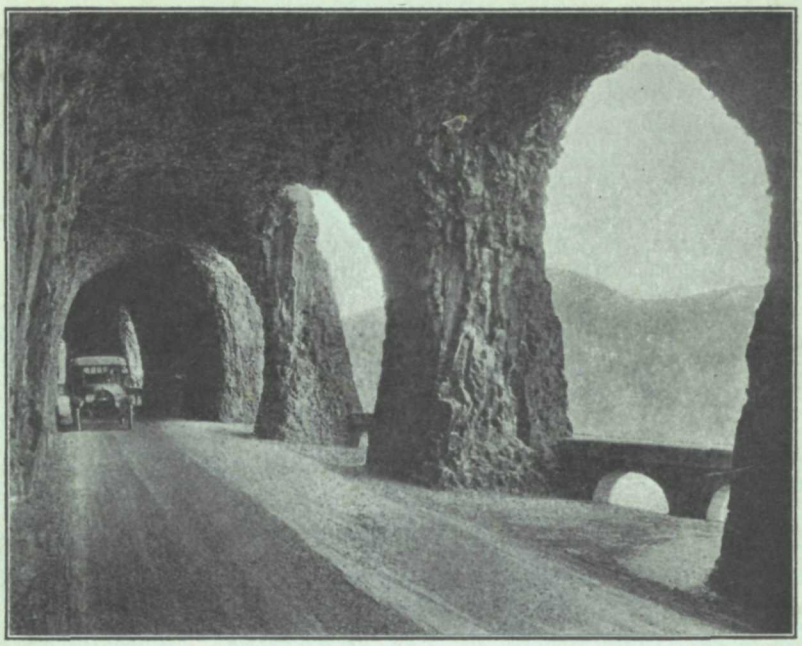
# THE COLUMBIA RIVER GORGE

## ITS GEOLOGIC HISTORY

Interpreted from the

# Columbia River Highway

By IRA A. WILLIAMS



Mitchell Point Tunnel—unrivaled in the world—
on the Columbia River Highway

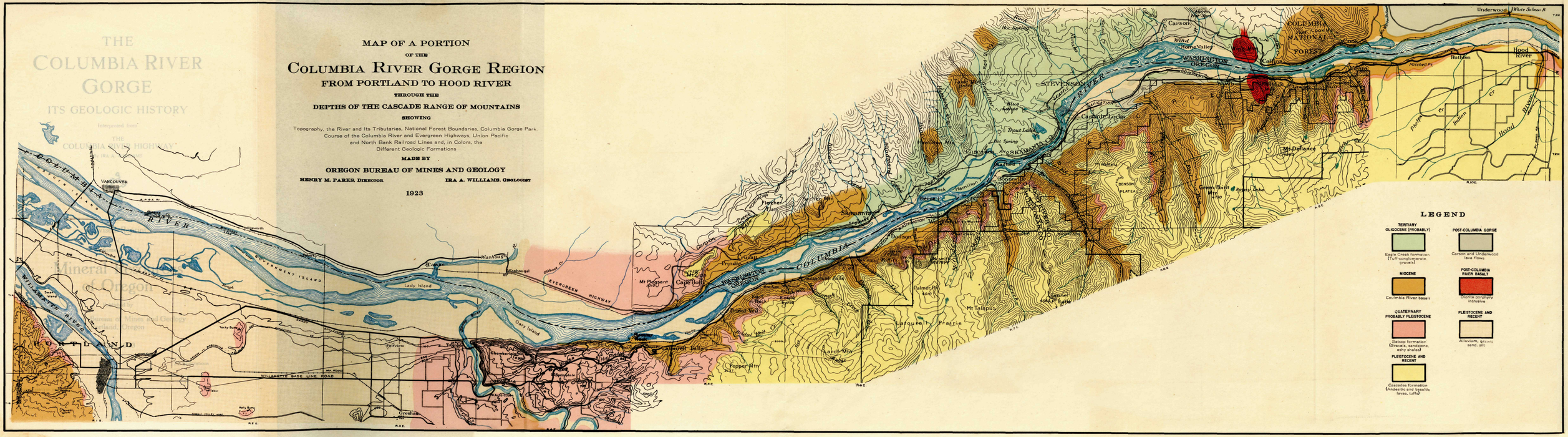
Revised Reprint of the

## MINERAL RESOURCES OF OREGON

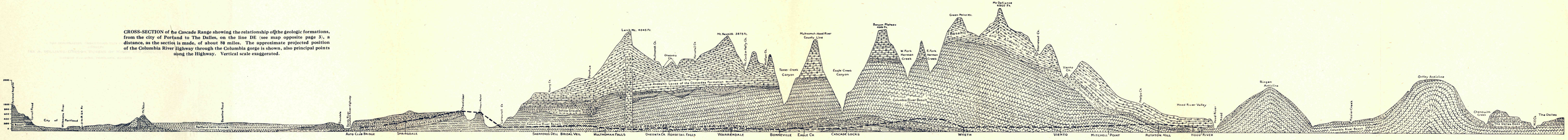
Published by

The Oregon Bureau of Mines and Geology

PORTLAND, OREGON
MAY, 1923


MAP OF A PORTION
OF THE
COLUMBIA RIVER GORGE REGION
FROM PORTLAND TO HOOD RIVER
THROUGH THE
DEPTHS OF THE CASCADE RANGE OF MOUNTAINS
SHOWING
Topography, the River and Its Tributaries, National Forest Boundaries, Columbia Gorge Park.
Course of the Columbia River and Evergreen Highways, Union Pacific
and North Bank Railroad Lines and, in Colors, the
Different Geologic Formations
MADE BY
OREGON BUREAU OF MINES AND GEOLOGY
HENRY M. PARKS, DIRECTOR
IRA A. WILLIAMS, GEOLOGIST
1923
LEGEND
TERTIARY
OLIGOCENE (PROBABLY)
Eagle Creek formation (Tuff-conglomerate, gravels)
MIOCENE
Columbia River basalt
QUATERNARY
PROBABLY PLEISTOCENE
Satsop formation (Gravels, sandstone, ashy shales)
PLEISTOCENE AND RECENT
Cascades formation (Andesitic and basaltic lavas, tuffs)
POST-COLUMBIA GORGE
Carson and Underwood lava flows
POST-COLUMBIA RIVER BASALT
Diorite porphyry intrusives
PLEISTOCENE AND RECENT
Alluvium, gravel, sand, silt
COLUMBIA RIVER
VANCOUVER
PORTLAND
WILLAMETTE RIVER
Sauvie Island
Lady Island
Gary Island
Washougal
Washington
EVERGREEN HIGHWAY
WILLAMETTE BASE LINE ROAD
Fairview
Troutdale
Gresham
Cascade Locks
Bridal Veil
Latourell Falls
Shepperd Falls
Wahkeena Falls
Multnomah Falls
Pepper Mtn
Larch Mtn
Mt Pleasant
Cape Horn
Prindle
Lyman
Fletcher Mtn
Shepperd
Dodson
Palmer Pk
Mt Talapus
Lafayette Prairie
Bonneville
Stevenson
Skamania
Trout Lake
Blue Ridge
Cascade Locks
Carson
Home Valley
Wind
Collins
Mt Defiance
Green Point Mtn
Rodney Lake
BENSON PLATEAU
Underwood
White Salmon R
Hood River
Mitchell Pt
Pheasant Cr
Indian Cr
Hood River
T.2N
R.10E.
R.5E.
R.6E.
R.7E.
R.8E.
R.9E.

**CROSS-SECTION of the Cascade Range showing the relationship of the geologic formations, from the city of Portland to The Dalles, on the line DE (see map opposite page 3), a distance, as the section is made, of about 80 miles. The approximate projected position of the Columbia River highway through the Columbia gorge is shown, also principal points along the Highway. Vertical scale exaggerated.**



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By IRA A. WILLIAMS

Revised Reprint
of
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130 Pages 77 Illustrations

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## PREFACE TO SECOND EDITION

The unusually big demand for the original issue of this report on the Geologic Features of the Columbia River Gorge has made a second publication of it seem advisable. A few typographic errors have been corrected, information obtained by more recent field work incorporated, and certain features of the geologic map brought up to date.

*The Author*

Portland, Oregon, May, 1923.

## PREFACE TO FIRST EDITION

The present number (Volume 2, No. 3) of the Mineral Resources of Oregon is devoted to a discussion of the salient geologic features of the Columbia river gorge. The work upon which this paper is based involved a somewhat detailed study of the structure of the Cascade Range, as it is exposed in the walls of the stupendous gorge which the Columbia river has cut, from summit to base, directly across its main axis.

In the May, 1916, issue, the geologic features of the higher parts of certain sections of the Cascade Range were given general consideration. The work in the Columbia gorge is a continuation of the investigation thus started, by which the foundation is being laid for a comprehensive understanding of the occurrence, distribution and value of the ore deposits of economic importance in this mountain range. It is of interest to announce that there has been found in the Columbia gorge, where its age and relationship can be made out, a great body of intrusive rock that is similar to the granitoid masses which have apparently influenced the deposition of workable bodies of ore in the various mining districts southward in the Cascade Range in Oregon.

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MAY, 1923

# MINERAL RESOURCES OF OREGON

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THE OREGON BUREAU OF MINES AND GEOLOGY

HENRY M. PARKS, Director

## THE COLUMBIA RIVER GORGE: ITS GEOLOGIC HISTORY INTERPRETED FROM THE COLUMBIA RIVER HIGHWAY

By IRA A. WILLIAMS

***Oregon's scenery is a fundamental commercial asset that awaits development only***

### THE COLUMBIA RIVER

THE Columbia river ranks as one of America's greatest waterways. Among the rivers of the United States it is for many reasons one of unquestioned distinction. It drains a total area of 259,000 square miles, 38,700 of which are beyond the Canadian boundary. Into the Columbia and its tributaries pass the surplus waters from 55,370 of the total of 95,607 square miles within the boundaries of Oregon. More than one-half of the area of this state thus drains into this master stream, which, from the Pacific, forms for better than 300 miles its northern boundary.

This great river discharges annually, into the Pacific ocean, seventeen and one-half trillion gallons, the equivalent of five hundred fifty-five and one-half billions of barrels or about sixteen cubic miles of water. Which is to say that if its flow were uniform in all seasons, it would pour into the sea each of the 365 days of the year nearly fifty-four million acre feet, enough to cover almost seven of every eight acres in the entire state of Oregon one foot deep with water. More than twenty-one hundred miles of the Columbia and its tributaries are navigable waters. It thus affords a commercial outlet for a vast inland territory, both in Oregon and as well for all of her neigh-

boring states except California. In the timber-lands of the Pacific Northwest the Columbia is said to drain what is probably the largest consolidated area of forest in the world.

The Columbia river is further distinguished because of its having cleaved from summit to base, completely through the structure of a giant mountain mass—the Cascade Range. This is a feat of achievement to which comparatively few of the rivers of the world may claim title. As a result of her prowess in geologic times past, this river has thus become the front doorway to a vast empire. There is no conceivable feat of nature that could render a more abundant service and be more fortunate to the life and movements of the people of a nation, than the provision of so ample and ready-made a channel of intercourse and communication through what would otherwise be a great land barrier.

**Commercial value of the Columbia**

The course that the Columbia has forged was followed by early explorers and many of the first settlers in this northwest country. The first wagon travel to the Pacific Northwest naturally sought passage down the Columbia and through its gorge. As much of the journey was necessarily made by raft upon its waters as along its in many places precipitous shores. Early pioneers therefore no doubt realized the need of a continuous roadway far more keenly than any one of later days. Settlement along the river began. The railroads finally came. And thus through the years the feasibility of the thoroughfare became established which today, in our Columbia River Highway, is one of the greatest of monuments to modern road construction, and truly a scenic highway if rivaled anywhere, certainly unsurpassed. On the Washington side of the river a permanently built parallel road, the Evergreen Highway, is rapidly nearing completion. Across the Cascade Range this river now affords an avenue of easy grade through which two parallel transcontinental railroad lines have built. Its waters teem with shipping, and the fisheries of the Columbia are legion.

We see that again, then, the Columbia is a river of unique renown. Skirted on either shore for hundreds of miles by steel rails, bordered by vehicle thoroughfares of up-to-date type and permanence, and capable of bearing upon its own surface a traffic of unlimited proportions, it has indeed become through the enterprise and ingenuity of man a commercial avenue of the first magnitude. What besides has this magnificent waterway to contribute to the contentment and prosperity of the people which it so efficiently serves in a commercial way, that further establishes its supremacy among those of its kind?

In the history of men, it is sometimes ancestry by which one is endowed with fame. Less often, perhaps, though more substantially, is a person made famous by individual achievement. Not exactly so in the case of rivers. Notoriety rarely attaches to them by inheritance. Somewhat more often are they celebrated because of some particular accomplishment in the course

of their own life history. Then again their renown among men is sometimes greatly enhanced by the labors and genius of man himself. To the Columbia was bequeathed by its ancestors little that is recognizable except by the discriminating eye of the geologist. It has had of itself a spectacular career, as already pointed out, to which it would seem scarcely likely that man should be able to add. But strange as it may seem, man has contributed immensely to the fame of this great river and its gorge, aside from its development as a carrier of the nation's commerce.

**Scenery of the Columbia**

Since the time of Lewis and Clark we have been told of the scenery along the Columbia river. It has been distantly pictured as impressive, wonderful, awe-inspiring. Until very recent time, however, relatively few had beheld this wealth of scenic beauty, and that few only by stress of hardships endured or great inconvenience. The Columbia River Highway has not only unlocked the way to the very heart of this wonder region but it has thrown wide the door, and all are bidden to enter and to enjoy the thrill of intimate touch with one of nature's most stupendous bits of handiwork.

It is doubtless true that nowhere else has a more substantial and thoroughgoing project of highway construction been carried to so successful a completion as the building of the Columbia River Highway. Conceived in the face of scepticism, laid out and built amidst almost insurmountable obstacles, it was the foresight and tenacity and enthusiasm of its promoters that have made both it and the river the enchanting beauties of whose wonderful canyon it has opened to the world, known far and wide.

The river thus provided the opportunity, which man has so taken advantage of that instead of being rivals, both the river and the Highway now inseparably contribute each to the fame and glory of the other. As a result the Columbia River Highway has rapidly become a name to conjure with. It is being heralded the country over, and justly, as *the* scenic highway of America, if not of the world.

**Columbia River Highway**

The Columbia River Highway is entirely completed from the Pacific at the mouth of the Columbia river, to The Dalles by way of the city of Portland, a distance of somewhat more than 200 miles. It is a hard-surface roadway uniformly 24 feet wide paved in part with bitulithic, in part concrete, has no grade greater than five per cent, and the radius of its sharpest curves is 100 feet. It was built by the State of Oregon, the counties which it crosses, and by contribution of private funds. Eastward from The Dalles it continues as The Oregon Trail, a trans-continental auto road which follows essentially the course taken by the early pioneers from the Mississippi valley to the Oregon country. Within the past two years a very great deal has been said and written about the building and attractions of this Highway. Some of its features are unique and it would seem that too much publicity can scarcely be given to it. Judge M. C. George, of Portland and The Dalles, has just published an attractive booklet on "The Columbia Highway" which contains a wealth of authoritative information on every feature of this wonder

region. Mr. Samuel C. Lancaster has written a most instructive illustrated book entitled, "The Columbia, America's Great Highway." The scenic features of mountain and river to be viewed from it are many of them unusual, and on a scale to excite in those who look upon them not merely interest but inspiring awe.

To some who travel the Highway there is much of meaning in the rocks that overhang the way, stories in the waterfalls that rush from precipitant heights as though to greet the passerby, a sermon in the master river itself. To many, however, this may not be so. It is the purpose of the writer of this paper to so dwell upon the interpretation of what is to be seen along the Columbia River Highway that he who travels it with eye and mind alert, and few can fail to do this, may more fully realize and appreciate the story, dramatic in general, though vividly tragic are some of the details, that is most eloquently recorded along this wonder way. In the main the following discussion will pertain only to that portion of the course of the Columbia river popularly referred to as the Columbia River Gorge. The course of the Highway for almost 70 miles, between Portland and Hood River, is in large part within the shadowing walls of this gorge, and it is as though unfolded to the traveler as he comfortably rides along its devious way that the story will be told. Here parapeted against the face of sheer cliff, there within the shadow of beetling basalt wall; dampened now by the spray from clinging waterfall the purr of whose downward rush lures us to linger, again by graceful weaving curves through cool forest, anon within the dark of rock-bound tunnel; at times hundreds of feet above the swiftly flowing Columbia, then at its water's edge—these are the view points, and no more advantageous could they be, from which our observations will be made.

## THE CASCADE RANGE

THE Cascade Range is the dominating mountain uplift of the Pacific Northwest. The main range extends from far to the south of the Oregon-California line, northward completely across both Oregon and Washington and into the Dominion of Canada. The altitude of its summit varies from four to seven thousand feet, but along its crest is arrayed a most imposing series of snow-capped peaks that rise, in some instances, to elevations above sea level more than double the average height of the range. In their order from the north in the state of Washington the most commanding and well known peaks are Mt. Baker near the Canadian line, 10,750 feet high, Glacier Peak almost 10,500, Mt. Rainier 14,508 feet, St. Helens and Adams, 9,697 and 12,307 feet respectively, the last two within 40 miles of the Columbia river which is the south boundary of the state. In Oregon our own revered Mt. Hood, in a straight line less than 25 miles south of the Columbia, overlooks that noble river from an altitude of 11,225 feet. Fifty miles south of Mt. Hood stands Mt. Jefferson 10,523 feet in height; then follow the Three Sisters each over 10,000 feet, Mt. Thielsen 9,178 feet, and Mt. McLoughlin

beyond Crater Lake within 35 miles of the California line, 9,491 feet high. In California, massive Mt. Shasta, 14,162 feet, towers over all, and Lassen peak, now an active volcano, lifts its restless head 10,466 feet above sea level. Many other peaks of lesser prominence are scattered along this 600 mile stretch of the Cascade Range.

Practically all of the higher peaks of the Cascades have been built up by the outpouring of lavas and other products of eruption from volcanic openings. They are, in other words, volcanoes that have been very active but are now, with the exception of Lassen peak, all quiet, most of them probably extinct. From these volcanoes great quantities of hot lavas have issued and spread widely upon the summit and down the slopes of the range. While we thus find that much of the super portion is made of cooled lavas that have come from this series of vents, the conspicuous peaks that have been formed themselves rest upon a base of different character. This base is not the same in all parts of the Cascade Range. In the portion of the Cascades contiguous to the Columbia river in Oregon and Washington, this base is composed of an extensive series of earlier lava flows and of associated volcanic and sedimentary beds whose exact source we do not now know in detail. Up beneath and through these earlier formations welled the liquid lavas that gave us what today are the principal elevations of the Range.

**Structure of Cascade Range**

A study of particularly the northern portion of the Cascade Range of mountains in Oregon discloses, therefore, that a part of its apparent height is due to the previous elevation of the underlying formations which thus served as a massive uplifted foundation upon which grew the great peaks of the present time. Perhaps the two processes continued together, uplift and the outpouring of molten lava. Doubtless also were lines of weakness developed, and even breaks, in these slowly rising rock beds, through which the lavas from beneath rose to the surface in voluminous seething streams, or were discharged in clouds of explosion fragments to drop upon the surrounding country and to build to the skies the many cone-shaped heaps that now strike awe and wonder to our gaze; the seething craters of yesterday, the Mt. Hood, Mt. Adams, the St. Helens, even Larch Mountain and Mt. Defiance of today.

The life history of a mountain range, as in the case of an animate being, can be worked out only by intimate study of its structure, its form and extent, and its relationship to other and neighboring land features. The geologist looks carefully at all surface indications and must very often be content to reach conclusions without the information that a cross section of the range would afford. He searches diligently in river canyon, mine shaft and road cut, for every possible peep at the order of arrangement and character of the rock materials that compose the range. What a wonderful stroke of good fortune is it then, that instead of such scattered and often meagre opportunity to actually observe the nature of the deeper make-up of so vast an earth structure as a range of mountains, there should be found ready-made and

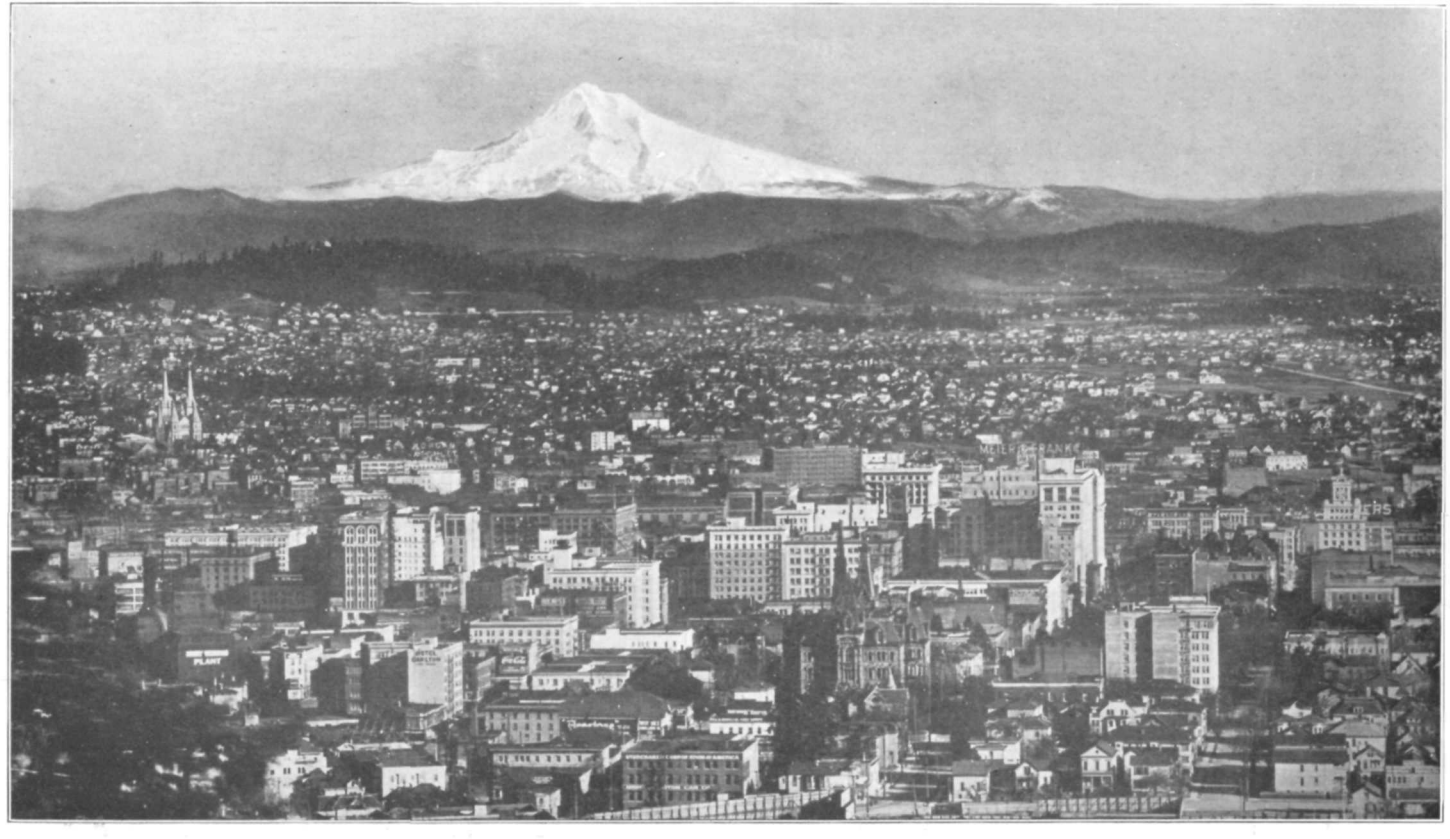
waiting for the interpretive eye of the geologist so grand a section of the Cascade Range, from top to bottom, as the Columbia river has made. It has cut directly across and at right angles to the axis of the range, a gigantic trench, in the walls of which, on the north in the state of Washington and at the south in Oregon, every characteristic of rock formation may be studied, each chapter in the growth of a mountain range may be read in its entirety. From the very roots of the range to its summit heights are the records thrown open for our reading and appreciation. And no peer is there among the chronicles of human history to compare in wealth of revelation, no testimonial of human achievement one-half so inspiring as the story that may be read there.

The Columbia River Highway has been a very great help in the deciphering of the history of this portion of the Cascade Range. It not only penetrates the depths of the Columbia river gorge, and reaches some points heretofore practically inaccessible, but in its construction the necessary excavations have brought to view in many places most excellent and instructive exposures of the different rock formations of which the Range is composed. So serviceable has it proved in this particular, that along portions of the Highway one may catch many of the conspicuous features as he rides. But so frequently is the nature student enticed by glimpse of fresh cut cliff, sheer canyon wall or river vista, to read more deeply than the fleeting glance permits, he will promptly decide that occasional stops are quite essential to an understanding appreciation of what is thus opened up to him.

**A Columbia gorge tour**

It is therefore proposed to pilot the reader through the gorge in a tour of a little short of 70 miles, over the portion of the Columbia River Highway between the city of Portland and Hood River. Between these two points the road passes through the most profoundly impressive parts of the chasm, and the journey will end at the outlet of the celebrated Hood River valley, interest in whose geologic features must prove scarcely secondary to its horticultural pre-ëminence. To take this trip, to enjoy and to profit by it, cares must be abandoned and a composed and not merely receptive but alert condition of mind assumed. It should be borne in mind that, if looked for, there is much of fascinating interest in every inch of the Highway that is passed over, that the materials on which that thoroughfare is founded are letters in the spelling out of the history of the country through which it passes, the pits from which these materials came the paragraphs and chapters that, matched together, progressively evolve the completed narrative of the Cascade Range.

There is much of legend and tradition associated with the Columbia river and its gorge. The geologic story is neither fable, myth nor tradition, but one of fact, facts that indisputably stand out in every rock and waterfall, as if begging for recognition. We shall, therefore, not need to draw upon else than truth for the framework on which to string the facts of our observations, and the connected story that these will tell. For, while true, they shall be no whit less romantic, but far more inspiring and wonderful, than the weird tales of Indian lore and tradition of mythical foundation, that have come to us down the years.




**East Portland, overlooking the Willamette river. Low wooded hill at left is Mt. Tabor. Mt. Hood overshadows all**
Copyright by Gifford

## THE CITY OF PORTLAND

**East Portland, overlooking the Willamette river, from Portland Heights.** The city of Portland is the starting point for our journey. Had we time to glance about, it would be learned that besides being a metropolis of already large proportions, Portland is located on the lower course of the Willamette river some 8 or 9 miles up from its confluence with the Columbia. At the west, beyond a narrow flat close to this river, its business streets climb rapidly to the foot of steeply rising hills whose summit elevations are 1,000 feet and more above the sea. East of the Willamette the city covers many square miles of an evenly rising slope which, with the exception of a few rocky knobs that stand abruptly above it, rarely attains an altitude of much over 300 feet for 18 miles due east to the Sandy river.

**Portland geology**

If we take a more careful look at conditions here it will be learned that the prominent hills west of Portland, up which many most attractive residence streets are being extended, are composed very largely of a dark lava called basalt. It is largely obscured by a heavy mantle of silt or loam, some of which without doubt resulted from the weathering of the basalt itself, some possibly deposited in the waters of a bay or sound, but much of which was probably shifted by the winds from the lower levels of the river floodplains. Resting against the lower slopes of these basaltic hills are masses of a similar sandy loam and beneath it stratified sand, silt and gravel to the river's edge. If, again, we search these hills, there will be found at different places along their flanks and extending far up the slopes, large masses of coarse, iron-stained gravels the pebbles of which are usually so firmly cemented together that when dug into they will hold a vertical face for years. At the west edge of Westover terrace, in part entering into the construction of these terraces, and for a half mile or so westward, an almost continuous exposure of these gravels may be seen at an elevation of between 300 and 400 feet to the Cornell road.

In the face of the quarry on the Linnton road, opposite the St. Johns ferry, several feet of these same ancient gravels rest upon the uneven surface of the basalt. They are composed of pebbles of volcanic rocks, mainly basalt, and usually from one-quarter to one-half of quartzite pebbles. Quartzite is a metamorphosed sandstone, the pure varieties being almost entirely silica. In this gravel formation they appear as white to pink or yellowish, smooth, hard, rounded pebbles showing comparatively little alteration. Those of the volcanic varieties are badly decayed, so thoroughly indeed that in some places the gravel bed has passed into the condition of a gritty clay in which the outlines of the original pebbles can frequently be seen, but where the quartzites alone remain largely unchanged and resistant. We shall find on our excursion many opportunities to examine other outcrops of this gravel-bearing formation, and will in every instance be greeted by the conspicuous presence of the friendly quartzites scattered among the usually weathered rocks of other varieties. So constant a feature are they, that they may be employed as a serviceable criterion for recognizing the gravels of this particular age.

It is at first a rather startling thought that these gravels were placed in their present position by the swiftly running waters of a river. We can conceive of no other origin for them. When they were deposited, the surface on which they rest was at a much lower level, probably but little above or actually below the level of the sea, and the great stretch of country over which, as we shall see, they are found, tells us that they have been accumulated in large part from very great distances. While the volcanic rocks were at that time doubtless already plentiful, and would furnish to the streams a supply of their kind, we know that masses of quartzite from which so abundant a quantity could have come were in existence in only very distant areas in eastern Washington and far north near the Canadian border. The only plausible inference is that they have traveled from these places hundreds of miles away. And their association and distribution lead us to no other conclusion than that the Columbia river some of whose main feeders extended into these far regions, was the agency responsible for their carriage and deposition.

**Old and new gravels**

Again, our departure would be ill-timed if a critical, even if hasty examination of certain features of East Portland were not made. We note that the land in most places rises rather abruptly along the east shore of the Willamette for 75 to 150 feet, beyond where the height increases more slowly by a series of low benches or terraces. Close along the river, as well as wherever exposures are made in street or railroad cut, fresh and evenly stratified or crossbedded gravels and sands are to be seen. In places fine sand predominates, or silt may cover the surface, but always all of these materials have the appearance of newness, they are never strongly cemented together, and the larger cobbles rarely show an advanced state of decay. In these particulars these beds are quite different from the ancient gravels observed about the slopes of the hills in West Portland. The latter are but clinging remnants of an earlier formation, while the newer gravels of the lower lands east of the river are a deposit of more recent age that the heavily burdened rivers, the Willamette, Columbia and tributary streams, have filled in among the upstanding irregularities of an earlier land surface.

**Ancient lavas**

We are able to get an occasional clue as to the character of this former surface. Mt. Scott and a series of other nearby hills to the southeast have all the appearance of being protruding parts of this old land, today sticking up through, as it were, and above all of the surrounding and flanking deposits of more recent date. Practically all of these elevations appear to be of volcanic lava, some of them of the basaltic variety. Kelly Butte at the west base of which is the city quarry, Mt. Tabor and Rocky Butte, all bear a similar relationship to the sheets of gravel that have been spread about them.

If now, the inferences thus far drawn from our observations east of the river are correct, viz., that there are here, as on the west side, elevations of earlier lavas around the base of which the more recent river-laid materials

have accumulated; we should hope to find also some signs about the higher slopes of these same elevations of the older, weathered, quartzitic gravels that we have seen along the Cornell road and elsewhere west of the river. Our search in this direction is rewarded with most satisfying and certainly unanticipated promptness. The main bulk of Kelly Butte is a hard variety of lava which the microscope assists us to classify as basic andesite. The Butte is 577 feet high, rising rather sharply 275 feet bove the surrounding plain, which is strewn with and built up of hundreds of feet of the recent gravels. An ascent from the Powell valley road, which passes at its south base, proves at once the presence of the old gravels. The entire south slope is aproned with the loosened pebbles from higher up, and the summit of the Butte is heavily covered with undisturbed gravels that in position and other particulars, are so similar in every way, that there is no hesitation in pronouncing them the same as already seen in West Portland.

**Mt. Tabor**

Mt. Tabor is the site of one of Portland's prettiest parks. Here too these same water-worn iron-stained old gravels show themselves on every slope, and over its entire main summit they obscure all else. The altitude of Mt. Tabor is 645 feet, and we find the ancient river-laid gravels to the topmost point. How much higher they extended originally, we have no means of knowing. Nevertheless, we can safely say that they were several hundred feet in thickness, and, by the position of the remnants of the formation we have seen on both sides of the river, properly conclude that they formerly filled all of the space now occupied by the Willamette and the filling of recent gravels, between East and West Portland, to a depth at least as great as the present height of Mt. Tabor. Studies made far up the Willamette, also across the Columbia river in Washington, show that this old gravel plain, for such it was, covered a wide scope both to the north and south. We shall see when our journey is really begun that it extended far to the eastward, and fragments of it still mark its former borders at intervals along the lower course of the Columbia, while the same formation is known to be represented by marine sediments both north and south along the ocean shore for practically the entire length of the states of Oregon and Washington.

**Portland's earliest history**

We find evidence without going much beyond the confines of the city of Portland of several epoch-making changes. Without at this time undertaking to pry further into the past, we have first, the conspicuous hills supported invariably with cores of lava that likely represent a much dissected land surface whose original character was determined by great lava flows and the planation of rivers. In order that the great gashes by which these hills are now separated, could be filled with the hundreds of feet of ancient gravels only small patches of which remain here and there, subsidence must have taken place, so that the highest of these hills were carried down close to sea level. The fact that these gravels have been largely removed, shows that elevation of the Portland region followed the period of lowering, in

which the Willamette actively excavated the gravel beds it had but finished depositing, down to the remnants that we find today clinging about the slopes of Portland Heights and covering Kelly Butte and Mt. Tabor. Geologists term this process of cutting away, degradation, and that of filling in, aggradation. Following the period of degradation there was again a depression of the land during which the heavy mantle of more recent gravels, sands and clays was spread out, so much of which we see over many square miles in East Portland and beyond. That these beds are now exposed to our view and unmeasured quantities of their substance removed, elevation must have in turn succeeded subsidence by which a returning energy enabled the Willamette river to proceed to the cleaning out of its valley once more. That it is no longer actually cutting downward, suggests a state of quiescence, and there are some indications that yet another slight downward movement has taken place in recent geologic times, by which the lower courses of both the Columbia and its chief confluent are in part inundated and the streams themselves thus robbed of their ability to carry clear to the sea the load brought to them by their various tributaries.

We must for the present be satisfied with this preliminary survey of the environs of our starting point. The journey over the Columbia River Highway should be begun, though, with the ever present thought that each mile has something new and, as we have seen about Portland, a history, a life story that but awaits our interpretation.

**Geologic map**

In connection with this paper, a folded map will be found (opposite page 3) covering a narrow area on each side of the Columbia river from Portland as far east as Hood River. The main roads, railroads and established trails are shown, besides the location of the Columbia River Highway. Contour lines are drawn to indicate the character of the land surface, insofar as the U. S. Geological Survey topographic maps and field data were available. Upon this map are shown, in colors, the approximate areas in Oregon covered by the various geologic formations to be seen in and bordering the Columbia River gorge.

**Cross-section Cascade Range**

The writer has prepared also a cross-section sketch (see opposite page 130) extending across the Cascade Range from Portland to The Dalles, a distance as the section is taken, of 80 miles, which is an effort to show the relation among the different rock formations of which the Range is made. The field work on which the preparation of both the map and the sectional sketch is based, has not been carried to the fullest degree of completion. While the author is confident therefore that they represent in general, and correctly, the geologic conditions, too much importance should not be attached to any slight failure to conform perfectly and in detail to such geologic field measurements as may in the future be made. The portion of the cross-section drawing between Hood River and The Dalles has been added to represent diagrammatically

the general geologic structure along this portion of the Columbia river, and no claim can be made for instrumental accuracy.

In the reader's perusal of what is here written, it is urged that the map and sectional drawing be referred to constantly, for in them is portrayed in far more vivid manner than words can be made to express, many of the fundamental features of the story our trip over the Highway is to reveal. A preliminary study of these as available sources of information should be made, just as do explorers into other unknown fields first search out every scrap of knowledge pertaining to the problem in hand.

**Acknowledgments**

Most of the field work on which this paper is based was done with the assistance of J. H. Bretz of the University of Chicago who was in the temporary employ of the Oregon Bureau of Mines and Geology. Credit is thus to be shared with Mr. Bretz for the broader conceptions relating to the geology of the Columbia river gorge and of the Cascade Range. His helpful counsel has also been had in the preparation of certain parts of this paper. G. E. Goodspeed, Jr., identified many of the rocks studied in the Columbia river gorge and his determinations have been employed in their classification and correlation.

**The trip begun**

Departure from the city of Portland may be made by any one of three paved highways, Sandy road, Base Line road, or Powell Valley road, for 18 miles east to Troutdale at the mouth of the Sandy river. Sandy road is easily reached from the Burnside bridge over the Willamette, by going east to 16th street, thence north three blocks, and turn to the east. This road passes to the north of Rocky Butte, already mentioned, a prominent ridge of basic gray andesite rounded from the west but sharp-walled, even sheer in places at the east side, and at the north end of which extensive quarrying has been done. In its structure there is some suggestion of proximity to a vent of eruption. In general character this lava resembles the rock of Kelly Butte and probably belongs to the same eruptive period as do the scoriaceous beds on Mt. Tabor, the time of accumulation of the ancient quartzitic gravels. Along the east base and parallel to the long way of this rock mass is a marked depression, as though an active stream of water had not long since been there, had etched its channel beneath the face of the cliffs, then once for all abandoned its bed. From Rocky Butte to Troutdale Sandy road parallels the Columbia and in elevation is but little above it at any point. The Powell Valley road passes to the south of Mt. Tabor and at the south base of Kelly Butte, running to Gresham, in its general course parallel to the Base Line road which it joins one and a half miles north of that enterprising town.

**Inclined volcanic ejecta, Mt. Tabor.** The Base Line road is so called because of its location on the dividing parallel of latitude from which, to the north and south, the numbering of townships is begun. This road is a continuation of East Stark street and passes, by a slight offset, at the north foot of Mt. Tabor. So sightly an outlook is to be had from the summit of this eminence that we cannot forbear to take

**The eruption products of a former active volcano, Mt. Tabor, within the City of Portland**

a passing stroll up its shaded slopes. Recalling that its top is one great heap of time-stained gravels, we are then not so much surprised to catch a glimpse where street excavations have scathed its sides, of what our general observations have already told us almost certainly must be there—the base or core of volcanic rock. But we are quite astonished to see that its character here is so different from what we have found elsewhere in the vicinity of Portland. Mt. Tabor consists of two parts, a rounded shoulder at the north being some 200 feet lower than the main summit. Material for grading purposes is being taken from this lower portion and it is thus shown to be a massive pile of volcanic cinder, scraggy and scoriaceous bombs, clinker and ash. And these are not thrown promiscuously together, but are arranged in parallel and highly inclined layers, exactly as are the products of explosive volcanic eruption arranged about the slopes of more recent cinder craters by the fall of successive showers of this class of lava fragments. To us, it is thus not merely a mass of volcanic detritus, but a deposit whose nature and position tell unmistakably of a nearby crater from which the pieces were forcibly thrown and on an outer slope of which they fell.

We may now speak with perfect correctness of Mt. Tabor as the site of an ancient volcano. During a time of land depression, gravels and sands

accumulated around the base of this volcano, rose to the level of its rim, filled the hollow of its crater, and finally buried its topmost points beneath we know not how many feet of these same waterborne sediments. We are now permitted the exhilarating satisfaction of unraveling its checkered career, because of the fortunate circumstance of its having again come above the level of the waters that engulfed it. And, though once deeply sealed from sight, it has been to such an extent uncovered by the very agent that concealed it, that, no matter if torn and battered, this bit of familiar topography speaks out today, as with defiance, of the exigencies of its early life.

For ten miles due east the Base Line road, with but little rise and fall, passes across a gravel built plain. Just where the newer gravels leave off and the old begin we are not certain. We know that the new are spread against the truncated edges of the older beds, just as they surround and overlap them at Mt. Tabor. It is remarkable, however, that the watershed between the Sandy river and the Willamette, over which we pass, is very close to the former stream. This divide is not elevated nor at all prominent. We shall observe later that only the old gravels appear opposite this place in the gorge of the Sandy river, which rather strongly suggests that these older more firmly cemented beds, and therefore their less rapid wearing down, may in large part account for both the unsymmetric location of the divide and be responsible as well for the bulk of its structure.

## SANDY RIVER

AFTER crossing Beaver creek, a small tributary of the Sandy river within one mile of which we now are, we will turn to the north to join the Sandy boulevard at Troutdale. The Sandy river is crossed at Troutdale and thenceforth we are on the Columbia River Highway proper. One mile beyond Beaver creek we may also depart from the Base Line road by turning southeastward, up-stream and round a curve in the Sandy for a mile or so, to cross that river and connect with the Highway just beyond the grounds of the Shriner Country Club.

On the Sandy road, and before reaching Troutdale, a reminder of the old gravel formation of Mt. Tabor and Westover terrace is had in the occurrence of low outcrops of gravelly brown sand in the road cuts, and a farm house of modest brown is seen built of the sandstone from this formation.

**Lava cliff along Sandy river at Troutdale.** Approaching the bridge after Troutdale is passed, we are confronted by an abrupt wall which the eye may scan from here far up the river. But here is some-

NOTE—The general plan of this story of the Columbia River Gorge is such that the photographs necessarily constitute an essential and vital part of it. They are the nuclei, the way stations as it were, round which center the successive chapters of the story, and upon which their sequence depends. The matter descriptive of the views should therefore be read continuous with the remainder of the text in order that no connecting link may be lost sight of.

