GEOPHYSICS

# Bunsen and the Geysers in Iceland

## "A Classic of Science"

**ALL geysers are named from Iceland's Great Geyser, "the gusher," one of the world's first discovered flowing hot springs.**

**After a trip to inspect these springs, the famous German chemist wrote describing them:**

ROBERT WILHELM VON BUNSEN

*Who described Iceland's geysers in 1846. At that time geysers of the Yellowstone in America had been seen by white men but a full written report was not made of them until several years later.*

*MEMOIR ON THE INTIMATE CONNECTION EXISTING BETWEEN THE PSEUDO VOLCANIC PHENOMENA OF ICELAND. By R. Bunsen. Translated from Annalen der Chemie und Pharmacie, bd. lxii., 1847, by Dr. G. E. Day. Published in Chemical Reports and Memoirs, edited by Thomas Graham. London: 1848.*

ON CONSIDERING the numerous chemical processes, whose foci are the solfataras and fumeroles of Iceland, we cannot fail to see that it is the great abundance of volcanic gases, especially sulphurous acid, which, together with the reaction of palagonite, constitute the main character of these phenomena. Where these gases are no longer prominently manifested, or where sulphurous acid is almost wholly absent, the scene suddenly changes. The observer finds himself at once transported to a totally different field of pseudo-volcanic phenomena, as it is represented by the innumerable thermal and geyser systems. The connection existing among these phenomena and those we have been considering, is not less simple than it is easy of comprehension. Here, too, the relation of the palagonite substance to the composition of the waters of the springs constitutes the starting point, from whence the observer, aided by experiments, may advance, step by step, from the most inconsiderably manifested chemical actions, till he arrives at a knowledge of that wonderful mechanism by which the grand activity of the violent sources of eruption in Iceland is maintained. As it will be necessary to direct our attention to some definite locality, I would select the Great Geyser, as the best known of all the intermitting eruptive springs of Iceland.

The thermal group belonging to this celebrated spring lies on the outskirts of the great glacier plain which constitutes the elevated plateau in the centre of the island, almost exactly south-west of the highest point of Hecla, and only distant from it about 20 geographical miles in a direct line. The height of the geysers over Reykjavik (at the residence of Counsellor of Justice, Thorstensan,) amounted, according to the barometrical measures made on two consecutive days, to 112.8 met. and 107.2 met. Their main direction runs about N. 17° E. and is therefore almost parallel with the chain of Hecla and with the general direction of the fissures. The oldest rock forming the base of the springs is also here composed of palagonite tuff, penetrated lengthwise by a vein of clinkstone, running from the western margin of the springs. Here and there a few boiling and vapour springs burst from the clinkstone, at a height of about 55 met. above the Great Geyser. The main focus of thermal activity is, however, situated in a loose palagonite tuff at the foot of the opening in the clinkstone. This rock, on the northwestern side of the geyser-cone, where the strata are broken through by a jet of water, is covered above by the siliceous deposits from the spring, whilst below it becomes transformed into the variegated fumerole clay, of which we have already spoken as a product of the decomposition of palagonite.

The characteristic phenomena of decomposition which mark the acid siliceous waters, are never wholly absent from the class of alkaline springs. Here, too, where the fumerole clay is freed from siliceous incrustations, a foaming pool may occasionally be met with, the dark viscid mud of which rises in huge bubbles, or a steaming bed covered with crystals of gypsum and alum, or, finally, a deposit of sulphur superposed on the clay, or even on the siliceous incrustations. But these phenomena, which depend on the occurrence of small quantities of sulphurous acid, sink into insignificance, or I might almost say, entirely vanish before the stupendous phenomena developed by the action of carbonic acid, sulphuretted hydrogen, and heated water, on the substance of the palagonite. In the mutual reaction of these four substances are combined all the conditions required by nature to convert, in the course of centuries, simple boiling springs into geysers, whose clear, vapoury, and foaming columns of waters, shall burst from the summits of their self-created siliceous tuff-craters, either continuously, or at periods extending from a few minutes to hours, or days. These geysers and the other alkaline siliceous springs of Iceland, do not evince that dreary character of wild devastation which is manifested by the fumeroles and solfataras, with

SPECTRA OF STARS

As contained in the Harvard photographs have greatly advanced astronomy. Prof. Edward C. Pickering, director of the Harvard Observatory when this work was begun, is the author of next week's

