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THE OPPONENTS OF VACCINATION in England have of late been more active than ever; and, as a result of their activity, a royal commissioner has been appointed, whose duty it shall be to make a full investigation of the whole subject, and submit a report thereon. Friends of vaccination should welcome such an inquiry, as the method stands upon such a firm foundation of facts as to be able to stand the most searching examination. If it has not accomplished all that is claimed for it, the failure is due to insufficient or inefficient performance of the operation; and the sooner such abuse of it is made public, the better. It is a rather remarkable coincidence that just at this time events should transpire at Sheffield, England, which show the value of vaccination. Small-pox has recently been very prevalent in that city. In a population of about 320,000 there have been 6,088 cases of the disease, of which number 590 proved fatal. Dr. Barry, who has made a report to the Local Government Board, finds that the attack-rate of the vaccinated children under ten was 5 in a thousand; of the unvaccinated of the same age, 101 in a thousand. The death-rates for the same classes were respectively .09 and 44. In every hundred-thousand of those twice vaccinated, there were eight deaths; once vaccinated, 100 deaths; and unvaccinated, 5,100 deaths.

SOAPING GEYSERS.[1]

AT the Buffalo meeting, October, 1888, Dr. Raymond presented a paper entitled "Soaping Geysers," in which he called attention to the use of soap by tourists to cause eruptions of several of the well-known geysers in the Yellowstone Park. Incorporated in this paper appears a communication received from me, written from camp in the park, in reply to some inquiries on the subject. The letter discussed somewhat briefly the means employed by visitors to the park to hasten the eruptions from hot-springs and reservoirs of hot water, which remain dormant for days, or even weeks or months, at a temperature near the boiling-point, without any display of geyser-action. As the paper has called forth considerable comment, I desire to elucidate one or two points in relation to the temperature of the springs, and to answer some inquiries about the composition of the thermal waters.

In the summer of 1885, a Chinaman, employed as a laundryman for the accommodation of the tourists at the Upper Geyser Basin, accidentally discovered, much to his amazement, that soap thrown into the spring from which he was accustomed to draw his supply of water produced an eruption in every way similar to the actual workings of a geyser. Tourists with limited time at their command, who had travelled thousands of miles to look upon the wonders of the Yellowstone, soon fell into the way of coaxing the laundryman's spring into action, to partly compensate them for their sore disappointment in witnessing the periodical eruptions of Old Faithful. Successful attempts upon this spring soon led to various endeavors to accelerate action in the dormant and more famous geysers. In a short time, so popular became the desire to stimulate geysers in this way, that the park authorities were compelled to enforce rigidly the rule against throwing objects of any kind into the springs.

In connection with a thorough investigation of the thermal waters of the Yellowstone Park and the phenomena of the geysers, I undertook a number of experiments to ascertain the action of soap upon the waters, and to determine, if possible, those physical conditions of various pools and reservoirs which permitted the hastening of an eruption by the employment of any artificial methods. This investigation, conducted from time to time, as opportunity offered, throughout the field-season of 1885, included experiments upon the geysers and hot-springs of the Upper, Lower, and Norris Geyser Basins. The results proved, beyond all question, that geyser-action could be forced in a number of ways, but most conveniently by the application of soap. The greater part of the more powerful geysers undergo no perceptible change with a moderate use of soap, although several of them may, under favorable physical conditions, be thrown at times into violent agitation. In most of the experiments, Lewis's concentrated lye, put up in half-pound cans for laundry purposes, was employed. Each package furnished a strong alkali, equivalent to several bars of soap. In this form, alkali is more easily handled than in bars of soap, more especially where it is required to produce a viscous fluid in the larger reservoirs; and, in conducting a series of experiments for comparative purposes, it seemed best, in most instances, to employ the same agent to bring about the desired results.

Old Faithful, the model geyser of the park, exhibits such marked regularity in its workings, that attempts to hasten its action appear futile. The interval between eruptions is about 65 minutes, and rarely exceeds the extreme limits of 57 and 72 minutes. After an eruption of Old Faithful, the reservoir fills up gradually; the water steadily increases in temperature; and conditions favorable to another eruption are produced under circumstances precisely similar to those which have brought about the displays for the past eighteen years, or as far back as we have authentic records. The few experiments which have been made upon Old Faithful are insufficient to afford any results bearing on the question; but it seems probable that soon after the water attains the necessary temperature an eruption takes place.

Of all the powerful geysers in the park, the Bee-Hive offers the most favorable conditions for producing an eruption by artificial means, all the more striking because the natural displays are so fitful that they cannot be predicted with any degree of certainty.

[1] Abstract of a paper read before the American Institute of Mining Engineers, New York meeting, February, 1889, by Arnold Hague.