Lava cliff along Sandy river at Troutdale

**Gravel and sandstone cliff along Sandy river; Columbia River Highway beyond Troutdale**
Photo Gifford and Prentiss

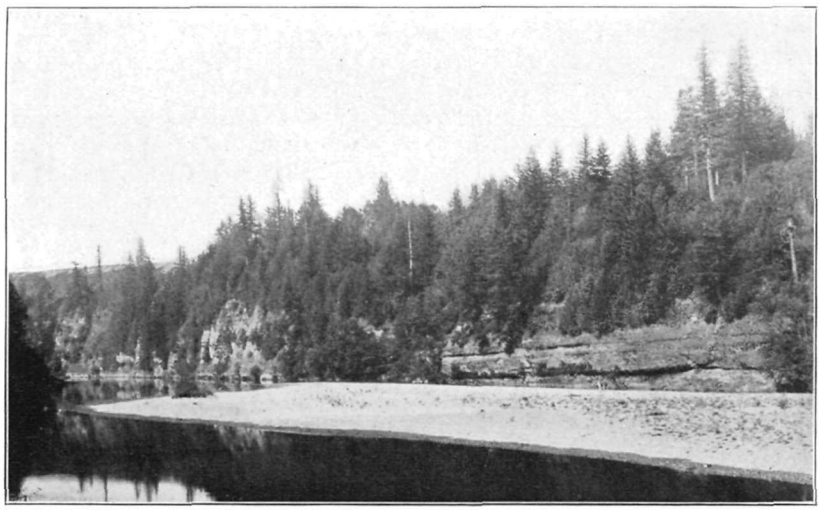
thing new. Heretofore we have seen almost nothing but waterlaid materials, sands, silts, gravels and the like, and the country has been fashioned chiefly by the action of running water. Now, though, we come face to face with a great protruding cliff of hard rock, itself as much as 200 feet or more above the river and 50, 75, sometimes 100 feet thick, and from which tumbling blocks strew the steep slopes below it to the border of the Highway. Running water had no hand in the making of this rock, although it will be decided at once it would not be so finely exposed to view were it not for the busy work of the Sandy river, that has severed it and underlying beds to the depth of its present level. In its upper course this river is still actively digging out its canyon, simple testimony of this fact being found in the mass of fresh sand and soil that it spreads beyond the limits of its channel during each successive high water stage.

Examination of the cliff before us shows promptly that the solid and in places columnar layer at the top is a thick sheet of volcanic lava, the microscope aiding in the determination that it is not basalt, but a somewhat less basic variety called andesite. The lava here rests upon heavy beds of the old consolidated quartzitic gravels whose acquaintance we have already made, and above, it is in turn covered by an increasing thickness of strata of similar character.

**Gravel and sandstone cliff along Sandy river beyond Troutdale.** As we pass southward after crossing the Sandy river, the Highway comes at times close within the shadow of a perpendicular face of coarse quartzitic gravel, interbedded with streaks and heavy layers of sand, most of which has been so compacted and the grains so firmly cemented together as to make the term sandstone a proper one.

**Inclined gravel strata along Sandy river beyond Troutdale.** On both sides of the Sandy river this formation is in view almost continuously for over two miles and until the Auto Club bridge is passed. In places it is inclined at a low angle up-stream, that is, to the south, as though it has been uplifted since its deposition, and somewhat tilted out of its original position. The bed of andesitic lava that we have just seen, fits into this formation, and is thus to be considered an integral part of it. Along the lower course of the Sandy the same beds are present in the walls of its gorge for many miles. We find them 10 miles and more up-stream reaching to the very bottom of a canyon several hundred feet deep where Bull Run river comes in. The associated lava bed and sometimes two of them, is ever present. In places there are great thicknesses of fine sand, at times beds of clay or shale and porous ash.

We have already noted the fact that besides a plenty of quartzite pebbles in the gravels, they contain various species of volcanic rocks. And the grains of sand are likewise mostly small scoriaceous, slaggy or pumiceous pieces that have been brought directly from a close-by region of stirring volcanic activity. Could we have looked on at the time there might have been cause for alarm, though certainly at this late date there is none for wonder that in addition to these merest of fragments there should come a great moving sheet of molten lava to overwhelm all in its path. Exactly where may have been its source we can only conjecture, but we do know that its coming seems to have disturbed the course of events but little if at all. For, as observed near Trout-



**Inclined gravel strata along Sandy river beyond Troutdale. Across the Sandy to the west from the Columbia River Highway**

dale and elsewhere, the accumulation of sediments long in operation prior to its appearance, continued merrily on without noticeable break, upon its tossed and ropy surface. Since the general character of this lava is similar to that which enters into higher contiguous parts of the Cascade Range, we infer that it too is probably but a forerunner, coming from one or more vents from which voluminous flows were soon to course their way down the slopes and among the foothills of a slowly rising range.

It is thus beginning to more fully dawn upon us that, aside from being merely a formation of wide extent, when it was put down conditions were not uniform but varied from time to time in the same spot, as well as differing in separate parts of the area in which the sediments were accumulating. The gravels, sand and sandstone are all river-laid materials such as are spread about in the river floodplains and deltas of today. The coarser gravels are carried and left where the current is more vigorous, the clays in protected pools, the cut-offs of river channels, or in shallow arms of the body of water into which the streams may flow. Here too would settle the leaves and stems and seeds of plants, and the trunks of trees be buried by the impervious sealing of fine sediments. Such remains are often so well preserved that their exhumed fossil forms may be recognized in every particular. The general character of the sedimentary beds before us, and the fact that the fossil remains which they contain (to be referred to later) are of land plants only, show that the whole is a river valley deposit, one probably in part of delta formation or sediments spread out upon a low-lying coastal plain.

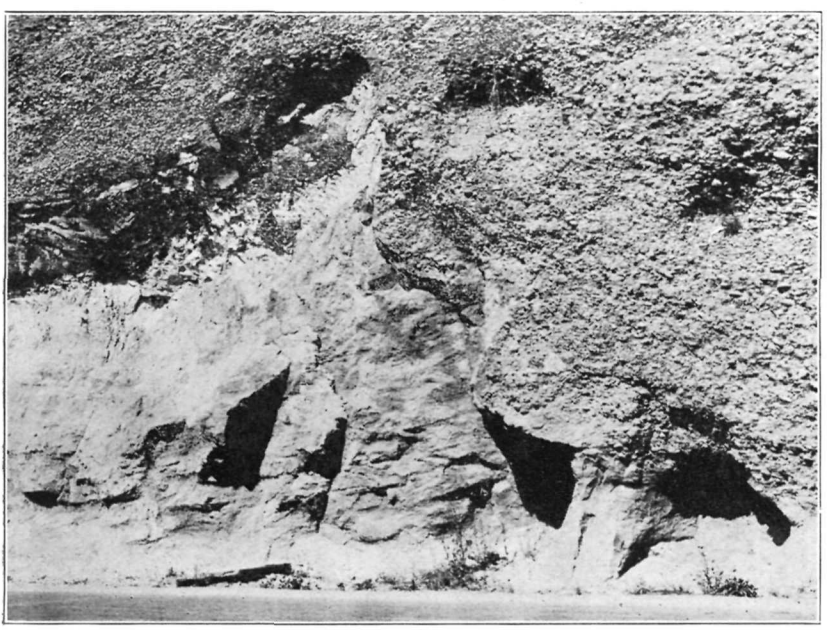
**The Satsop formation**

We must pause one moment longer. We have now studied at several

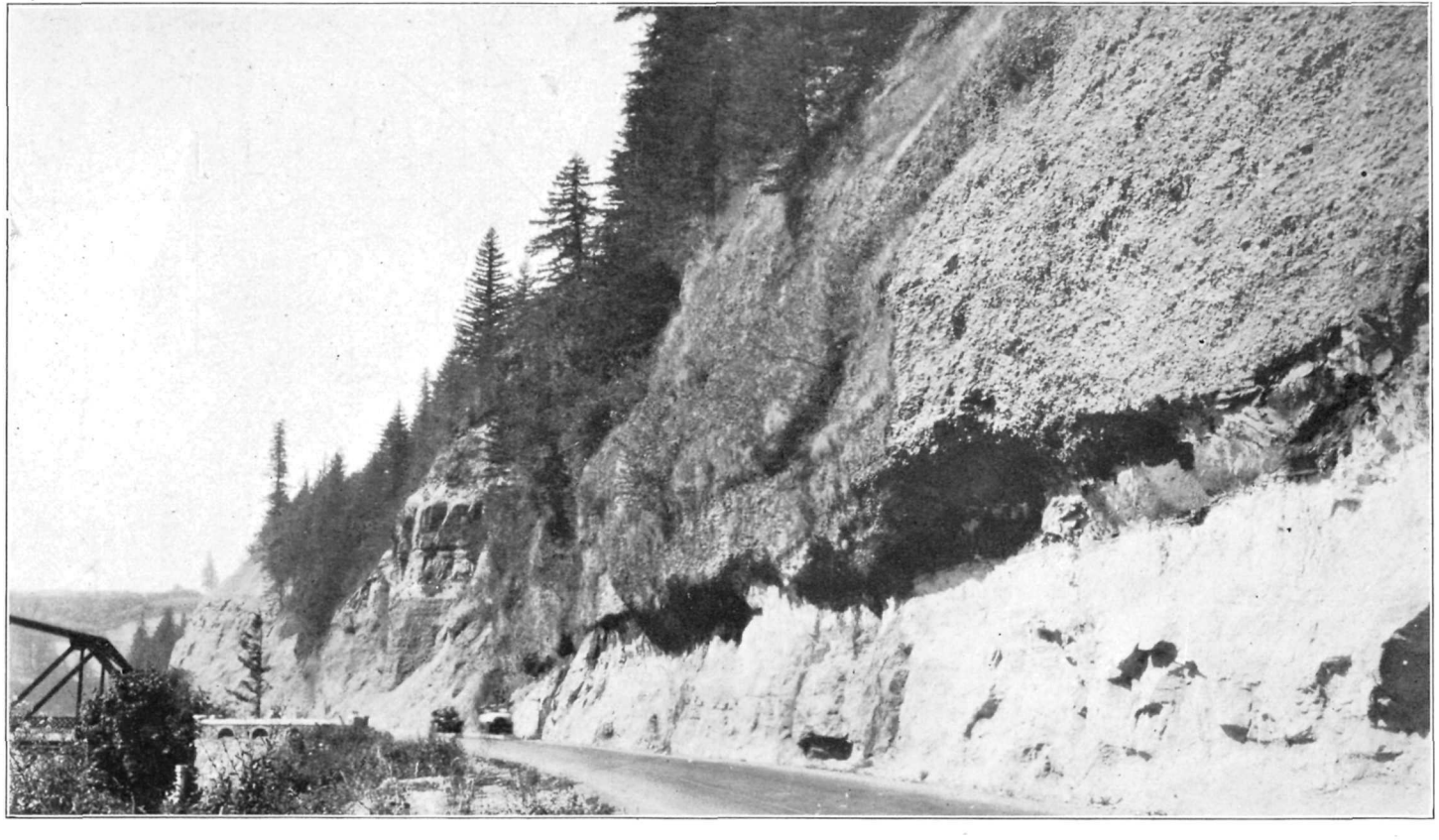
points the make-up of this series of geologic strata that once were spread out in considerable depth over, we now know, a large scope of country. Geologists are in the habit of attaching names to rock formations that are of wide extent, distinctive character or whose equivalence in age shows that they represent an important period, be it chapter, paragraph or meager line, in the history of the earth. As the story unfolds, the increasing significance of the chapter which our present formation stands for will be more and more appreciated. That it therefore deserves a name is without question. Within the state of Washington, this formation, as has been intimated, is of wide distribution. It has been studied there to some extent in years past and has been designated the Satsop formation by J. H. Bretz on account of its typical occurrence in the valley of the Satsop river, a branch of the Chehalis, in the Olympic mountains of Washington. Inasmuch as the lines by which states may be conveniently bounded very often, as here, bear no relation to geologic boundaries, we are really left no alternative but to accept and adopt the name already in established usage in our sister commonwealth. Henceforth, therefore, this will be for our purpose the Satsop formation.

**Auto Club to Chanticleer**

From the Sandy river at the Auto Club bridge the Columbia River Highway swings to the north of east and seeks an even grade by way of Springdale and Knights Corner to the top of the Columbia-Sandy divide at about 900



**Bed of sandstone overlain and cut off by the coarse gravels, 1/8 mile east of Auto Club bridge. Angular blocks of the sandstone are in places enclosed within the gravels. The sandstone was eroded and in part broken down, after which the gravels filled in and covered over all irregularities. The uneven contact is termed an unconformity**



Cornice of coarse cemented gravel overhanging less resistant sandstone. Auto Club bridge and Columbia River Highway

feet; whence the traveler slowly descends in the next mile and one-half to Crown Point, approximately 725 feet above sea level. Occasional shallow road cuts leave no question that we are passing across a land surface that has been carved in the Satsop formation. Where best seen, the sands are deeply iron-stained and all except the quartzite pebbles are more or less thoroughly disintegrated. Over the top in general is a mantle sometimes thick, elsewhere thin, of a silt or loamy material that the winds have very likely been instrumental in spreading about in comparatively recent times. The evident prosperity of the farms that are passed attest the fertility of the soils derived from it.

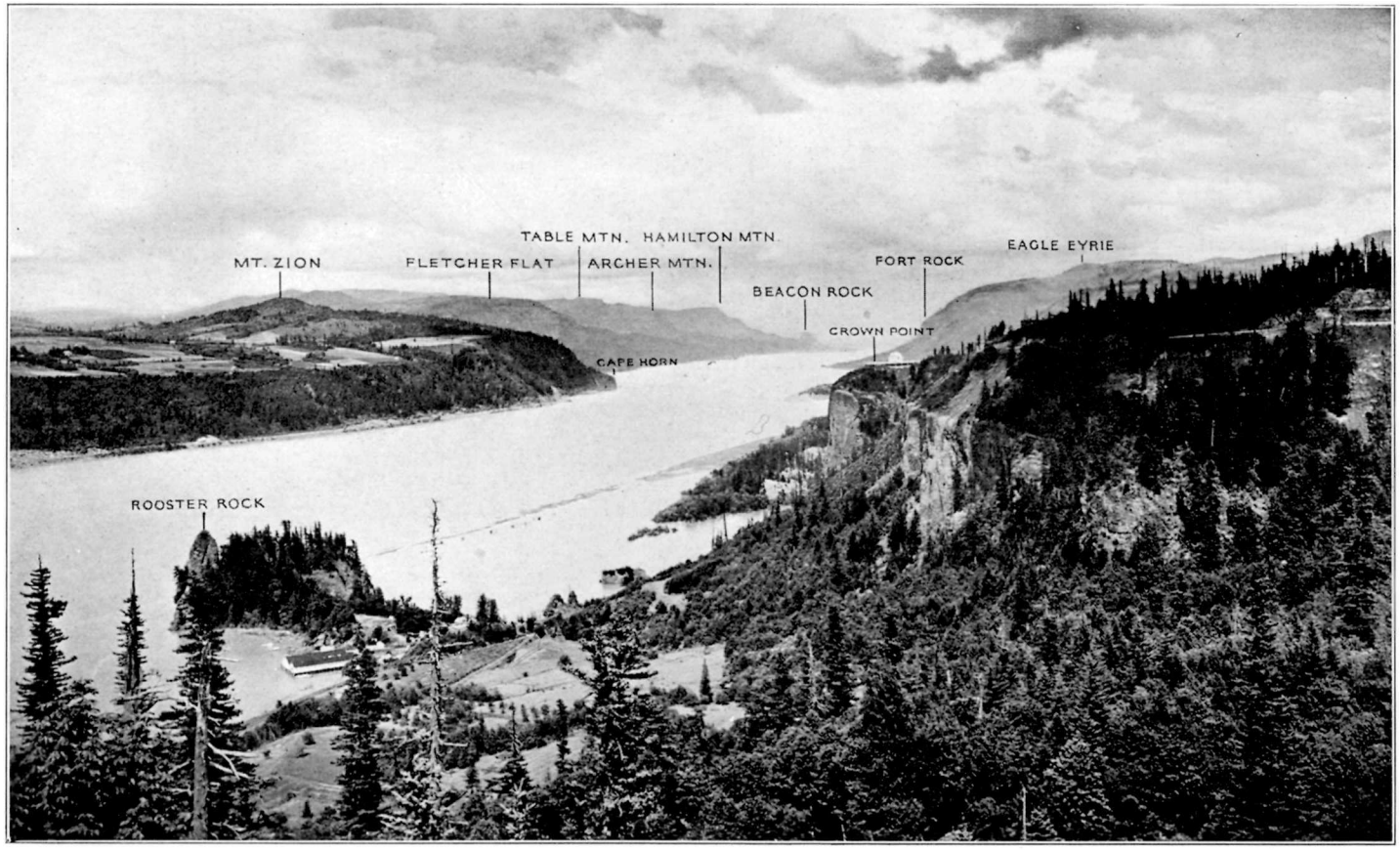
## THE COLUMBIA RIVER GORGE

**The Columbia river and its gorge from Chanticleer.** Within approximately one mile from Crown Point, at Chanticleer Inn, a first satisfying view up the Columbia river may be had. Here the Highway comes to the western rim of a broad circular amphitheatre at an elevation of 925 feet above the river. Diametrically across to the northeast is Crown Point the gleaming white of its encircling parapet, Vista House, and Crown Point chalet above it, in every line distinct and in contrast with the great black cliff below.

The Highway skirts the brink of this vast pit and, seeming to cling precariously within its niche against the sparsely forested gravel slope, creeps a full-fledged and magnificent thoroughfare, with perfect security, out upon the causeway of Crown Point. Below is an upright face of dark columnar basalt in places sheer for 400 or 500 or 600 feet, again aproned to the Columbia's shore with a talus slope of gravels, soil and shattered blocks of its own kind. Above this perpendicular wall of basalt, the line of contact sharply marked in the photograph, appear the gravels and sands of the Satsop formation. The less steep slope is particularly noticeable, and it is along this slope and through the materials of this formation that the Highway at and above Crown Point (in the view) is built.

**Mt. Zion**

A brief pause at this wonderful viewpoint and we are overwhelmed with anxiety to hurry on to that most sightly station of all the Columbia River Highway has to offer, Crown Point, now but a short span away. But there will perhaps be found no better place than this to linger for a moment, while the gaze follows progressively up the Columbia to the limit of vision, where the blue of the summer haze dims to indistinction the horizon, and the white ribbon of water is lost within the shadows of the great gash through which it pours. At the left across the river in Washington, the low dome well up the sides of which the geometric outlines of cultivated fields distinctly show, is Mt. Zion. It is an extinct volcano. The ropy scoriaceous lavas of its crater may yet be seen at its summit. A little below the top on its south side, hard gray basic andesite shows through. What relation does Mt. Zion bear to its surroundings? The broad slope of the upland, occupied by farms, that stretches down the river far to the west from Mt. Zion is determined by the position of that strata of the Satsop formation. Satsop gravels are found intermittently along the railroad from the town of Vancouver for 20 miles and more to and beyond Mt. Pleasant. One and a half miles east of the




**The Columbia river and its gorge from Chanticleer. O.-W. R. R. & N. tracks of the Union Pacific System at the water's edge in the center of the view. The S. P. & S. railroad, a western unit of the Great Northern-Northern Pacific System, along the opposite shore.**

latter place and within sight of the Cape Horn tunnel, beautifully columnar basalt appears beneath these gravels, and to the eastward they are carried gradually higher and higher upon the slowly rising surface of the basalt a prominent wall of which, distinctly seen from our viewpoint, rises perpendicularly from out the waters of the Columbia. Resting upon these gravels, which here as elsewhere carry an abundance of smoothly rounded quartzite pebbles and are a few hundred feet in thickness, is a heavy bed of andesite at the base of Mt. Zion, to be seen also from our present position. Mt. Zion is 1,658 feet in altitude. Upon its slopes a scattering of the Satsop gravel pebbles is to be found as high as 1,000 feet, much above the outcropping andesite between which and the underlying basalt, gravels of this formation are seen to be.

It would thus seem that we have recorded in Mt. Zion a somewhat similar series of events as along the Sandy river, where the andesite was found to have flowed down during the time of gravel accumulation, and to both rest upon and be covered by the strata of the Satsop group. In Mt. Zion, however, we have what appears to have been rather probably an active volcano during the Satsop epoch. If we were to assume that the andesitic lava exposed about its base came from Mt. Zion as a vent, we would then be confident that not only was it in eruption in Satsop times, but about it, as it grew, the accumulating gravels and sands and silts slowly rose, possibly originally to complete submergence for aught we know. Of its birth long after the coming of the basalt we have positive evidence, for at its summit pieces of its scoriaceous ejecta are found, that enclose and have fused fast to pieces of the basalt that were caught up as the fiery mass forced its way upward through the more basic lava.

**Peaks along the gorge**

Yet another glance at the photograph will enable us to recognize in order as we overlook the river beyond Mt. Zion, Fletcher flat a plateau of even but gently sloping top at about 1,600 feet; the conspicuous cliffs of Archer mountain at 2,000 feet or thereabout; and 5 or 6 miles still farther, the notched profile of Hamilton mountain whose summit is more than 2,400 feet above the sea. At the foot of Hamilton mountain and, from our distance, apparently rising from the river's edge is Beacon Rock, commonly known as Castle Rock. It is a massive lone pinnacle of jointed lava with clean sheer faces for hundreds of feet on all sides, and for long a defiant challenge to all comers of mountain scaling inclination. Shortly beyond Beacon Rock the narrows of the Columbia begin which culminate in the impassable rapids at Cascade Locks, from us, by the Highway, full 23 miles up the river. The flat top of Table mountain, 18 miles away, is distinct against the sky-line, its main bulk hidden behind Hamilton mountain. Its summit is 3,420 feet above sea level.

At the right and on the Oregon side, we look beyond Bridal Veil and against a rising mountain wall that largely cuts off a detailed view of what is farther on. The jutting castellated front of this wall which is called Fort Rock, lifts its pinnacled head 1,500 feet above the river. Fort Rock was formerly termed Angels Rest, one might imagine on account of its attitude

of guardianship between the great river and Devils Rest, now called Eagle Eyrie, a prominent former volcanic vent one thousand feet higher and but a short mile farther back. In the dim distance we catch the faint outline of the main summit of the Cascade Range beyond Carson and Wind river in the state of Washington, and were the atmosphere sufficiently clear, could probably recognize some of its features though as much as thirty miles away.

**Crown Point**

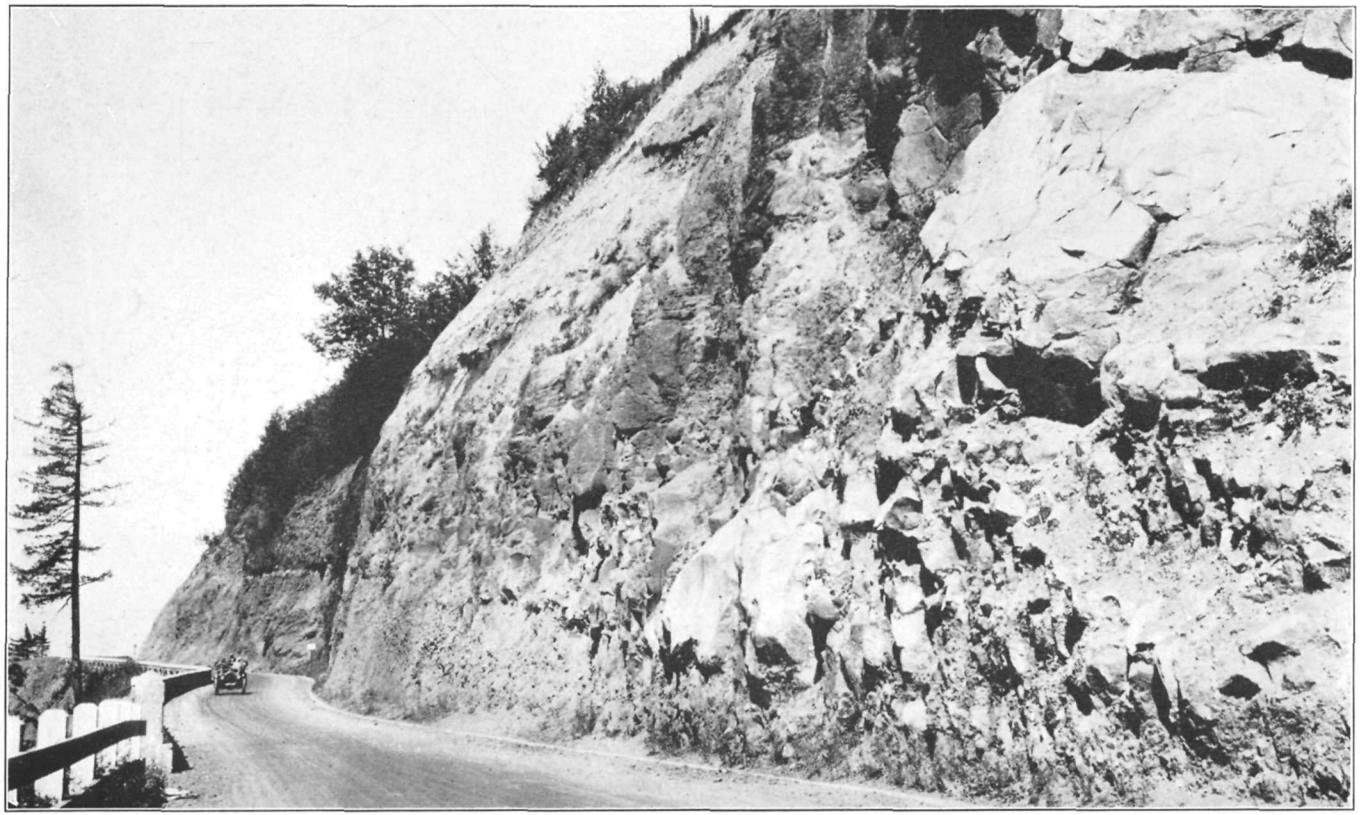
It seems indeed scarcely fortuitous that so favorable a body of materials as the Satsop gravel bed should be found just where it proved necessary to locate the Columbia River Highway in order to find a safe course out upon so spectacular and, at first sight, rather inaccessible a lookout place as Crown Point. Our ride to Crown Point from Chanticleer, whose fine accommodations we are loath to leave behind, is entirely over a roadbed carved along a steeply sloping face of this formation. The encircling concrete base and railing, and within the curve the Vista House, are all founded upon this same old gravel bed.

As the auto coasts almost effortless for the last half mile of approach, we are again permitted, as along the Sandy river, to examine at close range some of the characteristics of the Satsop formation. Instead of being down at water level it is here perched hundreds of feet above the river, these lower hundreds of feet upon which it rests being a succession of heavy flows of basalt. Our study of the Washington side has showed plainly that there, too, the gravels rise upon the top of a westward sloping surface of basalt, very well seen at Cape Horn. Were one to follow the railroad track east from Troutdale, only a great threatening wall of cemented gravels and sandstone enclosing a single layer of andesitic lava is seen to within a mile of the town of Corbett. Here the underlying basalt appears, its surface rising to a height beneath Crown Point of, as we see before us, at least 500 feet above the river. It is an uneven surface, and although the gravels have filled in to obscurity all irregularities, they too rise in conformity with the inclined basalt on which they rest.

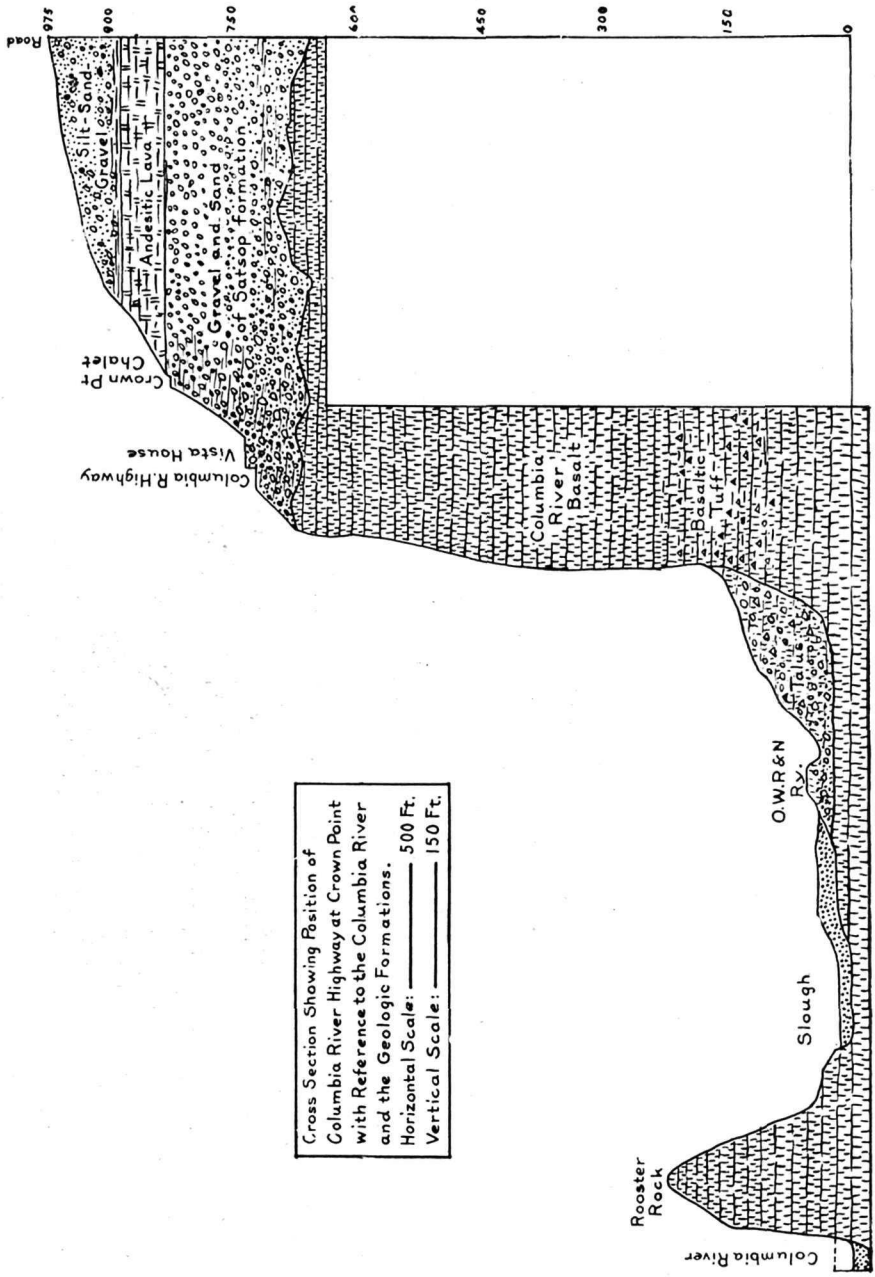
**Hard lava resting upon coarse gravels, near Crown Point.**

Just before reaching Crown Point we pass along a clean face of the intra-gravel andesitic lava, and can see to an inch the line of contact between it and the gravels below. We cannot fail to remark that the top foot or 18 inches of these gravels, which are clayey here, has an unusually reddish hue. Still closer inspection will show that this thin band is harder, as if more firmly cemented than is usual, and when shattered many of the pebbles break through, rather than pull loose, from the cementing matrix. We are then reminded that this sheet of lava, a molten hot, seething, flowing mass, came out upon a gravel bed, whether beneath or above the surface of a body of water we cannot say for certain. In any event its contact with these gravels raised the temperature of the upper foot or so to such an extent as to produce a hardening or baking effect, exactly as the solidification of clay is brought about when bricks are burned in a kiln. The temperature here must have been at least a glowing red heat.

The lava bed is at this place 30 to 40 feet thick and above it again is more of iron-stained clayey sands and of gravel similar in all respects to



Hard andesitic lava resting upon gravels, near Crown Point. The contact line, which is distinctly seen, is a vivid red color, caused by the flowing out of the seething hot lava upon the weathered surface of the gravels

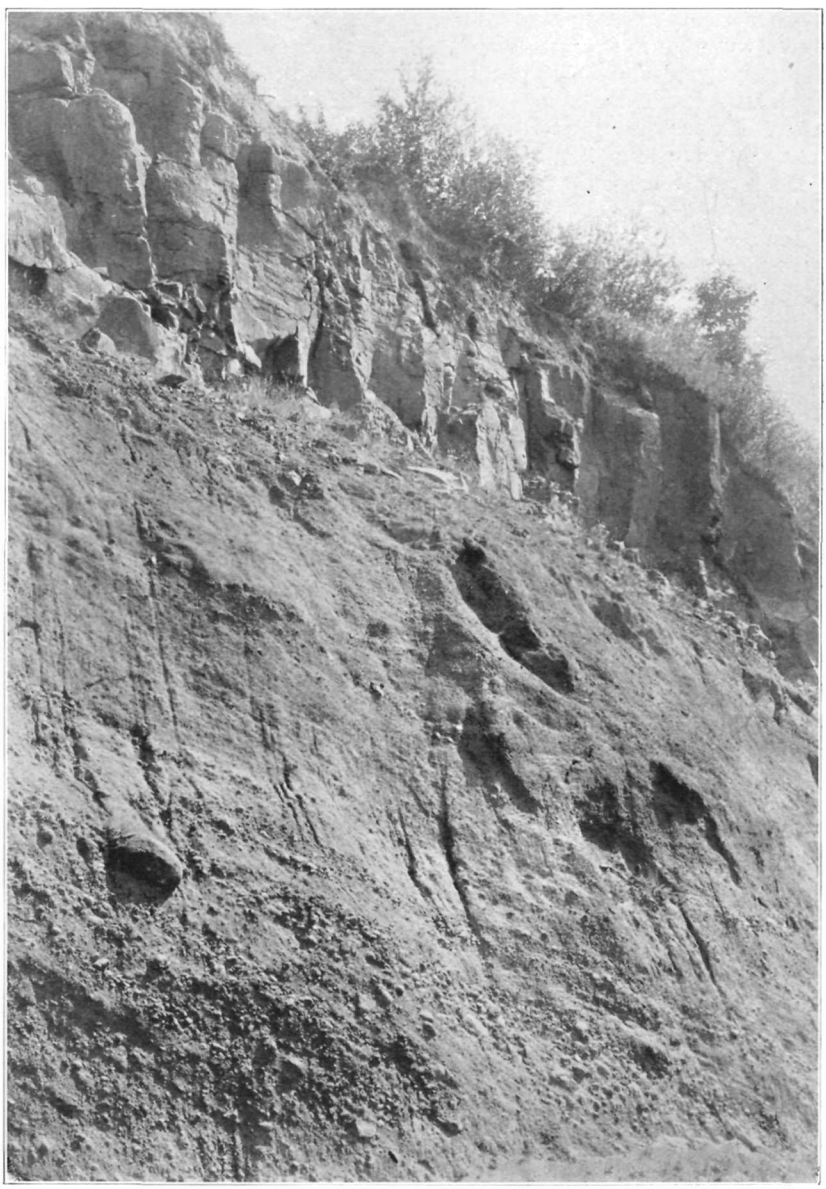



Section showing rock structure at Crown Point and Rooster Rock

those below. At once we realize the intra-gravel position of this lava, our thoughts promptly hark back to the exposure along the Sandy river opposite Troutdale, where a heavy andesitic layer resembling this in every phase occurs in the same identical relationship; yet there its base

was but 200 feet or slightly more above the river, while here we are overlooking the Columbia by fully 750 feet.

**Cross-bedded Satsop gravels overlain by blocky andesitic lava, near Crown Point.** The gravels themselves offer a wealth of suggestion as to the course of events in which they have had a part. Immediately beneath the lava the pebbles and boulders, always rounded



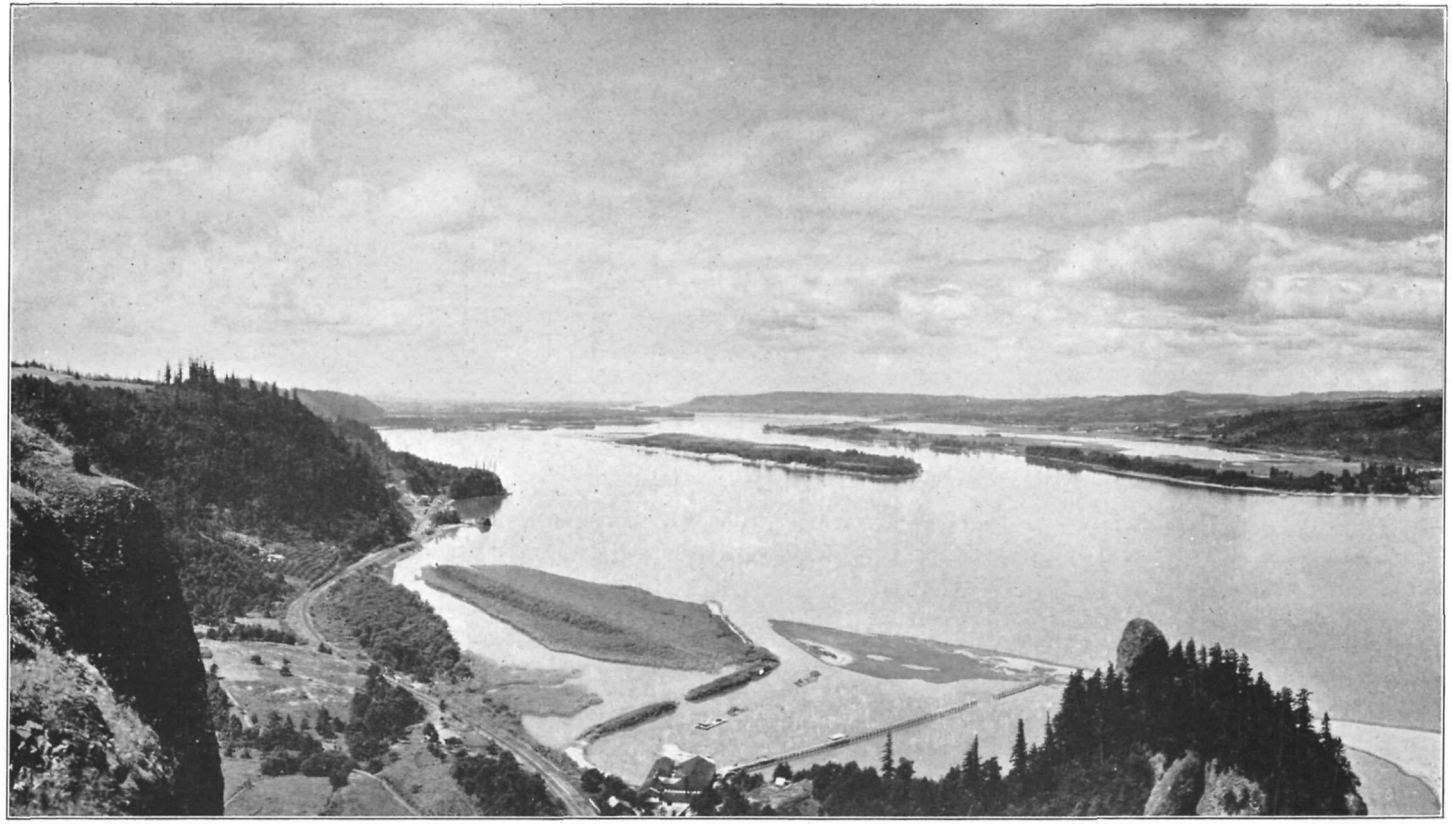
**Cross-bedded Satsop gravels and overlying lava, near Crown Point**

and waterworn, are predominantly of gray, cellular andesite with a filling of scoriaceous sand and ash, as if they were a great outwash carpet produced by the breaking down of a not distant mass of its own kind and distributed ahead by the waters in preparation for its hurried oncoming. This phase of the gravels is typically shown in the foundation of the Vista House. As a usual thing the layers, or bedding, of the sand and gravel are fairly even, as though they had been spread out with care upon a comparatively even surface. In some places, however, there is great variation in the attitude of the layers within a short distance. In the Highway cut, about opposite Crown Point chalet, whose peerless location is excelled if in any way only by the quality of the entertainment which it offers, is an excellent example of "cross-bedding" in the gravels. For the space of a few rods the alternating bands of sand and gravel pebbles which mark the manner in which the water put them down, are inclined to the southward as high as 30 degrees from the horizontal. Contiguous to those of such marked dip are relatively flat-lying strata that give the impression of abutting against those of steeper inclination. This is plainly shown in the photograph.

**Delta structure in gravels**

This variation of structure is quite characteristic of sedimentary beds that are deposited where the velocity of streams is checked as they flow into still water of some depth. It will be recalled that deltas are formed at the mouths of rivers and grow progressively farther and farther out as the river is forced to drop its burden. The heap thus built is one of steep slope on the down-stream or quiet water side, and sediment put down upon this slope will share the inclination of the surface of deposition. When streams are heavily charged with coarse materials, such as gravel and sand, they form bars which tend to clog their channels, and the current must shift first one way then another in order to avoid these obstructions. That, as the growing delta slowly rises toward the water's surface, is precisely what takes place. The channel forks into various distributaries, each depositing its load, then shifting, again depositing in its own way, again squirming about to circumvent the result of its work. In some later age when a former delta is elevated to become land surface, we find that the materials of which it is constructed have, as would be anticipated, the very same type of structure variations as we are now observing in the old Satsop gravels along the Columbia River Highway. What is our inference? There is but one conclusion, and that is that we are examining a cross-section of a portion of an old river delta; whether formed in the edge of the ocean, an inland lake or in the meanderings of the river itself we are now perhaps not quite ready to say. The materials of which it was built are largely river-worn gravels. And since we know that down the Columbia only could the abundantly plentiful quartzites have come, we are thereby compelled again to place at the door of that river the bringing down from parent ledges, and distribution, of at least a large proportion of the bulk of this formation.

