GUIDEBOOK
OF THE
WESTERN UNITED STATES

PART A. THE NORTHERN PACIFIC ROUTE
WITH A SIDE TRIP TO YELLOWSTONE PARK

By
Marius R. Campbell and others

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## PRINCIPAL DIVISIONS OF GEOLOGIC TIME

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<table>
<thead>
<tr>
<th>Era.</th>
<th>Period.</th>
<th>Epoch.</th>
<th>Characteristic life.</th>
<th>Duration according to various estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenozoic (recent life).</td>
<td>Quaternary.</td>
<td>Recent. Pleistocene (Great Ice Age).</td>
<td>&quot;Age of man.&quot; Animals and plants of modern types.</td>
<td>1 to 5.</td>
</tr>
<tr>
<td></td>
<td>Mesozoic (intermediate life).</td>
<td>Cretaceous.</td>
<td>(b)</td>
<td>&quot;Age of reptiles.&quot; Rise and culmination of huge land reptiles (dinosaurs), of shellfish with complexly partitioned coiled shells (ammonites), and of great flying reptiles. First appearance (in Jurassic) of birds and mammals; of cycads, an order of palmlike plants (in Triassic), and of angiospermous plants, among which are palms and hardwood trees (in Cretaceous).</td>
</tr>
<tr>
<td></td>
<td>Jurassic.</td>
<td>(b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carboniferous.</td>
<td>Devonian.</td>
<td>(b)</td>
<td>&quot;Age of fishes.&quot; Shellfish (mollusks) also abundant. Rise of amphibians and land plants.</td>
</tr>
</tbody>
</table>
### Paleozoic (old life)

<table>
<thead>
<tr>
<th>Epoch</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silurian</td>
<td>(b) Shell-forming sea animals dominant, especially those related to the nautilus (cephalopods). Rise and culmination of the marine animals sometimes known as sea lilies (crinoids) and of giant scorpion-like crustaceans (eurypodids). Rise of fishes and of reef-building corals.</td>
</tr>
</tbody>
</table>

| Ordovician | (b) Shell-forming sea animals especially cephalopods and mollusk-like brachiopods, abundant. Culmination of the buglike marine crustaceans known as trilobites. First trace of insect life. |

| Cambrian | (b) Trilobites and brachiopods most characteristic animals. Seaweeds (algae) abundant. No trace of land animals found. |

### Proterozoic (primordial life)

<table>
<thead>
<tr>
<th>Epoch</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algonkian</td>
<td>(b) First life that has left distinct record. Crustaceans, brachiopods, and seaweeds.</td>
</tr>
</tbody>
</table>

| Archean | Crystalline rocks. | No fossils found. | 50+ |

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*a* The geologic record consists of sedimentary beds—beds deposited in water. Over large areas long periods of uplift and erosion intervened between periods of deposition. Every such interruption in deposition in any area produces there what geologists term an unconformity. Many of the time divisions shown above are separated by such unconformities—that is, the dividing lines in the table represent local or widespread uplifts or depressions of the earth's surface.

*b* Epoch names omitted; in less common use than those given.
PREFACE

By GEORGE OTIS SMITH.

The United States of America comprise an area so vast in extent and so diverse in natural features as well as in characters due to human agency that the American citizen who knows thoroughly his own country must have traveled widely and observed wisely. To "know America first" is a patriotic obligation, but to meet this obligation the railroad traveler needs to have his eyes directed toward the more important or essential things within his field of vision and then to have much that he sees explained by what is unseen in the swift passage of the train. Indeed, many things that attract his attention are inexplicable except as the story of the past is available to enable him to interpret the present. Herein lie the value and the charm of history, whether human or geologic.

The present stimulus given to travel in the home country will encourage many thousands of Americans to study geography at first hand. To make this study most profitable the traveler needs a handbook that will answer the questions that come to his mind so readily along the way. Furthermore, the aim of such a guide should be to stimulate the eye in the selection of the essentials in the scene that so rapidly unfolds itself in the crossing of the continent. In recognition of the opportunity afforded in 1915 to render service of this kind to an unusually large number of American citizens, as well as to visitors from other countries, the United States Geological Survey has prepared a series of guidebooks \(^1\) covering four of the older railroad routes west of the Mississippi.

\(^1\)Guidebook of the western United States: Part A, The Northern Pacific Route, with a side trip to Yellowstone Park (Bulletin 611); Part B, The Overland Route, with a side trip to Yellowstone Park (Bulletin 612); Part C, The Santa Fe Route, with a side trip to the Grand Canyon of the Colorado (Bulletin 613); Part D, The Shasta Route and Coast Line (Bulletin 614).

These books are educational in purpose, but the method adopted is to entertain the traveler by making more interesting what he sees from the car window. The plan of the series is to present authoritative information that may enable the reader to realize adequately the scenic and material resources of the region he is traversing, to comprehend correctly the basis of its development, and above all to appreciate keenly the real value of the country he looks out upon, not as so many square miles of territory represented on the map in a railroad folder by meaningless spaces, but rather as land—real estate, if you please—varying widely in present appearance because differing largely in its history, and characterized by even greater variation in values because possessing diversified natural resources. One region may be such as to afford a livelihood for only a pastoral people; another may present opportunity for intensive agriculture; still another may contain hidden stores of mineral wealth that may attract large industrial development; and, taken together, these varied resources afford the
promise of long-continued prosperity for this or that State.

Items of interest in civic development or references to significant epochs in the record of discovery and settlement may be interspersed with explanations of mountain and valley or statements of geologic history. In a broad way the story of the West is a unit, and every chapter should be told in order to meet fully the needs of the tourist who aims to understand all that he sees. To such a traveler-reader this series of guidebooks is addressed.

To this interpretation of our own country the United States Geological Survey brings the accumulated data of decades of pioneering investigation, and the present contribution is only one type of return to the public which has supported this scientific work under the Federal Government.

In the preparation of the description of the country traversed by the Northern Pacific Route the geographic and geologic information already published as well as unpublished material in the possession of the Geological Survey has been utilized, but to supplement this material Mr. Campbell made a field examination of the entire route in 1914. Information has been furnished by others, to whom credit is given in the text. Cooperation has been rendered by the United States Reclamation Service, railroad officials and other citizens have generally given their aid, and other members of the Survey have freely cooperated in the work. For the purpose of furnishing the traveler with a graphic presentation of each part of his route, the accompanying maps, 27 sheets in all, have been prepared, with a degree of accuracy probably never before attained in a guidebook, and their arrangement has been planned to meet the convenience of the reader. The special topographic surveys necessary to complete these maps of the route were made by J. G. Staack, C. L. Sadler, J. L. Lewis, N. E. Ballmer, and W. O. Tufts.
GUIDEBOOK OF THE WESTERN UNITED STATES.

PART A. THE NORTHERN PACIFIC ROUTE, WITH A SIDE TRIP TO YELLOWSTONE PARK.

By MARIUS R. CAMPBELL and others.

INTRODUCTION

If his journey to the Pacific coast begins at one of the great cities on the Atlantic seaboard, the traveler, when he reaches St. Paul, the eastern terminus of the Northern Pacific Railway, will have gone nearly halfway across North America. He will have traversed or perhaps gone around the Appalachian Mountain region and then crossed the prairie States, which, in wealth and population, form in themselves an empire.

St. Paul is in the prairie region, but the boundary between the prairies and the Great Plains is vague and undefined, and the traveler will at no place perceive the change from prairie to plain or from the East to the West. On leaving St. Paul he first passes across rolling prairies, interspersed with forests of pine and hardwood trees, and within a short distance these prairies give place to the vast treeless plains which, stretching a thousand miles west of the Mississippi, rise almost imperceptibly to the foothills of the Rocky Mountains. The annual rainfall diminishes in the same direction from 28 inches at St. Paul to only half that amount in central Montana, and the traveler, as he goes Westward, will note more and more of the features that he has habitually associated with the West. Prairie dogs and jack rabbits are seen; one by one the flowers and shrubs of the Mississippi Valley disappear and are replaced by those of a semiarid country; trees grow only on the moist bottom lands along the streams; intensive cultivation is possible only in the valleys, though the uplands are being brought into use by dry farming and are yielding fair crops of the more hardy grains.

Throughout much of the region traversed the face of the country has been greatly modified by the vast ice sheets of the glacial period which covered the northern part of the continent and left immense deposits of loose material on the surface of hard rock in the northern part of the United States. The history and the phenomena of this glaciation are considered in detail at several places in this book.

The general features of the country west of the Mississippi are represented on Plate I. When, after crossing the Great Plains, the traveler reaches the foothills of the Rocky Mountains he will have attained a height of 4,000 feet above the sea, a height reached by few peaks in the Eastern States outside of the Adirondacks and the White Mountains. The Rocky Mountains form a great, irregular, rough-hewn "backbone" for the continent. They comprise many groups of ranges, in which some peaks in Montana and Idaho reach a height of 12,000 feet above sea level and some in Colorado rise more than 14,000 feet.
The western mountains, like the eastern, are the worn remnants of upward folds or crumples or of upheaved blocks of the fractured earth crust, but, unlike the eastern mountains, which are geologically old, the western mountains are geologically very young. They are therefore higher, for since they were uplifted there has not been time for ice, rain, heat, frost, and wind to wear them down to lower levels.

West of the Rocky Mountains lies a broad interior basin, in the northern part of which, with its inclosing mountains, there is sufficient rain and snow to maintain the flow of the great Columbia River; but in the southern part, in what is known as the Great Basin, the mountain streams find no outlets to the sea, their waters, so precious for irrigation, being soon lost in the thirsty lowlands, and the feeble or intermittent rivers of the valleys carry their waters down to be evaporated in alkali marshes or on saline deserts.

The part of the Columbia River basin or plateau that is traversed by the Northern Pacific Railway is made up of lava flows, among the greatest in the world, which in comparatively recent geologic time spread like a fiery flood over hundreds of thousands of square miles; and a wide expanse of hard, dark volcanic rocks, whose surface is here and there cut deeply by streams, shows the enormous extent and volume of these eruptions. The part of this old lava plain that is crossed by Columbia River is the most arid region traversed by this route. The precipitation in this region is sometimes not more than 6 inches annually, but despite the small rainfall the uplands have become the great wheat-raising country of the Northwest.

The last great natural feature to be crossed by the traveler is the Cascade Range, which separates the interior basin from the region of Puget Sound. This range is a broad upland that stands from 6,000 to 8,000 feet above the sea, and here the evidences of volcanic activity continue to be conspicuous. On the flanks of the range rise the snow-covered peaks of Mount Rainier, Mount Adams, and other cones, which were once active volcanoes, pouring forth streams of lava and showers of rock fragments. Of these great conical masses, built up by successive lava flows and by the accumulation of rock fragments blown from the craters, the highest is Mount Rainier, towering 14,408 feet above Puget Sound, from which it presents a magnificent spectacle, its upper slopes covered by great streams of moving ice, the largest
glaciers in the United States south of Alaska.

On emerging from the Cascades the traveler enters a broad lowland, which is separated from the Pacific Ocean by the Olympic Mountains, but which contains Puget Sound with its many branching waterways, one of the most remarkable bodies of salt water on the globe.

NOTE.—For the convenience of the traveler the sheets of the route map in this bulletin are so arranged that he can unfold them, one by one and keep each one in view while he is leading the text relating to it. A reference is made in the text to each sheet at the place where it should be so unfolded, and the areas covered by the sheets are shown on Plate I. A list of these sheets and of other illustrations, showing where each one is placed in the book, is given on pages 205-207. A glossary of geologic terms is given on pages 199-203 and an index of stations on pages 209-212.
The traveler who is interested in the geologic history of this country—a history that reaches back into the dim and misty past, to a time long before Father Hennepin first saw the Falls of St. Anthony and the Mississippi Valley in 1680—will find much to attract his attention about St. Paul and Minneapolis. If he has only a few hours at his disposal he can easily obtain a general view of the valley of the Mississippi and the rocks composing its bluffs from the Robert or Wabasha Street Bridge in St. Paul, both of which are within a few minutes' walk of the Union Station. If he chooses the Wabasha Street Bridge, which in some respects affords a better view, he will see that the Mississippi is flowing in a broad valley from 100 to 200 feet deep. In some places the walls of the valley are composed of solid rock, but in others they are made up of loose material, such as clay, sand, or gravel, which forms either large masses or is spread as a thin coating over the rocky slopes. As the valley has been cut in the hard rock by the river, it is a record of stream carving and of the climatic and geographic conditions under which the carving was done. Not only are the recent events of geologic history recorded in the size and shape of the valley, but the much earlier events in the history of the globe have left a record in the solid rock itself—a record that, when correctly read, tells of the presence of a sea in which limy muds were accumulating or along the shore of which sand was washed back and forth by the waves or drifted into heaps by the wind. Every one is more or less familiar with the history of Minnesota during the last 250 years, or since the white man first visited the region, but few know anything of the far more ancient history recorded in the rocks and in the hills and valleys of the region. It is to this ancient history, dealing with the time before man is supposed to have existed upon the globe, that the reader's attention is now invited.

The bluff upon which the Wabasha Street Bridge rests is composed almost entirely of white sandstone (St. Peter\(^1\)), which is very, very old, but despite its great age is so soft that it can be crushed in the hand. Streams of water flowing through the rock have carved great underground channels in it, and more recently boys have dug caves in the soft sand along the river front directly below the bridge. Jonathan Carver, in describing his journey to this region in 1766, mentions a large cave in the St. Peter sandstone about 30 miles below the Falls of St. Anthony, a cave called by the Indians the "Dwelling of the Great Spirit." In this cave they held religious ceremonies, and near it they buried their dead. When the sandstone is examined under a magnifying glass it is found to be composed of beautifully white translucent grains of quartz, resembling rock candy except that the fragments are round instead of angular. The even lines of bedding, which can be seen from either of the bridges mentioned, show that the sand must have been laid down in water, but the forms of the individual grains show with equal certainty that the sand before it was washed into the ocean and deposited along the shore was blown about by the wind and perhaps heaped into large dunes, such as are now seen around the head of Lake Michigan south of Chicago.

\(^1\)The rocks exposed at the surface in the vicinity of St. Paul and those revealed
by deep drilling are shown in the table on page 9. The natural order of the formations named in the table, from top to bottom, is shown by the order in which the names are printed. The place of each of the larger units of rock or of time (as Cambrian, Ordovician) in the general geologic column is shown in the table on page 2.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Thickness in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galena limestone (exposed)</td>
<td>15</td>
</tr>
<tr>
<td>Decorah shale (exposed)</td>
<td>60</td>
</tr>
<tr>
<td>Platteville limestone (exposed)</td>
<td>30</td>
</tr>
<tr>
<td>St. Peter sandstone (exposed)</td>
<td>150</td>
</tr>
<tr>
<td>Shakopee dolomite</td>
<td>60</td>
</tr>
<tr>
<td>Oneota dolomite</td>
<td>100</td>
</tr>
<tr>
<td><strong>Ordovician</strong></td>
<td><strong>415</strong></td>
</tr>
<tr>
<td>Jordan sandstone</td>
<td>75</td>
</tr>
<tr>
<td>St. Lawrence formation</td>
<td>100</td>
</tr>
<tr>
<td>Franconia sandstone, Dresbach sandstone, and underlying rocks</td>
<td>500</td>
</tr>
<tr>
<td><strong>Cambrian</strong></td>
<td><strong>675</strong></td>
</tr>
<tr>
<td>Red clastic series (Algonkian?)</td>
<td>1,125</td>
</tr>
<tr>
<td>Granite</td>
<td>2,215</td>
</tr>
</tbody>
</table>

The St. Peter sandstone, on account of its purity, is well adapted to glass making and in many places it is used for that purpose. It extends from St. Paul southward as far as central Arkansas and eastward as far as Detroit, and probably once extended much farther north, but in that direction it has been eroded—worn away by frost, rains, and streams—until all trace of it is lost. On account of its wide distribution and the purity of the materials that compose it, this deposit of sand is one of the most remarkable in the world.

