

Pleistocene Glaciers of the Eldorado Forest and How to Read Them

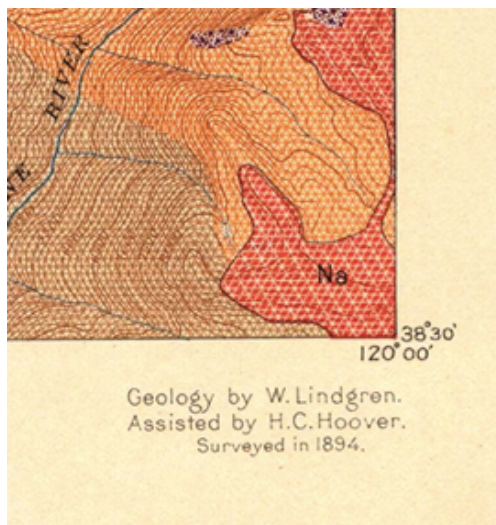
by Lester Lubetkin

Recently, I was looking through the 1896 geologic map and folio for the Pyramid Peak Quadrangle and I came across one of the most comprehensive and complete descriptions of the glacial history of the Eldorado National Forest that I have seen. This work was written by Waldmer Lindgren, who was a geologist with the US Geological Survey studying and mapping the geology of the Sierra Nevada. His studies led him to write a detailed report of the “Auriferous Gravels of the Sierra Nevada”; a seminal work that is still used extensively today. (If you are interested in learning about the ancient river system of the Sierra Nevada, active some 50 million years ago, this is the book for you.)



In the late 1880's and early 1890's, when Lindgren was mapping the geology of the Sierra Nevada, one of his field assistants was none other than Herbert Hoover, future US president. Hoover was a student of geology at Stanford University at the time and was hired by the US

Geological Survey as a field assistant in the summers, working under Lindgren. Hoover described in his memoir that much of the field work was done on horseback. In the legend for the geologic map in the Pyramid Peak folio, we find Hoover listed as Lindgren's field assistant in 1894. And it was here that he gained the early experience that allowed him to go on to become a well-respected mining geologist.



But, back to the glacial history of the Eldorado National Forest. Rather than trying to summarize Lindgren's narrative, I'd like to give you his own words, with some maps, annotations and other info to help locate yourself and understand some of the terms.

DESCRIPTION OF THE PYRAMID PEAK QUADRANGLE.

Epoch of glaciation.—The later part of the Pleistocene period was characterized by extensive glaciation, the traces of which are plainly marked everywhere near the crest of the range.

The Pleistocene period is a geologic time period spanning from 2.6 million years ago to 11,700 years ago; also known as the Ice Age

Finally the glaciers receded, giving to the region its present aspect. Even the smallest traces of actual glaciers have now disappeared, though patches of snow remain during the summer above an elevation of 8000 feet. The largest snow fields lie on the northeast side of the Pyramid Peak Range.

The area once completely covered by ice, névé, and snow comprises nearly one-half of the 930 square miles of the quadrangle. Its western limit is clearly indicated by the moraines stretching from the head of Gerlé Creek down to Bear and Mokelumne rivers. East of this irregular line everything was ice-covered, except the peaks, above an elevation of about 8500 feet. The lower part of Lake Valley and Mokelumne Canyon were also free from ice. Tongues of ice extended from this grand mer de glace down the valleys and canyons, carrying with them and depositing as morainal heaps and walls the enormous masses of loose débris swept away from higher elevations. While smaller débris heaps may be found at higher elevations, the great moraines lie at elevations ranging from 5000 to 7000 feet. Above this extend vast stretches of dazzling white granitic rock-surface, worn bare and rounded and frequently scratched and striated by rocks held firmly by the moving ice sheet. There are few

névé: granular
snow
accumulated on
high mountains
and
subsequently
compacted into
glacial ice.

more imposing sights than the ice-swept rock-deserts of the upper Rubicon or the Devils Basin. While a striation of the rounded outcrops is frequently observed, it is often absent where it would be expected. In explanation of this the observation may be recorded that the polished and striated surfaces have a marked tendency to scale off in thin flakes, only a fraction of an inch thick. This was especially noted in the glacial cirques on the west side of the Pyramid Peak Range. The areas designated moraines on the map include only the heavier deposits of the terminal, lateral, and ground moraines; scattered thin drift is not indicated. The moraines are composed of rough and angular, not waterworn, boulders of all sizes, admixed with sand and finer detritus. The topographic form of the valleys changes as soon as the lower limit of glaciation is reached. Below, they are narrow and V-shaped; above, broader and U-shaped, often also characterized by stretches occupied by small meadows separated by rocky portions with steep grade. The long lateral moraines at lower elevations often form conspicuous topographic features. The region of the high peaks of the Pyramid Peak and Tallac ranges is characterized by frequent glacial cirques, separated by sharp ridges (arêtes) leading up to rocky, jagged points. Lakes of glacial origin, in basins either formed by morainal dams or scooped out of the rock, are common in the once ice-bound region. Many grassy flats or meadows represent dried-up or drained lakes.

