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greenish water and sending up a great volume of steam, forming the first on the left of the array of steam columns, which at irregular intervals stand all round the cliffs behind the Gjá, but not inside it.

We had accomplished our purpose, and I was satisfied. Gathering some specimens of pumice and loam to compare with the specimens I had collected in 1875, we turned back; and, with quite as great toil as before, regained our team on the ledge at Jón's Skarth. Saddling up, we proceeded, on our return, in the same order as before; but Jón was mounted. Where we floundered before we floundered again, but we arrived at the pasture of Sudrá at midnight on Thursday. After a three hours' feed for the ponies, and three hours' sleep on the ground for ourselves (during part of which it rained), we arrived at Haldorsstathir at 9 A.M. on Friday morning, after an absence of thirty-nine hours.

We arrived at Akureyri on Saturday morning, and found the rivers swollen with melted snow and mountain streams converted into roaring torrents; so that, on my further journey west, I had to make long detours for ferries, swimming the ponies, instead of fording as I had done before.

THORODDSEN ON THE LAVA-DESERT IN THE INTERIOR OF ICELAND.[1]

By J. W. M'Crindle, M.A., M.R.A.S.

Iceland, in respect of its physical structure and its peculiar general aspect, is one of the most remarkable countries in the world. Amid its frozen solitudes, fires from the under-world have raged with a force and a frequency elsewhere wellnigh unparalleled. The island, indeed, consists of an elevated plateau formed mainly by masses of lava, which have been ejected from a great multitude of volcanoes. As Nature is unable, from the rigour of the climate, to cover over the naked deformity of this lava with a growth of vegetation, the island, except in the level tracts with which the coast is belted, and along the course of certain valleys, presents the general character of an unredeemed waste, totally unfit for human habitation. It abounds with lava-streams and with vast glaciers, with rifted rocks and yawning chasms. Here it is drenched with the hot spray of boiling springs, and there blackened with showers of scoriac ashes. It is, moreover, convulsed with earthquakes and volcanic eruptions of fearful violence. Its long winter is of Arctic severity, and, even during its brief summer, it is visited with furious storms of snow and hail. This description applies with peculiar force to the district in the interior called 'Odádahraun (Odáthahraun), of which till lately very little was known even by the natives themselves, who dreaded not only the difficulties and dangers which had to be encountered in traversing it, but were further influenced

[1] Based on Herr Thoroddsen's Paper in *Petermann's Mitteilungen*, No. ix., 1885.

by a superstitious belief that it contained fertile oases inhabited by whole colonies of outlaws descended from criminals who had escaped thither from justice in the days when the laws of the island were of Draconian severity.

The first attempt to explore this secluded region for scientific purposes was made in the years 1838 and 1839 by Björn Gunnlaugsson, the well-known cartographer of the island. He has unfortunately left no record, either printed or written, of his expedition, but has merely entered in his map the results of his observations. Provost Sigurdur Gunnarsson, who was his companion, made frequent journeys into the interior, and his works, along with Gunnlaugsson's map, are the head sources of information regarding it. A Danish naturalist, J. C. Schythe, encouraged by the success which had attended Gunnlaugsson's undertaking, attempted himself, in 1840, an exploration in company with Gunnarsson, but they were unable to pursue their investigations, having been baffled by the dreadful weather which exposed them to unspeakable hardships and privations.

No further expedition was undertaken till the great volcanic eruption of 1875 turned the attention of the world to this desert region. While the volcano was still active, an Englishman called Watts made his way to Askja, after having traversed the Vatna-jökull; and in February, 1876, a native of the island, Jón Thorkelsson, was deputed by a newspaper proprietor to report upon the phenomena of the eruption. An expedition, moreover, fitted out by Denmark under the conduct of Professor Johnstrupp of the University of Copenhagen, arrived in the summer of 1876, for the purpose of examining the volcanoes in the north part of the island. The Professor made a thorough exploration of Askja, while a survey of the valley belonging to it was undertaken by Lieutenant Caroc. The volcanoes in Sveinakjá and at Myvatn were on this occasion also examined. A visit was subsequently made to Askja by two Englishmen, Lock and Morgan, of which an account is given in the *Proceedings* of the Royal Geographical Society of London for 1881. In 1880 some peasants of Myvatn and Bárdardalur travelled round the desert in search of some stray sheep, and in the course of their wanderings discovered the grassy tracts of Gæsavötn and Vonaskard.

