VI. *An ACCOUNT of the HOT SPRINGS near Haukadal in Iceland: In a second Letter to Dr BLACK from JOHN THOMAS STANLEY, Esq; M. P. F. S. A. A. LOND. and F. R. S. EDIN.*

[*Read April 30. 1792.*]

DEAR SIR,

Grosvenor Place, March 30. 1792.

PART of my promise has been accomplished in a former letter, in which I gave you the fullest account I could of the springs of boiling water that rise in the valley of Rykum. It now remains for me to send you a description of those we visited in the neighbourhood of Haukadal.

THESE last are the most remarkable in the island, and the eruptions of water from some of them so astonishing, that I doubt whether any adequate idea of their effect can be given by description. Abler pens than mine might fail probably in attempting to do justice to such wonderful phenomena. The objects, however, are so highly interesting in themselves, that even the simplest narrative that can be given of them will be read with more than ordinary attention.

THEY are situated about six and thirty miles from Mount Heckla, and about twelve miles, in a north-east direction, from the village of Skalholt*. The road from thence to the springs
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* Skalholt consists of the Cathedral, a large building of wood, and of a very few houses belonging to the Bishop and his dependants. The Bishops of the southern division

is over a flat country, which, although marshy in several places, is not unpleasant to the eye, and abounds in excellent pasturage.

THE steam ascending from the principal springs during their eruptions, may be seen from a considerable distance. When the air is still, it rises perpendicularly like a column to a great height; then spreads itself into clouds, which roll in successive masses over each other, until they are lost in the atmosphere. We perceived one of these columns, when distant sixteen miles at least, in a direct line from Haukadal.

THE springs mostly rise in a plain, between a river that winds through it, and the base of a range of low hills. Many however break out from the sides of the hills, and some very near their summits. They are all contained, to the number of one hundred or more, within a circle of two miles.

THE most remarkable spring rises nearly in the midst of the other springs, close to the hills. It is called Geyzer*; the name probably in the old Scandinavian language for a fountain, from the verb *geysa*, signifying *to gush*, or *to rush forth*. The next most remarkable spring rises at a distance of one hundred and forty yards from it, on the same line, at the foot of the hills. We called it the New Geyzer, on account of its having but lately played so violently as at present.

THERE are others of consequence in the place, but none that approach to these in magnificence, or that, when compared with them, deserve much description. The generality of the springs are in every respect similar to those near Rykum; boil-

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sion of Iceland have always resided there; but in future their residence will be at Rykiavick, a town now building on the south-west coast of the island. The present Bishop, however, the worthy and learned Mr FINSSEN, has obtained the permission of continuing his residence at Skalholt during the remainder of his life.

* Three or four only of the principal springs in Iceland are distinguished by the name of Geyzer, and of all the springs near Haukadal the greatest is alone called Geyzer or Great Geyzer.

ing in caldrons of three or four feet diameter, and some of them throwing their water from time to time by sudden jets into the air. Many springs in this place, as in the other, boil through strata of coloured clay, by which they are rendered turbid. Here, however, the red clays were brighter, and in a greater proportion to the clays of other colours. Here also, as in the valley of Rykum, are many small springs, which throw out sulphureous vapour, and near which the ground, and the channel of the water, are covered and lined with a thin coat of sulphur.

THE farm of Haukadal, and the church of the parish, stand near to each other about three quarters of a mile beyond the great spring. The house is one of the best built in Iceland. It occupies a large space of ground, and consists of several divisions, to each of which there is an entrance from without. Some of these are used as barns and stables for the cattle, and others as work-shops *. The dwelling part of this house was small, but comfortable. There was a parlour with glass windows, a kitchen, and separate bed-chambers for the family. The building was partly of stone, partly of wood, and covered with fods, under which the bark of birch trees on boards are generally placed, as a greater security against rain.

