THE START FOR MOUNT OLYMPUS.

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Notes on the Bed Rock Geology of the Olympic Peninsula

By CHARLES E. WEAVER

PROBABLY one of the least known and as yet unexplored areas in the continental portion of the United States lies in the northwestern part of the state of Washington and is known as the Olympic peninsula. The interest in the geology of this region which was aroused during the writer's outing with The Mountaineers has resulted in a few scattered notes, part of which are derived from first hand information in the field, and part from the published investigations of Dr. Ralph Arnold of the United States Geological Survey, who has made a somewhat extended study of the geology along the coast. The results here given are only general and entirely from a popular standpoint and it is only after a detailed scientific study of the whole area has been made that any account even approaching accuracy can be attempted. The region is wild, heavily timbered and in many places difficult of access and as no suitable maps are available, geological work must be carried on under serious difficulties. However, the attractiveness of the field, the grandeur of the scenery and the interesting and varied geological problems to be worked out make the Olympic mountains of especial interest not only to those interested in elucidating the geology of the west coast of North America, but also to those who delight in the enjoyment of a vacation spent in a primeval district which is as yet so little known.

The Olympic peninsula is a rugged land area very nearly surrounded by water. On the east it is bounded by Puget Sound and Hood's Canal, on the north by the Straits of Juan de Fuca, on the west by the Pacific ocean and on the south by Grays Harbor and the Chehalis valley. The counties embraced within this area are Chehalis, Mason, Clallam, Jefferson and Kitsap. The area occupied by this peninsula approaches something like eight thousand square miles. The extent from east to west is about eighty miles and from north to south about one hundred miles.

The topographic features of the Olympic peninsula consist of a central mass composed of high, rugged and serrated mountain ridges which gradually diminish in altitude until they become a very low plateau along the coast with an elevation of less than three hundred feet above sea level. The high central portion of this peninsula, of which Mount Olympus is the culminating point, has a general east to west trend and is perhaps twenty miles long by ten to fifteen in width. The maximum elevation on the highest peak of Mount Olympus is 8,250 feet and the average elevation in the district around the mountain is between five thousand and eight thousand feet. West of this central area the elevation of the mountain ridges decreases and in the vicinity of the Hoh and Soleduck rivers it ranges from four to five thousand feet, and from then on continues to decrease to nearly sea level at the coast. To the northeast and southeast the elevation gradually decreases and finally we have only low foothills along the Straits of Juan de Fuca and Hood's Canal.

The main central mass is drained by a large number of rivers which head in the vicinity of Mount Olympus and from there radiate outward in all directions. The majority of the streams flowing east are short and have a much steeper grade than those flowing to the west. The latter have much longer courses and near the coast flow across lands comparatively low. There are three important inland bodies of fresh water which lie in the foothills near the coast. They are Lake Crescent, which is inland about sixteen miles southwest from Port Angeles; Quiniault lake, which is inland from the Pacific and about twenty miles to the northeast from the mouth of the Quiniault river; and Ozette lake, which lies inland about three miles from the coast and a little south of Cape Flattery. In addition to these three there is Lake Cushman, which lies in the southwestern portion of the region a short distance inland from Hood's Canal.

