Yosemite 3

1. Mesozoic magmatic madness ends in the Cenozoic.
2. As it did during the Nevadan Orogeny, the Farallon Plate continued to subduct under North America …
3. … but the accelerating westward motion of the North American Plate ….
4. … combined with ever younger and more buoyant crust arriving at the subduction zone…
5. … caused the uplift and erosion of the leading edge of the North American Plate. By the Mid-Cenozoic erosion had exposed the Sierra Nevada Batholith and a vast peneplain sloped towards the ocean.
6. Across this peneplain the Merced and several other Sierra Nevada rivers flowed. Because the gradient was very low, these rivers did little down-cutting.
7. But that will change considerably when the arrival of the Pacific Plate at the trench changes stress patterns from compression to shear stress and extension. Not only did this event initiate the formation of the Basin and Range Province …
8. … but at the same time the entire Sierra Block uplifts along a regional-scale normal fault.
9. That creates a steep fault escarpment bordering the Basin and Range Province on the east side of the Sierra Nevada, …
10. … and an arrangement similar in appearance to the Grand Tetons.
11. At 11,000 meters, displacement on the Sierra fault is much less than on the Teton Fault, but that uplift is very young and it has been accelerating. Uplift tilted the Sierran Block to the west, greatly increasing stream gradient for the main east-west flowing streams like the Merced, but it had much less effect on the more north-south oriented tributaries.
12. This caused the old, relatively stable Merced River …
13. … to down-cut into its canyon…
14. … and to a much lower elevation along the high gradient main channel relative to its low gradient tributaries. The smaller, less down-cut tributaries dropped-off steeply where they entered the main canyon, forming “hanging valleys”.
15. Pleistocene glaciation will accentuate this relationship …
16. … as large glaciers have far more erosive power than small glaciers.
17. Although hanging valleys are certainly a characteristic feature of glaciated landscapes, the exceptional drop-offs of Yosemite’s are in part due to pre-existing hanging valleys created by river erosion.
18. All that uplift and erosion unloaded the weight of 1000’s of meters of rock overlying the plutons.
19. The resultant reduction in pressure was one of the main reasons for the formation of joints within the plutonic rocks. Joints are rock fractures along which no displacement has taken place. Three joint types occur in Yosemite National Park and they play a major role in the development of many of the park’s landforms. Master joints are regional in extent, but widely spaced.
20. Half Dome’s near-vertical north face is a prime example of a master joint. Such joints probably are related to regional tectonic stress.
21. From this rarely seen aerial perspective of Half Dome you can see a second master joint shaping its back side.
22. Looking straight down on Half Dome you can see how its shape is not truly dome-like but, rather, is distinctly elongated parallel to the master joints.
23. A complex system of more closely-spaced, “lesser joints” lie buried beneath the valley’s sediments, weakening the rock and facilitating both stream and glacial erosion. Such joints can form by contraction associated with pluton cooling.
24. The third type of joint, the skin-like “sheet joints” are most obvious on the top of Half Dome, …
25. … which can be accessed via the infamous cable route. From this perspective you can see that Half Dome is more of a rounded-off vertical slab rather than a semi-circular dome.
26. The rounding is due to the action of sheet joints which are prominent on the top of Half Dome. Sheet Joints form from expansion due to pressure release as erosion removes the massive weight of rock that once sat on top of the plutons.
27. Because the pressure reduction on the top of the pluton is greater than in the pluton’s interior, …
28. … the amount of expansion is greatest near the surface. To accommodate the differential expansion, sheet joints therefore form parallel to the surface in a concentric onion-like arrangement.
29. Frost wedging and other processes widen and loosen the joint-bounded slabs until they eventually slide off …
30. …
31. … in a process called exfoliation. Exfoliation ultimately smoothes and rounds the exposed plutons ….
32. … forming exfoliation domes.
