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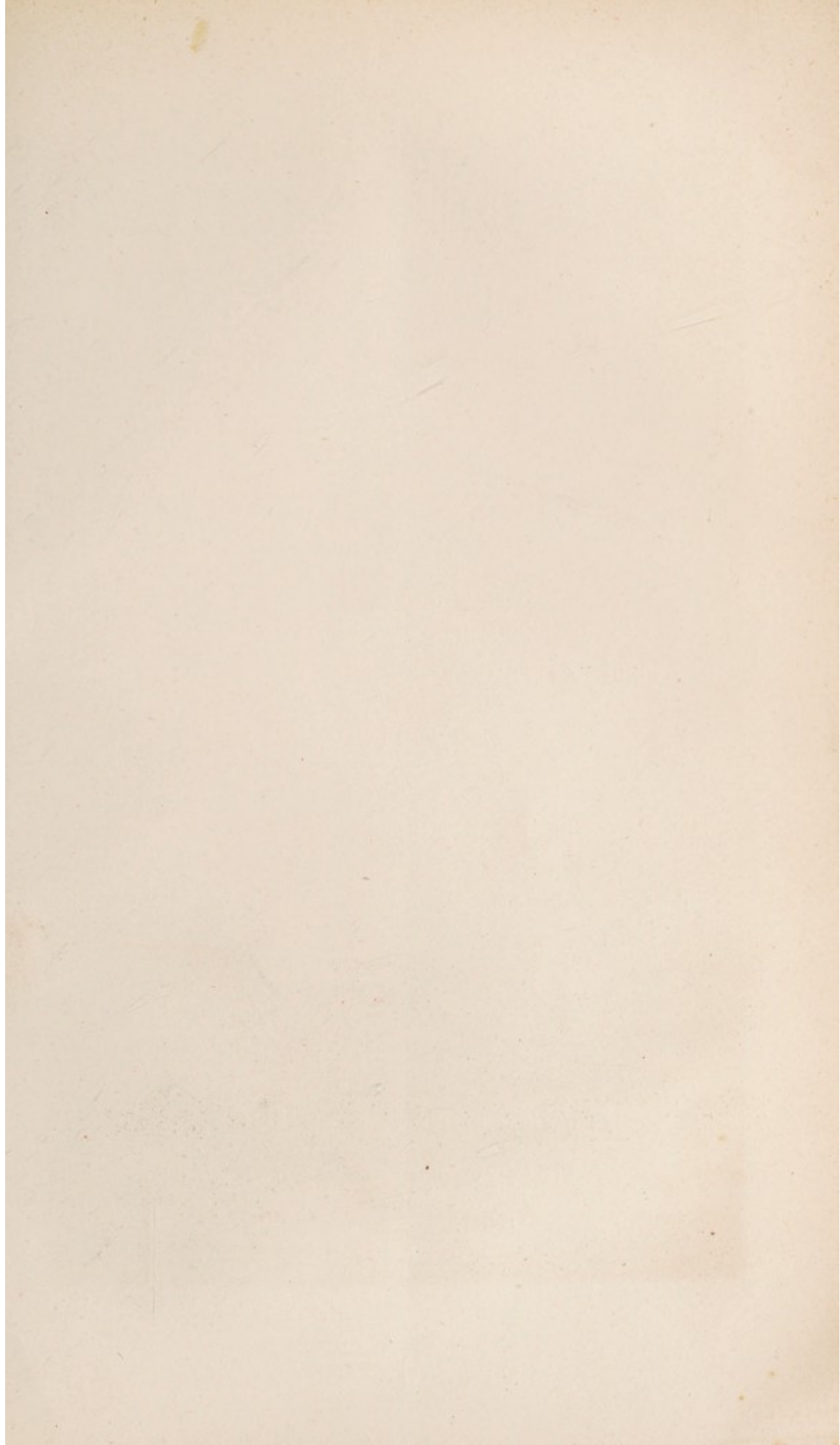
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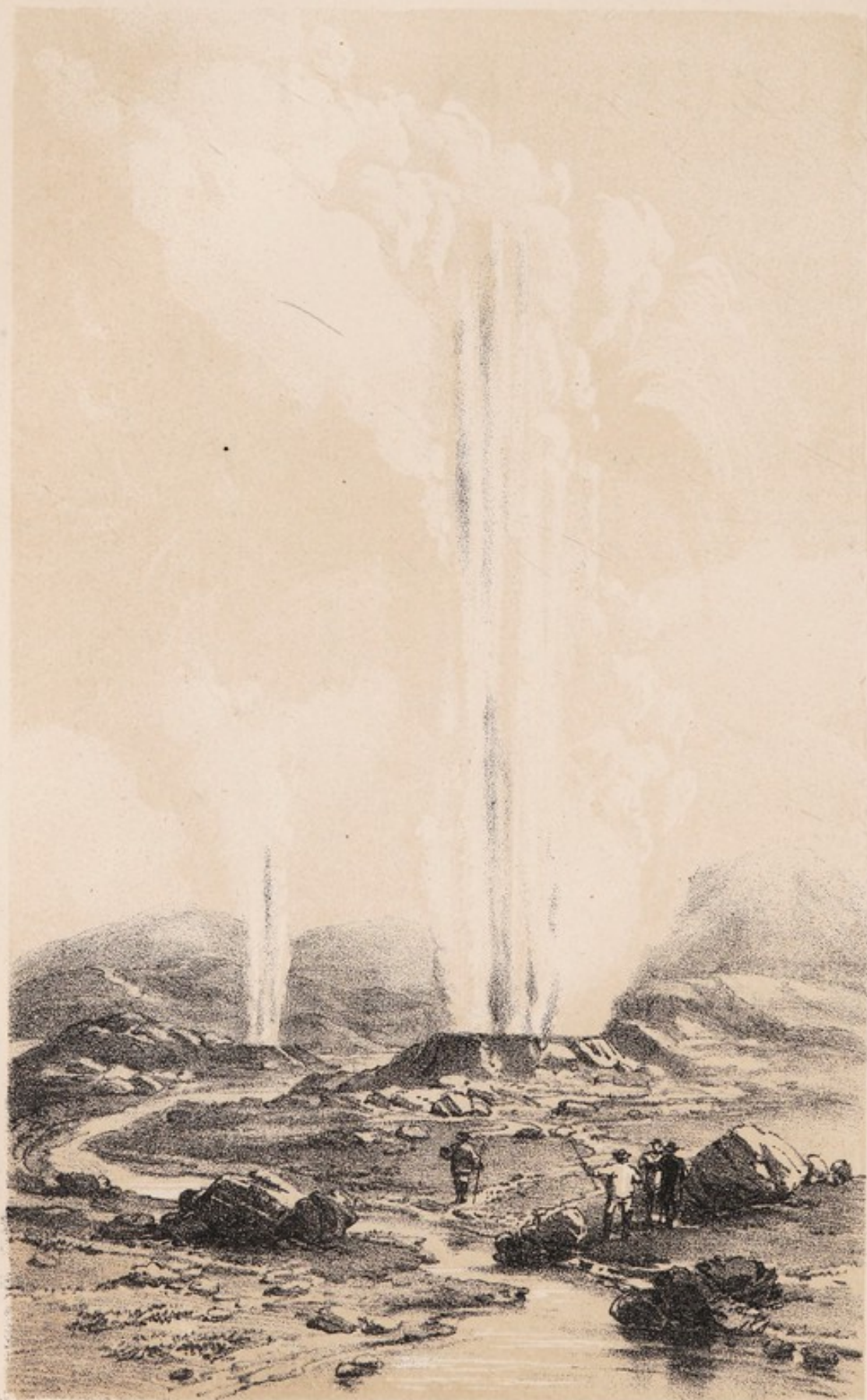
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THE GREAT GEYSIR.

SULPHUR IN ICELAND.

BY

C. CARTER BLAKE, DOCT. SCI.


HON. FOR. SEC. LOND. ANTH. SOC.

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"DAT LUCEM ET LATE CIRCUM LOCA SULFURE FUMANT."  
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LONDON:

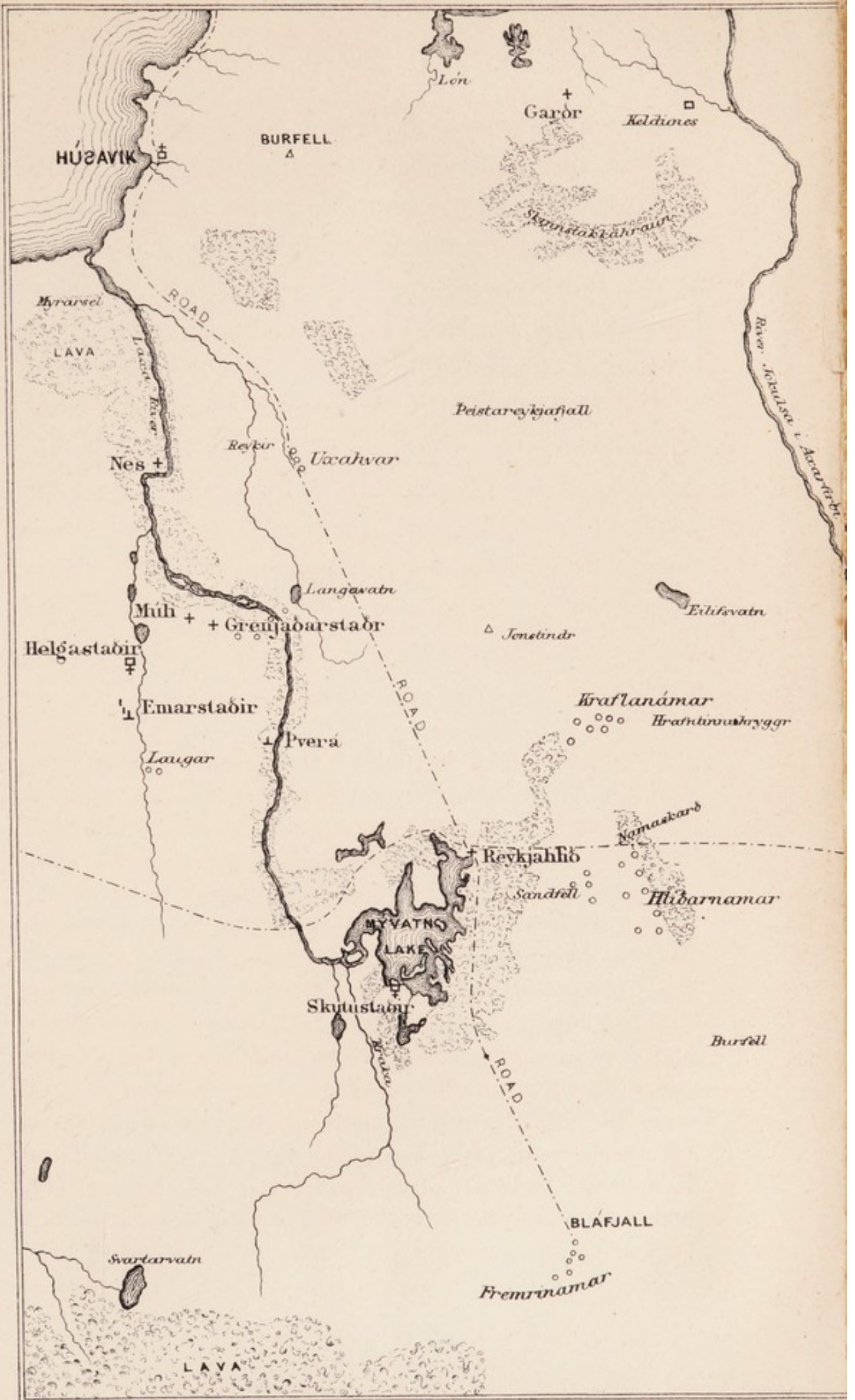
E. & F. N. SPON, 48, CHARING CROSS.