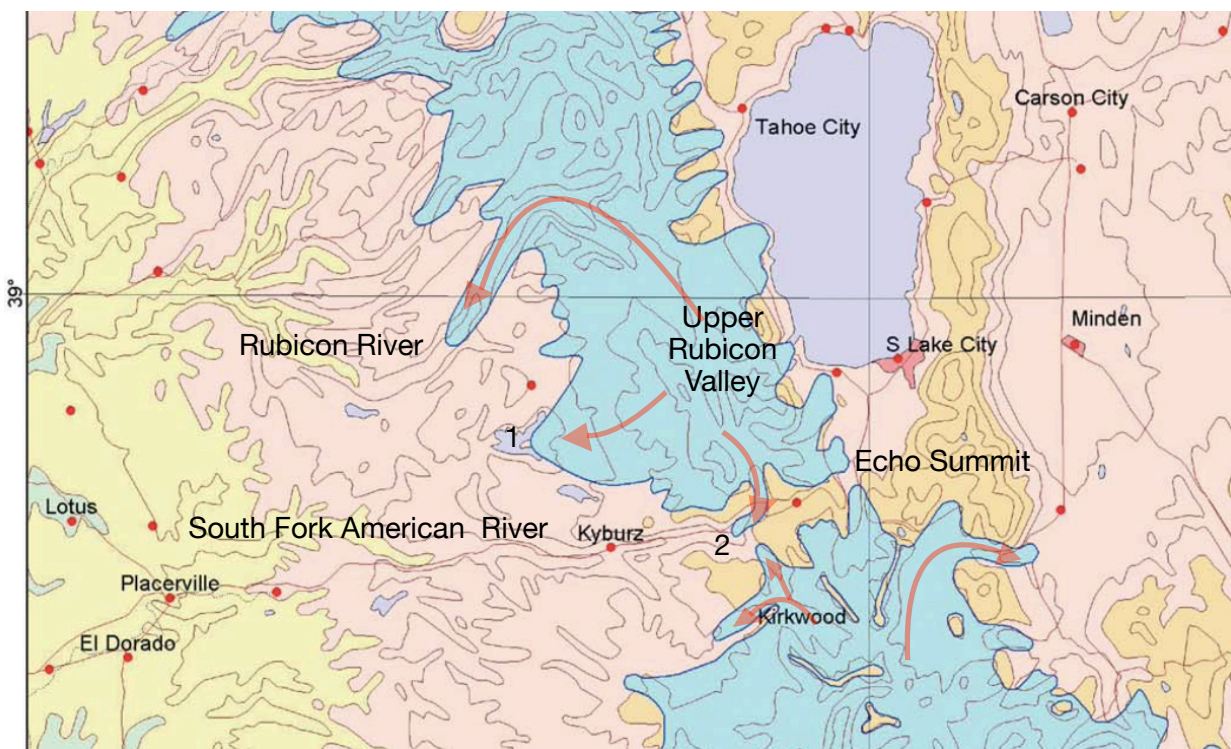
Devils Basin: This is the name of the valley that now contains Lake Aloha (which was a cluster of small lakes and ponds known as Medley Lakes at the time). The other name for this basin located in what is now Desolation Wilderness was 'Desolation Valley'.

moraines: masses of rocks and sediment carried down and deposited by a glacier, typically forming ridges at the glacier's edges.

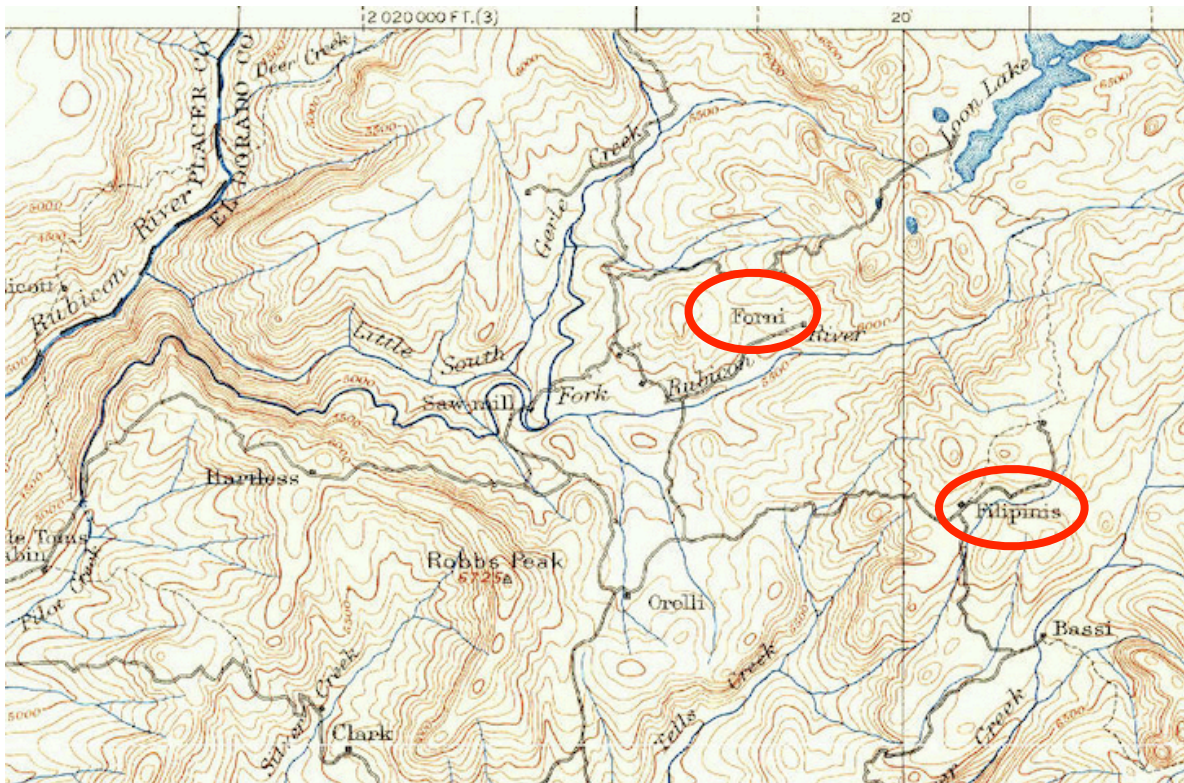
cirque: a half-open steep-sided hollow at the head of a valley or on a mountainside, formed by glacial erosion. Often there is a lake at the base of the bowl carved by the glacier.