Above this sandstone, if stone it may be called, lies a thin-bedded limestone known as the Platteville, which can be seen at the entrance to the Wabasha Street Bridge and which was formerly used about the "twin cities" for building material. The stone occurs, however, in thin layers and does not stand the weather well, so that very little of it is now used. This limestone contains here and there fossil sea shells, which show clearly that the sandy shore of the St. Peter epoch finally sank and was covered by the sea. The shells of the animals that inhabited this sea sank to the bottom when the animals died and were buried in the limy mud that later became hardened into limestone, which preserved not only the shells but all the beautiful ornamentation on their surfaces.

If the traveler can spend a day or two here instead of a few hours, he may take many pleasant rides by trolley or automobile into the surrounding country to places of historic and scenic interest. Whether his visit is one of business or one of pleasure, he should not fail to see old Fort Snelling and the Falls of Minnehaha. Fort Snelling stands on the green, tree-shaded bluffs that overlook the peaceful valley of the Mississippi, and it is hard to realize that when
it was established, only a few years after Zebulon M. Pike made his journey to the source of
the Mississippi,¹ it was in the heart of the Indian country. It is doubtful if at that time anyone
dreamed that near its site would rise such cities as St. Paul and Minneapolis. In the early days
Fort Snelling was the starting point of several military expeditions that were sent out to
explore the great Northwest.

¹Soon after the acquisition from France of Louisiana, which included most of
the territory west of Mississippi River, Lieut. Z. M. Pike was commissioned by
President Jefferson to explore the new territory and to find the source of the
river. When Pike reached the mouth of St. Peter (now Minnesota) River, in 1805,
he recognized the strategic importance of the point for military purposes and
procured from the Indians title for the Government to the land from the mouth of
St. Peter River to and including the Falls of St. Anthony. In his report on the
explorations he recommended that a fort be established on the bluff between St.
Peter and Mississippi rivers. Nothing came of his recommendation until February
10, 1819, when John C. Calhoun, Secretary of War, ordered the Fifth Infantry,
under Col. Henry Leavenworth, to establish headquarters at this place. Col.
Leavenworth reached the mouth of St. Peter River on September 24 of the same
year, but instead of occupying the bluff recommended by Pike he camped across
the river, where the village of Mendota now stands. In 1820 Col. Leavenworth
was relieved by Col. Josiah Snelling, who determined to build a permanent post
on the spot originally selected by Pike. The corner stone is supposed to have
been laid on September 10, 1820, and the post was occupied by the troops in
1822. The fort was originally called St. Anthony, but the name was changed to
Snelling at the recommendation of Gen. Winfield Scott, who visited it while on a
tour of inspection in 1824. Fort Snelling has been continuously occupied as a
military post from 1822 to the present time.

The Falls of Minnehaha, which are about 2-1/2 miles farther north, offer none of the sinister
suggestions of war that still linger round the fort; on the contrary, they have an atmosphere of
love and romance, and the journey of Hiawatha and Minnehaha, as related by Longfellow, is
fittingly commemorated by a bronze group at the head of the falls. (See Pl. II.)
Fort Snelling and the Falls of Minnehaha can be reached from St. Paul by several routes, but whoever wishes to see the rocks and the way they have been carved by the streams should take the Snelling car, which follows the Mississippi upstream for about 6 miles directly to Fort Snelling. The roadway is on a bench or terrace nearly half a mile wide, which stands about 100 feet above the river and on a part of which the business portion of St. Paul has been built. The terrace is underlain by the Platteville limestone, which may be seen at a number of places, and it is evidently a remnant of a valley that existed there before the present channel of the river was excavated in its floor. The accompanying diagram (fig. 1) is a cross section of the valley as it appears to-day. If the channel of the river should be filled to the broken line it would represent the valley floor as it was before the present channel was cut, when the river was flowing at the level of the terrace. As the rocks are not exposed at any place in the bottom of the valley it is evident that the old rock-cut valley has been filled by sediment (alluvium) brought down by the stream, but the depth of this filling has not been accurately determined. A deep well sunk in St. Paul northeast of the Union Station struck solid rock 100 feet below river level. At some remote time the river channel was therefore at least 100 feet deeper than it is now, and since that time it has been filled by mud and sand up to the level of the present river bottom.
At Fort Snelling the main valley continues to the southwest, but it is occupied only by Minnesota River,¹ a stream manifestly too small for the valley in which it is flowing; and, on the other hand, Mississippi River above Fort Snelling is out of proportion to the narrow gorge in which it is confined. To even the most casual observer the streams appear to be misplaced; the larger stream is flowing in the smaller valley and vice versa. The size and relation of the river valleys about St. Paul show clearly that they have undergone many changes which do not occur in streams developing under normal conditions. Changes of this kind have taken place in many of the streams in the northern part of the United States. They are due to the invasion of this country at various epochs in the past by great glaciers which filled existing valleys with the mud, sand, and gravel that they brought in from the north. (See footnote on pp. 26-30.) When the ice vanished the streams found different courses, developing lakes and falls, features characteristic of a newly established drainage system.

¹Featherstonhaugh says that the Indian name of this river was Minnay Sotor, meaning turbid waters. By the early white settlers the name St. Peter was applied to it; but later the Indian name was revived, with the spelling Minnesota.

Thus the original drainage about St. Paul consisted of a stream flowing southeastward through the city and following the present course of Mississippi River to a point 10 or 12 miles below St. Paul, where it was joined by a large stream from the west, which crossed the present river valley 4 or 5 miles above Fort Snelling. At that time there was no stream flowing from Fort Snelling to St. Paul. This area was then a rocky upland.

When the western ice sheet (see route map, sheet 1, p. 20) melted back from this region, all these old stream channels were filled with glacial materials, and the principal streams were developed along their present courses. After a time the glacier, which came from the north or northwest, melted back into the Red River valley, and Lake Agassiz (ag'a-see) came into existence. (See footnote on p. 32.) Warren River, the outlet of this large body of water, occupied the present valley of Minnesota River and received Mississippi River as a tributary from the north. This great river flowed across the rocky upland between Fort Snelling and St. Paul and cut a broad valley, upon the floor of which St. Paul has been built. Where it joined the old valley, at the site of St. Paul, there was a waterfall many times the size of St. Anthony. This fall gradually receded upstream until it reached the other old valley above Fort Snelling, and thus the inner rock gorge shown in the diagram was cut.

The gorge of the Mississippi from Fort Snelling to the Falls of St. Anthony, which are a short distance below the station in Minneapolis, shows from its extreme narrowness that it is new and that it has only recently been carved out of the solid rock by the swiftly flowing stream.¹ in fact, the process of carving the gorge of the Mississippi is still in operation, or was before it was arrested by the hand of man. Rivers always deepen their channels toward the head of
the stream, and the Falls of St. Anthony have doubtless receded slowly from a point near the edge of the main valley at Fort Snelling to their present position. As the rate of recession of this fall has apparently been fairly uniform, and as the distance which the fall has retreated is well known, it has been used in making estimates of the time that has elapsed since the river first started to cut its gorge near Fort Snelling. According to the best estimate, the fall has been 12,000 years in traveling from the vicinity of Fort Snelling to its present position, and it has been 8,000 years since glacial Warren River ceased to flow and the present river system came into existence.

Many take it for granted that the surface features of the earth have always been the same as they are to-day, that the valleys have always been valleys and the hills and mountains always eminences overlooking them. The incorrectness of such an assumption, however, can be realized by watching any small stream or rill after or during a rain. It will be seen that the stream is busily engaged in cutting the sand or clay over which it flows and carrying it down the valley to be dropped where the current slackens in some pond or lake. Every fragment, as it is loosened from the bed of the stream, is carried or rolled along by the water a few inches or a few feet and then dropped, because the stream is unable to move it farther, as a tired man lays down his burden a moment to rest. By dropping many grains the power of the water is restored and the grain of sand is again picked up, as the man recovers strength and resumes his burden, and is carried or rolled along for a short distance farther. This operation is repeated many, many times, until the grain of sand is finally transported to the sea and finds a resting place upon its sandy shore.

The method by which a stream cuts hard rocks is not so obvious as that by which it cuts sand and clay. The cutting is not done by the water itself, for water alone has no cutting power. The grains of sand and the pebbles that are swept along by the current act as a great rasp, scouring and cutting the hard rocks over which they are carried. Thus grain by grain the rocks are worn away and grain by grain the material is carried to the sea. The process, though slow, never stops; and in time it carves such gorges as that of the Mississippi and even the deeper canyons found in the western mountains.

When the receding Falls of St. Anthony reached and passed the mouth of Minnehaha Creek that stream plunged into the deepened gorge and the Falls of Minnehaha originated. Since that time they have been worn back about 400 feet to their present position. Each day some particle of rock is dislodged or worn away, and gradually the falls are working back up the stream. In the course of time they will reach Lake Minnetonka, and then this beautiful sheet of water will be drained, but that catastrophe will occur so far in the future that the owners of the hotels and summer cottages that line its shore need not be alarmed.

Lake Minnetonka is also the direct result of the occupation of the country by the ice, as are the 10,000 other lakes which Minnesota is reported to contain. Their mode of origin, which is extremely interesting, will be discussed in connection with a description of the many other lakes that will come into the traveler's view as he continues his westward journey. Lake Minnetonka is easily reached by trolley from both St. Paul and Minneapolis, and an afternoon or evening spent along its beautiful shores makes a most acceptable break in a long transcontinental journey. White Bear Lake, about 6 miles north of St. Paul, bears the same relation to that city as a summer resort that Lake Minnetonka bears to Minneapolis.

The site of the present city of St. Paul is said to have been a favorite gathering ground for the
Sioux Indians long before white men invaded their hunting grounds, and it is probable that for many generations Indian villages stood within what are now the city limits. When the white men came they located at Mendota, on the south side of Mississippi River near the mouth of the Minnesota, and this was the first settlement in the State. What is now the city of St. Paul was settled more recently, and its origin and the manner in which it received its name are interesting events in the history of this region.1

1When the military post of Fort Snelling was established, in 1820, the boundaries of the reservation had not been determined and consequently the post was overrun with all sorts of camp followers. In 1839 the limits of the reservation were fixed and efforts were made to eliminate the undesirable element, but not until May 6, 1840, were the troops successful in evicting all the roughs and in demolishing their cabins. The evicted persons crossed the river and started a hamlet near the spot where the Union Station at St. Paul now stands. This was soon graced by a Roman Catholic chapel called St. Paul's, which gave its name to the village. From such inauspicious beginnings the city has developed.
IMPORTANT PAPERS ON THE GEOGRAPHY, GEOLOGY, AND HISTORY OF THE REGION TRAVERSED BY THE NORTHERN PACIFIC RAILWAY

MINNESOTA.


NORTH DAKOTA.


MONTANA.

BARRELL, JOSEPH, Geology of the Marysville mining district, Mont.: U. S. Geol. Survey Prof. Paper 57, 1907.


______. The Electric coal field, Park County, Mont.: U. S. Geol. Survey Bull. 471, pp. 406-
422, 1912.


IDAHO.

WASHINGTON.


EVANS, G. W., The coal fields of King County, Wash.: Washington Geol. Survey Bull. 3, 1912.


GENERAL.

COUES, ELLIOTT, History of the expedition under the command of Lewis and Clark, 4 vols., New York, Francis P. Harper, 1893.

GANNETT, HENRY, Boundaries of the United States and the several States and Territories, with an outline of the history of all important changes of territory: U. S. Geol. Survey Bull. 226, 1904.


GLOSSARY OF GEOLOGIC TERMS

Alluvial fan. The outspread sloping deposit of bowlders gravel, and sand left by a stream where it passes from a gorge out upon a plain.

Andesite. A lava of widespread occurrence, usually of dark-gray color and intermediate in chemical composition between rhyolite and basalt.

Anticline. Arch of bedded or layered rock suggestive in form of an overturned canoe. (See fig. 20, p. 102.) (See also Dome and Syncline.)

Badlands. A region nearly devoid of vegetation where erosion, instead of carving hills and valleys of the familiar type, has cut the land into an intricate maze of narrow ravines and sharp crests and pinnacles. Travel across such a region is almost impossible, hence the name. (See Pls. VI—IX, pp. 62-63.)

Basalt. A common lava of dark color and of great fluidity when molten. Basalt is less siliceous than granite and rhyolite, and contains much more iron, calcium, and magnesium.

Bolson (pronounced bowl-sown'). A flat-floored desert valley that drains to a central evaporation pan or playa.

Bomb. See Volcanic bomb.

Breccia (pronounced bretch'a). A mass of naturally cemented angular rock fragments.

Crystalline rock. A rock composed of closely fitting mineral crystals that have formed in the rock substance as contrasted with one made up of cemented grains of sand or other material or with a volcanic glass.

Diabase. A heavy, dark, intrusive rock having the same composition as basalt, but, on account of its slower cooling, a more crystalline texture. Its principal constituent minerals are feldspar, augite, and usually olivine. Olivine is easily changed by weathering, and in many diabases is no longer recognizable. Augite is a mineral containing iron and magnesiam and is similar to hornblende.

Dike. A mass of igneous rock that has solidified in a wide fissure or crack in the earth's crust. (See fig. 15, p. 95.)

Diorite. An even-grained intrusive igneous rock consisting chiefly of the minerals feldspar, hornblende, and very commonly black mica. If the rock contains muck quartz, it is called quartz diorite. Quartz diorite resembles granite and is connected with that rock by many intermediate varieties, including monzonite. The feldspar in diorite differs from that in granite in containing calcium and sodium instead of potassium. Hornblende is a green or black
mineral containing iron, magnesium, calcium, and other constituents.

Dip. The slope of a rock layer expressed by the angle which the top or bottom of the layer makes with a horizontal plane. (See fig. 2, p. 17.)

Dissected. Cut by erosion into hills and valleys. Applicable especially to plains or peneplains in process of erosion after an uplift.

Dome. As applied to rock layers or beds, a short anticline, suggestive of an inverted basin.

Drift. The rock fragments—soil, gravel, and silt—carried by a glacier. Drift includes the unassorted material known as till and deposits made by streams flowing from a glacier.

Erosion. The wearing away of materials at the earth's surface by the mechanical action of running water, waves, moving ice, or winds, which use rock fragments and grains as tools or abrasives. Erosion is aided by weathering. (See Weathering.)

Fault. A fracture in the earth's crust accompanied by movement of the rock on one side of the break past that on the other. If the fracture is inclined and the rock on one side appears to have slid down the slope of the fracture the fault is termed a normal fault. If, on the other hand, the rock on one side appears to have been shoved up the inclined plane of the break, the fault is termed a reverse fault. (See fig. 20, p. 102; fig. 23, p. 112, and fig. 30, p. 143.)

Fault block. A part of the earth's crust bounded wholly or in part by faults.

Fault scarp. The cliff formed by a fault. Most fault scarps have been modified by erosion since the faulting.

Fauna. The animals that inhabited the world or a certain region at a certain time.

Fissure. A crack, break, or fracture in the earth's crust or in a mass of rock.

Flood plain. The nearly level land that borders a stream and is subject to occasional overflow. Flood plains are built up by sediment left by such overflows.

Flora. The assemblage of plants growing at a given time or in a given place.

Fold. A bend in rock layers or beds. Anticlines and synclines are the common types of folds. (See fig. 28, p. 129, and fig. 31, p. 144.)

Formation. A rock layer, or a series of continuously deposited layers grouped together, regarded by the geologist as a unit for purposes of description and mapping. A formation is usually named from some place where it is exposed in its typical character. For example, Denver formation, Niobrara limestone.