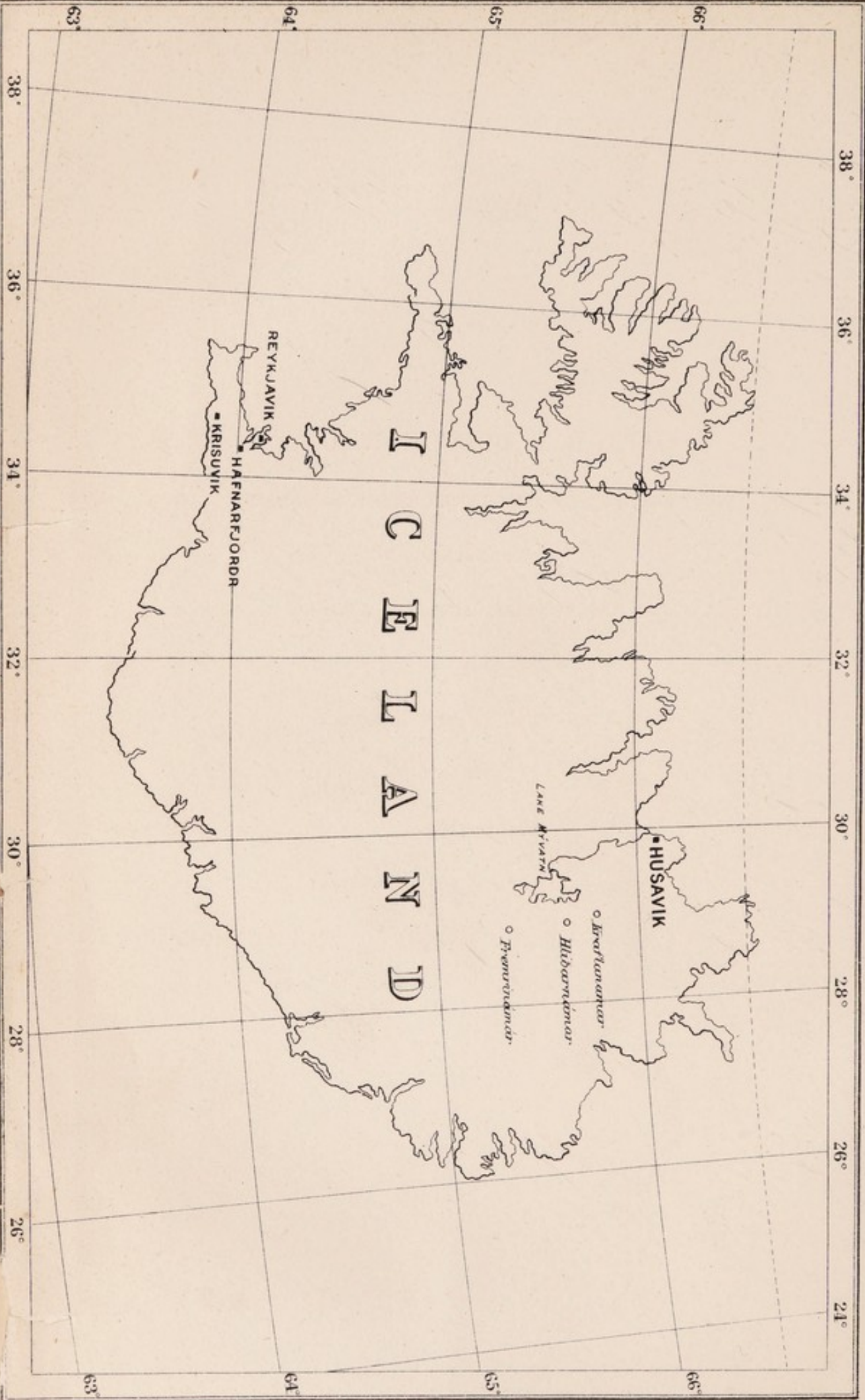
1874.



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ICELAND

REYKJAVIK
HAFNARFJÖRÐUR
KRISUVÍK

HUSAVÍK

LAKE MYVATN

○ Hlíðareykinn
○ Kvarnarnes
○ Þverofell

SULPHUR IN ICELAND

TO

CAPT. R. F. BURTON, F.R.G.S.,

VICE-PRESIDENT LONDON ANTHROPOLOGICAL SOCIETY,

A TRAVELLER

WHO HAS DESCRIBED ICELAND AS IT IS,

AND

HINTED WHAT IT MAY BECOME,

ARE

Dedicated

THESE PAGES, FROM HIS OLD FRIEND

THE AUTHOR.

STUDY IN THE HISTORY OF THE

UNITED STATES OF AMERICA

THE HISTORY OF THE UNITED STATES

OF AMERICA

AND THE HISTORY OF THE

UNITED STATES

OF AMERICA

OF AMERICA

OF AMERICA

OF AMERICA

OF AMERICA

SULPHUR IN ICELAND.

THE fact that sulphur, one of the most useful substances known, and, in the words of Mr. Crookes, "the mainstay of present industrial chemistry," has been an article of commerce throughout all time, and that a ready market has always existed for it, is familiar to all. Like the famous electrum of the ancients, its origin has been comparatively unknown. We shall briefly consider the conditions under which sulphur is found; its geographical distribution over the face of the globe; the methods of its preparation for the market, and the circumstances which may lead capitalists to seek for the productive mineral at a shorter distance from our own shores than the Mediterranean or Mexico.

Sulphur is a simple inflammable brittle substance, of which all the forms found native belong to the rhombic, or trimetric, system, and are more or less modified rhombic pyramids. These crystals could not be found at temperatures approaching that of boiling water, or be exposed to such a temperature without alteration; crystals of native sulphur must therefore have been formed at ordinary temperatures. Sulphur does not occur any-

where in sufficient quantity to constitute a rock, but is widely disseminated throughout rocks of different ages, either implanted in crystals, in small beds, nests, and nodules in a pulverulent condition, as a coating, as in some lavas, or as a cement of decomposed trachyte. Dr. Sullivan has said* :—

In volcanic regions the deposition of sulphur may result from two causes: 1st, the action of oxygen on damp sulphide of hydrogen gas, or on solutions of the gas; and 2nd, the mutual decomposition of sulphide of hydrogen, H_2S , and sulphurous anhydride, S_2O . If the former be in excess, water and sulphur appear to be formed; if the latter be in excess, pentathionic acid, $H_2S_5O_6$, and water are formed; the pentathionic acid is gradually decomposed into sulphur and sulphuric acid, which produce sulphates. In connection with this reaction, it may be observed that several sulphates are associated with the sulphur found in districts where the sulphur is formed from gases escaping through fissures. Old craters having such active fissures called fumaroles, are termed solfaterras."

So important an influence does the price of sulphur exercise upon the cost of production of bleached and printed cotton stuffs, soap, glass, and other valuable manufactures of this country,† that it was the express subject of a commercial treaty, and in 1838 the British Government took very decided steps to put an end to a monopoly attempted to be established in it by the Sicilian Government.

That the present supply of sulphur is inadequate

* Jukes and Geikie, 'Manual of Geology,' 3rd edition, p. 55.

† Liebig's 'Familiar Letters on Chemistry,' p. 152.

to the demand is proved by its high price, by the use of pyrites as a substitute, and by the inquiries recently made by the British Government as to its existence in Mexico. That the already large demand for this important substance must increase is quite evident when we consider the purposes to which it is applied.

Gunpowder.—Sulphur enters into the composition of this important article in proportions ranging from 10 to 20 per cent., according to whether the powder is required for war, sporting, or blasting purposes.* When we consider the vast quantity required by the gigantic armaments now maintained in every civilized country, as well as by the numerous mining and engineering operations at present in existence throughout the world (in which it is indispensable for blasting), we can form some idea of the immense amount of sulphur annually consumed in the manufacture of gunpowder alone.

Sulphuric Acid—so called because made from sulphur—one of the most important chemical agents required in the arts and manufactures, is used very extensively for making soda-ash for bleaching linen, woollens, &c., straw, &c.,† manure-making, and for a variety of chemical productions; also for refining metals.‡

* Ure's 'Dict.,' vol. ii., p. 432.

† Simmonds' 'Dictionary of Trade Products,' p. 367; Muspratt's 'Chemistry,' vol. i., p. 320.

‡ Liebig's 'Letters,' p. 149.

Soda-ash (alkali) is obtained from common salt by means of concentrated sulphuric acid. It is used instead of barilla for soap-making; as a substitute for pot and pearl ashes in glass-making; for cleaning and bleaching; and in the form of carbonate, for medicinal and domestic purposes. In the year 1862 the enormous quantity of from 100,000 to 120,000 tons of the former, and from 25,000 to 30,000 tons of the latter, was made in Great Britain alone.* That quantity has since vastly increased.†

Manures.—A great consumption of sulphuric acid has of late years taken place for agricultural purposes,‡ viz. in the preparation of superphosphate of lime, the most active manure for turnips, grass, and cereals.

