Mrs. Eugene Kingman
604 Sunset Street
Santa Fe, New Mexico 87501

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TWENTY FOUR PAGES OF ILLUSTRATIONS IN FULL COLOR

Imperial Rome Reborn
With 34 Illustrations — JOHN PATRIC

Caesar's City Today
21 Natural Color Photographs — BERNARD F. ROGERS, JR.

Crater Lake and Yosemite
With 7 Illustrations and 13 Paintings — WALLACE W. ATWOOD, JR. EUGENE KINGMAN

First Color Photograph from the Stratosphere
ALBERT W. STEVENS

Time's Footprints in Tunisian Sands
With 43 Illustrations and 2 Maps
MAYNARD OWEN WILLIAMS

The Mexican Indian Flying Pole Dance
With 13 Illustrations — HELGA LARSEN

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CRATER LAKE AND YOSEMITE THROUGH THE AGES

By Wallace W. Atwood, Jr.

With 13 paintings by Eugene Kingman

TO THE Klamath Indians, who lived long ago in the Cascade Range of southern Oregon, jewel-like Crater Lake in its massive rock setting was a weird and ghostly amphitheater where the gods were forever embroiled in conflict, sporting in the blue waters and dwelling on the highly colored crags of the crater rim. Rarely did these early inhabitants visit the lake, for they believed it to be the home of the gods, not to be molested.

Rumors of the existence of a deep-blue lake early reached the ears of Oregon miners, but its location remained unknown until June 12, 1853, when John Wesley Hillman, leader of a party of prospectors, found the hidden waters.

News of the discovery of Crater Lake spread rapidly throughout the West, but only a handful of travelers made the arduous climb to the crater's rim before the close of the century. In 1902 the area was set aside as Crater Lake National Park; good roads were constructed up the mountain, and now each summer thousands of visitors from near and far view its pastel waters.

A DRAMA OF THE ICE AGE

Like other visitors to Crater Lake, I was impressed with its deep-blue color and the rare beauty of the precipitous crater walls. But more than that, I wondered how the unique setting had come into existence. What story of earth history was hidden away in the massive rocks which formed the crater rim?

I recalled that Joseph S. Diller, of the United States Geological Survey, had studied the area many years before. After many weeks he had reached the opinion that a large volcano had collapsed to produce the basin now occupied by the lake. Was he right? Could a mountain top disappear and leave a huge caldera more than 4,000 feet in depth?

As a member of the scientific staff of the National Park Service, it was my duty to unravel further the geologic story buried in the rocks surrounding Crater Lake. From my tent tucked away beneath the branches of a mountain hemlock close to the rim, I could see the lake far below me. Each shift of the winds that ruffled the water produced new shades of blue, and drifting clouds floating high overhead sent shadows racing across the ever-changing picture. When darkness shut off the view, a nighthawk's call alone broke the silence.

The morning sunlight just touched the water as I worked my way along the rim to the Ranger Station. A welcome surprise awaited me there. "Hello, Doc, what brings you here?" came the familiar voice of my old friend and associate, George Grant, the chief photographer for the National Park Service.

I promptly asked him to join me for the day. "Sure will," was his hearty reply. "Maybe I can take some pictures for you."

Nothing could be better. Not venturing to ask outright for his services as a photographer, I had been secretly hoping he would bring his camera.

Within a few steps George saw his chance for a first picture. While he set up the tripod, I clambered down the steep slope of the crater rim. Suddenly I stopped. Before me was a grayish clay containing rounded bowlders of many sizes.

Had I seen this in New England, or in some high mountain valley of the West, I might have given it a casual glance, but here on the steep lava walls surrounding Crater Lake it brought me to a sudden halt.

FINDING GLACIER FINGERPRINTS

Immediately I was on my hands and knees examining the material. The bowlders were covered with scratches called "striae," and many of the smaller stones were highly polished.

These and the glacial till * before me were sure indications of former glaciation, and yet I was inside an ancient volcanic crater from which hot molten rock had once issued. How was I to explain this circumstance? A mystery story was unfolding. To the geographer these scratched stones were clues akin to those that Sherlock Holmes would seize upon.

* Glacial till is a mixture of stones, sand, and clay deposited by a glacier.



Photograph by Grant, courtesy National Park Service

A PARK NATURALIST TELLS THE STORY OF CRATER LAKE

To many visitors the morning hikes along the rim are highlights of the trip. Rangers who have studied the geology of the area explain rock formations and answer questions. Wizard Island, with its barren top above the trees, looks like a young volcano growing up in the caldera left when Mount Mazama disappeared (page 332, and Color Plate III).

Photograph by Grant, courtesy National Park Service

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Photograph by Charles Martin

VERTICAL CLIFFS OF YOSEMITE WERE PRODUCED BY STORMS AND ICE SHEETS OF THE AGES

El Capitan (left) and Cathedral Rocks, opposite, tower far above the parklike lowland where the Merced now wanders peacefully through rich meadowland (Plate VII). Lofty, swaying waterfalls, such as the Bridalveil (right), enliven the steep walls of the canyon. Unknown to the white man in the early part of the 19th century, it was the stronghold of Tenaya, leader of the Yosemite (grizzly bear) Indians. Captain Boling of the Mariposa Battalion discovered it on March 21, 1851, when he pursued the chief and his warriors to their lair. Congress made it a national park in 1890.



Photograph by Albert W. Stevens

AN AIRPLANE VIEW REVEALS THE SECRET OF HALF DOME

From aloft the observer can readily understand how Yosemite has been carved out of the high Sierra by rivers of ice and water (page 343). Cliff faces of this bald giant, towering nearly a mile above the valley, show clearly the marks of the glacier which carved them.

Just then I remembered my friend on the rim and shouted for him to come down. With some difficulty George and the camera reached the level where I was working. We photographed the "evidence" and continued the search for more.

A ROCK SANDWICH TELLS A STORY

Our glacial till appeared as sandwich filling spread between two layers of lava rock. On the layer beneath the till we found deep scratches produced by a rock-shod glacier as it moved slowly across the lava surface. Where did this glacier come from, and why was material once carried by the ice now sandwiched in between layers of lava? If we could answer these questions, perhaps we could unravel the story of Crater Lake.

