THE GEOLOGICAL STORY OF MOUNT RAINIER

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OUR majesic mountain, once a very symmetrical cone, and still quite young as mountain history goes, bears on its flanks deep scars of the never ending conflict between the forces of nature. For centuries the grinding glaciers have been working to level the immense mass of lava and ash piled up by a series of eruptions in recent geological time. They have accomplished only a small part of their task, but have added greatly to the beauty and interest of a trip to the mountain. The grand view we get of Mount Rainier from Puget Sound points is due to the fact that it is situated about eleven miles from the summit of the range, on the westward sloping surface of an uplifted peneplain, which has been deeply sculptured by erosional agencies to form the innumerable ridges, peaks, and valleys of the Cascade Mountains. It thus stands by itself, as does Mount Baker, far surpassing in height the surrounding peaks.

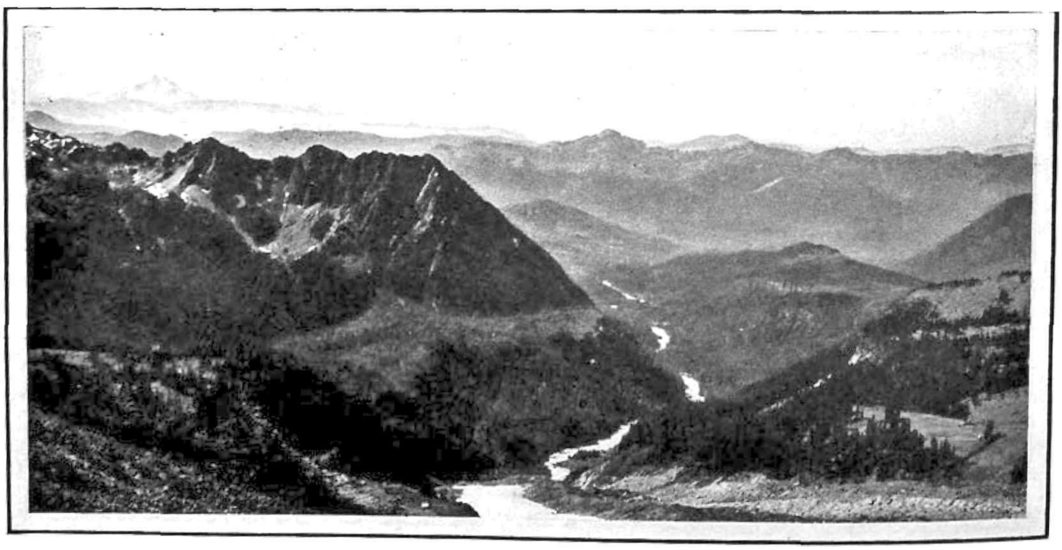
A glance at the eroded edges of the glacial trenches in the mountain and a study of the summit craters with their numerous steam and gas jets, still quite warm, proves beyond any question its volcanic origin, and furnishes us an interesting page in the geological history of the State of Washington. To get the complete story it will be necessary to outline briefly the geological events preceding and during its growth. And as these events can only be stated in terms of geological eras and periods an outline of the divisions of the present geological era known as the Cenozoic is given below:

Cenozoic Era	Quaternary	Recent or Human period.
		Pleistocene or Glacial period.
	Tertiary	Pliocene period.
		Miocene period.
		Eocene period.

Little is known of the pre-Tertiary history of this section. At the beginning of the Tertiary, a range of low mountains, in the general region now occupied by the Cascades, furnished abundant sediment which was laid down in a large embayment occupying what is now known as Puget Sound basin. Volcanic activity was common throughout eastern and western Washington, and immense masses of lava were extruded and intruded through these older rocks. If any large volcanoes existed along the Cascades at this time they have been entirely destroyed.

After these Eocene and Miocene rocks were laid down, an uplift, with intense folding and crushing of the rocks, caused the ocean waters to drain out of the embayment, and large rivers began to erode the newly uplifted rock mass. Before the end of the Pliocene period the whole Cascade rock mass was reduced to base-level or a gently sloping surface near sea-level, known as a peneplain. This has been called the Pliocene peneplain. Over this surface the Columbia and other rivers flowed toward the Pacific Ocean.