Oidium.—Within the last few years it has been discovered that the use of sulphur in its purest form (flowers of sulphur) is a protection against the vine disease—*oidium*. Although no reliable information exists as to the exact quantity used for this purpose, yet it is known to be very considerable.

Flowers of sulphur have recently been strongly recommended as a remedy for the potato disease.§

Such are a few of the principal objects to which sulphur is devoted, and for which it is needed;

* Simmonds' 'Dictionary of Trade Products,' p. 351.

† See Exports for 1872.

‡ Liebig's 'Familiar Letters on Chemistry,' p. 150.

§ See Smee's 'My Garden.'

thereby proving most conclusively that THE CONSUMPTION IS ONLY LIMITED BY THE SUPPLY.

Sulphur is found in Corfu, the neighbourhood of Rome, Spain, the clear or borax lake in California, the slopes of the Popocatepetl, in the province of Puebla, Mexico, in Montana, N. America; and in the Japanese islands. Supply from these sources is practically impossible, and the whole supply of sulphur to Europe and America is derived from the Sicilian sulphur deposits, the imports of which into this country rose from 16,686 tons in 1842 to 58,204 tons in 1859,* and over 75,000 tons in 1862;† and in France, from 6668 tons in 1820 to 33,361 tons in 1855.

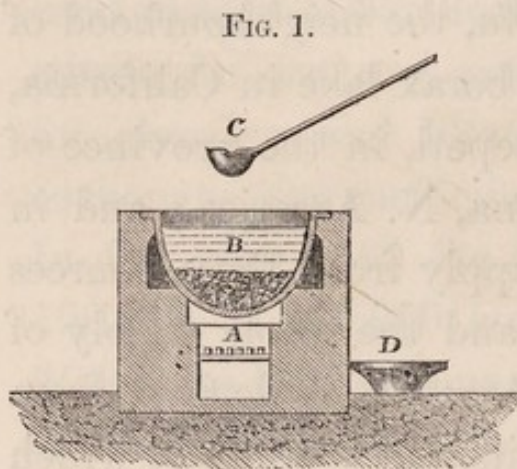
Sulphur is found either (A) in a pure native state, (B) as gas, or (C) in mechanical admixtures with clays or other earths. The method of extraction of sulphur when mechanically combined with foreign substances is thus described in Richardson and Watts' 'Chemical Technology,' vol. i., part iii., p. 314:—

“It has already been noticed that the deposits of sulphur are always associated with various mineral or earthy matters, and three processes are followed to separate the principal part of these impurities, which generally amount to more than one half of the entire weight of the deposit.

* Richardson and Watts' 'Chem. Tech.,' 2nd edition, 1863, vol. i., part iii., pp. 2 and 3.

† Simmonds' 'Dict. Trade Products,' 1863, art. "Sulphur."

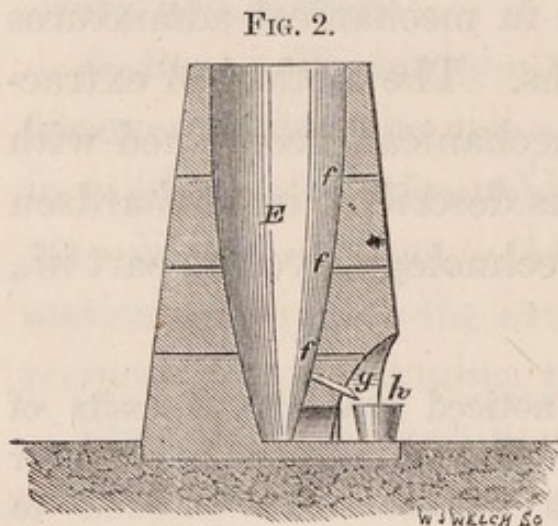
“When the deposit is rich in sulphur it is melted in a cast-iron pot B (Fig. 1), heated by an open fire A. The



melted mass is stirred with an iron rake to facilitate the separation of the earthy matters, which are allowed to fall to the bottom. The liquid sulphur is then removed by a ladle C, thrown into an iron vessel D, and allowed to solidify. The temperature ought to vary between 250° and 300°

Fahr., and never reach 480°, at which point the sulphur would take fire. The residue which remains, and contains more or less sulphur, is removed, and may be treated by either of the following plans:—

“A small blast furnace E (Fig. 2), constructed of fire-brick or stone, is charged with the sulphur stone at the bottom, which is ignited, and fresh charges of the sulphur stone are thrown in from time to time. The working holes *fff* at the sides admit a small supply of air to support combustion on the surface, by which

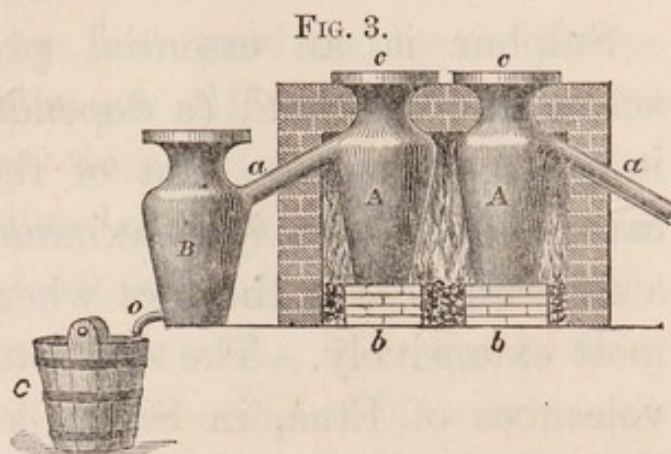


means sufficient heat is generated to melt the sulphur, which runs off at the bottom through a pipe *g* into an iron pot *h*, where it solidifies.

“The third plan is suitable for treating the impure sulphur stone, containing from eight to twelve per cent.

“The third plan is suitable for treating the impure sulphur stone, containing from eight to twelve per cent.

of sulphur. It consists of a furnace (Fig. 3) sufficiently wide to receive two rows of earthen pots A A—the vessels for distillation — which are arranged in pairs somewhat raised above the sole of the furnace, upon the supports *b b*, so that the necks of the pots are a little above the top of the fur-



nace. Thus the mouths of the pots are free, and having been charged from without, they are closed by the lids *c c*, cemented on, and the distillation begins. The sulphur vapours pass over by the lateral tubes *a a* to the receivers *B*, where they condense to liquid sulphur, which flows through *o* into a vessel *C* filled with water, and there solidifies.”

We have indicated the three conditions under which sulphur is found. The sulphur in a gaseous state in Iceland is now entirely lost, but with the adoption of the improved Mexican process an enormous saving would result; for besides the large and rapid deposit of the sulphur in and upon the ground, an immense quantity escapes in the sulphureous gas and vapour, and is lost. Now the whole of this may be obtained by condensing these vapours in clay vessels, which method is practised with great success in Mexico, where in certain places the sulphureous vapours escape from the soil, and could be only utilized in this manner.

The sulphur thus obtained is required at the Mint of the city of Mexico and at the assaying works.

Sulphur is an essential product of volcanic action: now Iceland (a dependency of Denmark) is *par excellence* the spot of the world where volcanic action is at its maximum, and Iceland, as a consequence, is the spot where sulphur is found most extensively. The districts round the active volcanoes of Etna, in Sicily, and Vesuvius, near Naples, supply the whole amount of sulphur now used. In seeking then for a new source of this commodity, we should naturally turn our attention to a volcanic district. And where in the whole world does there exist another country so pre-eminently volcanic as *Iceland*? Its fearful lava tracts, its vast plains of scoriæ and ashes, its numerous volcanoes belching forth smoke and flame, its pools of boiling water, its spouting geysers (see frontispiece), its vast caldrons of seething mud, proclaim its volcanic origin. It (Iceland) owes its upheaval entirely to volcanic agency, and is composed entirely of igneous rocks.

Almost while these pages are passing through the press, the volcanic force has broken out in Iceland, and Skaptar Jökull burst into eruption for four days in the month of January last.

The wildest theories have been uttered respecting the modes of origin of sulphur. An inquirer who investigated the southern Icelandic mines in

a superficial manner has thrown out a theory that the sulphur derived from Krísuvík, and other southern localities, has been produced by the action of water on the sulphurets of iron contained in the rocks. This theory, which rivalled some of the speculations of De Luc, was expressed by him in a paper read before the Society of Arts, on the 15th January, 1873. The theory was, that the hidden fires of Iceland dwell in the crust of the earth, and not in its interior; that the boiling springs and mud caldrons certainly do not derive their heat from the depths of our globe, but that the fire which nourishes them is to be found frequently at only a few feet below the surface, in fermenting matters which are deposited in certain strata! How far this theory is probable may be estimated when we glance at the converse hypothesis, which we must impress upon our readers. The lava at Myvatn is only a few feet, or at most, a few yards, thick; this is clearly shown by the fact that the gaseous vapour escapes from innumerable holes in the lava lying between the mines and the lake. The stoppage of an outlet for the upward flow of the gas has caused the outbreak of the fluid at spots far distant from the original central "crater" of the sulphur volcano. The geology of Mr. Vincent was decidedly vague.

That a great volcanic diagonal line evidently stretches from Cape Reykjanes to the lake of

Myvatn, is entirely a theory which is unproven by science, and which a glance at the map which shows the elevated hills of Lángjökull, Hofsjökull, and Vatnajökull, extending across this imaginary line, is sufficient to disprove. The relative elevations of the mountains, from Snaefell on the east, to Eyjafjallajökull on the west, seem to indicate that the central line of volcanic action has been along a line parallel with the south-south-east coast, and which has left the formations in the neighbourhood of Lake Myvatn, with the small volcanic chain of Sellandafjall, Bláfjall, Hvannfell, and Búrfell, entirely to the north. The abrupt escarpment of the greater chain lies along its south-eastern strike, and the fissures along which the parallel rivers from the Jökuldalur to the Hrótafjörðará flow are, according to a well-known geological law, produced on the less inclined slopes. Whilst Mr. Vincent's theoretical geology verges on the speculative, his assertion of known geographical facts is inexact.