During the next few weeks we searched the crater walls from top to bottom. It was not easy to negotiate jagged lava cliffs, but thanks to a strong rope and well-hobbed shoes we completed the work without serious mishap. Our adventures were not in vain, for we found not one but several exposures of glacial material, some of them buried beneath a thousand feet of volcanics.

Like leaves in a book, these geologic formations told a story of periods of vulcanism separated by periods of glaciation.

In a few localities charred remains of trees are interbedded in the volcanic rocks. At one place we saw the trunk of a tree preserved in its original upright position. These records indicate long time intervals during which soils formed, flowers bloomed, and trees flourished, later to be destroyed when molten rock and volcanic ash buried the landscape. Some day, when the carbonized remains are accurately identified by the paleobotanist, we may know much



Photograph by R. H. Cook

PHANTOM SHIP APPEARS SUDDENLY LIKE A FIGMENT OF A DREAM

Cruising around the southern shore of Crater Lake, one does not see this craggy island, camouflaged against lava cliffs, until suddenly the rocks seem to leap from the shore to rest upon the quiet surface of the lake.

more of the early forests of this region.

We also discovered that the layers of lava sloped gently away from the rim—another clue. Surely, we said, this indicates that the vent of an ancient volcano, the volcano that belched forth this lava, once existed above the present lake. Here was tinder to fire the imagination.

Diller's mystic mountain, Mazama, had then really existed. What had happened to this mountain? Where had it gone? What was its appearance in the days when those charred bits of wood were living tissue in mighty tree trunks? How did it look ...en glaciers moved down its slopes?

Gradually, as the evidence accumulated, ...became possible to reconstruct the story ... the past. Each piece of evidence served ...a magic clue to a marvelous story of earth ...tory. This epic is illustrated in a series ... paintings by Eugene Kingman. With his aid it has been possible to go beyond the realms of photography and reproduce the ancient landscapes interpreted from the geologic records.

In the first painting of the series Mount Mazama is pictured as a youthful, active volcano (Plate I, upper). Frequent eruptions caused layer after layer of lava to pour out on its slopes.

During this period most of the volcanoes of the Cascade Range were active and building up their cones. Lava flows spread over the regions to the north and east, forming extensive plateaus. Forces deep within the earth prepared tremendous amounts of molten rock with which to mold the landscape of our Pacific Northwest.

In time Mount Mazama rose high enough to force moisture-laden westerly winds to rise, chill, and give up the water they had gathered over the Pacific. Heavy rains

and snows fell upon the mountain slopes. While the volcano remained inactive, snows persisted throughout winter and summer.

A visitor to the mountain in that day would have had as few reminders that he was climbing a volcano as he might experience today in ascending Mount Hood or Mount Rainier. The young volcano was then the abode of living glaciers which were to leave their imprint on the rocks of the region (Plate I, lower).

A MONARCH OF THE CASCADE RANGE

Some may ask, "Why is Mazama pictured as a high mountain?" The glacial story supplies the answer. By careful observations geologists have estimated that glaciers did not form in this part of North America much below 8,000 feet. If this be true, Mount Mazama should have attained at least that height before its first glaciers formed. At its final stage, climax of a long period of volcano building, the mountain probably reached an elevation of at least 10,000 feet (Plate II, upper).

When at last lavas ceased to flow from the crater of Mount Mazama, ice and snow again enveloped the mountain. The increased height of the volcano caused heavier snowfall, and glaciers larger than those of the earlier period spread far down the mountain side to points five miles from the present rim. The broad valleys sculptured by the ice remain to the present day as reminders of the final stage in the glacial history of the mountain (Plate II, lower).

In placing a small cone on the western slope of Mount Mazama in the third and fourth paintings, the artist was guided by an interesting record visible on the rocks of the present rim. This consists of glacial scratches so oriented as to prove that ice must have radiated from two separate cones, the larger over the center of the present lake, the smaller approximately two miles to the west.

The smaller cone, called Little Mazama, was directly over the site of Wizard Island, a volcanic cone of more recent origin which now rises above the surface of the lake. The relative position of Little Mazama and the present island is certainly no mere coincidence. Renewed eruptions from the vent, which earlier supplied the material for the secondary cone, in later times undoubtedly built Wizard Island.

In the centuries which followed its final glacial stage, Mount Mazama underwent a profound change. The whole top of the mountain disappeared. Approximately 13 cubic miles of material were removed. Could an explosion have caused this great destruction, or did the volcano collapse and swallow its head?

In seeking an answer to this important question we turn to Alaska, where a terrific explosion in the early summer of 1912 destroyed Mount Katmai.* Here the remains of the former volcano are scattered over the surrounding country. If this history occurred at Crater Lake, we should find fragmental material near the present depression. The absence of such debris throws doubt on the "grand explosion" theory.

It may be that Mount Mazama, like Kilauea in Hawaii, had a broad crater which gradually enlarged, through a caving-in process, to form the present deep depression. Possibly a combination of explosion and collapse produced the caldera. Although several theories have been proposed, the disappearance of Mount Mazama is still shrouded in mystery.

The early history of Mount Mazama suggests that possibly Mount Rainier, Mount Hood, Mount Shasta, and other volcanoes of the Cascade Range are in the midst of similar careers. Suppose Mount Rainier, today a dormant mountain, should eventually resume eruption and destroy the glaciers which now radiate from its peak; possibly this has already happened several times in the early growth of the mountain.

If the summit of that volcano should suddenly disappear, leaving a giant caldera in the base of the mountain, a landscape history similar to that of Mount Mazama might be revealed.

From the summit of Union Peak, a few miles southwest of the crater rim, it is possible to reconstruct in imagination the mighty mountain of Mazama which for many centuries dominated the landscape. In spite of the many changes during the disappearance of the volcano, the broad, ice-formed valleys may be easily recognized where they notch the rim of the caldera (Plate III, upper).

* See "Valley of Ten Thousand Smokes: National Geographic Society's Explorations in the Katmai District of Alaska"; "Valley of Ten Thousand Smokes: An Account of the Discovery and Exploration of the Most Wonderful Volcanic Region in the World"; "Ten Thousand Smokes Now a National Monument," and "Our Greatest National Monument" by Robert F. Griggs, in THE NATIONAL GEOGRAPHIC MAGAZINE for January, 1917, February, 1918, April, 1919, and September, 1921, respectively.