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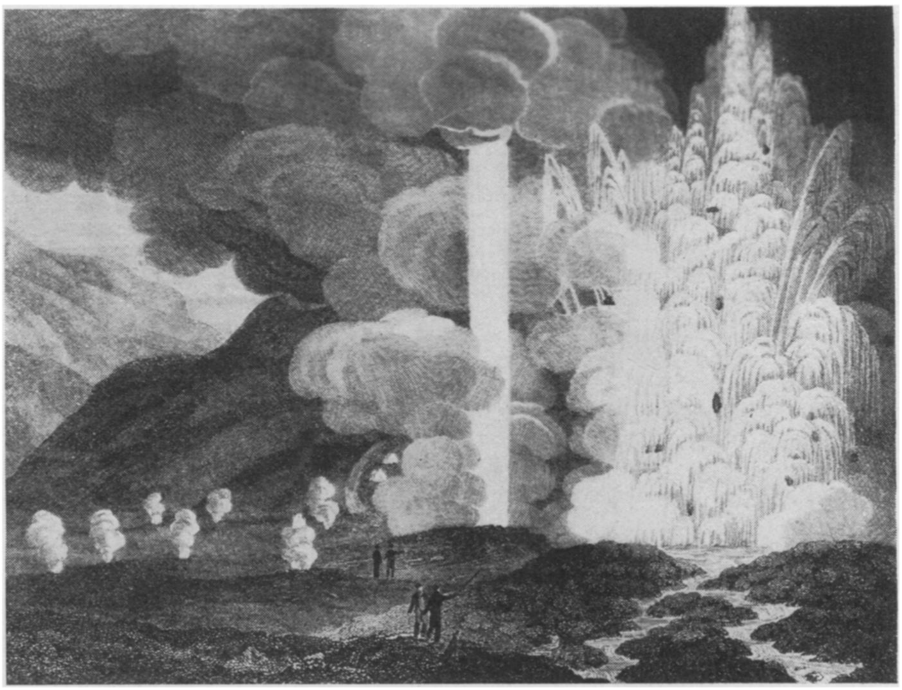
their boiling mud-pools and their steaming fields of sulphur. The eye rests rather with pleasure on the white ledges and stalactites, which rise now in the form of small conical craters, then in long furrows and vast basins, and again in round openings of the most regular configuration.

It will be necessary here to pause a few moments for the consideration of these incrustations. Their structure is simple and easy of explanation. It will be seen from the composition of the water of the geysers, as given in a subsequent part of this paper, that the silica is dissolved in the water by alkaline carbonates and in the form of a hydrate. No trace of silica is precipitated on the cooling of the water, and it is only after the evaporation of the latter that silica is deposited in the form of a thin film on the moistened sides of the vessel where evaporation to dryness takes place, whilst the fluid itself is not rendered turbid by hydrated silica until the process of concentration is far advanced. This apparently trivial circumstance is of the greatest importance in the formation of the geysers. It will be evident that the basin of the spring, in which the constantly renewed water affords only a very small field for the process of evaporation, must remain free from siliceous formations, whilst the margins projecting beyond the level of the water, will readily become covered by a siliceous incrustation owing to the rapid and easy drying of the moisture attracted by a capillary force. Further on, where the water spreads itself over the surface surrounding the spring, the incrustations increase in proportion as the surface evaporation expands. As the basin of the spring has no part in this incrustation, it becomes converted into a deep tube as it is gradually enclosed by a hillock of siliceous tuff, combining, when it has reached a certain height, all the requirements necessary to convert it into a geyser. If such a tube be narrow and be filled with tolerable rapidity by a column of water strongly heated from below by the volcanic soil, a continuous geyser must necessarily be produced, as we find them in so many parts of Iceland. For it will easily be understood that a spring, which originally did not possess a higher temperature at its mouth than that which would correspond to the pressure of the atmosphere, may easily, when it has been surmounted by a tube, formed by gradual incrustation, attain at its base a temperature of upwards of 100° C. owing to the pressure of the fluid resting in the tube. The mass of water rising in such a spring, which is constantly renewed from below, and possessing in the natural shaft of the spring a temperature of 100°, must immediately, on its escape from the mouth of the tube, experience a diminution of temperature corresponding to the diminished pressure of the atmosphere, by which the whole excess of heat above 100° will be expended in the formation of vapour. The water raised by the expansive force of these vapours, and mixed in a white foam, forces itself from the mouth of the spring foaming and hissing in one continuous gush. Iceland abounds in springs of this kind; although the Reykholter valley presents, perhaps, the largest number to be found in any one spot. I shall not, however, enter into any more circumstantial description of them, since the subject is only one of secondary interest. When the geyser tube, formed by the process of incrustation, is sufficiently wide to afford a considerable degree of cooling to the water at its surface, and the jet which is heated upwards of 100° C., falls but slowly back to the base of the wide funnel, we find all the requirements necessary for converting the spring into a periodically recurring geyser, which bursts suddenly forth by the action of the developed force of the vapour, and then forthwith falls back to a state of long continued repose. The Great Geyser is the most remarkable of these springs, which have been regarded as natural accumulators of the force of vapour.