The closing event of the Pliocene period was an uplift, with slight folding or warping, which caused the peneplain to be elevated to form the Olympic and Cascade plateaus, separated by the Puget Sound trough. The rivers were rejuvenated and immediately began anew their work of sculpturing the surface to the forms we now see in the Olympics and Cascades. The strain to which the rock mass was subjected by the uplift caused fractures through which the molten lavas forced and burned their way to the surface. Around the more active centers, or craters, volcanic cones were started, and Mount Rainier probably dates from this period. Continued eruptions of lava and immense volumes of ash, lapilli, and bombs gradually built up a very symmetrical cone towering 8,000 to 10,000 feet above the planed-off surface of granites, schists, and tertiary sediments. The light colored granite of this old platform may be seen at the end of Nisqually Glacier, in Carbon River valley, and in other localities where the glaciers have cut down through the overlying dark colored lavas of which the mountain is built. The view from Mount Rainier toward Mount Adams or Mount St. Helens shows very clearly, in the uniform elevation of the interfluve ridges, the remnants of this old plateau surface. (Fig. 1.) In the region about



DOWN THE NISQUALLY

Fig. 1. Showing even sky line of old peneplain as seen from Mount Rainier, looking toward Mount St. Helens. Lateral moraines show above surface of Nisqually Glacier in the foreground.

the mountain it is from 5,000 to 7,000 feet above sea level and slopes gently toward the west. As a proof of this notice the course of the headwaters of the White and Cowlitz rivers as they drain the eastern slope of Mount Rainier, and swing around toward the west when they strike the old peneplain surface.

The building of the mountain probably extended over many thousands of years. Numerous eruptions, the power of which can only be suggested by results, gradually built up around the crater an immense cone composed of many cubic miles of lava. Explosive eruptions gave rise to immense volumes of ash, lapilli, bombs, pumice, and the porous lavas one sees scattered for miles around the crater. Quiet flows of lava radiating from the crater served to bind together the loose materials by bands and layers of solid lava rock. One can almost imagine the rock just cooled from the molten state, the slaggy, scoriaceous surface representing the foaming surface of the lava streams. Different types of lava, as if from different sources, are found about the slopes, and various colors, due to difference in nature and weathering, break the otherwise

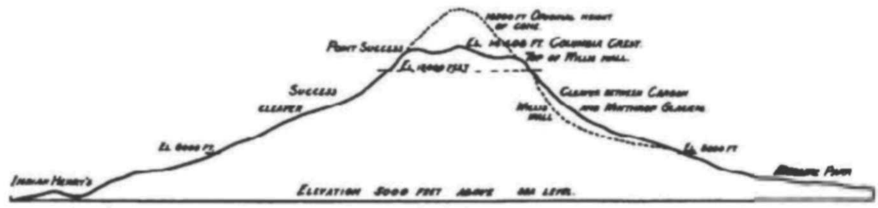


Fig. 2. Cross section to natural scale, through Success Cleaver, and the cleaver between Carbon and Winthrop glaciers, from Indian Henry's to Moraine Park. Dotted line indicates probable former height, and steep slopes of Willis Wall where eroded by Carbon Glacier.

monotonous appearance of the lava surface. The exact limits of these flows have not been carefully worked out, but the diameter of the cone at its base is about 20 miles. The interbedded lavas and loose ash materials are well shown in the eroded walls of the Wedge, Cathedral Rocks, Willis Wall, Gibraltar, or any of the various remnants above the surface of the glaciers.

The angle at which these strata appear in the different exposures indicates a cone at one time several thousand feet higher than the present summit, and much more symmetrical. This is shown very nicely in a cross section of the mountain through the Success Cleaver and the Cleaver below Willis Wall. (Fig. 2.)

After the cone was built and the crater probably plugged up by cool solid lava, it looks as if a violent eruption had blown 2,000 or 3,000 feet off the top, and left an immense crater, or platform, about three miles in diameter. Remnants of the old crater and slopes are seen in Peak Success, Liberty Cap, and Gibraltar.

Later eruptions then built up on this platform two small craters, the first about 1,000 feet in diameter, the rim of which has been partially broken down, the most recent about 1,500 feet in diameter and still perfect. The rim of the latter shows above the snow which now almost fills it. Steam and gas are still issuing from crevices in the floor and about the walls of this recent crater. The heat is sufficient to melt large caverns in the snow cap, thus furnishing a welcome protection from the strong cold winds, for belated mountaineers who stay over night at the summit. Mr. Russell describes the cave in which he stayed as 60 feet long and 40 feet wide with a great arched ceiling 20 feet high and numerous branching caverns.

Shortly after the elevation of the Cascade Mountains, culminating in the building of Mount Rainier and other volcanic cones in Washington, the whole country was gradually covered with a thick blanket of snow and ice. Mount Rainier, because of its elevation, was subject to very strong glacial erosion. Glaciers, radiating from the vast snow cap at the summit, followed the valleys already eroded by rivers, and began their work of tearing down the cone built by a long series of eruptions. The great amount of loose materials, the strong frost action on the solid lavas, and the melting and refreezing of the snow and ice made the work of destruction comparatively easy, and the glaciers have thus been able to carve out very deep but narrow trenches in the lower slopes of the mountain. That the glaciers were larger and therefore more active than at present, is shown by the numerous lateral moraines along the valleys above the glaciers (Fig. 1), and the immense piles of morainal debris scattered about the park below the ends of the glaciers. At present although the ice is constantly moving down the valleys, the melting at the lower end is greater than the ice supply, and the glaciers are said to be receding. They are also shrinking in their valleys, and the polished, striated surfaces of large rock knobs once covered are now visible above the surface of the ice.