WE were obliged to the mistress of this farm, who was a rich widow, for a very hospitable reception, although at first she seemed to consider us rather as unwelcome visitors, and left us, though we had requested admittance into her house, as we were drenched with rain, and our tents and baggage not yet arrived, to take up our lodging in the church. We had not been long there, however, before she invited us to her house, and

* As the division of labour is yet very imperfect in Iceland, the farmer is under the necessity, either of exercising himself the several trades required in the formation of the instruments of agriculture, or of maintaining such servants as are capable to supply them.

and by her kindness made ample amends for her former inattention. She put us in possession of her best room, and set before us plenty of good cream, some wheat cakes, sugar, and a kind of tea made of the leaves of the *dryas octopetala* *.

I MENTION these circumstances of our reception at Haukadal, as characteristic of the manners of the Icelanders. Several times during my stay in the country, I experienced this succession of civility to coldness. The Icelanders are naturally good, but not easily roused to feeling. When once their constitutional indifference was overcome, we usually found them desirous of pleasing, and zealous to do us service.

As the house was not sufficiently large to contain the whole of our party, we were under the necessity of returning again to the church as soon as our baggage arrived. Here we passed the first and second nights of our stay, in the neighbourhood of the springs. On the third day, we left Haukadal, to fix ourselves in some station nearer to them, from which we could watch their eruptions with more convenience.

THE view from near the church was very beautiful. It extended toward the south along the plain into an open country. On the other sides, it was bounded by hills, which had not the barren and rugged appearance that deform almost every scene in this division of the island. It was, however, still finer from some of the eminences near the springs. The plain and the surrounding mountains, seen from a height, appeared to more advantage; and the eruptions from the great wells breaking from time to time, the general stillness that prevailed, were much more distinct. The course of the river, winding under the eye, could be traced with greater accuracy. It flows through
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* Called in English the Mountain Avens. We found this plant growing very luxuriantly, and in great abundance, in every part of Iceland that we visited.

the plain into an open country, where, being increased by the waters of numerous streams and rivulets, it bends to the westward, and near Skalholt falls into a considerable river, the Huit-aa.

THE pleasant and fertile pastures near its banks were enlivened by numerous herds of cattle and sheep, the united riches of three or four farmers in the neighbourhood of Haukadal. The mowers also at work in the different fields surrounding each house, gave, at this season, additional beauty to the prospect. High hills to the westward were separated from the eminencies immediately above the springs by a narrow valley. They were partly clothed with bushes of birch, which, although in no place above five feet high, were gratifying to the sight, which so seldom in Iceland can rest on any appearance even of underwood. Above these, some vegetation still continued to cover the sides of the hills, and Mr WRIGHT found a variety of plants * near their summits, which were certainly, in some places, not less than sixteen hundred feet above the plain.

To the eastward, the plain, several miles in breadth, was bounded by a long range of blue mountains, extending considerably to the south. Beyond these, the triple summit of Heckla may be seen from the western hills; but I could not distinguish it from the plain, or even from the heights whence the view of the surrounding country was taken which I am now describing.

To the north behind Haukadal, there were many high mountains, but at a great distance, and of which the most distant were covered with snow. They formed part of a dreary assemblage

* Amongst others, he found the *salix herbacea* (tear willow), the *cerastium tomentosum* (woolly mouse ear chickweed), the *rumex digynus* (round leaved mountain sorrel), and the *koenigia*, (a plant peculiar to Iceland), growing in great abundance, though generally in low and marshy grounds.

assemblage of *Jökuls* or ice-mountains, which occupy a considerable extent of the interior country. Their forms were mostly conical; and from their general resemblance to other mountains in the island, from which streams of lava have been emitted, I think it probable they were once volcanos. They are not so connected as to form a continued range or chain of hills. Each stands insulated; and therefore the snows which have for ages rested on their sides, are no where accumulated in valleys and converted into lakes of ice and glaciers, as amidst the Alps of Switzerland and Savoy.

A view so different from the general features of the country, impressed us with the most agreeable sensations. Hitherto we could but compare one scene of dreariness with another; and although the view before us was destitute of trees, yet the verdure, and pleasant distribution of hills and plain, in some measure compensated for this deficiency.

