VOLCANIC STUDIES

BY TEMPEST ANDERSON

Sir Joshua G. Fitch
from the author

Jan. 1903.

P8

VOLCANIC STUDIES

VOLCANIC STUDIES

IN MANY LANDS

BEING REPRODUCTIONS OF PHOTOGRAPHS BY THE AUTHOR OF ABOVE ONE HUNDRED ACTUAL OBJECTS, WITH EXPLANATORY NOTICES

By TEMPEST ANDERSON

M.D., B.SC. LOND., F.G.S., F.R.G.S., A.C., FELLOW OF UNIVERSITY COLLEGE LONDON, HON. SECRETARY, YORKSHIRE PHILOSOPHICAL SOCIETY

LONDON
JOHN MURRAY, ALBEMARLE STREET
1903

DEDICATION

To those of my friends who, by their encouragement, advice, and in some cases active critical assistance, have materially helped to bring my work to a termination, I cordially dedicate this book.

TEMPEST ANDERSON.

PREFACE

VERY few branches of Science still remain available for the amateur of limited leisure.

Electricity, Chemistry, Bacteriology, most branches of Geology and Mineralogy, have all led to results of the highest economic value, and they are cultivated by a large body of professional men subsidised by Colleges or by the Government.

They are in a position to give their whole time to their work, and their results are so voluminous that to keep abreast of the literature of any single branch would occupy more than the entire available leisure of most men, yet this is a necessary preliminary to any attempt at original work.

I was consequently led to seek some branch of Science which gave no prospect of pecuniary return, and I determined on Vulcanology, which had the additional advantage of offering exercise in the open air, and in districts often remote and picturesque.

For the last eighteen years I have spent the greater part of my holidays in exploring volcanic regions, including Vesuvius (twice), Etna, the Lipari Islands, Auvergne (several times), the Eifel (repeatedly), the Canary Islands, Iceland (two long visits), and various British extinct volcanoes now and again, in 1900, the district of the Grand Cañon of the Colorado in the Arizona Desert, which contains many extinct volcanoes; the Snake River and Columbia Basalts; the Crater Lake in the Cascade Mountains in Oregon, and the Yellowstone Park.

At first sight there seems no excuse for encumbering mankind with another book on a subject on which the literature is already voluminous. To say nothing of other districts, the mere enumeration of the books and papers on Vesuvius and the other South Italian Volcanoes occupies 340 quarto pages of a Report of the Geologists' Association.

Much, however, of this literature is old, and some authors appear to have thought more of advancing theories, often of a highly imaginative character, than of accurate observation.

It is true, this defect is less noticeable in the valuable modern books mentioned in the Bibliography, and there are at least three good text-books by Bonney, Judd, and Hull, which fully occupy the field of which they treat. I have considered it useless to repeat what they have said so well, and beg leave to refer the intending student to one or other of them. I have also intentionally avoided one branch of this subject—the microscopic structure of volcanic rocks—which already has a voluminous and highly technical literature, engrosses the entire attention of numerous specialists, and requires study mainly in the museum and laboratory.

I have chosen as my special line of research the mechanical or physiographical side of the subject, which indeed offers problems of the greatest interest and on the largest scale, such as, for instance, the naked-eye structure and mode of formation of volcanic cones and lava streams; how the materials forming them got to their present position, and remained there rather than elsewhere; how they have affected the other rocks with which they came in contact, baking and hardening some, dissolving and removing others; in some cases by their superior hardness protecting the rocks over which they have been deposited, while the surrounding parts have been removed by denudation, so that what was once a molten stream on the floor of a valley is now a bed of hard, perhaps columnar, lava, capping a long hill-top, while in other cases, the volcanic beds have suffered most denudation; how veins and intrusive sills are sometimes harder than the rocks they traverse, and weather out into "Giant Walls," but in others are softer, and become gullies and the beds of streams.

