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Muir, Whitney and the origin of Yosemite Valley

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ABSTRACT

The nineteenth-century geological theory of J. Muir, an amateur, attributing the formation of Yosemite Valley in California almost solely to glacial erosion, outrightly contradicted a catastrophist model proposed by J. D. Whitney, the state geologist. In recent years, Muir's theory has been shown to be more nearly correct.

ZUSAMMENFASSUNG

Die im 19. Jahrhundert aufgestellte Theorie J. Muirs, eines Amateurs, nach der die Entstehung des Yosemite Valley fast ganz auf Gletschererosion zurückzuführen ist, steht in krassem Widerspruch zu dem katastrophistischen Modell von J. D. Whitney, dem Staatsgeologen. In neuerer Zeit hat sich die Theorie Muirs als weitgehend richtig erwiesen.

Though the beautiful Yosemite Valley of California is known worldwide, few of its admirers are aware that the valley's steep granitic precipices, rounded domes, and high waterfalls played an important role in the development of glaciology. Yosemite was, in particular, the occasion for an extended geological dispute during the 1870s between Josiah Dwight Whitney (1819–1896), the first state geologist of California, and a tatterdemalion vagrant named John Muir (1838–1914). Oddly enough, we now believe that of the two Muir was more nearly correct.

Born in Dunbar, Scotland, Muir grew up in a home dominated by the strong religious beliefs of his shopkeeping father, Daniel, a hardhearted scriptural literalist at odds with the established church. Seeking religious freedom, Daniel Muir and his family emigrated to America in 1849 and settled in the newly established state of Wisconsin. On coming of age, John Muir escaped from the manual labor of his father's farm to attend the University of Wisconsin at Madison, where in two years of study he learned for the first time about American Transcendentalism (the spiritual value of natural facts, as taught by Ralph Waldo Emerson and others). He learned also about the uniformitarian geology of Charles Lyell, the consistency of which accorded with his theological beliefs, and the glacial theory of Louis Agassiz. Heavily glaciated Wisconsin providing many examples of moraines, scratches, and other glacial phenomena, Muir soon learned to recognize and trace them.

Having experienced a deepening of his religious feelings toward nature, Muir learned of Yosemite Valley (discovered by Europeans only in 1851) and eventually went there to live as a year-round resident from 1869–1873. Supporting himself at various odd jobs, Muir had plenty of free time, which he devoted to thorough explorations of the Yosemite area. Finding there unmistakable signs of prior glaciations, Muir became locally reputable as a geological authority and an outspoken tutor of better educated persons. Some of the latter, like Joseph Le Conte, came to him from University of California at Berkeley; others journeyed from so far away as Boston and England, the completion of the transcontinental railroad in 1869 having made travel to California by land feasible.

J. D. Whitney shared none of the intensity with which Muir approached religious questions but was at least as dogmatic in science. Having accompanied Leoncé Elie de Beaumont on geological excursions in Europe during the 1840s, he endorsed