**Down the Columbia river from Crown Point.** Arriving at Crown Point, we shall find of nearly as great interest the view to be had for miles down the river as that up the gorge from Chanticleer.

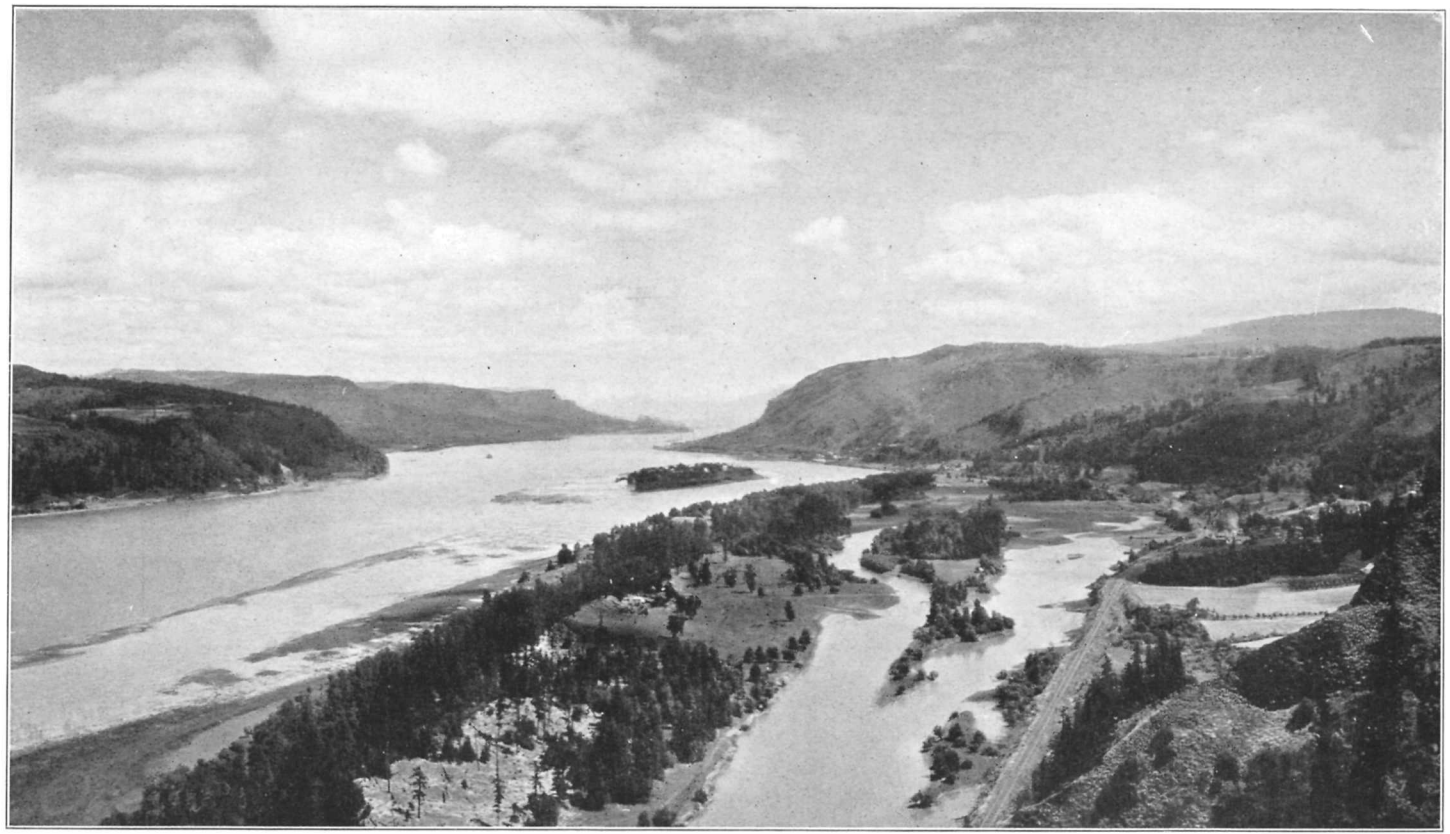


Down the Columbia from Crown Point. Rooster Rock and fish cannery in the foreground. Union Pacific line at the left. The flat sandy islands are a feature of this portion of the course of the river. The distant low horizon line is the dim shadow of the Coast Range more than 30 miles away

Our position is at the very brow of a basalt cliff 725 feet above the Columbia, whose proximity is so deceptive that it would seem a stone vigorously tossed would land in its waters. Rooster Rock, down upon which we look, is a group of spires, the culmination of a jutting ridge of basalt, that appears to be a remnant which the river in its task of cutting a channel has not yet cleared away. The notable cylindrical form with symmetric conical top is due in large measure to the presence of the characteristic columnar jointing of the basalt, because of which it tends in crumbling down to maintain steep if not quite vertical faces. Could one examine the face of the sheer basalt wall over which we now stand, it also would be seen to be coarsely columnar, with a hundred feet or more of its base (to be observed at the railroad level) of fragmental iron-rust brown basaltic tuff.

Across the river in Washington stretches of farming country mark the top of the Satsop formation, which surrounds or rises upon the flanks of prominent knob-like hills. Some of these hills doubtless represent, as we have seen in the case of Mt. Zion, former volcanic centers, whether or not their lavas can today actually be seen projecting above the surrounding gravels. Prune Hill, plainly outlined against the sky 15 miles to the west, and Mt. Pleasant directly across the Columbia are two of these elevations. Down-stream the channel of the river is broad, for many miles bordered by tidal sloughs, and its even flow is broken by a series of low wooded islands, sand points and bars. These features are produced in the course of a river when for some reason it is compelled to put down a considerable portion of its load of sand and silt before reaching the deep water of the ocean. We have already referred to the fact that, within comparatively recent geologic times, depression of the land has carried the lower Columbia to such a level that its old channel, which was doubtless well-defined, was "drowned" by incoming of the ocean water. Its great width, low gradient and the presence of the islands are some of the observable results of this incident in its normal development.

**Looking into the Columbia river gorge from Crown Point, 725 feet above its waters.** One is in a far more favorable position on Crown Point to study the region on both sides of the river than at any other place reached by the Highway. We observe plainly on the Washington side the series of relatively even-topped elevations already named, whose summits rise successively higher with distance, and culminate in the prominent outstanding profiles of Hamilton mountain and Table mountain. It is no illusion that the evenness of their summits is due to the slowly rising surface of a massive series of lava flows that, beneath Mt. Zion is a few hundred, and in Table mountain near 3,500 feet above sea level. On the Oregon side, similarly, we look beyond Bridal Veil where the jutting bulk of Fort Rock (Angels Rest) cuts off further details of the view close along the river. The base of Fort Rock is likewise basalt, but its top, as we shall also later learn, is hypersthene andesite, resting upon 500 to 600 feet of Satsop gravels that come in between the two great masses of lava of different types. Back from the Columbia and its bold canyon the mountain slopes rise to the summit of Larch mountain and, ever up, beyond the range of sight towards the major heights of the Cascade Range. We catch glimpses of the Columbia River Highway at intervals where, in finding its way to lower levels from our



Looking into the Columbia river gorge from Crown Point. Larch mountain, 4,045 feet, at the extreme right against the sky. Bridal Veil on the Oregon side at the foot of Fort Rock. Cape Horn and Mt. Zion at the left across the Columbia in Washington. S. P. & S., the North Bank road, at the left on the Washington side, and the O-W. R. R. & N. Co. track at the right, both transcontinental lines that thread the depths of the gorge throughout its entire length

present elevated position, it has been necessary to seek out a sometimes devious course.

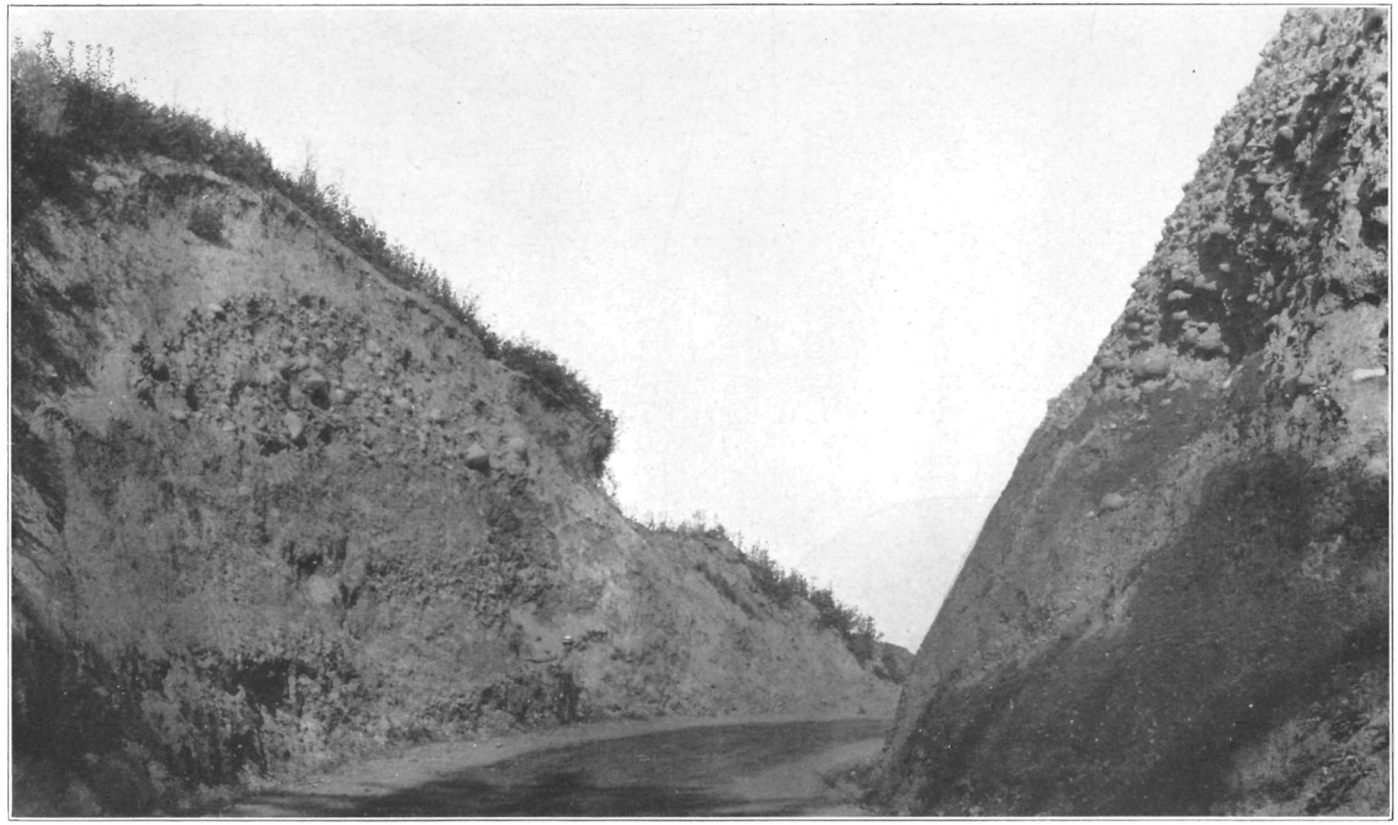
We are at the entrance to one of nature's great workshops wherein her forces have been and can now be seen actively at work. Crown Point and its environs is indeed a fitting introduction to the plethora of interesting things ahead, for it has given us just enough of a revealing glimpse to whet both curiosity and desire to a suitable state of keenness which will, we resolve, allow no single feature to escape our discerning attention.

**Bouldery Satsop gravels resting upon weathered basalt, east side of Crown Point.** From here we coast down even but exhilaratingly tortuous grade nearly to river level within the first two miles. We are told that the road in crossing a single 40-acre plot traverses a distance of 4,200 feet and drops in elevation 200 feet. At Crown Point we stood upon a great gravel bench; at the river, as would be anticipated, the rock is all basalt. At some point in the descent our watchful eye has not failed to note where gravels leave off and basalt appears. A start is but barely made when, within a few hundred yards, at the second turn, we see in a deep cut a great bouldery mass of the one resting undisturbed upon the other. Over all is a thick veneer of silty material such as we can conceive may have been shifted from the river flats by the wind. But so different than usual is the appearance of the basalt upon which the gravels lie, that we may excusably hesitate at this, our first immediate introduction, to identify any familiar mark or pleasing trait that may excite particular desire for further acquaintance. Since, too, long before our trip is over, almost continuous association must make of both inseparable friends, it will be well indeed to pause at this point and take advantage of the opportunity thus opened to us.

**Contact of gravels upon basalt**

We may trace the contact between the gravels and the basalt along the Highway for many rods at an elevation of 650 to 675 feet. It is an uneven contact, as if the gravels and sand were hurriedly tumbled in upon an old land surface that had been roughened by water and weather into gullies and ridges, possibly hills and canyons. And the testimony of the basalt itself that such was the case is strongly corroborative. Its upper portion is usually crumbly, iron-stained or yellowish with streaks of clay that has come from its alteration. The top weathered part is sometimes a few feet, sometimes 15 or 20, or how thick we do not know, and its original blocky or columnar structure is so entirely obliterated that resmblance to the fresh lava is quite lost.

**Weathering of the Columbia river basalt, east of Crown Point.** In places the weathered basalt presents the appearance of a bed of great rounded boulders separated by a filling of yellow or bluish clay. In the view the development of these "boulders of weathering" as they are called, is plainly brought out. Due to the jointed nature of the original basalt it is possible for water to find its way through the rock with little difficulty. Naturally in certain places channels become established along which the bulk of the slowly seeping water moves. Surface waters contain oxygen and carbon dioxide from the air, and acid constituents from decaying vegetable matter, and attack the rock with



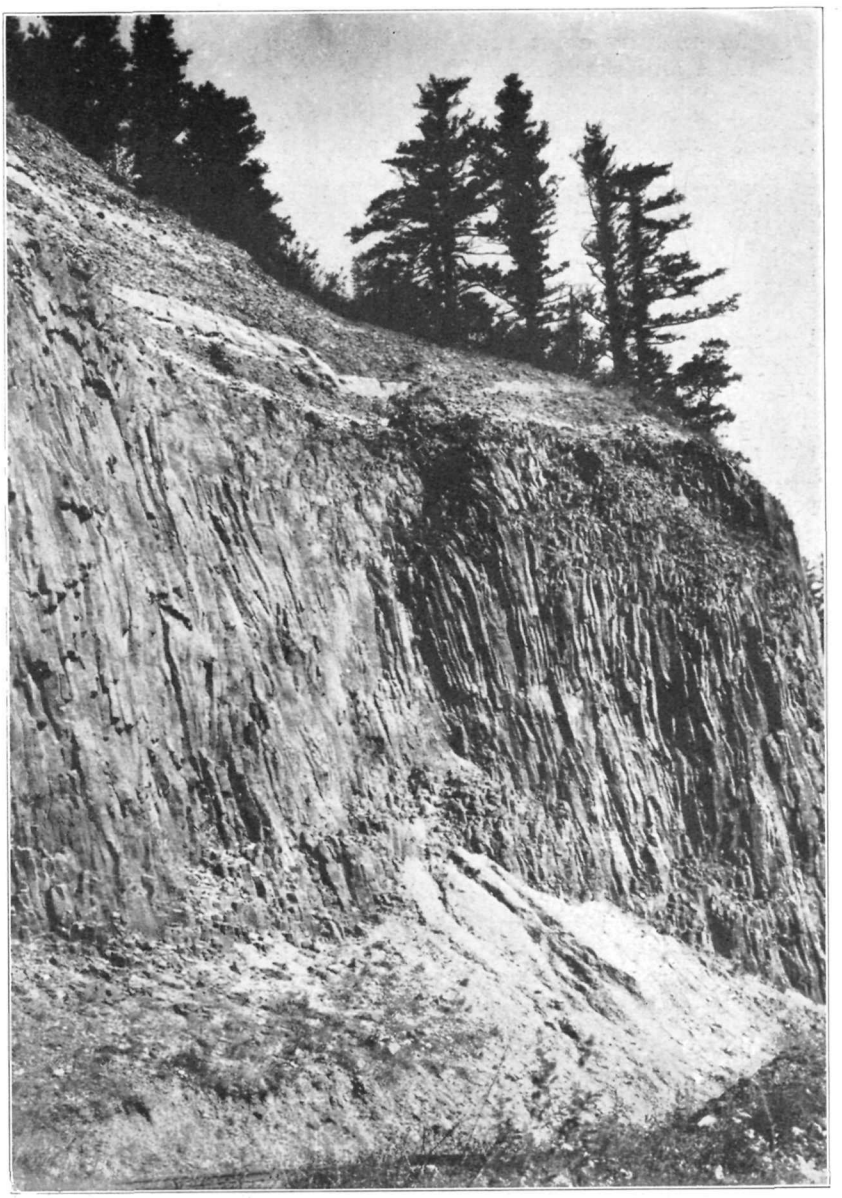
Bouldery Satsop gravels resting upon weathered basalt, east side of Crown Point

which they come in contact. The changes wrought in this attack are largely chemical, by which certain constituents are dissolved and carried away, while insoluble ones remain to mark the position, if not so very much as to the nature of the rock itself. Streaks of such residual material surround boulders in the middle part of the view, and grow less and less if followed either towards the top or bottom of the section. Low down

**Weathering of the Columbia river basalt, east of Crown Point**

the rock is less altered, some of its former columnar jointing being still in evidence, while above, much of its mass is so thoroughly decayed that even the boundaries of the boulders of weathering, if they once existed, have long since disappeared and the whole become a softened largely structureless earthy residue.

We read from these observations that, prior to the coming of the over-



**Beautifully columnar basalt overlain by horizontal layers of gravel and sandstone**

lying gravels, a long period of time passed while the basalt was a land surface, and during which erosion took place and deep alteration gave rise to a mantle of basalt soil and rotted rock. For the length of this interval in the past when tearing down of the land surface was going on we obviously have no direct measure. The fact that such a period did elapse is however shown conclusively by the erosional break (called unconformity) between the two formations before us, the gravels above resting upon the eroded basalt.

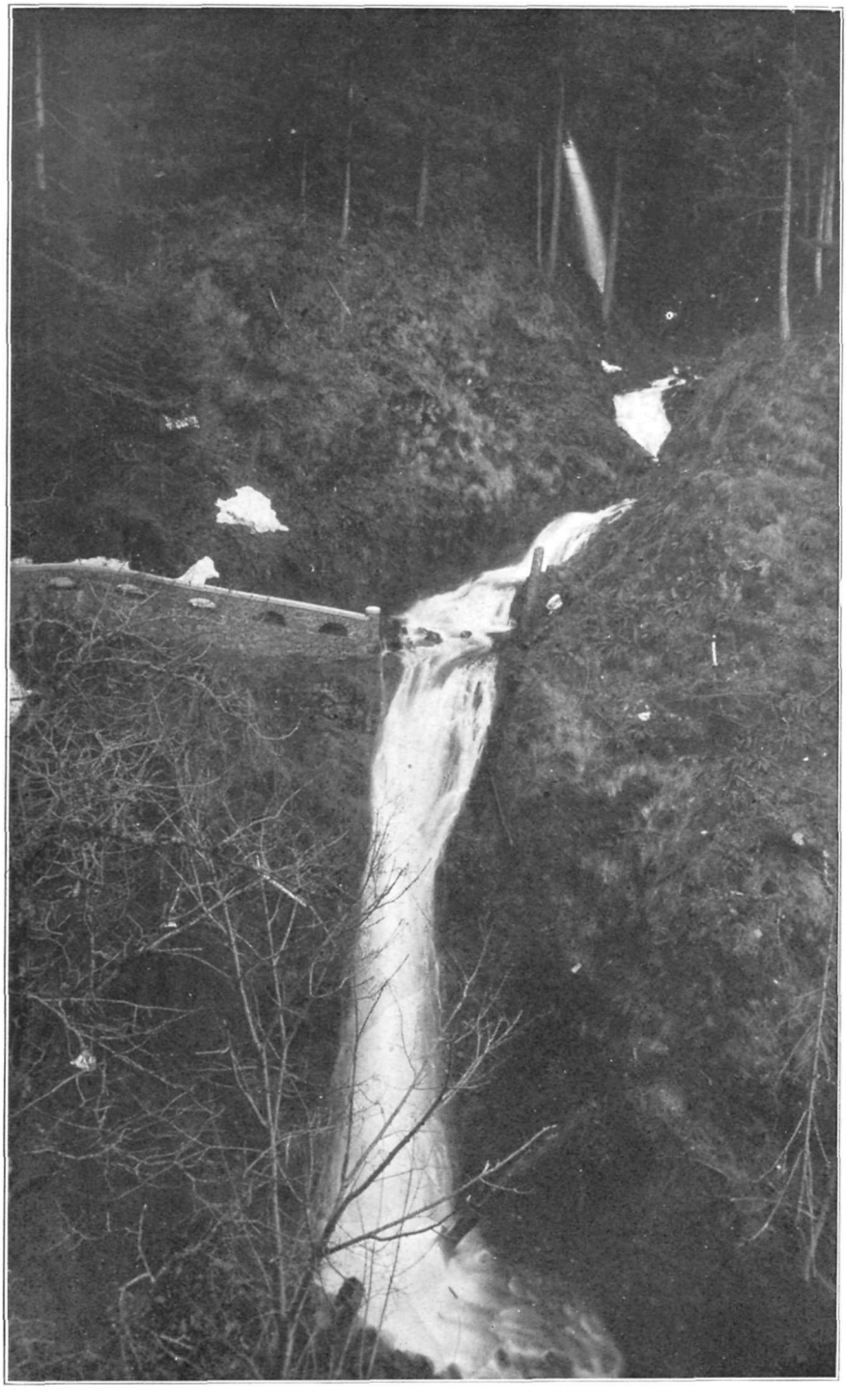
**Beautifully columnar basalt overlain by horizontal beds of gravel and sandstone.** The top portion of the basalt is not always so profoundly weathered where we find the gravels upon it. We cannot conceive of a land surface on which the residues of rock alteration and decay would remain or accumulate uniformly on all its parts. At one point every particle is swept away, elsewhere the forming soil remains in place or is even added to by mineral particles brought from a distance by wind or water, precisely as we see going on around us today. There is thus no occasion for surprise when we find so clean-cut a contact between these same gravels of the Satsop formation and the basalt as shown in the photograph. The long, hard upright columns of black basalt appear to break off squarely at the bottom of the gravel. The tops of the columns form a rolling surface upon which parallel layers of alternating partially cemented sandstone and gravel lie. This relationship between Satsop and basalt may be observed from the S., P. & S. railroad along the north bank of the Columbia for some distance west of the entrance to the Cape Horn tunnel and, as before us, is identical with their position on the Oregon side.

**Latourell falls.** Latourell creek is crossed at a little less than two and one-half miles from Crown Point. Here it is that we are greeted by the first of the thrilling series of waterfalls which has made famous the gorge of the Columbia river and is every day adding to the renown of the scenic Highway which threads its depths. Latourell creek is a stream of small volume, and it is this fact in connection with the comparatively great height, that lends to its falls and to each of more than a full dozen of others along the Columbia River Highway, so splendid a tinge of the awesome to their charm. Latourell falls is a practically vertical drop of 224 feet, as determined by Samuel C. Lancaster. It is at the apex of a broadly wedge-shaped cove formed by the recession of the falls as the stream has slowly eaten its way into the hard basalt of the canyon wall. It is a bold sheer front of black columnar basalt down which the water plunges. The maintenance of perpendicularity is largely favored by the pronounced columnar jointing, the columns being in general upright so that when they break away they do so parallel to the face of the cliff. Near the base of the falls the columns are conspicuously larger and vary in position from vertical to inclined or nearly recumbent. The large undercut or cavernous recess back of the falls is doubtless due to this varying attitude of the columns and to the additional fact that the columnar basalt here is in contact with one of a more platy structure, that gives way more rapidly under the incessant pounding action of the falling water and its load. At the east end of the bridge is Falls Villa, an attractive refreshment and lunch station.

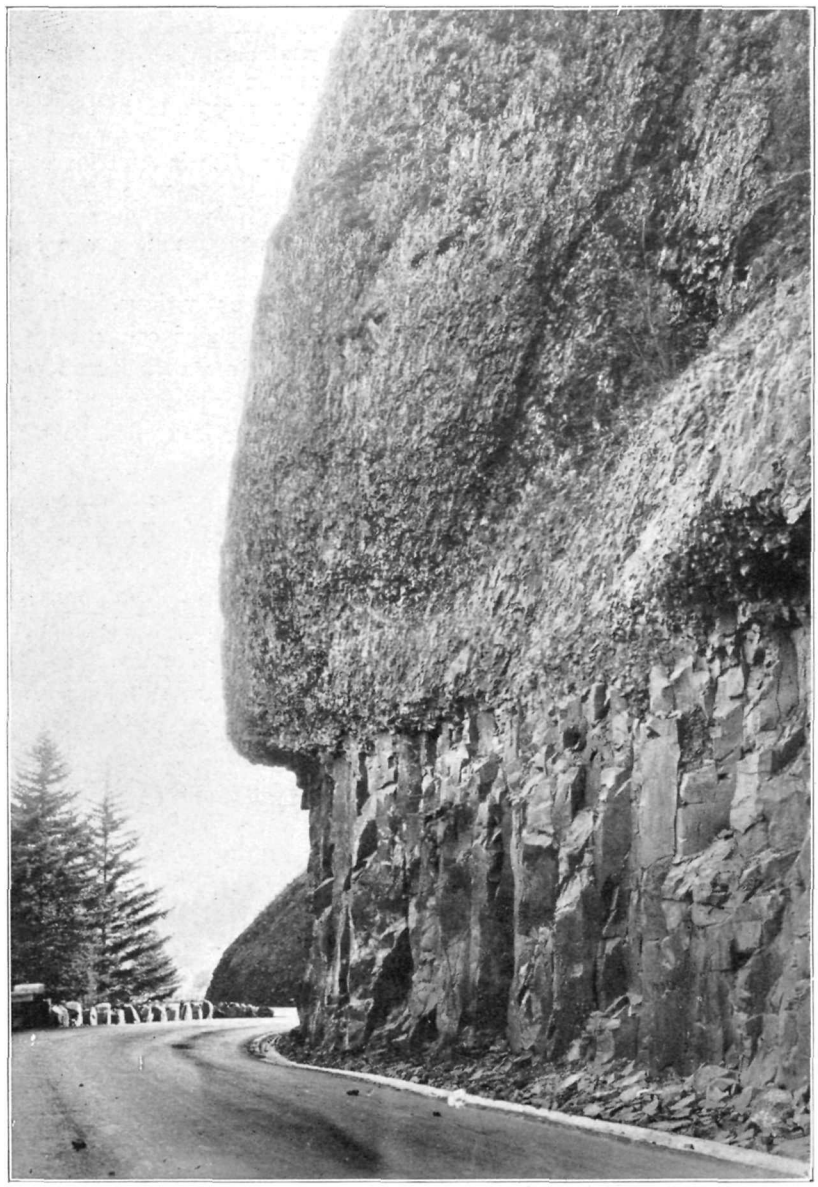
**Falls of Shepperds Dell.** Three and one-half miles from

**Latourell falls. 224 feet high. Note the curved columnar jointing of the basalt**
Photo Cross & Dimmitt

Crown Point is Shepperds Dell, a most fascinating rock-sheltered cove whose attractiveness is much enhanced in the series of cascades down which Young creek makes its hurried way towards the Columbia. From both the east and the west the approach along the Highway is at the base of an almost unbroken vertical wall of basalt that cuts off the view except on the river side. The long low wooded ridge, erstwhile island,



**The falls of Shepperds Dell**
Photo by Weister



*Overhanging wall of columnar basalt east of Shepperds Dell*

has been built by the river of the sand and silt with which its waters are ever loaded.

**Overhanging wall of columnar basalt east of Shepperds Dell.** Just beyond Shepperds Dell great columns form a splendid natural palisade, which is surmounted by a great thickness of basalt whose columns are on a much smaller scale. The latter breaks into

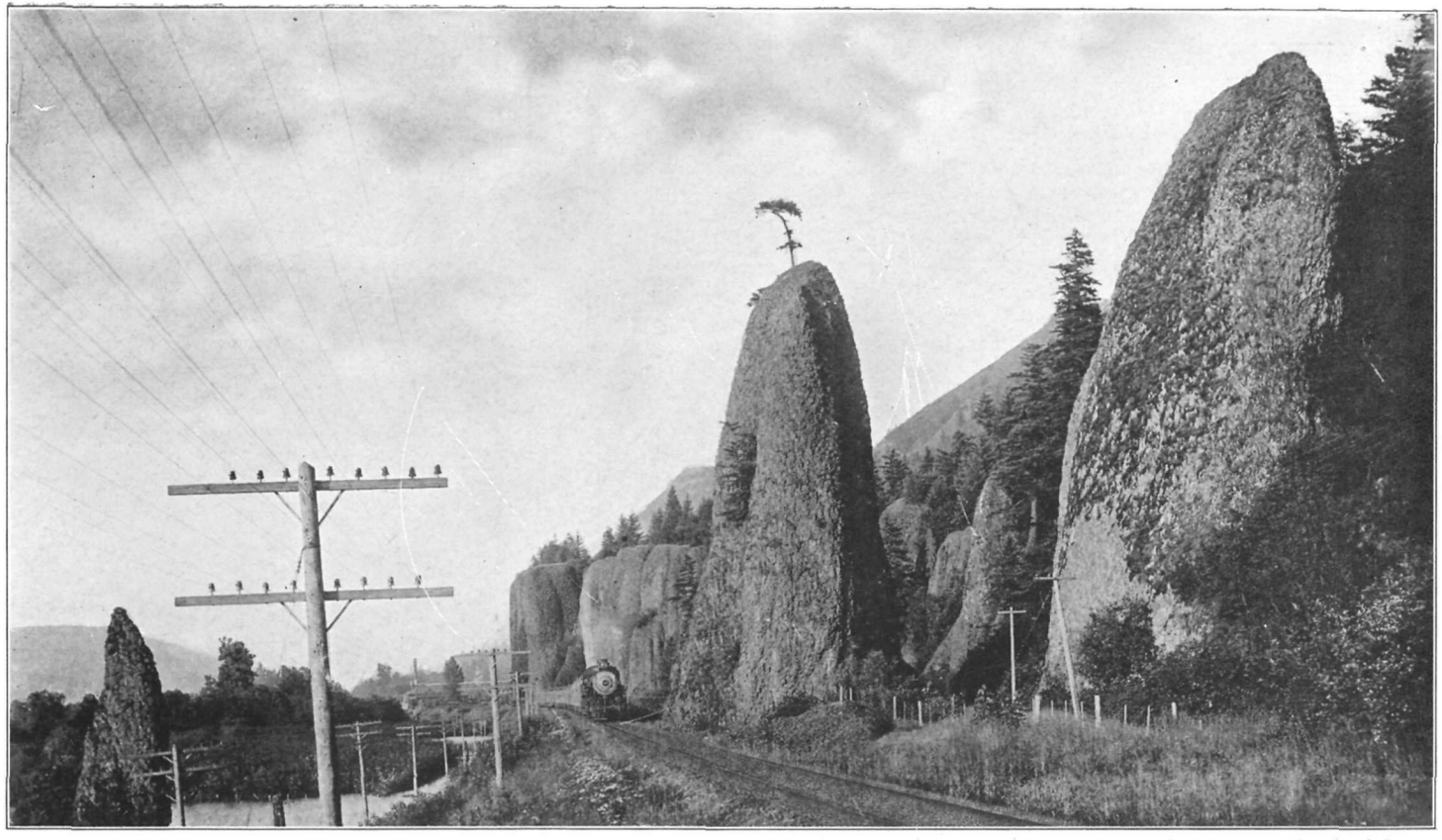
small angular blocks which, as they loosen, occasionally fall to the pavement. These automatically provide a subtle reminder to those who might unintentionally or otherwise forget, that an avenue of numerous no matter how graceful curves, cannot safely serve the purpose of a speedway. The heavy columns appear as though purposely designed to support the great overhanging rock load above them. They are seen in some instances to possess a regularity as to number of sides, and they separate from each other along fairly smooth and even joint faces as if for some cause these had been predetermined. Upwards the columns apparently grade into the less coarsely columnar rock.

**Columnar structure in basalt**

Columns are a common characteristic of basalts everywhere. Along the Columbia river a species of jointing in which well-defined columns are not always apparent is quite prevalent, and by which the rock breaks out in angular chunks usually of not large size. Whatever the particular type, this tendency of a once molten lava to separate along fairly definite planes, has been induced, we are told, by strains set up in the rock while it was cooling. Oftentimes the lines or parting planes, and therefore the columns, stand at right angles to the surface of the flow, as though they had developed thus ahead of and perpendicular to the zone of more rapid cooling as it progressed inward. Sometimes the columns are at the base of a flow, their lower limits being the contact with an earlier rock surface from which cooling doubtless took place somewhat rapidly. Very frequently groups of columns display a radial arrangement. We are not always able to determine that columnar structure bears a fixed relation to cooling surfaces, although it does seem that in all cases the particular conditions of cooling and hardening from the highly heated and viscous or even fluid state, has been the chief cause of this structural feature.

Henceforth, as we penetrate farther in the depths of the gorge, we are to be treated to a succession of most pleasing waterfalls, interspersed between promontories of increasing height and magnificence. One-fourth mile beyond the Dell is Forest Hall the gentility of whose service and the attractiveness of the surroundings having quickly made for it an enviable reputation. The falls of Bridal Veil creek, one mile beyond Shepperds Dell, though in perfect view from the O.-W. R. R. & N. railroad of the Union Pacific system, is below the Highway. It is not perhaps so serious a desecration as might at first seem, that the volume of these falls is lessened, and in the late summer even reduced to a bare trickle, by the needs of lumbering operations. For, through in its pristine vigor and surroundings, Bridal Veil falls was a thing of entrancing beauty, we may possibly condone its partial loss with the thought and knowledge that, before we are scarcely beyond hearing either to the east or west, others of its kind will greet us in all the fullness of their native splendor.

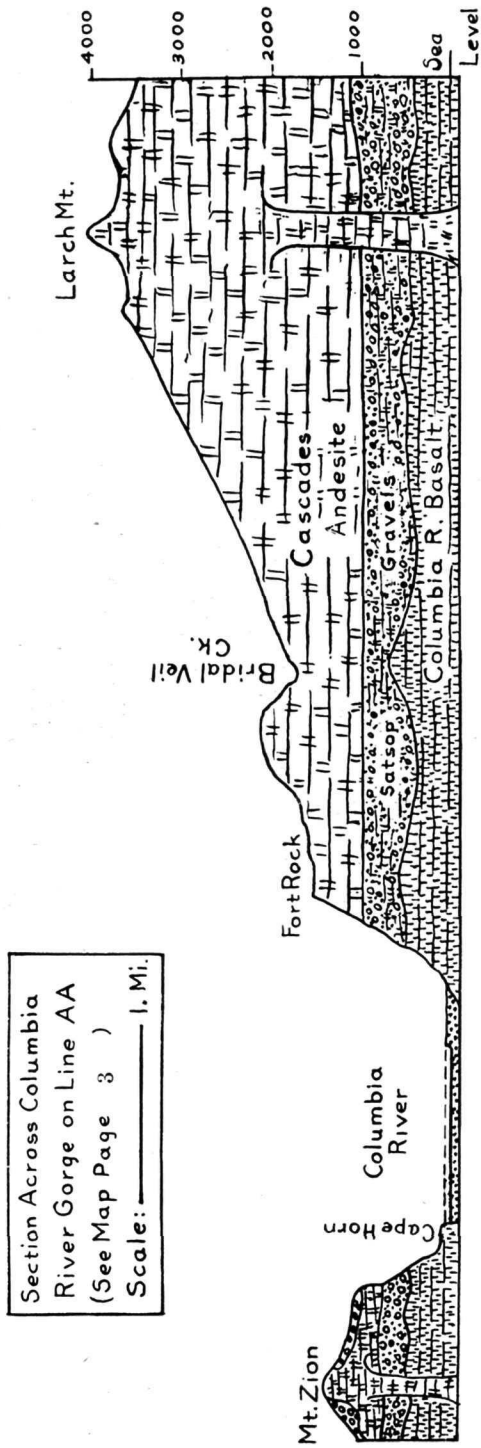
But we must not fail, as we traverse the distance from Crown Point to Bridal Veil, to note the occasional presence by the way of smoothly rounded gravel pebbles, many of them quartzite. These come down from



**Pillars of Hercules. South of O.-W. R. R. & N. track and just north of the Columbia River Highway east of Shepperds Dell. This peculiar type of pinnacle is a characteristic erosion form of the Columbia river basalt. They are remnants that the river has not yet torn down piecemeal and carried away**

the Satsop formation whose intimate acquaintance we have already made, it resting here as elsewhere upon the top of the basalt. The contact varies in altitude from about 675 at Crown Point to 900 feet on the trail to Fort Rock, where a total thickness of fully 500 feet of this formation is present. Opposite Bridal Veil, and to the east of it a few hundred feet higher than our roadway, the outcropping edge of this bed forms a steeply rising wall above the basalt which is so studded with projecting boulders and pebbles that its character cannot be mistaken. Up Latourell creek we find it at less than 1,000 feet and here too, as well as beneath Fort Rock, is a bed of andesitic lava that appears to be enclosed within the gravel and scoriaceous sandstone of the formation.

**Fort Rock (Angels Rest) from near Bridal Veil.** Fort Rock looms up directly ahead from Bridal Veil, its crest surmounted by an encircling palisade or rim of platy hypersthene andesite. Its summit is 1,500 feet above the river. Here we have our first glimpse from the Highway of the lavas that overlie the Satsop gravels. We have seen that heavy layers of basalt come below, and, as at Troutdale and Crown




Cross-section showing probable structure of Mt. Zion and Larch mountain

**Fort Rock (Angels Rest) from near Bridal Veil. Old Columbia river road before the Highway was built**

Point, at least one flow of a dark gray basic andesite came while the gravels were accumulating. But until now we have not been certain that upon the Satsop rested directly the lowest or first of the great series of andesitic lava flows of which much of the superstructure of the Cascade Range in Oregon is composed. We shall see that at many points ahead this same andesite is present in sufficient thickness in the upper part of the canyon wall, to very decidedly enhance many of its features of attractiveness.

Coopey creek comes out at the west side of Fort Rock. Its attractive lower falls, 117 feet in height, is to be seen a few steps from the Highway. The upper falls, which is passed several hundred feet up on the Fort Rock trail, appears to mark the contact of the gravels and the basalt, as if, in its downcutting the harder lava had proved so much of a barrier that the stream was compelled to tumble precipitately over, without the time to deliberately saw through it a channel of more uniform grade, such as it was able to do in the less resistant gravels above.

**Wahkeena falls. 242 feet high**
Copyright by Gifford

**Across the Columbia**

From this portion of the route a glance to the Washington side is of interest. Directly opposite, the heavily bedded basalt that supports Mt. Zion dips down-stream 2 to 3 degrees; and to our right beneath Fletcher flat, its summit 1,600 to 1,700 feet high, the same lava beds have a slope in the same direction of 3 to 4 degrees. We should expect to find the gravely beds of the Satsop, at least here and there, if not continuously resting upon the basalt. This it will be recalled has already been observed to be the case upon the slopes and at the river foot of Mt. Zion. Whether the gravels continue into the higher parts of the Range on the Washington as on the Oregon side, is a question to which a definite reply cannot now be made. Cape Horn at the river's edge is in the center of the view.