These and other problems equally interesting present themselves at every turn, and can be adequately studied only in the field, generally in places more or less remote and difficult of access, and occasionally not devoid of danger. It would obviously be impossible to bring a volcanic cone or a lava stream, to say nothing of an eruption, into a museum; yet these sometimes temporary and fleeting phenomena are frequently what are most important to record. I have made what a doctor calls a clinical or bedside study of many such cases, and endeavoured to generalise from them. The subject is, however, scarcely yet ripe for much theorising; we require to collect many more facts, and it is as a contribution in this direction that I venture to offer this volume to the reading public, who, in the nature of things, have only a partial access to the objects themselves.

In recording these facts, I have found the greatest assistance from photography, and have thought it much superior to the pencil or the brush. The manual artist can at best only record what he has noticed; there may often be important points which have escaped his attention, though they would appear in a photograph; while in any case he can never hope to approach in accuracy the work of the lens.

Composition is often considered the main duty of the artist, and he is in consequence sometimes tempted to introduce details which have no existence in Nature to add a finish to his picture.

Now the photographer must also pay a due regard to composition; and here, perhaps, the greatest demand is made upon his skill, for, when once his picture is taken, he can neither add details which do not exist nor remove those which his camera has depicted. So that, though the artist's picture may please the eye, the photographer's presents the truth; and, if he possesses the requisite skill, presents it in such a way as to exhibit those points on which he wished to lay stress.

The more I practise Photography, the more scope do I see for skill in this direction beyond what I already possess, and the more am I convinced that it is the man behind the camera rather than the machine that is the author of the work.

At the Aberdeen Meeting of the British Association in 1885, I read a paper on "The Volcanoes of Auvergne," of which the following abstract appeared in the annual Volume[1]:—

"The modern dry-plate process of Photography has placed in the hands of geologists the power of rapidly and faithfully recording and reproducing before an audience of any size many geological, and especially volcanic, phenomena which it would be impossible adequately to describe in words.

"By means of the oxyhydrogen lantern a number of photographs were shown on the screen, which had been taken by the author in the volcanic district of the Auvergne, and the adjacent one of the Velay and Vivarais, in Central France.

"Cones of scoria with craters were contrasted with the Domitic Puys in Auvergne, and these again with the Phonolitic Hills in the district of the Mezenc. The appearances of the various lava streams, both on the surface and where exposed in sections, were shown, especially those of the valleys of Jaujac and Montpezat.

[1] Report of the British Association, 1885, p. 1017.

Lakes in extinct craters were contrasted with those formed in pre-existing valleys behind dams of volcanic ejecta, and the general scenery of volcanic rocks was compared with that of other adjacent formations."

At the Bath Meeting in 1888 I read a similarly illustrated paper on the Volcanoes of the two Sicilies.

At the same Meeting Mr Osmond Jeffs read a paper on Local Geological Photography; and the next year the Association appointed a Committee to arrange for the collection, preservation, and systematic registration of photographs of geological interest in the United Kingdom.

This Committee, which has been annually re-appointed, and of which I am a Member, has collected several thousand photographs, many of which are of the highest value, and a selection from these is now in course of publication. They, however, include the whole range of Geology, and are limited to the United Kingdom.

I have repeatedly had the honour of exhibiting at the soirees of the Royal Society at Burlington House different series of photographs as projections by the Electric Lantern, accompanied in each case by an explanatory discourse; and in 1897 these were systematized into four Lectures,[1] which I delivered at the Royal Institution in Albemarle Street. I have also contributed photographic illustrations of volcanoes to the following works:

Prof. T. G. Bonney: *Volcanoes*
Prof. G. A. J. Cole: *Open-Air Studies*
Sir A. Geikie: *Volcanoes of Great Britain*

as well as to articles by myself in the *Alpine Journal* and elsewhere, but these have mostly been reproduced on a small scale.