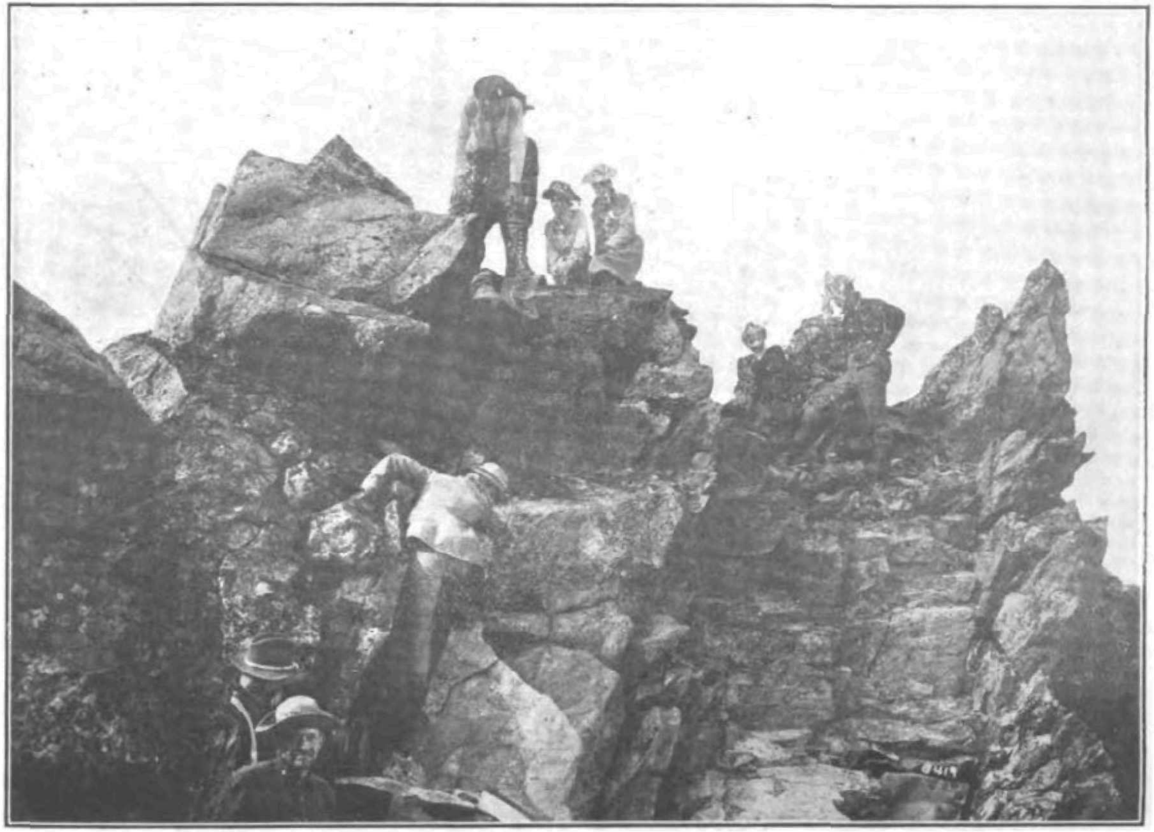
On the coast, both to the north along the Straits of Juan de Fuca and to the west along the Pacific ocean, the elevations range from fifty to three hundred feet and there is here what is usually termed a terrace with precipitous cliffs along the shore. This terrace is not absolutely level and in many places has prominent ridges rising upon it. Through the more highly elevated mountainous region in the interior and in the nearly level terraces near the coast the streams have cut cañyons which in some places are very narrow and precipitous. Both along the north and west coasts the shore line is fringed by a wave cut platform. The platform is well exposed at low tide and in places is dotted here and there with projecting rock prominences in the form of reefs or ledges. At high tide these are covered and not visible and are a constant source of danger to navigation. The northeastern coast, east of Port Angeles, is of a different nature. Here the bluffs or cliffs along the shore are composed largely of glacial material. Extending out from the bluff in several places are long, curved sand spits forming protected harbors. These may be seen at Port Angeles and at Port Townsend.

The bed rocks which go to make up the mountains of the Olympic peninsula are represented by the three main divisions which are known to geologists as igneous, sedimentary and metamorphic rocks. Under the igneous division are grouped such rocks as have solidified from a molten condition either in great masses beneath the surface of the earth or else as lava flows upon the surface. Under the division known as sedimentary are included such well known rocks as sandstones, shales, conglomerates limestones, etc. These have nearly all been formed along sea shore or other bodies of water, by the vast accumulation of waste material brought down by streams from the interior, or from the waste of the sea cliffs themselves for long periods of time. After such depositing the beds of sediment were uplifted high above sea level in the form of mountains as we know them today. Under the metamorphic division we have such rocks as slates, schists, quartzites, etc., which are simply sedimentary or igneous rocks which have been altered both in composition and general appearance by the effects of pressure or heat from intruded igneous rocks.