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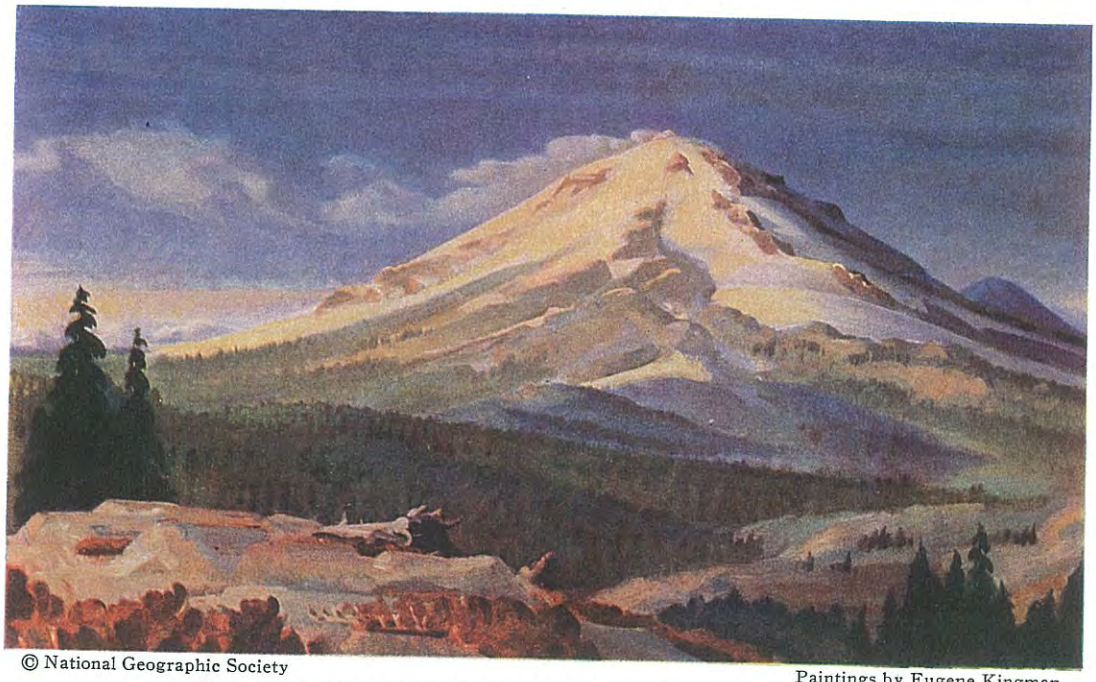
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A MIGHTY VOLCANO ONCE SEETHED WITH FIRE WHERE MYSTERIOUS CRATER LAKE GLISTENS TODAY

Many thousands of years ago molten rock from deep within the earth poured forth to build in the Cascade Range of southern Oregon lusty Mount Mazama, which the artist has re-created from geologic records. Its frequent explosions buried the surrounding landscape beneath pumice and ash, to be turned by the alchemy of millenniums into soil of remarkable fertility.