The principal glaciers which projected from the main ice and névé fields were as follows: The largest glacier, that which once filled the Rubicon Valley, probably terminated in the Truckee quadrangle, adjoining northward. The Gerlé Creek branch, filling the valley of the same name to the north of the boundary of the Pyramid Peak quadrangle, deposited its terminal moraines a short distance below this boundary line. The Little Rubicon branch filled the well-polished rock-basin of Loon Lake, and left its well-defined terminal 2 miles below Forni. An excellently

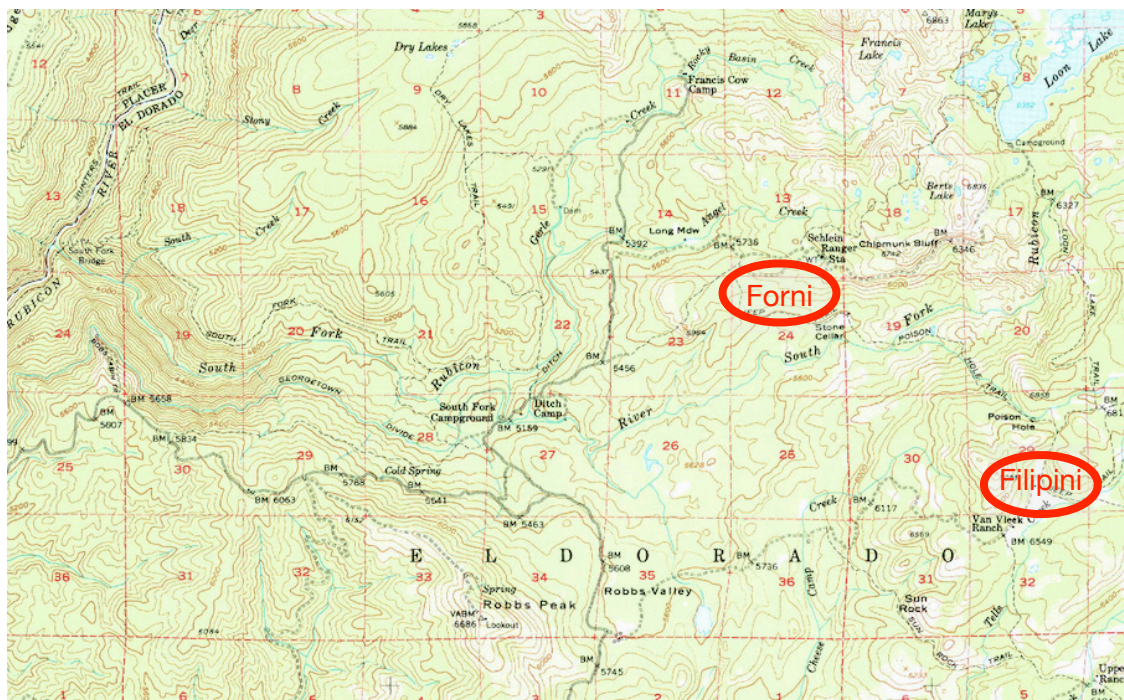
As shown in the map below, the glacier filling the Rubicon Valley is now known to have flowed down the Rubicon River canyon and had its terminus just above where the South Fork Rubicon River meets the main Rubicon River.



Map showing the extent of the latest major glaciation within the northern portion of the Eldorado National Forest and adjacent areas. Light blue area is the area covered by glacial ice. Yellow, pink and buff are to display elevation. Notice that Echo Summit was free of glacial ice. The red arrows show the direction that glaciers flowed. One glacier flowed west and terminated at the east end of Union Valley (1). Another glacier flowed south down Pyramid Creek/Horsetail Falls (2) to near Strawberry. Modified from Ehlers and Gibbard, 2003.



A portion of the 1889 Pyramid Peak topographic map, showing the location of Forni and Filipini.



A Portion of the 1952 Robbs Peak topographic map, with the locations of Forni and Filipini added. The original Forni Ranch is near what is now known as Stone Cellar and the Filipini Ranch is near what is now known as the Van Vleck Ranch.

defined morainal wall indicates its lateral extent on the basalt table northeast of Filipini's ranch, and it connects across a gap with the less well defined lateral of the large glacier filling the North Fork of Silver Creek. In these, as well as numerous other instances, it is very plain that when the glacier made a bend most of the load was deposited on the outside of the curve. The well-marked lateral moraines of the latter glacier cap the ridges southwest of Bassi's ranch, the southeasterly one being especially well preserved. Its terminal moraine is not clearly marked, but is probably represented by the morainal masses in Union Valley at an elevation of 5000 feet, thus reaching an unusually low elevation. The rocks in the low gap just east of the large basalt area of Union Valley bear every evidence of having been worn by ice.

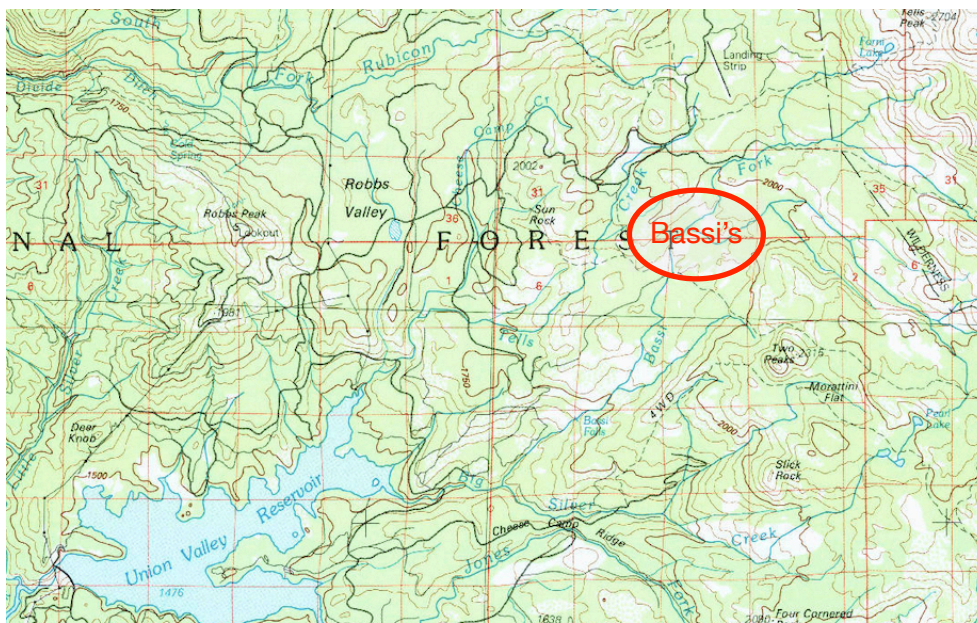
The North Fork Silver Creek is now known as Bassi Creek or Bassi Fork of Silver Creek.