In 1857, when the temporary cessation of war by England led the British Government to look for fresh sources of gunpowder supply for Europe, Captain J. E. Commerell, of H.M.S. 'Snake,' was sent to Iceland by the Lords Commissioners of the Admiralty to report upon the capabilities of the mines of Krísvík and Húsavík. He found the Krísvík mines, though comparatively close to

the sea, did not possess a safe port of debarkation nearer than Hafnarfjördr. An *ex parte* statement of the “objects, pleasures, and advantages” of the “truly eligible” Krísvík sulphur mines leaves itself open to severe criticism, and the opinion of Commander Commerell, that “the sulphur at Myvatn, though great in quantity, is at too great a distance from a port of embarkation to permit its extraction being carried on with any chance of competing with that from the Krísvík mines,” may be profitably contrasted with that of A. de Capel Crowe, Esq., H.B.M.’s Consul in Copenhagen.

His report to the Foreign Office is of such importance that we make no excuse for transcribing the whole passage at length.

“The right of working sulphur mines at Myvatn, in the northern portion of the island, has recently been conceded by the Danish Government to an Englishman, on a fifty years’ lease. They were worked some years ago for account of a Copenhagen house, but were abandoned in 1851, since which time they have remained closed. Many causes contributed to this result; the chief of which, doubtless, were ignorance of the proper method of gaining the sulphur, the cost of transport on horseback to the seaboard, and the want of remunerative demand.

“Since then these conditions have changed, and there exists no reason why these mines should not be worked profitably. They extend over a large tract of country, and their position is most advantageous, in the middle of a flat country, within an easy distance of Húsavík, a convenient shipping port; and during the many years they have been

closed the deposits must have very greatly accumulated, and should yield abundantly; indeed, so strong was this conviction in the minds of the natives, that they long opposed the leasing except on very onerous terms, although quite unable themselves to work them.

“ As these mines are now likely to remain in English hands for many years, a short account of their former history may be read with some interest.

“ They are situated between $65^{\circ} 20'$ north latitude and the Arctic Sea, or, more definitely speaking, lying in the tract between Myvatn (Midge Lake) on the east and Jökulsá (Glacier River) on the west.

“ *The right of working them was bought from PRIVATE owners by the Danish king Frederick the Second, in 1563, and this right has ever since been in the possession of the Danish Crown (now the State). During the reign of this king a considerable quantity of sulphur was extracted, amounting to AS MUCH AS 400 TONS ANNUALLY* Up to the beginning of the present century the Danish Government worked the mines for their own account, at times it appears with considerable profit, until 1806, when they were again leased to a foreigner; and subsequently have at times been worked by private speculators up to 1851, since which date, as already mentioned, they have remained untouched. The mines at Reykjaklidar-Námar are *the richest to be found in all Iceland, and produce large deposits of the purest sulphur.*

“ The reproduction is incessantly going on from upwards of a thousand small eminences called solfatarar, which are found on the ridge, along the sides, and at the foot of Námar-fjall. Rich sulphur deposits are also found at the Ketill crater (called Fremri-Námar), while the least rich are the Krabla-Námar; but at all these there is a continual deposition of sulphur going on. They all have the great advantage of lying in the track of one of the

few practicable roads in the island, leading to an accessible shipping port."

Consul Crowe's remarks as to the richness of these deposits are corroborated by Commander Commerell himself, who says in his Report:—

" I found at Námarsfiáll, which lies about six miles to the east of Lake Myvatn, large beds of sulphur in a very pure state; and though the quantities already deposited were very great, no signs appeared of their having been worked."

We shall give the testimony of a few of the more distinguished Icelandic travellers relating to the value of the Myvatn fields. But quotations are only made from authors whose scientific and literary position renders their opinion of value and authority.

The testimony of the Rev. Mr. Henderson, the celebrated missionary in Iceland, cites the following notorious and well-known facts:—

" To the east of Krabla the sulphur mines of Reykjahlid.*

" Of the sulphur mountains a particular description is given in the journal.†

" . . . Several huge dark mountains that are again relieved in the east by the Námars, or sulphur mountains, from the decomposition going forward, in which a vast profusion of smoke is constantly forming, ascending to a great height in the atmosphere.‡

* Henderson's 'Iceland,' 1818, Introduction, p. 4.

† Ibid., p. 7.

‡ Ibid., vol. i., p. 160.

“Olafsen and Povelsen, describing two pools on the south-east side of Krabla, say that the whole region completely answers to the well-known Solfatara in Italy.”*

Describing the neighbourhood of Myvatn he, in an eloquent description, says:—

“On either side lay vast beds of sulphur covered with a thin crust, containing innumerable small holes, through which the vapour was making its escape. In many parts the crust, which presented the most beautiful aluminous efflorescence, was not more than half an inch in thickness; and on its being removed, *a thick bed of pure sulphur appeared, through which the steam issued with a hissing noise.* The sublimation of the sulphur is produced by the constant ascension of this vapour; and it is found to possess greater and less degrees of purity, in proportion as the soil is more or less porous. In general, however, *these mines are VASTLY superior to any other in Iceland,* owing to the intense degree of subterranean heat, and the very loose and porous nature of the earth at this place.

“The sulphur mountain rises to a considerable height from the east side of the hollow in which these mines are situate. It does not exceed a mile in breadth, but is more than five miles in length, stretching from the east end of the lake in a northerly direction, between the volcanoes *Krabla* and *Leirhnukr*, where it joins the ridge by which these two mountains are connected. The surface is very uneven, consisting of immense banks of red bolus and sulphur, the crust of which is variegated with random mixtures of yellow, light-blue, and white colours, and in some places a soft sandstone makes its appearance through the predominant mould. I could also observe holes, out of which the sulphur has been dug by the peasants.

* Henderson's 'Iceland,' vol. i., p. 176.

“ The jetting is accompanied with a harsh roar, and the escape of a vast quantity of vapour strongly impregnated with sulphur. . . . Passing a desolate farm, and keeping at a distance from the sulphur banks, which appeared in the face of a contiguous mountain, we succeeded in reaching the base of Krabla. . . . On the northern margin rose a bank, consisting of red bolus and sulphur, from which, as the wind blew from the same quarter, we had a fine view of the whole. Nearly about the centre of the pool is the aperture whence the vast body of water, sulphur, and bluish-black bolus is thrown up, and which is equal in diameter to the column of water ejected by the *Great Geyser* at its strongest eruptions. . . . What was visible of Krabla appeared covered with the same clay, pumice, and sand as that on which I stood, only diversified by beds of yellow sulphur. . . . To the west of this wilderness lay a number of low mountains, where the *Fremri-Námar* are situated. Directly in front was the valley filled with lava above described; near the farther end of which the large columns of smoke ascending from the sulphur springs had a fine effect.”*

The Rev. S. Baring Gould, whose researches into Icelandic literature have been of such service to the philologist, gives the following description of the view from the slope above Reykjahlid, looking across the Lake Myvatn:—

“ You see the indigo chain of Blafell, beyond which is a *field of sulphur* and boiling mud called *Fremri-Námar*, not visited by travellers, as it is difficult of access, and inferior in interest to the *Námarfjall* springs. . . . (From *Námarfjall*) in half an hour we reach the sulphur mountains, a

* Henderson's 'Iceland,' 1818, vol. i., pp. 166, 167, 170, 171, 173, 174, 177.

chain of red hills, perfectly destitute of vegetation. We dip into a glen, and find it full of fumaroles, from which steam is puffing, and sulphur is being deposited. These run along the dale in a zig-zag. By the road-side I noticed a block of pure sulphur, from which every traveller breaks a piece, so that in time it will disappear altogether.

“ Passing through the Námarskarth, a winding cleft in the mountains, I came upon a plain of mud, the wash from the hills bounded by a lava-field; the mountains steaming to their very tops, and depositing sulphur, the primrose hue of which gives extraordinary brightness to the landscape. . . . Presently the beautiful Lake Myvatn, or Midge Lake, opened before us, studded with countless lava islets; beyond was the sulphur range, yellow as though the sun ever shone on it.” *

In Mr. Shepherd's work on the North-West Peninsula of Iceland, we find another lucid description :—

“ We rode to the sulphur mountains on the east of the lake (Myvatn). These large hills are a very wonderful sight. They are of various colours, a variety of mixtures of red and yellow. From their sides are emitted various jets of steam, and *masses of bright yellow sulphur* are strewed all around them. . . . All around the soil was very treacherous, consisting of hot mud, with a covering of sulphur about an inch in thickness, which in most cases was sufficiently strong to bear a man's weight. When the crust was broken steam issued forth, strongly impregnated with sulphur.” †

The distinguished Lord Dufferin (the present

* S. Baring Gould's 'Iceland,' 1863.

† Shepherd's 'North-West Peninsula of Iceland,' 1867, p. 157.

Governor-General of Canada) in his charming book, 'Letters from High Latitudes,' says:—

“Opal, calcedony, amethyst, malachite, obsidian, agate, and felspar are the principal minerals; OF SULPHUR THE SUPPLY IS INEXHAUSTIBLE.”

M'Culloch's 'Geographical Dictionary,' vol. i., p. 585, under the heading “Iceland,” says:—

“Few metals are met with. Iron and copper have been found, but the mines are not wrought. THE SUPPLY OF SULPHUR IS INEXHAUSTIBLE; large mountains are encrusted with this substance, which, when removed, is again formed in crystals by the agency of the hot steam from below. Large quantities were formerly shipped; but latterly the supplies sent to the foreign market were comparatively small.”

‘Chambers's Encyclopædia,’ under the heading “Iceland,” vol. v., p. 505, says:—

“The mineral wealth of Iceland has only begun to be developed. IN NO PART OF THE WORLD IS SULPHUR FOUND IN SUCH ABUNDANCE.”

An adequate idea of the value of the Icelandic sulphur fields, as compared with those of Italy, cannot be conveyed by the reports of travellers. To thoroughly comprehend this, we must bear in mind the reproductive properties displayed by solfataras, and the best means suggested by practice to extract the sulphur and yet not interfere with this peculiarity.