The great central mass of the Olympic mountains is composed of metamorphic rocks. The most conspicuous varieties are schists, slates and quartzites. Around the coastal border of this interior metamorphic area are sedimentary rocks, consisting of sandstones and shales, and associated with these are igneous lava flows. Along the eastern and southern margins of this area are boulders of granite and other rocks which are not found in the bed rock series of the Olympic mountains, but are common in the mountains on the east and north sides of Puget Sound. The granites and similar rocks were brought into the Olympics and deposited there by great glaciers which at one time came down from the Cascades and from the mountains of British Columbia. The glaciers occupied the Puget Sound basin and filled the broader valley of the Olympics.

In the history of the earth we find many principles which govern the study of human history. A study of the rocks and their fossil contents gives us a history of the geological development of our planet in the same way that a study of records, archives and works of art of former nations and races gives us a history of human civilization. In human history we have periods such as ancient, medieval and modern, and their subdivisions, so have we in geology; the only difference being that in geology we regard time as much longer than in human history. We conceive of geological periods in millions of years rather than in hundreds, the major divisions of geological time ranging from the older to the younger are spoken of as the Archaean, Palaeozoic, Mesozoic, Tertiary and Recent. Within the Olympic peninsula, the Archaean and probably the Palaeozoic rocks are not represented.

The hard metamorphic rocks composing the great central portion of the Olympic mountains in all probability belong to Mesozoic time. These rocks are made up for the most part of quartzites and schists, which at one time before they were metamorphosed were sandstones, conglomerates and shales. They have been uplifted into a mountain mass and then folded and crumpled and possibly invaded by great masses of igneous rock from deep down in the earth's crust, but which have never penetrated the surface. The result has been that these intense crustal movements have folded and disturbed the strata so that they no longer lie horizontal, but are tilted up on edge. Such disturbances have caused cracks and fissures to be formed, both large and small, and in these we have deposits of silica, well known as quartz veins. Sandstones, which originally contained pebbles and large boulders, have been squeezed to such a degree by the folding processes that the pebbles which were originally round and nearly spherical have been drawn out into great long elliptical forms, sometimes ten or fifteen times as long as they are wide. The majority of them are all elongated in the same direction and parallel with the strike or general direction in which the layers of the strata extend. A section across the strike of the strata, which in other words represents the character of the materials composing the beds from base to top, is beautifully represented in following up the Elwha river to its headwaters. The Tertiary lavas and sandstones which have been mentioned extend from Port Angeles to a point about four miles above McDonald, on the Elwha. Beyond this the slates and schists are represented. North of this contact the metamorphic rocks probably underlie the Tertiary formation. Between McDonald and Geyser the metamorphic rocks appear to be made up largely of slates with only a small proportion of quartzites and schists. The schist is simply a shale which has undergone much more intense metamorphism than the slates. As one proceeds further along the strike and examines the area along the Elwha between Gelser and Elkhorn, he finds the effects of metamorphism to be much more pronounced, schist and quartzite becoming much more common. The fracturing of the strata is more noticeable and every now and then a quartz vein may be observed. Farther up the valley near the Godstein, and even up to the Elwha basin itself, the effects of metamorphism become much more marked. In the vicinity of the basin bed rock is finely exposed. The recent



THE SUMMIT OF MOUNT QUEETS.
First Ascent From the West.

Photo by Asahel Curtis. Copyrighted by Roman's Photographic Co.