In spite, however, of all these visits, the knowledge of the geography and geology of 'Odádahraun remained extremely imperfect. Gunnlaugsson, in his map referred to, had indicated merely its main features, and up to the present time little was known of it in detail. As for its volcanoes, even Askja itself, which had oftenest been visited, was not very accurately known.

Taking all this into consideration, Th. Thoroddsen, who had been a member of the Danish Expedition of 1876, was induced to make a fresh exploration of the desert, and to make it as thorough as the slender means at his command would allow. This design he carried into effect in the summer of 1884, and he has contributed to the current volume of Petermann's well-known geographical publication an account of all the incidents of his expedition, and of the results of the observations which he had been able to make.

The foregoing particulars we have gathered mainly from his introductory remarks, and we proceed now to notice in brief outline the facts of most interest and importance which are brought to our cognisance in the narrative he has supplied. The area embraced in the explorations he describes is that which is included between the rivers Skjalfandafljót and Jökulsá, which both flow northward, and between the north part of the island which lies between the mouths of these rivers, and the great ice-field called Vatna-jökull in the south. It lies therefore between the 16th and 18th degrees of longitude west from Greenwich, and between 64° 30′ and 66° of N. lat.

After completing at Akureyri the preparations for his journey, Thoroddsen left that place on the 2d of July, and proceeded to Myvatn, where he spent some time in examining the volcanic phenomena of that remarkable district. The longest excursion he made was southward to Ketill, when he took the opportunity of ascending the lofty heights of Bláfjall and Sellandafjall. On the 16th of July he left this neighbourhood, starting from Reykjahlíd with a view to reach the interior and explore the hitherto unknown districts lying in the east of 'Odádahraun. On his route would lie the lofty and beautiful range of the Herdubreid Mountains. He had, however, first to cross the great plain of Myvatns-öraefi—a cheerless waste, what with its fields of lava, its volcanic depressions, and its shifting sands. Here is the crater Sveinagja which, in 1875, poured out a mighty stream of lava, and there are other craters besides. The south portion is entirely destitute of vegetation, and it is only in the north that some grassy patches are to be found, to which sheep are driven for pasturage. The weather was cold, and sand-storms and snow-storms, blowing alternately, made travelling extremely disagreeable. The route, which was at first easterly, ere long ran southward, and in a parallel line with the river Jökulsá. A convenient place for rest and refreshment was found when the neighbourhood of Herdubreid was gained. Here was a verdant piece of ground with wells of water situated on the edge of a lava-stream. The vegetation was comparatively luxuriant, so that the ponies were for a considerable time found in provender. The surrounding country is strikingly beautiful. Close at hand the Herdubreid lifts up its mighty ridges, which form part of the most magnificent mountain region in all Iceland. To the southward can be descried the level expanse of the Vatna-jökull robed in snow, while to the north there stretches away a boundless plain, which at sunset is suffused with glowing colours of unspeakable loveliness. Here, too, at mid-day, when the sun happens to be shining, can be seen exhibited in the airy firmament the manifold pictures of the Fata Morgana—the plain with its little lakes, the masses of rock which gird them round, houses also, and long caravans of beasts of burden.