My collection of photographs illustrating volcanic phenomena, the work of my own cameras, now reaches several hundreds. As they are chiefly foreign, they do not interfere with the British Association series, and it is of these that I now publish a selection, accompanied in each case with an explanatory description.

My thanks are greatly due to my friends to whom I have dedicated this book, and especially to Professor Bonney and Messrs J. G. Goodchild, and George Yeld, who have rendered me much geological and literary assistance while the work was in the press.

When the above was already in type and on the eve of publication early in May last, eruptions occurred at the

[1] The Tyndall Lectures.

Soufrière in St Vincent and Mont Pélee in Martinique [both islands in the West Indies]; and I had the honour of being appointed, along with Dr. J. Smith Flett, petrologist to the Geological Survey, a member of the Commission sent by the Royal Society to investigate the results of these eruptions.

We proceeded first to St Vincent, where every facility was accorded to us by the Governor, Sir Robert Llewellyn, and his officials, and also by residents who knew the topography of the Soufrière before the eruption, so that we had an opportunity of pursuing our investigations under unusually favourable circumstances.

After leaving St Vincent, we had the rare good fortune to witness from a distance, quite as short as was safe, an eruption of Mont Pelée, similar to the one which destroyed the town of St Pierre.

TEMPEST ANDERSON.

17 Stonegate, York.

November 1902.

CONTENTS

PHOTOGRAPHIC METHODS.

THE following observations on the technical methods employed may be passed over by those who are interested only in the results.

Nearly all the photographs are enlarged from "quarter plate" negatives, $4\frac{1}{4}$ in. × $3\frac{1}{4}$ in. I do not consider that there is any advantage in using a larger size, sufficient to counterbalance the extra weight and bulk of plates and apparatus, and I should be inclined to recommend lantern size, $3\frac{1}{4}$ in. × $3\frac{1}{4}$ in., or even smaller, except for the advantage that quarter plates are kept in stock by all dealers, and fit the ordinary developing dishes and storage boxes. If I were to work a larger size, I should prefer 10 × 8 inches, or 12 × 10 inches, so as to avoid the necessity of enlarging, and if films were used, the increase in weight and bulk need not be absolutely prohibitive.

A good lens of 6-inch focus will give an image on a quarter plate containing more detail than is visible to the naked eye from the position of the camera; but it must be remembered that it does not follow that all or most of this detail will appear in the photograph. To secure this amount, it is absolutely necessary that the camera-stand be very firm; as firm, for instance, as would be used for a camera taking a size of plate as large as the proposed enlargement. It is also necessary that a plate be used coated with an emulsion sufficiently fine grained to register the detail in the image, much of which, it must be remembered, is too minute to be visible to the naked eye. Most rapid plates are far too coarse grained to bear much enlargement, and are only fit for snapshots, in which case the camera being held in the hand, and the lens worked with a large aperture, the photographer is well satisfied if he obtain results which appear sharp to the naked eye.

Wet collodion would, no doubt, be the best if available, but the convenience of gelatine dry plates is so great that there is practically no choice in this respect. Dry collodion plates have not been a success.

Films offer great attractions, and if a good batch be obtained the results leave nothing to be desired. The main real advantage of films is the facility for changing. My hand camera takes about eight dozen cut films like a pack of cards, or about twenty glass plates, so that if loaded with films it holds a supply for several days, or if with plates, then only enough for one or two, a great consideration when all time and energy available in the evenings are wanted for other purposes than changing plates. The weight is really a secondary consideration. It is seldom that as many as two dozen plates are wanted in one day, and they weigh less than two pounds. The extra weight practically falls into the heavy baggage, which the photographer never carries himself, and thus means merely a little extra expense in moving, and even this is partly balanced by the greater cost of films. It is also generally admitted that films cannot be depended on to keep so well as plates, and that the average results on glass are better. On the whole, I consider plates worth the extra trouble, and therefore took nothing else last year.

