Old Faithful, An Example of Geyser Development in Yellowstone Park*

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Undoubtedly the best known geyser in the world is Old Faithful in the Upper Geyser Basin of Yellowstone National Park. The name itself is appealing and suggests regularity and unchangeableness. Visitors usually ask first, "When does it spout?" second, "How high does it go?" third, "How old is Old Faithful, anyway?" This article is presented in an attempt to answer these questions and others of similar nature on this most famous geyser.

Wherever the subject is introduced the geology and the mechanism of geysers seems to be fairly well understood. The fact that hot springs and geysers deposit white earth and mineral around their openings is also well known. Why these deposits are terraces in some places, mounds other places and in still others are cones of symmetrical or unsymmetrical outline, is not so well known. The writers believe there are essential differences between the formation of a terrace, a mound and a cone. But before discussing the deposits of Old Faithful Geyser in detail we will try to answer the first two questions given above.

With regard to the eruption of Old Faithful Geyser there has been considerable misunderstanding among visitors about its interval, duration and height. Some think it plays every hour and on the hour, but of course this has never been the case. Studies made by the Carnegie Institution[1] have dispelled much of the misinformation on geysers, but an attempt will be made here to give correct data on this famous geyser so far as it is in our possession at this time.

A daylight record made during the summer of 1938, between June 15 and September 1 by Ranger Naturalist H. R. Woodward and associates included the recording by use of an ordinary eight-day clock the time elapsed between the high point of one eruption to the high point of the next for 927 eruptions. This data gives the average interval as 66.54 minutes or 66 min. 32 sec. The variations in length of interval observed have run from 34 minutes to a maximum interval of 115 minutes though by far the larger number of periods are very near the average length of 66½ minutes. The duration of the main eruption will run from 2 to 5 minutes and usually there are several preliminary spurts in which the water column will rise from a few feet to ten or fifteen feet. As many as 19 preliminary spurts have been counted though only two or three are commonly noted.

The height of the water column during the main eruption has been measured with a transit, on a number of occasions, and found to vary considerably. The figures run from 116 feet to 171 feet and the average height is usually given as 150 feet, though an insufficient number of measurements have been made to give any reliable figure on the average height. Measurements made in 1870,[2] '71 and '72[3] indicate a height of from 106 to 130 feet. It appears that the height and activity of Old Faithful are very nearly the same as they were when observed by the discovery party in 1870, or 68 years ago.

The amount of water thrown out at an eruption was estimated in 1930 by Drs. Allen and Day of the Carnegie In-

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** Park Naturalist, Yellowstone National Park.

***Ranger Naturalist, Yellowstone National Park.

stitution, op. cit., at 10,000 to 12,000 gallons, though this figure is based on run-off and does not take into account the water which goes into the air as vapor.

Two minerals are commonly deposited about hot springs and geysers, travertine and silica. Travertine is soft and not given to forming geyser cones, whereas silica is hard and found practically everywhere geysers are found, although not absolutely essential to them. The hot water issuing from the ground may be saturated with one, or the other, or both. Furthermore, suspended silica is abundant in some of the springs. In general, the movement of hot water from springs and geysers results in the growth of the surface over which it flows causing an elevation known as a mound, group of terraces or a cone. But both erosion and deposition proceed together, with deposition being in the ascendancy only where the water is not too swift. As the water is poured out of the spring it may flow gently or swiftly. In either case it loses heat, and gas, because of loss of pressure, and by evaporation the volume of water is reduced so that the mineral in the solution is in part precipitated. The splash from the water or even vapor may be very effective in bringing about deposition. These actions aid evaporation and wherever evaporation is, deposition is likewise rapid. A pebble, a twig, or a leaf will produce a ripple and this will increase precipitation. Wherever the curvature of the water surface is bent sharply upward or outward evaporation is increased and deposition is accentuated (see Figure 1). Hence, terraces are the natural result of gently flowing water where ripples develop, and small terraces coalesce into larger ones. In reality the small terraces thus formed are most likely to be flat rimmed basins, at least in infancy, and later the "pulpit" terrace develops. After these coalesce the water is spread more widely and thinly than before with the result that a broad terrace is built. The level rim is maintained by the water level. If at any time a part

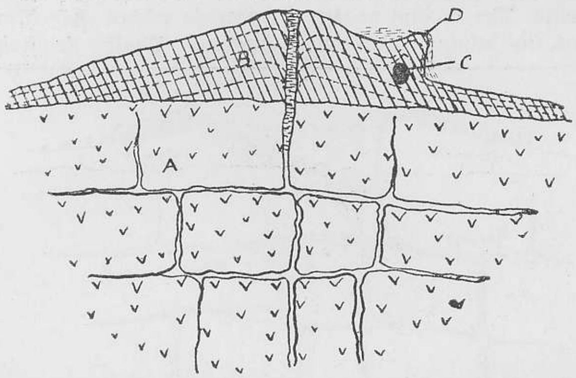

Figure 1. A diagramatic cross section of a hot spring, showing the development of a terrace. (A) Rhyolite. (B) Sinter. (C) Obstruction such as a pebble or a twig. (D) The locus of most rapid deposition coincides with the line of greatest evaporation, where the surface of the water has a decided convex curve. In the case of travertine springs increased loss of gas at this position is an additional cause of deposition.

of the rim becomes too high deposition is slowed up for lack of sufficient water and conversely if the rim is too low additional water, if not too rapid, will increase precipitation and hence a balance is maintained. Recurrent surges from the open pool or fountain type geyser may develop terraces in much the same way.