The process for the separation of the sulphur at the celebrated solfatara of Pozzuoli, near Naples, where the sulphur is condensed in considerable quantities, amongst the gravel collected in the circle which forms the interior of the crater, is conducted as follows:—The mixture of sulphur and gravel is dug up and submitted to distillation to extract the sulphur, and the gravel is returned to its original place, and in the course of about THIRTY *years* is again so rich in sulphur as to serve for the same process again.*

We thus see that the reproductive process occupies a period of THIRTY *years* in the Italian mines, whereas the same results are produced in THREE years in the Icelandic mines, i.e. that A GIVEN AREA IN ICELAND WILL PRODUCE TEN TIMES THE QUANTITY OF SULPHUR, OR IS TEN TIMES AS VALUABLE, AS THE SAME AREA IN ITALY.

“The permanency of the volcano, as a source of sulphur, would depend on the rapidity with which the sulphur would be replaced, after the sand had been once exhausted. The time required for this is not necessarily fixed to periods of twenty-five or thirty years. In Iceland, at a similar spot the sulphur is renewed every two or three years.” †

The nearest port suitable for shipment of the sulphur is “Húsavík,” situate in the Bay of Skjál-

* Ure's ‘Dict. of Arts, Manufactures, and Mines,’ 1860, vol. iii., p. 830.

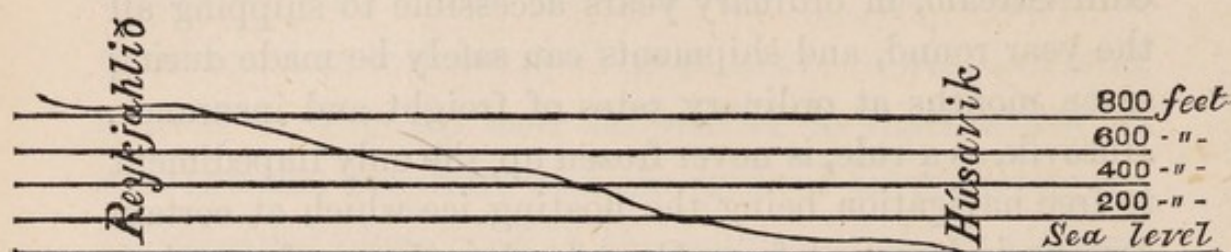
† Dr. F. J. Mouat's ‘Adventures and Researches among the Andaman Islands,’ 1863, p. 169.

fandi; it is perfectly accessible at all times of the year. Mr. Consul Crowe having been questioned on the subject, states* that:—

“The Icelandic ports are, owing to the influence of the Gulf Stream, in ordinary years accessible to shipping all the year round, and shipments can safely be made during seven months at ordinary rates of freight and insurance. Húsavík, as a rule, is never frozen up, the only impediment to free navigation being the floating ice which at certain seasons is loosened from Greenland, and may for a time lie off the coast. Such occurrences, however, have their stated times and seasons, which are well known to navigators in those waters; in some years there are no hindrances of the kind at all, and shipments in good vessels may be made all the year round. In support of this statement, I may mention the fact that steamers leave Copenhagen for Iceland as late as the middle or end of October, and would do so later were there sufficient goods or passengers to make them pay. Again, the Iceland ‘Althing’ have recently proposed to raise funds for running steamers round the island ‘*all the year,*’ and thus supply the want of internal communication, and, if the proposal fell through, it was only on financial grounds, and not from inaccessibility of ports from ice. I am therefore simply repeating facts in stating that as a rule Iceland navigation is free all the year round. *The island is but a two days’ journey from Scotland, and with suitable vessels an almost uninterrupted intercourse might, in ordinary seasons, be kept up.* In further confirmation of what I have stated, I may add that this same warm current from the Mexican Gulf, which is so beneficial to Iceland, keeps also all the Norway ports, from the Naze to the North Cape, ice-free all the year round.”

* Letter of A. de C. Crowe, Esq., 27th June, 1872.

The road from Reykjahlið to Húsavík, of which the following is a section copied from Gunnlangsson's large map of Iceland, is a gentle slope, having a gradient of 850 feet in about 40 miles.



It has been said by Prof. Paijkull that this road is one of seven or eight hours' journey.

“This road is one of the best in Iceland. The ‘heidi’ south of Húsavík is free from stones, and is level, although only sparsely overgrown with grass. Neither are there any hills or fjelds to be met with along it, and there are only a few small streams to be crossed. The last few miles north of Myvatn certainly consist of a sandy plain, but it is tolerably level, and the road is pretty good, owing, I suppose, to the sulphur traffic from the solfataras, near Myvatn, to Húsavík, in former days, in which 100 horses are said to have been employed at one time.”*

In 1868, the late foreign minister of the United States, Mr. W. H. Seward, one of the most far-sighted statesmen which that country has ever produced, was able to anticipate the future importance of the Iceland sulphur mines both to Europe and to America. It was even proposed that the United States' Government should purchase both Iceland

* ‘Paijkull,’ pp. 217, 244, 245, 246, 247.

and Greenland, as well as St. Thomas, from the Danish Government. To promote this object, Mr. B. M. Pierce was sent to Iceland to report on the mines. Extracts from his Report are subjoined:—

“The sulphur mountains, beds, and mines are very rich and extensive, easily worked, and of immense value. The sulphur is supplied at half the cost of that furnished by the Sicilian mines, which it is believed will soon be exhausted. *The possession of these mines as a part of our territory is a question of vital magnitude.*

“. . . . By the way of Reykjahlid and Krabla, where are the most extensive sulphur deposits of the island.

“There are two principal fields of sulphur in Iceland; one near Krabla and Reykjahlid in the north-eastern, the other at Krísuvík in the south-western corner. *The former is by far the most extensive region*, but the latter gives the purest product. Every traveller gives us a description, more or less minute, of these sulphur hills, and the beds of pure yellow, often a foot thick, which extend about them. Up to a few years ago the sulphur had only been explored in the rudest way by the natives. The industry thus carried on was almost insignificant in result, and was soon abandoned when the supply of surface material became scanty. Still the exportation of sulphur was enough during the days of the peasant mining to give the brightest hopes of what it would be under enlightened management and economy. One of the most interesting and remarkable facts connected with these mines is that a region apparently exhausted becomes re-sulphurized again, so that the stores of brimstone are PRACTICALLY AS INEXHAUSTIBLE as those of the infernal regions. Although the mines of Krísuvík are twenty miles from Hafnarfjodr, one of the best harbours in the island, and those of Krabla are farther still from the seaboard, and from the principal

trading station of Húsavík, it would appear that pure Icelandic sulphur is excessively cheap, half the price, say some, of Sicilian sulphur. *With improved means of transportation it would control the market.* The Oxonian, remarking on this, says (p. 138), 'like everything else in Iceland, the light is under a bushel.' Our most trustworthy information comes from Forbes, who, being an officer, sees the importance of the sulphur supply, and enters energetically into a thorough discussion on the prospects of the Iceland beds. We shall give the substance of what he says:—'The deposits are formed by the decomposition of the sulphurous fumes that burst up from the ground, and afterwards sublimated as solid sulphur. A part is mixed with clay; a part is almost pure sulphur, containing but 4 per cent. of gangue. The number and energy of these sulphur gases continually coming up is incredible. The sulphur-earth, or impregnated clay, averages from 6 ft. to 3 ft. in thickness, and contains 50 or 60 per cent. of pure sulphur.'

"Sulphur is found also at Námarsfjall, in the north of Iceland, in geological circumstances analogous to those of the beds at Krísuvík. It is found there generally in concrete masses of a citron-yellow colour, quite pure, sometimes very plentiful, and generally associated with lime and silica. It is to be regretted that the Danish Government does not favour this industry, which would furnish as fine sulphur as that of Sicily, and doubtless at a lower price. Besides, Denmark possesses in Iceland immense stores, which will one day be of great value to her when those of Sicily are exhausted. She ought never to grant the English the permission they have desired to work these mines, as has been done in Lapland in regard to the copper mines. So says the Frenchman, who sees the importance of the mines in time of war."

Before the concession was granted to Mr. Lock, Professor Johnstrüp was sent by the Danish Government to survey and make plans of the mines. His report is inserted at length.

“Referring to the consul’s request to me in date of the 27th of last month, I beg to inform him that on the journey which I made last year to Iceland I visited the sulphur mines belonging to the State there, which lie to the east of Myvatn, and I made maps of them, which were sent to the Minister of Justice, who will, no doubt, let you have copies of them. From these you will be able to see that the richest mines are to be found in that part called Reykjahlida-Námar, where large deposits of the purest sulphur are to be found.

“The reproduction is *incessantly* going on from about *a thousand small eminences (solfataras)*, which are found on the ridge, along the sides, and at the foot of Námarfjall.

“Further rich sulphur mines are to be found at the Kétill crater, called the Fremri-Námar, while the least rich mines are the so-called Krabla-Námar, but also at these there is a continual production of sulphur going on. The first-mentioned mines ARE THE RICHEST TO BE FOUND IN THE WHOLE OF ICELAND, and have the advantage of lying in the *track of a PRACTICABLE ROAD to the shipping port of HÚSAVÍK*, WHICH ROAD IS AMONG THE BEST IN THE ISLAND. As regards the position of the mines, I must refer you to Olsen and Gunnlangsson’s map of Iceland, on which they are marked. It will be a pleasure to me should these particulars be of service to you.

“(Signed) F. JOHNSTRÜP,

“*Prof. Mineralogy at the Copenhagen University.*

“April 30, 1872.”

The examination of these facts is quite enough to show the inquirer that the transit from Myvatn to Húsavík is more practical, and of more easy access, than that from Krísuvík to any of the ports at the south-west corner of the island, which have been extolled by Mr. Vincent in his *ex parte* glorification of the Krísuvík mines. We will now turn to the testimony of a far greater traveller, whose opinion on the subject ought, indeed, to be regarded as final. Captain R. F. Burton, in his recent exploration of Iceland, devoted much time to the examination of the Myvatn sulphur deposits. The great question is answered by him in the following letter which appeared in the London daily papers:—

“Sir,—Perhaps you will allow me, in continuation of my letter of October the 14th, to attack the subject of the sulphur deposits in Iceland now belonging to British subjects.

“For many years these diggings, so valuable since the exhaustion of the supply from Sicily, were a bone of contention between France and England. A certain M. Robert, geologist to the Gaimard Expedition, wrote in 1845—‘Aussi doit-il bien se garder de jamais accorder aux Anglais qui l’ont sollicitée la faculté d’exploiter ces soufrières comme on l’a fait en Laponie à l’égard des mines de cuivre.’ *En passant* I may remark that the same M. Robert quietly proposes to land a party of government sailors at Reydarfjördr, and to carry off the Iceland spar, which is private property. Let us hope that, under the enlightened rule of liberal governments, nations have in 1872 improved upon 1845.