The first excursion which Thoroddsen made from this encampment was to a huge volcano called Dyngju (or Kollóta Dyngju), one that had never yet been trodden by the foot of man. It lies to the north of Herdubreid,

and was reached in a journey of four and a half hours. It consists entirely of lava, and has the shape of a regular dome. The lava along the slopes assumes the most fantastic forms—here rising up in lofty pyramids —there engirdling yawning chasms, or combined in stalactitic clusters. Great fissures, moreover, are to be seen, with mouths of craters on the sides. During the ascent, snow began to fall, and when the summit was reached it was found to be covered with snow and ice. The principal crater, which was filled up with lava, measures about 500 mètres (165 feet) in diameter. While he was walking over the lava field here, Thoroddsen came, all unawares, upon the edge of a precipitous abyss, which seemed to him to be a newly-formed crater, with a cavity to the depth of 150 or 200 mètres, and with a diameter of about 150. Its slopes are extremely steep, and are covered from top to bottom with a snow-white incrustation of ice looking like chiselled marble. The sight of this awful abyss was most impressive. To the south of the volcano, or rising from its base, are several hills of tufa, one of which (Brædrafell) is crested with a row of mighty tufa pillars, which gives it the appearance of an enormous porcupine. It was more than two hours after midnight before the party returned to the encampment.

Southward from Herdubreid a range of mountains, called "Tögl," stretches away to southward, from which a stream of lava has found a passage through a deep fissure down to the river Jókulsá. Herdubreid itself is on all sides surrounded with lava-streams, though it is not itself volcanic. A view was obtained from its highest peak of the volcano of Kverkjöll, which rises from the edge of Vatna-jökull. Its huge mass is rent from top to bottom with an enormous fissure, through which a glacier descends to the lava plain below. On the 22d of July an excursion was made to explore the chain of Herdubreidafjöll (north from Dyngju), which no one had ever yet visited, and which was not to be found entered on any map. The road led to a little hill on the Jókulsá, at a point where formerly a ferry to Mödrudalur must have existed, and then to a *terrain* full of cliffs, where our traveller was surprised to find a row of very old stone pyramids, which he concluded must have been marks of a bridle-path made use of in former ages. The mountain he found difficult to ascend, and he had sometimes to creep along on all-fours. No trace of vegetation was anywhere to be seen, but there was abundance of lava ejected from numerous craters lying everywhere about.

On the 25th of July, Thoroddsen was again in the saddle, bound now for the well-known volcano of Askja, which he approached from the east by a route which had never hitherto been taken. He noticed on his way that the lava from the eruption of 1875 had become entirely covered over with pumice-stone, and that, in consequence, all rifts and holes had quite disappeared. He describes Askja as a flat or hollow-shaped valley, with an environment of steep cliffs in the centre of the northern side. It was once a deeper depression, but discharges of lava from numerous craters on the side of the mountain had gradually filled it up. The edge of the

volcano is about 250 mètres (820 feet) above the bottom of the valley, while Dyngjufjöll (in the north) stands 1400 mètres above the level of the lake. In the south-east corner of Askja a considerable depression occurs, whose northern and western walls show clearly in section all the lava-streams that cover the valley. At the bottom of the depression there appeared in 1876 a little round lake of warm water about 1300 mètres in diameter. This lake is now at least double its original size, and covers the entire bottom. In the year referred to, the depth of the depression down to the lake was 232 mètres; but since that time the surface of the water has risen 82 mètres, while its temperature has been reduced from 22° to 14° Centigrade. On the slope to the south of the lake, and close to the water, are several craters and clefts, from numerous crevices in which, aqueous vapours come steaming out with a hissing and roaring noise quite alarming. Little rills of warm water come trickling down from the clefts into the lake. In the eruption of 1875 enormous masses of tufa, basalt, and pumice-stone were discharged from the different craters.

In the middle of the southern or pumice crater there yawns an abysmal chasm across the masses of pumice-stone adjoining the wall of rock, and reaching quite down to the water's edge. This crater is in consequence difficult of access from the lake, and can only be reached by a long detour along the rim of the rock over an obsidian cleft, which runs in a southward direction a little beyond the pumice crater. The surface of the lake is constantly covered almost everywhere with masses of pumice-stone drifting to and fro, and the slopes of the hills, owing to the presence of sulphurous evaporations, are variegated here and there with patches of green and yellow sulphur. This deposition of sulphur is in full play on the southern crater.