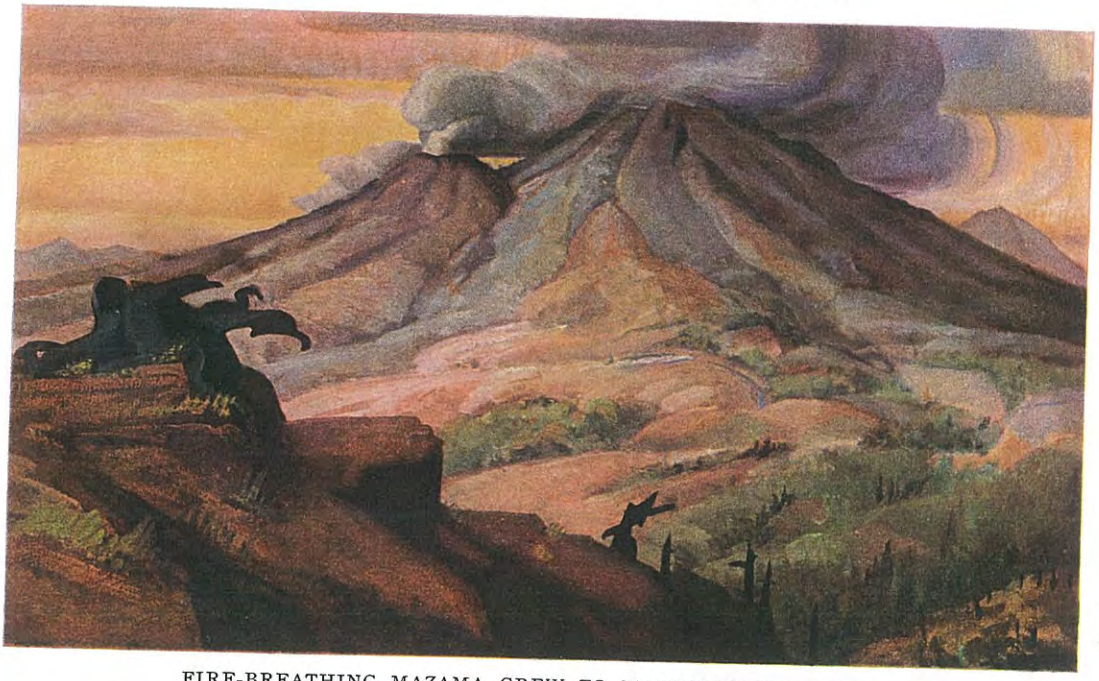


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Paintings by Eugene Kingman

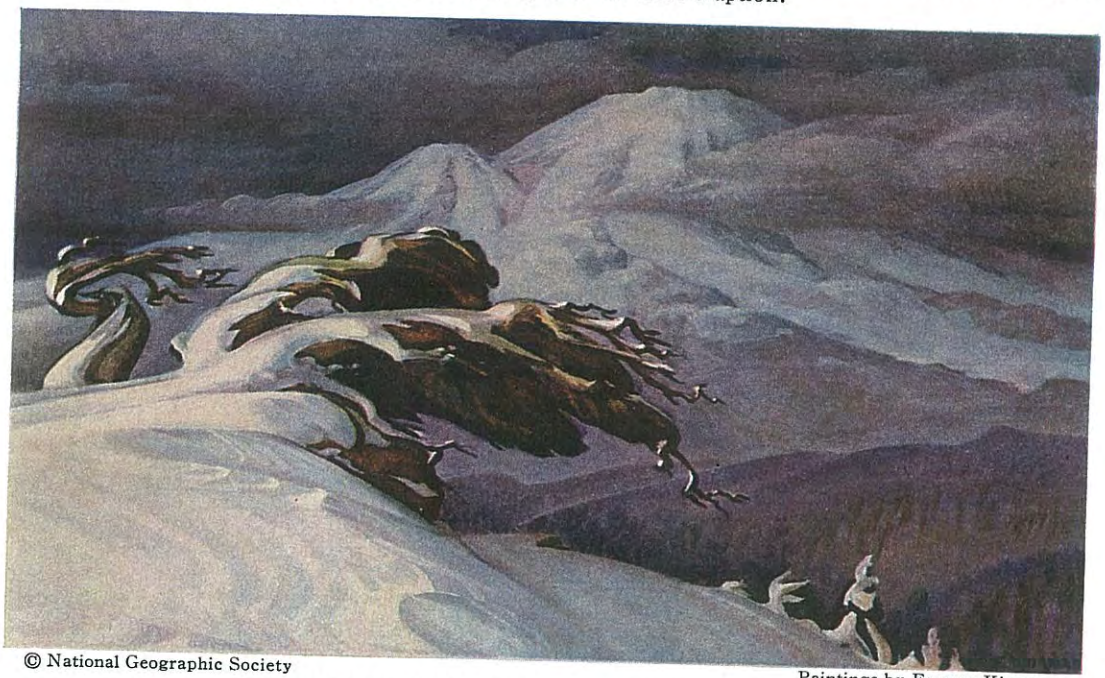
GLACIERS WERE BORN ON THE SLOPES OF THE VOLCANO

Continued outpourings of lava raised the mountain to at least 10,000 feet. Snows fell, massive layers of ice formed during periods when the subterranean fires were banked. But the record of these glacial caps is now buried under a thousand feet of rock, later poured in molten state from the crater.



FIRE-BREATHING MAZAMA GREW TO MAGNIFICENT STATURE

Slow but persistent volcano building gradually lifted the mountain higher and higher. A secondary cone developed on its western slope. Whenever the giant was dormant, glaciers cooled its head, and forests mantled its slopes, only to be destroyed at the next eruption.



© National Geographic Society

Paintings by Eugene Kingman

THE VOLCANO SMOLDERS BENEATH ITS ICY COVER

When the lava cooled, vast rivers of ice formed on top and moved in resistless majesty down the slopes. Broad valleys that remain today are verdure-clad reminders of the last glacial stage in the history of Mount Mazama.



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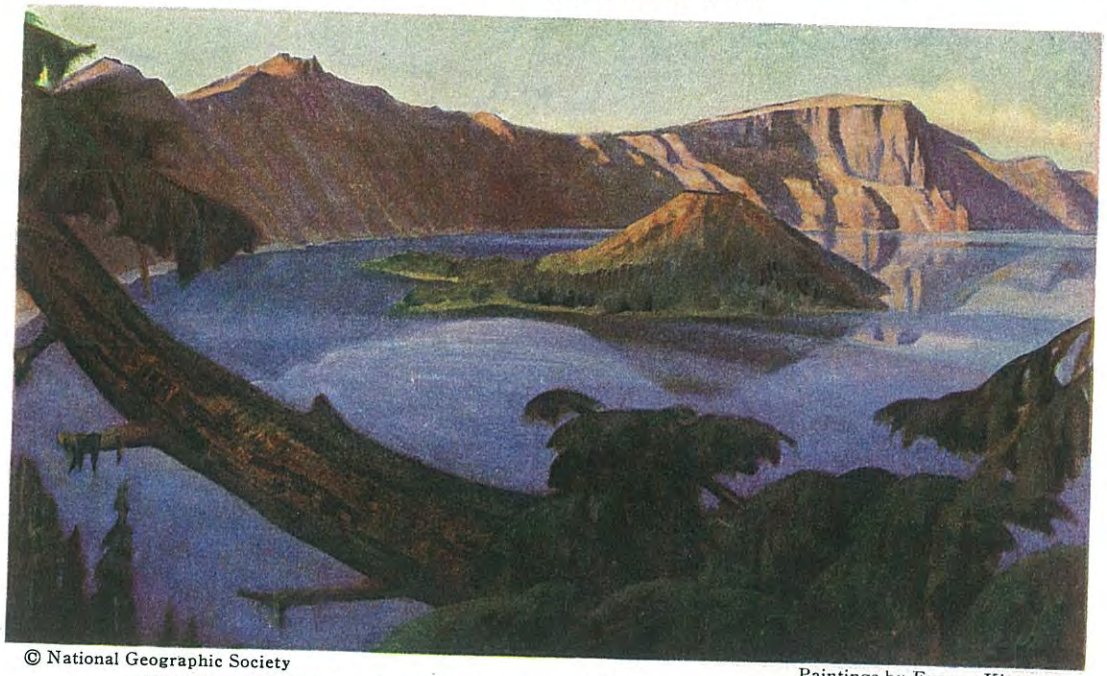
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ALL THAT NOW REMAINS OF THE MAJESTIC MOUNTAIN

Relentless forces leveled the towering peak. The top of Mount Mazama disappeared by explosion or gradual sinking, leaving a giant caldera six miles across and four thousand feet deep. Rains and snows have filled this huge depression with the waters of Crater Lake.