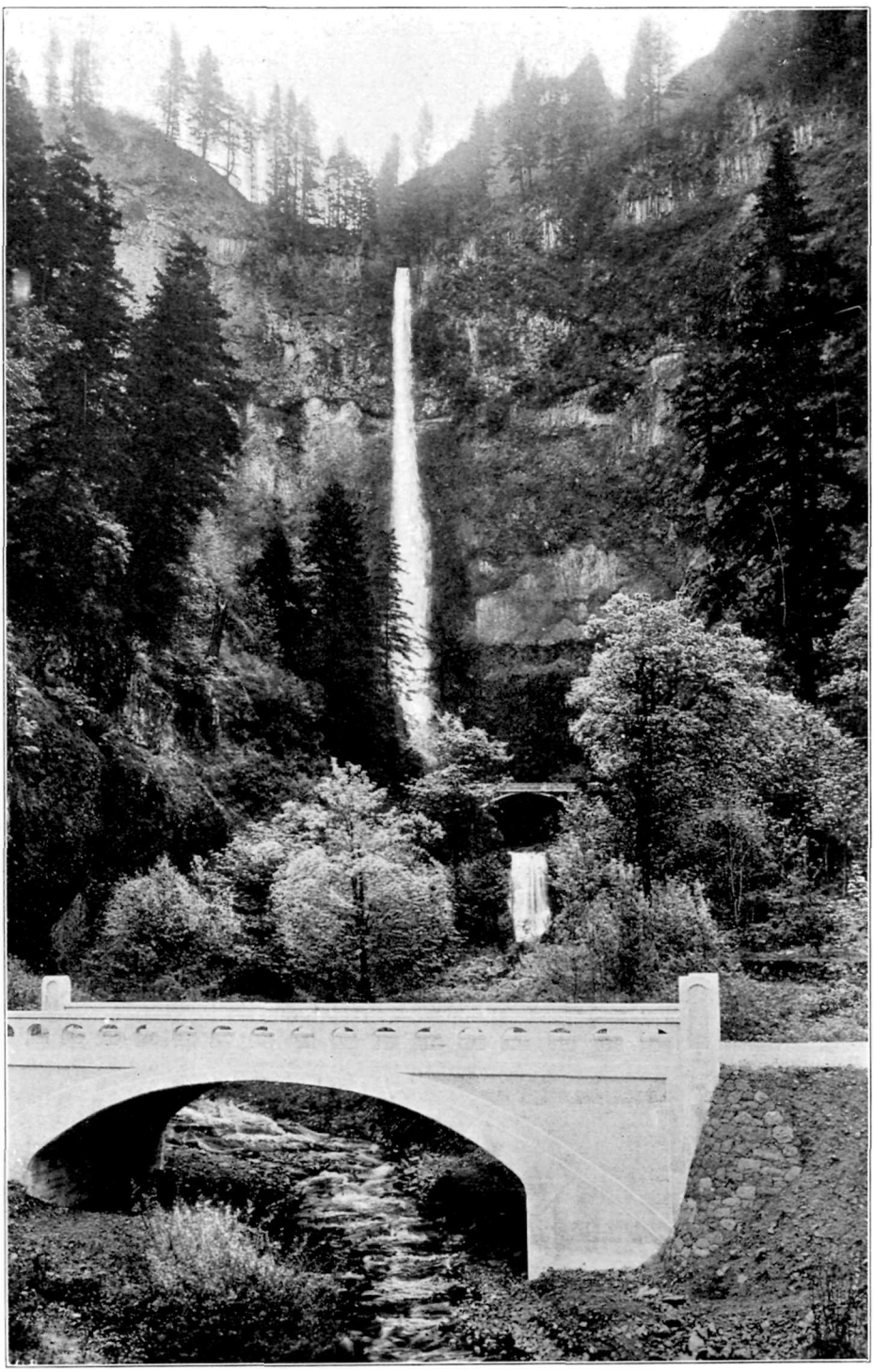
At the foot of Fort Rock and thence to Wahkeena falls, gravel, gray andesite, and basalt talus mingle, to show that each is present in the cliffs above. Mist Falls Lodge is three and one-half miles beyond Bridal Veil, a delightful hostelry, where visitors find both cheer and the fullest satisfaction of ordinary physical needs. Mist Falls springs from the cliff high up, a mere filament of water, so slender that before half of its sheer drop of near a thousand feet is made, it is none else than a spray of mist—hence its name.

**Wahkeena falls.** Wahkeena falls is without doubt in some ways the **most beautiful** of the many falls along the Highway. We are told that such is the Indian meaning of the name. The falls results from the confluence of two small streams and is a series of alternating vertical drops and rushing cascades, in total height, 242 feet. The waters come down a steeply sloping front of basalt. As much as the nature of the falls itself, is character and charm given to the place by the towering rock cliffs from high up between which in a niche of its own making, the whitened stream suddenly leaps into view. A foot-bridge spans the stream at the base of the falls and it is from here that the trail may be taken for the summit of Larch mountain. At Wahkeena falls is a public comfort station and, it is well perhaps to know, a station of the motorcycle Highway police patrol service.

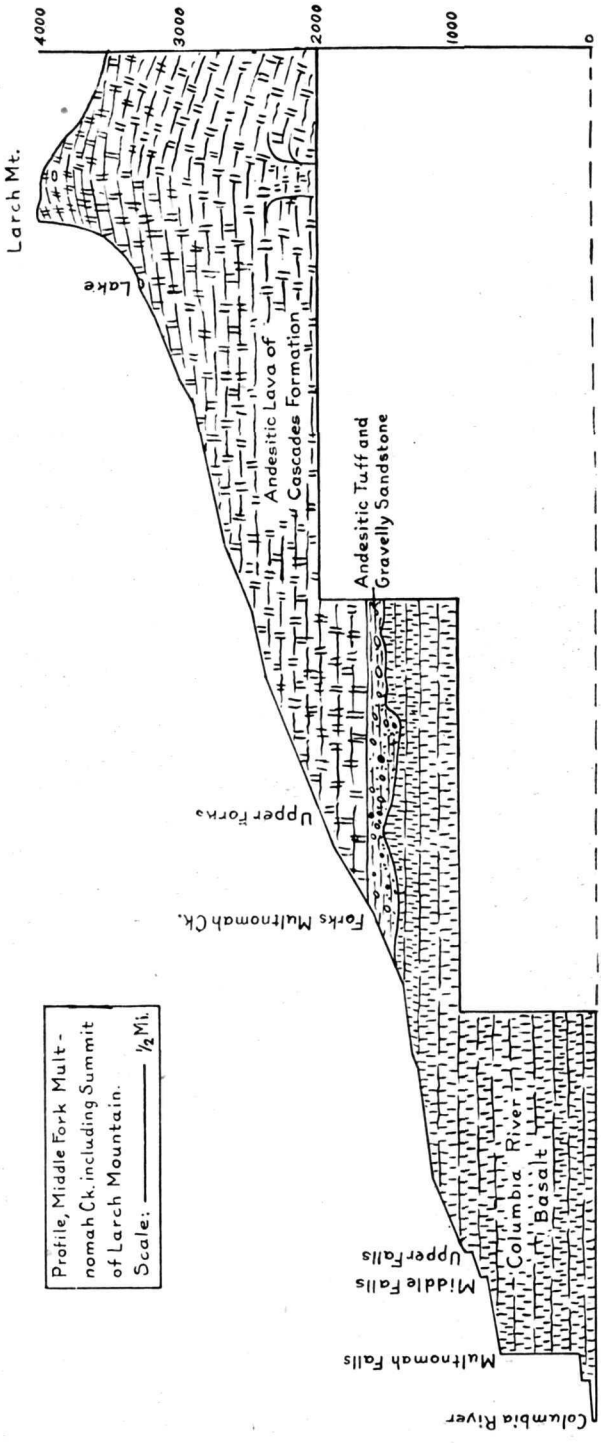
**Multnomah falls. Benson foot-bridge and Columbia River Highway.** Less than one-half mile beyond Wahkeena, and barely less than thirty-six miles from the center of the city of Portland, is Multnomah falls. It is within one-half mile of equidistant from Portland and from Hood River. No mention of the Columbia River Highway is complete but with and a part of it is the falls of Multnomah. Long have its praises been sung, and as our familiarity and knowledge of its idiosyncrasies grow, we come to realize that only the sweetest of strains can begin to express the love and reverence that this pygmy-giant but master stroke of Nature's busy hand must stir in every open heart. The rush of its waters is music that enthralls and its picturesque surroundings beyond the skill of the artist's brush to portray.

The main falls is 541 feet in height according to recent measurement by the U. S. Forest Service. The lower falls is 69 feet with a drop of 10 feet in the cascades between; in all, from brink to base, 620 feet.

In the main falls the waters of Multnomah creek spring from the edge of a slightly overhanging ledge of hard basalt, which carries

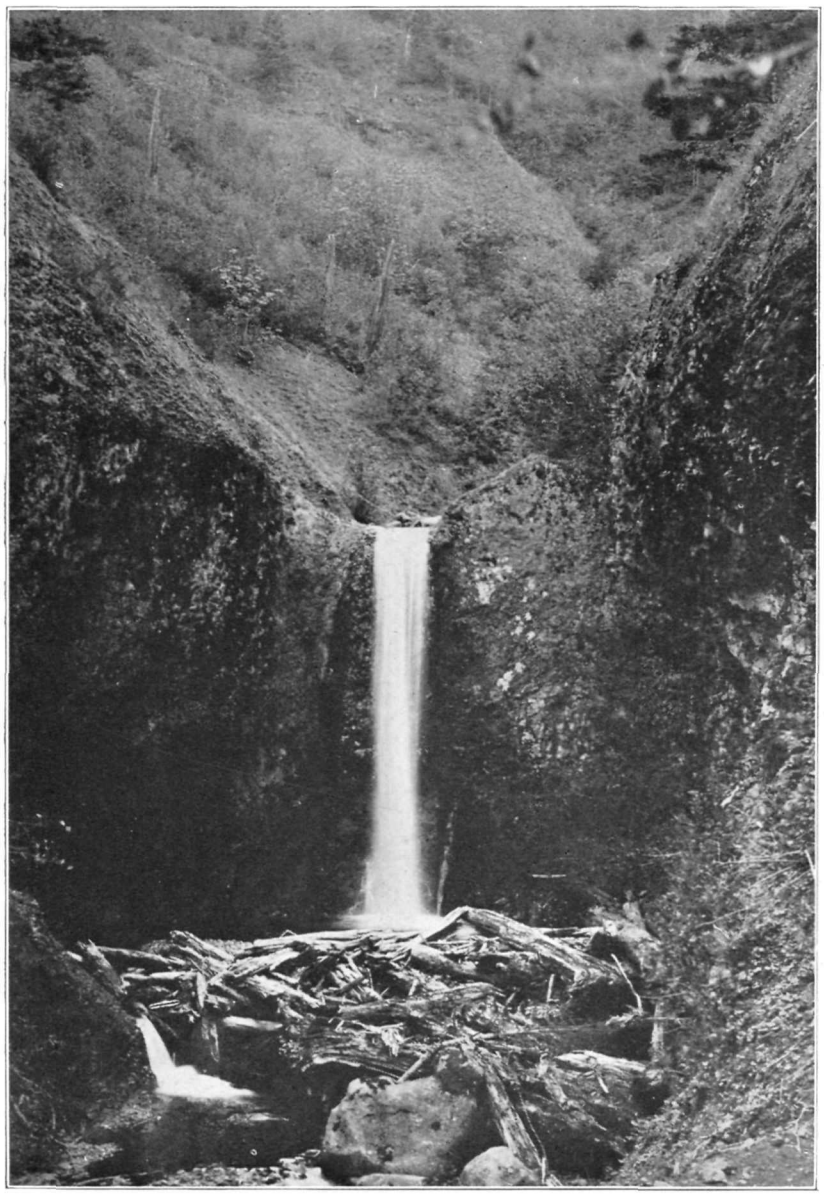


**Multnomah falls, 620 feet high. Benson foot-bridge and Columbia River Highway**




**Profile Multnomah creek from the Columbia to the summit of Larch mountain**

them entirely clear of obstruction to drop vertically in midair for better than 500 feet. In late summer when the flow of the stream is lessened, it is not an uncommon sight to see the entire, then frail ribbon of water shifted aside by each eddying breeze, like the quavering vibrations of a waving ensign, and beaten into spray long before its half thousand foot leap is over. In winter at times the entire setting is a frigid one of frost-fretted shrub and tree. The great rock wall is then faced with a glittering ornate veneer of rime-coated stalactites and stalagmites, in all the intricacy of their most splendid design; and the turbulence of the plunging water itself seems calmed to so peaceful a state that, beyond the range of sound, we are constrained almost to feel that it, too, has congealed to permanence in its place.



**Middle falls of Multnomah creek, on Larch mountain trail**

## LARCH MOUNTAIN

THE rock section behind Multnomah falls is a series of thick beds of basalt each bed representing an individual flow. In the upper 541 feet we see only three of these flows. All are typical Columbia river basalt, although columnar jointing is not developed on so grand a scale as in some other places. The trail to Larch mountain crosses Benson foot-bridge (shown in view, p. 52),

**Upper falls of Multnomah creek, on Larch mountain trail**

safely makes a zigzag way to the level of the top of the falls. Thence it follows up the canyon of Multnomah creek, which it later leaves to seek a devious upward way, its steepness increasing until in a distance of six and one-half miles the full summit altitude of 4,045 feet is gained. This trail was constructed jointly by the Progressive Business Men's club of Portland and the U. S. Forest Service. It is a popular and not difficult climb for any one in ordinary physical condition, whose frame of mind is such that the primitive,

the wild and the supreme in nature are of strong appeal. Up to about 1,250 feet above the Columbia river we see nothing else than columnar basalt, passing in the first two miles two beautiful falls (see pages 54 and 55) each 60 to 75 feet in height. Resting upon the basalt is a 75-foot bed of beautifully cross-bedded yellow sandstone, containing scattered masses of cellular andesite. The sand particles are made of volcanic ash and gray to black lapilli. This deposit is clearly water-laid and occupies the position of the Satsop formation as seen elsewhere, for the next exposed rock in the trail above it is a porphyritic gray andesite that continues to the top of Larch mountain. Here, then, is better than 1,200 feet of basalt, which means that we are finding its surface higher and higher as we pass eastward towards the center of the Cascade Range. The comparatively thin bed of pebbly lapillaceous sandstone marks the interval between the great floods of basalt and the coming of the newer andesites.

**Summit of Larch Mountain**

The highest point of Larch mountain is a platy augite andesite. In the low saddle between this highest point and that on which the U. S. Forest Service lookout station is located, is a great mass of red scoriaceous cellular lava resembling in every way those that accumulate immediately round a vent of eruption. There seems little question that the commanding height of this mountain represents a point of issuance for liquid lavas in great quantity; but whether they came from a fissure or crater cannot be stated, since later erosion has so profoundly modified its original slopes as to eliminate many of the marks by which its character may be recognized.

At the north base of the mountain there is an almost vertical drop of nearly 500 feet. This perpendicular rock wall, over the brink of which one is inclined to peer with extreme chariness, is a portion of a widely semicircular front at the foot of which a broad depression opens out to the northward. The three forks of Multnomah creek, and Oneonta creek, take their rise in the marshes, springs and small lakes within this depression. One is reminded very strongly of the glacial cirques so common in the higher Cascades and some of which are at altitudes no greater than this. In fact, so strong is the resemblance, that we can yet even almost see the great amphitheatre filled with the snow of centuries, from which streams of ice led down towards the Columbia, we know not how far. If we have thus correctly diagnosed conditions here, though we have climbed 4,000 feet to do so, we are now observing for the first time on our excursion the results of the work of an agent new to us, the glaciers, and whose activities represent a period of time more recent still than the andesite flows, the Glacial Period.

**Geology in passing**

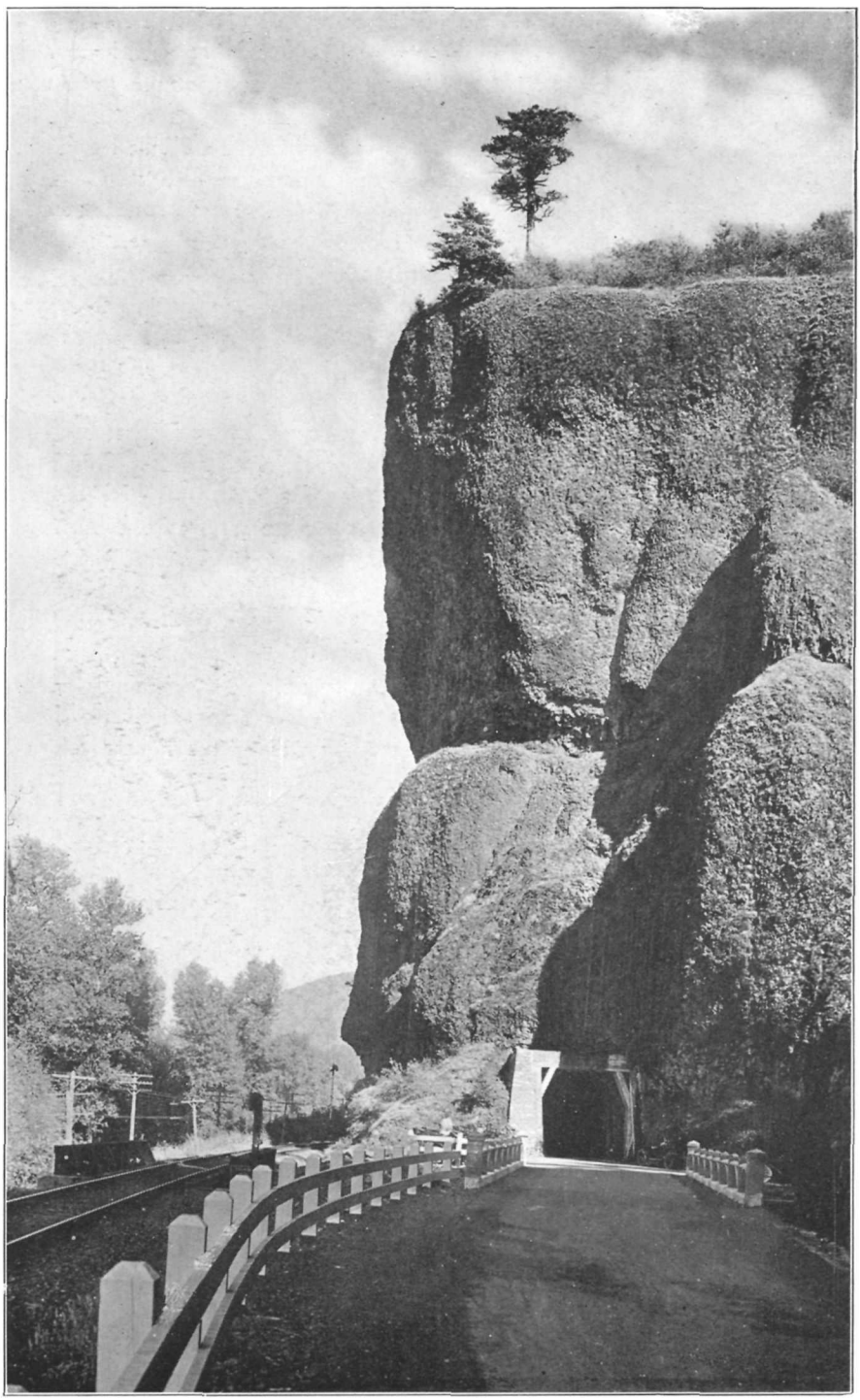
To review, therefore, in reverse order, as we return to the Highway, the sequence of events, we have nearest the present (a), the stage of ice or glacial erosion, passing into and followed by the active cutting of the present streams; prior to which (b) a great succession of andesite lava flows, exemplified before us in Larch mountain; preceded by (c) the deposition

of the gravels and sands and clays of the Satsop formation, already seen at many places; (d) a period of active stream erosion and weathering in which deep canyons were cut in the basalt and its surface intensely altered; to be antedated still again by (e) the time during which the inundating floods of basalt swept over a wide range of country. We shall be interested to know, if, in the Columbia gorge, there will be exposed to our view anything to give us a glimpse yet farther into the past. If satisfaction be not too long delayed, an anticipative state of mind is a healthful one. In partial relief of which at any rate it may now be promised that, before many miles, not merely glimpses but wide open panoramic views, so to speak, that none can mistake, will abundantly speak out the events of yet earlier days.

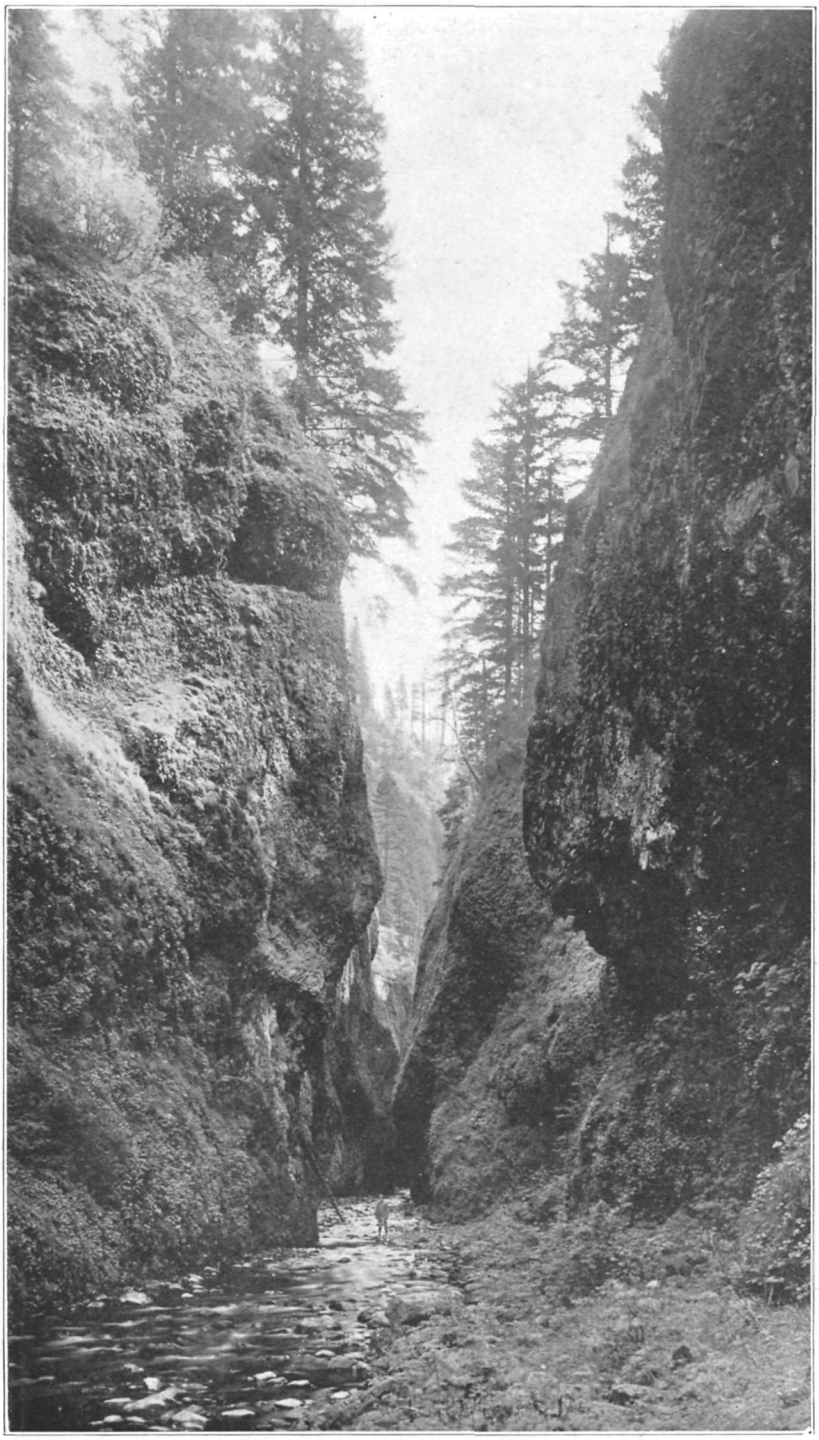
In the course of the descent from Larch mountain to the Columbia River Highway we shall be able to correlate to a satisfying extent the rock strata to be seen across the Columbia in Washington with those on our own side of the river. Directly opposite are the silent dark rims of Fletcher flat and Archer mountain, obviously made of the same formerly continuous layers of lava now separated by a shallow intervening canyon, and these are the same layers that, at a lower level, show beneath Mt. Zion at and above Cape Horn to our left.

Both eastward and to the west from Multnomah falls, the Columbia River Highway and the railroad have been compelled to sparingly edge their way between the base of thousand-foot cliffs and the river's shore line. The cliffs are basalt but the presence of blocks of the lighter colored andesite indicates that it, too, above the basalt, extends to the brink of the canyon.

**Massive basalt flows. Oneonta tunnel.** Both sides of Oneonta creek, which is two and one-half miles beyond Multnomah, the exceeding massiveness of some of the basalt flows is impressed upon us. From its bridge, and facing Oneonta tunnel, we are confronted with a perpendicular blank wall said to be over 200 feet high. Nor is "blank" in any way an appropriate adjective, for more expressive than this is wall of stone scarcely ever found to be. Its entire height appears to be made of but two flow layers of basalt, each when it came, therefore, more than 100 feet in thickness. Bearing in mind that we are looking at but a minute portion of a body of lava, each sheet of which spread out over a great many, perhaps hundreds, of square miles; and perhaps pressed forward for many miles as a great seething flood before coming to rest, what conception may we gain of how prodigious was its quantity or how vast the reservoir of supply whence the lavas issued? In the cliff before us, there is resting upon each horizontal square foot at the bottom, say, 200 cubic feet of rock; upon each 10 feet square, 20,000 cubic feet, or about 25 tons. But this meagre 200 feet of height is but a mere bagatelle in comparison with the thousands of feet of the same basalt, made up in the same way, to be observed as we pass on through the Gorge and far into eastern Oregon. Even at 2,000 feet thick, it would take but two and one-half square sections of land to carry



**Massive basalt flows. Oneonta tunnel**

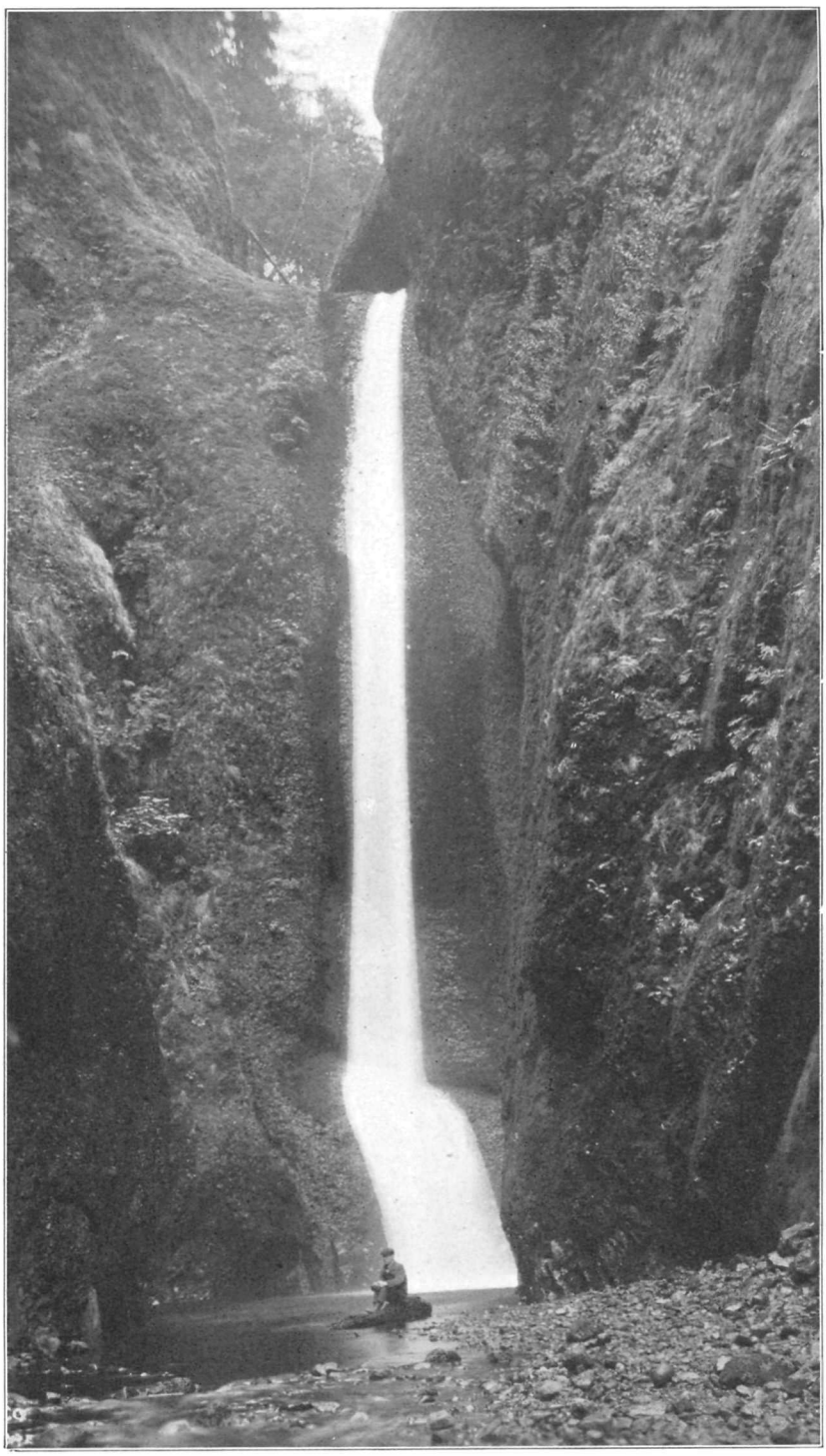


**Oneonta gorge as seen from the Columbia River Highway**
Copyright by Gifford

a cubic mile of lava. But it runs three and four thousand and more feet thick in places, and for hundreds of square miles in area. The wonder of the whole situation is that all this enormous bulk of rock came out from the interior of the earth. And when we ponder this fact we are, if anything, more concerned than ever that more surface evidence is not seen in this region of the existence, or filling in, of the profound void that at first thought it would seem must result from the disgorgement of a quantity of lava so great.

**Oneonta Gorge as seen from the Columbia River Highway.** Of the streams that enter the Columbia from the Oregon side, all of which are crossed by the Columbia River Highway, none present to the passerby a more unique type of gorge than does Oneonta creek. We have seen thus far that these streams, in full view as a rule, drop from the brink of the Columbia canyon in picturesque waterfalls, as though for some reason they were prevented from seeking a more gentle slope to join the parent river. Streams in general and particularly those having such steep gradients as the ones before us, are never at ease, but are always busy in an effort to lower their grade and to reduce it to one of gentle and uniform slope. Here however the great river seems, on account of its added capability, to have so completely outstripped its comparatively puny tributaries, as to have left many of them, hanging, as it were, high above its present shores with no alternative whatever but to spill their waters from the precipice rim, reck what will, in order that they may join those of the parent channel. Not all of the tributaries have been so outdistanced. Others have been able to retrieve lost ground by cutting their outlets to the level of the river.

Our first glance at Oneonta shows us no falls. On the other hand, it flows in a narrow gash between vertical basalt walls, whose very verticality tells not only that the creek has itself cut this narrow slit, but that the process has been one of such rapid incision that but little widening has been brought about by the crumbling of the rock. It is well not to resist the temptation to explore this chasm, for its lessons are several. And it must matter not if in so doing knee-deep pools a-plenty are to be negotiated, and if progress is at times one of hand and toe hold along the face of slimy walls or beneath dripping ledge. Along the way we will note the distinctly marked boundaries of the layers of lava, each an individual flow. In places a band of clay permeated with black carbonaceous matter, the remains of vegetable growth, marks the contact. Here and there are circular horizontal caverns whose full nature is not disclosed until one makes the discovery that they are lined or their floor strewn with broken fragments of fibrous partly petrified wood. These observations teach us that between at least some of the many flows by which the thousands of feet of lava have accumulated, enough of time elapsed for soil formation and for vegetable growth. Even forests flourished, but only to be overwhelmed, as all else of plant kind, by the succeeding flood of molten lava. It is the presence here of the charred remains entombed between these lavas that opens to our understanding one more page of record of the fiery ordeals of the past.



**Oneonta falls. Less than a thousand feet from the Highway. Approximately 100 feet high**
Copyright by Weister


**Horsetail falls. Within one half mile from Oneonta gorge and tunnel is Horestail falls. This wonderful falls is 208 feet high and is rather a tumbling sheet of water than a true falls. The water catapults down a very steep front of columnar basalt to land almost at the base of the Highway grade**

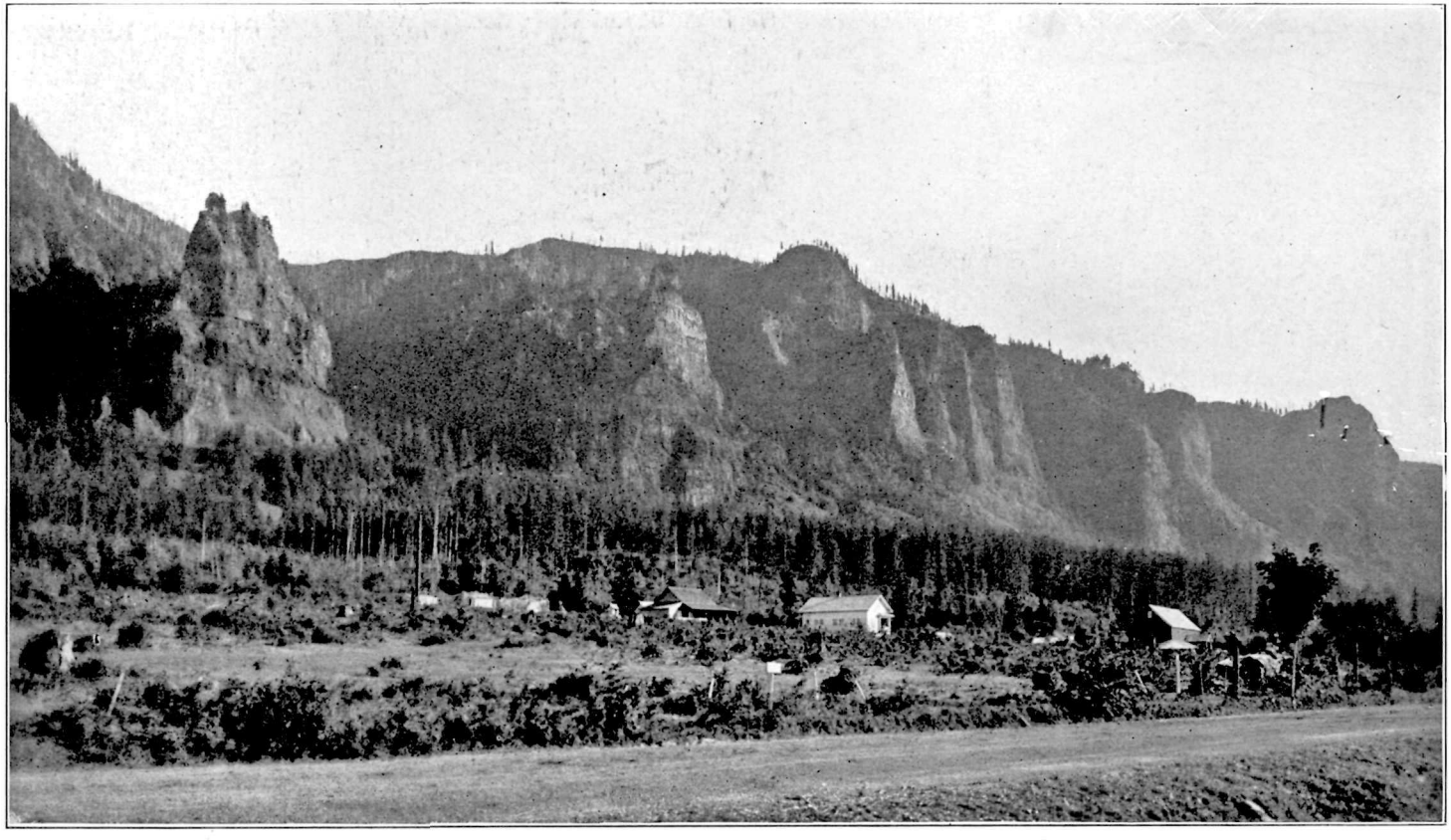
**Oneonta falls.** At somewhat less than a thousand feet from the entrance we are not surprised to come to Oneonta falls. In its seclusion it occupies so suggestive a position with reference to the "box" gorge through which we have just come as to leave little question that this gorge has been produced by the slow up-stream movement of the falls itself. Its recession is brought about by the vigorous erosive action of the stream and it is the normal history of a waterfall that, as it recedes, its height becomes less and less until self-elimination is accomplished. We conceive therefore that the falls of Oneonta was originally at the mouth of its sharp gorge, but that owing probably to the size of Oneonta creek, hence its ability to do work, it has cut its lower course for a fraction of a mile back from its mouth, down to an even grade, its falls retreating to a corresponding extent. It is an observation that one will not fail to make as we proceed that, though present, the falls in all of the larger streams that flow into the Columbia are not, as of Multnomah creek, at the brink of the canyon, but have receded a greater or less distance up the course of these streams. It is doubtless due to the way in which this process is favored by the columnar structure of the basalt that the falls, as they recede, are not more speedily eliminated than they are.

**South wall of Columbia river canyon west of Warrendale.** From Horsetail falls for four miles to Warrendale the bluffs have so withdrawn from the river that, for the first time, they really rise to their full stature within our range of vision, and we gaze to a clear-cut horizon 3,500 and more feet vertically above the Columbia River Highway. In no other portion of the gorge have the great crumbling cliffs been more spectacularly carved than here. Protruding ridges have been whittled to jagged points or serrate edge, isolated turreted pinnacles stand out, castellated towers, terraced battlements.

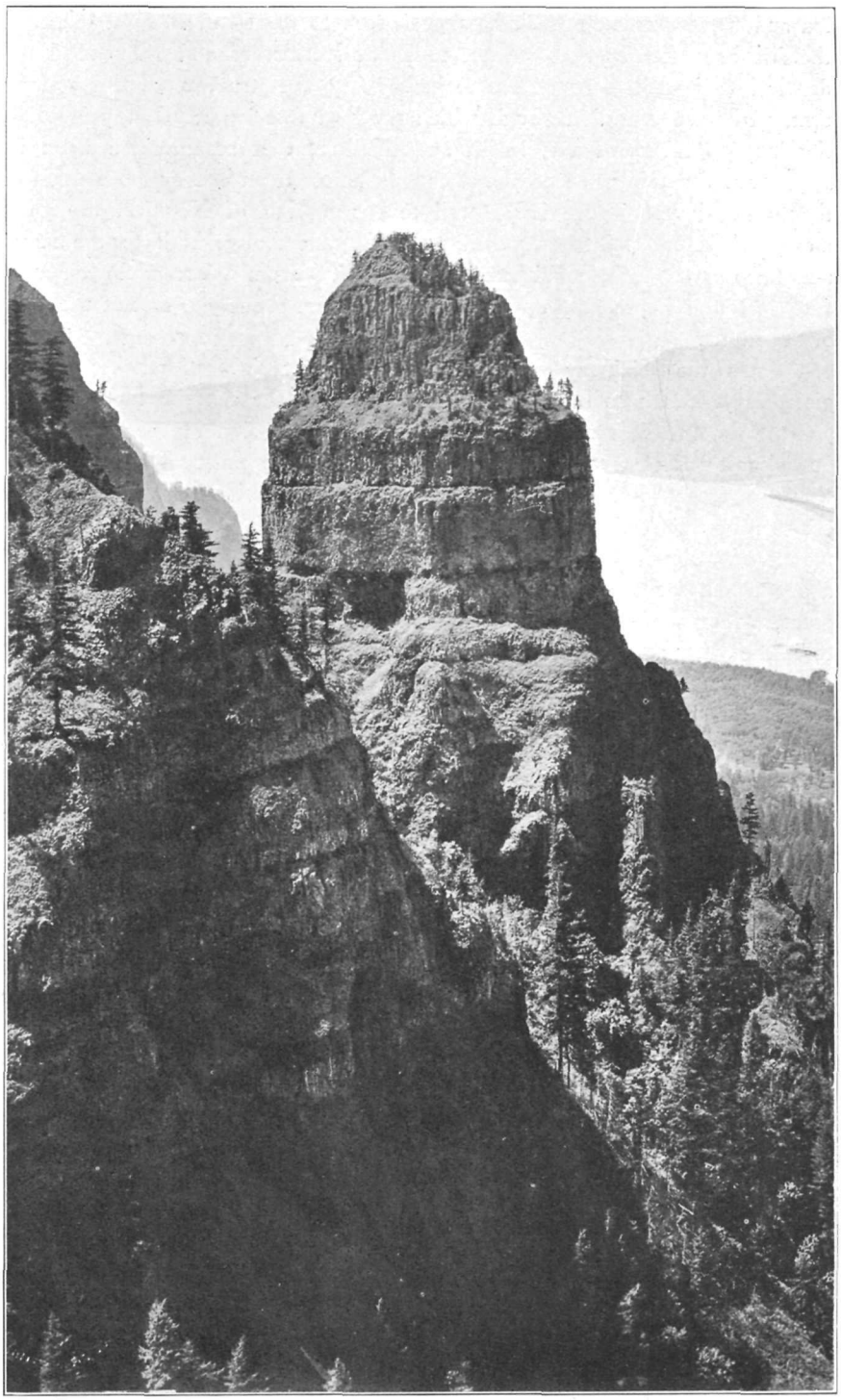
**St. Peters dome and Columbia river.** St. Peters dome and Katani rock stand sufficiently apart to appear now as far-seeing guardians for the great rock wall behind. But whatever of threat there may seem to be in their vigilant attitude is speedily dispelled on close approach; for both are seen to be but trembling fragments of these same parent cliffs, beyond whose protecting influence they are now unfortunately themselves separated. Each is made of a set of layers of Columbia river basalt, at first sight, as though the great cakes were carefully placed in horizontal position, each upon the one below. It is appreciated however that the method of construction was far more widespread, when we observe the continuation of each of these lava layers in the nearby canyon wall; and come thus to understand, that, instead of permanence, such forms as these are significant of an advanced state of deterioration. Soon, as geologic time flies, they will be no more. Today we see scattered upon their flanks and shelved upon each corniced ledge the sliding talus that is each season being added to from scaling wall higher up. Both Katani rock and St. Peters dome rise 2,000 feet above the Columbia.