The sight of this great theatre, whereon the action of volcanic forces had been so fearfully displayed, appears to have vividly impressed the imagination of our author. The scene, he says, is one which cannot fail to have an overpowering effect on the spectator. The deep profundity of the vast depression, with its lake of green-tinted water in tranquil repose,—the innumerable volumes of vapour, which burst forth from every crevice, stunning the ear with their deafening roar,—the clammy edges of the surrounding hills,—the piles of snow, and the vast glacier plains—all combine to form a scene which the pen of a Dante or the pencil of a Doré could alone adequately represent. No one, he adds, who has once stood on the edge of the depression can ever afterwards forget the spectacle which is there presented to his view.

The excursion occupied altogether thirty-six hours, during which he was either travelling on foot or riding, and before he could regain the encampment he could scarcely hold himself erect, so much was he overpowered with fatigue and drowsiness. After a few shorter excursions he set out (July 28) on the return journey to Myvatn, by way of the northern parts of 'Odádahraun, and reached his destination on the evening of the second

day. The ground over which he had to pass was at first full of fissures and depressions, which were dangerous traps for the feet of the horses, and when this was traversed the way was then blocked by a great lava-stream, which forced the party to make a long detour in order to go round by its southern extremity. This lava-stream had been produced by the eruption of 1875. The heat here was so oppressive that it produced a torturing thirst which there were no means at hand to relieve.

At Myvatn, Thoroddsen spent a week at a farm-steading in order to rest and refresh his ponies. At the end of that time he started on a second expedition in order to explore the western and eastern parts of 'Odádahraun. He took with him nine ponies and two guides, one of whom was the aforementioned Jón Thorkelsson, who had a good knowledge of that district. During this tour, which occupied half a month, the party suffered much from the unsettled state of the weather and the prevalence of snow and sand-storms. The distance traversed was 380 kilomètres, and, yet, only three grass-clad patches of ground were met with in the whole course of the journey. The route was at first to southward, and lay along the west bank of the river Skjálfandafljot, which was crossed in the neighbourhood of a deep lake called Ishólsvatn. In former times the land was here to some extent cultivated, but its productive power has gone, and nothing is now to be seen but gravel and quicksand. Here the tent was pitched, and an excursion was made to ascend the now extinct volcano of Trölladyngja, one of the largest of the dome-shaped lava hills in Iceland. The soil was soft and yielding, and the ascent difficult over the masses of snow and lava. The work of measurement also, which was begun as soon as the summit was reached, was interrupted by a dense mist and drifting snow. The crater is of an elliptic shape, 1100 mètres in length, and 380 in breadth. It is filled with ice and snow, and divided into two by a ridge of lava which overtops the snow. On the following day an excursion was made southward, along the banks of the Skjálfandafljot. Here there were no high hills, but only low downs of quartz. From the western edge of 'Odádahraun tiny rills of water, which trickle out from quagmires, find their way into the great river. A hot spring was discovered with water at a temperature of 35°·5 C. (91·5 Fahr.) There is another still warmer at Marteinsflœda. At evening the party reached Vonarskard, and quartered for the night at Gæsavötn, where there is a little lake and some vegetation, which is, however, but scanty, and consists chiefly of the Arctic willow (*Salix herbacea*) and some small kinds of grass fringing the borders of some small wells that discharge into the lake. Their temperature ranges from 5° to 7° C. (41° to 44·6 Fahr.), while that of the atmosphere is about, or under, zero. The scantiness of the vegetation, as compared with its former luxuriance, is no doubt due to the gradual exhaustion of the volcanic activity by which it had once been stimulated. It was with the utmost difficulty the ponies could find grass enough to satisfy their hunger. The weather, too, was piercing cold, and the whole aspect of nature chill and dreary. Animal life is fast dis-

appearing from the locality, and the living creatures that were seen could be easily counted: three birds, four or five spiders, and one mite. A wondrous stillness reigned here all round; the birds flew past with noiseless wing, and the silence was broken only by the roar of the glacier-torrent, and the howling of the wind round the clefts on the edge of the glacier.

