A TALE OF TWO VALLEYS

BY N. KING HUBER

Yosemite National Park is home to two exceptional valleys: Yosemite and Hetch Hetchy (figure 1). Yosemite Valley is renowned for its spectacular waterfalls and bold granite icons such as Half Dome and El Capitan and is a magnet for visitors from around the world. Hetch Hetchy Valley, although less well known and now the site of a reservoir for San Francisco's water supply, is also quite remarkable. Indeed, John Muir, emphasizing the similarities between the two valleys, wrote. "Nature is not so poor as to possess only one of anything."[1]

The first comparison of the two valleys was presented at a meeting of the California Academy of Natural Sciences in the fall of 1867 by Josiah Whitney, State Geologist and Director of the Geological Survey of California. Hetch Hetchy was characterized as "almost an exact counterpart of the Yosemite," and Whitney introduced a report by Charles Hoffmann, a member of his staff, who had explored Hetch Hetchy the previous summer. Hoffmann noted, "the scenery resembles very much that of the Yosemite, although the bluffs are not as high, nor do they extend as far."

He described one waterfall (Tueeulala Falls) as having a sheer drop of 1,000 feet, and a second one (Wapama Falls) as a series of cascades dropping 1,700 feet. Hoffmann remarked that a singular feature of this valley is the total absence of talus at the base of the bluffs, excepting at one place in front of the falls. Another remarkable rock [Kolana Rock], corresponding with Cathedral Rock in Yosemite Valley, stands on the south side of the valley; its height is 2,270 feet above the valley. These early observations[2] have relevance to the discussion of the two valleys presented here.

The fundamental similarities that caught Muir's eye were that both Hetch Hetchy and Yosemite are broad but steep-walled valleys incised into the surrounding uplands, and that both have relatively flat floors traversed by meandering streams. Both valleys occupy similar positions on the western slope of the Sierra Nevada, with Yosemite's floor at about 4,000-feet elevation and Hetch Hetchy's slightly lower. Nevertheless, as noted by Hoffmann, Hetch Hetchy's valley walls, while impressive, are not as high as Yosemite's for the full length of the valley.

Although Hetch Hetchy Valley is nearly 4,000 feet deep near its head, downstream near its lower end the sheer cliff near Wapama Falls rises only about 1,600 feet from the valley floor (now submerged by the reservoir) to the upland plateau on the north. Kolana Rock, across the Tuolumne River on the south side of the valley, however, stands more than 2,000 feet above the valley floor,

FIGURE 1. The "Two Valleys" of Yosemite National Park: Yosemite and Hetch Hetchy. Looking eastward toward the Sierra crest, Yosemite Valley is just right of center. It extends directly up from near base of figure, passing between Cathedral Rocks on the right beyond Bridalveil Fall (shown against dark shadow), and bold El Capitan on the left, and on to the valley head at the base of Half Dome. Tenaya Canyon can be seen entering Yosemite Valley from the left below the face of Half Dome. Hetch Hetchy Valley extends from its reservoir (3rd one from lower-left corner) diagonally up to the right. Topographic features are diagrammatic and exaggerated in this stylized graphic by Heinrich Berann (NPS poster, 1988).

a smaller version of Yosemite Valley's 2,700-foot Cathedral Rocks. Hetch Hetchy's valley floor narrows upstream where its cliffs give way to the steep slopes of the Grand Canyon of the Tuolumne River, whereas Yosemite Valley's floor remains broad to its head near Half Dome.

In addition to these noted differences, it is even more significant that the walls of the two valleys are very different in appearance. Hetch Hetchy's walls are comparatively smooth and regular, while Yosemite's are jagged and irregular, with many pinnacles, spires, and deep re-entrants. These differences are graphically displayed by comparison of topographic maps of the two valleys (figure 2).