Fossil. The whole or any part of an animal or plant that has been preserved in the rocks or the impression left by a plant or animal. This preservation is in variably accompanied by change in substance, and from some impressions the original substance has all been removed. (See Pls. VI, A, p. 62; XI, B, p. 75.)

Gneiss (pronounced nice). A rock resembling granite, but with its mineral constituents so arranged as to give it a banded appearance. Most gneisses are metamorphic rocks derived from granite or other igneous rocks.

Granite. A crystalline igneous rock that has solidified slowly deep within the earth. It consists chiefly of the minerals quartz, feldspar, and one or both of the common kinds of mica,
namely, black mica, or biotite, and white mica, or muscovite. The feldspar is the kind known as orthoclase, and may be distinguished from quartz by its pale-reddish tint and its property of breaking with flat shining surfaces (cleavage), for quartz breaks irregularly. The micas are easily recognized by their cleavage into thin, flexible flakes and their brilliant luster.

Horizon. In geology any distinctive plane traceable from place to place in different exposures of strata and marking the same period of geologic time. A particular horizon may be characterized by distinctive fossils.

Igneous rocks. Rocks formed by the cooling and solidification of a hot liquid material known as magma, that has originated at unknown depths within the earth. Those that have solidified beneath the surface are known as intrusive rocks, or, if the cooling has taken place slowly at great depth, as plutonic intrusive or plutonic rocks. Those that have flowed out over the surface are known as effusive rocks, extrusive rocks, or lavas. The term volcanic rocks includes not only lavas but bombs, pumice, tuff, volcanic ash, and other fragmental materials or ejecta thrown out from volcanoes.

Lithologic. Pertaining to lithology, or the study of rocks. (See also Petrology.) Pertaining to rock character.

Lode. An ore-bearing vein (see Vein); especially a broad or complex vein.

Loess (pronounced lurse with the r obscure). A fine homogeneous silt or loam showing usually no division into layers and forming thick and extensive deposits in the Mississippi Valley and in China. It is generally regarded as in part at least a deposit of wind-blown dust.

Meander. To flow in serpentine curves. A loop in a stream. The term comes from the Greek name of a river in Asia Minor, which has a sinuous course. Most streams in flowing across plains develop meanders. (See Pl. III, A, p. 11.)

Metamorphism. Any change in rocks effected in the earth by heat, pressure, solutions, or gases. A common cause of the metamorphism of rocks is the intrusion into them of igneous rocks. Rocks that have been so changed are termed metamorphic.

Monzonite. An even-grained intrusive igneous rock intermediate in character between diorite and granite. It resembles granite.

Moraine. A mass of drift deposited by a glacier at its end or along its sides.

Oil pool. An accumulation or body of oil in sedimentary rock that yields petroleum on drilling. The oil occurs in the pores of the rock and is not a pool or pond in the ordinary sense of these words.

Outcrop. That part of a rock that appears at the surface. The appearance of a rock at the surface or its projection above the soil.

Paleontology. The study of the world's ancient life, either plant or animal, by means of fossils.

Peneplain. A region reduced almost into a plain by the long-continued normal erosion of a land surface. It should be distinguished from a plain produced by the attack of waves along a coast or the built-up flood plain of a river.

Petrography. The description of rocks, especially of igneous and metamorphic rocks, studied with the aid of the microscope.
Petrology. The study of rocks, especially of igneous and metamorphic rocks.

Placer deposit. A mass of gravel, sand, or similar material resulting from the crumbling and erosion of solid rocks and containing particles or nuggets of gold, platinum, tin, or other valuable minerals, which have been derived from rocks or veins by erosion.

Playa (pronounced plah'yə). The shallow central basin of a desert plain, in which water gathers after a rain and is evaporated.

Porphyry. Any igneous rock in which certain crystal constituents are distinctly visible in contrast with the finer-grained substance of the rock.

Quartzite. A rock composed of sand grains cemented by silica into an extremely hard mass.

Rhyolite. A lava, usually of light color, corresponding in chemical composition to granite. The same molten liquid that at great depth within the earth solidifies as granite would, if it flowed out on the surface, cool more quickly and crystallize less completely as rhyolite.

Schist. A rock that by subjection to heat and pressure within the earth has undergone a change in the character of the particles or minerals that compose it and has these minerals arranged in such a way that the rock splits more easily in certain directions than in others. A schist has a crystalline grain roughly comparable with the grain of a piece of wood.

Sedimentary rocks. Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediment may consist of fragments or particles of various sizes (conglomerate, sandstone, shale); of the remains or products of animals or plants (certain limestones and coal); of the product of chemical action or of evaporation (salt, gypsum, etc.); or of mixtures of these materials. Some sedimentary deposits (tuffs) are composed of fragments blown from volcanoes and deposited on land or in water. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratification. Each layer is a bed or stratum. Sedimentary beds as deposited lie flat or nearly flat.

Shale. A rock consisting of hardened thin layers of fine mud.

Slate. A rock that by subjection to pressure within the earth has acquired the property of splitting smoothly into thin plates. The cleavage is smoother and more regular than the splitting of schist along its grain.

Stratigraphy. The branch of geologic science that deals with the order and relations of the strata of the earth's crust.

Strike. The direction along which an inclined rock layer would meet the earth's surface if that surface were level. The outcrop (which see) of a bed on a plain is coincident with its strike.

Structure. In geology the forms assumed by sedimentary beds and igneous rocks that have been moved from their original position by forces within the earth or the forms taken by intrusive masses of igneous rock in connection with effects produced mechanically on neighboring rocks by the intrusion. Folds (anticlines and synclines) and faults are the principal mechanical effects considered under structure. Schistosity and cleavage are also structural features.

Syncline. An inverted arch of bedded or layered rock suggestive in form of a canoe. (See fig. 28, p. 129.)
Talus (pronounced tay'lus). The mass of loose rock fragments that accumulates at the base of a cliff or steep slope. (See Pl. XXII, B, p. 166.)

Terrace. A steplike bench on a hillside. Most terraces along rivers are remnants of valley bottoms formed when the stream flowed at higher levels. Other terraces have been formed by waves. Some terraces have been cut in solid rock, others have been built up of sand and gravel, and still others have been partly cut and partly built up. (See Pl. XX, p. 142.)

Till. The deposit of mingled boulders, rock fragments, and soil left behind by a melting glacier or deposited about its margin.

Tuff. A rock consisting of a layer or layers of lava particles blown from a volcano. A fine tuff is often called volcanic ash and a coarse tuff is called breccia.

Type locality. The place at which a formation is typically displayed and from which it is named; also the place at which a fossil or other geologic feature is displayed in typical form.

Unconformity. A break in the regular succession of sedimentary rocks, indicated by the fact that one bed rests on the eroded surface of one or more beds which may have a distinctly different dip from the bed above. An unconformity may indicate that the beds below it have at some time been raised above the sea and have been eroded. In some places beds thousands of feet thick have been washed away before the land again became submerged and the first bed above the surface of unconformity was deposited. If beds of rock may be regarded as leaves in the volume of geologic history, an unconformity marks a gap in the record.

Vein. A mass of mineral material that has been deposited in or along a fissure in the rocks. A vein differs from a dike in that the vein material was introduced gradually by deposition from solution whereas a dike was intruded in a molten condition.

Volcanic bomb. A rounded mass of lava thrown out while in a hot and pasty condition from a volcano. A bomb, like a raindrop, is rounded in its passage through the air and may be covered with a cracked crust due to quick cooling.

Volcanic cone. A mountain or hill, usually of characteristic conical form, built up around a volcanic vent. The more nearly perfect cones are composed principally of lava fragments and volcanic ashes.

Volcanic glass. Lava that has cooled and solidified before it has had time to crystallize.

Volcanic neck. A plug of lava that formerly congealed in the pipe of a volcano. When the tuffs and lava flows that make up most of a volcano have been washed away by erosion the neck may remain as an isolated hill.

Volcanic rocks. Igneous rocks erupted at or near the earth's surface, including lavas, tuffs, volcanic ashes, and like material.

Weathering. The group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.
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Rome, Wash
Rosebud, Mont
Ross, Mont
Royalton, Minn
Roza, Wash
Ruby, Wash

S.

Sagemoor, Wash
St. Cloud, Minn
St. Paul, Minn
Salida, Minn
Sanborn, N. Dak
Sanders, Mont
Sandpoint, Idaho
Sappington, Mont
Sartell, Minn
Satus, Wash
Sank Rapids, Minn
Schley, Mont,
Scoria N. Dak
Seattle, Wash
Sedalia, N. Dak
Selah, Wash
Sentinel Butte, N. Dak
Shirley, Mont
Shoshkin, Wash
Sifton, N. Dak
Silver Bow, Mont
Sims, N. Dak
Skones, Mont
Skyline, Mont
Smeads, Mont
South Heart, N. Dak
Southdown, N. Dak
Sphinx, Mont
Spire Rock, Mont
Spiritwood, N. Dak
Spokane, Wash
Sprague, Wash
Springdale, Mont
Stampede, Wash
Staples, Minn
Steele, N. Dak
Sterling, N. Dak
Stockwood, Minn
Storey, Mont
Stuart, Mont
Sully Springs, N. Dak
Sunnyside Junction, Wash
Sweetbrier, N. Dak

T.
Talmage, Wash.
Tappen, N, Dak
Taylor, N. Dak
Teanaway, Wash
Terry, Mont
Thorp, Wash
Thompson Falls, Mont
Throll, Wash
Threeforks, Mont
Tokio, Wash
Toppenish, Wash
Toston, Mont
Tower City, N. Dak
Townsend, Mont
Trail Creek, Mont
Trident, Mont
Trout Creek, Mont
Turah, Mont
Tuscor, Mont
Tusler, Mont
Tyler, Wash

U.
Ulmer, Mont
Urbana, N. Dak

V.
Vale, Wash
Valley City, N. Dak
Velox, Wash
Vermilion, Mont
Verndale, Minn
Vista, Wash

W.
Waco, Mont
Wadena, Minn
Waldon, N. Dak
Wapato, Wash
Warm Springs, Mont
Watab, Minn
Watago, Mont
Weeksville, Mont
Welch, Mont
West End, Mont
Wheatmond, Idaho
Weston, Wash
Wheatland, N. Dak
White Pine, Mont
Whitehall, Mont
Wibaux, Mont
Willis, Mont
Willow Creek, Mont
Windsor, N. Dak
Winston, Mont
Woodlin, Mont
Worden, Mont
Wymer, Wash

Y.

Yakima, Wash
Yates, Mont
Yegen, Mont
Youngs Point, Mont

Z.

Zenith, N. Dak
Zero, Mont

<<< Previous <<< Contents >>>
MAP OF CUYUNA IRON RANGE, SHOWING ITS GEOGRAPHIC RELATION TO THE MESABI AND VERMILION RANGES OF MINNESOTA

EXPLANATION

Lease surface material
A. Gray drift of western end of sheet
B. Red drift of middle ice sheet
C. Quaternary

Underlying rocks
D. Granite and gneiss
E. Slate and schist
F. Shale
G. Cretaceous
H. Algonkian

Scale 1/24,000

MINNESOTA

Contour interval 200 feet
Elevations in feet above mean sea level
The distances from St. Paul, Minnesota, are shown every 10 miles
The streams on the main map are spaced 1 mile apart
GLACIAL LAKE AGASSIZ SHOWING SUCCESSIVE POSITIONS OF THE RETREATING ICE DAM THAT HELD THE LAKE
LAKE AREA BY UPHAM. ICE BORDERS BY LEVERETT
MORAINES FORMED BY THE ICE SHEET THAT CROSSED NORTH DAKOTA IN WISCONSIN TIME
GEOLOGIC AND TOPOGRAPHIC MAP
OF THE NORTHERN PACIFIC ROUTE
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Northern Pacific Railway Company and from additional information collected with the assistance of this company.

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U.S.G.S. Geologic Map Sheet of that name.

Scale 100,000
Approximately 8 miles to 1 inch

Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from St. Paul, Minnesota, are shown every 10 miles
The crossties on the railroad are spaced 1 mile apart.

Glacial drift east of and including the Altamont moraine was deposited at the last or Wisconsin stage of glaciation.
GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
NORTHERN PACIFIC ROUTE
From St. Paul, Minnesota, to Seattle, Washington
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Northern Pacific Railway Company and from additional information collected with the assistance of this company
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
B. B. Marshall, Chief Geographer
1915

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EXPLANATION
Loess-surface materials
A Stream deposits (alluvium)
North of the railway there are scattered remnants of drift, indicating that a pre-Wisconsin
ice sheet extended toward the southwest at least as far as Amidon, Geronimo and Hetton
Quaternary
Underlying rocks:

B Sandstone and shale, with beds of
lignite (Fort Union formation) 500 Tertiary
C Sandstone and shale (Cinnabar
marble member of Lance formation) 200 Tertiary (?)
GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
NORTHERN PACIFIC ROUTE
From St. Paul, Minnesota, to Seattle, Washington

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Northern Pacific Railway Company and from additional information collected with the assistance of this company.

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.

EXPLANATION

A. Stream deposits (alluvium)

B. Sands and shales, with beds of lignite (Fort Union formation)

C. Sands and shales, with thin beds of lignite (upper part of Lance formation)

D. Sands (Colgate sandstone member of Lance formation) - The Colgate probably includes the lower sandstone members of Fort Union. Carboniferous, age

E. Dark shale (Pierce)

Thicknes in Feet

Quaternary

Tertiary

Tertiary (?)

Carboniferous

Scale 500,000

Approximately 8 miles to 1 inch

0

1

2

3

4

5

6

7

8

9

10

10

10

10

10

10

Kilometers

50

100

150

200

250

300

350

400

450

500

550

600

650

700

750

800

850

900

950

1000

1050

1100

1150

1200

1250

1300

1350

1400

1450

1500

1550

Continental shelf 200 feet

ELEVATIONS IN FEET ABOVE M.R. NA.S.L.
The distances from St. Paul, Montana, are shown every 10 miles.
The contours on the quadrangles are spaced 1 mile apart.
GEOLeC AND TOPOGRAPHIC MAP OF THE NORTHERN PACIFIC ROUTE
From St. Paul, Minnesota, to Seattle, Washington

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Northern Pacific Railway Company and from additional information collected with the assistance of this company.

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parentheses is mapped in detail on the U.S.C.S. Topographic Sheet of that name.

EXPLANATION

A. Stream deposits (alluvium)
B. Dark shale with some sandstone and beds of lignite (Lance shale member of Fort Union formation)
C. Sandstone and shale, with thin beds of coal (Lance formation)
D. Dark shale, marine deposit (Bearpaw)
E. White sandstone and shale, marine deposits (Judith River formation)
F. Shale and sandstones, marine deposits (Cretaceous)

Scale 1:50,000

Approximately 8 miles to 1 inch

Elevations in feet above mean sea level.

The distances from St. Paul, Minnesota, are shown every 12 miles.

The crests on the railroads are spaced 1 mile apart.

CONTRAST INTERVAL: 200 feet

http://www.cr.nps.gov/history/online_books/geology/publications/001/611/images/sheet12.jpg
GEOLOGIC AND TOPOGRAPHIC MAP OF THE
NORTHERN PACIFIC ROUTE
From St. Paul, Minnesota, to Seattle, Washington
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Northern Pacific Railway Company and from additional information collected with the assistance of this company
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
H. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.