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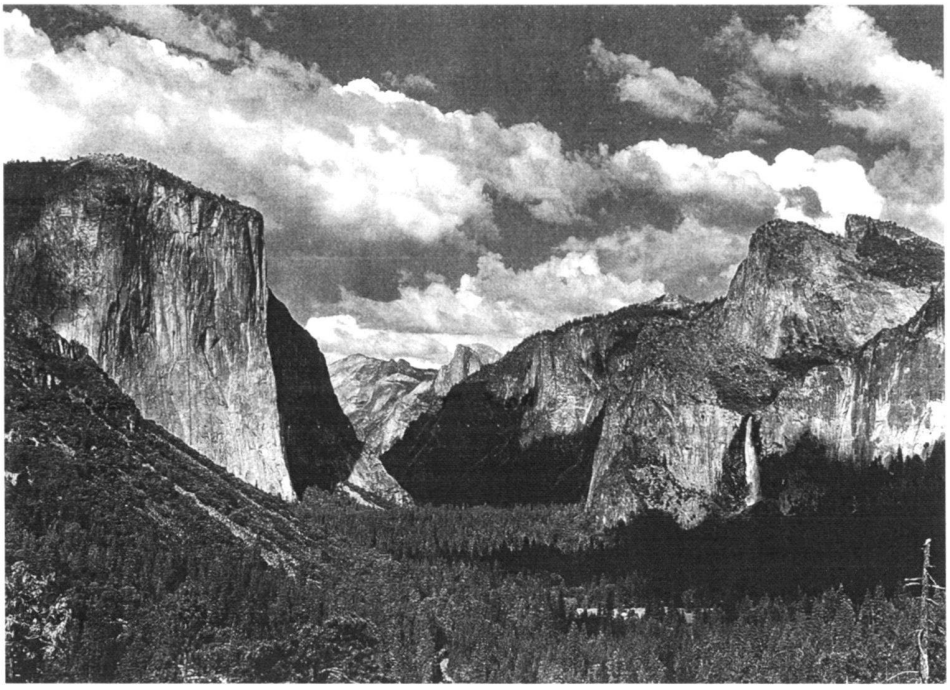

Fig. 1. Yosemite Valley (looking east). Major features include, from left, Rockslides (diorite talus), El Capitan (Granite; the cliff face is 900 m high), entrance to Tenaya Canyon, Half Dome (on horizon), Mount Broderick, Cathedral Rocks (granite, group of three on right), and Bridalveil Fall. This last, in a hanging valley, plunges 190 m, indicating the extent of glacial excavation in the main valley.

the French geologist's cataclysmic orogenic theories. Before returning to the United States in 1847, Whitney also explored the Alps and their glaciers. But he followed Elie de Beaumont again in rejecting the Ice Age theory of Louis Agassiz.

After thirteen years of lesser assignments, field work, publications, and manoeuvering, Whitney was at last appointed the first state geologist of California on 21 April 1860, with Agassiz (now at Harvard) among his supporters. He was unable to reach San Francisco until November and then devoted his efforts to the Coast Ranges for more than a year. In June and July of 1863 Whitney and his chief assistant William Brewer surveyed the High Sierra (a term Whitney coined), including one brief week in Yosemite. Both men recognized abundant evidence of former glaciation beyond Yosemite Valley, as did Clarence King, a Survey volunteer, in 1863 and 1864.

Survey's first volume on geology appeared in October 1865 (Whitney 1865). Summarizing the field work accomplished thus far, it included the Coast Ranges, the mining district, and the Sierra. Despite the brevity of his investigation, Whitney (the report's principal author) not only described California's most celebrated valley but attempted to explain its origin as well:

> All (he thought) will recognize in the Yosemite valley a peculiar and almost unique type of scenery. Cliffs absolutely vertical, like the upper portions of the Half Dome and El Capitan, and of such immense heights as these, are, so far as we know, to be seen nowhere else. The dome form of mountains is exhibited on a grand scale in other parts of the Sierra Nevada; but there is no Half Dome, even among the stupendous precipices at the head of Kings River. It is natural to ask, then, how these vertical cliffs (and domes) have been formed, and to what geological causes does the Yosemite Valley owe ist existence? (pp. 420–421).

Whitney's response to this dilemma was a reductive one, in which he arrived at what was for him the necessary answer only by eliminating the one possible alternative.

"Most of the great canyons and valleys of California", he conceded, "have resulted from denudation. ... But these eroded canyons, steep as they may be, have not vertical walls; neither have their sides the peculiar angular forms which the mass of El Capitan, for instance, has, where there are two perpendicular surfaces of smooth granite meeting at right-angles, and each over 3000 feet high." For Whitney, then, Yosemite had necessarily to be tectonic rather than erosional. "This mighty chasm", he proposed, "has been roughly hewn into its present form by the same kind of forces which have raised the crest of the Sierra and moulded the surface of the mountains into something like their present shape." Even the granitic domes, he believed, had been formed "by the process of upheaval itself." Half Dome, moreover, "seems, beyond a doubt, to have been split asunder in the middle," though no traces of its missing half could now be found (p. 421).

