemite National Park

Yosemite National Park located in California, reaching across the western slope of Sierra Nevada. It's 747,956 acres in size. It belongs to the National Park Services. Specially, Yosemite is famous for its "granite, waterfalls, clear streams, giant sequoia groves and biological diversity" (Wikipedia website). Yosemite Park was generated from Yosemite Valley. In 1864, Yosemite grant was signed by President Abraham Lincoln. Later on, John Muir built a much larger National Park which included much more than Yosemite Valley alone. In 1984, the Park became a "World heritage site" (Wikipedia website)

Yosemite National Park is the home for a large variety of plants and animals including some rare ones because of the unique geology formations and the composition of soil. Besides, 89 per cent of the National Park was characterized as "Yosemite Wilderness", which is a highly protected area. People have made huge effort to protect the "Yosemite wilderness". For example, buses are created to be quiet and without pollution. (Wikipedia website)

Yosemite is also famous for its spectacular landform. Generally speaking, Yosemite National Park is widely known for granite, glacier erosion and rockfalls. Especially that glacier plays an important role of shaping Yosemite's spectacular landform. (Wikipedia website)

2. Glaciers

Glacier is a huge block of ice that formed long time ago which moves slowly, originating from "accumulation", "compaction" and "recrystallization" of snow. (Lutgens and Tarbuck) The growth of glacier starts from snowflakes. After that, snow flakes become "powdered snow", "powdered snow" become "old snow", "old snow" becomes "firn," "firn" becomes glacier. The whole process lasts for hundreds of years in total. During the formation, the "ice-snow mass" become heavy and stronger with time.(Hill 2006) Glacier belongs to both rock circle and hydrologic circle. Water in high altitude and high elevation can be stored in glacier for very long time. In general, glaciers are located all over the world. But at the same time, most of them are found in remote areas. Glaciers are sorted in four different kinds: alpine glaciers, ice sheets, ice caps and piedmont glaciers based on their distinctive features. (Lutgens and Tarbuck) While sierra Nevada is known for alpine glaciers, the glacier which is much warmer than ice sheet. (Hill 2006) The margin of glacier can be advancing, retreating and stationary depends on the balance of the accumulation and wastage. Generally, glaciers can erode in two ways, plucking and abrasion. More specifically, plucking means the putting the rocks into the ice. While abrasion means using the ice and rock fragments to polish the bedrock. At the same time, glacier can also work for deposit. Since it can transform huge amount of debris.

Moreover, both glacier erosion and glacier deposit can form landform. For example, glaciated valleys, cirques, arêtes and horns, fiords are created by glacial erosion. Moraines are created by glacier deposit. By the way, glaciers not only contribute to the landform in the past, but also contribute to the landform in the present days. (Lutgens and Tarbuck)

3. Glaciers and its controversy in Yosemite

Yosemite is a great example of alpine glaciation. (Kiver and Harris 2005)

The birth of Yosemite started with the birth of Yosemite Valley. 25 million years ago, the Merced River eroded a deep V shaped valley with the uplift and tilting of mountains. Then, about a million and a half years ago, the most extensive glaciers formed because of the unique climate. Furthermore, the glaciers from crest of mountains ran down in to the valley for at least three times. Finally, it becomes a major trunk glacier. Later on, the glacier made the valley wider, straighter and deeper. And the V shaped valley became a U shaped valley. After that, glaciation happened a couple times, making the Yosemite Valley full of ice. What need to be noticed is that some valleys are filled with smaller tributary glacier instead of majority of large “trunk glaciers”. Specifically, tributary glaciers are very hard to see compared to “trunk glaciers”. When glaciers melted, the valleys with tributary streams were far above the other valleys. Although the glaciation mentioned above is a millstone, it has been partly erased by the later ones. The most remarkable glaciation nowadays is those happened 20000 years ago since it left moraines, hanging waterfalls and Lake Yosemite. (Hill 2006) One of them is called Wisconsin Glaciation. (Kiver and Harris)