The plates which I have found to present the greatest combination of advantages are the medium Isochromatic, of B. J. Edwards & Co. The small trace of Eosine, and perhaps of other colouring matters incorporated in the film, renders them much more sensitive to the red end of the spectrum than ordinary plates, and gives much truer colour values. They are very free from halation, and are excellent for clouds and most other landscape work, as well as geological subjects. They are of finer grain, and give better density than the more rapid brands. They do not require a yellow screen for most subjects, and I seldom use one. I have, however, recently tried a "bichromate Ray filter" by Bausch and Lomb, which I find useful for distant objects if there is any blue haze.

LENSES.

It is essential to be provided with several lenses of different focal length, and much of the photographer's success will depend on his skill in selecting the right lens for any particular view. Artists and photographers are practically agreed that the most agreeable and natural perspective is given by a lens of a focal length of from 1½ to 2 times the longest diameter of the plate, as an angle of view about equal to that ordinarily used by the eye is thus included. I use for a majority of my exposures on quarter plates a rapid rectilinear, by Dallmeyer, of 6 inches focus, and am not sure whether one of 7 inches might not be even better. If well stopped down, it gives a picture sharp to the corners, and will bear the use of a rising front, which is much better, and gives truer perspective than a swing back. Unless stopped down, however, which reduces the rapidity, it does not give an image sharp to the corners; and consequently for hand exposures I use a Cooke lens, also of 6 inches focus, which gives much better definition when worked at full aperture, though no better when stopped down. These lenses, however, give too small images of distant objects, for which a lens of longer focus is necessary. I have tried one half of the rapid rectilinear, which gives a focal length of 12 inches; but this plan admits dirt inside the lens, and on the whole it is much better to carry a separate lens of 12-inch focus, which I use quite often. It is only a common view lens, but being only used on a plate so small in proportion to its focal length, it covers perfectly, and without appreciable distortion. A small lens of this kind is much lighter and more portable than a R. R., which, if of this focal length, would weigh perhaps one pound; the only advantage of carrying such an one would be if it were proposed to work from the deck of a ship, or on distant objects requiring the use of a shutter, such as birds, or shipping. For ordinary rocks and mountains the lighter and cheaper lens is equally good.

The Telephoto lens is an apparatus from which much was expected, but I have scarcely met any one who has beeen satisfied with the results he has obtained from it. It consists of two parts. The front half may be an ordinary photo-lens of any good construction, and the telephoto attachment consists of a concave or negative combination of short focus placed within the principal focus of the front lens. It is analogous in its action to the eye lens of an opera glass, and takes up the rays of light before they come to a focus, and spreads them out so as to produce an image on a considerably larger scale, but with a much smaller field than is given by the front lens if used alone. It is to be noticed that this image cannot possibly contain any detail which would not have been present in the smaller image formed by the original lens, and in the majority of cases not so much, owing to errors introduced by the negative lens. It is obvious, therefore, that if we could be certain of plates of grain fine enough to do justice to the lens, it would be much better to avoid using the negative attachment, and thus obtain a negative including a much larger field, the best portion of which could be enlarged afterwards. The telephoto also magnifies the effects of any shaking, and hence requires a very steady stand. This however, as explained above, is necessary in order to obtain the best performance of other lenses, so it should not be held to be a disqualification for this. It is hopeless to attempt to use a telephoto in a high wind, or when the air is tremulous from the heat of the sun. On the whole, though I generally carry one of these lenses, I very seldom use it. None of the plates in this volume were done with it.

Besides the above, it is necessary to be provided with a short focus wide angle lens, for use in confined situations, such as quarries and craters. I use one by Dallmeyer of 3-inch focus. I have also one of 2-inch focus, which includes the very wide angle of 90°. It gives a truly rectilinear image, but the perspective is so exaggerated, and the images of distant objects are so small, that I generally leave it at home. I also have, but seldom carry, lenses of 4- and 9-inch focus. These intermediate lenses are really scarcely necessary. The 3-inch, 6-inch, 12-inch, and telephoto lenses are sufficient for practical purposes.