BULLETIN 611
SHEET No. 14

EXPLANATION

A Stream deposits (alluvium)
B White sandstone and shale (upper part of Fort Union formation)
C White sandstone and shale (middle part of Fort Union formation)
D Dark shale and sandstone composed largely of volcanic materials (late shale member of the Fort Union formation) (including volcanic agglomerate (C))
E Dark shale and sandstone (La Barge formation)
F Dark shale, marine deposit (Bacoue)
G Sandstone and shale, fresh-water deposits (Judith River formation)
H Sandstone and shale, marine deposits (Claggett formation)
I Sandstone and shale, marine deposits (Eagle sandstone)
J Dark shale, marine deposit (Cohoba)
K Dark shale, marine deposit (Cohoba)

Formation C, D, F, G, H, and I change toward the west into dark volcanic materials and near the western border of this area are grouped into the Livingston formation.

Scale 1,000,000
Approximately 8 miles to 1 inch

Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL
The distances from St. Paul, Minnesota, are shown every 10 miles
The courses on the railroad are spaced 1 mile apart.

GEOLeC AND TOPOGRAPHIC Map
OF THE
NORTHERN PACIFIC ROUTE
From St. Paul, Minnesota, to Seattle, Washington

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Northern Pacific Railway Company and from additional information collected with the assistance of this company.

UNITED STATES GEOLeCAL SURVEY

GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist
R. B. Marshall, Chief Geographer
1915

Each quadrangle shown on the map with a name in parentheses in the lower left corner is mapped in detail on the U.S.G.S. Topographic Sheet of that name.

EXPLANATION

A Stream deposits (alluvium) and glacial drift
B Bed sandstone and shale (Weldwood Formation; probably equivalent to the Spokane formation farther east
C Eocene limestone (New-hald)
D Quarztite and shale (basaltic quartzite)
E Bluff quartzite and shale (Priestland Formation)
F In places formations R, F, G, and H, have not been separated and the entire mass is called simply Blast series
G Granite, intrusive

Scale 1,000,560
Approximately 8 miles to 1 inch

Contour interval 200 feet
Elevations in feet above mean sea level
The distances from St. Paul, Minnesota, are shown every 10 miles.
The crossings on the railways are spaced 1 mile apart.

GEOL O GIC AND TOPOGRAPHIC MAP
OF THE
NORTHERN PACIFIC ROUTE
From St. Paul, Minnesota, to Seattle, Washington

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Northern Pacific Railway Company and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist      R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic Sheet of that name.

BULLETIN 671
Sheet No. 24

EXPLANATION

A. Stream deposits (alluvium)
B. Clay, sand, and gravel (Ellensburg formation) 300
C. Lava flows (Yakima basalt) 2,000-4,000

Scale 1:625,000
Approximately 8 miles to 1 inch

Contour interval 200 feet
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

The distances from St. Paul, Minnesota are about every 10 miles.
The crossroads on the highways are spaced 1 mile apart.
RELIEF MAP SHOWING SURFACE FEATURES OF THE WESTERN PART OF THE UNITED STATES.

Areas shown on the sheets of the route map are indicated in red.
The State of Minnesota has a gross area of 84,682 square miles, of which 3,824 square miles is covered with water. It was admitted to the Union in 1858, and its population according to the census of 1910 was 2,075,708. The earliest settlements were made along Mississippi River, which was then the main artery of commerce in this part of the country. From this valley the incoming people spread to other valleys and to the general upland between the principal streams. This was essentially an agricultural population, and it has covered all the southern and western parts of the State. The northeastern part was originally a land of swamps and heavy timber, not at all inviting to the man in search of a farm, and for this reason all of that part except a small area about the head of Lake Superior remained for a long time comparatively unknown.

While the agricultural lands of southern Minnesota were being converted into prosperous farms, the natural water power at the Falls of St. Anthony attracted the attention of millers, and great flour mills sprang up to grind the wheat that came pouring in from the surrounding region. At the same time the pine forest began to be utilized, and soon the great mills were denuding the country of its valuable timber.

The last great industry to develop was the mining of iron ore in the northern part of the State. Though the output of the mines is of less value than the products of either agriculture or manufacturing, it has probably brought the State into public notice to a greater degree than either of the others, for Minnesota is now the greatest producer of iron ore in the country, having in 1913 an output of nearly 39,000,000 long tons, out of a total for the entire country of 62,000,000 tons. The first iron mines in the State were opened in the Vermilion range in 1884. The great Mesabi range was opened in 1892 and the Cuyuna range in 1911.

The term range, as applied to a deposit of iron ore or to the ore and the rocks with which the ore is associated, is limited to the Lake Superior region. It doubtless resulted from the fact that in the first districts developed the rocks associated with the ore are hard and form ridges or low ranges. From these districts the term has been carried to the other deposits of iron ore in the region, until now they are all known as ranges, even if the surface is flat and swampy.

The values of the products of the State are approximately as follows: Manufactures (1909), $409,000,000; agriculture (1909), $275,000,000; mining (1913), $70,000,000.

The locations of the centers of commerce and industry in this State, as in many others that were settled in the early days, were determined largely by the availability of water transportation. Thus St. Paul, which stands at the head of navigation on Mississippi River, and Duluth, which is at the upper end of Lake Superior, were the principal points. The use of
Mississippi River as a commercial highway has gradually diminished, until to-day it has little or no effect on the commerce of the Northwest; but St. Paul and Minneapolis still continue to form a center for all the northern transcontinental railroads and also for those that connect central Canada with the United States. Lake Superior still holds its own as a water route for heavy freight—iron ore and grain going east and coal and manufactured articles going west—and the places at which most of this traffic concentrates are Duluth and Superior, at the extreme western point of the lake.

On leaving the Union Station at St. Paul (see sheet 1, p. 20) the Northern Pacific Railway follows a small ravine almost due north for about 2 miles, gradually climbing from an altitude of 732 feet at the station to more than 900 feet at the highest point within the city limits. In passing over this part of the road the traveler unacquainted with glacial topography will have an opportunity to become familiar with some of its peculiarities—its knobs and basins composed of materials which the moving ice carried or pushed along and deposited near its margin.

The figures for population in this book are those of the United States Census of 1910. For unincorporated places the figures give the population of the election precinct, township, or like unit; such figures are marked with an asterisk (*).

The region was at one time covered (as shown on the map of Minnesota on sheet 3, p. 32) by
what is here called the middle ice sheet, which, as it came down from the north, brought into
this region clay and fragments of red rock from the country north of Lake Superior. This
body of ice extended southward beyond St. Paul and on melting left its load of reddish clay,
sand, gravel, and bowlders, commonly known as drift, spread over the surface like a blanket.
Later another large glacier, the western ice sheet, invaded Minnesota from the northwest and
spread a mantle of gray drift over part of the area already covered by red drift. The boundary
between these two drift sheets passes through St. Paul but is not a sharp line of separation.

When the front of the western ice sheet rested on the hills about St. Paul streams of water
issued from the ice and carried with them vast quantities of sand and gravel, which they
deposited beyond the ice front. One of these streams left the ice mass in the vicinity of
Minneapolis and spread a great sheet of sand and gravel over the country upon which St. Paul
has been built. It is mainly these outwash materials that can be seen from the Northern
Pacific trains as they pass from St. Paul to Minneapolis. The gravel was deposited irregularly
and now forms knobs that are separated by kettle-like depressions. Lake Como, on the right
(north)¹ of the railway, lies in a basin of this character.

¹The terms right and left refer to the westbound journey.

Descending somewhat from the high land the railway crosses the gorge or canyon cut by
Mississippi River in the Platteville limestone and St. Peter sandstone. These rocks were
formerly well exposed here, but they have been obscured by the construction of mills and the
slumping in of soil from the top of the bluffs. While crossing the river the traveler can see on
the right what remains of the Falls of St. Anthony, after a large part of the water has been
diverted for the development of power. Further erosion of the rock has been prevented by the
building of a low dam at the crest of the fall, and about 35,000 horsepower has been
generated for running the great flour mills that line the river bank for some distance.

On the left are the buildings of the University of Minnesota, which
occupy a commanding position on the east side of the river. The
rocks rise toward the north, as shown by figure 2 (p. 17), even more
steeply than the grade of the stream, and the top of the St. Peter
sandstone and the overlying Platteville limestone appear higher in
the canyon wall than they do at Fort Snelling. Immediately after
crossing the river the train enters the Union Station at Minneapolis,
to receive other travelers bound for the far West.

²The figures giving distance from St. Paul are taken from the Northern Pacific
Railway folder of 1915.

FIGURE 2.—Diagram showing northward rise of the rocks in the vicinity of
Minneapolis, Minn.
North of Minneapolis the railway again crosses Mississippi River, but here there is no gorge, the river flowing in a shallow valley in the drift-covered plain. Just beyond Northtown, on the right (east), the St. Peter sandstone is visible for the last time. This outcrop lies at considerably higher level than any outcrop of the sandstone in the gorge below the Falls of St. Anthony, indicating that the beds of rock rise northward more steeply than the surface of the ground. As this northward rise continues up the Mississippi until the underlying granite is brought to the surface about St. Cloud it is probable that in the past the St. Peter sandstone and associated beds extended farther northward than at present. They were, however, worn away by the weather, the streams, and the ice, until now the railway passes over their beveled edges onto lower and lower formations toward the north, as shown by figure 2.

The Great Northern and Northern Pacific railways operate the line from Minneapolis to St. Cloud jointly. At Coon Creek a branch of the Great Northern turns nearly due north and joins a line of the same system from St. Cloud to Duluth. In this part of the valley the surface is composed largely of sand and gravel washed out from the glacier when its front lay a short distance to the northwest. The fine part of this material when dried was picked up by the west winds and carried over the country to the east, forming sand dunes which, with intervening marshes, still characterize this part of the country, as shown on the map.

The succession of events during the several invasions of this country by the ice and the various materials deposited by the ice sheets are described in the footnotes on pages 26-30.

For nearly 100 miles the railway follows the valley of the Mississippi, here a broad and flat depression much of which has the appearance of a level plain; but in places the low hills on both sides approach the river and the valley is confined by fairly definite bounding walls. About Anoka the floor of the valley consists of a gently undulating plain. The river has cut its channel but little below the general surface, and it seems to wander over the plain without plan or purpose, except to discharge its waters southward. The valley is well cultivated, and the glacial hills and wooded banks of the river are just sufficient to break the monotony of its even surface.

Although no rocks are exposed about Anoka, deep drilling for water has shown that the glacial drift there is about 80 feet thick and that the underlying rock is probably a part of the Dresbach sandstone. (See footnote on p. 9.) About Anoka flowing wells obtain water from this sandstone, and in the southeastern part of Anoka County millions of gallons are pumped from it daily to St. Paul for the city supply.

The route followed from Minneapolis through Dayton and beyond in historic association. The first white man to traverse it was Father Louis Hennepin, who in 1680 named the Falls of St. Anthony and St. Francis River. There is some doubt about the stream to which Hennepin applied the name St. Francis. Some think it was the stream now bearing that name; others think it was Rum River, which joins the Mississippi at Anoka. Hennepin traversed part of the Indian trail to Lake Superior, which is generally supposed to have passed by a portage from St. Francis River to Mille Lacs, thereby saving greatly in distance over the route up Rum River.

At the village of Elk River the stream visible from the train is Elk River, and this is in sight for several miles west of the station. St. Francis River enters Elk River nearly due north of Big Lake station, but can not be seen from the railway. At the town of Elk River a
branch of the Great Northern turns to the right (north) and joins the St. Cloud-Duluth line at the town of Milaca.

The second white man to traverse this part of the valley was Jonathan Carver, who visited the region in 1766 in order to claim it for the British sovereign. Carver ascended the Mississippi as far as St. Francis River in an endeavor to reach the Pacific coast, but owing to lack of supplies he was obliged to abandon the expedition and return to the East. Of the American pioneers, Lieut. Zebulon M. Pike, for whom Pikes Peak was subsequently named, was the first to visit the newly acquired territory in his search for the source of Mississippi River in 1805. An account of his journey will be found in the footnote on page 20.

Later the route up the Mississippi from Fort Snelling to Sauk Rapids became widely known as a part of the Red River trail. Over this trail several exploring expeditions went into the Big Lake. Northwest, but probably the most important, at least so far as its influence on the location and building of Northern Pacific Railroad was concerned, was the party of Government engineers under the leadership of Gov. I. I. Stevens, which made the first surveys for a Pacific railroad in 1853. This expedition followed the Red River trail by the sites of Big Lake, Becker, and Clear Lake to Sauk Rapids, and thence westward to Bois des Sioux River, which it crossed just below the outlet of Traverse Lake. Although the country traversed by this expedition in Minnesota and a part of North Dakota was well known, even at that early date, its route farther west lay in large part over virgin territory, and the results of its explorations have been of great value in the subsequent development of the region. The engineers of this expedition explored most of the prominent passes through the Rocky Mountains in Montana and the Cascade Mountains in Washington, and practically outlined the route that was followed by the Northern Pacific engineers some 20 years later.

In the vicinity of the village of Clear Lake the railway passes from the gray drift that was brought into this region by the western ice sheet from the Red River valley to the red drift of the middle ice sheet. The exact point of change from one of these drift sheets to the other can not be determined from the train, but close observation will show that there are more fragments of red rock in the drift north of Clear Lake than there are in the drift south of that place.

Although the glacial drift covers this country so completely that the hard rocks are hidden from view, deep drilling for water has shown that all the sedimentary rocks underlying the drift in the country farther south have been eroded from this region and that nothing is left but the granitic rocks which are supposed to form the basement or foundation of this part of the continent. Fortunately these rocks are exposed at several places along the line, so that the traveler may see them and realize how different they are from the stratified sandstone and limestone that show at the surface in the vicinity of St. Paul and Minneapolis.

1Sedimentary rocks are those that were laid down as sediments, either in lakes or in the sea. They were deposited layer upon layer, and these layers show to-day in what is known as the bedding or stratification of the rocks. Where the material deposited was very fine and was supplied in small amounts and intermittently the layers are very thin, in some places as thin as paper; but where the material deposited was coarse and was supplied in great abundance, or where it was of such character that it did not form distinct layers, the beds may be very thick or even massive—that is, they may show no bedding planes.
After passing milepost 71, beyond Cable, the train runs close to the State reformatory, which stands to the left of the railway. The walls and buildings of this institution are constructed of blue-gray granite quarried on the premises. The granite is an excellent building stone, being durable and of pleasing appearance, and beyond the reformatory it is quarried commercially. The stone can be obtained in fairly large blocks, and it has been used extensively in St. Paul and Minneapolis and shipped to different parts of the country. A large amount of it was used in the new State capitol. The granite is hard and resistant, forming the rapids in the river and the rough topography that marks the valley for some distance.

The quarrying of granite for buildings and monuments is an old and well-established industry in this part of the State. The first quarry was opened at East St. Cloud in 1868. Since that time numerous quarries have been developed at East St. Cloud, Sauk Rapids, and Watab, on the east side of the river, and at St. Cloud and Rockville, on the west side. The quarries in this vicinity produce both red and gray granites of varying degrees of coarseness, ranging from fine gray granite suitable for monuments to coarse red and gray granites that can be used only as building stone. In 1913 the granite quarried in Stearns, Benton, and Sherburne counties, with St. Cloud as a center, was valued at about $850,000.
Although the railway is steadily descending as it follows Green River, the canyon grows no deeper, for the reason that the westward slope of the top of the plateau in which it is cut is about the same as the grade of the stream. In the vicinity of Lester the stream flows about 3,000 feet below the tops of the highest hills on either side and this depth is maintained for a considerable distance.

Hot Springs (see sheet 27, p. 196) was once a noted resort, with a large hotel on the right of the track; but a number of years ago the hotel was destroyed by fire, and it has not been rebuilt. Green River is now utilized by the city of Tacoma for its water supply, and great care is exercised in keeping the stream free from pollution. The intake of the waterworks will be seen lower down the stream.