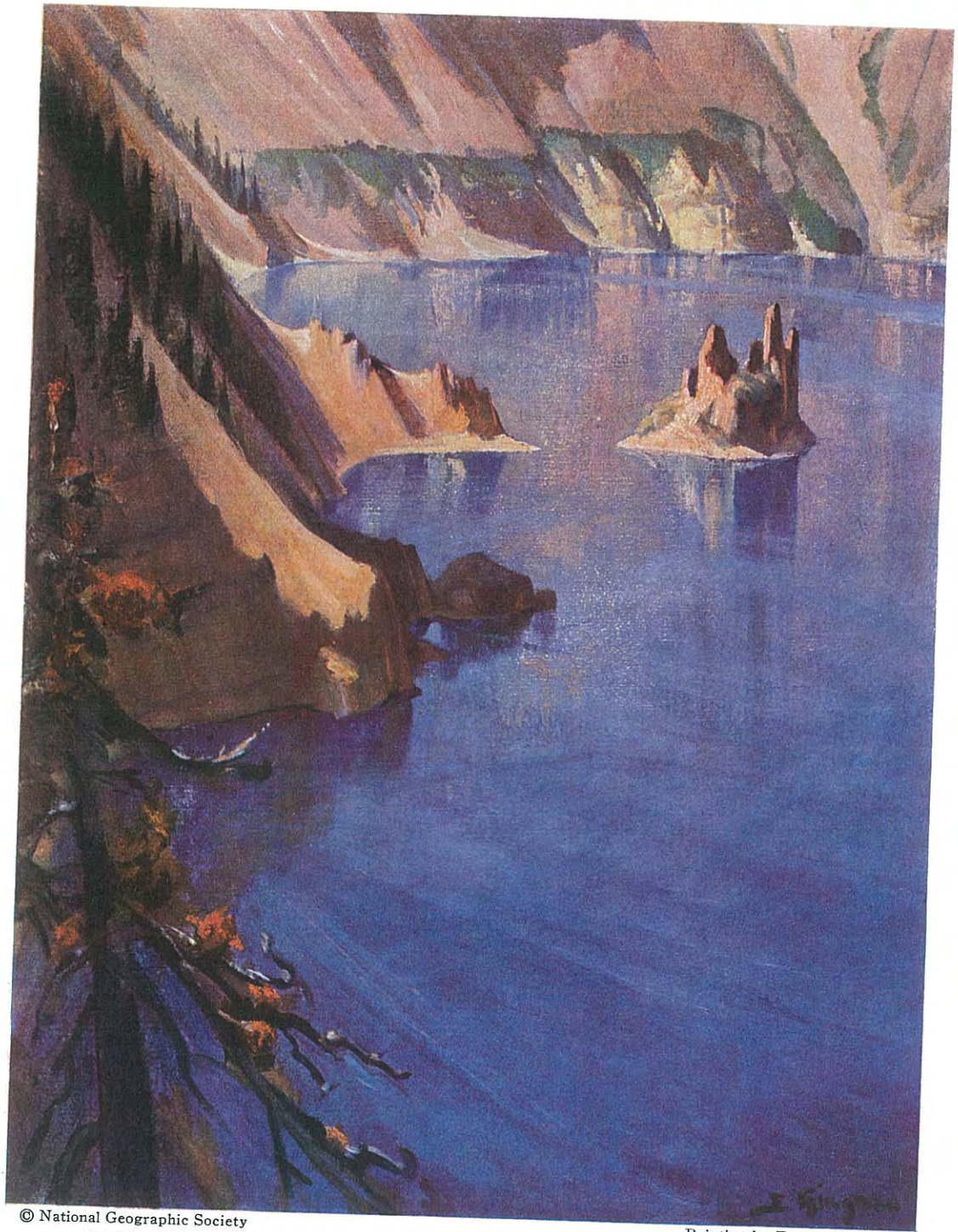


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Paintings by Eugene Kingman

INCREDIBLY BLUE, CRATER LAKE SPARKLES IN ITS ROCKY SETTING

Sheer walls rise in some places 2,000 feet above the water. Graceful hemlocks, clinging to the rim, soften its sharpness with feathery foliage. Clouds that drift above the water send shadows racing across the mirrorlike surface.



© National Geographic Society

Painting by Eugene Kingman

WIND AND LIGHT ARE FOREVER ALTERING THE COLOR OF CRATER LAKE

Like rival artists seeking an impossible shade, they change their palettes with whimsical suddenness. One moment the gold of the sun may lie unbroken on the still water, the next a brush of breeze erases it and leaves a patch of dancing blue ripples. The small, rocky island close to the shore is Phantom Ship.



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THE ARTIST ILLUSTRATES THE FIRST CHAPTER IN THE TEN-MILLION-YEAR-OLD ROCK STORY OF YOSEMITE

Originally the Sierra Nevada were low mountains, and the Merced River wound sluggishly through a wide valley flanked by rolling hills. The ancestor of Half Dome, in center of the horizon, rose only 1,500 feet above the stream, and none of the picturesque features that now attract thousands of visitors to Yosemite Park had come into existence.