Observations extending over a period of several years have failed to determine any established law of periodicity for the Bee-Hive, even for three or four consecutive months; although they indicate that some relationship may exist between its display and those of the famous Giantess. Frequently the Bee-Hive will play several times a day, and then become dormant, showing no signs of activity for weeks and months, although the water may stand above the boiling-point the greater part of the time. The name "Bee-Hive" was suggested by the symmetry of the cone built around the vent. It rises about 4 feet above the sloping mound of geyserite, and in cross-section measures about 3 feet at the top, while at the bottom of the cone the vent is less than 10 inches in width. From the top of this narrow vent it is possible to sink a weight only 17 feet before striking a projecting ledge, which interferes with all examination of the ground below. The constant boiling and bubbling of the water, the irregularity of its action, and the convenient location of the geyser, within an easy walk from the hotel, make attempts to accelerate the eruptions of the Bee-Hive most attractive to tourists.

In most instances such efforts are futile: yet success does so frequently reward the astonished traveller, that, unless the geyser were carefully watched by the authorities, attempts would be made daily throughout the season. If the conditions are favorable to an eruption, it usually takes place in from 10 to 25 minutes after the addition of laundry-soap or lye. It is doubtful if more than two eruptions of the Bee-Hive have ever been produced on the same day by artificial means, although I know of no reason, based upon the structure of the geyser, why more displays might not be obtained; for the reservoir and vent fill up with boiling water very rapidly after each eruption.

Although the Giantess is situated only 400 feet from the Bee-Hive, these two differ in surface and underground structure, and mode of action, as widely as any two of the more prominent geysers of the park. Around the Giantess no cone or mound has formed. The broad basin is only partially rimmed in by a narrow fringe of silicious sinter, rising above and extending out over the deep blue water. At the surface, this basin measures about 15 to 20 feet in width by 20 to 30 feet in length. It has a funnel-shaped caldron, 30 feet in depth, ending in a vertical vent or neck 12 feet deep, through which a sounding-lead may be dropped into a second reservoir, meeting a projecting ledge or obstruction of some kind 61 feet below the surface. After an outburst of the Giantess, the basin, which has been completely emptied of its water, gradually fills again to the top; and for days before another eruption a steady stream of hot water overflows the brim. The intervals between the eruptions of the Giantess vary from twelve to twenty days, and the displays last several hours, being unsurpassed for violence and grandeur by any geyser in the Upper Basin. Artificial means have never been successful in bringing this geyser into action, although for days before an eruption it is an easy matter to cause an agitation of the water by throwing into the basin small pieces of sinter, or to produce a boiling on the surface, lasting several minutes, by simply stirring the water with a stick.

The Giant, one of the most violent of the geysers in the Upper Basin, more closely resembles the Bee-Hive than any other of those along the Firehole River. It has built up a cone 10 feet in height, one side of which has been partly broken down by some eruption more violent than any witnessed at the present day. Through this notched side, steam and broken jets of water are constantly emitted; and on this account but little examination has been made of the underground reservoirs and vents. The Giant is fitful in its action, at times playing with considerable regularity every fourteen days, and at other times lying dormant for nearly a year. I have no positive knowledge that an eruption of the Giant has ever been produced by any other than natural causes. At the time of my experiments, no eruption of the Giant had taken place for several months, although the water was constantly agitated; so much so, that it was quite impossible to examine the vent with any satisfactory results. The only effect produced by the application of lye was additional height to the column of water thrown out, and a decided increase in the thumping and violence of the boiling.

In the Lower Basin, the Fountain has been more carefully studied than the other geysers; and, its action and periodicity of eruptions having been fairly well ascertained, it afforded the most favorable conditions for observing the action of soap and lye upon the waters. In its general structure, the Fountain belongs to the type of the Giantess, having a funnel-shaped caldron, which, long before an eruption, overflows into an adjoining basin. At the time of my experiments upon the Fountain, the intervals between eruptions lasted about four hours. This interval allowed sufficient time to note any changes which might take place. My own experiments with lye yielded no positive results; although it seemed highly probable that action might be hastened by the application of soap or lye just before the time for an eruption, or when, for some cause, the eruption was overdue. I preferred to make the attempt to bring about an explosion before the usual time, only waiting until the water in the pool had nearly reached the boiling-point. All experiments failed. The previous year, when wishing to produce action for the purpose of photography, I was enabled to accomplish the desired result by vigorously stirring with a slender pole the water near the top of the vent connecting with the lower reservoir. In this instance, it should be said, the usual interval of time between eruptions had long since passed: the geyser was, so far as time was concerned, a half-hour overdue. My opinion now is that the experiments with lye failed because the temperature had scarcely reached the boiling-point.