Mounds result from a somewhat different process, although many mounds have terraces built around them. The most common type of mound is built by a combination of basin, splash, vapor and rivulet deposits. The rivulet erodes on the bottom of the channel and deposits at the edges. After a time the edges extend over the surface of the rivulet and gradually stop the flow which then overflows in a new place starting a new rivulet at a slightly higher point. Many springs thus have two, three or more overflow channels. This spreading of the flow increases evaporation and accordingly deposition. The mound is a result of all the activities of a hot spring or geyser and not of any simple process. The part played by the splash, spray and vapor is extremely important. It is by this means that the saturated water is spread most thinly over solid materials and is therefore evaporated most rapidly. Only the freezing of the water can cause more rapid precipitation than constant splashing.

At this point it may be well to call attention to the character of many of the streams draining geyser basins. They have the character of distributaries found on the flood plains and deltas of large and sluggish rivers, where deposition exceeds erosion. A few examples such as Tantalus, Tangled, White and Rabbit Creeks serve to illustrate the type of braided stream channels where deposition is exceeding erosion. Their drainage basins are gradually being filled with sinter.

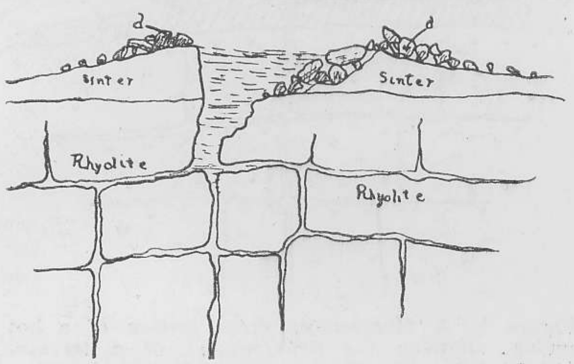

Figure 2. An explosion crater caused by steam. (d) indicates debris thrown out by the explosion. This may happen to a hot spring such as that one shown in Figure 1.

Where geyser action or intermittent spouting is predominate different deposits are the result. Cones, pillars, and various vertical forms are evident. Monument Geyser Basin presents some excellent examples of pillars or chimneys built under the influence of a more or less constant spray.

Thus it becomes evident that the character and structure of a deposit reveals the kind of activity which has produced it.

Where tremendous volumes of water are thrown out with an eruption we can look for erosion instead of deposition.

This is the case around the cone of the Giant Geyser particularly along the south side where a deep gully is now being carved. It is also true on the northeast flank of Old Faithful where the prevailing southwest winds cause a great fall of water. Here erosion has cut a ravine four feet deep into the edge of the mound of a former hot spring. Erosion is also uncovering the stumps, roots and trunks of trees which grew on Old Faithful's own cone not so very long ago. The prevailing direction of the wind being from the southwest causes a great fall of water on the northeast flank, so here erosion is exceeding deposition.

The fact that about one-third of Old Faithful's cone is now being eroded suggested to the writers that a different form of activity has given rise to the main structure than that which is going on today. If we grant that the character of the hot spring or geyser activity determines the form and structure of the deposit which results therefrom, there is a definite suggestion that the water from Old Faithful's orifice has been, up to a few hundred years ago, that of a quietly flowing hot spring or at best of the fountain type geyser such as is displayed at Great Fountain.

Terraces are plainly visible on the sides of Old Faithful's cone up to within two or three feet of its very top. Furthermore, the thickness of sinter such as would result from geyser activity—splashing, spray and vapor—is a mere shell of a few inches to a maximum of ten inches in thickness. As a geyser, then, Old Faithful is only a few hundred years old.

In regard to the presence of partially petrified wood in the form of stumps, roots and trunks of trees on the mound of Old Faithful we find no less than 40 stumps and 60 sections of trees now exposed within 125 feet of the orifice and at least two of these stumps are right at the summit. The protuberances at the northwest of the vent have long been considered as the usual structural prominences built up by geyser activity. Close inspection shows that these lumps are merely tree stumps covered with a layer of geyserite eight to ten inches thick. Therefore, there was a quiescent period prior to the present activity which permitted the growth of

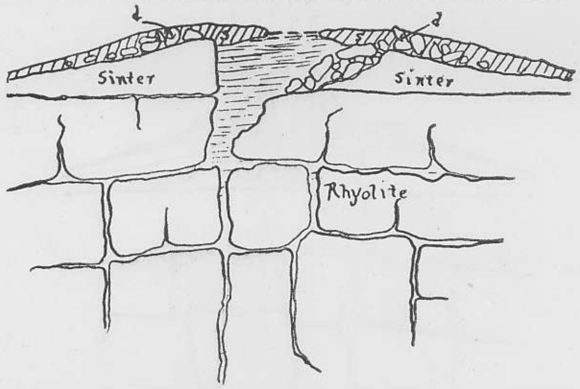

Figure 3. The building of sinter at the water line reduces the water surface and retards the loss of heat. This may cause a surging in the hot spring and later bring about intermittent eruptions. (s) sinter, (d) debris.

trees up to 15 inches in diameter at all points on the mound even up to its apex. From the size and number of the trees present the inactive period must also have been several hundred years in length.