The 3-inch lens is of focus short enough to require no adjustment for distance, and the plates fit against stops in a fixed position. The plates also fit in a fixed position for the 6-inch lens, which has a sliding tube adjustment with scale for focussing different distances. This is constantly used. The 12-inch lens has also a sliding adjustment, but as it is only used for distant objects this is rarely required.

Some years ago I designed and made a panoramic camera, with a revolving lens, on the plan since independently brought out by the Kodak Company. It gives excellent results, but the carrying of an extra camera is practically prohibitive.

PLATE I.

[*To face page* 1.

VOLCANIC STUDIES

PLATE I

VESUVIUS AND SOMMA FROM NEAR RESINA

THE apparent height is reduced by the rising of the foreground, which alters the perspective. Vesuvius is to the right, at a distance of about 3 miles from the point of view, and Somma is to the extreme left. The low hill behind the stone pine near the centre is the cone of the eruption of 1898. The Observatory is just visible through an opening in the trees in front of Somma. The hill on which it is situated is a detached portion of the great crater ring of Somma, left standing by the eruption of A.D. 79, which destroyed Herculaneum and Pompeii, and in which Pliny lost his life. Prior to this date the present cone of Vesuvius did not exist, but what is now Somma formed part of a great single cone with a crater at its summit. In the Plinian eruption an explosion or succession of explosions blew away the upper part of the mountain and left the broken crater ring of Somma standing. The present cone of Vesuvius is not in the centre of the Plinian crater, but more to the south-west. Besides the mountain wall of Somma to the north and east, traces of the edge of this crater, called Pedimentina, are still to be found round the south and west part of the foot of the existing cone, though what is left of this is much obscured by lava flows of later date.

PLATE II

VESUVIUS.—(The Eruption of 1898.)

From the Top of the Observatory, September 1898.

Somma is seen to the left, Vesuvius to the right, at a distance of 1½ mile.

The hill on which the Observatory is situated, forms part of the great crater ring of Somma, but is separated from that part of the mountain by the Fossa Vetrana, a valley beyond the left of the picture, opposite the head of which the eruption took place. The road in the foreground leads from the Observatory to the Station of Cook's funicular Railway. The prolongation of the Observatory Hill along which it runs extended further, and was called the Crocella. It was entirely covered up by lava in the early part of the eruption. Some of the lava streams crossed the road and ran down the Fossa Grande, a valley more to the right. The eruption lasted several months, but was never very active. Lava was poured out continually, but not in very large quantity at once. It therefore had time to cool near its point of exit, and so built up a rather considerable cone.

PLATE II.

[*To face page* 4.

PLATE III

VESUVIUS.—(Eruption of 1898.)

From Monte Somma, looking across the Head of the Fossa Vetrana.

Vesuvius is beyond the left edge of the plate, and the Observatory beyond the right one. The lava streams are seen on the slopes of the new cone. They generally cooled and solidified before they had run many hundred yards, with the result that the lava, which was still being poured out, took another course, and formed another stream, which behaved similarly. These, when fresh, were visible during the day by the vapours which they gave off, and at night by the light from the red-hot or occasionally white-hot lava.[1] The writer stayed about a week at the Hermitage just below the Observatory, and examined the lava flows each night from the top of that building, when they presented a most striking spectacle. They were not above a quarter of a mile distant.

[1] *Cf.* "A pillar of cloud by day and of fire by night" (Exodus xiii. 21).

PLATE III.

[*To face page* 6.

PLATE IV

VESUVIUS.—(Eruption of 1898.)

Detail of a Lava Stream in the Fossa Vetrana.

Somma is in the distance to the left, the new cone with its moving streams to the right. The *coulée* in the foreground is of the "corded," "slaggy," or "pahoehoe" type. Its texture is, however, coarser, rougher, and more approaching the "cindery" or "aa" type, than some of the older but still recent lavas of Vesuvius, such as that shown in P. vi. The loose blocks around also approach that structure. This stream is a small and narrow one. Many of the other flows were much larger.