I now return to the account of the springs, which I have already observed break out in different places from the sides of a hill, and the space inclosed between its base and the windings of a river. The soil through which they rise is a mixture of crumbled materials, washed by degrees from the higher parts of the hill. In some places, these have been reduced into a clay or earth; in others, they still remain loose and broken fragments of the rocks from whence they have fallen, or a dust produced by their friction against each other. Wherever the ground is penetrated by the steam of the springs, these fragments are soon decomposed, or changed into coloured clays. In other places, the surface of the ground is covered with incrustations deposited by the springs, or with a luxuriant vegetation of grass or dwarf bushes of willow and birch, and the *empetrum nigrum* *, the berries of which were at this time ripe and in great abundance.

ABOVE

* The crow berry. This is almost the only fruit we met with in Iceland. Mr WRIGHT found a few strawberries. Neither gooseberries nor currants will come to perfection by any management whatever.

ABOVE the great spring, the hill terminates in a double pointed rock, which Mr BAINÉ found by measurement to be 310 feet higher than the course of the river. The rock is split very strangely into lamina, and at first sight has much the appearance of a schistus or bed of thick slate. It consists, however, of a gray coloured stone of a very close grain, the separate pieces of which, although divided as they lay, do not break in the hand in any particular direction. I should suppose the substance of this rock to be chiefly argillaceous, and that, like every other stone in the island, it has suffered some change by the action of fire. I do not mean to call it lava, as it bears no mark of having been once in a melted state, whatever baking or induration it may have sustained in the neighbourhood of subterraneous heat. It contains no heterogeneous matter, or cavities, in which agates, or zeolites, or vitrified substances of any kind, could have been formed.

ALL these rocks that have been either altered or created by fire, seem much more liable to decay and decomposition than any others I have ever seen. Mounds, similar to those in the valley of Rykum, have been formed by the ruins of the hill half way up its ascent between the Geyzer and the pointed rock. Springs boil in many places through these mounds, and near to one of them, I observed that the coloured clay felt much more soapy than any I had tried before. This quality probably was owing to a greater proportion of the earth of magnesia in its composition, as in other respects it agreed perfectly with the rest.

My attention, during the four days I remained in this place, was so much engaged by the beauties and remarkable circumstances of the two principal springs, that I cannot (were I so inclined) give you a minute account of those which, next to them, were deserving of notice. The springs in general resemble those at Rykum; but there are five or six which have their peculiarities, and throw up their waters with violence to

a considerable height. Their basons are of irregular forms, four, five or six feet in diameter, and from some of them the water rushes out in all directions, from others obliquely. The eruptions are never of long duration, and the intervals are from 15 to 30 minutes. The periods of both were exceedingly variable. One of the most remarkable of these springs threw out a great quantity of water, and from its continual noise we named it the Roaring Geyzer. The eruptions of this fountain were incessant. The water darted out with fury every four or five minutes, and covered a great space of ground with the matter it deposited. The jets were from thirty to forty feet in height. They were shivered into the finest particles of spray, and surrounded by great clouds of steam. The situation of this spring was eighty yards distant from the Geyzer, on the rise of the hill.

I SHALL now, Sir, attempt some description of this celebrated fountain, distinguished by the appellation of Geyzer alone, from the pre-eminence it holds over all the natural phenomena of this kind in Iceland.

By a gradual deposition of the substances dissolved in its water for a long succession of years, perhaps for ages, a mound of considerable height has been formed, from the centre of which the Geyzer issues. It rises through a perpendicular and cylindrical pipe, or shaft, seventy feet in depth, and eight feet and a half in diameter, which opens into a bason or funnel, measuring fifty-nine feet from one edge of it to the other. The bason is circular, and the sides of it, as well as those of the pipe, are polished quite smooth by the continual friction of the water, and they are both formed with such mathematical truth, as to appear constructed by art. The declivity of the mound begins immediately from the borders of the bason. The incrustations are in some places worn smooth by the overflowing of the water; in most, however, they rise in numberless little tufts, which bear a resemblance to the heads of cau-

lilflowers, except that they are rather more prominent, and are covered, by the falling of the finer particles of spray, with a crystalline efflorescence so delicate as scarcely to bear the lightest touch. Unmolested, the efflorescence gradually hardens, and, although it loses its first delicacy, it still remains exceedingly beautiful.