The rivers flowing from the glaciers are so heavily loaded with coarse and fine debris that they have filled up the valleys, once much deeper, and have built broad level flats in which they meander irregularly. Thus stretches of the river in which the valley is narrow and deep with falls and rapids will be separated by stretches in which the valley is broad and rather flat. In many places the rivers flowing near the steep valley walls have undermined them, causing landslides to block the river temporarily, thus giving rise to a series of rapids and cascades. The many falls on the main streams throughout the park are due to irregularities of erosion by the larger glaciers once occupying the valleys. These are similiar to the ice cascade in Nisqually Glacier or the breaks in the Paradise and Stevens glaciers where the ice now falls over irregularities in the valley floor. Due to the overdeepening of the main valleys by stronger glacial erosion, many falls occur where the tributary streams join the main streams over the steep valley walls.

The glaciers are the never-resting enemies of the higher mountains, and especially of a conical peak like Rainier. The work they have done and are doing is well shown in the great amphitheatre, or cirque, at the head of Carbon Glacier, which is surmounted by Willis Wall, also in the steep front of Gibraltar at the head of Cowlitz Glacier, and in the Sunset amphitheatre seen from Indian Henry's at the head of Tahoma and Puyallup glaciers. (Fig. 3.) Almost perpendicular walls of interbedded lava and ash rise hundreds of feet above the ice mass which is constantly gnawing away the base of the cliffs and will finally destroy these remnants of the old crater. Where the glaciers move along the sides of the different wedges and cleavers they are gradually undermining them and carrying tons of debris down to lower levels, as evidenced by the immense piles of debris on the surface and in the ice mass.

TAHOMA GLACIER

Fig. 3. Cirques at head of Puyallup and Tahoma glaciers, showing their ,work in tearing down the mountain. Point Success to the right.

The mountain has already lost one-third of its bulk, and the work goes on slowly but surely. Imagine trying to reconstruct the mountain as it was in youth, by bringing the millions of tons of debris from all over western Washington and filling up the trenches and cirques until the whole surface would be even with the existing remnants. The amount of work done by rivers and glaciers is thus suggested.

As time goes on these great cirques will gradually work back toward the solid lava core near the center of the cone, and removing most of the loose materials and lava, will destroy the graceful slopes of the mountain. (Fig. 3.) The Matterhorn type of mountain with many pinnacles and crests will be the result. Gradually the core or plug itself will weather and waste away, and Mount Rainier as we know it will be a page in the past history of the Cascade mountains. By this time the Cascade range itself will again be reduced to a peneplain similar to that existing before the uplift which caused Rainier to be built.

The circumference of the mountain at the 8,000-foot level is about 20 miles. Below this the slopes decrease rapidly and a series of natural parks or flat areas, separated by deep glacial trenches, surrounds the silver dome. They lie between 5,000 and 7,000 feet above sea level and are covered with a veneer of glacial debris either in the form of rough moraines or as a thin coating of fine soil deposited by water flowing from the glaciers. Many large boulders deposited by the ice are scattered about the parks. Even before the snow disappears in the spring, flowers begin to peep through their winter covering, and by the end of July the parks are a veritable flower garden. In the upper part of many of these parks are found the smaller interglaciers. The beauty and interest of the park region are greatly increased by the picturesque, deep, glacial trenches incised below the general surface, and the hundreds of cascades where the streams from the smaller glaciers tumble into the main streams.

Other interesting features of the mountain scenery are the many rugged ridges around and above the park region, like Tatoosh Range, Mother Mountain Range, and many others. These seem to be remnants of the more resistant rock mass that withstood erosion when the general mass was worn down to base level. Having since been subject to a long period of erosion they have become rugged saw-tooth ridges steep enough to task the energy of many a stalwart mountaineer. In some cases they contain mineral veins like the one that is being worked on the Paradise Valley trail near Longmire's Springs.

No less interesting are the many mineral and hot springs found at various points, usually below the parks in elevation. These have their source at some depth and reach the surface through fractures, joints, or porous beds in the rock. Coming from different sources or through different kinds of material they vary greatly in mineral content, the most common being sulphur, iron, and soda. The hot or warm springs no doubt have their source where more recent masses of heated lava may be near the conduit to furnish heat, and thus raise the temperature of the waters as they travel toward the surface.

Following many geological revolutions then, almost comparable in number to the late Mexican revolts, the Cascade Mountains have been maturely dissected in the present cycle and Mount Rainier is still quite a young volcanic cone. But the peculiarities of volcanism shown are characteristic of a volcano in its later quiescent, or dormant stages. Whether we can call it an extinct or dormant volcano, and whether or not it will ever again become active is a matter of pure conjecture.