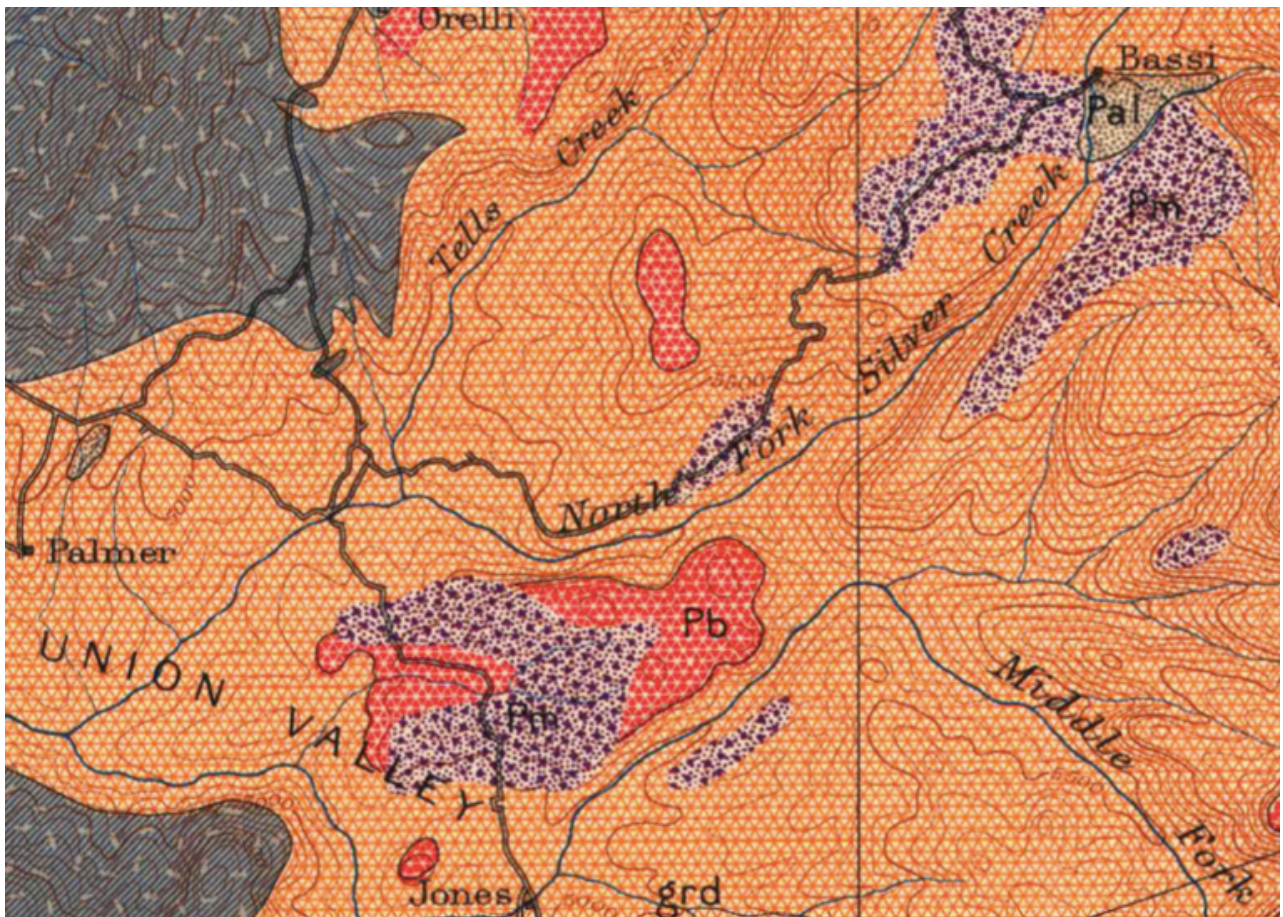
Bassi's Ranch is now shown on topographic maps as Upper Bassi and is a little over 2 miles upstream from Bassi Falls.

Union Valley is now flooded and submerged beneath Union Valley

Reservoir. The glacier map above shows the extent of the glacier into Union Valley.

A portion of the 1976 Placerville topographic map showing Union Valley Reservoir flooding Union Valley, the location of Bassi's Ranch and Bassi Fork of Silver Creek.