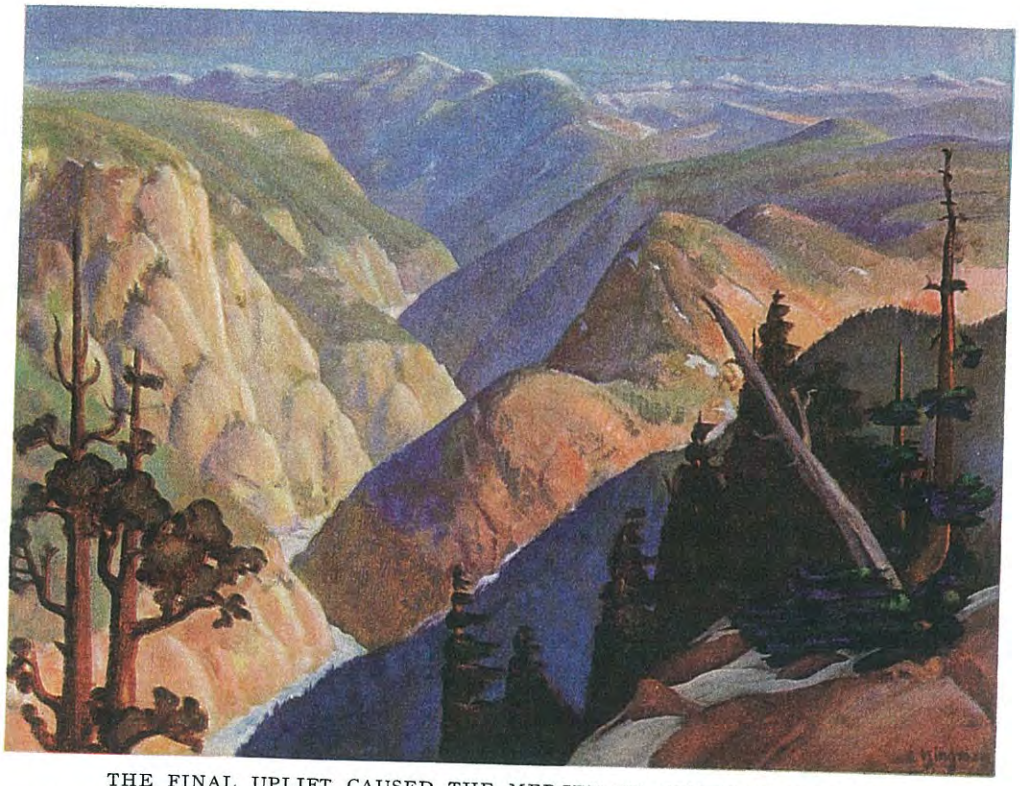


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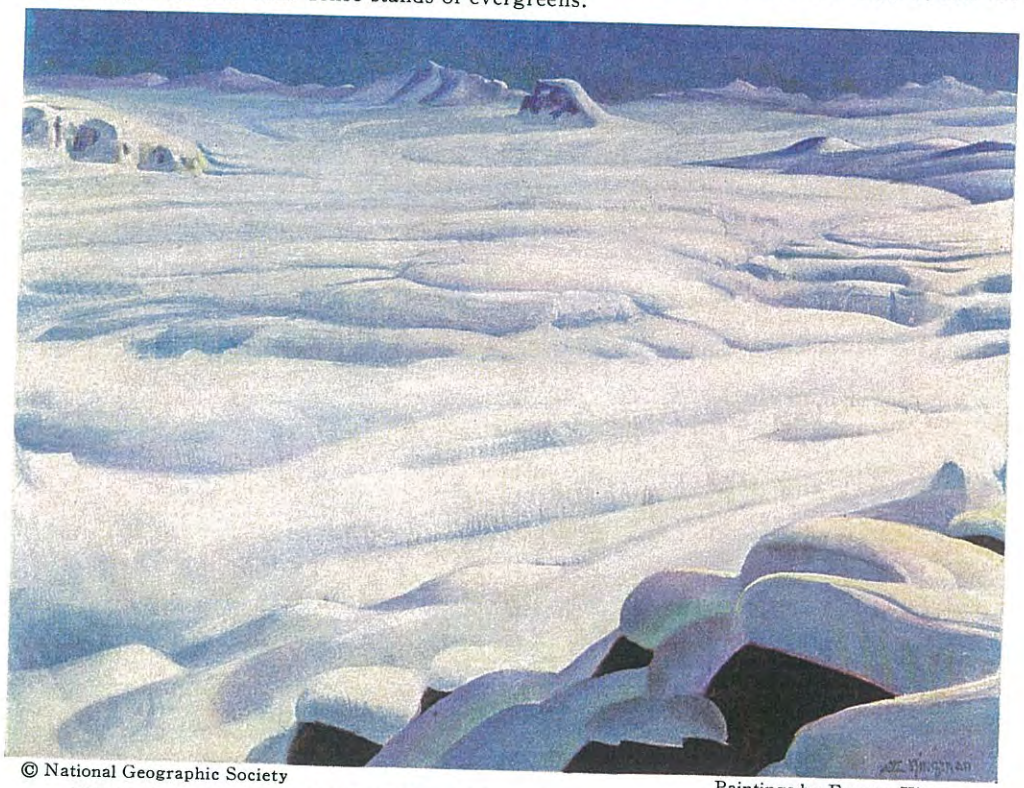
SEVERAL MILLION YEARS LATER THE ENTIRE REGION WAS RAISED AND TILTED

In response to this increased elevation the Merced River cut a broad V-shaped valley below its former plain. Such landmarks as El Capitan and Half Dome then became prominent features.



THE FINAL UPLIFT CAUSED THE MERCED TO CUT STILL DEEPER

Thus more than a million years ago, just before the Great Ice Age, was produced the canyon shown in this painting. The higher peaks of the Sierra Nevada became snow-capped, and the lower slopes covered with dense stands of evergreens.



© National Geographic Society

Paintings by Eugene Kingman

THEN A FROZEN SEA HID THE MERCED RIVER AND YOSEMITE VALLEY

Cold, snowy winters and cool summers favored accumulation of snow and ice in the high mountain valleys. Glaciers formed and gradually pushed into Yosemite, burying the canyon. Half Dome, Sentinel Dome, and El Capitan rose only slightly above the frigid mantle.