**Nesmith point**

As Warrendale is neared, we may look far back into the angle at the head of Tumalt creek (formerly Devil creek) to where, near the top of the cliff, a series of flat-lying beds occur, alternating in color from red to light gray or, at our distance, almost white. These beds lie at the flank of Nesmith point, the summit of which we also see. It rises 3,878 feet above the Colum-



**South wall of Columbia river canyon west of Warrendale. Katani rock at left. Yeon mountain and St. Peters dome near center of view**
Photo Oregon Commercial Studio



**St. Peters dome and Columbia river. The dome rises more than 2000 feet above the Columbia**

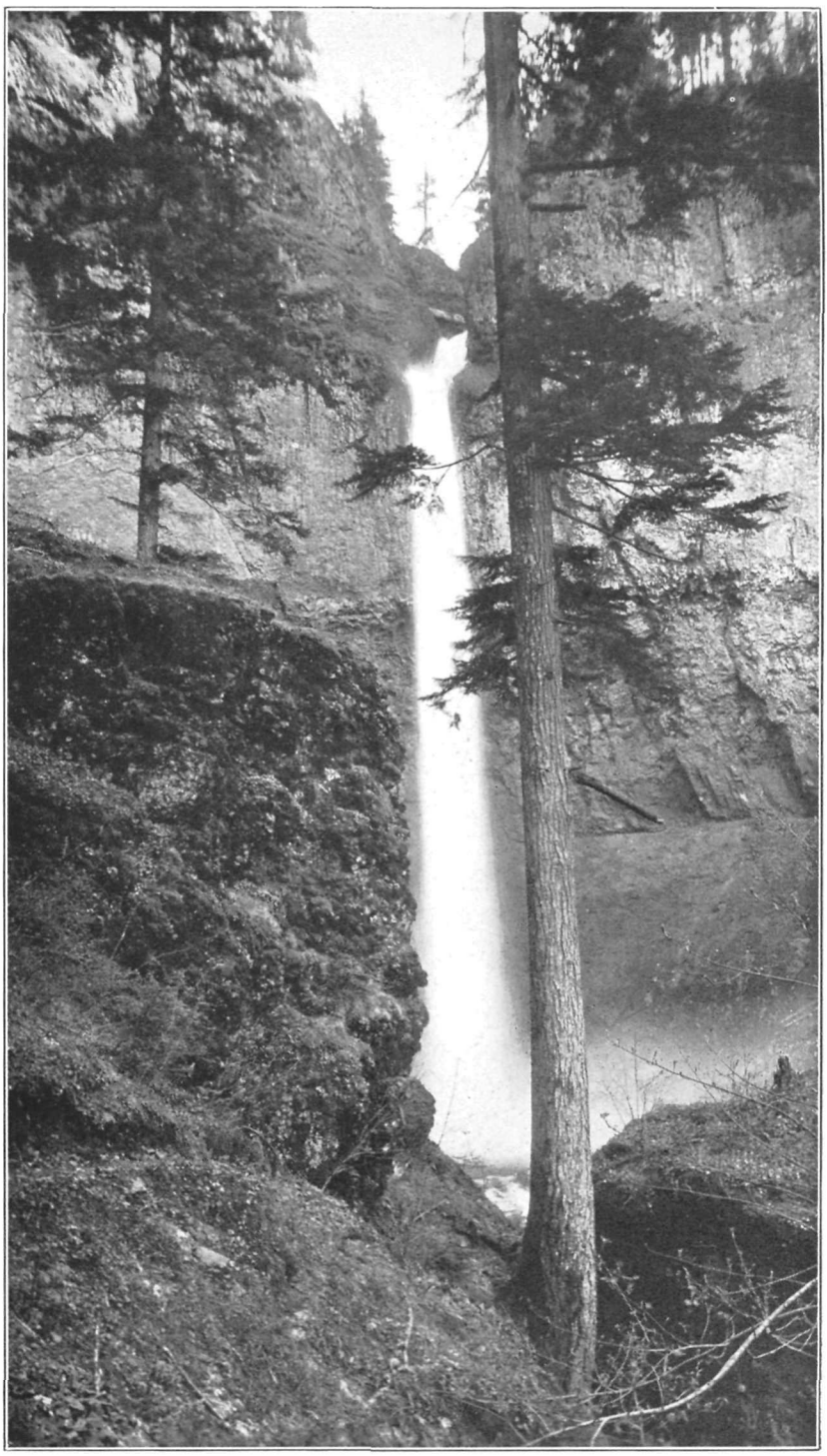
bia and when examined at close range is seen to represent, without question, the site of a former vent whence much of scoriaceous and fragmental andesitic lava issued. Erosion has so gashed into the structure of this volcano that, while the conduit through which the lava rose is not actually in view, the inclined layers of ash, lapilli and the like, that accumulated upon its slopes, are beautifully exposed and cutting across them one or more dikes of the harder lava. There is no trail to the summit of Nesmith, though a more satisfactory point for viewing the Cascade Range both to the north and far to the south, could scarcely be asked. From Warrendale the most feasible course is probably up McCord creek from about 950 feet at the head of the flume.

From the Highway we have already caught sight of patches of suspiciously yellowish to brown material high up in the cliff beneath Nesmith point. We are naturally on the lookout for every sign of the presence of our almost constant companion thus far, the gravely Satsop beds that mark the top of the basalt and the beginning of the andesites. In the bouldery channel of McCord creek a rare quartzite pebble is found and occasional masses of yellowish pebbly tuff, both of which belong to the time interval about which we are concerned. Though these sediments are not seen in place, evidence of their presence in their usual inter-lava position is such as to locate with reasonable exactness the top of the Columbia river basalt at about 1,800 feet above sea level. It will be recalled that on Multnomah creek the basalt may be seen resting upon and in contact with this underlying

**Tuff below basalt**

So far on our Highway tour the oldest rock formation to which attention has been directed is the Columbia river basalt. Although at times curiosity has been piqued almost to the limit of endurance, we have as yet seen nothing below this. At the crossing of McCord creek, ample satisfaction on this score may now be enjoyed for here, in the cuts along the Highway itself and in the canyon walls below the falls, as if waiting in subdued expectancy our approach, we are suddenly face to face with better than 200 feet of pebbly gray volcanic tuff in general filled with angular blocks of andesitic lava and a variety of other boulders. Better still, for many rods along the creek the basalt may be seen resting upon and in contact with this underlying tuff-conglomerate upon which its whole enormous thickness of in places 2,000 to 3,000 and more feet is foundationed.

**Elowah falls.** At the foot of the falls of McCord creek, called Elowah falls, these basal materials are more rapidly eaten back by the falling water than is the basalt so that the latter breaks off from time to time as its support is removed. Perfect columns of basalt rest upon a pebbly basaltic tuff which in turn passes into the ash-gray unsorted bouldery mix so characteristic of this formation. The undercutting of the softer materials helps to maintain the perpendicular wall over which the water drops, yet at the same time, is apparently a factor that contributes to the more rapid up-stream shifting of the position of the falls. Elowah falls is a practically vertical drop of 289 feet, and in the sheltered soli-

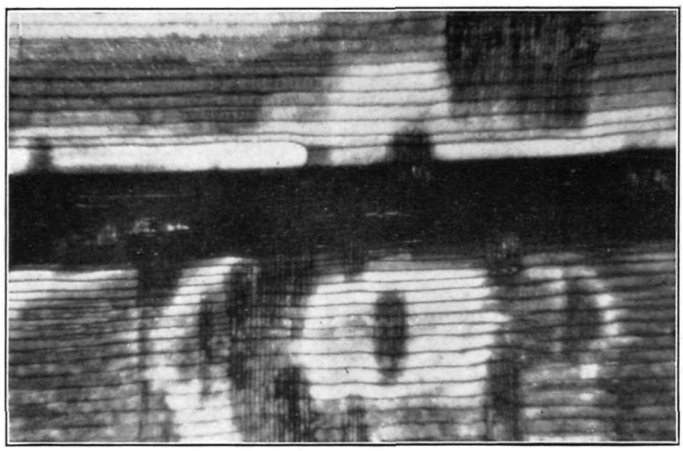


**Elowah falls, McCord creek. 289 feet in height**
Photo by Weister

**Petrified tree upright in tuff-conglomerate. McCord creek bridge**

tude of its setting, one of the most attractive spectacles of its kind along the Highway.

**Petrified tree trunk standing upright in tuff-conglomerate, McCord creek bridge.** Aside from the cheer of its instructive presence, for the next 15 miles the congeniality of this sub-basalt forma-

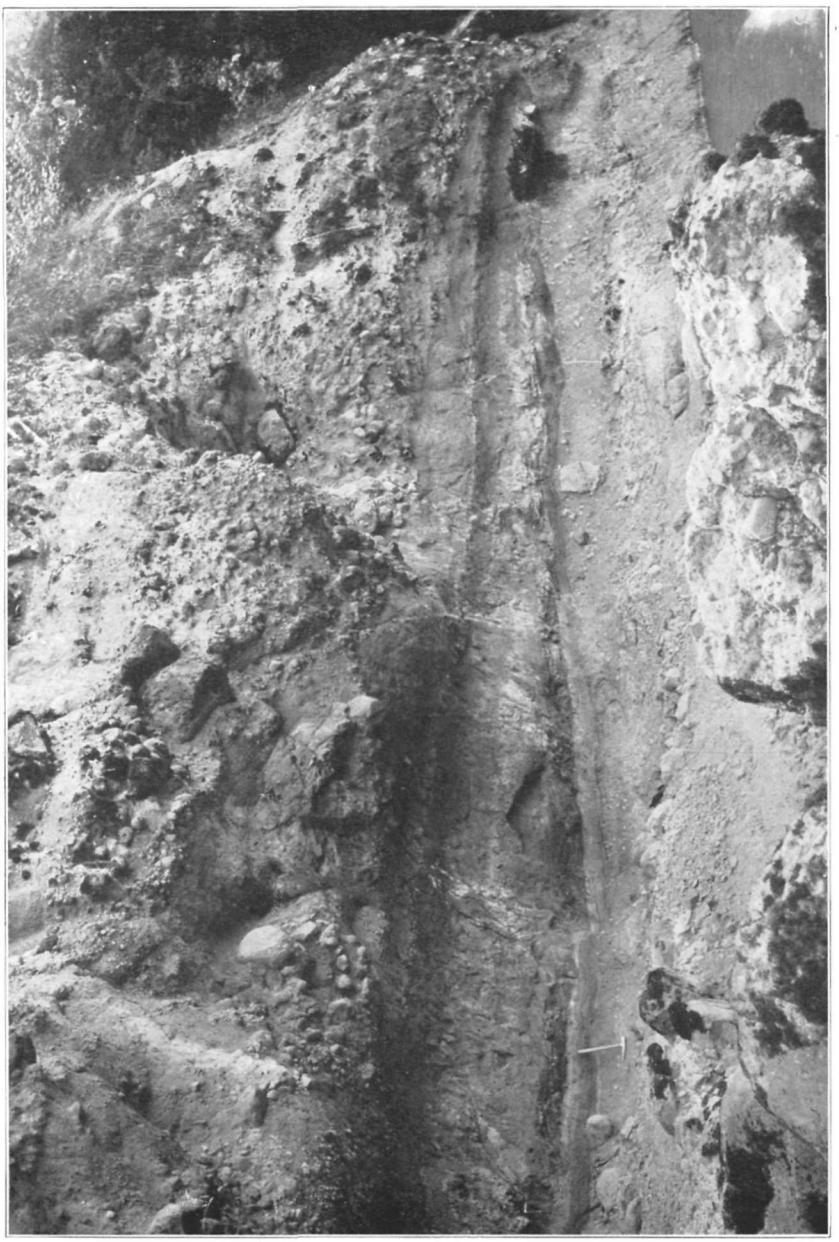


**Magnified thin section of petrified wood from the Eagle creek formation. So thoroughly is the structure sometimes preserved that the paleobotanist can very often determine not alone the kind of tree, but as well the general character of the climatic environment in which it grew. This section is of silicified coniferous wood**

tion will be expressed in various ways. A few steps from the east end of the McCord creek bridge the Highway excavation has exposed the partially petrified trunk of a large tree. The tree stands upright and is entirely enclosed within the friable bouldery tuff. Were it capable of relating its life story we should probably hear of ancient days when, as now, coniferous forests flourished, and in a climate not widely different from the present; of a time when rains fell and rivers flowed and a luxuriant vegetation lived and died much as today. But we should doubtless further hear of the beginning days of threatening volcanic activity, when the light of sun was obscured by an increasingly dense fall of ashy dust that settled in smothering profusion upon all living things; when volcanic bombs pelted dangerously from the air; and of how our tree, among its neighbors, finally succumbed and the spot where once it grew in full-fledged vigor became the tomb in which so gently yet mercilessly was its interment brought about, that it was compelled to pass into the great future, though cruelly battered and worn and seared, still upright and in the attitude of vigorous youth. Measures are to be taken to protect and preserve in place this splendid remainder of the past so that its story may be read and appreciated for time to come.

**Fossiliferous beds**

**Fossil-bearing bed at mouth of Moffett creek.** In many other places the partially silicified remains of trees are found, some standing as they grew, others recumbent. Interbedded sands and gravel occur in this formation and here and there lenses of ashy clays or shale contain the leaves and stems, branches and seeds from the flora of the times. At the mouth of Moffett creek, which is crossed about a mile and a half east of McCord creek, the coarse firmly cemented conglomerate gives rise to a projecting cornice that overhangs the re-entrant made by a few feet of more readily weathered sandy shale. Beneath the west abutment of the railroad bridge the etching away of this softer layer has necessitated additional reinforcing with concrete at this level. It is from a dark carbonaceous band in this shaly layer which in July, 1915, was



Fossil-bearing bed at mouth of Moffett creek. Bouldery conglomerate above. Water of the Columbia at right

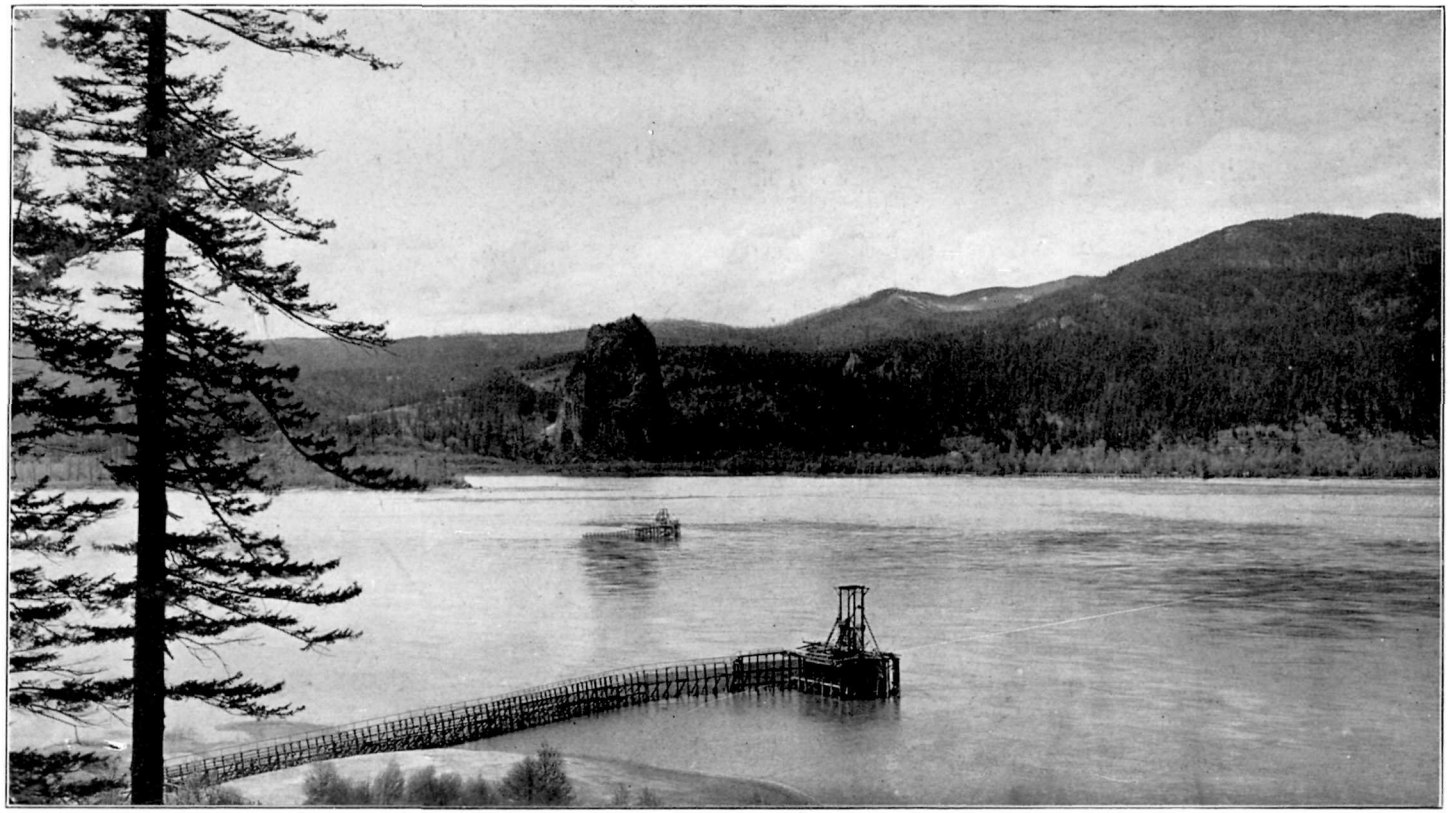
not over 8 feet above water in the Columbia, that Professor LeConte of the University of California in 1871 and 1873, and later Mr. Diller of the U. S. Geological Survey, collected the fossil leaves that gave us perhaps our first accurate knowledge of the age of these beds. In the view the hammer indicates the dark band that is most prolific in fossils. Above it is a friable pebbly shale likewise carrying the leaves and stems of plants, besides fragments of partly preserved wood. The extremely

bouldery nature of the tuff above the fossil-bearing layer is also very nicely shown. It appears to be a vast boulder-bed filled in and bound together with light gray ash and likely some clayey matter.

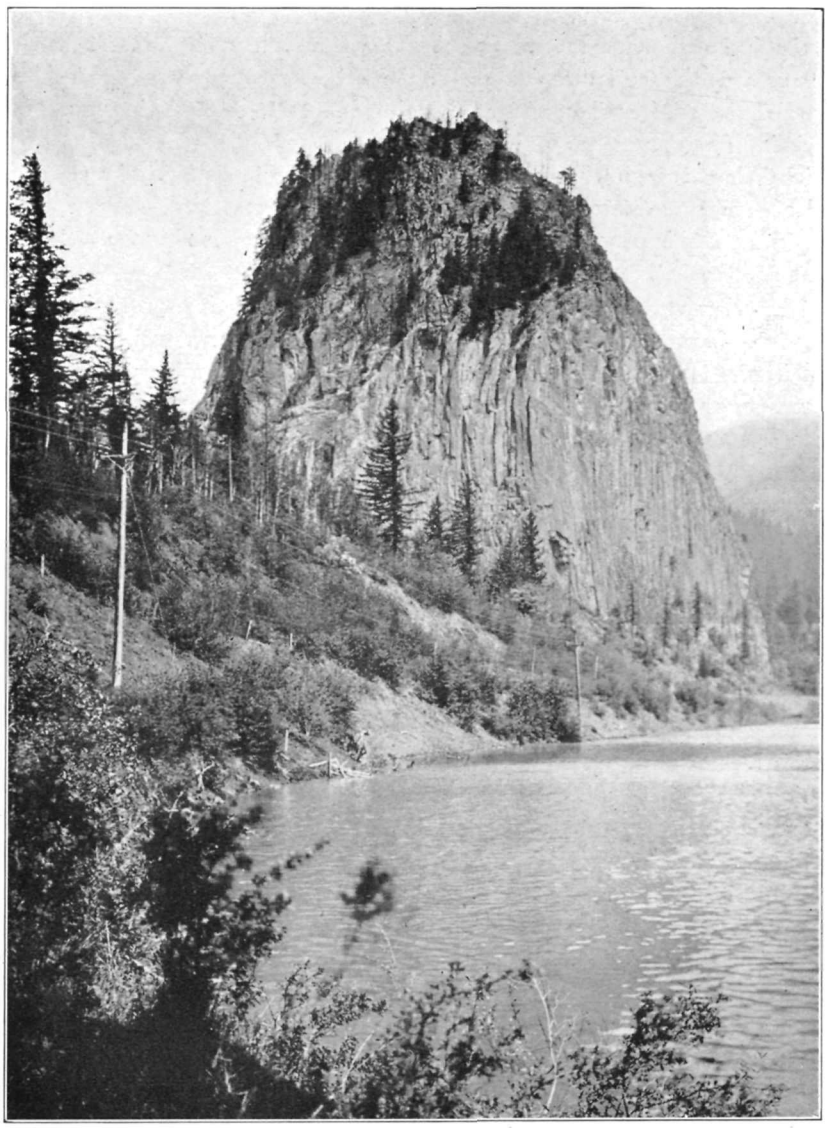
It is an observation we are certain to make that while occasional pieces of wood, petrified tree trunks, etc., are rather common in the coarse bouldery portions of this formation, the more fragile parts, particularly leaves, stems and seeds, are found only once in a while in the finer textured beds, where clay or mud predominates. In order that they may be preserved to even the slightest extent, these organic remains must, after falling from the parent plant, be promptly covered or sealed away from the oxidizing and decaying influence of the atmosphere and of moving waters. This happens only when they are at once permanently buried in a dense mud or river silt or clay. Ordinary sand, or gravel, or a porous volcanic ash would afford poor protection from these agents of decay. We see the process going on today in the beds of streams and at the mouths of rivers, for example, where a little digging will always bring to light the parts of present day plant life in more or less perfectly preserved condition. Here, then, enclosed within this ancient volcanic conglomerate, is what was perhaps once a bar or spit of river mud, now filled with pieces of the plants that then flourished along its banks. All was soon imprisoned beneath an overwhelming mantle of volcanic detritus, the same as that upon which it rests, compressed and solidified to a more or less firm rock. The fossil bed today contributes its own small but integral part to the story of the past because, in the normal course of earth events, its contents have been again brought to light; exhumed, so to speak, from their burial place by the erosive cutting of the Columbia river.

## BEACON ROCK

**Beacon Rock from the Columbia River Highway.** Lest we become too entirely absorbed in the nearby features of the Oregon side our attention should be called occasionally to things not to be missed across the Columbia. Opposite Warrendale, and to be seen from many points of the Highway, is Beacon rock, so named by Lewis and Clark in 1805, although since frequently called Castle rock. In the view, we look across almost two miles of water at the head of Pierce island. Beacon rock stands practically at the water's edge and rises, according to approximate determination with the aneroid, better than 800 feet above the river. Its sides are perpendicular for hundreds of feet and exhibit most beautiful pillar jointing on a large scale. In the main the columns are horizontal, or nearly so, as if the cooling surface of the lava were a vertical one. At the south or river side of the Rock the long giant columns stand upright, this face appearing to represent an inner portion of the mass from which the outer casing of inclined or horizontal cooling columns have been taken away by the Columbia. Its base is said to cover barely less than 17 acres, while the top is a sharp serrated hogback of uncomfortably narrow width. Mr. Henry J. Biddle has built a substantial trail up Beacon rock, which for many years remained unscaled. This trail zigzags securely up the face of the cliffs for much of the 4,000 feet of its length, and offers not alone a most exhilarating bit of exercise in ascent, but a thrill unparalleled in the view, in all directions, from the top.



Beacon rock from the Columbia River Highway. Fish wheels in the Columbia. Slopes of Hamilton Mt. at right



**Beacon rock from south of west, showing columnar structure and jagged summit. New trail along the face of the Rock**
Photo by H. J. Biddle

**Geology of Beacon Rock**

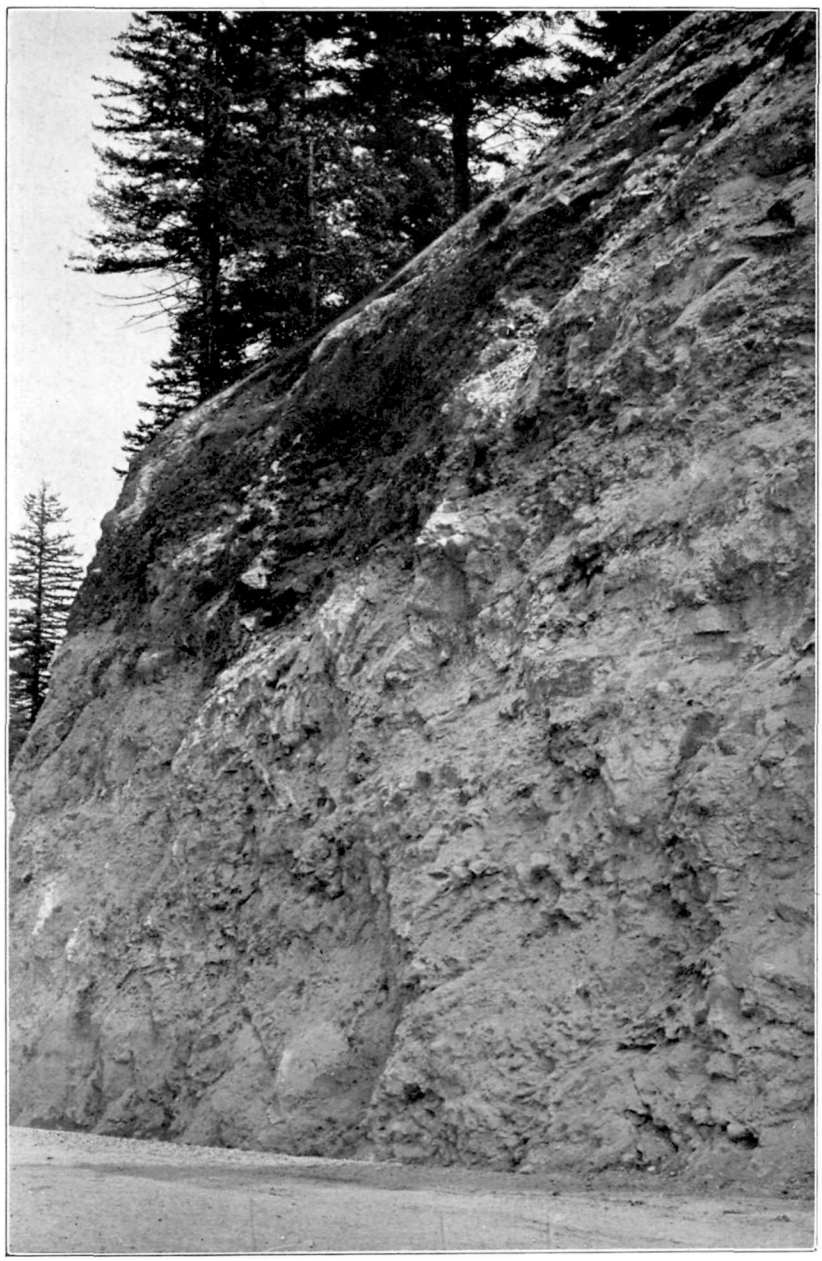
And into what part of our story may this massive isolated monolith enter? That all of its immediate surroundings have been cut out and carried away by the river is apparent. That it itself has not been destroyed is obviously due to its structure and greater resistance. At its right, in the view, and in part obscured in the forest, is little Beacon rock, rugged points of rock which are to all appearances similar to the more conspicuous pinnacle. We may easily conceive that both represent the site of former volcanic vents

from which lavas issued, or that they may be but separated parts of a dike, or the filling of an extensive fissure through which molten rock escaped to the surface. Careful examination of the neighboring country will doubtless give definite additional light on this point, but a most interesting clue in the Rock itself must not be overlooked. At its summit, the texture of the lava, which below is somewhat granular and light gray in color, is in places red and of scraggy scoriaceous character; and there are scattered, cindery looking chunks, as if this upper portion were exposed to the air and there was movement as it cooled.

In other words, our inference is that Beacon rock is a part of the hard plug in a former conduit through which volcanic eruption took place. And that its top is about the level of the surface opening or, somewhere near the bottom of the crater, at the time of eruption. That there may have formerly been a volcanic cone of considerable proportions here is entirely within the bounds of logical conclusion. The further natural question to be asked is as to the time of the volcanic activity now indicated only by this outstanding remnant. For now, that must be answered by saying that it may represent either a recent period of eruption in which it is possible a great cone crater may have grown up, at the base of which lapped the waters of the Columbia, and the structure of which these waters at once proceeded to undermine and remove as any other barrier. What is left, we see today as Beacon rock. Or, on the other hand, the likelihood is even greater that this old plug belongs to the time of the accumulation of the tuff-conglomerate that is to be seen in contiguous hills along both sides of the river, before the coming of the Columbia river basalt, before there was a Cascade Range or a Columbia river. That it broke up through these sediments and contributed its products to their upbuilding either locally or in a widespread way, then to grow quiet, the filling of its active vent to harden and in entirety be buried beneath these and the hundreds and thousands of feet of later lavas. In this case we would explain its present condition in the manner already observed with reference to Rooster rock near Crown Point, and the pillars of Hercules, namely, that it is but a portion of the rock formation to which it belongs, that the Columbia in the normal cutting of its gorge has not yet quite entirely torn down and taken away. Slopes of Hamilton mountain at the right in the view, Fishwheels in the river.

**Hamilton mountain and Table mountain (Washington) from the Columbia River Highway.** Across the Columbia, in Washington also, the bold face of Hamilton mountain presents such striking features, even at our distance, that it must not be passed by without comment. It is evident that its fairly even top which rises to 2,432 feet is capped, as found on our own side of the river, with heavy layers of basalt. The lower boundary of the basalt is however seen to be uneven, as if the surface of the underlying tuff beds had been eroded into hills and valleys before the lava poured out upon it. The added thickness of the basalt showing beneath the center of the main part of the mountain appears at a little distance to be due to the filling of a former depression,

**Hamilton mountain and Table mountain (Washington) from the Columbia River Highway**
Photo by Weister



**Gray-white bank of Eagle creek tuff-conglomerate west of Bonneville. Protruding petrified log near middle of view. Many fossil plants are found in this bank**

although on close approach one may still be somewhat in doubt as to whether or not it may represent the position of a former vent for the issuance of the basaltic lava. The conspicuous shoulder at the left in the view is of bedded basaltic tuff the layers dipping toward the moun-

tain, as though part of the structure of a former cinder cone whose center was yet farther to the westward. Stately Table mountain stands at the right. The applicability of its name is most apparent from this view point.

**Gray-white bank of Eagle creek tuff-conglomerate west of Bonneville.** There is upwards of 175 feet of the tuff-conglomerate at Moffet creek. It outcrops almost continuously in the banks of the Columbia, along the railroad, and on the Highway, from the first exposure at Warrendale to Bonneville, a distance of over two and a half miles. At Bonneville the Highway excavation has opened a vertical gray-white wall of it 75 and more feet high, from which all sizes of boulders protrude, and an occasional petrified log adds its tinge of the tragic to the record. The town of Bonneville is at the outlet of Tanner creek. Here is a most attractive pleasure park, and the state fish hatchery which is said to be the largest in the world for trout and salmon. Tanner creek is one of the largest of the streams flowing into the Columbia in this central part of the Cascade Range. Its lower course is cut in the conglomerate whose surface rises to nearly 500 feet above the river. One-fourth mile beyond Bonneville is the first of the series of splendid camps established and operated by Samuel C. Lancaster, who was engineer in the original construction of the Columbia River Highway.

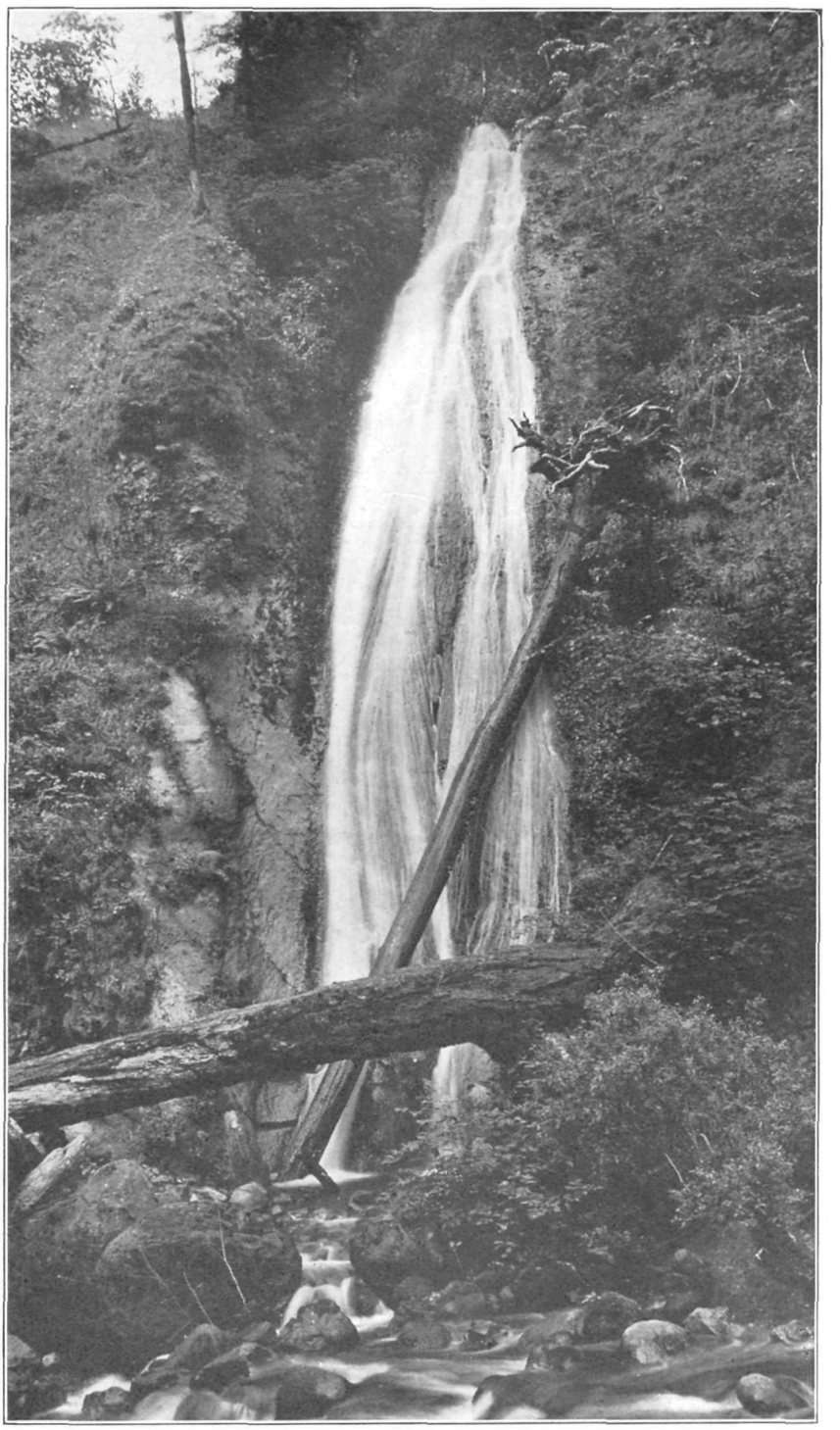
**Wahclella falls, Tanner creek.** The falls of Tanner creek, called Wahclella falls, is nearly two miles upstream. It is a falls of great beauty, 125 feet high, the rock over which the water pours being the basalt that overlies the conglomerate, which in all streams so far has been responsible for the waterfalls.

Since passing Warrendale, we have been within the boundaries of the Oregon National Forest. At Warrendale, too, we entered Columbia Gorge Park. This park, which is a relatively narrow strip parallel to the Columbia river (see map), extends for 22 miles to Viento, a public playground dedicated forever for "recreational purposes."

**Oldest rock in Columbia gorge**

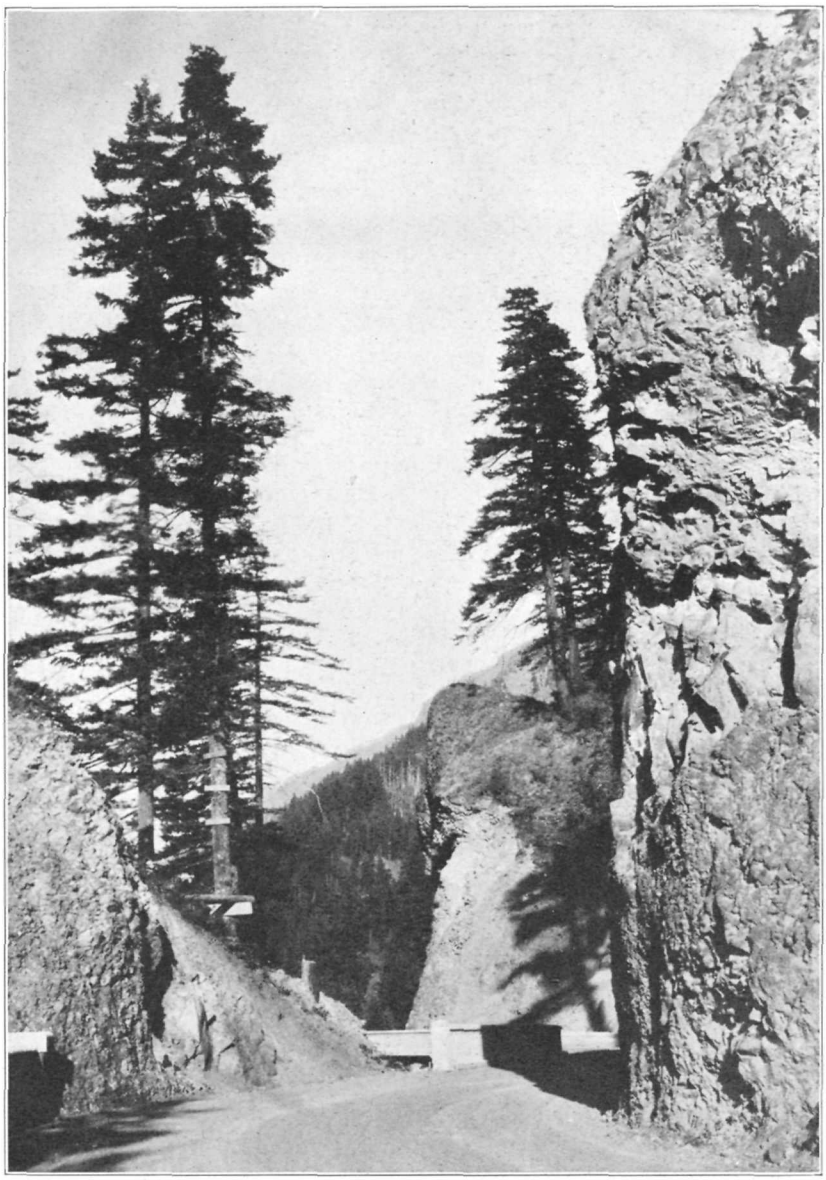
As our journey lengthens we are passing farther and farther into the depths of the Columbia river gorge. We have been permitted to make most pleasurable and fairly intimate acquaintance with a succession of rock formations as this great river has opened them up for our inspection. Gravels at Portland, older gravels along the Sandy river, above which, in the Cascade Range, are the massive andesite flows; hundreds of feet of basalt at Crown Point beneath the old gravels; and finally below and older than the basalt the tuff-conglomerate of the past few miles. As each of these has in turn presented itself, and we have studied its characteristics, the question has ever arisen, what will come next? Shall we have a peep yet farther into the past and what will that peep reveal? What was here before the coming of the deluging falls of volcanic ash and boulders that buried forests in their path?

In the hatchery grounds at Bonneville, and extending eastward from these grounds to and across the railroad and into the waters of the river, is a conspicuous, in part precipitous, ridge of hard, dark gray or black semi-crystalline lava. In the railroad cut and at the banks of the Columbia its layers are bent as though the whole mass had at some past time been warped and disturbed. Against its southeasterly slope the tuff-conglomerate may be



**Wahclella falls, Tanner creek. 125 feet high**
Photo by Weister

seen in contact with its surface in such a way as to leave little question that this bouldery material formerly covered it over completely. In other words, here, showing through where the river has washed it bare, is a small area of the old country rock surface of the days before the tuff-conglomerate came. It appears to be basaltic, and either before or soon after it was covered over, was subjected to pressures by which its former structure was deformed and



**Tooth rock. Giant slip-block of basalt. West approach to Eagle creek bridge**

distorted, as we see it today. Perhaps we may call this a portion of the center or core of the Cascade Range, inasmuch as it is the lowest or deepest of the rock layers that the cutting of the Columbia river will enable us to examine. And it tells us the interesting fact that at that early time, before there was a Cascade Range, when the unthinkable quantities of lava that compose its vast bulk were yet in the interior of the earth, before, it is probable, the Columbia itself was in existence, that even then volcanoes were active, and earth movements took place, just as we know has happened since that time.

## EAGLE CREEK GORGE

**Giant slip-block of basalt (Tooth Rock). Approach to Eagle creek bridge.** For the present therefore we will return to the cultivation of a further acquaintance with the sub-basalt bouldery tuff in its various phases, of which we have seen a little but shall see much for miles ahead. It alone is present along the Highway east of Bonneville for the next two miles to Eagle creek, with the exception of a great tilted slip-block of basalt which at one point carries that thoroughfare nearly 200 feet vertically above the river and the railroad. From here one may gain a first view of the lower Cascades of the Columbia, of many small bouldery islands, and against the horizon, of Table mountain, to the meaning of whose great crumbling cliffs more mystery attaches perhaps in the popular mind than to any other of the many equally spectacular features of the Columbia River Gorge. Eagle creek, whose bridge we now approach, issues from a canyon that for rugged wildness and inaccessibility, therefore scenic value, has few peers within the whole scope of the Cascades. That we must explore it, within the limits of our leisure, goes without saying.

