On Actual Glaciers in California.

John Muir
gravelly clay so slightly eroded as to forbid the belief that they have been transported to any considerable distance from the place of their origin.

The fragments of strata referred to have been recognized, so far, only at Lime Springs, but their presence there, as well as the condition in which they are found, inspires the confident hope that we may yet find some of these Cretaceous strata in situ in that vicinity.

These discoveries also suggest that we should scan more closely than ever before, not only the character and contents of the drift of central and eastern Iowa, but also some of the strata of the same regions, especially sandstones, to determine with certainty whether some of them may not be of Mesozoic age.

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2. On Actual Glaciers in California; by John Muir.—On one of the yellow days of October, 1871, when I was among the mountains of the “Merced group,” following the foot-prints of the ancient glaciers that once flowed grandly from their ample fountains, reading what I could of their history as written in moraines, canions, lakes, and carved rocks, I came upon a small stream that was carrying mud of a kind I had never seen. In a calm place, where the stream widened, I collected some of this mud, and observed that it was entirely mineral in composition, and fine as flour, like the mud from a fine-grit grindstone. Before I had time to reason, I said, “Glacier mud—mountain meal!”

Then I observed that this muddy stream issued from a bank of fresh quarried stones and dirt, that was sixty or seventy feet in height. This I at once took to be a moraine. In climbing to the top of it, I was struck with the steepness of its slope, and with its raw, unsettled, plantless, new born appearance. The slightest touch started blocks of red and black slate, followed by a rattling train of smaller stones and sand, and a crowd of dry dust of mud, the whole moraine being as free from lichens and weather-stains as if dug from the mountain that very day.

When I had scrambled to the top of the moraine, I saw what seemed to be a huge snow-bank, four or five hundred yards in length, by half a mile in width. Imbedded in its stained and furrowed surface were stones and dirt like that of which the moraine was built. Dirt-stained lines curved across the snow-bank from side to side, and when I observed that these curved lines coincided with the curved moraine, and that the stones and dirt were most abundant near the bottom of the bank, I shouted “A living glacier!”

These bent dirt-lines show that the ice is following in its different parts with unequal velocity, and these imbedded stones are journeying down, to be built into the moraine, and they gradually become more abundant as they approach the moraine, because there the motion is slower.

On traversing my new-found glacier, I came to a crevasse, down a wide and jagged portion of which I succeeded in making my way, and discovered that my so-called snow-bank was clear, green
ice, and, comparing the form of the basin which it occupied with similar adjacent basins that were empty, I was led to the opinion that this glacier was several hundred feet in depth.

Then I went to the “snow-banks” of Mts. Lyell and McClure, and, on examination, was convinced that they also were true glaciers, and that a dozen other snow-banks seen from the summit of Mt. Lyell, crouching in shadow, were glaciers, living as any in the world, and busily engaged in completing that vast work of mountain-making accomplished by their giant relations now dead, which united and continuous, covered all the range from summit to sea.

But, although I was myself thus fully satisfied concerning the real nature of these ice masses, I found that my friends regarded my deductions and statements with distrust; therefore, I determined to collect proofs of the common, measured, arithmetical kind.

On the twenty-first of August last, I planted five stakes in the glacier of Mt. McClure, which is situated east of Yosemite Valley, near the summit of the range. Four of these stakes were extended across the glacier, in a straight line, from the east side to a point near the middle of the glacier. The first stake was planted about twenty-five yards from the east bank of the glacier; the second, ninety-four yards; the third, 152, and the fourth, 225 yards. The positions of these stakes were determined by sighting across from bank to bank, past a plumb-line, made of a stone and a black horse-hair.

On observing my stakes on the sixth of October, or in forty-six days after being planted, I found that stake No. 1, had been carried down stream eleven inches; No. 2, eighteen inches; No. 3, thirty-four, and No. 4, forty-seven inches. As stake No. 4 was near the middle of the glacier, perhaps it was not far from the point of maximum velocity—forty-seven inches in forty-six days, or one inch per day. Stake No. 5 was planted about midway between the head of the glacier and stake No. 4. Its motion I found to be, in forty-six days, forty inches. Thus these ice-masses are seen to possess the true glacial motion. Their surfaces are striped with bent dirt-bands, and are bulged and undulated by inequalities in the bottom of their basins, causing an upward and downward swegding, corresponding to the horizontals wedging as indicated by the curved dirt-bands.

The Mt. McClure glacier is about one-half of a mile in length, and the same in width at the broadest place. It is crevassed on the south-east corner. The crevasse runs about south-west and north-east, and is several hundred yards in length. It is nowhere more than one foot in width.

The Mt. Lyell glacier, separated from that of McClure by a narrow crest, is about a mile in length. I have planted stakes in the glaciers of “Red Mountain,” also, but have not yet observed them.

The Sierras adjacent to the Yosemite Valley are composed of slate and granite, set on edge at right angles to the direction of
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the range, or about north 30 deg. east, and south 30 deg. west. Lines of cleavage cross these, running nearly parallel with the main range; and the granite of this region has a horizontal cleavage or stratification. The first mentioned of these lines have the fullest development, and give direction and character to many valleys and canons, and determine the principal features of many rock forms. No matter how hard, how domed or homogeneous the granite may be, it still possesses these lines of cleavage, which require only simple conditions of moisture, time, etc., for their development. But I am not ready to discuss the origin of these planes of cleavage, which make this granite so easily denuable, nor their full significance with regard to mountain structure in general. I will only say here, that oftentimes the granite contained between two of these north 30 deg. east planes is softer than the rock outside, and has been denuded, leaving vertical walls, as determined by the direction of the cleavage, thus giving rise to those narrow-slotted canons, called "devil's lanes," "devil's gateways," etc.

In many places, in the higher portion of the Sierras, these slotted canons are filled with snow, which I thought might prove to be ice; might prove to be living glaciers, still engaged in cutting into the mountains, like endless saws. To decide this question, on the 23d of August last, I set two stakes in the narrow-slot glacier of Mt. Hoffman, marking their position by sighting across from wall to wall, as I did on the McClure glacier; but on visiting them, a month afterward, they had been melted out, and I was unable to decide anything with any great degree of accuracy.

On the 4th of October last, I stretched a small trout line across the glacier, fastening both ends in the solid banks which at this place were only sixteen feet apart. I set a short, inflexible stake in the ice, so as just to touch the tightly-drawn line, by which means I was enabled to measure the flow of the glacier with great exactness. Examining the stake in twenty-four hours after setting it, I found that it had been carried down about three-sixteenths of an inch. At the end of four days, I again examined, and found that the whole downward motion was thirteen-sixteenths of an inch, showing that the flow of this glacier was perfectly regular.

In accounting for those narrow-lane canons, so common here, I always referred them to ice-action in connection with special conditions of cleavage, and I was gratified to find that their formation was still going on. This Hoffman glacier is about 1,000 feet long by fifteen to thirty feet wide, and perhaps 100 feet deep in the deepest places.

I go back to the mountains to complete these observations. These are the first fruits, and the rest of the crop I will bring in when I come to study in the Coast Range. — Overland Monthly for December.

3. Return of the Yale College Geological Expedition.—Professor Marsh and party returned on the 7th of December from the Rocky