disappearance of the glaciers has left to view a vast rock-scoured country. In going up the divide between the Elwha and the Quiniault, the section may be studied in detail. The strata are not only tilted, but they are squeezed and contorted and made to fold upon themselves. In areas only a few feet in diameter, the individual strata may be seen folded back and forth and even faulted to a minor degree. Quartz veins are numerous and represent fissures and cracks which have since been filled with silica. In general the veins are nearly parallel to the strike of the strata and lie nearly parallel to the bedding planes. They are not persistent; that is, they do not continue with the same thickness for any great distance, but taper out and either entirely disappear or become merely thin stringers which may or may not coalesce to form again a well-defined vein. One of the most remarkable features in this region of high mountain ridges is the increased proportion of quartzite layers. They generally have a light color and are extremely hard and upon weathering break up into huge blocks. They are much more resistent to weathering than the softer schists and shales, and. as a result, make up the major portion of the ridges and high, rugged peaks. The highest peak of Mount Olympus is for the most part composed of this quartzite. From Mount Olympus to the north, east, south and west the country rock appears to be composed of this same metamorphic material; namely, quartzite, schists, slates, etc. How far to the south it extends is not certain. No attempt has been made to study this region and no accurate data are available. The Tertiary rocks are known to occur on the Humptulips, Wynooche and the Satsop rivers and it is probable that the contact where the Tertiary beds overlie the metamorphic rocks is somewhere near, but to the south of the Jefferson and Chehalis county line. To the east the metamorphic rocks appear to extend at least as far as Mount Constance and the Sawtooth range, and to the west probably far down into the low-lying country near the Pacific ocean. In one place it is known that they extend even to the ocean itself. The general dip of the strata, or the angle which their plane makes with that of the horizon, is about 45 degrees. Where the strata are first exposed near McDonald the dip is lowest, but it gradually increases until in the high Olympics the beds stand nearly vertical or are even reversed. The dip is not constant, however, and at one or two localities near the headwaters of the Quiniault repeated folding or possible faulting is suggested. Viewed from Mount Olympus the dip appears to be reversed on the north side of the Hoh river valley, which, if true, means a broad fold or syncline between Mount Olympus and the Hoh valley. To the north the metamorphic formations may be seen nearly to Lake Crescent and to the north side of the canyon of the Soleduck. Beyond this they are covered with strata of Tertiary age.

The rocks belonging to the Tertiary are divided into three periods, known as the Eocene, Miocene and Pliocene. The oldest is the Eocene. They are all represented by sandstones, shales and conglomerates. In these rocks may be found the remains of former marine life, consisting of clam shells, snail shells, sea urchins, etc. Such remains are petrified and are known as fossils. It is by means of the different species of fossils that we know the rock to be of Tertiary age, and by comparing the characteristic species with those of other areas, where the ages of the rocks are well known, we are enabled to divide the Tertiary into the Eocene, Miocene and Pliocene. The main mass of the Olympic mountains is made up of metamorphic rocks, which might be styled the Olympic formation. No rocks of known Tertiary age are known to occur within the mountain. On the coast we have the Tertiary well represented. The Eocene formation is well exposed north of Lake Crescent and from then westward along the Straits of Juan de Fuca. It is composed of basaltic lava and interbedded tuffs and has an estimated thickness of something over one thousand feet. The hard, dark igneous rock, so well exposed at the bridge across the Elwha river near McDonald, is probably of the same age. Farther to the west and stratigraphically higher in the Tertiary series we have an extensive formation composed of sandstone, conglomerates and shales, which are of Miocene age. They extend from Clallam westward and make up the great bulk of Cape Flattery. The estimated thickness of this formation is in the neighborhood of fifteen thousand feet. At several intervals from the base to the top of the formation bands of conglomerate occur, composed for the most part of pebbles derived from the various members of the metamorphosed Olympic formations. Interbedded with the sandstones are shales and clays which are fossiliferous. In one or two small areas strata of Pliocene age are reported.

The last deposits to be laid down are known as Pleistocene, and they consist partly of marine and partly of glacial material, such as till, sand, clay and gravels. On the Pacific side of the peninsula the deposits consist of sand, clay and gravels of marine origin and have a thickness of over one hundred and twenty-five feet. To the east of Port Angeles, on the Straits of Juan de Fuca and along the arms of Puget Sound, the majority of the Pleistocene deposits are probably of glacial origin. In the interior and high up in the mountains are glacial deposits, but of local origin, and having no connection with the glacial deposits on the coast.

The Olympics may have been submerged during Miocene time and at its close uplifted and then the overlying Miocene rocks removed by erosion, or the central portion may have been a land area during Miocene time and sandstones and shales may have been laid down around its margin and then uplifted at the close of Miocence deposition. At any rate, an uplift at the close of the Miocene seems evident and another one late in Pliocene time. There is evidence that deformation is still in progress, as is shown by the folding and tilting of Pleistocene deposits along the coast.