On the 17th of August the party left Gæsavötn, and took their way eastward along the northern skirts of the Vatna-jökull, which reaches an elevation at its highest point of 1900 mètres above the level of the sea. A halt was made at Kistufell, in order to refresh the horses, now jaded by the severe exertions of the trying march. The poor brutes, too, had to be put upon very short commons, as the provender was nearly exhausted, and Hvannalindir, the next place where a fresh supply could be procured, was still a long way off. At this halting-place there was afforded a striking proof of the terrible force of the south wind in the cliffs of dolerite found in its neighbourhood; for, on their southern face, they are seamed with regular furrows from being constantly struck by chips of stone when high winds are prevalent. The southern part of Kistufell is completely spanned by a mighty glacier, which, stretching from the glacier-field of the Vatna-jökull, reaches to the very plain, and fills all the space between Kistufell and Kverkfjôll. This glacier is certainly one of the largest in Iceland. The view obtained from Kistufell of this mighty mass of ice is described as being most impressive from its extreme wildness and grandeur. It is for the most part covered over with sand and large pieces of rock, so that from a distance it looks like a plain of gravel or a lava-stream, which, if the fall of snow be but slight, retains its own colour of grey. The edge of the glacier consists of *débris*. Towards the east of Kistufell its floor is at its strongest, and here also it is cloven with numberless fissures which have transformed its surface into an indescribable chaos. The glacier at this part is studded over with pyramids of ice fully 30 mètres in height, covered over with quartz-gravel, and separated each from each by wide chasms. Further to the east the ice-pyramids lose in height, but are at the same time more fantastic in their shapes. Here, below the limit of the glacier, there stretches a plain of bare loam and gravel, permeated by numerous streamlets of a whitish colour, scattered about in all directions. The march along the edge of the glacier was difficult and slow, the ponies frequently sinking down even to their bellies in the soaking ground, and daylight had waned before the party had yet passed the limits of the glacier. They had consequently to encamp on its edge, where they spent a most miserable night. Next day the Jókulsá River was reached at an early hour, and at a point where it is split into eight or nine arms, and can thus be crossed without much difficulty. On the banks a welcome sight met the eye, that of some plants, among which were specimens of the *Oxyria digyna* and the lovely *Chamenœrium latifolium*. Not far from the eastern bank of the river, up towards its source, rose the volcano of Kverkfjöll, now in full and near

view. From this stretches away northward a long chain of volcanic mountains, which exhibit phenomena that are reckoned among the most peculiar in Iceland. On the eastern side of this range lies Hvannalindir, which the party reached about mid-day. Here was found grass enough for the horses, and here a halt was made for three days and a half. In the vicinity of the encampment there were found on the edge of a lava-stream the ruins of several huts, which, it was conjectured, had probably been built in former times or occupied as places of refuge by outlaws. Several excursions were made for the exploration of the localities around. One of these was made to Kverkfjöll, but the dreadful severity of the weather made an ascent of it impracticable. On the 21st of August a furious snowstorm raged, and on the following morning the return journey to headquarters was begun. The Jókulsá was recrossed with some difficulty at a point where its waters had become united into a single stream. Westwards from its left bank, which was now reached, there stretches, for a distance of twenty kilomètres, a plain of quicksand, and the passage through this was found to be the most unpleasant part of the whole tour. A storm was unfortunately blowing, which darkened the air and pitilessly pelted the ears of the luckless travellers with gravel and chips of stone. They would indeed have lost their lives, had it not been that the wind was blowing from behind them. In the midst of Valdalda pumice-stone again made its appearance, and here also was discovered in the midst of the sand a large lake of glacier water which had only recently been formed, probably by streams issuing from Kistufell. The lake also receives tributary waters from the south-eastern parts of Dyngjufjöll. After much toil the volcano of Askja was next passed, and thereafter a halt for the night was made on the most northern spur of Dyngjufjöll. Next day, after the northern slopes of this mountain had been traversed, and Jonsskard had been gained, a comparatively easy route was followed, that which led to Svartárvatn, the same which had been taken by Professor Johnstrupp and his party. Bardadalur was reached towards evening of the same day, and Thoroddsen's journey through the lava-desert, properly so called, was thus brought to a happy close.