Immediately after an eruption, the water which fills the tube to the height of 1 or 2 met., gradually rises during several hours to the margin of the basin, whence it flows over the cone in the form of a small cascade.

It may easily be shown by experiment, that the column of fluid filling the tube, is constantly being heated by water entering it from below, whilst it experiences a constant cooling and evaporation above on the broad surface of the basin. Evaporation is likewise effected within the funnel itself by means of a current which rises and falls in its upper portion; driving a column of heated water up the centre of the funnel, it spreads itself over the surface of the basin towards the edges, and after the evaporation has been completed flows back to the funnel.

The direction of this current may be observed by throwing a few shreds of paper into the middle of the basin of the geyser, as they will be driven to the margin of the upper surface, and then again be carried back to the bottom of the tube. . . . (*Turn to page* 271)



**THE ICELAND GEYSERS**
***As they appeared in an old engraving of 1814***

ORNITHOLOGY

## Nature Ramblings

By FRANK THONE

***Ptarmigan***

THE PTARMIGAN, a fine American bird which few of us ever get a chance to see, because he lives either too far north or too high up, is now shifting garments. All summer long he was mottled rock gray, now he is becoming snowy white. Both guises are protective camouflage, and both are highly effective.

Properly, the ptarmigan is an arctic bird; it is on the great wastes of the empty North that he thrives best. But like many other forms of arctic plant and animal life, he can come south by sticking to the mountain tops, and thus we find him within the United States proper, holding to the pinnacles of our loftiest western mountains, high above timberline, where few other creatures as large as himself can exist. He stays there the year round, too, even when winter drives such hardy creatures as mountain sheep down into the valleys. How the ptarmigan manages to pick up a living then is a riddle, but he seems to survive; for when hardy climbers scramble back to the peaks next spring, there he is, and his mate and babies, picking a good living out of the snow and from the dwarf juniper bushes.

The ptarmigan is a confirmed dependent on the refrigerator. He picks over the snowfields for frozen insects and for those peculiar wiggling creatures called "snow worms," and it is stated by alpine naturalists that the mother ptarmigan takes her family to snow patches even in the summer when mealtime comes.

*Science News Letter, October 25, 1930*

There are more than 8,000 varieties of dahlia on the market.

Almost 100 mills in the South are manufacturing paper from the southern pine.

## Bunsen and the Geysers

(*Continued from page* 263)

If we now consider the period which immediately precedes an eruption, we shall find that only a very slight impulse is necessary to bring a large portion of the column of water, suddenly into a state of ebullition, and, as we shall soon see, even to produce an eruption. Every cause that tends to raise this column of water only a few meters, must necessarily be attended by this result. If, for instance, we assume this elevation to be equal to 2m, the column of fluid pressing on the point *a* will be shortened by the height *ab*. The temperature *a* of the stratum of water lying under a pressure diminished by *ab* is now about *bc*, or 1° higher than the corresponding boiling-point of the water. This excess of 1° is immediately expended in the formation of vapour, generating in the present case, as may be proved by an easy calculation, a stratum of vapour nearly equally high with the stratum of water 1m in height. By this diminution in the superincumbent water a new and deeper portion of the column of water is raised above the boiling-point; a new formation of vapour then takes place, which again occasions a shortening in the pressing liquid strata, and so on, until the boiling has descended from the middle to near the bottom of the funnel of the geyser, provided always that no other circumstances have more speedily put an end to this process.

It appears from these considerations that the column of water in the funnel of the geyser extending to a certain distance below the middle, is suddenly brought into a state of ebullition, and further, as may be shown by an easy method of computation, that the mechanical force developed by this suddenly established process of vaporization is more than sufficient to raise the huge mass of the waters of the geyser to that astounding elevation which imparts so grand and imposing a character to these beautiful phenomena of eruption. . . . We can easily understand the reason that this enormous force should not be expended in one single jet of eruption, when we remember that the jets of water erupted in the air are continually falling back into the tube of the geyser, and interrupting, at different moments, the force of the upheaving column of vapour, which is condensed in the cooled water as it falls, until the temperature of the latter again reaches the boiling-point, and has consequently regained the power of being again propelled upwards. At the same time the water may be seen flowing from the basin back into the funnel, between the different spearate ascents of the water. Occasionally, the water even appears as if it were forcibly drawn back.

The condensation in question, with the consequent restoration of heat to the water of the geyser, explains, at the same time, the fact of the great eruptions continuing frequently for a period of more than five minutes.

*Science News Letter, October 25, 1930*

Queen Elizabeth advised this prescription for a cold: Take a quart of newe milk, put into it 2 sponefulls of honey, 4 ounces of linseede, and as it boyles put in pieces of scarlett or redd cloth and laye one peece on your stomack and one opposite to that on the backe, and soe goe to bedd: sweat and you shalbe well.