The Monarch, in the Norris Basin, is quite unlike those already described, and affords evidence of being a much newer geyser. It is formed by two convergent fissures, on the line of a narrow seam in the rhyolite, probably coming together below the surface. The main vent measures about 20 feet in length, and at the surface 3 feet in width. But slight incrustation is found around the vent, the conditions not being very favorable to deposition. In this narrow fissure, the water, which ordinarily stands about 15 feet below the surface, constantly surges and boils, except immediately after an eruption. The intervals between eruptions vary somewhat from year to year; but at the time of these experiments the action was fairly regular, the geyser playing every four hours. I was successful in obtaining an eruption quite equal to the natural displays, which throw a column of water 50 feet into the air. Here at the Monarch there is no surface reservoir; and the narrow fissure, filled with loose blocks of rocks around which the water is in constant agitation, prevents all measurements of depth.

The results of the many experiments, not only upon active geysers, but upon a large number of hot-springs, determine fairly well the essential conditions which render it possible to bring about geyser-action by artificial means. Negative results are frequently as valuable for this inquiry as experiments yielding imposing displays.

Outside of a few exceptional instances, which could not be repeated, and in which action was probably only anticipated by a few minutes in time, geyser eruptions produced by soap or alkali appear to demand two essential requirements, — first, the surface-caldron or reservoir should hold but a small amount of water, exposing only a limited area to the atmosphere; second, the water should stand at or above the boiling-point of water for the altitude of the geyser-basin above sea-level. The principal factor which makes it possible to cause an eruption artificially is, I think, the superheated and unstable condition of the surface-waters. Many of the geysers and hot-springs present the singular phenomena of pools of water heated above the theoretical boiling-point, and, unless disturbed, frequently remain so for many days without exhibiting any signs of ebullition. It may not be easy to describe accurately these superheated waters; but any one who has studied the hot-springs and pools in the park, and carefully noted the temperatures, quickly learns to recognize the peculiar appearance of these basins when heated above the boiling-point. They look as if they were "ready to boil," except that the surface remains placid, only interrupted by numerous steam-bubbles, rising through the water from below, and bursting quietly upon reaching the surface.

Marcet, the French physicist, has specially investigated the phenomena of superheated waters, and has succeeded in attaining a temperature of 105° C. before ebullition. Superheated waters in nature, however, appear to have been scarcely recognized, except during the progress of the work in the Yellowstone Park, in connection with a study of the geysers. The altitudes of the geyser basins above sea-level have been ascertained by long series of barometric readings, continued through several seasons. In conducting a series of observations upon the boiling-points of the thermal waters in the park, Dr. William Hallock, who had charge of this special investigation, determined the theoretical boiling-point by noting the mean daily readings of the mercurial column. The exact boiling-point of a pure surface-water, obtained from a neighboring mountain-stream, and the boiling-point of the thermal waters from the springs, were determined from actual experiments by heating over a fire, employing every possible precaution to avoid sources of error. Surface-waters and deep-seated mineral waters gave the same results, and coincided with the calculated boiling-point at this altitude. Hundreds of observations have been carefully taken where the waters in the active and running springs boiled at temperatures between 198° and 199° F.

As will be shown later in this paper, the thermal waters are solutions of mineral matter too dilute to be affected to any appreciable extent as regards their boiling-point by their dissolved contents. The theoretical boiling-point for the springs and pools in the Upper Geyser Basin may be taken at 92.5° C. (198.5° F.). In many of the large caldrons, where the water remains quiet, a temperature has been recorded of 94° C. (201.2° F.) without the usual phenomena of boiling. This gives a body of superheated water, with a temperature at the surface of 1.5° C. (2.7° F.) above the point necessary to produce explosive action. Thermometers plunged into the basins show slightly varying temperatures, dependent upon their position in the basin. They indicate the existence of numerous currents, and a very unstable equilibrium of the heated waters, which are liable, under slight changes, to burst forth with more or less violence. It is under these conditions that geyser-action can be accelerated by artificial means. If into one of these superheated basins a handful of sinter pebbles be thrown, or the surface of the water be agitated by the rapid motion of a stick or cane, or even by lashing with a rope, a liberation of steam ensues. This is liable to be followed by a long boiling of the water in the pool, which in turn may lead to geyser-action. There is some reason to believe that, at least in one instance, an eruption has been brought about by a violent but temporary gust of wind, which either ruffled the water or disturbed the equilibrium of the pool, and changed momentarily the atmospheric pressure.

In Iceland, travellers have long been accustomed to throw into the geysers turf and soft earth from the bogs and meadows which abound in the neighborhood, the effect produced being much the same as that of sinter pebbles and gravel upon the geysers in the National Park. So well was this understood, that at one time a peasant living near the Iceland locality kept a shovel solely for the accommodation of those visiting the geysers.