The great recreational value of the valley of Eagle creek, and of its canyon, has been foreseen by the U. S. Forest Service, which has actively undertaken its improvement. A trail, much of which is cut in the solid rock, now threads its depths for 8 miles, beyond where it climbs to the summit of the Cascade Range and to Wahtum lake where the permanent Boy Scout camp is located. At the Highway is a well-appointed comfort station, commodious camp grounds, abundant parking space, and other public accommodations.

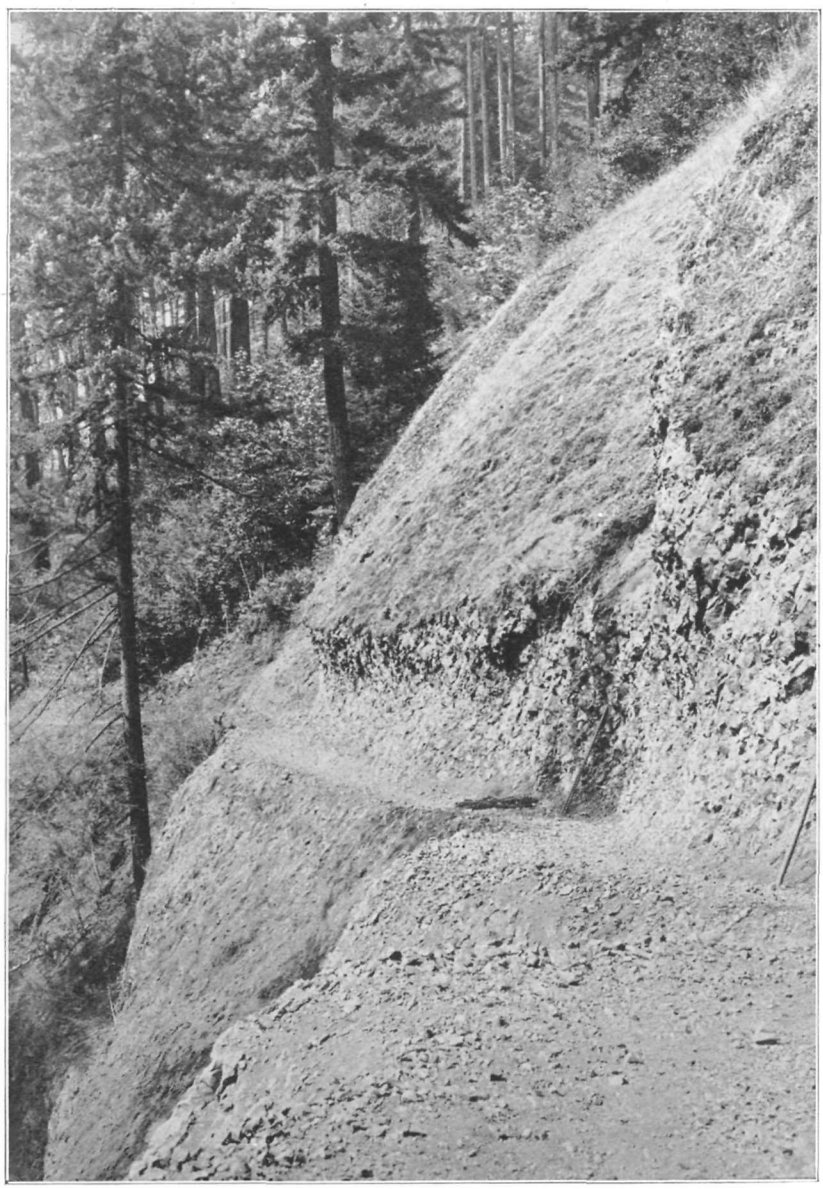
**The "Punch Bowl," canyon of Eagle creek.** At two and one-half miles is the so-called "punch-bowl," a large circular pit with overhanging walls of basalt, at the bottom and sides of which the tumultuous fall is ever vigorously beating away. Words do not begin to convey a conception of the enthralling attractiveness of places such as this.

**Eagle creek formation**

Before leaving Eagle creek canyon it should be said that in the building of the new trail, a bed of hardened ashy clay was opened up in which were found a great abundance and variety of most excellently preserved fossil plant remains. Their character and the tale they relate will constitute a later page in the story of the Columbia gorge. But the finding of so wonderful a fossil-bearing bed in Eagle creek canyon has given us just the excuse for which we have sub-consciously been seeking to attach a definite and appropriate name to the formation in which they occur. We have seen that it lies below the

**The "Punch Bowl," canyon of Eagle creek**

Columbia river basalt, that it is persistent in general character, and that it represents a definite period in the past, just as does each of the distinct groups of rock strata above it. We see typical exposures of it along Eagle creek where its surface rises nearly 200 feet above the river, and here we find beautifully preserved fossils in it. It shall therefore be christened and referred to henceforth as the Eagle creek formation.



Eagle creek trail cut in solid basalt. One of the finest of mountain trails now enters the heretofore most inaccessible depths of Eagle creek gorge. For over a mile from the entrance this trail is cut in part in the tuff-conglomerate, but as it rises with the grade of the stream the superincumbent basalt is reached, and thence the trail becomes an almost continuous miniature shelf along the face of the basalt canyon wall; in places within the shadows of the forest, elsewhere worming a tenuous way along the front of perpendicular cliffs thrilling hundreds of feet above the water and, we know not nor guess how far below the canyon's rim. Eight miles of this new trail is entirely within the rock-bound gorge of Eagle creek. It then rises out of this canyon to the Cascades summit and becomes one of the entrance ways to the wonderful Mt. Hood region

**Metlako Falls in Eagle creek. At about two miles from the Highway, this falls is most unique as viewed from the trail on account of the disappearance of the foaming stream into the dark depths of a box canyon. The falls is 108 feet in height**

**Black basalt intruded into the tuff-conglomerate.** And now that a speaking acquaintance has been gained, shall we not call attention before proceeding on our way to one more feature in connection with the Eagle creek formation. At the west end of the approach to the bridge over Eagle creek there is a fresh exposure to which one is attracted in passing, by the unusual amount of mixed light gray and vivid

**Black basalt intrusion in the tuff-conglomerate, Eagle creek bridge**

purple color it displays. A careful examination of this section will, if not with surprising promptness, at least ultimately reveal the group of ramifying "fingers" of semi-crystalline igneous rock that has pushed up from below into the conglomerate. The latter is baked at the contact into a hard dense condition, by which we know that the intrusion, as it is called, was at the time in a highly heated state. At the lower side of the Highway grade, more of the intrusive rock is in view as though, as

would be expected, it widens downward, and more "baked" or metamorphosed contact may be seen.

All this tells us that although itself composed mostly of the products of volcanic eruption, much of which no doubt was allowed to peacefully settle into place and so repose for untold ages, the Eagle creek formation was not in all its parts to remain entirely undisturbed. From beneath it, at vulnerable points as it were, highly heated lavas sought their way upward, at times melting into and assimilating the substance of the over-lying beds, again squeezing in along joint or bedding planes, and yet again bodily uplifting the load by which they were weighted down. We are rather certain that this process was in operation at a great many points during the elevation of the Cascade Range, and doubtless some if not many of the prominent peaks of the Cascade Range of today had their beginning where such uprising lavas were able to reach and flow out upon the surface of the land.

**Axis of Cascade range**

We should be reminded that we are now very nearly in the position of the axis of the Cascade Range. Thus far, the inclination of the successive rock formations has been to the south of west, that is, each has slowly risen higher and higher as we have gone farther into the gorge. Were we to climb now to the summit of the divide between Tanner and Eagle creeks we would reach altitudes of over 4,000 feet in but a few miles back from the Columbia river. A well-improved trail starts up the mountain side shortly west of Eagle creek bridge to Waunt point, a delightfully satisfactory outlook point, in direct line not over one-half mile from the river and between 2,500 and 3,000 feet above it, from which the Columbia is in sight for many miles in both directions. This trail continues to the boundary of the Bull Run division of the Oregon National Forest, beyond which, no matter how urgent or sufficient the excuse, the public is not allowed to go, as it is from within this portion of the Forest that the water supply for the city of Portland is drawn.

On the other hand, wherever we are able to observe the attitude of the main rock strata to the eastward from Eagle creek, it will be seen that they now incline in general at a low angle in an easterly direction. It would thus seem that we are here passing beneath the crest of the broad spreading arch, or up-fold, by which the main elevation of the Cascade Range was produced. Further evidence that this is the case will be found if, from Cascade Locks, which is but three and a half miles ahead, we make our way from the Highway up Dry creek over an all but abandoned trail to the top of the divide east of Eagle creek and between it and Herman creek. Benson plateau, the summit of this divide, is between 4,000 and 4,100 feet A. T., and is so noticeably even as to leave little question that it is but a remaining portion of the former great carved andesite upland, or sloping lava roof, if we may use the expression, into and through which the streams have since gashed in all directions to great depth. On the way up to Benson plateau we find blocks of the bouldery Eagle creek formation to 500 feet, as great a thickness as we

have yet seen. The falls of Dry creek is at about 1,000 feet. From the top of the Eagle creek beds, there is the usual type of basalt in heavy layers to about 3,000 feet, approximately 2,500 feet of this lava, the greatest thickness observed thus far. Between the basalt and the less basic andesites above, at least a thousand feet of which enter into the structure of Benson plateau, is the customary unconformity marked by the sedimentary material of Satsop times. Here the Satsop is from 125 to 250 feet of yellow to brown ash or tuff so conspicuous as to be seen from the Highway, filled with scoriaceous masses, much of the smaller lapilli and some rough and rounded volcanic bombs. This shows no signs of being a water deposit, yet was put down upon the basalt and later covered with newer andesitic lavas, so it is properly correlated as representing the Satsop formation.

## CASCADES OF THE COLUMBIA

FROM Eagle creek to Cascade Locks we see little else than Eagle creek tuff and gravels along the road, although we are riding almost within the shadow of some of the most precipitous rock cliffs in the entire gorge. We note that the Columbia river is unusually narrow and its waters rough. Opposite the mouth of Eagle creek is the rocky lower rapids where broken blocks of tuff-conglomerate appear to partly choke the channel. A careful inspection of the topographic map (opposite page 3) will better than anything else indicate the unique character of the country here for several miles along both sides of the river. Back of the town of Cascade Locks many closed contours show the presence of isolated sharp hills and intervening depressions far up the slopes above the river where we should least of all expect to find them.

**Table mountain at left, Red Bluffs, and landslide area between.** More particularly, and on a much grander scale, are these features displayed on the Washington side where between Table mountain and the river, several square miles are dotted with lakes and ponds and the contour lines are in places most intricately irregular. One can, however, gain a full conception of the exact character of these places only by actual exploration on the ground. And when with the map as a guide we climb back into these hills, particularly toward Table mountain, we are not only almost bewildered by the clearness with which we can see what is taking place, but as well, if the trip is not carefully timed, apt to be overwhelmed by the force of our own enthusiastic exertions. For from the river's bank to the very base of the thousand-foot sheer face of Table mountain and Red Bluffs, we find a most complicated jumble of shifted and intermixed masses of Eagle creek conglomerate, with blocks and loosened ledges of andesitic and basaltic lava. The land surface is one of pit and ridge, of enclosed swale and crumbling tilted divides, of clogged drainage wherein streams drop from sight, springs issue and their waters drop from sight, ponds fill then mysteriously depart. To add to the meleé all is clothed with forest and if evidence were needed that this whole great honey-combed slope not only has been but is now slowly in motion, none more conclusive

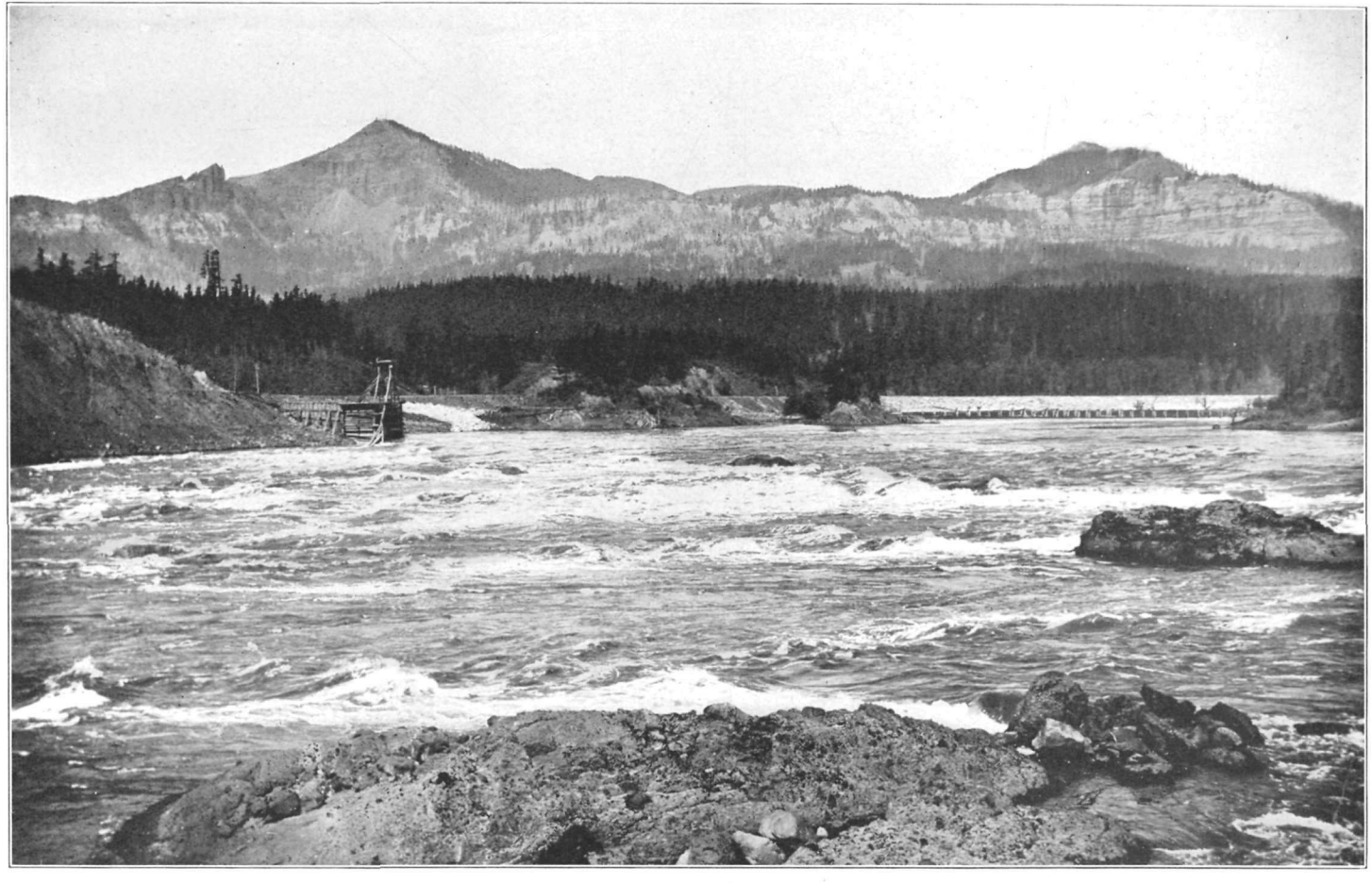


Table mountain at left, Red Bluffs, and landslide area between. Cascades of the Columbia. Eagle creek conglomerate in the foreground
Photo by Weister

could be asked than the abundant forest wreckage that is present everywhere. Giant firs, individually and by the acre, lie flat and at all angles from prostrate to vertical. Tops lean together; foundations settle away. Even the works of man are not exempt; buildings are carried out of plumb, trails offset, roads upheaved; and at the river's edge on both sides, we are told, the railroad rights-of-way have refused to remain within statutory bounds. In a word, this entire area is one of landslides, landslides of the past and landslides that are now, while we watch, taking place.

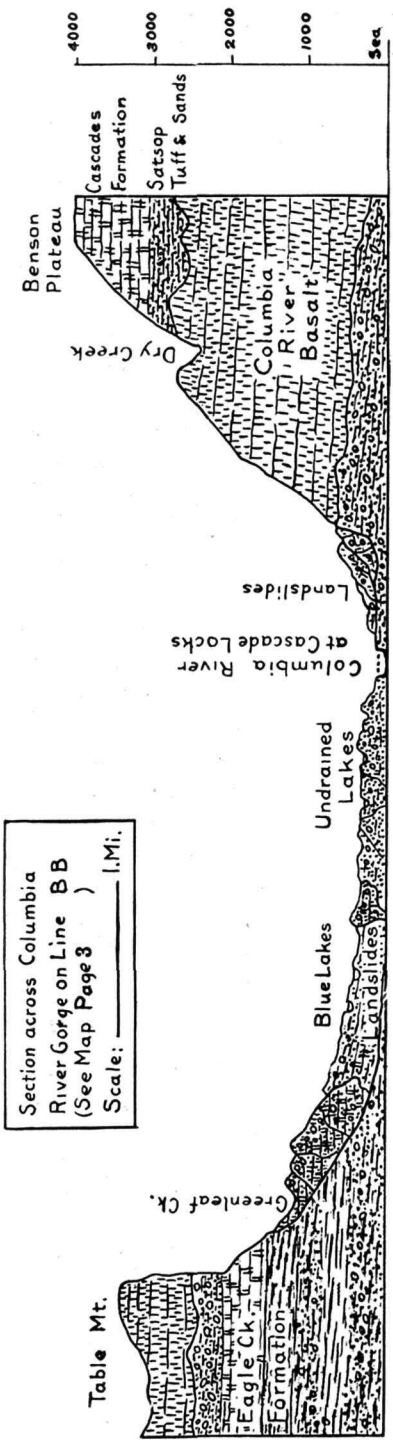
**Landslides**

An inquiry not only natural but insistent is as to the cause of so much slipping in this region. It is to be expected that in so deep and constricted a gorge as is the Columbia, bodies of rock would here and there overbalance or by gravity settle from higher points in the canyon walls to more stable positions lower down. Some will be undermined by the cutting of the river and pass suddenly or by degrees to lower levels. If we explore the entire gorge, however, we will learn that the region in which landslides predominate coincides exactly with the area of exposure from beneath the basalt, of the bouldery, tuffaceous, sandy, sometimes clayey beds of the Eagle creek formation. Where these are thickest above the river level, there landslides are and have been most plentiful. If we now examine the Table mountain region with this thought in mind, we are not surprised to discover that instead of the paltry maximum of 500 feet as on the Oregon side, the entire base of this mountain, and of its equally prominent east limb the Red Bluffs, are made up of Eagle creek beds. They rise beneath Table mountain close to 2,000 feet and in Red Bluffs to full 2,700 feet. They contain interbedded gravels, ash, bright red and brown scoria, and some clay, besides the usual tuff-conglomerate phase. Near the south end of Red Bluffs is a feature of this formation not so far observed elsewhere. Apparently enclosed within it is 200 to 300 feet of hard platy andesitic lava and associated with this lava is a mass of inclined layers of cinder-like ejecta that are evidently in precisely the position they assumed about the vent whence they were erupted. Where the waters of the east fork of Greenleaf creek tumble down the front of this composite cliff, there is a fine dike of horizontally columned lava cutting almost vertically through the Eagle creek beds and reaching to the lava above. We are thus convinced that not only were volcanoes active in Eagle creek times but at this point was one of the centers of eruption. We read from the section before us that contemporaneous with eruption, accumulating Eagle creek sediments from other sources slowly rose about the base of the growing cinder cone, finally probably covering it over entirely.

**Cause of landslides**

Resting upon the Eagle creek beds are the usual overhanging thick layers of black basalt to a total thickness in Table mountain of 1,000 to 1,200 feet. Compared with the dense stony lavas, the fragmental Eagle creek beds are soft, and they crumble and disintegrate much more readily when exposed. Streams cut into them with greater ease. It would natur-

Recent landslips at base of Red Bluffs. If evidence were needed that this great honeycombed slope not only has been but is now slowly in motion; none more conclusive could be asked than the abundant forest wreckage everywhere. Giant firs lie flat and at all angels; tops lean together, foundations settle away




Relationship of formations at cascades of Columbia

ally be expected that in this portion of its course the channel of the Columbia river would be a broad and roomy one, rather than one so anomalously narrow and deep as we observe it to be. There appear to be two principal reasons for this exception to the general rule. First, the enormous thickness of the series of only partially consolidated Eagle creek beds. It is not difficult to conceive that, were all talus cleaned away, there would open to view in Red Bluffs as much as 2,000 vertical feet of these loosely aggregated sediments. The face of Table mountain and of Red Bluffs has doubtless experienced slow recession from a former position very close to if not at the river's edge. The position of the river too has from time to time doubtless shifted materially. Formerly these cliffs rose as precipitously as today, though not, it is likely, to so great a height; nor would there be by several hundreds of feet as much of the Eagle creek series. But such materials when and wherever exposed in even moderate thickness are notoriously unstable. We need today to hesitate for but a single minute within hearing distance, or even sight, of Red Bluffs' precipitous wall, to be reminded of its wayward character. The air resounds with the clink of tumbling pebble, the rattle of trains of gravel as they start from cliff high up and gain in force and numbers with descent, the thud of ricocheting boulder. At times undermined masses of the lava top come down. There is constant movement, and all is in response to the pull of gravity by which unbalanced

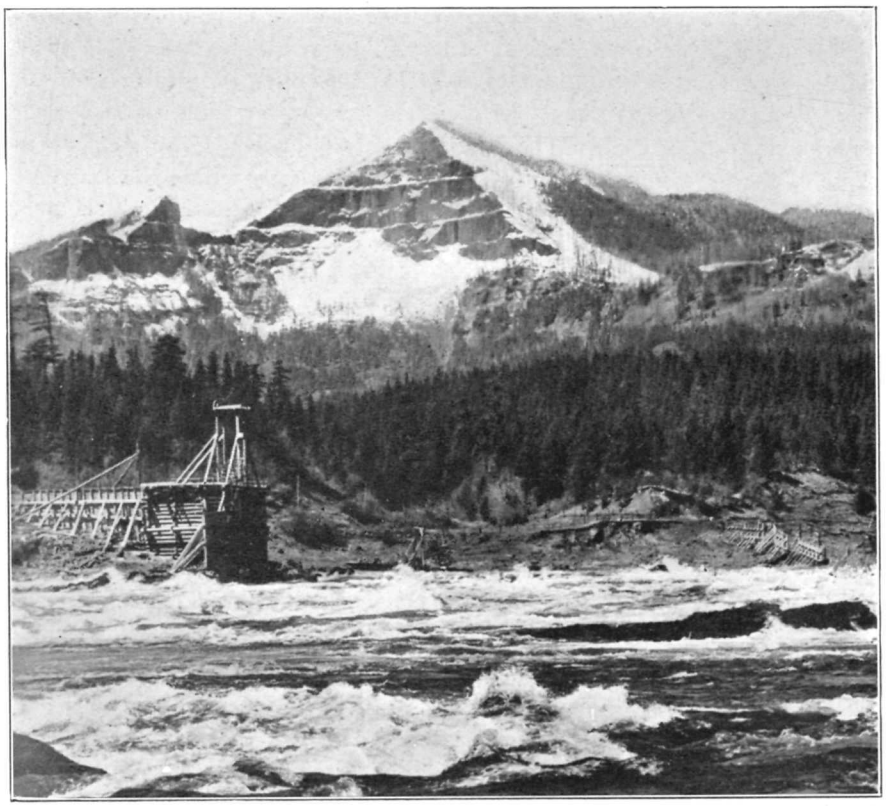
objects of whatsoever sort or station are ever moving to positions of repose.

But this alone is not enough to account for conditions here. We must turn in addition to the fact that there is in the Eagle creek formation occasional, more or less persistent, though usually thin, strata of readily softened shale or ashy clay. Such a phase of the formation may be seen along the Oregon shore of the Columbia, in stages of medium low water, within the first mile below the Locks. These intercallated clayey layers, as is well known, become most exceedingly slippery in contact with moisture, and thus comprise as it were self-lubricated gliding planes along which, if there is the least excuse, slipping movement will take place. It is probably rare that such clayey layers are perfectly horizontal, in fact, we already know that the entire Eagle creek series has a decided inclination southward, that is, toward the Columbia river. If, in connection with this fact, we recall also the obvious condition that in a cliff such as that of Table mountain, the open face is quite unsupported against whatever tendency there is to move, we are really surprised that these great hills have not slumped yet more rapidly into the chasm the Columbia has for ages been sawing at their feet.

**Narrow channel at Cascade Locks**

At the present time the extreme constriction of the channel from Cascade Locks for several miles downstream is accounted for entirely by the constant pinching in, to some extent from both, but mostly from the Washington side, of the slowly moving miscellany of materials from the cliffs farther back. These cliffs will continue to recede, until, if conditions do not change, they eliminate themselves, and an even slope is established. At some even more distant date slipping towards the river may cease. But until that day arrives, and its coming is not to be expressed in any man-made unit of human history, the grand old Columbia will have before it as it has today, the task of clearing away as rapidly as it can in order to keep its channel open, not alone that which falls from its banks, but, as now, all that promiscuous mixture of rock detritus that is being constantly fed to it by the bodily movement of chiefly its north confining wall; and who knows but from the bottom of its channel as well.

**North abutment of legendary Bridge of the Gods. Cascades of the Columbia.** The appearance from Cascade Locks of the precipitous bold fronts of Table mountain and of Red Bluffs, particularly the latter, is such as, it is easily conceived, might inspire unquestioning belief in the Indian legend of the Bridge of the Gods. Little stretch of an absorbed imagination is needed to make of the terraced rock wall before us the stupendous abutment of a once giant span across the Columbia. But the absurdity of the thought becomes apparent when we reflect that this span must have stretched across a minimum space of full five miles in order to reach secure footing on the Oregon side of the river. As legend, it is one of several that have come to us from without the haziness of the past in connection with historic points along the Columbia river. Like others, its romantic plot is a most beautiful and inspiring conception, and as tradition based upon the



**North abutment of legendary Bridge of the Gods**
Copyright B. A. Gifford

mythical facts of a primitive intelligence, may possibly be worthy of perpetuation. But to our cruelly searching workaday mind the possibility of its concrete truth must be denied.

**Bridge of the Gods**

No one, however, may ponder over the past events that have given rise to the cascades of the Columbia, or study their present characteristics and environment, without at least a possible twinge of resentment at the entire loss of so captivating a link between the present and the past. When the Columbia gorge was somewhat younger, and the sweep of its waters was more energetically eating a path into the slowly rising Cascade Range, its walls rose steeper and its shadowing cliffs stood closer by than now. It is no far-drawn speculation that at times large bodies of rock would suddenly slump from these cliffs into the river. Particularly would this be expected from the Table mountain side where so favorable and unsubstantial a combination of strata still exists. We are not at all certain but that many times may the trough of this masterful river have been partially or entirely clogged and its current checked if not actually ponded by gigantic

landslides. Each such interruption in its eventful career followed by the reopening of the channel through its own undaunted efforts. What more natural then, than that the latest of these cataclysmic slides of which the channel is not yet wholly cleared, may have swung the river far aside and formed temporarily so much of a barrier as to completely dam the river, and even to permit passage across of the native inhabitants, whomsoever were they, of those early days. As one soliloquizes over the question the likelihood of the idea grows. Indeed there is tangible evidence on the ground to further strengthen the essentials of it.

Sprinkled about in midstream today at the main rapids are rock masses, some small-island in size, others covered over in times of high water, a part of which are seen to be jutting points of beds of hard Eagle creek conglomerate, while many others have unquestionably moved down from neighboring cliffs. Above the cascades for miles there are in places erect stumps of trees that were obviously killed by the encroachment of the water about their base, just as would happen were an obstruction unexpectedly thrown across the river at some point below. That the low water level of the Columbia above its cascade was markedly raised for a time there seems little question. Whether it has receded since to any considerable extent can be said only after a more detailed study of it has been made. That the cause was the choking of its channel by a barrier at the site of the present cascades available evidence seems to point. And not beyond the range of reality is the possibility that at one time this barrier may have constituted the causeway about which grew the enchanting tale of the Indian maiden Lowit and the contesting rivals for her hand. But far from fabulous "Bridge of the Gods" was this, rather instead plain tottering blocks of lava and a crumbling, sloughing clay-stained bouldery assemblage from yon proud cliff was its makeup, over the rise or fall of which, in our humble judgment, inexorable gravity, not Sahale the Great Spirit, Klickitat nor Kiyeast, exercised complete control.

**Government Locks**

The town of Cascade Locks is built in part upon a gravel terrace of comparatively recent formation. The government locks are here by which in a two-stage lift boats are enabled to pass the unnavigable rapids. The locks are founded upon a hard conglomerate phase of the Eagle creek formation, which, as shown in the excavation for the new bridge pier, probably rests upon a thick bed of waterworn gravels. It may be that the rapids is in part caused by the greater resistance of the conglomerate and the comparatively ready wearing away of these gravels and of a pebbly shale that we see outcropping along the water below the locks. Here, over the narrows immediately downstream from the locks, is to be built a new, man-made "bridge of the gods." The concrete pier is already in place on the Oregon side. This span, 705 feet long, is to be of stiff suspension type, and will connect with Washington's wonder road, the Evergreen Highway, which skirts the north bank of the Columbia through the entire length of the gorge.

**Erosion remnant of lava flow, Columbia bottom east of Herman creek.** Just beyond the crossing of Herman creek, two miles

**Erosion remnant of lava flow, east of Herman creek**

up the river from Cascade Locks, our attention is attracted by the presence in the road and to our left along the railroad, of a hill of light gray rock along the west base of which Herman creek flows to the Columbia. A mile further on an isolated dome-shaped monadnock of the same rock stands out in the overflow flat next to the river, opposite the Herman creek U. S. Forest Service ranger station. The rock is marked by two sets of joint planes which give to it in places a massive columnar structure. About its base is a stagnant slough very obviously a portion of a former channel of the Columbia, which is doubtless responsible for its sharply rising walls and for the narrowing down of its large bulk to the present proportions. Along the railroad there are occasional exposures of this same rock to within two miles of Wyeth which is a total distance of seven miles from Cascade Locks. Examination shows its presence too, as high as 500 feet above the river, as a more or less continuous ridge or series of knobs, at our right and at the foot of vertical cliffs of basalt and top andesite that rise 3,000 feet and over.

Though apparently a fine-grained lava, the rock is sufficiently different from others with which we are familiar to excite more than passing interest. Our map shows that instead of taking a hurried shortest possible course to join the Columbia, as would properly befit a stream of its high gradient and volume, Herman creek turns sharply to the west behind an even-topped ridge of this same new lava, and runs parallel to the larger river for better than a mile, before by another right-angled turn the former direction is assumed to bring it to its final exit. At no point does the new-found lava extend across or to the west of Herman creek, but that stream appears to skirt its border for the last two or three miles of its course. And its observed distribution from west to east is limited to the scant three and a

half miles from Herman creek to about two miles west of the town of Wyeth, beyond where there is again the usual basalt and an occasional cropping of Eagle creek conglomerate.

**The Carson lava**

Were we limited alone to what can be seen on the Oregon side, we would be compelled to confess a somewhat puzzled state of mind as to the exact nature of this body of lava. But the fact that eroded knobs of it stand apart in the sloughy bottom land along the river, and indeed menacing rocky points dot its entire mile width of current, opens at once the question whether enlightening evidence may not be found in the prominent gray wall of layered lava that, directly across, rises promptly for 500 feet above the railroad station of Carson in Washington. The ferry at Cascade Locks lands one conveniently at Stevenson. Close examination of what we could but indistinctly discern at a distance discloses the presence, as on the Oregon side, of the Eagle creek conglomerate a little west of Carson, and what is less common, a flow of lava-filled variety of it. Resting upon the Eagle creek strata, as Carson creek is approached, is not the customary dense black basalt, but instead what appears to be the same kind of lava already seen along Herman creek in Oregon. The cut-off edges of a great series of flows rise above Carson station and extend eastward to the deeply incised canyon of Wind river. The town of Carson is located at the outlet of a broad fairly even stretch of country between Carson creek and Wind river, whose oval soil and gravel scattered surface is broken here and there by protruding bunches of scoriaceous ropy lava. A few miles north of Carson at the Wind river bridge that stream runs in a "box" canyon more than 250 feet deep. In the walls are dark gray layers of blocky lava, resting upon southerly dipping Eagle creek beds.

We are thus left no other inference than that an erosional valley cut deeply through the basalt and into the Eagle creek conglomerate, while the Columbia too was safely establishing its position, was later filled with deluging flows of lava from a source somewhere to the northward. Its unheralded oncoming seems to have recognized no priority right of possession; for the stream whose valley it filled was pushed ruthlessly aside and, if again we read aright, no ceremony whatever delayed its spreading embouchment into and across the Columbia itself. Reaching the Oregon side, mighty basalt cliffs stood in the way, at the base of which its crumpling viscous borders could shift only downstream, and it spread in that direction covering all in its path. Herman creek, whose exact former course we do not know, was protestingly thrust ahead and into the position it occupies today.

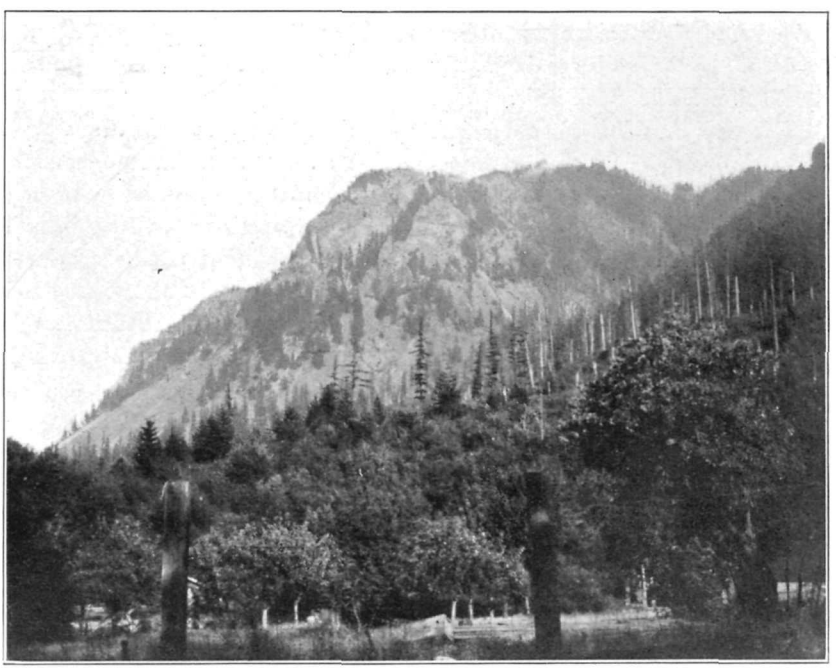
The Carson lava, as we will henceforth call it, obviously came as a series of heavy flows which, in order to reach the Oregon side followed each other in rapid succession. Though the Columbia river must have unavailingly retreated ahead of this invasion of its position, they rose as high as 500 feet above its level, and it is difficult to conceive else than that the river was for a time dammed to essentially that height. But no such minor obstruction

could more than momentarily check its powerful waters; for had they not and in the face of untold obstacles already sawed through a few thousand feet of rock strata, whose ominous shadows even now stand by in frowning acknowledgment of the humiliating fact!

More careful study of the situation, and particularly search along its upstream borders, shall in some future day yield more details of this now historic emergency. Until that time we must be content with our hurried conclusions on the outcome of the contest here between the forces of volcanism and of river erosion. That the channel of the Columbia was choked with lava at geologically a relatively recent time, and since its gorge was fully established much as we see it today, seems certain. That the undaunted assault of its sweeping current has all but cleared away the obstruction, yet not quite, seems likewise strongly evidenced by the similarity of the lavas on the two sides of the river, by the detached remnants which first attracted our attention along the Highway, and the solitary wave-dashed points of rock within view in the stream itself. These are the fragmentary records of a stirring incident in the growth of the Columbia river; the, for us, fortunately belated ripples in its waters so to speak, that make both legible and credible the story they relate.

**Trail to Summit resorts**

From Herman creek ranger station a well-made forest trail goes up Herman creek over which, with its connections, some of the most elevated and wildest adjacent portions of the Cascades summit may be reached. We



**Shellrock mountain from Wyeth on Columbia River Highway**

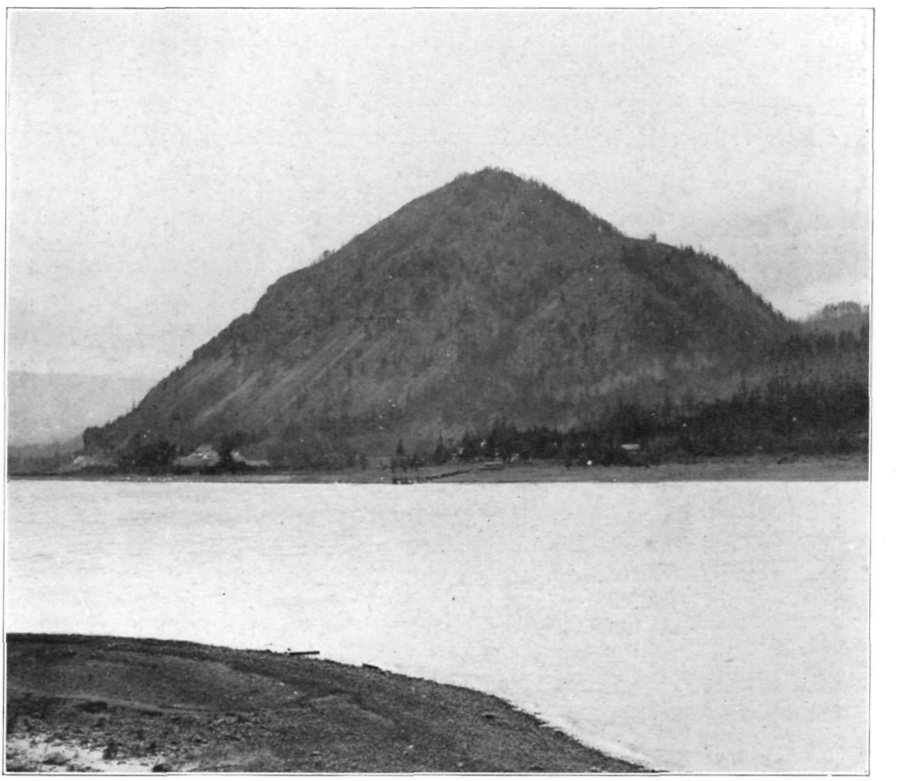
are still within the limits of the Oregon National Forest and of Columbia Gorge Park and all trails are constantly being improved and extensions made by the U. S. Forest Service. Wahtum lake, Mount Chinidere and Indian Mountain are accessible by way of this trail, as are also Green Point mountain and Rainy lake, all places of recreation and delight rarely surpassed.

## SHELLROCK AND WIND MOUNTAIN

**Shellrock mountain from Wyeth on Columbia River Highway.** At Wyeth station we are 57 and one-half miles from the city of Portland. Ahead the great glistening whitish-gray cliffs of Shellrock mountain appear, at a little distance, to almost block the way. We are struck with its lack of resemblance to anything we have yet seen. Before proceeding to its very base however, as inclination would prompt, it may be well to learn if possible something of its surroundings, particularly of the steeply rising dark canyon wall at the foot of which we now are. It is not the good fortune of the geologist to always find satisfactory trails leading to points he would examine. On the contrary, it is frequently if not more often the case that places least readily reached are the very ones that harbor the most illuminating of geologic secrets. It is to elicit the giving up of these secrets that the nature student braves the hills, thankfully accepting the assistance of such as trails if they take him where he wants to go, though if needs be oblivious to their absence. And so up a branch of Gorton creek to the south of Wyeth a few hours of uncharted solid clamber takes one to an altitude of about 3,900 feet before the top of the Columbia river basalt is surmounted, and where upon it, without the customary inter-lava Satsop, the andesites begin. This is, by over a thousand feet, the greatest thickness of the basalt seen in the entire Columbia river gorge; and this too, appears to be a part of the east limb of the main Cascades uplift, the summit of which we have passed by between Eagle and Herman creeks.

Shellrock mountain is a mile beyond Wyeth, a great conical pile with hundreds of feet of loose, sliding "shell" rock about its lower slopes that reaches to the river's edge. It rises to an elevation of 2,068 feet and on all except the river side is hemmed in with walls of basalt. At the east side close to the Highway the latter is seen to rise somewhat upon its flanks as if it may originally have covered over or been uplifted by the Shellrock mountain mass. In places partially absorbed inclusions of pieces of dark basalt are to be noted in the lighter colored rock, which again suggest the idea of disturbance or intrusion during which basalt fragments were incorporated into a yet viscous and yielding hot magma.