33. These lie just north of Half Dome hence the name “North Dome”.
34. Below North Dome lie the great sheet joints known as the Royal Arches. These are somewhat special sheet joints in that they formed in response to the release of pressure on the *wall* of the valley as glacial erosion of the valley removed the confining pressure on these rocks. Nonetheless, they ultimately have the same rounding affect as all sheet joints. As these great slabs spall off, North Dome will widen and blend more seamlessly into the valley slopes.
35. The absence of jointing also controls topography. The massive, non-jointed El Capitan granite was strong enough to resist glacial erosion and support some of the highest vertical cliffs in the world.
36. No study of the geology of Yosemite National Park is complete without a thorough discussion of the affects of Pleistocene glaciation.
37. During numerous times in the Pleistocene the entire Yosemite Valley …
38. …was covered with glacial ice.
39. Glacial Polish on the walls of the valley …
40. … and importantly, above the valley rim…
41. .. where random, ice-deposited boulders called glacial erratics rest, attest to the erosion of glaciers …
42. … and that they spilled out from the confines of the valley on to the surrounding terrain. Ice thickness was not enough to cover the entire land surface around Yosemite and so, like this ice field in Greenland, numerous rocky peaks called Nunataks were exposed above the ice.
43. Half Dome was once a Nunatak.
44. Roches Moutonnees are of particular interest in Yosemite.
45. You should remember them from our study of Isle Royale. Remember that the steep side forms as glacial ice freezes to jointed rock and “plucks” it away as the ice moves.
46. Lembert Dome in Tuolumne Meadows is a beautiful (and huge!) example of a roche moutonnée. Can you tell which direction the glacier moved?
47. Right to left is correct.
48. Just below Half Dome lie two other good examples of roche moutonnées - Mt Broderick and Liberty Cap.
49. From the right angle the characteristic roche moutonnée asymmetry is apparent.
50. Glacial plucking on the down flow side of Liberty Cap formed the steep drop-off down which Nevada Falls cascades.
51. Nevada Falls belongs to a type of waterfall called a glacial “staircase” fall.
52. Vernal Falls is part of this same “staircase”.
53. If you look closely at this Google Earth view you can see that the steps that create Vernal and Nevada falls are aligned parallel to the system of master joints that were so influential in the formation of Half Dome.
54. This suicide view of Nevada Falls clearly shows the master joint surface exposed by glacial plucking.
55. The half-mile distance between Nevada Falls …
56. … and Vernal Falls provides some perspective …
57. …on the spacing of the master joints.
58. Yosemite’s second type of waterfall issues from the much higher hanging valleys.
59. Remember that hanging valleys form where a small glacier joins the far deeper trough of a much larger glacier.
60. Bridal Veil Falls issues from this hanging valley and is a classic example.
61. Although one of the most popular waterfalls in the park, at 620 feet Bridal Veil is nowhere near the highest.
62. Ribbon Falls comes in at 1,612 feet …
63. … and Yosemite Falls at 2,425 feet – making it the 7th highest in world. Both exemplify the terrific heights typical of hanging valley water falls.
64. For nearly a hundred years there was another type of fall in Yosemite. Back in the day, a great pile of embers would be pushed nightly from the top of glacier point …
65. … towards great crowds of onlookers below. Congestion and heightened environmental consciousness led to the popular attraction’s termination in 1968.
66. The final geologic touches on the park were applied by glacial deposition.
67. Although touted as a classic example of a U-shaped glacial trough, you can see that the valley is actually quite flat from side to side.
68. That’s because of the sediment that accumulated in Lake Yosemite – a large lake that formed behind a recessional moraine located below Bridal Veil Falls.
69. Because lake sediments are more permeable than the unsorted till that makes up moraines, the water table is lower in areas where the lake sediments deposited. Lower water tables and periodic natural wildfires combine to inhibit tree growth such that only grasses survive and thus meadows form. Note that trees only grow next to the Merced River here.
70. Meadows used to cover much more of the valley but by one estimate, they only cover 6.8% of their 1866 area.
71. Meadow size reduction in Yosemite Valley is largely a result of human fire-suppression, which has allowed tree seedlings to gain a foot hold.