THESE incrustations are of a light brown colour, and extend a great way, in various directions, from the borders of the basin. To the northward, they reach to a distance of 82 feet; to the east, of 86; to the south, of 118; and of 124 to the west. They are very hard, and do not appear, in any part, decaying or mouldering into soil*.

WHEN our guides first led us to the Geyzer, the basin was filled to within a few feet of its edge. The water was transparent as crystal; a slight steam only arose from it, and the surface was ruffled but by a few bubbles, which now and then came from the bottom of the pipe. We waited with anxiety for several minutes, expecting at every instant some interruption to this tranquillity. On a sudden, another spring, immediately in front of the place on which we were standing, darted its waters above an hundred feet into the air with the velocity of an arrow, and the jets succeeding this first eruption were still higher. This was the spring already mentioned under the name of the New Geyzer.

WHILE gazing in silence and wonder at this unexpected and beautiful display, we were alarmed by a sudden shock of the
ground

* The substance of these incrustations has been analysed by Professor BERGMAN, and he gives a long and particular account of it, in a letter to the Archbishop of Upsal, published with the Archbishop's Letters on Iceland. He says, "The strongest acids, the fluor acid not excepted, are not sufficient with a boiling heat to dissolve this substance. It dissolves very little (if at all) by the blow-pipe with the fusible salt of urine, a little more with borax, and makes a strong effervescence with sal soda. These effects are peculiar only to a siliceous earth or flint. There cannot remain therefore a doubt concerning the nature of this crusted stone."

ground under our feet, accompanied with a hollow noise, not unlike the distant firing of cannon. Another flock soon followed, and we observed the water in the basin to be much agitated. The Icelanders hastily laid hold of us, and forced us to retreat some yards. The water in the mean time boiled violently, and heaved as if some expansive power were labouring beneath its weight, and some of it was thrown up a few feet above the basin. Again there were two or three flocks of the ground, and a repetition of the same noise. In an instant, the surrounding atmosphere was filled with volumes of steam rolling over each other as they ascended, in a manner inexpressibly beautiful, and through which, columns of water, shivering into foam, darted in rapid succession to heights which, at the time, we were little qualified to estimate. Indeed, the novelty and splendour of such a scene had affected our imaginations so forcibly, that we believed the extreme height of the jet to be much greater than it was afterwards determined to be. In a subsequent eruption, Mr BAINE ascertained, by means of a quadrant, the greatest elevation to which the jets of water were thrown, to be 96 feet.

Much of the water began to descend again at different heights, and was again projected by other columns, which met it as they arose. At last, having filled the basin, it rolled in great waves over its edge, and forming numberless rills, made its way down the sides of the mound. Much was lost in vapour also, and still more fell to the ground in heavy showers of spray. The intervals at which the several jets succeeded each other, were too short for the eye to distinguish them. As they rose out of the basin, they reflected, by their density, the purest and most brilliant blue. In certain shades, the colour was green like that of the sea; but in their further ascent, all distinction of colour was lost, and the jets, broken into a thousand parts, appeared white as snow. Several of them were forced upwards perpendicularly; but many, receiving

a slight inclination as they burst from the basin, were projected in beautiful curves, and the spray which fell from them, caught by a succeeding jet, was hurried away still higher than it had been perhaps before.

THE jets were made with inconceivable velocity, and those which escaped uninterrupted terminated in sharp points, and lost themselves in the air. The eruption, changing its form at every instant, and blending variously with the clouds of steam that surrounded it, continued for ten or twelve minutes; the water then subsided through the pipe, and disappeared.