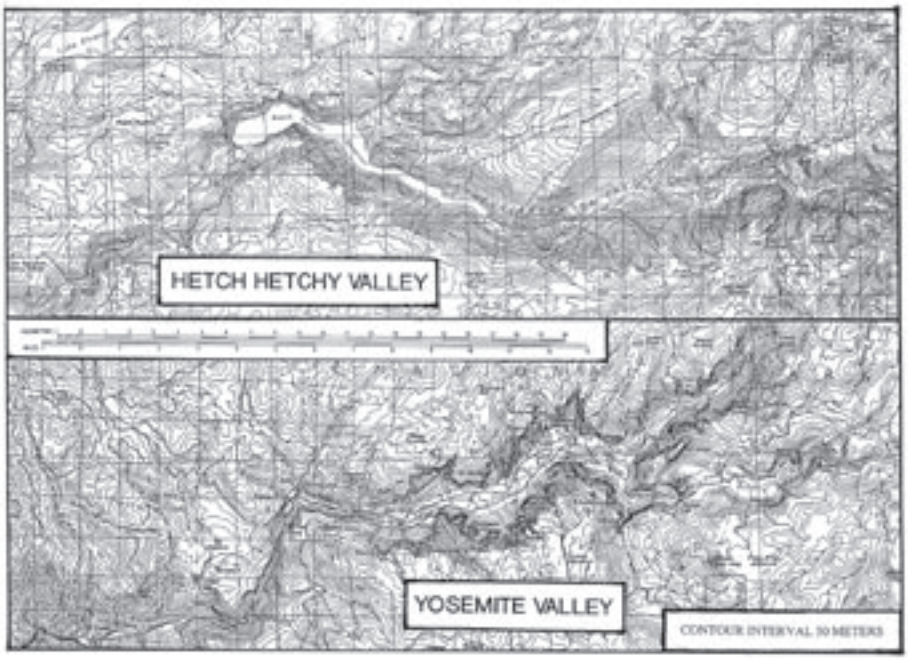

FIGURE 2. Topographic maps of the "Two Valleys." Note the comparatively smooth contours along the walls of Hetch Hetchy Valley as contrasted with the irregular, jagged ones in Yosemite Valley.[3]

Hetch Hetchy Valley has relatively smoothly-curved elevation contours for most of its length; the only major indentation is where Tiltill and Rancheria Creeks breach the northern wall to enter the valley. In contrast, Yosemite Valley's contours emphasize the countless indentations and numerous pinnacles and spires jutting from the main walls.

Although we now know that both valleys owe their gross forms to glacial activity, Yosemite Valley's present morphology seems anomalous in that respect. The pinnacles and spires that punctuate its landscape, such as Lost Arrow, Sentinel Rock, and Cathedral Spires, could not have survived the erosive action of a glacier that filled the valley to the brim, as we know once occurred. How can we explain the presence of these striking features of Yosemite Valley, and thus the significant differences between the two valleys?

The answer to this question lies in the different glacial histories of the two valleys. Both histories had similar beginnings when the broad general shape of both valleys probably developed from glacial excavation during the Sherwin glaciation, a glacial epoch that ended nearly one million years ago. Sherwin-age glaciers filled each valley to its present rim, and locally beyond, with the Tuolumne Glacier probably extending downstream a dozen miles below Hetch Hetchy to the Cherry Creek junction, and the Yosemite glacier as far as El Portal, some 10 miles downstream from Yosemite Valley proper.

The Sherwin was the most extensive, and evidently the longest-lived, glaciation documented in the Sierra Nevada. Later Sierran glaciations were of lesser areal extent and apparently briefer than the Sherwin, and here is where the glacial history of the two valleys diverges.

Following the Sherwin, each major glaciation including the last one—the Tioga which peaked about 20,000 years ago—produced glaciers that completely filled Hetch Hetchy Valley (figure 3). Moraines of Tioga age bounding Harden Lake, located on the south side of the canyon above the upper end of Hetch Hetchy Valley, indicate that the glacier was 3,700 feet thick there. Farther down, near the lower end of the Hetch Hetchy Valley, the glacier was 2,800 feet thick, with the north wall of the valley buried under ice delivered by tributary ice tongues flowing from the north down Rancheria-Tiltill and Falls Creeks to supplement the ice flowing down the main trunk of the Tuolumne River.