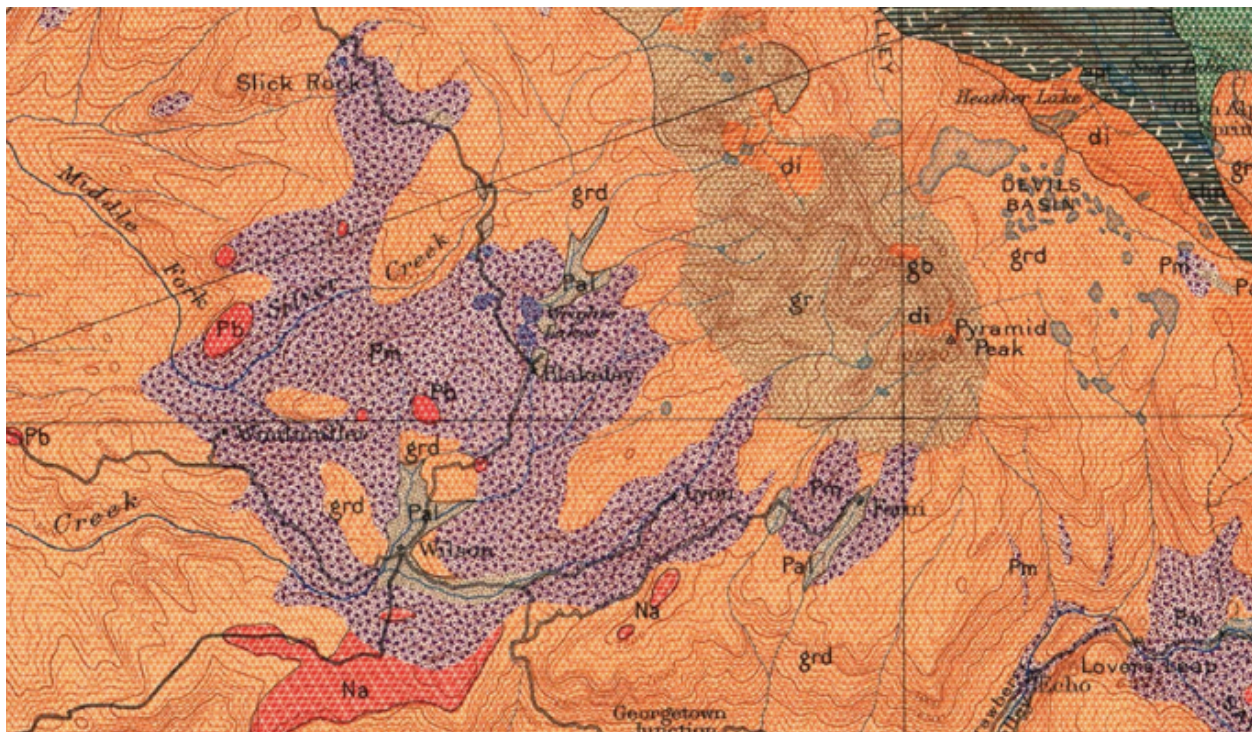




A portion of the 1896 geologic map of the Pyramid Peak Quadrangle showing the area near Union Valley and the North Fork Silver Creek, now known as Bassi Creek or Bassi Fork of Silver Creek. The red hatchured areas, labeled Pb are areas of Pleistocene basalt. The purple hatchured areas labeled Pm are glacially deposited moraines of Pleistocene age. Lindgren's text (above) mentions that the rocks in the low gap just east of the basalt shown south of North Fork Silver Creek "bear every evidence of having been worn by ice".

The extensive moraines of the Middle and South forks of Silver Creek join in the vicinity of Wilson's and Windmiller's ranches. The accumulations may in places reach a depth of 100 feet. Wilson Valley was evidently once a lake or swamp, retained by the terminal moraine below. On the ridges on both sides of the South Fork of Silver Creek there are no glacial traces in the shape of scattered drift; it would be easy

Wilson's Ranch is the large open meadow along the west side of the Wright's Lake Rd between where it crosses Lyon's Creek and the intersection with the Wright's Tie Rd (coming from Ice House Reservoir). Windmiller's Ranch is along the Wright's Tie Rd.



A portion of the 1896 geologic map, showing the large deposits of glacially derived material between Wright's Lake and Wilson Meadow. The South Fork of Silver Creek is the stream flowing westward through Wilson Meadow. The valley fill areas colored in grey and labeled Pal are Pleistocene alluvium. The extensive areas colored in orange and labeled grd are areas underlain by the granodiorite bedrock that makes up the core of the Sierra Nevada.

to discover any granitic boulders on the flat lava tables on the south side had the glaciation once extended farther west than is indicated by the end of the moraines on the map. A smaller glacier extended down the southwesterly slope of Pyramid Peak for a few miles,—as far down as Forni's meadow. There are no indications that any of the glaciers from the western side of the Pyramid Peak Range extended down into the canyon of the American River.

Forni's meadow is now referred to as Upper Forni and can be seen on the geologic map on the previous page.

Owing to the peculiar character of the drainage of the South Fork of the American River, it contained no large glacier, being in this respect unlike the other forks of the same river. No decided evidence of former glaciation has been discovered below the mouth of Strawberry Creek. Devils Basin, a broad depression east of Pyramid Peak, dotted with little lakes filling rock-basins, is really a continuation of the Rubicon Valley, from which it is separated only by a low divide. The large ice sheet once filling it extended down to the South Fork of the American, reaching, however, no farther down than Echo, where its comparatively small terminal moraines now lie. A short distance above Echo there is a knob 700 feet high, rounded especially on its eastern side by ice action, to the south of which rises the nearly perpendicular cliff of Lovers Leap, 1000

Strawberry Creek flows into the South Fork American River at the western end of Strawberry Valley (west of Strawberry). Echo is now referred to as Strawberry. And Devils Basin is the area now filled by Lake Aloha in Desolation Wilderness.

feet high, which has great similarity to the cliffs of the Yosemite. The vertical joints traversing the granodiorite have evidently facilitated the forming of this scarp, and glacial sapping at its foot has also been an important factor. The moraines of the Devils Basin glacier lie chiefly on the eastern side of the great bend the ice stream was forced to make where it reached the main river. High up on the trail leading to Ralstons Peak a magnificent view of this glacier path and its moraines is obtained. Above rises a vast extent of clean-swept and polished, white granodiorite, with the towering Pyramid Peak in the background; below recedes the narrowing canyon of the river, with the moraines, which appear insignificant in comparison with the denuded surface. On the western side the upper limit of the ice sheet is marked only by a narrow but sharply drawn lateral moraine, sloping downward at the rate of about 800 feet to the mile. On the east a crescent-shaped and double lateral moraine is thrown across the river like a dam. It is $1\frac{1}{2}$ miles long, three-fourths of a mile wide, and 600 feet high at most. Of the two parallel walls, indicating two stages of glaciation, the outer is the larger. Minor glaciers, one coming down the creek south of Pyramid Peak and

glacial sapping: the plucking or quarrying of blocks of rock at the head and base of a glacier, leading to the creation of steep headwalls. A popular theory at the time, but the term is not used commonly any longer.