PLATE IV.

[*To face page* 8.

PLATE V

BLAST FURNACE SLAG. EATON CAREW, HARTLEPOOL, ENGLAND.

It is well to compare the slag produced artificially in a blast furnace with its analogue in Nature's laboratory.

Both are fusible compounds of silica, combined with varying quantities of lime, iron, magnesia, and other bases. Both contain more or less included vapour, and in both the structure approaches the corded or the scoriaceous type, according to the amount of vapour present. At most blast furnaces the slag when drawn from the furnace is received in iron waggons, where it is allowed to cool and solidify, and the masses thus produced are merely casts of the inside of the waggon, and show no special structure.

At the furnaces where the above photograph was taken, the molten slag, instead of being cooled in the waggon, is conveyed rapidly to the spoil bank, where it is tipped and takes its natural form. The resemblance between the structure shown in this plate, and some of the natural corded lavas, such as Pls. iv., vi., and liv., is very striking. There were also abundant examples of the scoriaceous type.

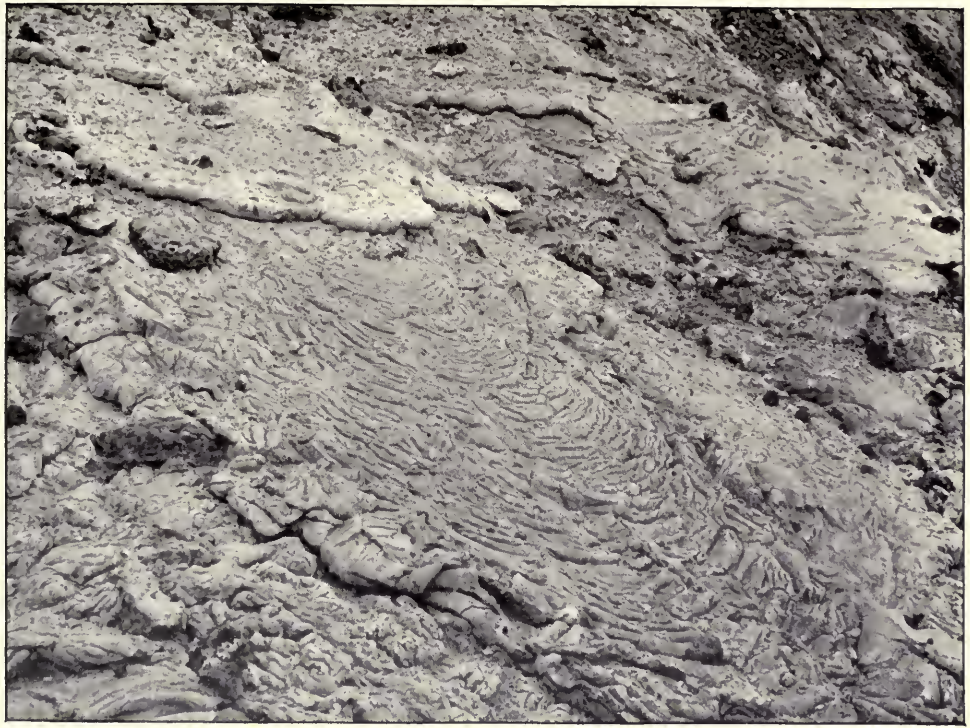

PLATE V.

[*To face page* 10.

PLATE VI

VESUVIUS.—(Lava of 1858.)

In the Fossa Grande near the Observatory.