Thin sections of the partially petrified wood were reported by Professor E. A. Longyear of Colorado State College to be of Lodgepole pine (Pinus contorta).

The presence of lodgepole pines on the mound indicates that Old Faithful was a long time as inactive as any of the seven neighboring cones which now lie dormant in the immediate vicinity. The factors that brought about this complete cessation of thermal activity in Old Faithful are rather difficult to ascertain. That the early activity varied between hot springs and fountain type eruption is quite certain from the structure of the mound as now exposed on its partially eroded side.

The usual evolution of a geyser from a hot spring as pointed out by Allen and Day is brought about somewhat as shown in the diagrams, Figures 2, 3 and 4. First, water flows from a simple crack or crevice. As the adjacent rock is disintegrated by the heat and gases, caving takes place. If the current is strong enough some of this is washed away. The residue of the material thus formed may choke or partially obstruct, the circulating water. If sufficient steam is available a preliminary explosion may occur which will produce a crater or open well. Dissolving of silica at some depth will widen the crevices and develop caverns. If the flow of water still remains fairly constant, the crater or well of the spring will gradually close in at the top by deposition of sinter at the water line. After this has gone on for a time the partially covered well retards the loss of heat and again accumulated steam may cause an ex-

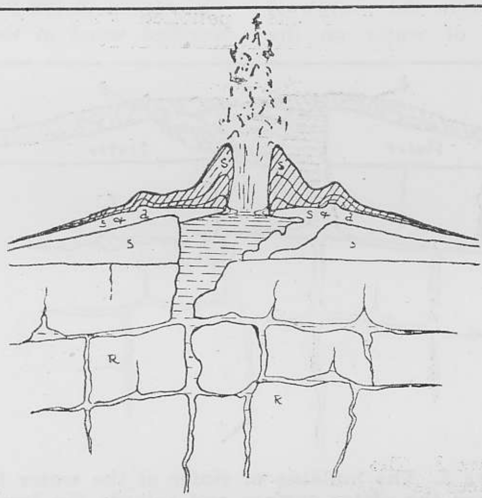

Figure 4. Spray and splash will develop the cone or elevated portion about the orifice. If the eruptions are violent they may cause more erosion than deposition; however, deposits will be formed by the spray and splash during the so-called quiet intervals. (R) Rhyolite, (s) sinter, (s) & (d) sinter and debris.

plosion in which part of the cover is removed, or a surging may set in which will cause a fountain type of geyser to develop as in the Sapphire Pool. As the mound builds higher and the shelf of sinter grows toward the center a sort of nozzle may be developed. Why there should be a total cessation of activity for a time is more obscure. Though it is most likely explained by assuming a diversion of the hot gases supplying the heat or a choking of the channels of water supply, or both. Eventually these factors will cause the extinction of the hot spring or geyser.

The height and size of the mound of sinter on which Old Faithful sets indicates that thermal springs have been active in this place for a very long time. Estimates based on the thickness of silica exposed are not likely to represent the quiescent periods nor take into account the changes in rate of deposition. That thermal activity has been recurrently at work in this locality in excess of 10,000 years seems to be a safe guess. On the other hand Old Faithful as a geyser is a newcomer compared with Giant, Castle and Lion geysers.

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[1] Allen, E. T. and Day, A. L. "Hot Springs of the Yellowstone National Park." Carnegie Institution of Washington, 1935.

[2] Langford, N. P. "The Discovery of Yellowstone National Park." PP. 168-169, 1923.

[3] Peale, A. C. "The Thermal Springs of Yellowstone National Park," U. S. Geol. and Geog. Survey of the Territories, 1878, Part II. PP. 219-220.

The meeting of the Northwest Conservation League was held at the Central Washington College of Education in Ellensburg for three days from July 10th to 12th. In addition to general programs there were section programs on county and local planning, fisheries, wild life, scenic resources, power resources, soil resources, and forest resources. Dr. Paul H. Landis from the State College of Washington spoke on the conservation of human resources. The last general session was devoted to a general discussion of the place of conservation in education in the public school curriculum.

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The article by Rexford F. Daubenmire, of the University of Idaho, in the May issue of "Northwest Science" entitled "Contributions to the Ecology of the Big Bend Area of Washington," was made possible in part by a grant from the research funds of the Northwest Scientific Association.