Below Hot Springs the timber was originally very heavy, but most
of it has been cut off or burned, and the traveler can obtain a very inadequate idea of a virgin Washington forest from what he sees along this route. In many places, however, the second growth is very dense, and it would be difficult to force one's way through it. In this vicinity the traveler gets his first good view of the luxuriant growth of ferns that characterizes the forests of the coastal belt of Oregon and Washington. (See Pl. XXVI, p. 194.) The rocks, although much obscured by vegetation, are similar to the lava flows and breccias that occur near the summit of the range and also on the east side. In the Green River valley the rocks have been smoothed and rounded by the glaciers that formerly flowed down the valley and spread out on the plain below. The smooth and open character of the valley continues down as far as Eagle Gorge, but beyond that place the river enters a narrow, steep-walled canyon that in no respect resembles the valley higher up. The contour map shows that a broad valley continues below Eagle Gorge to Barneston, but that neither the river nor the railway follows it. From the arrangement of the valleys it is evident that Green River, at some time in the past, flowed in this valley instead of in its present course below Eagle Gorge.
The old and new valleys of Green River afford an excellent example of changes that may take place in the drainage system of a country as a consequence of the invasion of a glacier. The river valleys on the west slope of the Cascade Mountains are in general well developed, showing that the streams have occupied them for a long time. The original course of Green River below Eagle Gorge was doubtless north by way of Page Mill and Barneston, for the present canyon below Eagle Gorge is so narrow that it must have been formed comparatively recently. The relative size of the two valleys is shown in figure 38, which represents a cross section about 3 miles below Eagle Gorge.
FIGURE 38.—Section showing size and shape of the valley of Green River below Eagle Gorge, Wash., compared with the valley the river abandoned when it was blocked by ice.

To divert a stream intrenched in a valley from 2,000 to 3,000 feet deep must have required a formidable barrier. Such a barrier could have been produced only in one of four ways—(1) by a landslide which filled the valley below the point of diversion; (2) by a lava flow occupying a similar position; (3) by a fault across the valley and the sudden upward movement of the land below the fault; or (4) by the blocking of the valley by ice. If the change were due to any one of the first three of these causes there should remain in the old valley some traces of the barrier, but, as no such features have been observed, it must be concluded that ice was the agent that caused the change. Ice would leave no permanent barrier, and so no surface indications would be expected, except the ordinary deposits that are made by a glacier. Evidence of this kind is abundant and clearly shows that the region was deeply covered with ice at a recent geologic date.

The exact manner in which the ice blocked this outlet of Green River is a matter of speculation, but probably the glacier came down the Sound after the local glaciers in Green and Snoqualmie valleys had melted back from the mountain front and crowded up the valley of Green River until it completely blocked that valley with a great dam of ice, hundreds and possibly thousands of feet in thickness. This barrier seems to have been sufficient to raise the water of Green River until it flowed over a low divide that must have existed between the Green River valley and a small stream flowing to the west past Palmer Junction. Beyond this divide the river found an unobstructed outlet which it at once proceeded to deepen and which it finally cut below the level of the former outlet by Barneston. By the time the ice had disappeared Green River had become so deeply intrenched in its new course that it persisted, and it remains to this day in the new valley it was thus compelled to occupy.

Although this change occurred during the Great Ice Age, geologically it was very recent, as is shown by the narrowness and steepness of the new part of the gorge. Time enough has not elapsed for the river to broaden its channel, and this difference the traveler will doubtless realize as the train passes from the open valley in the vicinity of Eagle Gorge into the dim shadows of the narrow canyon below, in which there is barely room for the track between the river and the bluffs, and even to make this passage deep rock cuts and many crossings of the stream are necessary.

That part of the Green River valley below Eagle Gorge has all the features characteristic of newly cut gorges in fairly hard rocks. It is narrow and tortuous and the stream abounds in tumbling cascades and pools of deep water. It is a beautiful glen in which the rocks are
covered with delicate mosses and draped with ferns whose graceful fronds sparkle with mist from the numerous cascades.

Just after passing milepost 81 the traveler can see the head gate of the Tacoma waterworks, and the deep-blue pool above, which certainly looks as if no polluting substances had ever affected it. After being accustomed to the water supplied to some of the eastern cities the traveler may envy these Pacific coast towns their nearness to mountain sources and the never-failing water supply they can procure there. Seattle also draws its supply of water from the Cascade Mountains, but as it is taken from Cedar River, the next stream on the right (north), neither the intake nor the conduit are visible from the train.

At Palmer Junction the Northern Pacific divides into two branches, the older line turning to the left (south) and going by way of Buckley to Tacoma, which at the time of the completion of the railway was its western terminus, and the other turning slightly to the right and going to Seattle by way of Auburn.¹

¹The original plan of the Northern Pacific was to build on the north side of Columbia River from the mouth of Snake River to Kalama and thence northward to Puget Sound. That part of the road from Kalama to Tacoma was the first to be constructed, the first train reaching Tacoma on December 16, 1873. Financial difficulties forced a suspension of operations for some time, but in 1880 building was resumed and actively pushed from Mandan, N. Dak., westward and from the mouth of Snake River eastward. The line along Columbia River from Kalama to Snake River had not yet been touched, but it was thought that if the line east of Snake River could be completed, boat service on the river would accommodate the traffic until the company was strong enough financially to undertake the building of that line. In the meantime a franchise for the construction of a road along the south bank of the Columbia had been obtained by the Oregon Railway & Navigation Co., and traffic arrangements had been entered into between this company and the Northern Pacific for the joint use of this line from Wallula to Portland. While these negotiations were under way the construction of the main line was carried on rapidly, and the last spike connecting the eastern and western sections was driven a little west of Garrison in September, 1883.

As early as 1876 a line was built from Tacoma up Puyallup River to the Wilkeson coal mine for the immediate purpose of procuring coal, and ultimately as a part of the Cascade branch, which the Northern Pacific, even at that early date, was considering a necessity. Work on this branch was suspended during the reorganization of the company in the years 1873-1879 and also while the company was bending all its energies to the completion of the main line in 1880-1883. Finally work was begun on this branch in earnest in 1884, but owing to the delay in constructing the Stampede Tunnel, the first train over the line did not reach Tacoma until July 3, 1887. In 1883 the railroad from Seattle to Auburn and Puyallup was built by a company of local capitalists, but later it was taken over by the Northern Pacific. The last cut-off constructed was the road from Palmer Junction to Auburn, which now gives a direct line from St. Paul to Seattle.

About a mile east of Palmer Junction the railway enters one of the productive coal fields of the State, though little coal or evidence of coal mining can be seen from the train. Several mines have been developed, however, south of the river, within a distance of 3 or 4 miles, and one or two mines to the north.
Between Palmer Junction and Kanaskat the Northern Pacific is crossed by a branch of the St. Paul road which leads to several mining towns along the mountain front and terminates at Enumclaw, on the Tacoma line of the northern Pacific, 10 miles to the south. The mountains end abruptly at Kanaskat and give place to a glacial plain. The glacial drift on this plain is underlain by shale, sandstone, and coal beds, which belong to the Puget group and which are of about the same age as the Roslyn (Eocene) formation on the other side of the Cascade Range, but few of the rocks are exposed at the surface. There are two large coal mines at Ravensdale, one of which can be seen on the left (south) as the train passes through the village.¹

¹The large coal tipple which the traveler can see on the left is used for hoisting coal up a slope about 1,500 feet long from the workings below. Three coal beds are being worked in this mine. The main slope leads down one bed and a rock tunnel has been driven from it to the other two.

The main bed ranges in thickness in the mine from 4 feet 4 inches to 10 feet 7 inches and where thickest is broken by many partings of shale and bone that make mining expensive and detract greatly from the value of the coal. The other two beds are 5 feet 7 inches and 7 feet 10 inches thick, but contain much impure or dirty coal. The heating value of the coal ranges from 11,290 to 11,850 British thermal units.

The McKay coal bed, which is worked in a mine some distance away from the main line of the road, is about 5 feet thick and is all clear coal without partings. This coal has a heating value of 12,210 British thermal units. Although this mine is less than a mile distant from the one near the track, it has not been possible to determine the relative positions of the coal beds, for the rocks are thrown into numerous folds and broken in many places.

As the presence of coal beds means that swamps, prevailed at one time in this region, it is reasonable to suppose that vegetation flourished in that far-off time much as it does to-day. Careful search has shown that plants did grow luxuriantly then, and their fossil forms are so well preserved that the botanist has been able not only to distinguish the species that grew here, but to determine from the kind of plants the climate that must have prevailed. In the note below F. H. Knowlton compares the fossil flora with that living in Washington at the present time.²

²The State of Washington now exhibits great diversity in soil and climatic conditions, with the result that it supports a large and varied flora of not less than 2,500 species of the so-called higher plants alone. As these soil and climatic conditions vary from place to place, there are many sharp, almost abrupt changes in the character of the vegetation. Thus the Cascade Range, although only 6,000 or 7,000 feet high, constitutes an effective barrier which relatively few plants are able to cross. On the east side of the mountains there is an arid transition area where the sagebrush plains of Columbia River give way to the slightly higher, treeless, grass-covered zone known as the bunch-grass prairies. Still higher and
nearer the mountains is the yellow-pine belt. Here the forests are composed
mainly of the yellow or bull pine, with such undershrubs as the pinebark,
buckbrush, roses, and a tall huckleberry.

On the western slope of the Cascades the change in the character of the
vegetation is marked. The dominant forest tree is the red fir, which covers fully
90 per cent of the heavily timbered area, in places with a stand so dense that the
sun can scarcely penetrate. In a narrow strip along the coast the dominant species
is the Sitka or tideland spruce. In the bottom lands, mainly river valleys, the
conspicuous trees or shrubs are the red cedar, giant cedar, white fir, large-leaved
maple, Oregon ash, cottonwood, western cornel, vine maple, crab apple, willows,
the terrible devil's club, and salmonberry. On the gravelly prairies are the only
species of oak growing in the State, as well as the black pine and, until the
middle of July, a carpet of brilliant flowers.

The fossil flora of this region, found mainly in more or less closeassociation
with the numerous coal beds, was also an exceedingly rich and diverse one,
numbering, as at present understood, about 350 species, with the probability that
it may reach 400 or 500 species when fully known. Not a single one of these
fossil species is now known to be living, although many of them belong to
genera that are the same as or similar to those that make up the present flora. In
view of the so-called accident of preservation, it is probable that the total fossil
flora may have equaled the living flora in number of species.

The almost complete change in the character of the flora since the Puget epoch
(Eocene) is well shown by the conifers. This group is now dominant in
conspicuousness and number of individuals, whereas in Puget time it was almost
negligible, being represented by only three kinds—cypress, cedar, and juniper—and
these were so scarce that less than twenty examples out of many thousands
of specimens have been observed. Another marked difference between the two
floras is shown by the presence of palms in the Puget flora. Two very distinct
kinds of palms have been found, one with rather small, feather-like leaves, and a
huge fan palm, with leaves that must have been at least 5 or 6 feet across. At
present palms do not grow wild within a thousand miles of the Puget Sound
region.

The traveler will doubtless be struck by the abundance of beautiful ferns now
growing along the forest borders in the open, partly shaded locations. Ferns were
also present during Puget time, though none that have been found are very
closely related to the living forms. Tall, bushy horsetails (Equisetum) are
conspicuous in many places, and the group was represented in the fossil flora.

The deciduous-leaved plants, to judge from their fossil remains, were in the vast
majority during Puget time and show much diversity. They included figs of
several kinds, hackberries, mulberries, many willows, alders, birches, and oaks, a
number of poplars, two species of pepper tree, elms, ashes, maples, magnolias,
cinnamonos, laurels, plums, service berries, dogwoods, custard apples, chestnuts,
crab apples, sumachs, bittersweets, blueberries, bush thorns, primroses, and
others that are without well-known vernacular names.

The Sound country of Washington, at the time of deposition of the lower beds of
the Puget group, is supposed, on account of the abundance of ferns, gigantic
palms, figs, and a number of forms now found in the West Indies and tropical
South America, to have enjoyed a much warmer climate than it does to-day; but
the presence of sumachs, chestnuts, birches, maples, dogwoods, sycamore, etc., in the upper beds of the group would seem to indicate an approach to the climatic conditions prevailing at present.

A number of fossil plants have been found to be common to the east and west sides of the Cascades. This would indicate that approximately similar conditions of climate and topography prevailed throughout this general area during the Puget epoch. The Cascade Range, as it now exists, did not then intervene.

West of Ravensdale the railway pursues a westerly course, crossing under the Columbia & Puget Sound Railroad and then following in a general way a slight depression in the drift without any marked features of relief.

Beyond Covington the valley deepens and becomes more restricted, and the railway cuts show that the valley has been excavated in a thick deposit of glacial gravel. This material, known as the Orting gravel, was deposited by streams flowing from the ice front of the Admiralty glacier (see p. 192) after it had retreated to a position farther north.

At milepost 102 is the State fish hatchery, which supplies fish fry for many of the streams on this side of the mountains. Soon after passing this point the train crosses Green River and is once more in a broad valley in which the timber has been cleared away and farms established. To one not accustomed to the thick forests of the Pacific slope, it is a relief to emerge from their dense shade and enter open country.

After crossing Green River and the broad valley in which it flows the train passes under a high bluff of gravel (Orting) on the south. The origin and geologic age of this gravel, as well as of the other formations of the drift in Washington, are discussed below by W. C. Alden.¹ This gravel has been extensively used by the railway for ballasting the track. At Auburn the railway line across the mountains unites with the line from Portland to Seattle. The rest of the route is directly north down the valley to its junction with Black River, which is the natural outlet of Lake Washington. Below the point of junction the stream is known as Duwamish River, and this the road follows to the tidal flats of Elliott Bay at Seattle.

¹At a time which probably corresponds to the last or Wisconsin stage of glaciation in the eastern part of the United States, the mountains of Washington were largely covered with ice, and the Vashon lobe of the Cordilleran ice sheet extended southward from British Columbia into the Puget Sound basin. This glacier is believed to have attained a thickness of about 2,500 feet. The ice filled the depressions composing the Sound, from the foot of the Olympic Mountains on the west to the base of the Cascades on the east. On the south it reached and covered much of the plains south of Olympia. The ice of this glacier probably coalesced on the east with the local glaciers that descended the slopes and valleys of the Cascades.

The melting of these glaciers left deposits of clay, sand, gravel, and bowlders (the Vashon and Osceola drift), which may now be seen on the elevated tracts between and around the troughs of the Sound but which were not thick enough to fill the deep depressions, so that when free of ice these were occupied by
The broad valley at Auburn is distinctly different from the ordinary stream valleys of this region, in that it is wider than is required by such streams as now occupy it, is flatter than valleys excavated by erosion, and it is open to tidewater at both ends—Elliott Bay (Seattle) on the north and Commencement Bay (Tacoma) on the west. The floor of the valley is so flat that streams entering it build delta-like accumulations of sediment upon which the stream channel shifts from place to place. White River, next to Green River on the south and named because of the milky color of its water, derived from the glaciers of Mount Rainier, enters the valley a few miles above Auburn. Part of the stream at times turns south into Puyallup (poo-yal'up) River and reaches tidewater at Tacoma and the other part flows north and unites with Green River. The arrangement of the valleys and their peculiar connection with bays and similar indentations of the coast line strongly suggest that at one time this entire valley from Tacoma to Seattle was an arm of the Sound similar to but smaller than Admiralty Inlet and that it has become a land valley simply by being filled with sediment brought down by the rivers from the Cascade Mountains.

Bailey Willis, who has made a careful study of the Puget Sound region, is of the opinion that the peculiar branching channels of the Sound could have been produced only by the submergence of a land on which a branching river system had formerly existed. If this view is correct, it is evident that many modifications must have been made, for a peculiarity of the channels of the Sound is that they not only unite as the tributaries of a river system unite, but they separate in a most intricate fashion. Taken as a whole, the conclusion appears well founded, but there are many minor points that still remain to be explained.