Although Yosemite National Park is widely known for glaciers nowadays, there used to be a debate of whether there were glaciers in Sierra Nevada area between two scientists Josiah Dwight Whitney and John Muir. They are both well-known scientists in Sierra Nevada area in late 1800s. Mt Whitney and Mt Muir in Sierra Nevada are named after them. In 1871, Muir claimed that he found a living glacier called “Maclure glacier” in sierra. Furthermore, Muir made an experiment next year which proved the glacier he found was actually moving. But Whitney, who always claimed that there weren’t any glaciers in Sierra Nevada, didn’t agree with him at all. While another guy, Clarence King, who agreed with Whitney’s idea said that motion alone wouldn’t prove the existence of glaciers. During 1871 and 1872, both Whitney and Muir wrote books to claim their opinion on the glaciers in Sierra Nevada. At the same time, the study of glacier during 1870s wasn’t very mature. Glaciology relied on observation much to some extent. Although Tyndall (a geologist) used surveying equipment to made his experiment of glaciers more accurate. (Hill 2006)

4. The bedrock of Yosemite Valley

Bedrock floor in Yosemite Valley is a wavy surface with three basins and a total bedrock closure. The bedrock covers the Yosemite Valley from the top to the bottom steeply. Because of the pre-Wisconsin glaciation, the glacial excavation on the bedrock floor doubled 450 meters. Besides, the deepest excavation is in massive granite rocks. Furthermore, the effective erosion is created by the combination of exfoliation sheeting and compressive flow in the glacier. (Gutenberg et al 1956)

23 sites along Tuolumne River valley and five sites in Tenaya Canyon in Yosemite National Park were chosen to study the role of rock jointing on glacial erosion rates. Cosmogenic ^{10}Be is used in glacial polish and

measurement of bed rock fracture in order to study the connection between erosion rates and bedrock fracturing. While the ^{10}Be concentration yielded by most sites reflects postglacial nuclide accumulation alone. The high concentration yielded by six sites implies incomplete removal of pre-glacial nuclide inventory from last glaciation. The data indicates that the distance between fractures in bedrock, controls the pace of glacial erosion in Yosemite. (Duhnforth et al 2010)

5. The domes in Yosemite

Yosemite National Park is famous for domes.

The half dome located at the eastern end of Yosemite Valley in Yosemite National Park. The elevation is about 2695 meters in height. There's a noticeable phenomenon of half dome: the northwest side of the dome is almost as steep as the southeast side. George G. Anderson conquered half dome in 1875, breaking the claimed made by Whitney that the half dome was "perfectly inaccessible". (Wikipedia)

The half dome in Yosemite is a granitic exfoliation dome. Besides, it's a well- formed half dome, which is very rare in the whole world. Although people originally consider that the northwest side of the half dome has been removed by glaciers. It's likely that the half dome was born to be half. (Kiver and Harris 2005)

The shape of domes in Yosemite is irregular due to the trend of master fractures that bounded the monoliths initially. But half dome is different from them. Since the northwest side of dome has been exposed to glacier plucking before long, the glacier didn't have enough time to make it angular. Thus it's still plane compare to many domes just as the southeast side of dome does because of exfoliation. (Matthes 1930)

Lembert Dome is a granite dome located in Yosemite national park. It was named after Jean Baptiste Lembert. The elevation of Lembert Dome is 2882 meters. (Wikipedia website)

Lembert Dome is distinctly elongate and asymmetrical. Since it was overridden and reshaped by glaciers. The up-glacier end was polished by abrasion and the down-glacier end was influenced by plucking, making it a steep cliff. (Kiver and Harris 2005) A lot of glacially polished domes such as the Lembert Dome are located near the low-gradient, broad Tuolumne shadow. (Duhnforth et al 2010)

6. The glacier point.

Glacier point is a point for view located on the south wall of Yosemite Valley and above Yosemite Valley. The elevation is about 2199 meters. It's a great place to observe Yosemite Valley, including Yosemite falls, half dome, Vernal Falls, Nevada Falls and Clouds Rest. (Wikipedia website)

The glacial materials are abundant on glacier point such as the hollow to the west and the wooded slope. But the extreme point of the promontory of Glacier Point does not include any glacial material. The rocks of glacial point are derived from Little Yosemite Valley and high sierra is the evidence of the glacial origin. (Wikipedia website)