“Denmark can hardly work the mines for herself without a great expenditure of capital, which will find its way into Icelandic pockets, and thus she wisely leases her property to strangers. She relies upon the fact that sulphur has risen from 4*l.* 10*s.* to 7*l.* per ton, and consequently that her Iceland diggings must become more valuable every year.

“I spent three days—from August 7th to August 9th, 1872—at the solfataras of Myvatn, or Midge Lake, situated to the north-east of the island. I lodged at the farm of Reykjahlid (Recky Ledge), under the roof of the well-known Hr. Pjetur Jonsson, whose alacrity in composing a bill of charges has won for him a wide reputation. He has a large family of young loafers, who recall to mind the Maori proverb, ‘Your people are such lazy rogues that if every dirt heap were a lizard no one would take the trouble to touch its tail and make it run away;’ so Hr. Pjetur Jonsson is compelled to plunder the passing stranger in order to fill the enormous gapes which characterize his happy home.

“On Wednesday, August 7th, I set out under the guidance of this worthy to inspect the diggings of Krabla, generally but erroneously written Krafla: *ad Krabla* in Icelandic means to scratch, and probably the obtuse national mind has instinctively connected a certain ailment with its recognized panacea. And now a verbatim extract from my diary will assure the reader that my statements are completely free from the process called ‘cooking.’

“Rode to Leirhnúkr (mud knoll) in 1 hour 15 minutes. At once understood an *emplacement* very imperfectly described by old travellers, whose topography is even weaker than their anthropology. It is the northern head of a spine, a sharp prism about one mile broad, with a magnetic direction of 215 deg., in fact nearly due north—south. It is a mass of palagonite (sea-sand forming a

stone), everywhere capped by spills and gushes of modern lava, and sulphur abounds at the junction of these formations. The hillock of *Leirhnúkr* is one vast mass of sulphurous deposits. I counted seven wells upon the slope, whilst the lowlands around were spotted with unwholesome looking eruptions. Rode east to Helvíti, which the Rev. Mr. Henderson described in 1815 as a crater not unworthy of its grim name. 'Hell,' here as elsewhere, has been 'dismissed with costs,' the placid blue lake, ruffled at times by the passing breeze and blowing off odours the reverse of Sabæan, is now hardly worth visiting. At Hrafninnuhryggr (Raven Stone Ridge)—excuse the word, I did not make it—expected to find, as the 'Obsidian Mountain' has been described, 'a heap of broken wine bottles shining with their jet-like colouring.' Found nothing of the kind, but picked up some decent specimens. Rode back much edified, &c., &c. . . .

"On the next day rode to the Fremri-Námar (outer warm springs) to the south with some easting to Reykjahlid. Found the road utterly dissimilar to anything laid down in maps. After 4 hours 30 minutes of rough travelling, reached the *deposit, which has been worked for some generations, but which cannot be said to have been EVEN SCRATCHED*. The 'lay' is upon the north-eastern, the eastern, and the southern flank of a crater described by the late Professor Paijkull, as 'probably the largest in Iceland.' *Immense deposits covered the ground, and white fumes everywhere filled the air. Whole torrents of what Mr. Crookes calls the 'mainstay of the present industrial chemistry'—I mean sulphur—have here been ejected.* Could not count the hissing 'hot coppers,' popularly called fumaroles. Returned after a stiff ride of 8 hours 30 minutes, which gave a fine view of the Ódáða hraun, the 'great and terrible wilderness' of lava to the south-west, &c.

"August 9th was a lazy day, spent in preparing for a

trip to the desert. Inspected the Hlidar-Námar (Ledge Springs), from which the farm of Reykjahlid takes its name. Bravely objected to be deterred by the 'smell of rotten eggs,' by the 'suffocating fumes,' and by the chance of being 'snatched from yawning abysses by the guide's stalwart arms.' These have been weighty considerations with some travellers: it reminds me of two Alpine men who, instead of crossing it, sat down and argued whether, as fathers of families, they were justified in attempting the snow bridge. Perhaps the conviction that the abyss nowhere exceeds three feet in depth may account for my exceptional calmness in such deadly peril. The Hlidar-Námar, or Ledge Springs, lie west of the sulphur mountain, and on a lower plane than the eastern deposits. They are bounded north by two lava streams issuing from the base of the Hlidarfjall, and south by independent outbreaks of lava, showing hosts of small detached craters. East is the hill, and west the Myvatn water, and its selvage of firestone. The area of this fragment of the grand solfatara may be one square mile. It is not pretty, except to the eye of the capitalist, this speckled field of yellow splotches, in dark red and chocolate-coloured bolus, fuming, puffing, and making the tender Icelandic flora look dingy as a S'a Leone mulatto.

"The spade deftly wielded threw up in many places pure flowers of sulphur. According to Dr. Augustus Vöelcker, this bright yellow matter gives 95·68 per cent., and according to the Icelandic traveller Olafsen, it is readily renewed. Below the golden colour usually is a white layer, soft, acid, and mixed with alum; it is calculated to yield 20 to 30 per cent. Under it again are the red, the dark purple, the chocolate, and other tints, produced either by molecular change in the mineral, or by oxygen which the sulphur no longer modifies. Here the material is heavy and viscid, clogging the spade, and the yield is

reported at 50 to 60 per cent. These figures will show the absolute value of the supply. Beneath, at short distances, say at 3 feet, lies the ground rock, invariably palagonite: thus 'falling in' merely means dirtying the boots. Between the yellow outcrops stretch gravelly tracts which the spade showed to be as rich as the more specious appearances. Many of the issues are alive, and the dead vents are easily resuscitated by shallow boring, in places even by pulling away the altered lava-blocks which cumber the surface.

"Leaving my horse in a patch of the wild oats that everywhere characterize this region, I walked up the sulphur mountain, whose white and yellow washings, so conspicuous from afar, prove to be sulphur, stones, and sand deposited by the rain upon the red clay. Here we picked up crystals of alum and lime and fragments of gypsum and selenite. The crests and box-shaped masses of palagonite and altered lava gave fine views of the lowlands. On the summit we found some small mud-springs, which Iceland travellers have agreed to call by the corrupted name 'Makkaluber' (Macaluba, i.e. el Maklúb, in Sicily); the people know them as 'Hvers.' This peculiarity is therefore not confined, as writers assert, to the eastern hill feet. The richest diggings lie below the crest, and here the fumes escape with a fizz and a mild growl, which vivid fancy has converted into a 'roar.' *I returned from the immense soufrière vastly edified with the spectacle of so much wealth lying dormant in these days of capital activized by labour, &c., &c. . . .*

"But, as a wandering Jew once said to me, in my green and salad days, 'gold may be bought too dear,' the question is not whether sulphur exists in Iceland, it is simply this: Will sulphur pay its transport?

"I reply unhesitatingly, Yes, if great care and moderate capital be expended upon the mines. In the first place,

the live vents which waste their sourness on the desert air must be walled round with stones, or better still with planks, and the fumes should be arrested, as in Mexico, by pans and other contrivances. The working season would be the summer, AND THE QUANTITY IS SO GREAT THAT MANY SUMMERS MUST ELAPSE BEFORE THE THOUSANDS OF TONS WHICH COMPOSE EACH SEPARATE PATCH CAN BE CLEARED OFF. In winter the produce can be sent down to Húsavík (House's Bay), by sledges, not the Esquimaux-like affair at present used in Eastern Iceland, but the best Norwegian or Canadian. The road is reported by all travellers to be exceptionally good, running for the most part over gently undulating heaths, overlying basalt. There are no rivers of importance on the way, and the fall is about 1500 feet in 45 English statute miles. The line is wrongly placed in Gunnlangsson's map: it runs on the eastern, not the western shore of the Langavatn, and it passes to the east of the celebrated Uxahver. I am also assured that the much-abused Bay of Húsavík is a safe harbour when proper moorings are laid down, that no vessel has been lost there during the last thirty years, and that Capt. Thrupp, of H.M.S. *Valorous*, judged favourably of it. This also was the verdict of an old Danish skipper, who assured us that during the last twenty-five years he has been trading between Copenhagen, Hull, and Húsavík, reaching the latter place about the end of February, and making his last voyage home in October. During the 'balance' of the year masses of floe-ice prevent navigation.

“ From such a speculation present returns may be expected. When income justifies the outlay a tramway would greatly cheapen transit. The ships which export the sulphur can import coal, and now that the officinal treatment of sulphur has been so much simplified by the abolition of train-oil, nothing else except pressed hay for

the cattle is wanted. When one patch is exhausted the road can be pushed forward to another. I am persuaded that the *whole range, wherever palagonite and lava meet, will be found to yield more or less sulphur*. Of course it will be advisable to purchase sundry of the farms, and these in Iceland range in value from 300*l.* to 800*l.* maximum. The vast waste lands to the east will carry sheep sufficient for any number of hands, and good storehouses will enable the Englishman to weather a winter at which the Icelander in his wretched shanty of peat and boarding looks with apprehension. I have already spoken about the excellence of the summer climate, and any gazetteer shows that the change of temperature at Montreal is more to be feared than in Iceland.

“ The sulphur trade will prove the most legitimate that the island can expect to maintain. An exploitation of *these deposits, which will probably last as long as those of Sicily have done*, will be a source of wealth to a poor and struggling country, free from the inconveniences of the pony export and from the dangers of sheep and cattle traffic: and the foreigner may expect to enrich not only the native but also himself, as long at least as he works with due economy, and avoids the errors which, in Brazil and elsewhere, have justified the old Spanish proverb, ‘ a silver mine brings wretchedness, a gold mine ruin.’ ”

“ I am, &c.,

“ *Athenæum*,

“ *October 16th, 1872.* ”

“ RICHARD F. BURTON.

The very language of Iceland seems to indicate the importance of its sulphur deposit. It is a significant fact that the Icelandic language indicates sulphur as the “ burning stone ” *brennisteinr*, unlike the Danish *svovel*, which is obviously derived

from *sulphur*, Lat. So a sulphur mine is called *brennisteinrnàmar* in Icelandic, but in Danish *svovelgrubr*.