Thus, with each glaciation, including the latest Tioga, Hetch Hetchy's valley walls were being scraped clean and debris was being removed. Recall Hoffmann's early observation regarding the lack of significant talus in Hetch Hetchy Valley. There has been insufficient time since the Tioga glaciation for weathering and erosion to release significant amounts of talus from the "smoothed" valley walls or carve out pinnacles and spires from those walls.

In contrast, ice has probably not completely filled Yosemite Valley since the Sherwin glaciation about one million years ago (figure 3). The last glacier to enter Yosemite Valley, the Tioga, advanced only as far as Bridalveil Meadow. The extent of the somewhat earlier Tahoe glacier in the valley is uncertain, but evidence elsewhere in the Sierra suggests that it probably did not extend greatly beyond the Tioga. The fact that glaciers subsequent to the Sherwin failed to fill the valley to its

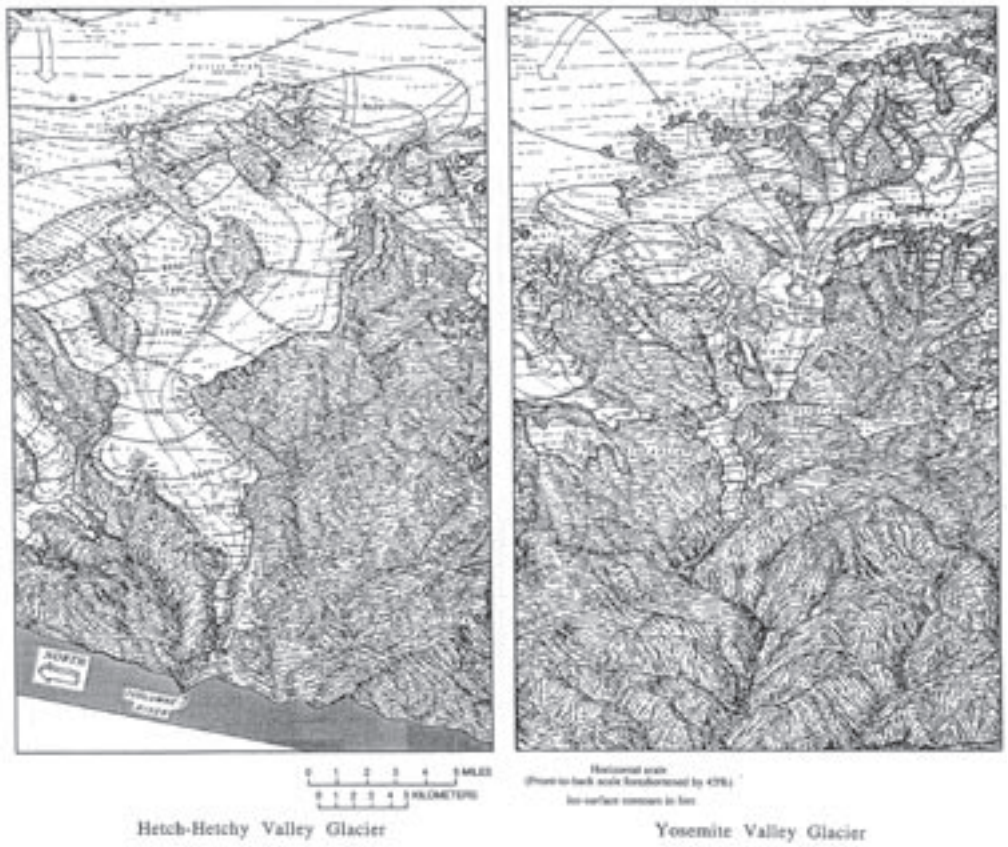

FIGURE 3. Comparison of Tioga-age glaciers in Hetch Hetchy and Yosemite Valleys. In left diagram, Hetch Hetchy Valley lies beneath glacial ice from about the 6400-foot to 7200-foot ice-surface elevation contours. In right diagram, glacial ice in Yosemite Valley reaches only as far as Bridalveil Meadow. Note that the ice tongue down Yosemite Creek (middle left) stops short of valley rim.[4]

rim has important consequences for the scenery.