Devils Basin glacier: This is describing the glacial features at Pyramid Creek and Twin Bridges. The "double lateral moraine" mentioned is the large moraine that Highway 50 traverses, east of Pyramid Creek. Note the early recognition of at least 2 glacial periods in the Sierra Nevada.

others occupying Strawberry Creek and Sayles Canyon, also reached the river. Behind the crescent moraine the river was dammed up to a depth of at least 200 feet, sandy and gravelly deposits now marking the extent of the flooded area, but in the course of time the morainal barrier was trenched by a narrow canyon, and meadows now extend over the site of the lake.

Above these meadows, in the vicinity of Phillip's ranch, there is much scattered drift, but no well-defined moraines are found until the canyon which heads 1 mile north of Bryan's ranch is reached. This tributary contained a well-defined glacier, which threw its western lateral moraine across the main river, damming it again and causing swamps and meadows about Audrains Lake. Immediately east of this lake is Johnsons Pass, at the suddenly ending canyon of the South Fork. The Echo Lake glacier pushed part of its lateral moraine over into the valley of the main river, while the glacier itself escaped toward Lake Valley. The glacier once filling the canyon heading 1 mile northeast of Bryan's ranch likewise threw part of its moraine over toward Audrain Lake, while the main ice stream found its way into Lake Valley.

This section is describing the large flat where Camp Sacramento is now located. This was a lake dammed by the Pyramid Creek glacier some 15,000 years ago.

Bryan's
Ranch is located at what is now known as Bryan Meadow, at the head of Bryan Creek (a tributary of Sayles Creek). The canyon Lindgren is referring to is Huckleberry Canyon, which opens northward and extends to near Highway 50. As described, another glacier flowed down to Lake Audrain

leaving a well formed moraine on the north side of Lake Audrain.

South of the American River the tongues of the ice sheet divided themselves between Silver Fork and the Mokelumne tributaries. The Silver Fork glacier, fed by the névé fields of the cirques of Round Top, Thimble Peak, and the vicinity of Silver Lake, was of imposing extent, and its ice-swept, broad valleys rival those of the Rubicon system. The deep flows of andesitic breccia of this region do not present the desolation of the glaciated granitic area, for, owing to the crumbling nature of the rock, it soon produces a fair soil, which supports scattered timber and in summer is covered with patches of grass and flowering alpine herbs. The well-defined lateral and terminal moraines, which are singularly small in extent, lie near the junction of the main branches of Silver Fork, no indications of glaciation being found below an elevation of 5500 feet. The Bear River glacier left its lateral moraines piled up against the breccia flows high up on both sides of the canyon, and a terminal moraine lies a mile below the dam. The glacier extended down at least to an elevation of 5500 feet. The bare, desolate canyon of Cold Creek also contained an ice stream, which left a lateral moraine 3 miles north of Mokelumne Peak and other well-defined morainal walls near the mouth of the canyon; the glacier may have descended into the Mokelumne Canyon. Summit Creek was doubtless also occupied by a glacier, but it probably did not extend down to the junction with the main river. The glacier which once filled the great

The "junction of the main branches" is referring to the confluence of Silver Fork of the American River and North Tragedy Creek. This is also where the Silver Fork Road crosses Fitch-Rantz Bridge and leaves the river canyon.