Mr. Vincent's theory, that sulphur is produced by the action of water on pyrites, though having some elements of probability in it, is nevertheless entirely unproven in the present state of science, and it is most unfortunate that throughout his paper theory and fact are mingled in equal proportions, each being independent of the other. "*Tant pis pour les faits.*"

It was left for Captain Burton to point out that the testimony of Commander Commerell, which appears in Mr. Vincent's paper to make the transit from Krísuvík to Hafnarfjorðr a real path of roses, did not actually speak with such unqualified enthusiasm. Commander Commerell says—

"A tramway might also be laid down, but as there are two hills to cross, with other difficulties, I could not positively state whether this were possible or not."

Another objection by Captain Burton appears to be of greater force. It is alleged that the Krísuvík deposits extend over an area of twenty-five miles. No precise geological map is given of the locality, and it is most significant that when Captain Burton and Mr. Chapman rode from Krisas Bay eastward to the Little Geyser, and although they looked anxiously for the enormous area theoretically as-

signed to the sulphur formation, they failed to see any sign of it. The sulphur, like the Spanish fleet, was not in sight, and the absence of the palagonite, which is invariably in other Icelandic localities found in juxtaposition with the sulphur, ought to hint to geologists the true state of the case. Captain Burton goes on to say:—

“All these, however, are minor objections to Mr. Vincent’s paper. But when speaking of, or rather alluding to, Mr. Lock’s concession, he is unpardonably wrong. If he has studied the subject, he simply misrepresents it; if *not*, he should have avoided all depreciatory notice of the Myvatn mines. I read (p. 137)* with unpleasant surprise, ‘a violent eruption of the mud-volcano Krabla to a great extent buried the then active strata beneath enormous masses of volcanic mud and ashes, so that the energy has been probably transferred along the line,’ viz. the great volcanic diagonal stretching, or supposed to stretch, from Cape Reykjanes to the Myvatn Lake southwards, that is to say, to Krísuvík.

“Without dwelling upon the fact that Mr. Vincent’s theory about the local production of sulphur renders such ‘transfer of energy’ impossible, I remark that, firstly, the Hlidarnámar, the nearest deposits of the Myvatn sulphur, are at least two miles removed from the extremest influence of Krabla, whilst the Fremrinámar are four times that distance, and are situated upon a much higher plane. Did the volcanic mud, then, flow uphill? As for the ashes, neither you nor I, nor ‘any other man,’ saw, or could see a trace of them. To those who have breathed the live sulphur, tainting the air for mile after mile, this ‘transfer of energy’ becomes a mere matter of fancy, and I regret

* ‘Society of Arts Journal,’ Jan. 17th, 1873.

that a man of science should commit himself to such a statement. Secondly, on the very flank of Krabla the hollow called Hell (Helvíti) shows an abundance of sulphur, which extends right across the valley westward to Leirhnukr (Mud Knoll). In this small part of Mr. Lock's concession Gunnlangsson shows no less than seven Hverar (boiling springs) lying close together. I need hardly pursue this part of the subject: to me, who have seen the country, the assertion that any eruption from Krabla has affected either the Hlidar or the Fremri diggings appears inconceivable. Suffice it to say, that Mr. Lock's SIX SQUARE MILES OF LIVE SULPHUR contrast wonderfully well with the two at the south-western end of the island. Krabla alone contains as many solfataras, boiling springs, and makkalubers (mud caldrons), as exist in the whole district of Krísvík, and Krabla is only a part, a very small part, also, of the north-eastern deposits.

“Again, I see with astonishment (p. 143)* that ‘the sulphur at Myvatn, though great in quantity, is at too great a distance from the port of embarkation to permit its extraction being carried on with any chance of competing with that from the Krísvík mines.’

“It is true that Mr. Lock's concession lies some twenty-five direct geographical miles from Húsavík, the nearest available port, while those of Krísvík are only ten distant from Hafnarfjörður. A simple statement of the kind is fallacious; it conveys the wrong impression. It is known to every Icelander that *the northern line is one of the BEST, the southern one of the WORST, if not THE WORST, in the island.* The Húsavík road has the immense advantage of an easy and regular slope from 800 feet high to sea-level, and thus, in the depth of a protracted winter, sledges can always carry down the material dug up during the long summer days. There is nothing to prevent the construc-

* Society of Arts Journal, Jan. 17th, 1873.

tion of a tramway, when such expensive article becomes advisable.”

These considerations, which have been so well urged by Captain Burton, are sufficient amply to demonstrate that there exists at Myvatn an enormous supply of sulphur for the use of the European colonist.

The Danish Government were not slow to perceive this, and have on numerous occasions endeavoured to attract attention to the value of their mineral products. Mr. Lock, an Englishman, some years ago petitioned the Danish Government, and expressed his wish to take a lease of the sulphur mines at Myvatn. A committee was elected by the Icelandic Althing to report upon this subject. This report, which is dated the 14th August, 1869, exhibits the utmost timidity in permitting an alien to acquire rights over the mineral products of Iceland.

It is argued,

“That the inhabitants will not be able to benefit by this if the mines are made over to strangers, neither can it be controlled that they should not destroy the mines altogether, and render them completely useless, after a lapse of some years.

“The sulphur mining at Krísuvík has shown that these mines are better and richer than had been expected, and this may be the case, too, with the mines on the north, which have most frequently been deemed richer and more extensive than those of Krísuvík.”

It will not here be necessary to narrate the circumstances under which the Danish Government declined to adopt the recommendation of the local "Home Rule" organization. It will suffice to say that on the 13th April, 1872, a contract was signed between Alfred G. Lock, of London, and the Danish Minister of Justice, Andreas Frederik Krieger, on the part of the Danish Government. This contract will be found in full in the Appendix. The lease lasts for fifty years, and the terms, although costly to the English concessionaire, were satisfactory to the Danish Government. The greatest possible irritation has consequently been produced among a very small section of "Home Rule" Icelanders, who objected to the working of the mines by a stranger. The matter, however, being entirely taken out of their hands, their criticism on the arrangement becomes a mere historical question.

A fuller description of Mr. Lock's property will be of interest to the English inquirer, as it shows to what an extent capital may be productively invested.

Description of the Property.

The property comprises the Solfataras, or sulphur springs, the sulphur banks or fields, and the sulphur quarries belonging to the State of Denmark, and situated in the Things Syssel in the North and East Provinces of Iceland.

The sources of sulphur in this property are threefold:—

1st. The *solfataras*, or sulphur springs.

2nd. The *sulphur banks*, or fields.

3rd. The *sulphur quarries*.

The Solfataras.—Sulphur is formed by certain gases generated underground by volcanic action, and in solfataras these gases find their way to the surface of the earth through sand, ashes, or other volcanic substances, and in their passage sublime and deposit a certain portion of their sulphur, a certain amount escaping into the air.

This formation of sulphur is continuous and increasing, and in proportion to the strength of the volcanic influences so is the rapidity with which the sulphur is formed and the amount taken from the solfatara replaced. For this reason they are called “living.”

The solfataras of Italy require a period of twenty-five or thirty years to renew the sulphur in sufficient quantities to pay for extraction, whilst these are said to require only three years to produce the same result, the same area of solfataras in Iceland being consequently ten times as valuable as an equal area in Italy.

The methods of extracting the sulphur from these are most inexpensive, and the plant required of the simplest description.

The gases at present escaping into the air can be condensed, and the sulphur obtained in a pure crystallized state, without any expenses for refining, by collecting the gases in clay vessels.

2nd. *The sulphur banks, or fields.*—The gases before mentioned escaping into the air condense and deposit sulphur, which, were the atmosphere always calm, would be precipitated in regular banks, but owing to the constant shifting of the wind it is blown in all directions, forming layers varying from a few inches to several feet in thickness, and extending over vast areas of the surface of the surrounding ground.

3rd. *Sulphur Quarries.*—In these localities the accumulation of sulphur has ceased, and when once extracted is not replaced; they are therefore called “dead.” The sulphur is found imbedded in, and mixed with, lime, clay, &c., and nearly all the sulphur exported from Sicily is obtained from this description of sulphur-bearing strata.

The same kind of strata exists in the Romagna in Italy, and in some districts of Spain, but in the Romagna the deposit is 390 feet below the surface, and only yields, in the furnaces, 15 per cent. of sulphur, while the best of those in Spain are from forty to sixty feet below the surface, and contain a varying quantity of sulphur of from 21 to 36 per cent.—the poorest strata being nearest the surface

—whilst these (in Iceland) are upon the surface; and Henderson, the missionary, a most trustworthy authority, describes a valley one mile wide and five miles long in the neighbourhood of Krabla, the surface of which is very uneven, and consists of immense banks of red bolus and sulphur, with mixtures of yellow, light-blue, and white coloured earth.

Forbes found similar clays to contain, the white from 30 to 40 per cent., and the red and blue clays about 16 per cent. of sulphur.

The map (No. 1) shows the relative position of the mines to the port of exportation, Húsavík, copied from Gunnlangsson's large four-sheet map of Iceland. The plans made by J. F. Johnstrup, Professor of Mineralogy at the University of Copenhagen, by order of the Danish Government, and attached to the leasing contract, show the solfataras, or living sulphur fields, to extend over a district of more than SIX SQUARE MILES, viz. :—

	Acres.	Sq. miles.	Acres.
No. 2. Krabla-námar	about 1998	= 3	78
No. 3. Reykjahlid-námar	„ 1068	= 1½	108
No. 4. Fremri-námar	„ 808	= 1¼	8

As a gauge of the value of the Icelandic sulphur fields we have been describing, it would be well to compare them with those of other countries. To

arrive at this result, we shall give a comparison of the estimated cost of Sicilian and Spanish sulphur, and contrast it with that derived from Iceland.

COST OF THE SICILIAN AND SPANISH SULPHUR COMPARED WITH THAT OF THE ICELANDIC.

Cost of Sicilian sulphur, according to Signor Pawdi's Report to the Italian Government, vouched by English engineers, viz. :—

	Per ton of sulphur.	
	Fr.	c.
Excavation of mineral	13	0
Oil and tools	5	0
Extraction of mineral	16	5
Pumping	10	0
Fusion	5	5
General charges and taxes ..	11	0
Carriage from mines to port ..	20	0
Rent to proprietor of soil.. ..	15	0
	<hr/>	
	96	0 = £3 16 10
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To England.