From its terminus at Bridalveil Meadow, the ice surface of the Tioga Glacier would have sloped upward toward the east end of Yosemite Valley, with the ice reaching a thickness of perhaps about 1,000 feet at Columbia Rock west of Yosemite Falls, 1,500 feet at Washington Column, and 2,000 feet in Tenaya Canyon below Basket Dome. Thus the Tioga and similar Tahoe glaciers could do very little to further modify or smooth the upper walls of Yosemite Valley.

Above the ice surface of those glaciers, the valley walls have had a million years to be affected by the weather; joints have widened, rock has fractured and crumbled, and waterfalls and cascades have eroded alcoves and ravines. Thus, the pinnacles and spires that seem so anomalous for a glacial valley have had about a million years to form above the level of later glaciers, and so remain to amaze us today.

Meanwhile, back in Tenaya Canyon, the Tioga ice was closer to its source and thicker, rasping higher up on the valley walls and thereby smoothing them and removing irregularities so that no pinnacles or spires are found there.

Having ascribed the different geomorphic aspects of the two valleys to their different glacial histories, the next question is why those histories differ so. It was noted that the Tioga glaciation was much less extensive than the Sherwin glaciation that profoundly modified both valleys. The greater extent of the Tioga glacier in Hetch Hetchy, however, can be attributed to the fact that the drainage basin, or snowfall-catchment area, of the Tuolumne River system above Hetch Hetchy is more than three times as extensive as that of the Merced River above Yosemite Valley (figure 4).

As a result, the much larger icefield feeding the Tuolumne glacier was able to provide the volume of ice necessary to fill Hetch Hetchy Valley even though the Tioga glaciation was regionally less extensive than the Sherwin. This ice was delivered to Hetch Hetchy Valley, both down the main trunk of the Tuolumne River, and by tributaries entering the valley from the north that were fed from the northeastern part of the Tuolumne icefield.

This tremendous influx of ice is what helped "clean out" Hetch Hetchy Valley. The smaller Merced River icefield was unable to provide sufficient ice to fill Yosemite Valley during the Tioga glaciation, even though supplemented by ice from the Tuolumne glacier that flowed southwest over several low passes in the Cathedral Range (figure 3), and over one from Tuolumne Meadows into Tenaya Canyon.

Having noted the significant differences between the two valleys, and having attempted to explain the why and wherefore of those differences, our tale cannot end without considering some of their consequences, especially with respect to Yosemite Valley itself. The Tioga-age glacier did little to further modify Yosemite Valley other than to remove fractured rock from the lower valley walls that had weathered and loosened since the previous glaciation. It also removed talus from the base