Three types of glacial-deposit rocks are found at glacial point. Most of them are deeply-weathered rounded boulders and cobbles and angular fragments. But they're also two other types of rocks. One is coarse-grained, highly siliceous granite, deriving from Mount Clark. Another one is Fragments of yellowish quartzite and gray schist originated from the long northern spur of Mount Clark. (Wikipedia website)

7. Hanging valley and waterfalls.

Glaciers created hanging valleys that contain large waterfalls such as Bridal Veil Falls and Yosemite Falls. (Kiver and Harris)

A hanging valley is a tributary valley which is taller than the main valley. Hanging valleys are closely related to the U shaped valley created by the main glacier erosion. More specifically, the main glaciers erode deep valleys with nearly-vertical sides. While tributary glaciers erode shallower valleys (hanging valleys) since the tributary glaciers generally contain a smaller volume of ice. Hanging valleys are also the products of varying rates of the main valleys and tributary valleys. The tributary valleys are eroded at lower rates compared to main valleys which is closely related to the composition of adjacent rocks. Generally, the tributary valleys hang over the main valleys because they contain more resistant rocks.

(Wikipedia Website)

The hanging of a tributary valley is the result of alpine glacial erosion for 10^4 to 10^5 years. A numerical model of glacial erosion driven by the past 400k.y. of variable climate is used to explore the development of longitudinal profiles of glacier valleys. The locus of most rapid erosion is expected to follow the transient ELA (equilibrium-line altitude). A step which immediately down valley of the tributary junction that persists over multiple glaciations and leaves tributary valleys hanging is created by inclusion of a tributary glacier. Steps are the results of an increase in ice discharge immediately below the tributary junction, which is related to an increase in thickness and sliding rate. The size of the step is proportional to the ratio of tributary to trunk ice discharge. The height of a hanging valley is inversely proportional to the discharge ratio. Since it reflects the difference in time-integrated ice charge in tributary and trunk valleys. (MacGregor et al 2000)

A waterfall is a place where water flows over a vertical drop in a stream or river. Waterfalls are commonly formed in upper course of river where the channel is often narrow and deep. Downstream the erosion happens more rapidly compare to upstream. The erosion capacity is increased by whirlpools created in the turbulence and sand and stones carried by watercourse. Materials are plucked from the riverbed by waterfalls. (Wikipedia website)

Bridalveil Fall is 188 meters in height. The hanging valleys in Yosemite generate waterfalls which run into Yosemite Valley. Unlike many other waterfalls, the waterways which fed these don't carve the hanging valleys. Although the edge of the cliff moves back into an alcove from the original edge of the valley, Bridalveil Creek still runs into the valley from the edge of cliff. (Wikipedia website)

Yosemite Falls is the highest waterfall in Yosemite National Park. The total height of the waterfall is 739 meters. The Yosemite Falls contain three sections: Upper Yosemite Fall, Middle Cascades and Lower Yosemite Fall. Unluckily, sometimes the falls do not flow altogether because of the lack of snow. The upper fall is among the twenty highest waterfalls in the world. After going through Eagle Creek Meadow, Yosemite Creek hurl itself over the edge of hanging valley with great force. The height of Middle Cascades is 206 meters, which is not visible from the valley. The lower Yosemite Fall is 98 meters in height. The base of the Lower Yosemite Fall is where Yosemite Creek emerges. (Wikipedia Website)

8. El Capitan.

El Capitan located on the north side of Yosemite Valley. It's a famous place for rock climbing. The elevation is 2308 meters in height. The cliff is covered almost entirely with EL Capitan granite, a pale, coarse granite,

extending 900 meters. El Capitan granite is under enormous internal tension just as many other formation of rocks in Yosemite. (Wikipedia website) At the same time, El Capitan is influenced by exfoliation. Since the granite is relatively non-jointed, the expansion happens mostly at the surface of earth. (Kiver and Harris)

El Capitan is carved mainly by Sherwin Glaciation. Since El Capitan isn't as jointed as many rocks nearby, the rock face of El Capitan isn't eroded by glacial ice very much. (Wikipedia website)



El Capitan. Figure reproduced by Wikipedia Website.



Half Dome. Figure reproduced by Wikipedia website.



Lembert Dome. Figure Reproduced by Wikipedia Website.

The Yosemite fall. Figure reproduced by Wikipedia website.

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