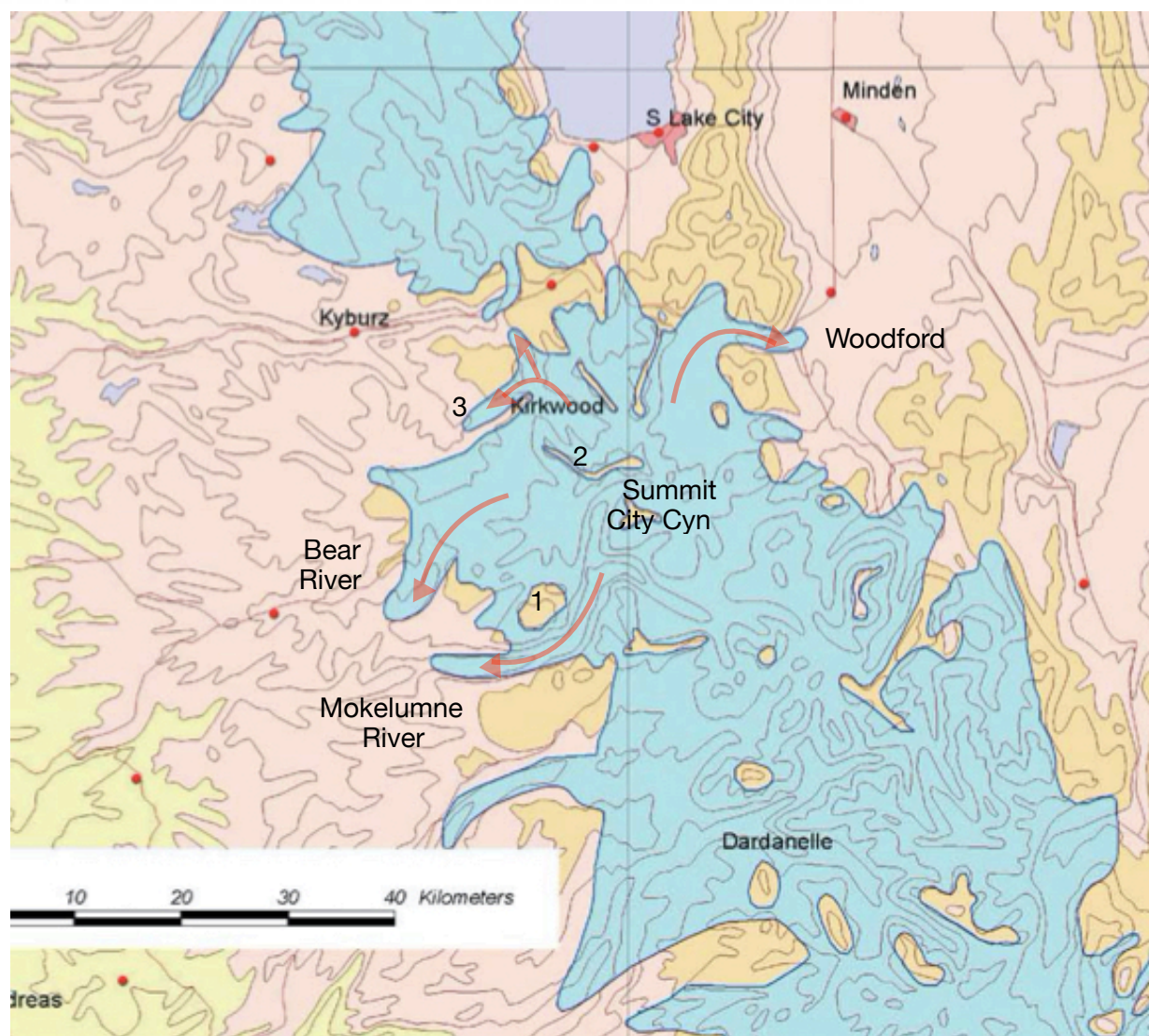
The "dam" mentioned is an early dam at the location of Lower Bear River Reservoir.

Cold Creek is a south flowing stream on the north and west side of Mokelumne Peak, now known as Cole Creek. It's location was mismapped in the 1889 topo map - the glacier did not reach the Mokelumne River.

Summit Creek is now known as Summit City Creek. As shown in the map below, currently the glaciers did extend well past the

Mokelumne Canyon to the east of the boundary line of the quadrangle may have extended a short distance into the quadrangle, but this is doubtful. No moraines are found in these precipitous canyons.

junction with the North Fork Mokelumne River, joined with the main ice mass and terminated a little below the location of Salt Springs Reservoir.



Map showing the extent of the latest major glaciation within the southern portion of the Eldorado National Forest and adjacent areas. Light blue area is the area covered by glacial ice. Yellow, pink and buff are to display elevation. Notice that Mokelumne Peak (1) and the Round Top/Thimble Peak Ridgeline extended above the glaciers. The red arrows show the direction that glaciers flowed. A glacier that flowed down Caples Creek (3) had one arm that flowed northward through the saddle and down Strawberry Canyon. Modified from Ehlers and Gibbard, 2003.

There remains to be mentioned certain glacial deposits along the canyon of the Rubicon which tend to show that the great glacier, fed by its many tributaries, extended much farther westward than had at first been supposed. Among these is the scattered but shallow drift on the andesite table in the extreme northwestern corner, extending over into the adjoining Colfax, Placerville and Truckee quadrangles. Further, a well-defined, though short, moraine lies on the andesitic ridge west of Uncle Toms Cabin; and scattered, often large, granite boulders occur along the crest of the ridge from Uncle Toms Cabin up to an elevation within 300 feet of the summit of Robbs Peak on the northern side. Scattered drift of granodiorite also occurs generally over the andesite table between the Rubicon and the Little South Fork of the Rubicon. These facts admit of scarcely any other explanation than that the whole basin of the Rubicon River in this vicinity was at one time filled with ice. If it was, the tongue of the glacier in the canyon must have projected into the adjoining Placerville quadrangle, reaching a least elevation of about 3000 feet. This seems, however, difficult to believe, for the canyon of the Rubicon does not in the Pyramid Peak quadrangle present such decided evidence of glaciation as would be expected if the whole deep valley had been filled with ice. More detailed examination may be needed to settle this point. An earlier and more extensive period of glaciation can scarcely be

In this section, Lindgren is describing a much older glacial event, likely about 800,000 years ago. The glacial deposits are found on the ridge tops on the north and south sides of the Rubicon Canyon, near where the 11 Pines Road enters the Rubicon Canyon on the north and south sides, but glacial deposits are not found in the canyon bottom here. At that time, the Rubicon Canyon was not as deep as today and so had not been affected by this older glacier. Evidence of this much earlier glacial period is not well preserved, and so the fact that Lindgren did not observe evidence in other places does not preclude the fact that there were other glacial events during the Pleistocene.

assumed, for elsewhere within the quadrangle there are no such occurrences as those stated above, outside of the clearly marked glacial limit. North of the boundary, in the Truckee quadrangle, the glaciation of the Rubicon Valley is clearly and indubitably indicated.

While much of this next section does not describe glaciers within the Eldorado Forest, it does help to explain the landscape and glacial deposits immediately east of the Forest and around Lake Tahoe.