THE eruptions of the Geyzer succeed each other with some degree of regularity, but they are not equally violent, or of equal duration. Some lasted scarcely eight or ten, while others continued, with unabated violence, fifteen or eighteen minutes. Between the great eruptions, while the pipe and basin were filling, the water burst several times into the air to a considerable height. These partial jets, however, seldom exceeded a minute, and sometimes not a few seconds, in duration.

AFTER the eruption of it had been violent, the water sank into subterraneous caverns, and left the pipe quite empty. If the eruption had been moderate, the subsidence of the water was proportionably less. The first time the pipe was perfectly emptied, we sounded its depth, and found the bottom very rough and irregular. The pipe remains but a short time empty. After a few seconds, the water rushes into it again with a bubbling noise, and during the time that it is rising in the pipe, it is frequently darted suddenly into the air to different heights, sometimes to two or three, sometimes sixty feet above the sides of the basin. By a surprise of this kind, while we were engaged measuring the diameter of the well, we had nearly been scalded; and although we were able to withdraw ourselves from the great body of water as it ascended, yet we remained exposed to the falling spray, which fortunately was so much cooled in the air as to do us no mischief.

OF these jets we counted twenty in an hour and an half, during which the waters had filled the pipe and in part the bafon. It then seemed oftentimes agitated, and boiled with great violence. The jets were more beautiful, and continued longer, as the quantity of water in the bafon increased. The resistance being greater, their force was in some degree broken, and their form, more divided, produced a greater display of foam and vapour.

WHILE the pipe was filling, we threw into it several stones of considerable weight, which, whenever the water burst forth with any violence, were projected much higher than itself. These stones in falling were met by other columns of water, and amidst these they rose and fell repeatedly. They were easily distinguished in the white foam, and contributed much to the novelty and beauty of this extraordinary phenomenon.

WHEN the bafon was nearly full, these occasional eruptions were generally announced by shocks of the ground, similar to those preceding the great eruptions. Immediately after the shocks, the whole body of water in the bafon heaved exceedingly; a violent ebullition then took place, and large waves spread themselves in circles from the centre, through which the column forced its way.

WHEN the water had been quiet in the bafon for some time, the thermometer placed in it stood at 180° only, but immediately after an eruption it rose to 200° . We boiled a piece of salmon in it, which was exceedingly well tasted. Our cookery at Rykum had not been quite so successful.

THE water thrown out from the Geyzer is joined at the bottom of the mound by that which flows from the spring called the roaring Geyzer, formerly described. The stream produced by their united waters flows three or four hundred paces before it falls into the river, where its temperature is reduced to 72° . Even at this place it deposited much of the substances it contained; but during the whole of its course, the plants growing

growing on its banks were covered with beautiful incrustations. Some of these we wished to preserve, but from their extreme delicacy they fell into pieces on every attempt to remove them.

THE situation of the new Geyzer * is in the same line from the foot of the hill with the great Geyzer. Its pipe is formed with equal regularity, and is six feet in diameter, and forty-six feet ten inches in depth. It does not open into a basin, but it is nearly surrounded by a rim or wall two feet high. After each eruption, the pipe is emptied, and the water returns gradually into it, as into that of the old Geyzer. During three hours nearly that the pipe is filling, the partial eruptions happen seldom, and do not rise very high; but the water boils the whole time, and often with great violence. The temperature of the waters after one of these eruptions, was constantly found to be 212° . Few incrustations are formed round this spring, excepting in the channel where the water flows from it.