The White River valley is largely given up to truck farming and dairying. The dairying industry centers about Kent, where there is a large plant for the manufacture of condensed milk. On the left (west) are the lines of the Oregon-Washington Railroad & Navigation Co., the St. Paul road, and the Interurban Electric Co.; on the right the town of Renton, perched partly on the hillside, about 2 miles distant. This is another coal-mining town—in fact, coal mining is the chief business in many parts of the country back from the Sound. Renton is nearer tidewater than the other mining towns of the State, and the coal mined here has a fine reputation in the cities on the Sound as a clean fuel for domestic use.¹

¹Renton is one of the oldest coal-mining centers of this part of the country, as mines were opened here in 1874. This early activity can not be attributed to the quality of the coal, for that is of a much lower rank than those already described,
but it is probably due to the nearness to tidewater, the cleanness of the coal, and its suitability for domestic use.

Two coal beds are worked, and, like most of the other coal beds of this region, they are not lying flat, but dip at an angle of about 12° to the southeast. The coal is brought to the surface through a slope on one of the beds, and a rock tunnel in the mine connects with the other. Each bed is over 8 feet thick everywhere, but this is not all merchantable coal. The average heating value of the coal of these two beds is 11,290 and 10,060 British thermal units.

The Renton coal, when exposed to the weather, slacks badly. On account of this property it is classed as subbituminous coal, the next lower in the scale to bituminous coal, such as is mined at Roslyn and Ravensdale.

Between mileposts 11 and 10 the Black River branch on the right leads to Renton and other towns in that direction, and at milepost 10 the Renton branch of the interurban trolley line crosses the St. Paul road and then crosses Black River, which is the outlet of Lake Washington. Beyond the crossing of Black River the railway is at the foot of the bluffs on the right side of the valley, and the hillside cuts expose, in several places, sandstone and shale (Puget group), but no coal beds occur in this part of the formation. This part of the valley is known as the Duwamish Valley. At its lower end the stream is actively engaged in filling the bay with the sediment which it carries. The work of the stream has been supplemented in recent years by civic activity in cutting down some of Seattle's hills and in reducing the grades in the business part of the city. On some of the streets the grade was lowered as much as 30 feet, and on others there was a corresponding fill. As the material on which the city is built is glacial drift, steam shovels were largely used for the excavation, but the methods used in hydraulic mining were employed to get rid of the large hill upon which the old Washington Hotel was situated. The railway crosses the wide tidal flats, which are being more and more utilized for business purposes, and reaches the Union Station at Seattle.

Seattle.
Elevation 24 feet.
Population 237,194.
St. Paul 1,904 miles.

The most important natural feature at Seattle is the wonderful harbor, with deep water at the very door of the city. The depth of water is shown on the small map on sheet 27. Other features of interest are the steep water front and the way in which it has been modified and shaped for the use of man, and Lake Washington, which bounds the city on the east and is soon to be thrown open to the commerce of the world by the construction of a ship canal from Salmon Bay through Lake Union and across the narrow neck of land south of the State University. This will greatly increase the harbor facilities, and the fresh water of the lake will afford an efficient means of freeing ocean-going vessels of barnacles.

The State University is beautifully situated on the shore of Lake Washington, and its campus was utilized for the site of the Alaska-Yukon-Pacific Exposition in 1909. The city is well supplied with parks and connecting boulevards, and one of the finest views about the city is that of Mount Rainier\(^1\) from the boulevard that follows the shore of Lake Washington.

\(^1\)Of all the mountain masses and rugged snow peaks in the region described in this book, none will compare with the beautiful majestic cone of Mount Rainier (Pl. XXVII). This mountain giant is the dominating feature of this part of the Pacific slope. There may be other snow-clad peaks that seem to pierce the sky, such as Adams, Baker, and St. Helens, but these are dwarfed beside the mighty symmetrical cone of Rainier.
Mount Rainier (14,408 feet) is of about the same height as Pikes Peak, in Colorado (14,108 feet), or Mount Whitney, in California (14,502 feet), but it is superior in beauty to either, for it is not only a symmetrical cone but it can be seen from sea level and at close range, so that it stands out in all its massive grandeur. Mount Rainier when it comes into view from Tacoma, Seattle, or any other point along the winding channels of Puget Sound or from Lake Washington, reveals its full height, as there are no other peaks to obstruct the view or to detract from its commanding presence.

The early exploration of the Puget Sound region is a matter of some uncertainty and doubt. Apostolos Valerianus, an old Greek pilot in the service of Spain, better known by his Spanish sobriquet Juan de Fuca, claimed to have discovered the main entrance to the Sound about 1600, but grave doubt has been cast upon his narrative and many believe that his account was pure fiction. The first reliable account of the Sound was written by Capt. George Vancouver, of the British Royal Navy, who in 1792 mapped the Sound, named it after Peter Puget, one of his lieutenants, and also named many other natural features of the region, including Mount Rainier.

It is said that the original Indian name was Tacoma or Tahoma, meaning "big snow mountain," but Vancouver disregarded or did not know of the Indian usage and named the peak after Rear Admiral Rainier, of the British Navy. This name has been adopted by the United States Geographic Board. Nevertheless, there are many people who would gladly see the foreign name abandoned, even though usage has given it great weight, and the aboriginal name Tacoma revived.

Naturally, the high peaks of the Cascade attracted the attention of everyone who entered the region, and many were eager to scale them. The earliest record of mountain climbing was the ascent of Mount St. Helens in 1853. During the following year parties reached the summits of Mount Hood, in Oregon, and Mount Adams. Several unsuccessful attempts were made to climb Mount Baker, but not until 1868 did a party reach the top.
Lieut. A. V. Kautz made an almost successful ascent of Mount Rainier in 1857, reaching within 1,000 feet of the summit. His trip, however, proved to be very important, for he established the existence of glaciers here, which up to that time had not been known in this country. The first expedition to reach the top of the mountain was that of Gen. Hazard Stevens and P. V. Van Trump, who attained the summit on August 17, 1870. In the same year S. F. Emmons and A. D. Wilson, at that time members of the Fortieth Parallel Survey, made a brief study of the geology of the mountain and of the glaciers on its side and reached the top October 17, just two months after it had been attained by Stevens and Van Trump. Since that time numerous ascents have been made, and each year the trip is gaining in popularity, especially since the mountain and some of the adjacent territory has been set aside as the Mount Rainier National Park. The base of the mountain can easily be reached from either Seattle or Tacoma, and the views obtained on such a trip will amply repay anyone for the journey.

Mount Rainier, like Mounts Adams, St. Helens, and Baker, and Glacier Peak, is a great volcanic cone built upon the summit of the Cascade Range by successive layers of material thrown out of its crater. The great height of these peaks has not been materially reduced by erosion, for the time since their formation has not been long enough to permit very effective work by the elements. Steam escapes from most of these old volcanoes, showing that the rocks are still hot at some distance below the surface. It is noted in the records of old Fort Vancouver, on Columbia River, that Mount St. Helens emitted smoke and ashes since the establishment of that post. The recent activity of Lassen Peak, in northern California, which is situated on the same general range of mountains, is another indication that volcanic activity in this region is not quite extinct.

The heights of the great volcanic peaks of Washington are as follows: Mount St. Helens, 9,697 feet; Glacier Peak, 10,436 feet; Mount Baker, 10,750 feet; Mount Adams, 12,307 feet; and Mount Rainier, 14,408 feet.

Although Capt. Vancouver mapped and named Puget Sound in 1792, there was no permanent settlement or even trading post in the region until 1833, when Fort Nisqually was built by the Hudson's Bay Co. on the ground now occupied by the city of Tacoma. This post was for many years, even up to the time it was purchased by the United States Government in 1869, the leading commercial place on the Sound and was surpassed only on the northwest coast by Fort Vancouver, on the Columbia, which was the headquarters of the Hudson's Bay Co.

Capt. Wilkes, when on his exploring expedition of 1840, landed at Fort Nisqually and sent a party inland to explore the country tributary to the Sound and to Columbia River. One party traveled southward and explored the Willamette (Wil-lam'et) Valley of Oregon, and another, under Lieut. R. W. Johnson, on May 29, 1840, crossed the Cascade Mountains by way of Naches Pass. This seems to have been the earliest passage by white men across the Cascades. At that time it was only an Indian trail, but in 1853 a road was cleared so that emigrants over the old Oregon Trail could make a short cut to the Sound instead of having to keep to the south along Columbia River.

The first settlement in the vicinity of Seattle was made at Alki Point in 1851. This was named New York, to which somebody facetiously added the Chinook word "alki," meaning "by and by." On February 15, 1852, the claims which became the town site of Seattle were staked, but up to 1860 there were not more than 20 families in the town. The town of Tacoma was laid out in 1872, and since that date there has been the most intense though friendly rivalry
between the two places.

The Puget Sound basin lies in what is called the moist district of Washington. It has an annual precipitation of 25 to 60 inches, three-fourths of which occurs in the "wet season," from November to April. It is therefore intermediate between the extremely wet country of the coast, having an annual precipitation of 60 to 120 inches, and the dry belt east of the Cascade Mountains, where the annual precipitation is only 8 or 10 inches. The Puget Sound region is regarded by many unfamiliar with it as a region of excessive rainfall, but the figures given by the Weather Bureau show that the precipitation here is about the same as in southern Ohio. The mean annual temperature of Seattle for December, 1894, to December, 1903, was 52°. The maximum for that time was 96° and the minimum 3°.

Although the great forests that have made this part of the north westcoast famous are fast disappearing, lumbering continues to be the chief industry along the Sound, and millions of feet of lumber are each year sent east by the railways or shipped by vessel to various parts of the world.

Seattle has one of the finest deep-water harbors on the coast. As shown by the sketch map of Elliott Bay on sheet 27, the water deepens rapidly to 100 feet and then the depth increases gradually and some what irregularly to 600 feet where the bay opens into the Sound.

The harbor facilities of Seattle and its position near the Strait of Juan de Fuca and also the inland passage to the north have made it the most advantageous place on the northwest coast for the center of the Alaskan trade and also for a large part of the oriental commerce to the United States.
ITINERARY

St. Cloud.  
Elevation 1,050 feet.  
Population 10,600.  
St. Paul 76 miles.

The town of St. Cloud (see sheet 2, p. 26) lies on the opposite side of the river from the railway, so that the traveler can see only the station and a few houses. A rapid in the river near this place is utilized to produce power for a large milling industry. Here the main line of the Great Northern Railway crosses the river, but a branch of that road leading from St. Cloud to Duluth is crossed by the Northern Pacific train a short distance beyond the station.

Sauk Rapids.  
Elevation 1,034 feet.  
Population 1,745.

At Sauk Rapids the low granite and drift hills that border the valley on the right (east) approach so close to the river that there is room only for a few streets and the railway between the hills and the
St. Paul 77 miles. Masses of granite can be seen in the river channel and the resistance of this rock has produced the rapids at this place. Rock of the same kind is quarried in the bluffs some distance back from the river and is brought to the main line over a short spur for shipment. Above the rapids the river flows quietly between low wooded banks, or rather in a slight depression in the bottom of the broad valley.

Although the hills are less precipitous beyond Sauk Rapids, the presence of granite in the vicinity of Watab station is attested by great bowlders of this material that were evidently picked up by the glacier and distributed along the valley, and also by old quarries that are faintly discernible on the left (west).

The traveler is now approaching the place where Pike's party wintered in 1805-6 on their memorable trip to the source of the Mississippi.¹

¹As soon as Louisiana had been acquired from France by the treaty signed at Paris on April 30, 1803, President Jefferson took steps to have the newly acquired country thoroughly explored. He personally planned the expedition to the Pacific coast which was conducted by Lewis and Clark (see p. 47) in 1804-1806 and other expeditions by Lieut. Zebulon M. Pike to the headwaters of the Mississippi and to the great Southwest. Pike's search for the source of the Mississippi took him over ground with which the traveler is now somewhat familiar, and an account of the trip may be of interest.

The country through which Pike traveled was at that time fairly well known, but the earlier explorations had been made by French and English adventurers who were using every means to further the interests of their respective Governments. It had now become the property of the United States, and Jefferson wanted first-hand information not only regarding the geography of the country but also regarding the attitude taken toward the new owner by the Indian tribes and the trappers and traders who gathered furs from this vast wilderness.

Pike left St. Louis on August 9, 1805, with 1 sergeant, 2 corporals, and 17 privates. He found settlements and villages as far up the river as Prairie du Chien, but above that place there was no white settlement and only scattered trading posts of the various fur companies. He reached the mouth of St. Peter (Minnesota) River on September 21, and spent some time visiting the Indians and acquiring for the Government the title to 100,000 acres of land, including the site of Fort Snelling and the Falls of St. Anthony.

He then portaged around the falls and proceeded up the river, but at many places he had considerable difficulty in getting his boats over the rapids. He finally reached the vicinity of Little Falls, but here the river was so rough that he decided it was useless to take the boats farther, so on October 16, 1805, he went into winter quarters on the west bank of the river about 4 miles below the present town of Little Falls.

Pike with a few companions pushed on afoot and endeavored to find the source of the great river. He succeeded in a general way in settling the question, though he did not discover Lake Itasca. Pike returned to Little Falls on March 6, 1806, and on April 10 the entire party embarked once more, reaching St. Louis on the 30th.
Between Watab and Rice the railway runs in a flat valley that extends as far as the eye can reach. It is well cultivated, and the fields of grain and potatoes are broken only by some small lakes that are to be seen on the right of the track but these have low shores and are not particularly attractive. As the train glides though mile after mile of waving grain or pasture fields, with here and there a farmhouse nestling beneath the shadow of some ancient oak, it is hard to realize that a little more than a century ago this was a wilderness in which roving bands of Indians found only a scanty subsistence and trappers and traders made journeys with the greatest hardship and discomfort.

Although there are no exposures of rock between Rice and Royalton, the route map opposite page 26 shows many isolated outcrops of granite and slate; and it will be noticed that all the areas of granite lie east of a line passing nearly though Royalton and that all the hard rocks which appear at the surface west of that line are slates or schists (for definition see footnote on p. 155) with the exception of one exposure of Cretaceous shale on the west side of the river nearly opposite Royalton.

A short distance beyond milepost 95 a branch of the Soo Line (Minneapolis, St. Paul & Sault Ste. Marie Railway), extending from Brooten to Duluth, crosses the valley and the Northern Pacific track by a long, high fill. North of Royalton, on the right, some rather prominent morainic hills give a pleasing variety to the landscape; and at Gregory the traveler is about opposite the point where Pike's party spent the winter of 1805-6.

Taken all in all, the Mississippi Valley, in which the train runs from Minneapolis to Little Falls, is one of the richest and most attractive valleys in the State.

From Little Falls lead two branch lines of the Northern Pacific, one running up the east bank of Mississippi River to Brainerd and thence to International Falls, on the northern boundary of Minnesota, and the other turning to the left and running to Morris, near the western edge of the State. The falls in the river are produced by hard slate and schist and by diorite (molten material that was forced up and into the sedimentary rocks and that has since been consolidated, forming a hard, dense, dark rock) of Archean age. (See table on p. 2.) These rocks are not massive like the granite at St. Cloud and so they do not make good building material, but they are as hard or harder and form a persistent obstacle to the easy flow of the river. The falls are of great commercial importance, as they furnish 10,000 horsepower, which is utilized by sawmills having a capacity of 70,000,000 board feet of lumber annually, flour and paper mills, and an electric-light plant.

Here once lay the margin of a great evergreen forest that stretched wild and unbroken to Duluth and the falls of Sault Ste. Marie, but now only a few pine trees can be seen here and there along the railway, for most of them have disappeared in the insatiable maws of the great lumber mills. Little Falls is noted among archeologists as a place where a large number of flint implements, belonging to an early race of men, have been found.