In my letter to Dr. Raymond, I mention the curious fact that the laundryman's spring, now known as the Chinaman, in which geyser-action may most easily be produced by artificial means, has never been regarded by the Geological Survey as any thing but a hot-spring; and no one has ever seen it in action without the application of soap, except in one instance, when it was made to play to a height of twenty feet after stirring it vigorously with a pine bough for nearly ten minutes. In our records it is simply known as a spring.

If soap or lye is thrown into most of the small pools, a viscous fluid is formed; and viscosity is, I think, the principal cause in hastening geyser-action. Viscosity must tend to the retention of steam within the basin, and, as in the case of the superheated waters, where the temperature stands at or above the boiling-point, explosive liberation must follow. All alkaline solutions, whether in the laboratory or in nature, exhibit, by reason of this viscosity, a tendency to bump and boil irregularly. Viscosity in these hot-springs must also tend to the formation of bubbles and foam when the steam rises to the surface; and this, in turn, aids to bring about the explosive action, followed by a relief of pressure, and thus to hasten the final and more powerful display. Of course, relief of pressure of the superincumbent waters upon the column of water below the surface basin is essential to all eruptive action. These conditions, it seems to me, are purely physical. Undoubtedly the fatty substances contained in soap aid the alkali in rendering the water viscous. On the other hand, when concentrated lye is used, it acts with greater energy, and furnishes a viscous fluid where soap would yield only surface suds, insufficient to accomplish any phenomenal display.

It is well known that saturated solutions of mineral substances raise the boiling-point very considerably, the temperature having been determined for many of the alkaline salts. In general, I believe the boiling-point increases in proportion to the amount of salt held in solution. Actual tests have shown that the normal boiling-point of silicious waters in the park does not differ appreciably from the ordinary surface-waters; mainly, I suppose, because they are extremely dilute solutions.

The amount of lye required to produce a sufficiently viscous condition of the waters increases but slightly the percentage of mineral matter held in solution.

All the waters of the principal geyser-basins present the closest resemblance in chemical composition, and, for the purposes of this paper, may be considered as identical in their constituents. They have a common origin, being, for the most part, surface-waters which have percolated downward for a sufficient distance to come in contact with large volumes of steam ascending from still greater depths. The mineral contents of the hot-springs are mainly derived from the acid lavas of the park plateau, as the result of the action of the ascending steam and superheated waters upon the rocks below. These thermal waters are essentially silicious alkaline waters, carrying the same constituents in somewhat varying quantities, but always dilute solutions, never exceeding two grams of mineral matter per kilogram of water. When cold, they are potable waters, for the most part slightly alkaline to the taste, and probably wholesome enough, unless taken daily for a long period of time.

Dr. Raymond has made the suggestion that the addition of caustic alkali would possibly precipitate some of the mineral ingredients found in these waters, thereby changing their chemical composition sufficiently to affect the point of ebullition. At the same time he remarks that the geyser-waters are probably too dilute solutions to be much influenced by such additions. Any one who glances at the analyses of the waters of the Bee-Hive, Fountain, and Fearless must see, I think, that they are not only too dilute to undergo any marked change of temperature, but that the mineral constituents consist mainly of the carbonates and chlorides of the alkalies, associated with a relatively large amount of free silica, which would remain unacted upon by caustic alkali. There is nothing in the waters to be thrown down by the addition of alkali, or to permit any chemical combinations to be formed by the addition of a small amount of soap. The desire of tourists to "soap a geyser" during their trip through the park grows annually with the increase of travel; so much so, that there is a steady demand for the toilet-soap of the hotels. If visitors could have their way, the beautiful blue springs and basins of the geysers would be "in the suds" constantly throughout the season. Throwing any thing into the hot-springs is now prohibited by the government authorities. It is certainly detrimental to the preservation of the geysers, and the practice cannot be too strongly condemned by all interested in the National Reservation.

THE EAST GREENLANDERS.

CAPT. HOLM'S expedition to East Greenland was as remarkable on account of its geographical results as in regard to the ethnological observations made among the isolated tribes of the northern parts of the east coast of Greenland. The results of his journey have been published, and form the tenth volume of the "Meddelelser om Grönland." In a recent number we referred to the linguistic and folk-loristic papers. Of no less importance are the general anthropometric and ethnographical results of the expedition.

Dr. Sœren Nansen has submitted the craniological material and the measurements of Capt. Holm to an elaborate discussion, from which we glean the following facts. The whole population consisted of 548 heads, 245 of whom were males, while 303 were females. The size of the people is below the average, being 1,647 millimetres; while in the southern parts of the coast the average