THE great eruption is not preceded by any noise, like that of the great Geyzer. The water boils suddenly, or is heaved over the sides of the pipe; then subsiding a little, it bursts into the air with inconceivable violence. The column of water remains entire, until it reaches its extreme height, where it is shivered into the finest particles. Its direction was perpendicular, and greatest elevation 132 feet. Like the eruption of the old Geyzer, this consisted of several jets, succeeding each other
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* BEFORE the month of June 1789, the year I visited Iceland, this spring had not played with any great degree of violence, at least for a considerable time. (Indeed the formation of the pipe will not allow us to suppose, that its eruptions had at no former period been violent.) But in the month of June, this quarter of Iceland had suffered some very severe shocks of an earthquake; and it is not unlikely, that many of the cavities communicating with the bottom of the pipe, had been then enlarged, and new sources of water opened into them. The difference between the eruptions of this fountain, and those of the great Geyzer, may be accounted for from the circumstance of their being no basin over the pipe of the first, in which any water can be contained to interrupt the column as it rises. I should here state, that we could not discover any correspondence between the eruptions of the different springs.

with great rapidity. Whatever we threw into the well was hurled into the air with such swiftness that the eye could scarcely discern it *, and the division of the water at the extremity of the column was so minute, that the showers of spray which fell were cold. Towards the end of an eruption, when more steam than water rushed from the pipe, I ventured to hold my hand near the edge of the column, in the way of some of the divided particles of water, and found them tepid only. You may probably think this a rash experiment, and certainly it was so. But we had made our observations on the uniform direction of the column, and confided our safety in it. Once or twice, however, we had reason to think ourselves more fortunate in escaping, than prudent in avoiding, the danger which attended a too near approach to these eruptions of boiling water. During ten or fifteen minutes, the water continued to be thrown upwards with undiminished impetuosity. At the end of that period, the quantity became less, and at length, ceasing entirely, steam alone ascended. In one instance, the eruption continued thirty minutes. It seldom however exceeded twenty minutes, and sometimes was completed in fifteen minutes. The force with which the steam rises abates as the water sinks in the pipe, and when this is exhausted, that soon disappears.

I HAVE now, Sir, given you such a description of these celebrated fountains as was in my power. I hope that it will afford you some satisfaction, and I could wish that it might serve as an inducement to some curious enquirer into the history of nature to visit them, who shall have all the knowledge requisite for making such observations as are yet to be desired concerning them. I cannot flatter myself, that the description I have attempted of their eruptions will impress you with a just idea of their beauty. Sources of comparison are wanting, by which
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* Mr BAINE measured the height to which a stone was thrown up by one of these jets, and found it 129 feet. Some others rose considerably higher.

the portraiture of such extraordinary scenes can be assisted. Nature no where offers objects bearing a resemblance to them ; and art, even in constructing the water-works of Versailles, has produced nothing that can at all illustrate the magnificent appearances of the Geyzer. All then that I hope for is, to have said so much as may enable you to complete in your imagination, the picture which I have only sketched. Imagination alone can supply the noise and motion which accompany such large bodies of water bursting from their confinement ; and must be left to paint, what I have not been able to describe, the brilliancy of colouring, the purity of the spray, the quick change of effect, and the thousand varieties of form into which the clouds of steam, filling the atmosphere on every side, are rolled incessantly.

I HAVE avoided entering into any theory of the cause of these phenomena, that you may not suppose the account I give you has been biased by a favourite hypothesis. I have given you an accurate state of facts, and I leave to you the explanation of them. There cannot, however, be two opinions concerning the immediate cause which forces the water upwards. It is obviously the elasticity of steam endeavouring to free itself. In addition to this, the form of the cylinder through which the water rises, gives it that projectile force which carries it so high. Beyond this, it would not become me to hazard any opinion.

Of the antiquity of these springs I can say nothing, further than that they are mentioned as throwing up their waters to a great height by SAXO GRAMMATICUS, in the Preface to his History of Denmark, which was written in the twelfth century ; but from the general features of the country, it is likely, that they have existed a great length of time. The operations of subterraneous heat seem indeed to be of great antiquity in Iceland, and the whole country probably owes its existence

istence to the fires which burn beneath its surface. Every hill proves, at least, with what violence these fires have acted for ages ; and the terrible eruptions of lava, which burst from the mountains of Skaptefield in 1783, show that they are as yet far from being extinguished.

I am,

Dear Sir,

With great regard and esteem,

Your very obedient servant,

JOHN THO. STANLEY.