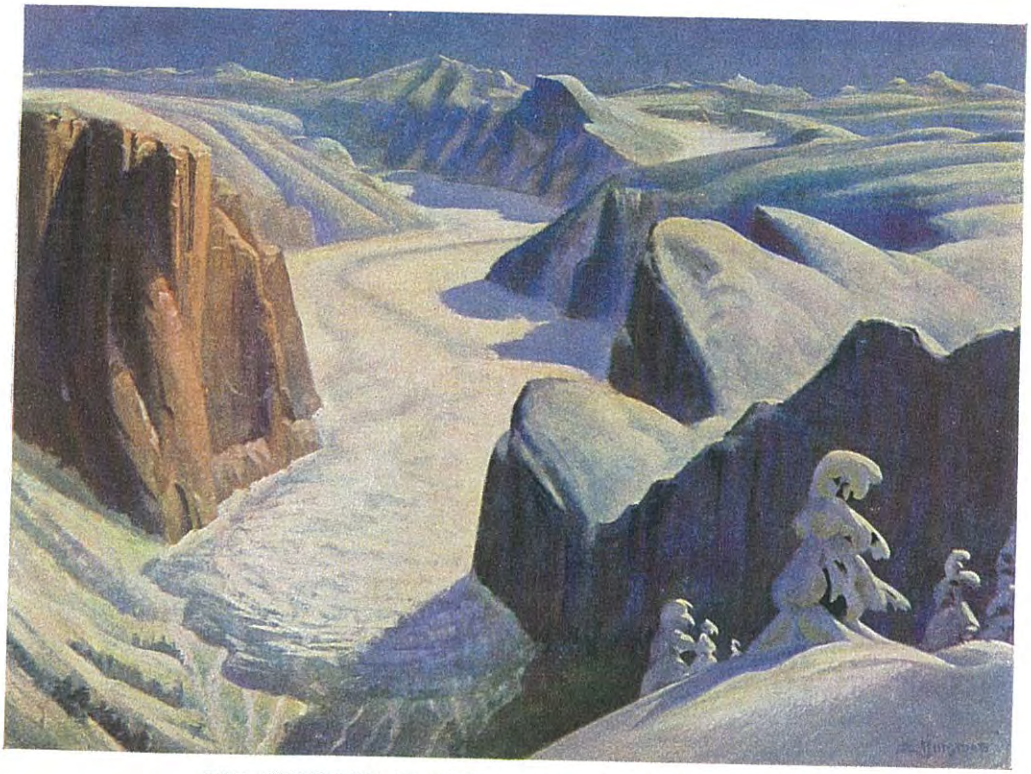
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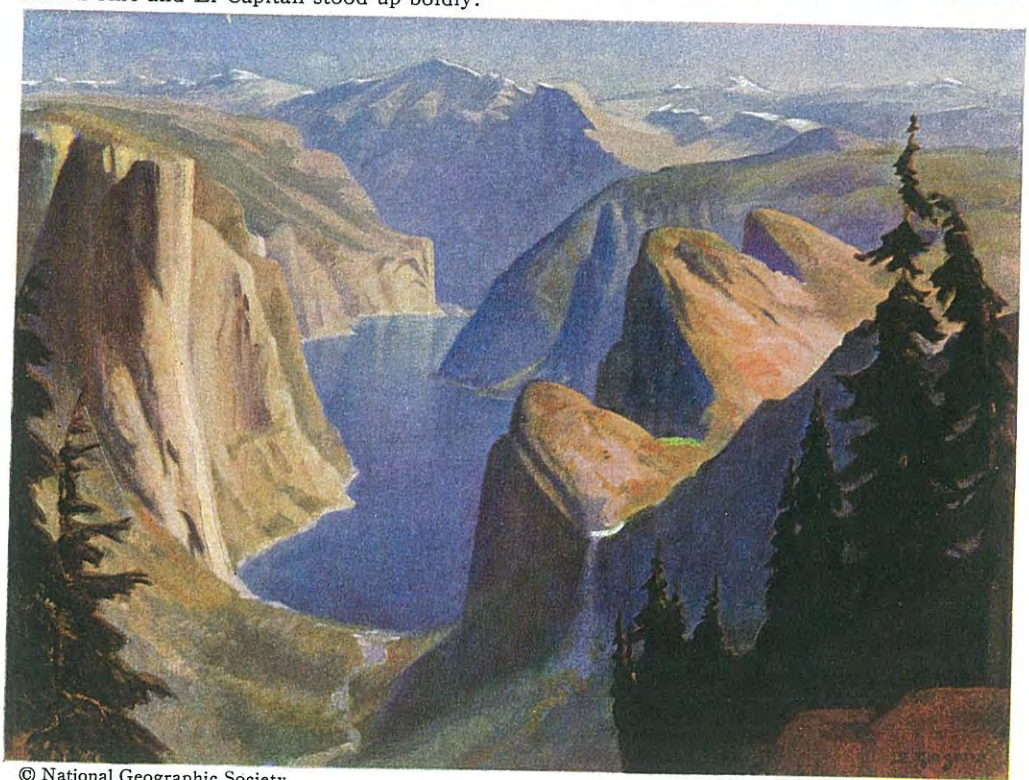
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THE YOSEMITE GLACIERS MADE A LAST ADVANCE

When the frozen sea (Plate VI) had melted away, a smooth-walled U-shaped valley remained. Many centuries later ice came again, further deepened the valley, and polished the steep cliffs. Half Dome and El Capitan stood up boldly.



© National Geographic Society

Paintings by Eugene Kingman

LAKE YOSEMITE REFLECTED THE GRANDEUR OF ITS WALLS

The debris left by the glacier impounded a large lake which remained for several centuries to grace the valley. But silt gradually filled the shallow basin and produced a broad lowland, now the site of National Park headquarters and of hundreds of tents and cabins that visitors enjoy.

Far away in the Alaska Peninsula two volcanoes await careful study by the geologist. One of these, Aniakchak,* has a caldera nearly seven miles in diameter on the floor of which is a small cone closely resembling Wizard Island. Veniaminof has a crater rim more than 6 miles in diameter. Within its huge depression lies a large ice field whence tongues of ice radiate outward and across the rim.

The similarity between these Alaskan volcanoes and Mount Mazama commands the attention of the scientist. Did these mountains pass through the same sequence of events as that recorded at Crater Lake? Were they once higher than they are today?

When Mount Mazama's stormy history ended, a lake formed in the bottom of the caldera. Today this body of water maintains a relatively constant level, although no streams enter or leave the depression (Plates III, lower, and IV).

All visitors marvel at the lake's vivid blue color. Some believe that minerals in the water account for this, but analysis indicates that the water is remarkably pure. Some believe the blue is the sky's reflection, but the water is blue, rain or shine. Others think the color may be due to a diffusion of light and intensification of the blue portion of the color spectrum. As yet, the blue of Crater Lake, like the disappearance of Mount Mazama, remains a mystery.

YOSEMITE HAS A DIFFERENT STORY

Many miles to the south of Crater Lake, in the high country of the Sierra Nevada, California, a very different story of earth history has been recorded. Instead of a mighty volcano built up by repeated outbursts of molten rock, we see the valley of Yosemite carved by streams and glaciers.

Today this land is one of our national parks. Each year more than half a million visitors revel in its glory. Many come to enjoy the scenery of the valley, some seek its gracious climate, and others find enjoyment in understanding its geologic past.

I entered Yosemite by the John Muir Trail after traveling several weeks by pack train in the high mountain country south of the park. My first glimpse of the canyon was from one of the high granite cliffs east of Half Dome. As I looked at this majestic form, I had a desire to scale its steep walls and see more of the huge canyon cut so deeply into solid granite (page 330).