At Little Falls the traveler crosses Mississippi River for the last time in his westward trip; he will soon pass out of the Mississippi drainage basin and enter another whose waters find an outlet to the north. After leaving the river the train passes though a country that is typically glacial in all its features. The hard rocks are covered by
drift varying in thickness from 35 to 400 feet. Owing to this thick cover the present surface of the ground gives no indication of what is beneath, and for many years it was supposed that this swampland country, covered only with brush and scrub oak, was of no value whatever. After some of the great deposits of iron ore in Minnesota and Wisconsin had been exploited it was found that the best way to prospect for iron ore in this region was with the magnetic needle. Many parts of Minnesota were tested unsuccessfully, but in 1895 it was found that the magnetic needle was affected in this area, and drilling has shown that it is underlain by a large body of iron ore. This deposit is now known as the Cuyuna (ki-you'na) iron range and is one of the three important iron ranges of the State. This range (see map of Cuyuna range on sheet 2, p. 26), as now prospected and developed, extends from Aitkin, about 27 miles northeast of Brainerd, southwestward to the vicinity of Randall. It is about 55 miles long, but its width has not been fully determined. No mining is done near this line of the Northern Pacific Railway, but several mines are operated some 40 miles to the northeast.\footnote{Whoever wishes to see something of iron mining in Minnesota should make a short trip from Little Falls or Staples to Crosby or Ironton, on the Duluth line. The Pennington mine, which is within easy walking distance of either of these towns, consists of a large open pit from which the glacial drift was first stripped away and the ore then mined by steam shovels. The ore is hematite, an iron oxide, and has resulted from the deep weathering or decomposition of a slaty sedimentary rock that was originally rich in iron carbonate. The sedimentary rocks strike about N. 50° E., are folded closely, and dip at high angles. The workable deposits are vertical or steeply dipping lenses, which generally have a maximum width of 400 or 500 feet and an average depth of about 300 feet, but the maximum known depth is about 1,000 feet. Some of the lenses extend for more than half a mile along the strike. The ores, some of which are soft and some hard, are in the main non-Bessemer—that is, they contain too much phosphorus to be converted into steel by the Bessemer process, which is one of the processes generally used. Some of the ores contain considerable manganese.}

Little farming is carried on in this region, and the country is covered with a dense growth of scrub oak.

The traveler wishing to make a more extended excursion into the iron country may go from Little Falls or Staples to Duluth and take either the Duluth, Missabe & Northern Railway or the Duluth & Iron Range Railroad to one of the great iron-producing towns on the Mesabi range. This range is about 100 miles long and 1 to 3 miles wide. The most productive part is served by a trolley line which runs between Hibbing and Eveleth, making all the mining towns between easily accessible. The Hull-Rust open pit at Hibbing is the largest iron mine in the world, producing in 1913 nearly 3,500,000 long tons of ore. A description of the iron ranges is given by W. H. Emmons, State geologist of Minnesota, in the following paragraphs:

The iron ore of the Mesabi (me-sah'be) and Cuyuna ranges is contained in the Biwabik (be-wah'bick) formation, named from one of the iron-mining towns in the Mesabi range. This formation consists of ferruginous cherts, iron ores, slates, iron silicate, and carbonate rocks, with a small amount of coarse detrital material at its base. It grades upward and in places laterally into more slaty rocks, known as the Virginia slate; and it is underlain by the Pokegama quartzite, consisting mainly of quartzite but containing also conglomerate at its base. These three formations are generally known as the Animikie (a-nim'i-kee) group and belong in the upper part of the Algonkian system as exposed in this region. All these rocks were laid down after the close folding which affected the lower Algonkian
rocks, consequently the formations of the Animikie group are not on edge but generally dip at low angles.

The Biwabik or iron-bearing formation extends along the Mesabi range (see map on sheet 2, p. 26) for its entire length. Its average thickness is about 800 feet, but owing to the prevailing low dips the width exposed varies from a quarter of a mile to 3 miles. The great bulk of the formation is ferruginous (iron-bearing) chert, with varying amounts of amphibole (asbestos), some lime and iron carbonates, and bands and shoots of iron ore. Associated with the chert, mainly in the middle zone, is the iron ore, which occupies about 5 percent of the total surface area of the formation. Throughout the iron-bearing formation, particularly in its upper part, are thin layers of slate and paint rock, the paint rock usually resulting from the alteration of the slate.

At the east end of the range, near Birch Lake, the iron formation has been considerably metamorphosed in consequence of the intrusion of granite to the north and of gabbro to the south. As a result considerable amphibole has been developed in the ferruginous rocks, magnetite has segregated into layers, and the rocks have become hardened.

Thin beds of conglomerate and shale of Cretaceous age, lying nearly horizontal, cap the various Algonkian and Archean formations. The basal beds of the Cretaceous locally carry detrital iron ore derived from the weathered Biwabik formation.

Only small portions of the Biwabik formation are rich enough to constitute iron ore. These occur in isolated masses along the eroded surface of the formation and are generally not over 200 feet thick, although some are thicker. The workable deposits are secondary concentrations due to the action of surface waters, which have leached out the silica and some other elements and have left the iron in a more highly concentrated form. Concentration of this nature, in places to which water solutions have found more ready access, has been going on through long geologic periods. That it was well advanced in Cretaceous time is shown in the detrital zone of the Cretaceous rocks, in which iron ore is abundant in the form of polished pebbles.

The geologic conditions in the Cuyuna range appear to be almost identical with those in the Mesabi range, described above, but as the Cuyuna range has been only slightly developed its geology can not yet be described in detail.

Cushing.
Elevation 1,288 feet.
Population 313.*
St. Paul 123 miles.

For some distance beyond Randall the country consists largely of swamps and scrub-oak uplands, but north of Cushing the surface becomes rougher, consisting of knobby hills with swamps or lakes between them. When seen from some commanding eminence the country appears to be a maze of more or less regular conical hills among which the railway turns and twists to find a level pathway. As the traveler proceeds he will note that the depressions between the hills become more pronounced, and when he is within a mile of Lincoln, or at milepost 126, he can see on his right one of the largest depressions in the region, occupied by Lake Alexander. Evidently the character of the submerged surface is much the same as that around the lake, for the surface of the lake, although extensive, is broken by morainic islands that add greatly to the charm of the scene.
Lincoln.
Elevation 1,304 feet.  St. Paul 129 miles.

The rough topography reaches its culmination near Lincoln, where the hills range in height from 100 to 150 feet and are very steep. As described in the footnote on pages 26—30, the morainic material forming these hills was brought by a great glacier (the middle ice sheet) that pushed into this region from the northeast. It extended only a little beyond Mississippi River, and the rough topography about Lincoln is due to the deposition of a part of its terminal moraine.

Lincoln is mainly a summer resort and is an attractive place for those who enjoy boating and other aquatic sports. The wooded islands in Lake Alexander afford an almost unlimited number of camping places and sites for summer cottages.

Philbrook.
Elevation 1,269 feet.
St. Paul 135 miles.

The strong morainic topography continues for several miles beyond Lincoln but gradually becomes more subdued, and even the gently rolling ground that is noticeable around Philbrook soon gives place to a country that is flat and swampy as far as the eye can see. Philbrook is supposed to stand on the dividing line between the red drift of the middle ice sheet and the gray drift of the western sheet, but no distinction between the two drift sheets can be observed from the car window.

Staples.
Elevation 1,298 feet.

From Philbrook the land continues flat and swampy to Staples, which is a division point and one of the main junctions on the railway. Here the line from St. Paul joins the original main line of the Northern Pacific from Duluth. The country west of Staples is as flat as that to the south, over which the traveler has just passed, and as far as the eye can see there are no hills to break the monotony of flat and swamp. The railway follows, in general, the valley of Leaf River, which lies north of the track.

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1 As early as 1853 the Government made a survey to determine the best location for a Pacific railroad, and one of the routes examined and recommended is practically that which the Northern Pacific follows, but after the survey was made the undertaking seemed so great that capital could not be found with which to make even a beginning. On the completion of the Union Pacific Railroad in 1869 the faith of the public in the success of transcontinental roads seems to have revived, and in 1870 the construction of the Northern Pacific line was actually begun. Work was started at the two extremities—near Duluth, which was to be the eastern terminus, and between Kalama, on Columbia River, and Tacoma, the western terminus in Washington. In Minnesota the rails were laid in 1870 as far as Brainerd, on Mississippi River, 30 miles east of Staples, and in 1871 were extended entirely across the State.

At that time Duluth, on account of its location on one of the Great Lakes, was considered the most desirable place to connect with the East. Duluth is a convenient port for the westward traffic in coal and other heavy materials and for grain shipments eastward to the seaboard, but it then stood in a great wilderness, without railway communication and at the head of a lake closed to navigation by ice for five months of the year. The Northern Pacific Co. early recognized that water transportation was losing its importance and that in the future St. Paul, with its unlimited possibilities of railroad connection with Chicago, was the natural eastern terminus of the road. Accordingly negotiations for a line to St. Paul were undertaken.
Sometime between 1864 and 1870 a railroad was built from St. Paul up Mississippi River to Sauk Rapids by an independent company. This line was purchased by the Northern Pacific Co. in 1870 with the understanding that the road was to be completed to Brainerd, where it would connect with the main line of that system. In the panic of 1873 the Northern Pacific could not fulfill its obligations and so lost control of this line. The road was completed to Brainerd on November 1, 1877, by other persons, and it afforded the first railroad connection between the Northern Pacific line and the cities of Minneapolis and St. Paul. The Northern Pacific Co. leased this line in 1878 and later acquired control of it through the purchase of its capital stock. Still later the company built the road from Little Falls to Staples, giving it the through connection desired.
North of Umptanum Creek lies Manastash Ridge, which, like the others already crossed, is an arch in structure; but the fold is much flatter than those down the river, and its shape is not apparent from the train. The layers of basalt rise gradually northward from the mouth of Umptanum Creek, and they appear to be nearly horizontal in the great Beavertail Bend between mileposts 115 and 118. The axis of the fold is more than a mile north of this bend and not far from milepost 120, where the railway again crosses to the east side of Yakima River. From this crossing the layers of rock descend rapidly northward, and the great sheets of basalt that form the walls of the canyon for more than 20 miles dip below water level and the train emerges upon another broad flat that seems to be even more extensive than the one at North Yakima. This also is mostly under cultivation, and the view on the right as the train leaves the canyon is particularly charming, as one looks off to the distant mountains across a wide stretch of fertile fields and orchards, crossed here and there by lines of tall trees planted as windbreaks.
Although much hard rock is exposed in the Yakima Valley stone suitable for building material is very scarce. The basalt is a lasting material, but its dark color renders it unsuitable for buildings and it is used only for foundations and for road metal. For the latter use it is admirably adapted. On the north slope of Manastash Ridge, about 2 miles east of Thrall, the sandstone of the Ellensburg formation has been hardened by the pressure that arched and overturned the basalt so as to make it a very good building stone, and it has been utilized in some of the business blocks of Ellensburg.

Ellensburg is the end of a division and a prosperous town in the broad Kittitas Valley, which stretches far to the east along Manastash Ridge. It is served not only by the Northern Pacific but also by the Chicago, Milwaukee & St. Paul Railway, which gives it an advantage over most of the other towns of the Yakima Valley. Owing to the altitude, the land is much better suited to the raising of hay and to dairying than that of the lower valley.

A little north of Ellensburg Mount Stuart, far to the north, stands up as a narrow, jagged crest carrying much snow. This view is not so imposing as that of Mount Adams seen from a point farther down the valley, but the summits here are much narrower than that of Mount Adams and the mountain has a more rugged outline. The railway is bordered by broad meadows of timothy or clover and by fields of oats or wheat that roll in great billows under the strong wind that at times sweeps down the valley from the mountains. About a mile from the station the St. Paul Railway is visible on the right, having crossed Columbia River by a route leading directly west from Connell.

The bluff on the right near milepost 4 is composed of the Ellensburg formation, which overlies the great flows of basalt and is composed of white clay (in most places volcanic ash), sand, and gravel. This material is only partly consolidated, but it stands in steep bluffs, as can be seen on the right. The material is so soft and the slope so steep that in carrying water along the bluff to irrigate lands lower down the valley a timber flume had to be built along the entire face of the bluff a distance of more than 2 miles. This gives an idea of the elaborate and expensive work that must be done in many localities in order to obtain the necessary water for irrigation. Not only is the first cost of such a flume great, but the maintenance is a considerable item of expense which must be met every year.

Just after passing milepost 7 the train crosses Yakima River, here a small stream but beautifully clear and pure, and then it follows the river bottom, in some places on the bank of the stream and in others back at the foot of the bluff as the river swings from side to side of its flood plain. Near milepost 10 the railway again crosses the river, and the St. Paul road is on the other side under a high bluff, in which is exposed a prominent band of white volcanic ash. At the first sharp curve north of the river crossing the basalt is at track level, but it rises up the stream with the soft, stratified beds of the Ellensburg formation which rest upon it and which rise in the same direction and at the same rate.

The canyons south of this place have been cut by Yakima River through low rolls or folds in the basalt, but none of these folds have been of sufficient magnitude for the river to reach the base of the lava sheets; but north of Ellensburg the whole series of rock formations has been turned up like the rim of a basin, and the canyon which begins at Dudley, 10 miles above Ellensburg, is the cut made by Yakima River through the basalt of this rim. Figure 37 shows
the gradual rise of the basalt northward and its final disappearance in the hilltops far above river level.

FIGURE 37.—Section showing structure of Yakima basalt north of Ellensburg, Wash. The basalt rises from a level below Yakima River near Dudley and is far above track level at Teanaway.

Bristol.
Elevation 1,803 feet.
St. Paul 1,794 miles.

In some parts the canyon is bounded by rugged walls of basalt which makes it somewhat picturesque, but in general there is little to attract attention except the interesting geologic section that is exposed here. In places the canyon opens out and the sides are covered with scattered pine trees that are but the fringe of the great mantle of forest that covers all of the Cascade Range except the highest summits and that once extended unbroken to the shores of the Pacific Ocean. The basalt rises steadily and near milepost 18 the whitish sandstone and clay of the underlying older formation makes its appearance in cuts along the St. Paul road, on the opposite shore of the stream.

The traveler should be prepared to see Mount Stuart on the right (north) as the train emerges from the canyon, for the view, if the weather is clear, is superb and lasts for only a few minutes.1

1Mount Stuart is the culminating peak of a spur which extends eastward from the main crest of the Cascade Range. The summit of the peak rises to an altitude of 9,470 feet, or 7,600 feet above the railway at Teanaway station. This granite peak, with its deeply carved spires and crags, more or less covered with snow throughout the summer, is the most striking feature in the varied scenery of the region; but its wildest and grandest scenery lies hidden within its own fastnesses.

The southern face of the mountain is a precipitous slope, rising 5,000 feet or more above the creek which flows at its foot. The lower part of this wall can be scaled at several points, but by only one route has the highest peak been attained by the mountain climber. This peak is so acute that the greater part of the available space is taken by the United States Geological Survey triangulation monument which crowns its summit.

On the north side of Mount Stuart are broad and deep amphitheatres, in which lie small glaciers and glacial lakes, draining northward into Icicle Creek. The glaciers immediately below the main peak are mere remnants, some of them only a few hundred yards across; yet these exhibit most of the characteristic features of larger ice streams.