**Wind mountain.** Almost directly across the Columbia in Washington is the companion to Shellrock, Wind Mountain. It is in every way similar though something more than 100 feet less in height. Between these two crumbling sentinels the Columbia's waters hurry, as if, one might imagine, they had courteously stepped apart to let the river pass. But we can scarce attribute to them so much of civility, and particularly knowing the Columbia as we do, we are more certain that it instead, when the occasion arose, in silence but firmly, forced its own way across what would otherwise, but for its prowess, have

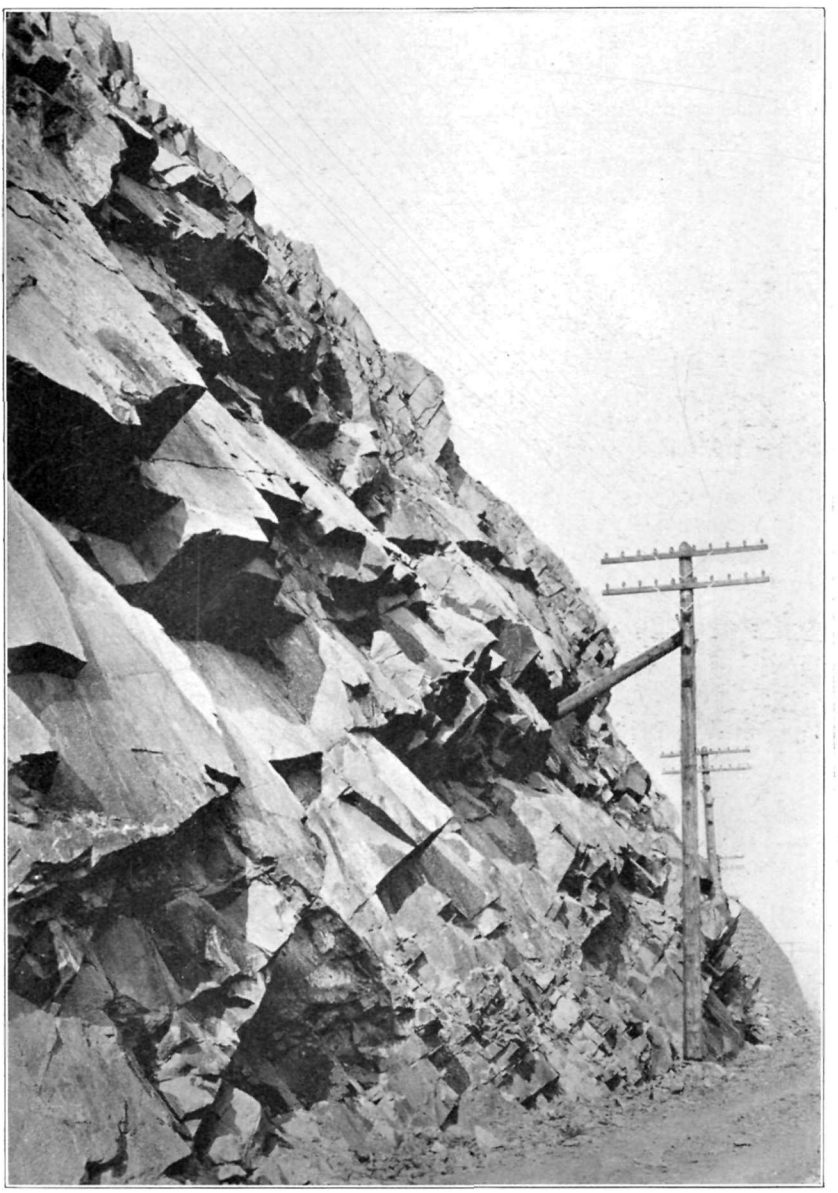


**Wind mountain, across the Columbia from the Oregon side**
Photo by Weister

been an unsurmountable barrier. In which case Wind and Shellrock mountains of today are but the remnant ends of a once connected rock mass with which, while it cautiously rose as though to thwart the prior designs of that master stream, the Columbia promptly proceeded to deal in its own implacable way. North of and in line with Wind and Shellrock mountain the same type of rock is seen to stand out in a prominent low jutting hill.

**Shellrock-Wind mountain intrusive**

Let us now before deserting this, another new found friend, inquire somewhat more intimately into the individuality of the rock of Shellrock mountain and its relation to its surroundings. In the hand specimen it is seen to be finely granular and light in color. A thin section under the microscope proves it composed of larger crystals of plagioclase feldspar, augite and hypersthene, set in a matrix of finer texture, but made largely of crystalline grains of some of these same minerals with possibly some quartz. As compared with its closest associates, the basalt and andesites, its texture is wholly crystalline, holo-crystalline as petrographers say it, while they typically possess a stony or even glassy unresolved groundmass in which the few crystallized minerals are set. When a rock cools slowly from the molten state, there is opportunity for all of its constituents to combine and to separate



**Close view of a freshly opened face at the base of Shellrock mountain. The rock naturally breaks out in angular flattened pieces by reason of intersecting sets of joint planes. In places higher up it appears columnar on a broad scale**

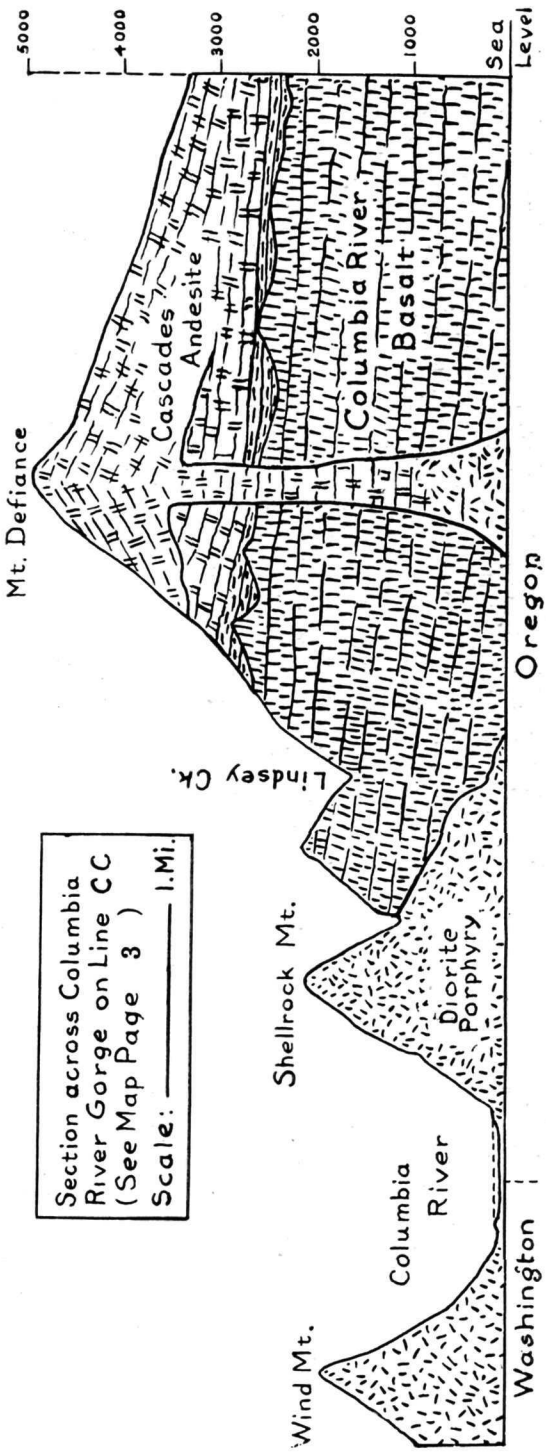
out as definite crystalline mineral species. Under sudden chilling only minerals of quick growth have sufficient time to form. Hence we infer from the granitoid texture of this rock, whose species is probably most closely designated by the name diorite porphyry, that cooling and solidification took place while

**Rockslide at base of Shellrock mountain. Wherever the rock scales away, long unstable talus slopes result. In the view it is evident that constant vigilance must be practiced to maintain the road in passable condition. A hundred feet or so up we see occasional signs of the old state road, whose position could not but be a notoriously insecure one**

it was still buried to such a depth that its temperature decreased with great slowness.

We have already remarked the presence of included pieces of basalt near the contact where heavy beds of this lava rest against the steeply sloping sides of Shellrock mountain. These and other indications there are that Shellrock and Wind mountain represent a large, probably connected body of granitoid rock that rose beneath the Columbia river basalt, to some extent at least melting its way into that lava, "stoping" geologists call the process, but in general uplifting the superincumbent strata for a thousand feet or more. We have no way of proving whether breaks or fissures were produced through which some of the intruding rock reached the surface, but it is entirely within the range of probability that this dioritic mass may have contributed some of the less basic lavas now found high up on adjacent parts of the Cascades summit. Since the basalt is arched up around its borders, we

know that the introduction of the Shellrock mountain mass occurred after the country was entirely overspread with the basalt flows. As yet we do not know whether the still later andesites and the Satsop were likewise uplifted, nor have the field data yet obtained disclosed its exact relation to the Eagle creek beds, evidence of the presence of which we still see both to the west of Shellrock mountain and for several hundred feet up to the north and east of Wind mountain on the Washington side. It is fairly safe to say, however, that the Shellrock-Wind mountain intrusive was in place and had come to rest before the widespread elevation of the Cascade Range began, and that the Columbia simply uncovered or, as a matter of fact, discovered and brought to light, that which beneath long lay concealed from view. These two conspicuous peaks thus stand forth today, first, because in their own upward movement the overlying formations



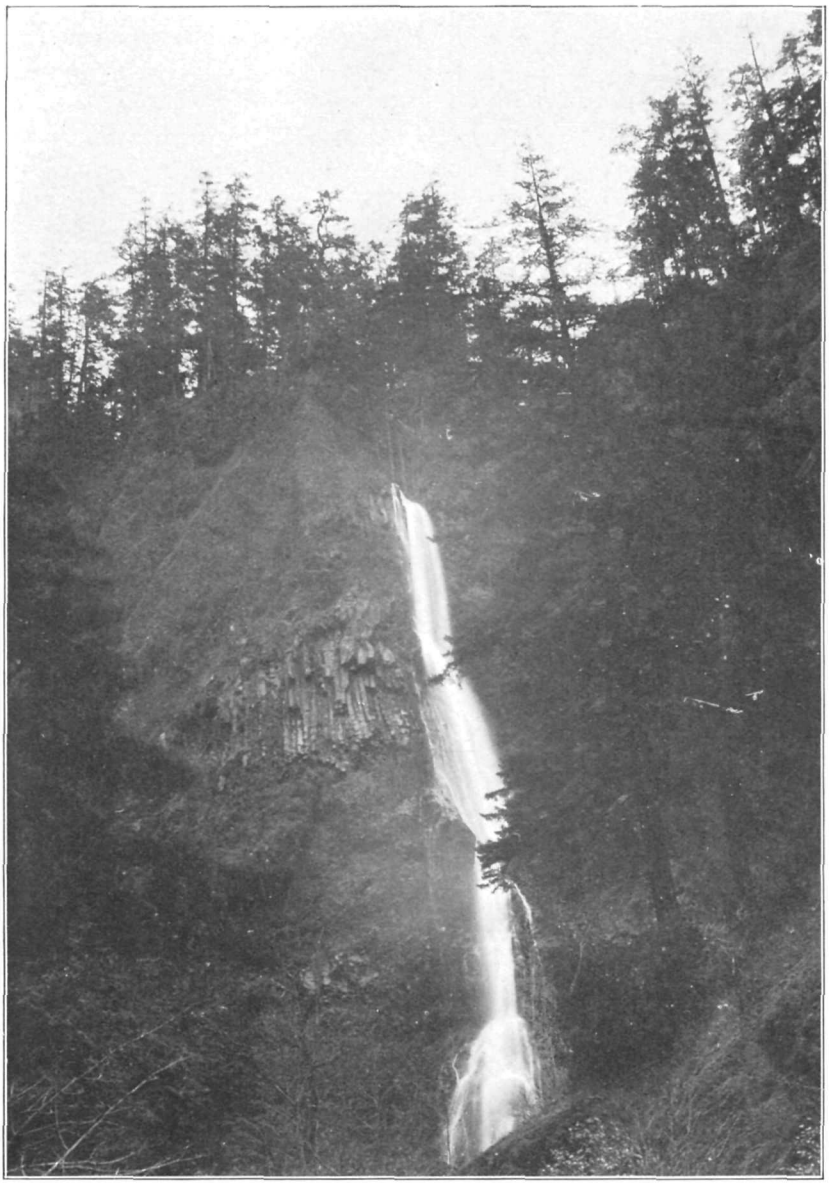

Cross-section Wind and Shellrock mountain. Mt. Defiance

were entirely eroded away; second, because of their unstable character little of forest or other plant growth can gain a foothold, and lastly, the provoking reason at the bottom of it all, because the Columbia in its down-cutting was left no alternative but to cleave an unerring way, dividing into two, the menacing obstacle that essayed to rise across its laid out path.

**Mt. Defiance**

Beyond Shellrock mountain and for the next seven miles to Mitchell Point, though beyond its central axis, we have little reason to feel that we are not still within the overshadowing depths of the Cascade Range. At our right are cliffs that rise a thousand feet to the sky-line, waterfalls leap from their brink and our way is cheered by the echoing murmur of their music. The falls of Lindsey creek are 104 feet in height and are not visible from the Highway. Just before crossing Warren creek, where signs of former flourishing habitation still exist, a watchful eye will catch a passing glimpse through a screen of firs of a most charming little falls over 200 feet in height, where for most of the year an as yet unnamed stream from the slopes of Mt. Defiance spills its waters to the flat below.

And this calls to mind the fact that we are at this moment within a horizontal distance of not over two and one-half miles slightly east of north from, next to Mt. Hood, the highest peak in the entire region of the Columbia gorge on the Oregon side, Mt. Defiance. Its summit, as the map shows, reaches an altitude of 4,960 feet above the sea. Its ascent from the Columbia river side has ever proved a most strenuous undertaking. At present, thanks are due to the Mazama mountain climbing club for seeking out and marking a most feasible course up this mountain along the divide between Warren and Lindsey creeks. The start is made by first climbing the slide-rock slope to near the top of the beautiful 90-foot falls of Warren creek from about opposite the end of the Lindsey switch; whence the course is to the right along the rim until about a thousand feet of elevation is gained, and then through forest due south to the foot of the open rock slides that skirt the summit. On the north slopes of this peak, amongst a most thrifty and productive tangle of huckleberry brush, and at its top, scoriaceous lava and scattered volcanic bombs leave no question as to its having been a vigorously active volcano. By its outpourings, which are in general a rather basic andesite, its vast bulk was built and doubtless much of surrounding country covered with lava. As is true of other neighboring peaks, the upper slopes of Mt. Defiance have been modified somewhat by the scouring action of glaciers which, owing to its height, originated there in glacial times. The little lakes at the head of both Warren and Lindsey creeks occupy what appear to be the position of former glacier cirques from where valley streams of ice flowed down their gorges, we know not exactly how far, towards the Columbia. From the slopes and top of Mt. Defiance a most wonderful panorama for many miles in all directions may be enjoyed. The celebrated Hood River valley culminating in Mt. Hood at the south is spread out as though a great map, to the north, only the Columbia seems to separate us from a magnificent



**Falls of Starvation creek; so named in commemoration of the three weeks' snow blockade of a train at this point in the winter of 1884-85. Back upon the Highway again at Lindsey, from the ascent of Mt. Defiance, our sigh of relief is in one short mile quickly transformed to burst of rapture if perchance we fail not of one brief peep into the restful nook whence rush the turbulent waters of Starvation creek. Not so close that the sound of its falling interferes with composure of speech, nor so far away that the pulsating rise of its spray shall obscure the beauty of its setting is Starvation falls, in a series of playful leaps springing from the confinement of a constricted channel above to make, from us, a hidden landing 186 feet lower down. Belying its name, this last of the spectacular waterfalls in plain view as we pass eastward along the Columbia River Highway, does nothing if not provide a gratifying even if fleeting repast of delight to every keen lover of the finest that Nature affords**

Photo by Weister

array of snow-capped peaks in Washington, and to the west the line of sight entirely clears the highest corrugation in the Cascades summit and reaches to where, beyond the limit of clear vision, the dark bulk of the Coast Range alone is between us and the Pacific Ocean.

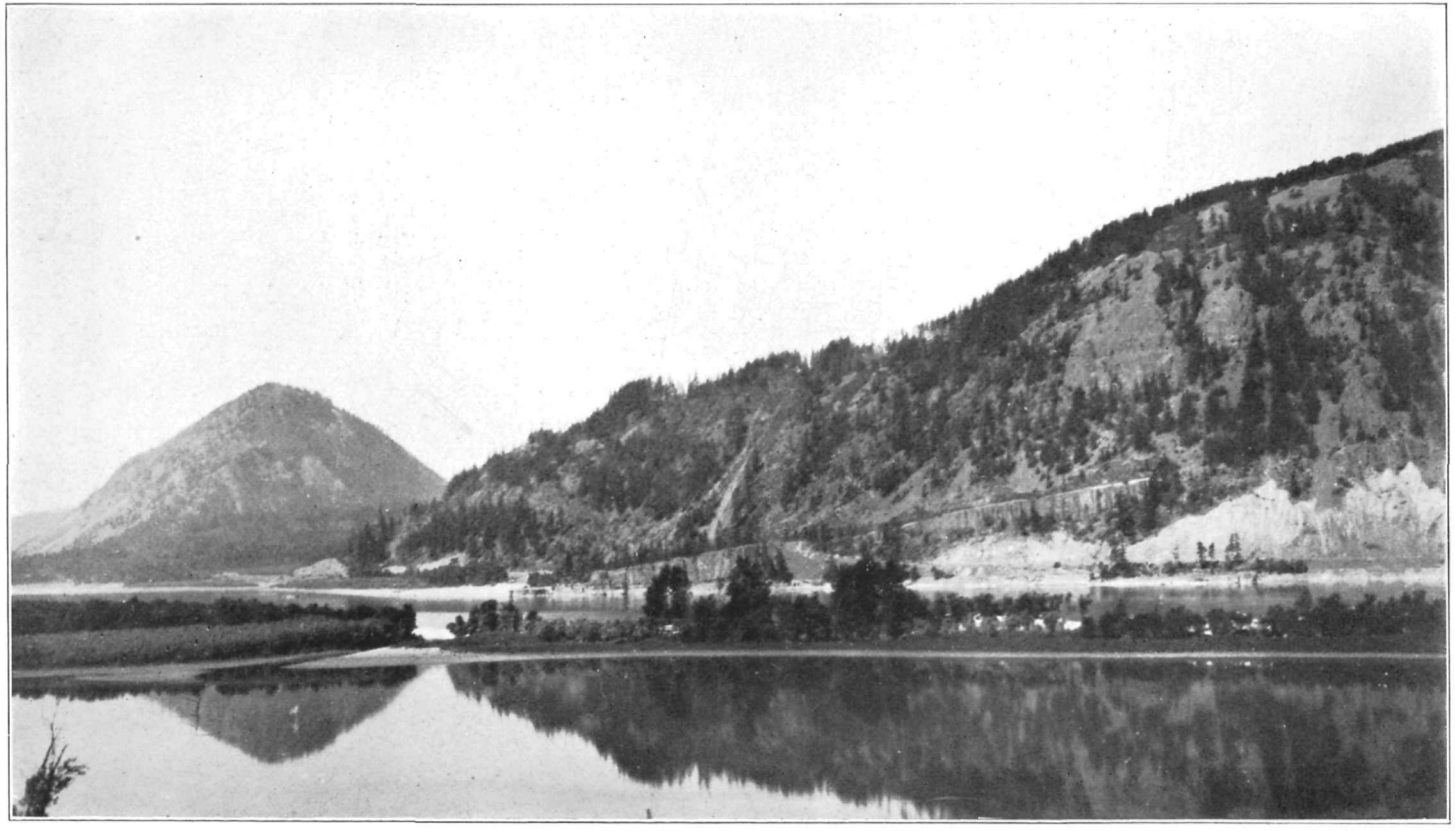
From the town of Viento, four miles from Shellrock mountain, is caught the first glimpse of Mitchell Point yet three miles ahead. The renown of this, as between man and nature, combination masterpiece, has whetted our anticipation to a scarcely controllable state of apprehension. But undue haste must here of all places be foregone, that our journey's end may be approached understandingly.

**Satsop in Viento canyon**

A brief excursion up Viento creek reminds us that for some distance we have seen very little of a former most persistent companion, the gravelly Satsop beds between the Columbia basalt and the later lavas. We are thus impulsively determined to make a hurried ascent of Viento canyon to learn of the source of the occasional beautifully rounded quartzite pebbles discovered in the bed of this creek. The top of the basalt is reached at about 2,000 feet and here begins a series of clayey, sandy, ashy, bouldery water-laid beds that continue for more than 500 feet. Quartzite pebbles are still found in the creek bed at 2,500, so it is clear that this is again the Satsop formation on the east flank of the Cascade Range, and developed too, to an unusual thickness.

**Looking across the Columbia. Wind mountain and west slope of Cook Hill.** Yet again will we briefly delay, to inspect the dome-like mountain on the opposite side of the Columbia that rises to barely short of 3,000 feet. It is called Cook hill, formerly known as Bald mountain. In the view its long westerly slope leads down towards Wind mountain now nearly four miles away. We can see that from the river's edge the heavy layers of basalt of which it is composed rise to the eastward beneath the mountain, their dip as measured at the railroad one and one-fourth miles east of Collins, being 12 degrees in a direction 50 degrees south of west. The beds continue to rise until truncated by the canyon of Dog creek. Near the outlet of this stream the dip is 26 degrees, its direction having changed from southwesterly to 20 degrees east of south. East of Dog creek the beds have a general southeastward inclination rising thus towards the west and north. As we reach Mitchell Point and pass beyond we shall be better able to see that Dog creek has cut its gorge into the top and apparently parallel to the axis of a great curving upward arch in the basalt strata. To the east and to the west the layers incline away from this axis, whose position is marked in a general way by the course of Dog creek; and besides this, the entire series of lava flows, axis and all, plunges rather steeply in a southeasterly direction toward the river.

We shall be anxious to discover on the Oregon side some evidence of this rather unusually marked deformation that so plainly shows across the river. At intervals between Starvation creek and Viento we have already interpreted the southerly inclination of the basalt in outcrops along the Highway as due to slipping of large masses from the cliffs above. Now that



Looking across the Columbia from Viento. Wind mountain and west slope of Cook Hill

suspicion is aroused, we see, however, that their disposition is not out of harmony with what we observe beneath Cook hill across the river. And we are further assured by the finding of other croppings of the basalt beyond Viento that display similar deformation. About one mile west of Mitchell Point measurement shows the lava to be dipping all of 35 degrees practically due southeast.

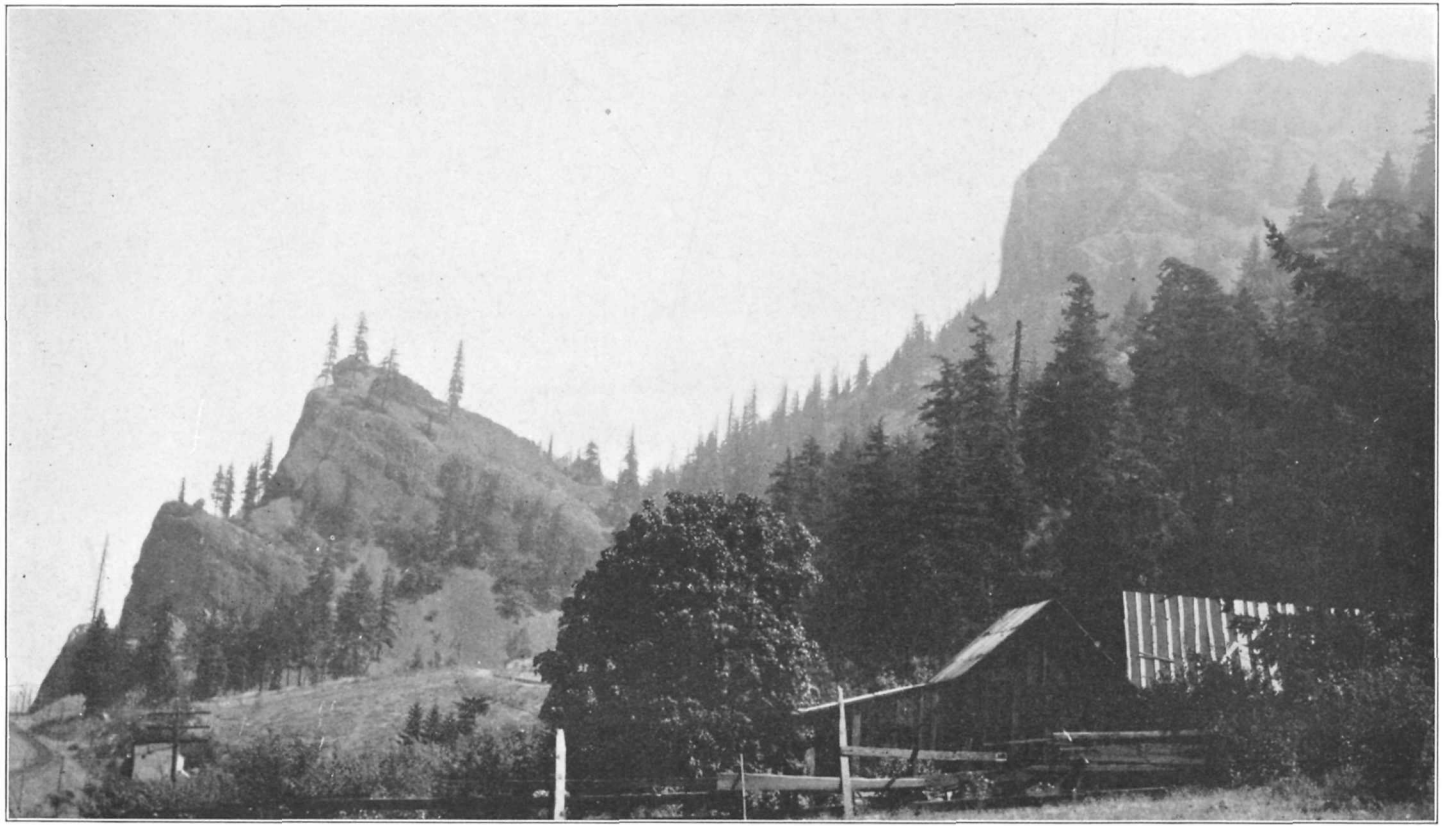
## MITCHELL POINT

**Big and Little Mitchell from the west.** Mitchell Point itself, the first open view of which is had from Sonny, a small lumber town one-half mile to the west, is seen to be likewise made of layers of basalt that dip steeply away from the river. In the view notched "little" Mitchell is at the left. At its base and close to the river is to be seen the railroad, and a hundred feet or more up, the cleft along which the Columbia River Highway rounds the Point before entering its spectacular tunnel. Central in the photograph is the pass through which the old wagon road went, its grade a steep and harrowing one now abandoned. At the right is "big" or "high" Mitchell, its structure too, being one of southeasterly dipping beds. Big Mitchell rises about 1,400 feet above the river. Its face is seen to be precipitous and is really the protruding point of a jagged ridge the sides of which have been so gnawed away that its crestline is now one of unstable moldering crags, the negotiation of which is a task for only the most daringly intrepid to undertake.

About the foot of big Mitchell is an abundance of iron-stained gravel talus intermixed with that of blocky basalt. Again, as though by some link of common concern, we seem not to be able to lose touch with the familiar Satsop formation. High up in the walls of big Mitchell close to a hundred foot bed of it glares down at us. The gravels are in part the cause of this one of the most spectacular headlands in the whole Columbia river gorge. They rest as usual upon an irregular eroded surface of Columbia river basalt and are in turn buried by the later lavas that cap the ridge of big Mitchell. The overlying lava here seems not to differ in general nature from that below, while elsewhere the gravels have almost universally separated the basalt from superjacent lavas of somewhat less basic character. Since igneous rocks often grade into each other without regard for specific dividing lines, it is to be not unexpected that some of the earliest of the great series of flows that cover over the entire summit of the Cascade Range would be strongly basic, or even basalt.

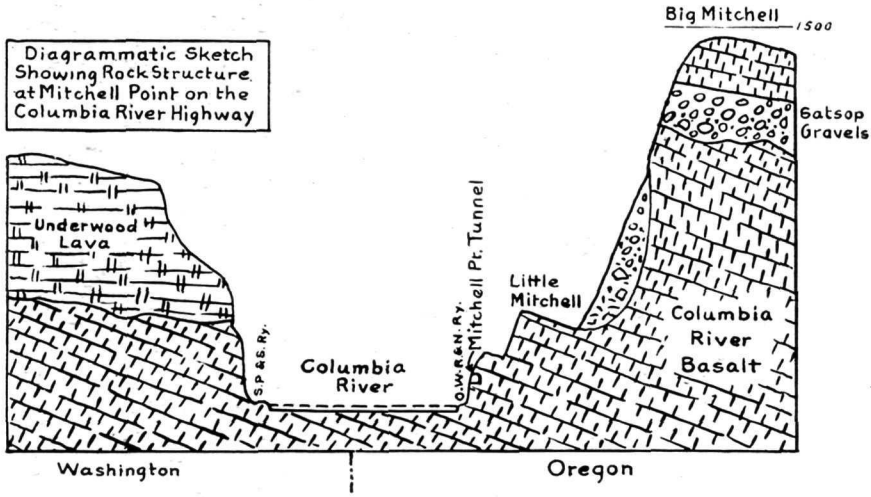
**Geology at Mitchell Point**

At any rate, the time interval which these gravels represent would seem to be the same. We found them low down in the region of Portland, rising on the flanks of the range at Crown Point and many other places, up nearly 3,000 feet beneath its crest in the walls of Herman creek canyon, at 2,000 in Viento gorge, and here in big Mitchell between 1,200 and 1,400 feet above the sea, again contentedly dropping with the eastward slope of the underlying basalt. As we study the situation here, and across the river, we can see that the dip-



Big and Little Mitchell from the west. O.-W. R. R. & N. railroad at extreme left; Columbia River Highway in first rock-shelf above the railroad

ping beds at Mitchell Point are in general conformity with those at the east side of the axis of the Dog creek arch, and are a component part of a great upward bend in the strata, or anticline, that pitches to the southeast parallel to its axis; which may in part be illustrated by calling attention to the fact that a given stratum rising from water level on the Washington side can be seen to reach into the heights of the mountain east of Dog creek. Deeper beds pass below the river; those above, as shown in accompanying sketch, having been truncated by the Columbia and their substance carried away; until, as we come to the Oregon side, Mitchell Point, both little and big,



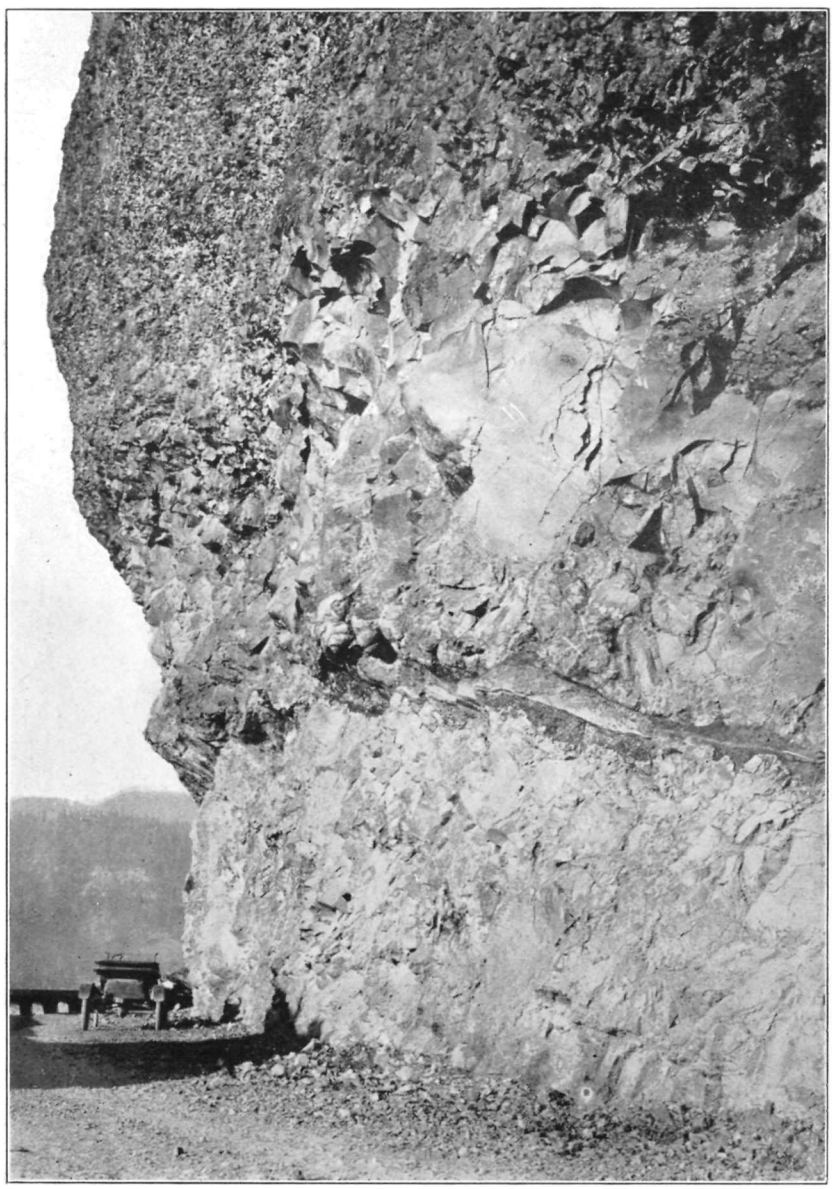

**Geologic structure at Mitchell Point**

represent just as truly similar truncated layers, but their edges happen now to occupy an uplifted position in one wall of the Columbia gorge rather than in its bottom beneath the water of the river. What was the former extent of the basalt flows composing Mitchell Point, we dare hardly conjecture, but certain it is that before they were uplifted and folded as a part of the Cascade Range, they extended across the space now occupied by the Columbia and to probably a great distance beyond.

**Mitchell Point tunnel**

Construction of the Columbia River Highway beneath Mitchell Point necessitated the blasting out of a shelf-like niche for some distance along the sheer face of the basalt cliff that formerly rose vertically from the bank of the Columbia. At the water's edge a rock fill carried the railroad safely by. No alternative was there then for those who laid out and built the Columbia River Highway but to tear away and finally bore through the rock itself. In so doing, it must be said, a roadway was produced that for security and substantialness cannot be improved upon, while from the scenic standpoint, we are assured by those who know, in the Mitchell Point tunnel there is added to this already celebrated thoroughfare a feature unparalleled, go where you will.

**Coaly seam between basalt flows, Mitchell Point.** What has thus been accomplished through necessity and intention from the engineering and scenic points of view, has fortunately at the same time, without previous design not to say expectation, thrown open intensely interesting records of some incidental happenings of the geologic past. At the entrance of the first rock-cut we more thoroughly than ever appreciate that the Point is made of inclined layers of basalt, one on top of another. Here, for a couple of hundreds of feet we may view at close range the



**Coaly seam between basalt flows, Mitchell Point**

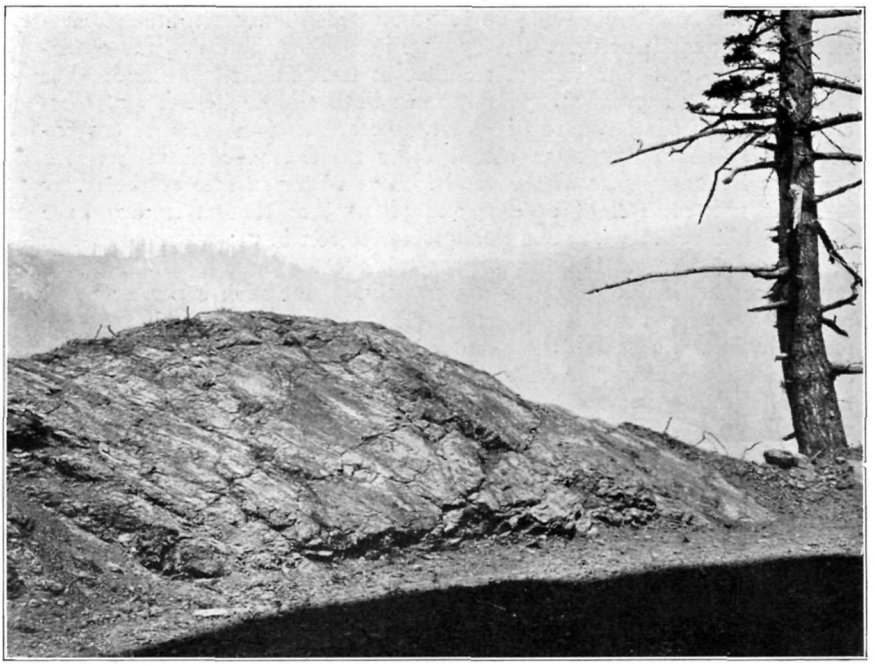
**Clay-soil seam penetrating basalt, Mitchell Point**

contact between two successive flows. We have continuously marveled at the hundreds, sometimes thousands of vertical feet of lavas that rise above us in all parts of the Columbia gorge. Everywhere we see that these great thicknesses are built up of relatively thin individual layers, how many at any one place we usually cannot count, each representing a separate flow. It is easy to drop into the habit of thinking that these flows followed each other in rapid order, and that therefore

their accumulation would pile up into hundreds of feet within comparatively short periods of time. Every once in a while, however, the opportunity is thrust in our way to see that at least in many instances, not merely few but a great many years must have elapsed between the successive coming of the flows of basalt. Before us is a seam of carbonaceous clay containing some actual coaly matter, pinched in between two massive flow layers of the basalt. The under surface of the upper basalt is twisted, full of caverns and pillowy, as though it may have pushed while cooling, into and finally come to rest in the water and slime of a muddy swamp. On the other hand, the top surface of the lower lava, beneath the coaly seam, is not so definite, the rock is more altered and crevices extend into it to greater or less depth. From these facts we promptly infer that upon the older lower lava a soil once accumulated, and conditions were favorable for the growth of plant life and at death, for its partial preservation as the black, carbonaceous or coaly residue we find today. That this soil and its organic matter were not bodily carried here in the course of lava movement is shown by the alteration of the underlying rock, meaning that it contributed its own substance to the forming soil.

**Clay-soil seam penetrating basalt, Mitchell Point.** That plant life flourished is evidenced by the way in which the soil and carbonaceous matter extend into the irregular vertical cracks, just as we see ramifying roots penetrate to draw sustenance from disintegrating rock surfaces of today. In the view the dark band across the top is the main clay-coal seam, and branching from it below is a narrowing crevice several feet in depth that is wedged full of the same sort of clayey soil containing the carbonized remains of vegetable life. There can be no question that this inter-lava soil-bed represents a time interval of considerable length. The under lava was exposed long enough to first become cold and solid, and then for its upper part to alter sufficiently that plants could gain a foothold, and indeed develop in some degree of luxuriance it would seem, in order to leave so much of a residue. How long in years we can gain little notion, for our knowledge is slight of the climatic conditions of those times, but it is quite safe to venture that, under the most favorable environment, at least a few hundreds of years must have gone by before again the lava came on to wipe away, or entomb, all of living thing to which the interim may have given rise. Even in the great basalt formation alone we count the flows by the score, between many of which, could we but ascertain the truth, would probably be found some signs of a time interval of duration long or short. Be the individual interval ever so brief, as geologic time flies, in our units whether centuries or generations, their sum must be immensely great.