A good example of "slaggy," "corded," or "pahoehoe" lava. This lava was viscid and tenacious, and it therefore moved slowly. It has been suggested that this viscidity was the cause of the lava assuming the rope-like form. But the truth appears to be, that whether a lava stream will assume the "slaggy" or "cindery" structure depends chiefly on the amount of aqueous vapour entangled in it. If much is imprisoned, bubbles or vesicular cavities are formed in the still liquid mass, which hardens into a sort of solid froth, and forms the cindery lava. I have seen a lava stream slaggy in one part and cindery in another part of its course. (See Pls. liv. and lv.). Lava eventually weathers into soil, which is often very fertile. This particular lava, erupted in 1858, and photographed in 1888, thirty years later, was then beginning to support a few tufts of grass.

PLATE VI. [*To face page* 12.

PLATE VII

VESUVIUS.

Moving Lava. (Instantaneous Photograph, September 1898.)

This lava was of the "cindery," "scoriaceous," or "aa" type. It was very viscid, and therefore moved very slowly, probably not above a foot or two a minute, and the large blocks of vesicular lava (which were, in fact, solidified scum) kept rolling down the ends and sides of the flow, which were quite steep, like a railway embankment. The moving rocks made a very characteristic rattling noise. Much vapour was emitted from the lava.

PLATE VII.

[*To face page* 14.

PLATE VIII

VESUVIUS.

(*Lava of 1872, in the Fossa Vetrana,* A.D. *1888*).

This was a rapidly moving and very fluid lava. It issued from a large vent in the Atrio del Cavallo, the great valley seen to the left of the plate, and in three days ran several miles down the Fossa Vetrana, and destroyed many houses in the villages of San Sabastiano and Massa di Somma. Another branch descended the Fossa Grande on the other side of the Observatory, and thence threatened the town of Resina. It is interesting to note that though this was such a rapidly flowing and very fluid lava, it presented a structure similar to that of a very viscid one on the same spot a few years later. Vesuvius is seen in the distance, and the cone of 1898 has since been thrown up in front of it. Compare Pl. vii.

PLATE VIII.

[*To face page* 16.

B

PLATE IX.

VESUVIUS.

Part of the Crater, September 11, 1898.

The crater of Vesuvius in September 1898 was a vast pit, probably a quarter of a mile in diameter, with almost vertical sides, and a depth that was certainly considerable, but which could be only guessed at, as it was obscured by vapour, which issued from its depths, as well as from innumerable fissures and holes in its walls. Occasionally the wind afforded a clearer view, and showed the strata of lava and tuff, dipping away in all directions from the central axis. Every few minutes, and sometimes almost continuously, explosions took place in the bottom of the crater with a loud bellowing noise. Showers of red-hot stones were ejected, some of which fell unpleasantly near us. It was only occasionally that it was safe to make the ascent; at other times, as for instance when the next plate was taken, it would have been most dangerous to attempt it.

PLATE IX.

[*To face page* 18.

PLATE X.

VESUVIUS.

An Explosion seen from near the Observatory, September 13, 1898.

The characteristic shape assumed by the cloud of vapour and ashes is well seen, and the outline is made more visible by the sun, which, just at the moment, was rising from behind the cone. The slope, as usual, appears less than in reality, owing to the camera being necessarily tilted, so as to include the whole cloud.

PLATE X.

[*To face page* 20.

PLATE XI.

VESUVIUS.

The Crater in 1888.[1]

During eruptions the main crater of Vesuvius is cleared out by the explosions, and presents the appearance shown in Pl. ix.

As the eruption subsides, and the explosions become less violent, the masses of red-hot lava are no longer thrown mainly outside the crater, but fall back into it, and gradually fill it up, and thus form one or more small cones inside the main crater.

[1] See the figures which are copied from Sir William Hamilton's works into most of the text-books. In 1888 the principal crater was nearly filled up; its edge appears in the foreground of the present view, and there is a small cone in the middle distance. The photograph (a snapshot) shows ejected masses of pasty lava still up in the air during an explosion.

PLATE XI.

[*To face page* 22.

PLATE XII.

VESUVIUS.

A Fumarole.