The general absence of fragments was a distinct embarassment, and had been pointed out to Whitney by members of his own surveying party, who regarded the valley's bottom as being of solid rock. In response, Whitney offered alternative explanations. First, he theorized, the fallen masses may have

been of such enormous size as to appear perfectly contiguous with the adjacent cliffs. Second, the fallen granite may have been only partially congealed, and was therefore able to flow, thus obliterating the original disjunctures. Of course, either alternative involved serious questions of petrology and physics with which Whitney was unprepared to deal with.

Whitney's theory also took no account of glaciation, though King and others, he admitted, had "obtained ample evidence of the former existence of a glacier in the Yosemite Valley" (p. 422) during their survey of it in 1864. King held that the glacier must have been at least a thousand feet thick. He claimed, moreover, to have discovered no fewer than four separate valley moraines, an assertion the primary author did not contest. Like King, Whitney assumed that the surprising lack of talus (since rock falls in the valley were by no means infrequent) could be explained only by assuming recent glacial occupation, through which earlier fragments had been swept away. With so little post-glacial accumulation following, he reasoned, "the time which has elapsed since the Yosemite was occupied by a glacier cannot have been very long" (p. 423). John Muir owned a copy of the formidable volume in which these remarks of Whitney's appeared, but when he aquired or read it is not recorded.

Almost certainly, Muir first learned of Whitney's Yosemite theorizing through a more accessible publication, The Yosemite Guide-Book (Whitney 1868), which had appeared as a limited edition (featuring real photographs) in 1868 and was then reprinted almost annually in more popular forms for half a dozen years. Though an official publication of the state's geological survey (which was discontinued in 1874), it served basically "to call the attention of the public to the scenery of California, and to furnish a reliable guide to some of ist most interesting features, namely, the Yosemite Valley, the High Sierra in its immediate vicinity, and the so-called 'Big Trees' (i.e., *Sequoia gigantea*, huge redwoods)" (p. 1). Much had already been written on these topics, Whitney conceded, but almost all it – the Geological Survey's 1865 volume excepted – was inaccurate and of litte value. While successive editions of the Guide-Book where somewhat revised in other respects, Whitney's geological explanation of Yosemite never changed, though itself a revision of what he had originally said in 1865.

"The principal features of the Yosemite", he wrote now in the Guide-Book, "and those by which *it is distinguished from all other known valleys* are: first, the near approach to verticality of its walls; second, their great height, not only absolutely, but as compared with the width of the valley itself; and, finally, the very small amount of *talus* or *debris* at the base of these gigantic cliffs" (Whitney 1868:85). Its domes and waterfalls were also notable, of course. How, then, could this unique scenery be explained? Most of the great canyons and valleys of the Sierra, he again declared, had been excavated by water, and in comparatively recent times. But such canyons never have vertical walls nor the peculiar angular forms like those of El Capitan, the best known sheer monolith in Yosemite. "Aqueous erosion," Whitney therefore concluded, "could not have been the agent employed" (p. 116). Nor would the erosive action of ice be sufficient. "A more absurd theory was never advanced", Whitney declared intemperately, "than that by which it was sought to ascribe to glaciers the sawing out of these vertical walls, and the rounding of the domes. Nothing more unlike the real work of ice, as exhibited in the Alps, could be found" (p. 117). Besides, he added, *"there is no reason to suppose, or at least no proof, that glaciers have ever occupied the valley or any portion of it* ... so that this theory, based on entire ignorance of the whole subject, may be dropped without wasting any more time upon it" (p. 117). This remarking passage, appearing in all editions, not only displays the testiness for which Whitney was renowned but directly contradicts his acceptance in 1865 of the observations of King and other subordinates regarding the glaciation of Yosemite Valley.