Seated on the brink of a cliff overlooking the valley, I attempted to unravel Nature's handiwork, which I knew was recorded in the landscape. I saw waterfalls leaping from valleys which seemed to end in mid-air; I could see the tiny Merced River more than 3,000 feet below me (page 326). Could this stream have cut the canyon which lay before me?

I recalled the story told by François E. Matthes, eminent scientist of the United States Geological Survey, of a great ice age when Yosemite Valley was filled with a giant glacier which moved slowly toward the lowlands to the west. Was it, then, the work of this ice which produced Yosemite? No, not entirely, for streams had played their part long before the ice came.

Most visitors to the park enter from the west, passing between El Capitan and Cathedral Rocks (page 329). These granite forms tower 3,000 and 2,600 feet, respectively, above the valley bottom. Once through this gateway, the visitor finds himself in a magnificent canyon cut in the granite rocks of the Sierra. At his left are Yosemite Falls, ribbons of white descending the sheer granite cliffs.

After a brief visit to Mirror Lake, where Half Dome casts its reflection in the quiet waters, he proceeds to Inspiration Point high on the side of the canyon at the other end of the valley. Across the valley are the snow-capped peaks of the Sierra.

Yosemite seems no longer the isolated canyon held in by giant walls, but instead a part of a glorious landscape, an interesting bit of the grand Sierra Nevada panorama. The mighty El Capitan, which rose so abruptly from the valley floor, blends into the upland country as if it belonged to the mountain landscape rather than to the valley. Half Dome appears as a low mountain rising above the gently rolling upland.

I overheard one visitor say as he stood at Inspiration Point, "It looks as if Yosemite Valley was cut right out of a mountain."

He probably did not realize how truly he had spoken.

Frequently I have heard the question, "Where is the other half of Half Dome?"

For many years the origin of Yosemite Valley remained unknown even to the geologists who visited the region. All attempts to shape its history were incomplete and based upon meager information. It was

* See "World Inside a Mountain," by Bernard R. Hubbard, in THE NATIONAL GEOGRAPHIC MAGAZINE, September, 1931.



Photograph by Ralph Hopewell Anderson

HOW HAVE THE MIGHTY FALLEN!

Far from the wild state when it foraged for food, the black bear has become a beggar, posing in the hope of getting a taste of sweets and raiding garbage cans. In Yosemite National Park visitors are cautioned not to feed these animals. A bear is quick and strong, and even a scratch from its sharp claws is serious.

Mr. Matthes who finally solved the mystery. He visited every valley and mountain fastness. He examined every bit of ground in his search for the pages of Yosemite's history.

On the uplands above the present valley he found remnants of earlier valleys once occupied by ancestral streams. On the granite walls that rise almost vertically from the valley floor he detected scratches produced by glacier ice. All around him were the tools of mighty glaciers which once filled the valleys of the Yosemite region. High on the mountains were the broad valleys down which the ice had moved.

Let us close our eyes on the landscape of today and go back to a time ten million years ago.

The ancestor of the Merced River meandered through a broad valley in a region of low hills (Plate V, upper). Instead of the present invigorating climate, an enervating subtropical type with high temperatures and heavy rainfall prevailed. The entire area was densely covered with rain-loving vegetation. Evergreens had probably not yet developed in that early period of Yosemite's history.

In response to an uplift of the entire region, the Merced received a new lease on life and the climate became cooler. Instead of the subtropical growth of the earlier period, a forest of hardwoods and evergreens, including the first sequoias, covered the landscape (Plate V, lower).

Several million years later the Sierra Nevada attained approximately its present height and the Merced River cut a deep canyon in the granite rocks of the range. The lower slopes were covered with dense stands of evergreens. Tall sequoias graced the forest landscape (Plate VI, upper).

The narrow, rugged canyon of the Merced was to undergo still further transformation. High in the mountains to the east heavy snows fell during the winter months, so deep that the summer sun could not melt them. Continued snowfall produced glaciers, one of which completely filled the valley of the Merced (Plate VI, lower).

This icy mantle which enwrapped the Yosemite region for several thousand years

accomplished remarkable results. It obliterated the sharp turns of the Merced River. The jagged edges of the narrow canyon were worn off.

Scouring its path, the rock-shod ice carved the steep northern face of Half Dome (page 330), and created hanging valleys from which today beautiful waterfalls pour forth and leap into the master stream far below.

Twice again glaciers visited Yosemite Valley. During the last stage the terminal margin of the ice lay just west of El Capitan (Plate VII, upper). The valley was deepened and the steep walls were resmoothed and repolished.

The vegetation at this time, approximately 20,000 years ago, consisted in the main of types now growing there. Pine, fir, and the giant sequoia flourished.

With the disappearance of the last Yosemite glacier a beautiful lake came into existence. Had the ice left a higher barrier, this ancient Lake Yosemite might have remained to grace the valley today (Plate VII, lower).



Photograph from M. Hall McAllister

EVEN WITH HANDRAILS IT'S A HARD CLIMB

To reach the top of Half Dome, 8,852 feet, hikers in rubber-soled shoes toil up a trail of zigzag steps cut in the smooth granite, then pull themselves up the last 300 yards by cables strung on firmly anchored posts. If the scaling equipment were not removed each autumn, it would be swept away by snow avalanches.

THUS NATURE FASHIONED A SCENE OF IMPRESSIVE GRANDEUR

No major change has since affected the landscape. A scene of impressive grandeur awaits the visitor.

Early belief that Yosemite Valley was the result of some catastrophic dislocation of the earth's crust is no longer accepted.

Instead, Yosemite's long record, when rightly read, shows that changes in elevation, and the slow but persistent work of running water and moving ice have wrought the marvel.

A visit to Yosemite National Park compels at least an hour of meditation and reverence at Inspiration Point. Here the artist set his easel and translated to canvas the geologic story of Yosemite.

From this point of vantage, it is not hard for the imaginative visitor to transcend the barrier of time and to slip eons back into geologic history.

By so doing he may visualize the landscapes of Yosemite's past and comprehend the wonders of earth history that Nature has recorded.