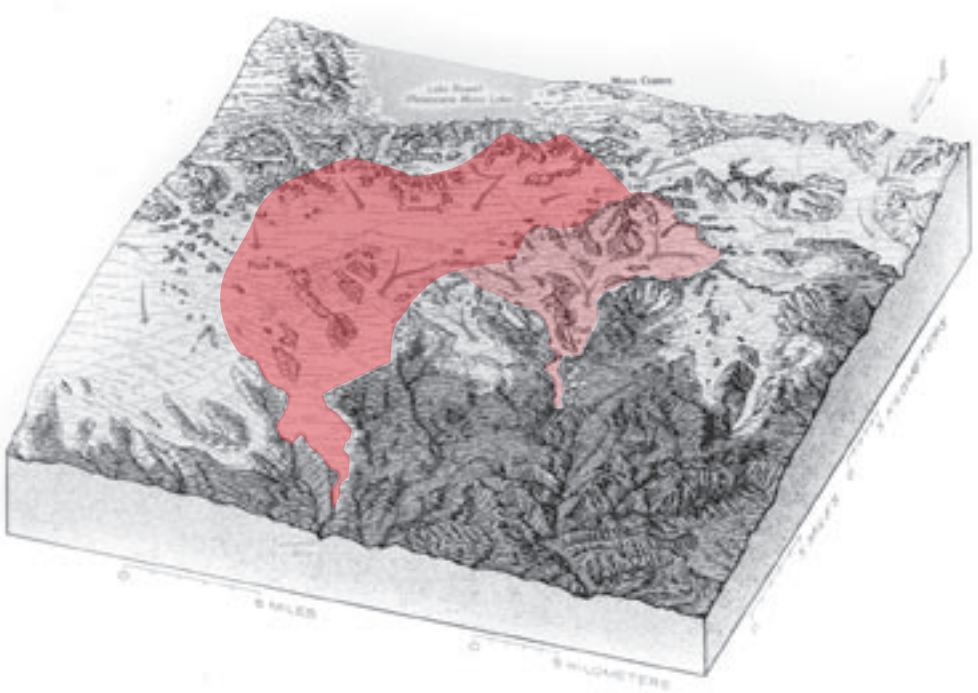

FIGURE 4. Extent of Tioga-age glaciers in Yosemite National Park. Light color tone indicates areal extent of icefield feeding into Yosemite Valley. Darker color tone indicates the much larger extent of the icefield feeding into Hetch Hetchy Valley. Note that the small glacier in Yosemite Creek (uncolored in center of figure) did not reach the rim of Yosemite Valley and thus did not contribute any additional ice to that valley.[5]

of cliffs east of Bridalveil Meadow; all of the talus now there has accumulated in the last 15,000 years or so, after the Tioga Glacier departed. For the past million years or so the rock walls of the valley that remained above the ice-level of the smaller post-Sherwin glaciers have weathered, joints have been enlarged, and rock has loosened and fallen to form the irregularly sculptured surface that we see today.

This geologic history provides the setting for frequent rockfalls. Every significant historical rockfall in Yosemite Valley has originated in vulnerable fractured rock derived from above the level scoured by the Tioga Glacier. Some rockfalls have been quite large, but most are relatively small and gradually build up cones of debris below the more active sites. Thus the size of a debris cone can reflect the volume or the frequency of individual rock falls, or, most likely, a combination of both volume and frequency.

Less talus in Hetch Hetchy indicates less rockfall there, while in Yosemite Valley the opposite is true. The shattered rock high up on the east side of Middle Brother provides material for a debris cone, at one of the most historically active rockfall sites in the valley. Both the 1996 "Happy Isles" and the 1998-9 "Curry Village" rockfalls added material to pre-existing debris cones that marked the sites of multiple, earlier events. Given the setting, such rockfalls will clearly play a major part in the dynamic processes that continue to shape Yosemite Valley.

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NOTES

1. John Muir, "Studies in the Sierra-Origin of Yosemite Valleys," *Overland Monthly*, June 1874, p. 496.

2. C. F. Hoffmann, "Notes on Hetch-Hetchy Valley," *California Academy of Natural Sciences, Proceedings*, v. III, 1863-1867, p. 368-370 [1868].

3. Figure derived from: U. S. Geological Survey 1:100,000-scale Topographic map of Yosemite Valley, California, 1976.

4. Figure derived from: Alpha, T. R., Wahrhaftig, Clyde, and Huber, N. K., 1987, *Oblique map showing maximum extent of 20,000-year-old (Tioga) glaciers, Yosemite National Park, Central Sierra Nevada, California*: U. S. Geological Survey Miscellaneous Investigations Series Map 1-1885.

5. Figure derived from: Huber, N. K., 1987, *The Geologic Story of Yosemite National Park*: U. S. Geological Survey Bulletin 1595 (reprinted by Yosemite Association, 1989), Figure 67.

General note: *At the small scale of the maps shown here, it is not possible to clearly show all the place names mentioned. Other maps are readily available for those not as familiar with Yosemite geography.*