After a few days' rest our indefatigable traveller started on a third and final expedition. Proceeding again to Myvatn he travelled thence to the north-east with a view to explore the northern course of the Jókulsá. He reached that river by way of Reykjalid and the agricultural steading of Eilisvatn, and saw Dettifoss, the greatest and most imposing waterfall in all Iceland. Here the full flood of the Jókulsá is precipitated to the depth of 107 mètres into an abyss of narrow limits where the waters bubble and hiss and roar, and then pursue their course along the bottom of a prodigious volcanic fissure which extends as far as 'As, a distance of 20 kilomètres. At Svnadalur, the scenery is described as being strikingly picturesque, its gigantic rocks, its deep craggy ravines and bush-grown declivities, all combining to impart to it a wild romantic beauty such as is seldom met with elsewhere in the island. At 'As, the extreme verge

of the plateau sinks down into the alluvial plain formed by the river towards its mouth, where lies Asbyrgi, celebrated through all Iceland for its exquisite beauty.

From this place Thoroddsen made his way to Húsavik, and from thence to Akureyri, which he reached on the 4th of September. He had travelled for nine weeks, of which five had been spent in uninhabited parts, where his tent had been his sole shelter.

THE CAROLINE ISLANDS.

By Thomas Muir, LL.D., F.R.S.E.

The reader who has an accurate conception of the geographical position of New Guinea, and the newly baptized Bismarck Archipelago, may readily acquire a tolerably correct idea of the whereabouts of the Caroline Islands. New Guinea, we know, lies like a gigantic saurian between Australia and the equator, stretched at full length in a N.W. and S.E. direction, its head almost just reaching the equator, and the tip of its tail going slantwise across the line of 10 degrees south latitude. Roughly speaking, then, the Caroline Islands are to the N.N.E. of New Guinea, and occupy a situation north of the equator corresponding to that which New Guinea and the Bismarck Archipelago occupy to the south, none of them quite reaching the equator, and those which are furthest north being just beyond the line of 10 degrees north latitude. In other respects the occupants of these two belts are a wonderful contrast. New Guinea belongs to the front rank among the large islands of the world, and its neighbours of the Bismarck Archipelago are not by any means diminutive; the Caroline Islands, on the other hand, are but tiny specks dotted over a vast extent of ocean surface. Almost due north of the head of New Guinea, the sprinkling, if we may so speak, begins, giving us first the Pelew group, which, however, has been often viewed as distinct from the Carolines; then, after a break, the scattered group which includes Yap, Ngoli or Matalotes Islands, Uluthi or Mackenzie Islands, and Sorol or Philip Islands; then, after another break, a long succession of small clusters, Wolea or Ulie Islands, Swede Islands, Los Martires and Enderby Islands, Namonuito or Lütke Islands, Hogolu or Truk Islands, the Mortlock Islands, and others; then there is a break once more, and we come to the Seniavina group, of which Ponape or Puynipet is the chief; and finally, after passing a straggler or two, we reach Kusaie or Ualan, the extreme eastermost of the long chain. In our survey, we have traversed from west to east 2000 miles of ocean, and have confined ourselves within a belt 300 miles broad at the greatest. To the west of the belt lie the most southern islands of the massive group of the Philippines; to the north of the middle of the belt lie the isles of the Marianne or Ladrone group; and to east and south-east are the Marshall and Gilbert Islands, closely resembling the Carolines themselves. Though