John Muir had, in the meantime, been encouraged by several friends to publish his rather different analysis of the valley and ist origin. His earliest reference to Whitney appeared in a letter to his friend Mrs. Carr on 13 April 1870 and takes issue with an assertion in the Yosemite Guide-Book that Yosemite Valley was formed by cataclysmic subsidence: "Whitney says that the bottom has fallen out of the rocks here – which I most devoutly disbelieve." On 16 November 1871 Muir informed his mother in Wisconsin that he had now begun to synthesize his geological discoveries. "The few scientific men who have written upon this region," he told her, with slightly veiled reference to Whitney, "tell us that Yosemite Valley is unlike anything else, an exceptional creation, separate in all respects from all other valleys, but such is not true. Yosemite is one of many." Whereas Whitney attempted to explain Yosemite by postulating a unique catastrophe, Muir asserted (and would later demonstrate) that its most characteristic features recurred wherever similar causes and materials were present.

Muir first published his observations regarding the glacial shaping of Yosemite in an anonymous piece destined to surface in faraway New York; called "Yosemite Glaciers. The Ice Streams of the Great Valley. Their Progress and Present Condition – Scenes among the Glacier Beds," (Anonymous 1871) it appeared in Horace Greeley's New York Tribune on 5 December 1871 and earned Muir $ 200, his first profits as a writer. Thus encouraged, he then published several pieces under his own name and moved from the valley to Oakland, on San Francisco Bay, where he attempted to synthesize and consolidate his geological discoveries.

The product of this effort (not to be a book until the twentieth century) was a series of seven unorthodox essays collectively entitled "Studies in the Sierra" (Muir 1874–75). They appeared between May 1874 and January 1875 in a Bay Area periodical, The Overland Monthly, and have twice been reprinted since. Yosemite Valley was for Muir "the noblest of Sierra temples, everywhere expressing the working of Divine harmonious law yet so little understood that it has been regarded as 'an exceptional creation' or rather exceptional destruction accomplished by violent and mysterious forces" (Part One, p.

18). For Muir, any such assumption was scientifically and theologically unacceptable.

Those who support the theory of exceptional creation, he tells us, have argued as follows: Yosemite is "too wide for a water-eroded valley, too irregular for a fissure valley, and too angular and local for a primary valley originating in a fold of the mountain surface during the process of upheaval; therefore, a portion of the mountain bottom must have suddenly fallen out, letting the superincumbent domes and peaks fall rumbling into the abyss, like coal into the bunker of a ship" (Part Two, p. 10). This violent, chaotic hypothesis – an unmistakable parody of Whitney's – seemingly accounted for the remarkable sheerness of the Valley's walls. But it also depended on an uninvestigable, the valley floor, which was blanketed in this instance with lakes, meadows, and gravel. By citing other, more exposed Yosemites, however, Muir sufficiently established that the expected physical evidence resulting from a major subsidence was invariably missing. He explained the valley's conspicuous lack of talus by asserting that Yosemite had only recently been formed, so no vast quantity of debris ever existed. Finally, Whitney's idea of an abyss was made to appear logically absurd. Once Muir's arguments were published, the Whitney theory was often regarded as untenable, perhaps even by Whitney himself.

It did not, however, disappear from the literature immediately and would continue for a time to win support from those who took for granted the superiority of a Harvard professorship like Whitney's to a background of manual labor like Muir's. Controversy regarding the origin of Yosemite valley continues to this day, but while there is still some question regarding the role of tectonic displacement, we know now that the hidden floor of the valley is rounded in the glacial manner and that the Whitney theory has been falsified. Running water (undervalued by both disputants) and moving ice, as Muir held, were primary agents in the sculpting of America's most beautiful valley.

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