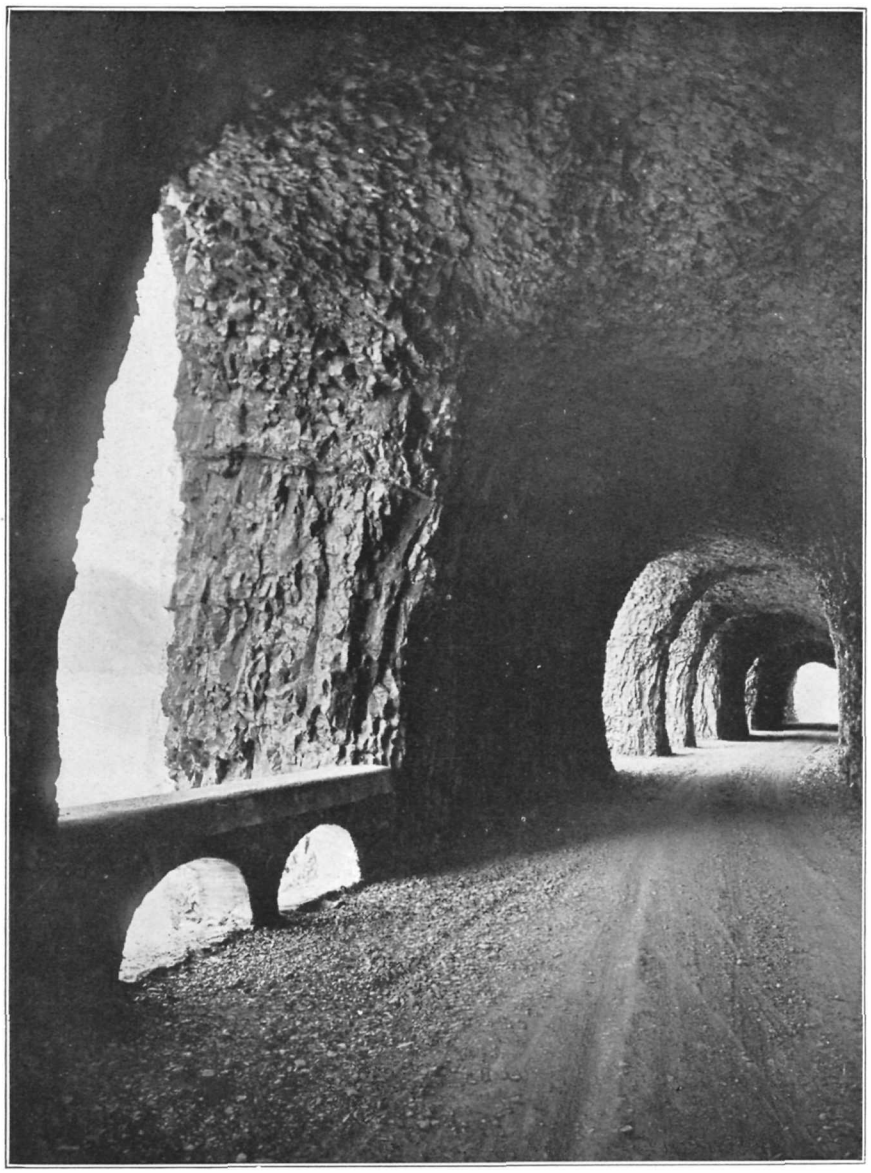
**Slickensided basalt, Mitchell Point.** We are again reminded that since the basaltic lavas came to rest the entire series has been uplifted and tilted at various angles from the position they at first assumed. It is very evident that the soil-band we have just examined accumulated in a much more nearly flat-lying position than is its attitude today. Just how an enormous thickness of rock like the Columbia river basalt composed of many individual layers, submits to being heaved up and bent into arches and intervening troughs is not at first the



**Slickensided basalt, Mitchell Point**

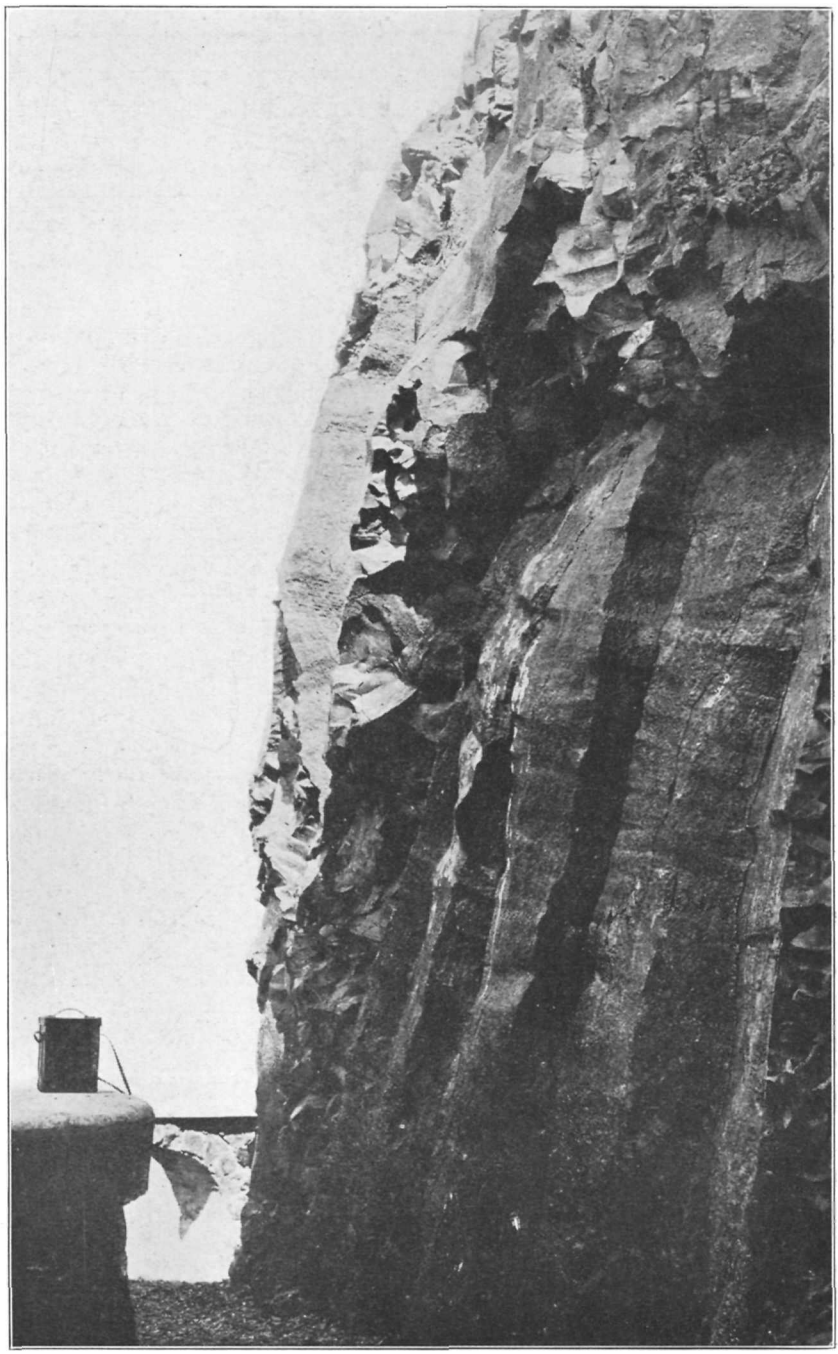
easiest possible of conceptions to grasp. That stretching must take place on the outside of curves and compression on the inside is obvious. That so strong and brittle a substance as a hard lava can stretch very much under ordinary conditions is scarcely to be imagined. As a matter of fact, we know that fracturing takes place, fissures form, and there is often slipping along lines of break called faults or fault planes.

Nor can we comprehend the possibility of any great amount of movement after the lavas are cold and rigid without some adjustment between the separate layers, the slipping of one layer bodily upon another, just as would the leaves of a book if kinked up by pressure along the edges. Shortly beyond where at its eastern terminus the coaly seam referred to disappears below the level of the roadbed, and on the river side of the floor of the Highway, the rounded dome-like and smoothened lava surface shown in the view may be observed. It is grooved and shows some parallel scratches though in general seems to have been rubbed to an almost slippery smoothness. This surface is the probable continuation of the contact between beds represented by the coaly soil layer, where instead the two lava surfaces were in immediate contact. During the uplift and crumpling that gave rise to the Dog creek anticline, of which we have seen Mitchell Point is a part, movement doubtless occurred in many places between flows. The friction and heat developed by one hard rock rubbing upon another, particularly under the enormous pressure of their weight and the elevating forces, often produce profound changes in the rock along the surfaces of movement. The polished surface is spoken of as "slickensides." The film of greenish-



**Mitchell Point tunnel. Cramped into yet closer quarters, the Columbia River Highway for the last four hundred feet around the base of Mitchell Point passes through its celebrated tunnel. The passage is cut through solid columnar basalt and is lighted by means of five windows artistically carved through the river side of the tunnel wall. It was the fortunate favorable structure of the basalt at this point, and particularly the attitude of the main sets of columns, that contributed largely to both success in driving the tunnel and the tasteful shaping of its portals, pillars and archways. And the very factors that promoted ease of construction seem providentially to likewise promise enduring permanence for time to come. The entire roadway is now a smooth pavement.**

Photo by Oregon Commercial Studio



**Portion of rock wall, Mitchell Point tunnel. Close view showing structure of pillar at one of the windows. Heavy basalt columns from floor to spring of arch where they curve inward from sight, as though to more strongly brace and bind together the structure of which Nature had already made them an integral part. Where is man-laid masonry more designedly methodical than this!**

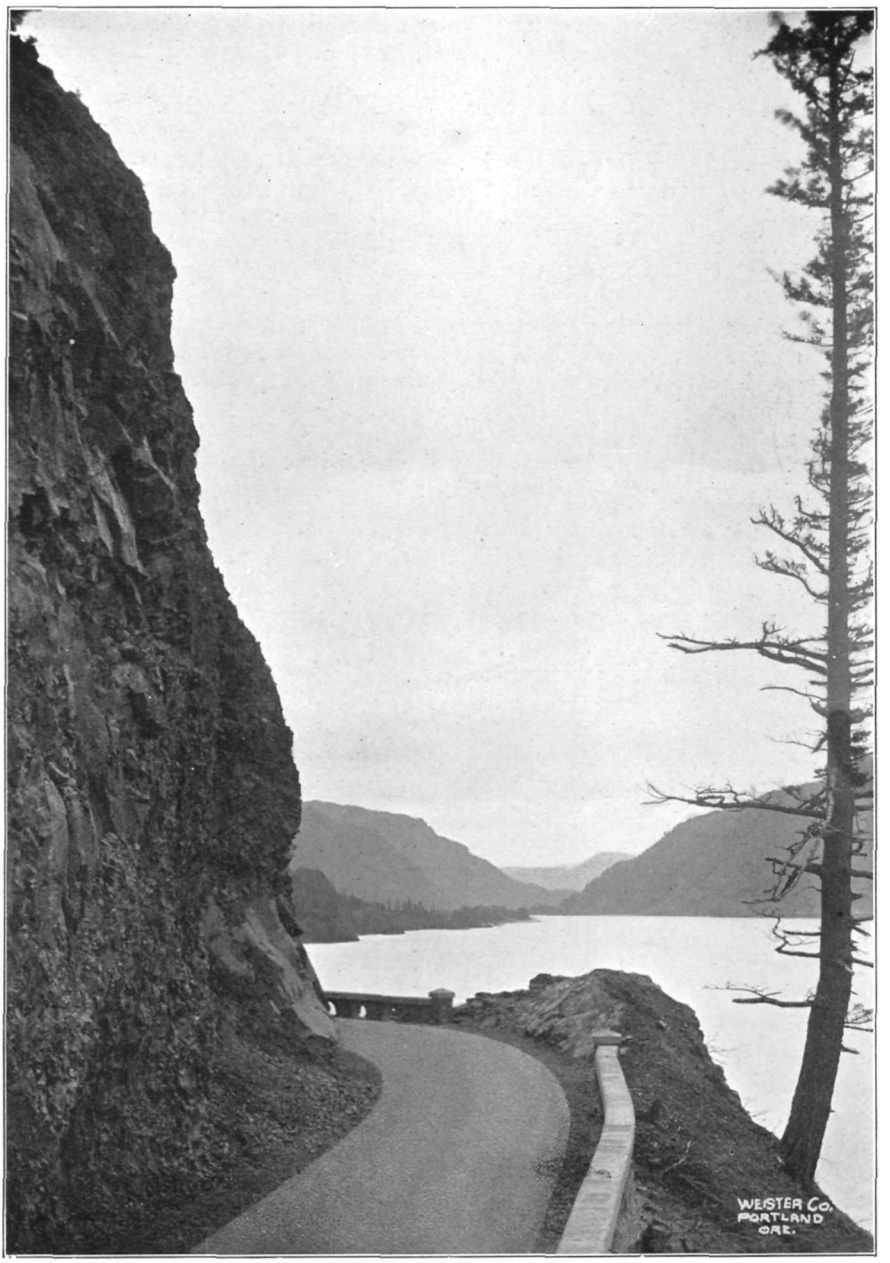
yellow with which it is coated is the alteration product of the friction movement. All of which is but a bit of additional testimony as to the former course of events here.

**Down the Columbia from Mitchell Point.** From the roadway or the tastefully railed windows of Mitchell Point tunnel there is an unobstructed view both up and down as well as across the Columbia river. Downstream we gaze to the horizon back into the Titan or chasms through which we have come. At the last the angular sky-line is the high divide east of Herman creek, and in shadowy outline against its dark bulk is Shellrock mountain. In the hazy distance is the even top and sloughing slopes of Table mountain, full 19 miles away. Cook Hill whose interesting structure we have but recently studied is nearby on the Washington side. Dog creek has carved into its eastern base and east of this creek the southeasterly sloping layers of basalt stand out, their bold broken edges in places showing as abrupt revetment walls that rise diagonally toward the axis of the Dog creek anticline. The deep notch through which the Little White Salmon flows, and its lakes, are slightly to our left.

**Underwood lava**

Directly across and low down next the river, we see the same inclined beds of basalt, their successive jutting edges punctured repeatedly for the S. P. & S. railway to pass. But here, above these dipping beds, and as though resting upon their cut-off edges, is a series of massive strata that lie practically horizontal. Up the river, as far as the eye can discern, this great wall of flat-lying beds extends, except where its continuity is interrupted by the sharply incised canyon of White Salmon river at Underwood, four and a half miles from us. It rises precipitously to a maximum of 1,400 feet above the river, and at intervals from the crossing of the Little White Salmon river for ten miles to Bingen, beyond the town of White Salmon, the eroded surface of the basalt shows below. Opposite the Hood River valley its inclination flattens out in the trough of a syncline as we shall see the basalt does also beneath the valley of Hood river. We are at a loss to explain this apparently anomalous state of affairs by what can be seen at our distance, and our curiosity shall be satisfied only by taking the ferry at Hood River which will land us at Underwood and at the very foot of the cliffs we would examine.

Here we see at once that they are a series of flows of dark gray lava that have come since the basalt was distorted by the folding of the Cascades uplift. The basalt rises as prominent hills a few miles back from the river, the newer lava having obviously filled in about their lower slopes. Not all of the higher points are of basalt however. Underwood mountain, the prominent rounded peak that stands about midway between Little White Salmon and White Salmon rivers, is found to be a comparatively recent volcanic cone. It rises between 2,900 and 3,000 feet above sea level and its upper steep portion is entirely of cinder, ash, lapilli and scoriaceous volcanic fragments. The lower wide-spreading slope of about 10 degrees that reaches to the brink of the Columbia, west to the Little White Salmon and lowers eastward so as to reach the river level beyond White Salmon town, is with little doubt a lava surface, its slope determined by the cooling position of the final liquid flows. And all indications go to show that Underwood mountain, and possibly other nearby hills to the north of it, was at least in part the source of these new born lavas. That they were squeezed




**Down the Columbia from Mitchell Point**

out through a number of vents is most likely. The hill at the northwest edge of the town of White Salmon, rising, all told, about 1,000 feet above the river, possesses many of the features of a volcanic cone from which lavas issued similar to those about the base of Underwood, sometimes called Storm mountain. Whatever their source, these relatively flat-lying lavas

are new, younger by far than the Columbia, at the edge of whose gorge their cut-off edges form so spectacular a wall, as we view it from Mitchell Point and as it can be seen from the Hood river valley. When we project across the Columbia the average inclination of the lava surface from the foot of Underwood mountain, we are impressed with the extreme likelihood that the flows must have pushed at least part way if not entirely across that river, although we find no certain evidence of their encroachment upon Oregon shores.

The new Columbia Gorge hotel is about one mile west of Hood River, 70 thrilling miles of pavement from the city of Portland. Its picturesque site at the brink of the gorge is a very satisfactory outlook point for viewing the river and its surroundings here, particularly the wide-spreading panorama of mountain and canon across on the Washington side.

## HOOD RIVER VALLEY

FROM Mitchell Point to Hood River is a little more than five miles. In this distance a climb of a few hundred feet is made along a sharp wall of grayish lava to one of the lower levels of the broad Hood river valley. Geologically, we must not fail to observe that the southeastward dipping basalt at Mitchell Point is succeeded by these similarly inclined and less basic lava flows to be seen along the railroad and the river at Ruthton as well as at the roadside in the Ruthton hill. Were we to continue along the river we should see that the inclination of the lava layers slowly flattens out so that beneath at least the lower part of the wide valley of Hood river the beds are practically horizontal. East of Ruthton some interbedded scoriaceous materials, to all appearances water-laid, may represent the inter-lava Satsop formation, the basalt being carried by its dip so low that its upper surface is now little if any above the river level. Upon it and partaking of the same general inclination is from 300 to 500 feet of Cascades lava, whose position, while at one and two and even three thousand feet in the center of the Range, is now depressed to as many hundreds of feet above the river. The general level of the northern part of the Hood River valley floor is about 500 feet. From the Columbia we rise to this altitude over a series of rather abrupt benches that are strewn with gravel and show signs of having been once overrun by the river. That these terraces may have been produced by the intermittent lowering of the Columbia from these higher levels is a possibility that promptly enters our minds. And particularly since there faces us from the other side of that river the great mute wall of lava whose eloquent silence has already definitely told us that its strata must formerly have extended far towards if not to actually touch the Oregon side. It would seem quite in order therefore to postulate the not distant day in the past when the Columbia was without compunction thrust aside by a great filling of lava from its northern shore, when its waters rose and it was compelled to seek a devious shifting way around the obstruction on Oregon soil. After quiet was restored, in course of time the river undismayed tore down the barrier in its path, and stage by stage comfortably settled again into its former and present restful bed.

Hood river valley from near White Salmon in Washington. Mt. Hood, 11,225 feet, at the head of the valley. Mt. Defiance at the right, 4,960 feet high. City of Hood River and mouth of Hood river itself near center of view. Hood river valley is a broad synclinal trough or down-fold in the rock formations that rise to the west (right) into the main Cascades uplift, and to the east (left) to form the sharper upward flexure, or Bingen anticline, between the city of Hood River and Mosier. The Columbia river, which crosses our view, as we have seen, has cut through and opened thus for our inspection the entire series of deformed rock strata

Photo courtesy S. P. & S. Ry.

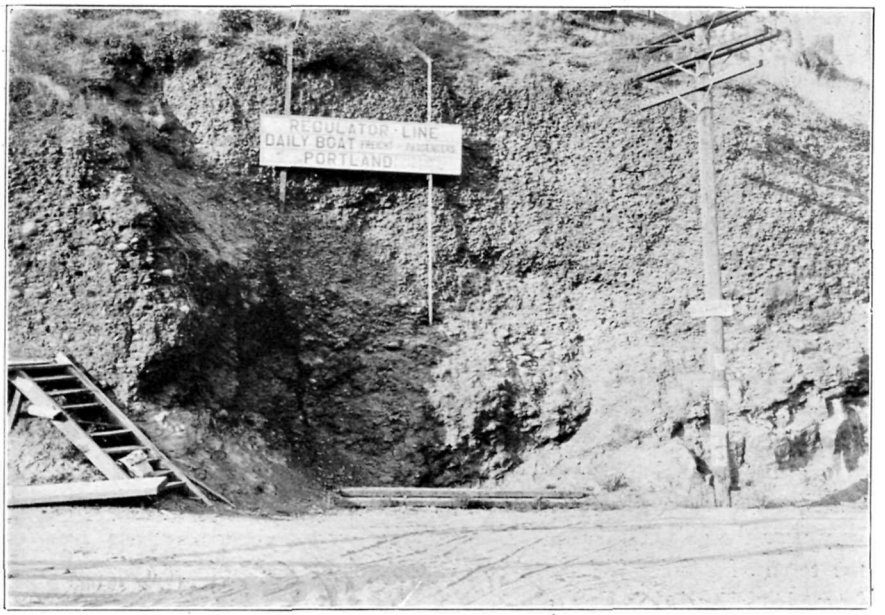
**Hood river valley.** The city of Hood River is but three miles of boulevard beyond the climb up Ruthton hill. It is situated where Hood river joins the Columbia and is the outlet for the vast fruitage from its celebrated valley, whose productive acres stretch for 15 miles and more due south to the very base of Mt. Hood itself. The valley is a great sloping lava plain broken here and there by protruding groups of basalt hills or of heaps of ejecta from more recent vents of eruption. Van Horn butte is a cinder crater of the latter class, while Booth Hill at Dee will represent the former. Upon the very summit of Van Horn butte is a large granite boulder. Its occurrence here marks another most thrilling epoch into the writing of which we cannot go now. It may be said, however that this boulder is but one of quite a considerable number of the granite type that have been found here and there both in the Columbia and Willamette river valleys in positions where they could have been placed only by floating ice. They are visitors from the highlands of eastern Washington stranded during a geologically recent period of submergence never to return to the land of their origin.

**Glacial till in Hood river canyon.** And we will not scurry over this undulating valley platform for long before we begin to see the prints of yet another most eventful day. The summit of Mt. Hood is today surrounded by a group of miniature active glaciers. In glacial times this mountain was the elevated source whence glacier streams, verily ponderous sheets of ice, coursed we know not how much farther down than do the meagre remnants of the present time. Hood river has cut and occupies a literal gash below the general level of the valley floor. In its canyon walls we catch a not infrequent clue to what has happened in days by gone. Mt. Hood railroad threads for its first few miles the deepening canyon of Hood river. And we need to go only some three miles up, to the switch-back, by means of which this railroad ascends the canyon wall, to be fully reassured that the glaciers were once busy here. In the railroad cut high banks of sandy, bouldery clay are exposed, each boulder fresh and unweathered and but little if any rounded. The clay is light gray or buff in color and through it pebbles and boulders are scattered promiscuously with no sign of definiteness or order in arrangement. "Till" is what glacialists call it and its structure is characteristic of the unsorted manner in which the moving melting ice lay down the load it carried. We are thus convinced that during the frigid glacial period, which as earth events accrue is but one brief moment past and gone, the glaciers quite thoroughly dominated the valley of Hood river. Doubtless much of its fertility of soil is due to the contributions of that period, just how much we are not now able to say. Nor are we at all certain but that in the wintry heyday of that climatic swing of pendulum, glacial streams extended to the Columbia, and its sweeping waters may have been called upon to clear its channel of heaps of morainal rock debris if not of tongue of solid ice itself. All of the main headwater branches of the Hood river of today originate in the glaciers on Mount Hood. This condition and the fact that it is actively deepening every part of its gorge, cause this stream to be surcharged with silt and sand and gravel, particularly in the summer season when melting is most active. It is constantly dumping this load of rock detritus where it enters the Columbia. The new plant of the Pacific Power and Light Company, said to be largest single hydro-electric unit in the state of Oregon, is located on this river within view from the Columbia River Highway.

**Glacial till in Hood river canyon, along Mt. Hood railroad**

The Mount Hood Loop road branches from the Highway at the east end of Hood river bridge and swings up-stream to the right to become a part of the wonder boulevard that will before long completely encircle that majestic mountain.

**Old gravels resting upon basalt, east end Hood river bridge.** Reluctant to feel that our journey through the gorge of the Columbia river, a journey so replete with thrills, must end here, we cannot forego with peace of mind the opportunity to take at least yet one look ahead.




**Old gravels resting upon basalt, east end Hood River bridge**

At the east end of the bridge across Hood river we are face to face with a wall of iron-stained gravel whose familiar appearance it is impossible to mistake. It is sprinkled with quartzites and, in the view, at the right we can see where the gravel bed rests upon a surface of weathered basalt. The railroad cuts through it, and it appears at intervals along the Highway eastward between Hood river and Mosier. Wherever found these gravels mantle the basalt just as have the Satsop gravels always. They creep up to scarcely less than 1,800 feet on the divide between Hood River and Mosier, and yet on to more than 2,000 on the Ortley ridge, thence down toward The Dalles where they seem to join with The Dalles beds whose exact age has long been in question. That the latter are the exact equivalent of the Satsop in age cannot now be definitely stated. It seems very probable, however, that at least the upper portion of the fragmental beds exposed in the region of The Dalles will prove to be of Satsop age. Between the forks of Mill creek a sheet of andesitic lava overlies The Dalles tuff, but this may prove to be a recent valley flow, which would not therefore preclude the possibility of more or less of these hundreds of feet of bouldery volcanic sediments having accumulated in the slackwater of an inland lake temporarily formed by the waters of the Columbia drainage after the Cascades uplift had begun or was nearly completed.

We saw the Satsop gravels high up in Big Mitchell, we now find them nearly at the water level of Hood river, again on top of two high divides between, and yet again coming low down in the region of The Dalles. How much farther into eastern Oregon the formation may be traced remains to be determined. On the Washington side of the Columbia Satsop gravels are found upon the basalt at intervals along the Klickitat river to Goldendale, over the Simcoe divide to an altitude of over 3,000 feet, and on into

the Yakima country. And it is of interest to recall, that these gravels of such wide distribution are the equivalent, in time of deposition and character, of those of Westover terraces in the city of Portland, the top of Mt. Tabor, for miles along the Sandy river, at Crown Point, and of an unrecorded number of other places where they have been seen to enter into the structure and uplift of the Cascade Range.

**Hood River-White Salmon syncline**

We have seen that the great Hood River valley depression and its counterpart and continuation, White Salmon valley in the state of Washington, the latter since partly filled with newer lavas, are the result of a downward curving of the same series of formations that have by being arched upward produced the foundation of the Cascade Range. Andesitic lavas of the Cascades formation as well as the basalt pass beneath its floor. At the eastern edge of this valley we find that the basalt promptly rises again and it is the successive waves or folds into which it is thrown that give rise to the two prominent divides between Hood River and The Dalles. We shall designate the first the Bingen anticline inasmuch as Bingen on the Washington side is very near the axis of this uplift. The succeeding trough or syncline in which the town of Mosier is located is appropriately termed the Mosier syncline. Beyond Mosier is the Ortley anticline, before passing down into The Dalles trough. East of Hood river the Cascades lava rises in places upon the flank of the Bingen anticline, from the upper portions of which, if it were once there, it has been eroded away. Southward towards Mt. Hood, along the strike of this anticline, andesite is found upon its crest.

**Looking up the Columbia above Hood River.** A trip from Hood River to The Dalles by boat reveals in a most enlightening way the structure of this section of the Cascades; for a part of the Cascade Range we must call these minor oscillations as well, since so far as our present knowledge goes, they grew as did the main Cascades uplift, by the same forces and in the same period of time. From the river the severed edges of alternating arch and trough give one at a glance a correct view of their relationship. The Bingen anticline, the dipping basalt in the eastern limb of which can be seen in the view, strikes somewhere near northeast-southwest, and is paralleled in direction somewhat closely by the Mosier syncline. The Columbia for a short distance above Mosier appears to flow in and be influenced somewhat by the trough of this syncline. East of Mosier the slope of the basalt layers steepens but slowly for several miles until about opposite the mouth of the Klickitat river and nearly to the town of Lyle. Here the change in dip is notable and it becomes as high as 30 degrees where they enter into the sharply flexed limb of the Ortley anticline. The axis of this anticline is some two miles beyond Lyle and it too has a general northeast-southwest trend. Its eastern limb is less abrupt, and in the vicinity of The Dalles the basalt can be seen to flatten out and to pass beneath the tuff beds of The Dalles formation.

## RESUMÉ OF COLUMBIA GORGE TOUR

WE have now traversed for nearly 70 miles, from Portland to Hood River, the course of the Columbia river, and have projected our fascinating observations 25 miles further to the city of The Dalles. We have fol-

Looking up the Columbia above Hood River. Inclined lava layers at the left across the river are a part of the eastern limb of the Bingen anticline

lowed the windings of that powerful stream in its deepcut canyon across the Cascade Range of mountains. It has severed that range so that in the walls of its gorge many of the details of the structure of the range stand out. Now that our hurried examination is completed and we have partaken of the varied scenic joys that in all the world only the Columbia river gorge and its Highway afford, there must indelibly remain in mind the graphic picture of the building of this mountain range. So far back as our records go, volcanic action has been the dominating force. When the Eagle creek beds were deposited volcanoes were active and their products were scattered far and wide, some to settle in bodies of water, others upon the surface of the land. There was no Columbia river then, and of the drainage systems we know but little. There followed protracted floods of basic lavas, the Columbia river basalt, that overwhelmed and obscured all else. Of their source, we are not certain, although from their widespread distribution they were doubtless poured out from many vents generously scattered over a large area of country. And even yet we know of no Columbia.

Then, in our region, came a time of comparative quiet. The surface of the basalt lay relatively low with reference to sea level, yet not so low but that it was subjected to the action of all the forces of atmospheric weathering and erosion. As a land surface the rock was deeply decayed, soils formed, stream gorges and gullies, hills and ridges were carved upon it. And the courses of rivers and their ramifying tributaries must have been established by which the surplus rains that fell were carried back to the sea. One of these became so overgrown that all others were compelled to pay tribute to it, and when a general lowering of the land took place it so spread out, and repeatedly shifted its course that many of the former irregularities of surface were filled with its gravels and sands. And when finally, from its western edge this basalt land surface progressively sunk beneath the waves, this master stream, as many others for hundreds of miles both north and south along the ocean shore, with herculean effort heaped hundreds of vertical feet of far-borne sediments into the slowly widening pit along its border.

**Birth of the Columbia**

Thus was the Columbia born. And it continued its work for many, many years, throughout minor oscillations of level, by which in land-locked lakes, lagoons, bays and in its own partially drowned valley there came about just such a varied assortment of gravels, sands, silts and clays as comprise what we know as the Satsop formation of today. During this time its branches were reaching far into the contiguous country where a new era of volcanic activity was about to begin. Already they were bringing down the abundance of mixed basaltic and andesitic gravel, of lapilli, sand and ash we now find in the Satsop. Until at last there came from inland a great devastating sheet of new lava itself that filled in upon the gravels and clays, and was in turn covered by them, as we see today at Troutdale and at Crown Point. So was presaged the beginning of a new volcanic era, the era of eruption that soon gave us the lavas of the Cascades formation that rest above all today.

But our river did not cease its constructive labors until forced to do so by the commencement of another uplift, which brought the old land surface, now loaded with gravels, up to not merely its former position, but hundreds of feet higher as shown by the present elevated remnants of the Satsop beds. Contemporaneous with its progress, the andesitic lavas came in increasing profusion. And at its beginning was the Columbia river established in practically its present course, and set to the Cyclopean task of forging its way through a rising mountain range; a task in the doing of which it has never for a moment faltered and the fruits of whose accomplishments are ours to enjoy for time to come.

This was the main Cascades uplift; a long drawn-out period of elevation, during which the Columbia river basalt was arched upward as one broad fold, and at least three sharper ones, carrying above it its load of Satsop gravels, and, wherever they had yet arrived, the still younger Cascades flows. Beneath the basalt the earlier strata of the Eagle creek formation as we know entered into the deformation. To how much greater depth the disturbance extended there is no way of knowing. The upward movement was slow, not cataclysmic, with probably intermittent pauses. The river cut downward as rapidly as the land uplifted, else it would have been diverted from its place; and scarcely a conjecture have we as to how different the story might have been had so entirely possible a thing have taken place.

Nor has time been uneventful since, in the not long ago, the bodily elevation of the Cascade Range ceased. Volcanic action then begun has continued; volcanoes almost without number have grown, some of which now virtually cast their shadows into the Columbia gorge, as though grudgingly acknowledging its priority. The Carson and Underwood flows of liquid lava certainly without design from the sister state at the north, have even attempted to fill it up, but without success. It is lean assurance to observe that just now no such catastrophic happenings are under way. True they neither come on in a moment nor unannounced, and their passing is not to be measured in terms of human generations. Nevertheless, as geologic time goes, our peerless Columbia gorge is ever threatened, if not by such as we see have essayed its destruction in the past, then by the hand of the majestic river that flows through it. For by its own efforts will the confining cliffs in time be undermined and eaten away. But for appreciable harm to familiar scenic features in our day we need feel no concern. They are ours today and they shall outlast all human habitancy ere they crumble away.

## AGE OF THE CASCADE RANGE

IN the history of earth features, eons, eras, period and epoch correspond to the generations, the life-times, cycles, and the seasons of human development. The occurrence of important human events is chronicled in terms of years and centuries, of kingdoms and dynasties. So too, may we separate and denominate the various stages of earth history and classify the evolutionary

**NOTE: Reference to the cross-section sketch of the Cascade Range accompanying this paper will, it is believed, greatly assist in gaining a correct idea of its structure and history.**

**Fossil leaves of the birch or alder, found in a bed of ashy shale in the Eagle creek formation, canyon of Eagle creek, near the Columbia River Highway. Geologists say these trees lived and died in Oligocene time, how many millions of years ago we do not know; and their leaves were entombed and preserved in the river muds in which we now find them**
Photo by R. W. Chaney

changes through which it has passed. As now, both plant and animal life have long existed on the earth. All life has been slowly changing, early forms disappearing to be succeeded by new and in general more highly organized types. We find the evidence of these changes entombed today as fossils in the rocks that were formed when each lived and died. And their recognition provides the measuring scale whereby the age of the rocks may be determined.

**Eagle Creek flora**

What more natural thought than to ask when did the Cascades uplift occur? In other words, what is the age of the Cascade Range, and how long ago did the Columbia begin to cut its gorge? We recall that the bulk of its structure is composed of lavas that were highly heated or molten when they came to rest, in which, therefore, there is little hope of finding recognizable remains of the organic life of their day. Both above and below the Columbia river basalt, however, there is a sedimentary formation, and in both of them

**Fossil leaf (natural size) of a species of the black oak, not now living, occurring plentifully in a bed of ashy shale in the Eagle creek formation (Oligocene) Eagle creek canyon, Columbia river gorge. This formation represents a time period prior to the coming of the thousands of feet of Columbia river basalt, hence long before the present Columbia river or its gorge were in existence**

Photo by R. W. Chaney

has our search been most abundantly rewarded. As already stated, in the Eagle creek formation, at the mouth of Moffett creek, along Eagle creek, and elsewhere, ashy clay beds have been discovered that carry the fossil remains of a fairly extensive flora. At the former place Professor LeConte long ago identified the leaves of two different species of oak and one of conifer; and Mr. J. S. Diller later found in addition both poplar and maple. The Eagle creek fossil-bearing bed was opened up in the summer of 1915 in the progress of trail-building by the U. S. Forest Service. Among the many perfect specimens collected from it by Mr. Ralph W. Chaney, then of the University of Chicago, he has recognized at least 20 different genera and some 40 species. These include the maple, black oak, sweet gum, smilax or greenbrier, elm, walnut, sycamore, magnolia, sumac, cherry, poplar, horn-beam, birch, alder, pine, fan palm, fig, plum, the ginkgo and willow. What luxuriance of forest growth must this have been! And though of types that yet flourish upon the earth, the individual species found in these ancient beds are now all extinct.

**Age of Eagle creek formation**

It was the conclusion of both LeConte and Diller that the flora found in what we are now to call the Eagle creek formation was representative of the Miocene epoch of Tertiary times. From the new flora, we must now revise this conclusion and may fairly definitely say that this formation belongs to the next earlier epoch, the Oligocene. In this period, the Tertiary, geologists are practically agreed, there followed two other epochs, the Miocene and Pliocene, before the beginning of the Quarternary in which man first appeared. It would seem then that the Columbia river basalt, which rests upon the upper Oligocene Eagle creek formation, may belong either to that epoch, or more likely, to the succeding Miocene, or Pliocene, inasmuch as the top of the Eagle creek is an erosional surface, and represents thus a border line or interval of physiographic adjustment.

**Satsop flora**

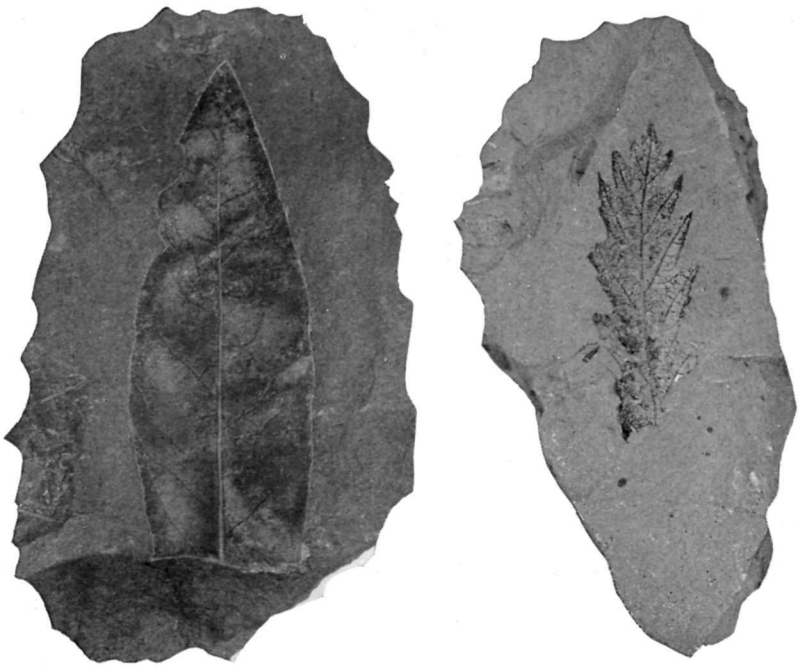
Yet above the basalt and entering into the deformation of the Cascade Range, is the ubiquitous Satsop. From its occurrence in the state of Washington this formation has been correlated by J. H. Bretz* as the equivalent of sedimentary beds widely distributed along the Oregon coast that were considered by J. S. Diller† in 1895 as belonging to the Pleistocene epoch of the Quaternary. In the absence of more definite data, we might accept such long range correlation and decide that the Satsop, as we have found it, is likewise Pleistocene. But fortunately for our cause, and through the efforts and knowledge of an enterprising citizen of Portland, Mr. J. B. Winstanley, these sedimentary strata have themselves been allured into the yielding up of their own secrets. Mr. Winstanley several years ago discovered a fossil-bearing bed of compact ashy shale in immediate association with the gravelly members of this formation, in the bed of Buck (also called Trapper) creek, a tributary entering the Sandy river about four miles barely west of south from Crown Point on the Columbia. Through the enthusiastic co-operation of this gentleman, and the assistance of Dr. R. W. Chaney, a representative collection of the plant remains from this locality was obtained. The fossil horizon is exposed three-fourths of a mile back from the Sandy river road, in the south side of the canyon of Buck creek 25 feet above the water, beneath an overhanging cliff of conglomeratic phase in which pebbles of polished quartzite are common. Mr. Chaney states that in this one exposure of the Satsop, four genera and at least seven species of plant life are represented. They in-

*Unpublished manuscript.
†17th Ann. Rep. U. S. G. S. 1895, Part I.

clude the oak, willow, walnut and the sequoia. The latter is apparently the living redwood of California. Both the oak and the willow likewise closely resemble their living relatives in that sister state at the south.

**Age of Satsop formation**

There are in this Satsop flora above the Columbia basalt, remains of several of the same genera found in the Eagle creek strata below that great body of lava, but their specific characters are so markedly more modern as to brand this flora at once as belonging to a distinctly later age. On the other



**Fossil leaves from the Satsop formation on Buck creek. These represent living species of the oak and willow, though long entombed in the ashy shale where they are now found. Specimens loaned by J. B. Winstanley.**

hand, this flora includes plants that at present grow upon the earth, most of them, however, flourishing only in the warmer climate of lower latitudes. Such equivalence to living forms might imply enforced migration, the retrieval of lost territory having not yet, to the present, been made. Or more likely, that the climate in which they grew, and prior to their displacement, was a more equable one than ours of today. In any case, similarity with land plants found elsewhere in undoubted Pleistocene strata, as well as with those of the present, affords us tentative grounds at least for saying with added confidence that the Satsop formation, as it enters into the structure of the Cascade Range, appears to belong to the Pleistocene.

In many parts of the world the Pleistocene epoch of the Quaternary period is characterized as a time of predominatingly widespread glaciation, the Glacial period. With the exception of the higher altitudes in the main mountain ranges, Oregon was not covered by the ice during glacial times. Portions of the state of Washington were ice-covered, a large part of Canada, and in the United States a vast area from the Missouri river to the Atlantic coast.

There must have been a general lowering of temperature to bring about frigid conditions, which, with the proximity of the great ice mantle itself could not but markedly affect the climatic conditions of Oregon. Ours was perhaps a sub-arctic, or even arctic climate, when glaciation was at its height. Both plant and animal life would, it would seem, be in part destroyed, and those surviving forced to migrate.

At any rate, the character of our Satsop flora indicates a set of climatic conditions far more moderate than probably existed in glacial times, whether or not they were more so than now. And the fact that these plants grew in this time period whose dominating feature elsewhere was the accumulation of ice and snow, makes us reasonably certain, that, here at least, a warm climate of considerable duration prevailed before frigid conditions came on. It would seem thus from the best evidence that the Pleistocene was an epoch of relatively greater length than ordinarily assumed, in which glaciation was an incident near its close, if it may yet be past, rather than the dominant event either in duration or evolutionary importance. Certain it is that the effect of the Glacial period in the Cascade Range of mountains in Oregon was but as a minor aftermath in comparison with the revolutionary significance of the master stroke of that geologic day, the uplift of this great range itself, and the outpouring of the thousands of feet of liquid lavas upon its summit. For we have seen that the Satsop beds, containing the remains of what is apparently Pleistocene plant life, enter into that uplift, as do also some of the andesitic lavas of equivalent and in some instances somewhat later age. The materials of which they are composed were thus accumulated before this mountain-making elevation began. We are led to the plausible inference that uplift, the eruption of lavas, and glaciation may all have been taking place here at the same time.

**Youth of Cascade Range**

How long ago was this? Those who have studied farthest into the evolutionary history of man are not agreed as to the definite geologic date of his coming upon the earth. It is fairly well established that he was present during certain of the later stages of the Glacial period. Some say man lived prior to the advent of the ice age. Yet others have found evidence of a possible ancestry antedating the Pleistocene entirely. We are thus not absolutely certain but that human beings may have trod the land of Oregon in Satsop, therefore pre-glacial times, and indeed while yet the position of the Cascade Range was but a rolling land surface with little relief, and the Columbia a meandering river of relatively sluggish mien. The chances that man was present at that early time, or that he existed anywhere upon the earth, are acknowledgedly rather scant. But the possibility is a fascinating as well as serviceable thought, insofar as man's connection with the course of recent earth events affords a comprehensible standard of measurement for their duration. And it shows to us that as earth changes go, the elevation of the Cascade Range, accompanied by its complete severance by the river which gave us the peerless Columbia gorge, is a momentous event of almost the immediate geologic past. If our deductions are proved correct, the uprising of its massive basalt foundation, accompanied and succeeded by the building of its summit heights, began at so late a day as to make of the Cascade Range one of the very youngest of the great mountain ranges of the world. This portion of it would be younger even, and by far, than the Oregon Coast Range, to which a state of comparative youth has long been ascribed.

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