Glaciers of the eastern slope. — The peculiar and narrow drainage basin of the Upper Truckee River, which with its deep trench separates the watershed of the American from that of the Carson River, bears ample evidence of once having contained a glacier, the névé fields of which must have connected with those of the adjoining glaciers on the west. The upper valley is, as usual, swept bare. Where the road leaves Lake Valley to wind up to the summit of Luthers Pass, toward Hope Valley, a considerable amount of lateral and ground moraine is found. The final terminal moraines begin about 1 mile above Myers. There are at least six of them within a distance of 3 miles, indicating stages in the retreat of the glacier, and they are well marked by low, crescent-shaped ridges, best visible from a high point on the adjoining ridges. Below Myers no morainal matter is found. The glacier filling the basin whose lower part is now occupied by Echo Lake seems to have flowed out through a gap about one-half mile northwest of the present outlet, the knobs rising above the lake and the slope toward Lake Valley being worn smooth. It flowed down

Terminal moraines are the glacially deposited ridges that mark the farthest extent of the glacier. The text refers to "at least six", however, these moraines recording the glacier's retreat are now called "recessional moraines".

the steep rocky wall, a veritable cascade of ice, and its terminal semi-circular moraines, joining those of the Lake Valley glacier, lie around the little lake at the foot of the scarp.

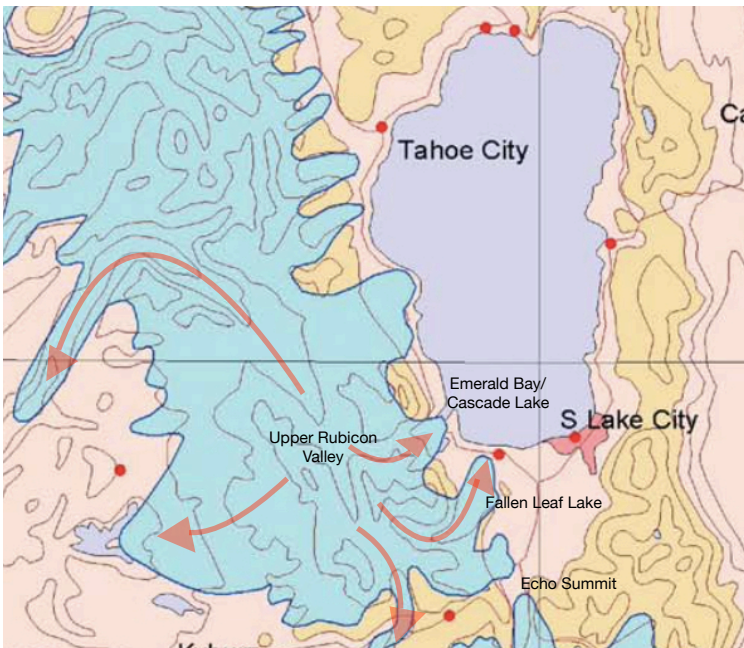
This little lake can be seen below Highway 50 as you drive from Echo Summit towards Meyers.

While the glaciers draining toward Lake Tahoe were comparatively short, their moraines are unusually well marked and of large size. The Fallen Leaf glacier, occupying the basin of the same name, swept everything bare above the head of the lake, the only well-indicated lateral moraine of the upper drainage being found north-east of Half Moon Lake. At the head of Fallen Leaf Lake the glaciated surface reaches at least 1000 feet above the valley, but Angora Point (elevation 8625 feet) shows by its rocky crags that it must have been above the ice line. On both sides of Fallen Leaf Lake the lateral moraines are very large and typical. The eastern is 3 miles long, from one-half to 1 mile wide, and 900 feet high, gradually sloping at its northern end. Being on the outer side of the bend the glacier was forced to make, it is natural that this moraine should have received the largest amount of débris. The moraines are composed of granitic and porphyritic rubble. The westerly lateral moraines are beautifully indicated; there are at least three of them, forming sharp parallel ridges, sometimes splitting in two at the lower end. The terminal moraines have dammed Fallen Leaf Lake, the surface of which lies less than 100 feet

Half Moon Lake is located in Desolation Wilderness, west of Mt. Tallac and at the eastern base of Jack's Peak and Dick's Peak.

Lateral moraines are moraines that are deposited along the sides of a glacier, in contrast to terminal moraines which form at the downslope end of a glacier.

above Lake Tahoe. There are at least three, and probably four, low terminal moraines, from 15 to 45 feet high, forming crescent-shaped walls surrounding the lower end of the lake. These moraines generally split in two near the western end; between them lie little flats covered with pebbles and sand.



Map showing the extent of glaciers in the northern part of the Eldorado Forest, Desolation Wilderness and Lake Tahoe, during the last major glacial period. Light blue area marks the extent of the ice cap. The red arrows show the direction of ice flow. Modified from Ehlers and Gibbard, 2003.

The glaciers once occupying Cascade Lake and Emerald Bay are similar to the Fallen Leaf glacier, but smaller. Cascade Lake lies somewhat over 100 feet above Lake Tahoe. Its upper, clean-swept and polished drainage basin is nearly circular in shape and contains several small lakes. On both sides of Cascade Lake lie lateral moraines up to 2 miles long and 500 feet high, and a well-defined terminal moraine dams its outlet. This glacier evidently did not reach the present shore of Lake Tahoe. The ridge between

Emerald Bay and Cascade Lake forms a medial moraine common to both glaciers. Emerald Bay connects with Lake Tahoe by a narrow inlet. The upper glacial basin and the lateral moraines, 600 feet high, are as well defined as those previously described. No terminal moraine is visible, but the débris dropped at the end of the glacier now forms a shallow bar across the inlet to the bay.

During a part, at least, of the glacial period the surface of Lake Tahoe stood several hundred feet higher than at the present time, so that many of the glaciers must have projected into the lake. But there is no evidence that the glaciers once filled the whole of the basin of Lake Tahoe.

A medial moraine is a glacially deposited moraine that forms where 2 glaciers merge and flow together. Highway 89 along the west side of Lake Tahoe traverses the crest of this medial moraine.

For those that would like to see the original Pyramid Peak Folio or read more of Lindgren's description of the geology of this amazing area, as the geology was understood in the 1890's, here is a link to the document: <https://pubs.er.usgs.gov/publication/gf31>