	£	s.	d.
Freight	1	0	0
Export duty	0	8	0
Port charges, commission, &c.	0	4	6
Insurance, brokerage, &c. ..	0	8	0
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Cost of Sicilian sulphur, per ton ..	£5	17	4
	<hr/>		

“ *Estimated cost of Spanish sulphur*, from a Report by Mr. J. Sopwith to the Hellin Sulphur Company:”—

The first tin contains 21 per cent. of sulphur.

„ second „ 36 „ „
 „ third „ 28 „ „

It takes 6 tons of Spanish ore to make 1 ton of sulphur.

	Per ton of sulphur.		
	£	s.	d.
Cost	2	13	0
Carriage to railway station	0	2	4
Railway carriage to Cartagena	0	6	6
Loading, &c.	0	4	6
Freight from Cartagena to England..	0	14	0
Royalty to Government	0	2	8
Insurance	0	8	0
<i>Estimated cost of Spanish sulphur</i> ..	£4	11	0

“ This sulphur should be worth, either in England or Marseilles, from 6*l.* to 7*l.* per ton.

“ Flowers of sulphur would cost 6*l.* per ton, and their value would be 10*l.*”

Estimated Cost of Icelandic Sulphur.

The deposits of the sulphur-producing clay, sand, ashes, &c., in Iceland, lie on the surface, and will only need *digging*, whereas those of Sicily are at a depth of from 40 to 60 feet below, and require *mining*; the item for excavation will therefore be unnecessary.

With regard to the items for extraction and

fusion, as there exists no proof of their cost from actual experience in Iceland, it has been thought advisable to be on the safe side by taking them to be in each case the same; but the comparatively short distance of the Iceland mines from the coal-fields of Scotland should very greatly reduce the expenditure on these heads. If the vast masses of brown coal (*Surturbrande*) known to exist in the vicinity of the port Húsavík, were utilized, these items would be still further decreased.

The estimated cost would then be:—

	Per ton.		
	£	s.	d.
Oil and tools	0	4	2
Extraction of mineral	0	13	9
Fusion	0	4	7
*Carriage to port	0	15	0
Freight and insurance to England ..	0	15	0
	<hr/>		
	£2	12	6

To cover all contingencies say 3*l.* per ton.

	Per ton.		
	£	s.	d.
Cost of Sicilian sulphur	5	17	4
Estimated cost of Icelandic sulphur	3	0	0
	<hr/>		
Profit in favour of Iceland ..	£2	17	4

	Per ton.		
	£	s.	d.
Estimated cost Spanish sulphur ..	4	11	0
„ „ Icelandic „ ..	3	0	0
	<hr/>		
Profit in favour of Iceland.. ..	£1	11	0

* This is an extravagant figure, and could only be justified until the completion of a tramway.

Estimated Profit on Icelandic Sulphur.

The market price of sulphur ranges from about 6*l.* 5*s.* per ton for third quality to 8*l.* for best. As by far the greater part of the Icelandic sulphur would be best quality, its average market price may be safely put at 7*l.* per ton:—

Market price	£	s.	d.
		7	0	0
Estimated cost price	3	0	0
		<hr/>		
<i>Estimated profit, per ton</i>	£4	0	0
		<hr/>		

Estimated Profit per Annum.

Italy, in the year 1870, exported 52,546 tons. From the comparison between the relative formations, there is every reason to believe that as large a quantity can be exported from Iceland as from Italy; but, supposing that for the first year or two only one-third that quantity is exported, viz. 17,515 tons, at a profit of 4*l.* per ton, the annual profit would amount to over 70,000*l.*

Copy of Analyses of Samples of Sulphur from these Mines.

1st. By Messrs. Huson and Arrott, of Liverpool.

Sample No. 1 contains 98·00 per cent. of sulphur.

„ No. 2 „ 90·90 „ „

2nd. By Dr. Augustus Vöelcker, of London.

Sample contains 95·68 per cent. of sulphur.

APPENDIX.

—♦—
(*Translation.*)

LEASING CONTRACT.

The undersigned, Andreas Frederik Krieger, His Majesty the King of Denmark's Minister of Justice, Commander of the Danebrog and Danebrogsman, Commander of the Order of the North Star, in virtue of the authority given him by a Royal Resolution of the 9th March, 1812, hereby grants to Alfred G. Lock, of London, a lease of the sulphur mines belonging to the State, situated in the Things Syssel in the North and East Provinces of Iceland, on the following conditions.

I.

Exclusive right to work the above-mentioned mines is given to the lessee for the duration of the lease; they consist of the so-called Reykjahlidar, Krabla and Fremri-Námar; on the other hand, the present contract gives the lessee no right to the use of, or to the possession of the land around the mines, which ground does not belong to the State. It must be remarked that the mines on the church lands at Theistareykir are not included in this leasing.

II.

The lease is given for fifty years, reckoned from the 1st September, 1872, to the 31st August, 1922, without either of the contracting parties having the right to withdraw from it. Liberty, however, is conceded to Alfred G. Lock

to withdraw from the contract at any time before the 31st August this year, date inclusive.

The lessee can make over his rights acquired by this present contract, together with his obligations, to other parties, against whose respectability and solvency no reasonable objection can be made, but he shall nevertheless be bound to communicate such transfer to the Ministry of Justice. His rights likewise shall at his death be transmitted to his heirs.

III.

Full liberty is given to the lessee as regards the working of the mines. The sulphur, however, must not be washed in running waters which have their outlet in the sea, nor in fishing-waters, and as a matter of course the sulphur beds or mines must not be destroyed, with respect to which it is remarked that the earth during the diggings must not be trodden down into the warm beds, which are designated by a green colour in the maps attached to the contract, which in the year 1871 were made by J. F. Johnstrup, Professor of Mineralogy at the Copenhagen University.

On the delivering over of the mines a survey will take place, at which the maps in question will be used as guides. On the delivering back of the mines a survey shall likewise take place.

IV.

Neither the lessee nor the workmen he employs at the mines shall be subject to any extraordinary taxes or imposts by the State or the municipality, other than those imposed on the other inhabitants of the island; and he shall in this respect enjoy the same rights as natives; but on the other hand, he shall not be exempted from the ordinary taxes and charges imposed by the general laws of the land.

V.

The lessee shall be bound to allow the State authorities to inspect the mines whenever they may think fit to do so.

VI.

The lessee shall pay an annual rental of 50*l.* for the first year; 60*l.* for the second year; 70*l.* for the third year; 80*l.* for the fourth year, 90*l.* for the fifth year; and 100*l.* for the sixth and for each of the succeeding 44 years.

The rental shall be paid *in advance* to the Minister of Justice in Copenhagen in two half-yearly payments,—viz.: on the 1st September and 1st March, each time with the half part of the yearly amount. The first time on the 1st September, 1872, with 25*l.*: for the half year from that day to the 28th February, 1873.

The lessee shall, on the signing of this present contract, as security for the due payment of the rental and the proper working and re-delivery of the mines in an uninjured condition, deposit a sum of 5000 rix-dollars in the private bank of Copenhagen, in such manner that the Minister of Justice retains the certificate of deposit in his possession, and can, without trial or sentence, and without the lessee's authority, take them out of the private bank, which institution shall be forbidden to return them to the lessee or others without the Justice Minister's permission.

As long as the above-mentioned amount is deposited in the private bank the interest of the sum may, without let or hindrance from the Minister of Justice, be paid to the lessee or his representatives.

On the expiry of this leasing contract and the re-delivery of the sulphur mines in an uninjured state, the Minister of Justice shall be bound to return the certificate of deposit to the lessee or other duly authorized persons.

VII.

Should the rental not be paid at the proper times, and should the lessee destroy the mines, he (the lessee) shall lose the rights conceded to him by this contract, and the Minister of Justice shall in such case be empowered to take from him the lease (eject him from the mines), and the deposit money be forfeited to the Iceland Land Fund (State Fund). Should, however, a breach of contract take place only through omission to pay the rental, and the collective amounts of the rentals still to be paid be less than the deposit, the Minister of Justice will refund the difference.

VIII.

Should the lessee not have removed, within two years from the expiry of this contract, or from the date of its annulment (see § 7), all buildings, machinery, and the like put up at the mines, they shall become the property of the State without indemnity.

IX.

Disputes arising as to whether the lessee's treatment of the mines is destructive to them, shall be settled by arbitration, each of the contracting parties choosing one man, and these latter in case of disagreement to choose an umpire. If from any cause an arbitration cannot be obtained, the parties at issue are empowered to appeal to the law courts; as likewise in all other disputes arising out of this contract, in which cases the Royal Supreme Court of Copenhagen shall be the proper tribunal; for which reason the lessee, on signing this contract, shall appoint a Copenhagen resident, who on his behalf shall receive summonses for his appearance. Should the Minister of Justice think fit to

take law proceedings against him in Iceland he (the lessee) shall be bound to receive summonses at the sulphur mines for his appearance at the Iceland courts.

X.

The expense of drawing up this contract, with the stamped paper and registration, as well as the expense of surveys on the delivering over and the delivery back of the mines mentioned in this contract, shall be borne by the lessee.

The contract shall be drawn up in duplicate, of which the one copy is held by the Minister of Justice and the other by Mr. A. G. Lock.

On the above conditions I, Alfred G. Lock, of London, have signed the present contract.

Copenhagen, 13th April, 1872.

(Signed) KRIEGER.

(Signed) { For Alfred G. Lock,
A. DE C. CROWE.

Witnesses—

(Signed) RICARD.

(„) POULSEN.

The value of the stamp on this contract is calculated at 9 rigsd. to the pound sterling.

who has proceeded against him in Iceland in (the
cases) shall be bound to receive him at the subject
of his application in Icelandic courts.

The Government of Iceland shall be bound to receive
him at the subject of his application in Icelandic courts.

The Government of Iceland shall be bound to receive
him at the subject of his application in Icelandic courts.

The Government of Iceland shall be bound to receive
him at the subject of his application in Icelandic courts.

On the above conditions I Albert G. Jack of London
do hereby certify that the above is a true and correct
copy of the original of the said instrument.

(Signed) Albert G. Jack
(Signed) A. de G. Crowe

The Government of Iceland shall be bound to receive
him at the subject of his application in Icelandic courts.

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him at the subject of his application in Icelandic courts.

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