It is apparent that Mount Stuart is different from Mount Adams, which, as seen from a point near Toppenish, consists essentially of a gigantic cone resting upon the broad platform of the Cascade Range. Mount Stuart, as can be seen from Teanaway, is rugged in the extreme, and consists of a serrate ridge with one high point. The difference in the form of the two peaks is due to differences in
Mount Stuart consists of a great mass of granite which long ago was forced up through the rocks from below but probably never reached the surface. Before Tertiary time this great mass, together with the surrounding sedimentary and igneous rocks, was deformed by earth movements and possibly was uncovered and carved into mountains, though the record is not complete enough to determine that with certainty. The surface of the country was finally reduced to a low land, except the granite mass, which owing to its hardness was left projecting about 1,000 feet above the plain. Late in Tertiary time the Cascade Range was formed by a great uplift of the rocks, and then the streams began their present work of cutting it away. Great canyons were eroded in the uplifted mass, and the pinnacles and towers of the jagged crest of Mount Stuart have been formed merely by the removal of adjacent material.

Thus while Mount Adams is a mountain of construction, Mount Stuart is a mountain of erosion. No better representatives of the types could be found than these two peaks of the Cascade Range.

The white sandstone of the Roslyn formation is visible in a low bank on the right near the old station of Teanaway. It rises toward the north, like the formations observed in the canyon, and it forms the southward-facing slope of the great ridge on the right. The red rocks on the mountain side on the left are the Teanaway basalt, which underlies the Roslyn formation and is of Eocene age. The layers of basalt in this mountain are not horizontal but are turned up on edge, so that the relation of the Teanaway to the Roslyn is not apparent.

The valley here was formerly covered with dense forest, in striking contrast to the valley lower down, where there were few trees of any kind until the country was settled.

Near Clealum a heavy-bedded white sandstone, underlying some coal beds, dips to the south with the same slope as the side of the valley, and consequently it covers the entire hillside. Three coal tipples are in sight from the train. Some coal is produced here, but most of it comes from mines farther from the main line of the railway. From Clealum a branch line leads to the right to Roslyn, where are situated the mines of the Northern Pacific and also of companies that are mining coal for sale. The Roslyn coal field is one of the most valuable in the State. It has made its reputation largely because of the cleanness of the coal and its good quality for steam raising and for domestic use. The Northern Pacific Co. uses the coal mined here for all its locomotives and stationary engines between the Stampede tunnel on the west and Butte and Helena on the east. Clealum has also been the supply point for the three principal gold-mining districts in central Washington.1

1The coal-bearing rocks of the Roslyn field lie in an open trough or syncline, the axis of which extends in a northwesterly direction parallel with the main valleys of the region. The Roslyn formation, which contains the coal beds, is about 3,000 feet thick, but the coal occurs in the upper part alone, and for this reason the coal beds are much less extensive than the formation which carries them. So far as known they are restricted to an area about 7 miles long by 3-1/2 miles wide, extending from a point just a little east of Clealum northwestward nearly to Clealum Lake. Along the northeastern limb of the syncline the coal beds are well known, as the principal bed has been mined out throughout most of that area, but
on the southwest side the rocks are badly covered, and although considerable drilling has been done the extent of the workable coal is somewhat problematic.

So far only one bed, the Roslyn, has been worked; another bed of workable thickness underlies the Roslyn, but its extent and value have never been determined. The Roslyn bed is remarkably regular in thickness and composition throughout the district, but the quality of the coal improves regularly from Clealum westward toward the mountains. The average thickness ranges from 4 feet 4 inches to 4 feet 9 inches. The bed is not all clear coal but contains a number of partings of bony coal. Government analyses show that the heating value of the coal ranges from 11,950 to 12,980 British thermal units.

The Roslyn district contains some of the largest mines west of Mississippi River, and the field as a whole is the most productive in the State. Its output for the year 1913 was 1,334,155 short tons, or more than one-third of the coal produced by the entire State.

The gold-mining districts in central Washington are the Swauk, Peshastin, and Negro Creek, and lie from 18 to 24 miles northeast of Clealum. Placer gold has been found in all these districts, but the Swauk is particularly noted for the coarseness of the gold. Large nuggets have been found here, one being worth $1,100. Gold was discovered in this region in 1860, and at least $2,000,000 worth has been produced.

West of Clealum the railway follows the north bank of the river under the cut bank of an extensive terrace of gravel, which is doubtless the outwash from the glacier that once occupied Clealum Valley. The road then bends sharply to the south around a narrow point of the terrace that has been protected from erosion by a projecting boss of the Teanaway basalt. In the early days of railroading in the Yakima Valley this was known as Deadman's Curve, from the number of fatal accidents that occurred here, but now with the use of block signals the danger has been removed.

About a mile west of this curve the railway crosses Clealum River, which drains a large valley heading far to the north and containing Clealum Lake, a body of water 4 miles long and nearly a mile wide. At the outlet of this lake the Reclamation Service has constructed a low dam to raise the level of the lake and make a storage reservoir. It is proposed to increase the height of this dam and thus impound a much larger volume of water for use in the lower valley. As the railway rounds the next point of the terrace and crosses the river a corresponding point is seen on the left, as if at one time there had been a continuous ridge across the valley at this place. This ridge has many of the characteristics of a terminal moraine, including a steep face upstream against which the ice front may have rested, a hummocky surface in that part lying to the left (south) of the track, and bowlder clay at the bottom of the cut near the railway. These features, together with the flat, smooth floor of the valley above, indicate that at a certain stage of the glaciation of this region a large body of ice came down the tributary valley now occupied by Kachess Lake and extended down Yakima Valley to this point. Here it rested for a while, pushing out in front the clay and rock fragments that it had ground off the rocky bed over which it had moved, and then the water flowing from the ice carried sand and gravel and spread them in a somewhat irregular sheet above the till.

Besides the moraine just described, one lies at the lower end of Kachess (ka-chess') Lake and another just below Keechelus (kee'che-lus) Lake. These show that the glacier, after retreating several miles up the branching valley, came to a halt and probably readvanced a little, piling
up the rocky material in each valley as a terminal moraine. Kachess Lake, the largest lake in the region, is a beautiful sheet of water nearly 6 miles long and a mile wide. A wagon road extends to the lower end of the lake, but the upper part is still encircled by unbroken forest, which covers the inclosing mountain slopes to a height of 3,200 feet above the lake. The deep basin in which the lake lies was scoured out by the glacier that once occupied this valley. The outlet of the lake has been dammed by the Reclamation Service and the level of the water raised several feet, thereby increasing the amount of stored water available for irrigation.

The mountain side on the left (south), which can be seen to good advantage in the journey up the broad valley above the moraine, consists of schist (the Easton schist), which is the oldest geologic formation that will be seen in the Cascade Mountains. Its exact age has not been determined, but it is supposed to be Carboniferous or older. It is a part of the great foundation upon which the Tertiary sediments and lavas were laid down. The rocks on the right (north) are the Teanaway basalt, which covers large areas east of the summit of the range. Near milepost 36 the sheets of lava that make up this formation are well exposed in the high mountain summit just north of Silver Creek. The sheets of lava here dip away from the valley and they make a rugged mountain front, the steepness of which has been greatly accentuated by the scouring that the old glacier has done along the bottom of the slope.

Easton, which lies at the foot of the steep climb up to the Stampede tunnel, is mainly a place for helper engines to wait until their services are needed in pushing up the grade. The broad valley which the railway has been following for some distance continues directly ahead to Kachess Lake, but just beyond Easton the road swerves to the left and appears to plunge directly into the hillside.

From the bottom of the valley the reason for this change of route is not apparent, but from any commanding summit in the neighborhood it may be seen that Easton is situated at the junction of two valleys, each of which has a width of nearly 2 miles. The chief difference in the valleys is that they are not at the same level. The Kachess Valley has an altitude of 2,150 feet, whereas the old floor of the Yakima Valley, represented by the tops of the hills above Easton, is 350 feet higher. It is clearly evident that for some reason the Kachess Valley has been deepened below that of Yakima River, and that the latter is now cutting a narrow trench in its old valley bottom in order to reduce its grade to that of the stream which it joins near Easton. These changes seem to be connected in some way with the occupation of the valleys by glacial ice, but the manner in which it has been accomplished has not been worked out.

Both the Northern Pacific and St. Paul roads follow the river through the narrow gorge above Easton, where the stream boils and tumbles over the rocky ledges toward the open valley below. The sand and gravel carried down by the stream are constantly grinding away the hard rocks, but it is a slow process, and many generations will pass before the obstruction is removed. The narrow gorge is short, and beyond it the railway enters the relatively open valley above.

As the Northern Pacific crosses the summit of the range near Stampede Pass, about 9 miles from Easton, it climbs at a steep grade. The St. Paul road, which is here on the right, crosses at Snoqualmie Pass, 11 miles farther north. A short distance beyond Easton the railway enters the great mass of andesitic lava flows and tuffs that in this region make up the great bulk of the Cascade Range.

From a scenic point of view the climb to the pass is not striking, for the traveler sees only rounded mountain slopes thickly covered with timber and the broad valley equally well protected by a tangle of dense vegetation. It is reported that bowlders of granite and similar rocks have been found perched on the mountain sides from 1,200 to 1,700 feet above the bottoms of the valleys. These indicate that at some early stage of the glacial epoch the
glaciers were much more extensive than they were at a later stage when the moraines previously described were formed.

One of the most striking features of the valley is the low pass on the right, leading to the upper end of Kachess Lake. This pass has an altitude of about 2,500 feet and doubtless was an outlet for either the drainage of the upper Yakima Valley or that of Kachess Valley, on the east. Its cutting and abandonment are doubtless connected with the trenching of the old valley of the Yakima above Easton, but the conditions which resulted in these changes have not been determined.

This valley, like the two next east, is occupied by a lake (Keechelus Lake) which doubtless had its origin in the erosive action of the glacier that evidently lay for some time in the lake basin and built the moraines around its lower end. Many beautiful views of Keechelus Lake may be obtained, either from the wagon road that follows the eastern bank or from the St. Paul Railway, which overlooks it on the west. (See Pl. XXV, p. 175.)

![Image](PLATE XXV.—BEAUTIFUL LAKE KEECHELUS, WASH. The heavy forest covers the mountain slopes down to the water's edge.)

After a long climb the railway reaches Martin, the last station on the east side of the range, and a short distance beyond turns sharply to the left and faces the east portal of the Stampede tunnel. At this point there are visible on the right remnants of the old line, which wound up to the top of the mountain before the tunnel was built.

The Stampede tunnel is nearly 2 miles long. So many trains pass through it that great difficulty has been experienced in keeping it free from smoke and gas, but now an enormous fan has been installed at the west end, in a building which the westbound traveler will see on his right as the train emerges from the tunnel. It is expected that this fan will free the tunnel of smoke and gas in a very short time.

Stampede Pass has an elevation above sea level of about 3,600 feet, but the long tunnel enables the railway to cross the range at a much lower level. In order to maintain a regular grade down the west side of the range, the track winds in and out and around spurs in a most confusing manner to one who is endeavoring to keep directions or to see the mountains. From Stampede two lines of rails are visible far below on the left,
which seem to belong to another road, but later it appears that they are parts of a large loop which the Northern Pacific is forced to make in order to get down the mountain side.

The mountain slopes are generally smooth and round, and the thick mantle of trees and brush covers all except here and there a lava cliff or an old scar that marks the passage of some forest fire. The outlook is confined generally to the valley of Green River, which the railway descends, but at one place, if the weather is favorable, a fleeting glimpse may be caught of the towering white cone of Mount Rainier. This view may be had on the right while rounding the extreme point of the loop about 2 miles west of Stampede. The mountain is in view only for a moment and then is hidden by the nearer slopes.

1The traveler from the train can get only a very imperfect idea of the character of the country, for he is looking at it from a position below the level of the mountain tops and hence can not see its upper surface. Although it is not possible to see much of the Cascade Range, a study of the contours on sheets 26 and 27 will show that the mountain summits on both sides of the railway are at nearly the same elevation, ranging from 4,000 to 6,000 feet above sea level. It will show also that the range is not sharp crested, like those in the vicinity of Helena and Butte, but a broad plateau which has been so cut into by the streams that its originally regular surface has disappeared, leaving only a labyrinth of narrow branching valleys and steep-sided hills.

Sheet 26 also shows the location, about 12 miles south of the Stampede tunnel, of Naches Pass (altitude 4,923 feet) and the old Naches trail, which was the first road to be opened across the Cascade Range north of Columbia River. The early explorers learned of this route from the Indians and utilized it in their wanderings around the headwaters of Yakima River. It was not, however, used to any great extent until the rush of homeseekers about 1850 made it desirable to find a shorter route to Puget Sound ports than that by way of Fort Vancouver, on Columbia River. Accordingly in 1853 the Naches trail was made passable for wagons, though probably a pretty rough road, and many settlers found their way to the Sound by this route.

The rocks in the valley of Green River are the same as those seen on the east side. They consist of lava flows and beds of volcanic tuff that have been tilted in various directions. These rocks are known as the Keechelus andesitic series and most of them are of Miocene age. They represent the great floods of lava and fragmental material that were poured out before the Cascades were formed. They now form part of the broad platform upon which the great volcanic cones of Mount Rainier, Mount Adams, and Mount St. Helens are reared.

The train runs down the mountain slope on the left side of Sunday Creek to the junction of that stream with Green River, which comes from the south. At present the road makes a long loop up Green River, but a new line is being constructed that will cut off this loop. The valley of Green River, as well as that of Sunday Creek, is broad and rounded and shows clearly that it has been cleared and modified by a glacier. The development, maximum extension, and retreat of the glaciers of this region are described below by Bailey Willis.1

1Glacial development began in the high mountains. The climate, at one time milder than that now existing, gradually though not continuously increased in severity. As cold seasons grew longer and warm ones shorter, snow banks in the
shadows of high peaks increased in volume and drifts accumulated in hollows less protected from the sun. As they grew, the snow banks consolidated to ice, and, flowing downward, became glaciers. Each canyon received an onward-moving ice stream proportionate in size to the tributary area above it. The air was chilled, precipitation increased, and glaciers extended, and thus the effect of climatic change was accelerated. The mountains became mantled with white, except over sharp, wind-swept peaks and ridges. Issuing from the foothills, the glaciers spread and adjacent ones coalesced, forming broad piedmont glaciers. A piedmont glacier (that is, a glacier at the foot of the mountain) is related to the mountain or alpine glaciers which feed it as a lake is related to its tributary streams.

Three great piedmont glaciers met in the Puget Sound basin. One was fed from the Olympic Mountains, on the west; a larger one gathered along the base of the Cascade Range, on the east; the largest flowed south from the area between Vancouver Island and the mainland of British Columbia and poured a great mass of ice westward into the Strait of Juan de Fuca and another into Puget Sound. Tongues of these piedmont glaciers advanced along the valleys until opposing ice streams met and coalesced. Then the ice mass deepened, as water may deepen in a lake. Land divides became peninsulas and isolated hills stood as islands. Hills of the Puget Sound basin were finally submerged, the ice reaching a thickness of 2,500 feet or more in the present site of Admiralty Inlet, the main channel leading to Puget Sound, and the southern extremity of the ice sheet spread beyond Tacoma and Olympia on the south and west.

Finally the glaciers ceased to increase in the mountains and to deepen in the valleys as the climate changed either to milder seasons or to less precipitation, or both, a change due to ultimate causes, which, like those that brought on glaciation, are not understood. Then followed an epoch during which the ice melted earlier and more rapidly in the lowlands, later and lingeringly in the canyons of the ranges. The piedmont glaciers shrunk till they parted, and each mantled the foothills of its parent range. The margins of the glaciers consisted of masses of stagnant ice buried beneath accumulations of gravel, sand, and loam, and hardy vegetation may have flourished in soil upon the ice. Rivers flowed on the glaciers, through tunnels in them, and from beneath them. Ice-bound lakes were formed in embayments of the hills. Changes succeeded one another frequently, and each phase of ice and stream and lake left a meager record of its existence in deposits of detritus.