When the volcano is active, fissures form in the cone. From these heated vapours issue, and deposit sublimates of ferric chloride, as well as of borax, sulphur, and other mineral substances. The vapours also act chemically on the rocks through which they issue, and thereby produce a mass of material of variegated colours, in which white, yellow, and red predominate. As the volcanic discharge at that point becomes less violent, the vents become blocked by the sublimate, and a mass such as that shown in the plate remains. This particular fumarole was situated at the north side of the cone a few score yards from the summit (1898).

The same process may occur on a scale of any magnitude, and may affect the whole vent of the volcano. Usually, however, in such a case, it marks a period of quiescence when there is a gradual cessation of discharge of vapours. Such a phase in the history of a volcano gives rise to a solfatara.

PLATE XII.

[*To face page* 24.

PLATE XIII.

THE CRATER OF ASTRONI.

An Extinct Crater in the Phlegræan Fields, near Naples.

It is used as a royal game preserve, and is surrounded by a wall which is shown in the photograph. In order to get access to the interior, a road, seen behind the bushes in the foreground, has been made through the lip of the crater, the cutting for which exposes the strata of tuff (consolidated volcanic ash), of which it is composed. The outward dip of these fragmentary volcanic rocks is well shown in the plate, which should be compared with that of the crater of Vesuvius (Pl. ix.). This, however, is a much more simple case. The beds of volcanic ash, at any rate in the part shown, may very well have been formed during a single eruption.

PLATE XIII.

[*To face page* 26.

PLATE XIV.

MONTE SOMMA.

Looking east from nearly the highest point of the ridge.

The sweep of the great crater ring is well shown, as is also the usual outward dip of the beds of lava and tuff, of which the mountain is composed. Cutting across these strata are many dykes, which mark the site of radial fissures formed during eruptions, while Somma still formed part of the working cone of the mountain. Molten lava was injected into them and solidified there, as now often happens in the present cone of Vesuvius. The structure of this section is thus much more complex than that of Astroni, illustrated by the last photograph, and it shows the anatomy not of a cone of single eruption, but of one built up by, and repeatedly altered during, successive eruptions. The modern cone of Vesuvius is beyond the right edge of the plate.

PLATE XIV.

[*To face page* 28.

PLATE XV.

A ROAD ON SOMMA.

It is a matter of history that the Plinian eruption, in which the great crater ring of Somma was partly destroyed, took place in A.D. 79. No lava has overflowed its rim since that time. It is therefore clear that, for over 1800 years, no addition more important than a few showers of ashes has been made to the slope of this part of the mountain, and that it has been exposed during that period to the ordinary forces of denudation, which have scored its outer slope with many ravines, and given it the umbrella-like appearance so usual in volcanic piles, when seen from a distance.

For ages the inhabitants of the neighbourhood have cut wood on its slopes, and generally dragged the bundles down the ridges between two valleys. They have thereby loosened the soft tuff, of which it is largely composed. The next shower of rain, which here is apt to be almost torrential, washes down much of the loose material, and the result is, that the paths now run in the bottom of deep cuttings, which have very steep sides. These are good examples of geographical changes indirectly caused by human agency.

PLATE XV.

[*To face page* 30.

PLATE XVI.

PHLEGRÆAN FIELDS.

Grotto del Cane. Lago Agnano.

Even when volcanic action becomes dormant or almost extinct in a district, it often happens that a considerable amount of vapour still rises to the surface through fissures in the ground, and is apt to accumulate in any natural or artificial hollow. This grotto has been excavated into the side of a hill, forming part of the crater of Lago Agnano, one of the extinct volcanoes near Pozzuoli, west of Naples. The floor of the grotto descends by steps to a level of several feet below the surface of the ground outside. Carbonic acid gas escapes copiously, and flows over the threshold. Up to a well-defined line at this level, the rock is stained a different colour. A lighted candle put below this level is extinguished. A man, however, can go into the grotto, provided he keeps his head above the line; but a dog held with its head below it becomes insensible, though on being taken outside the animal quickly recovers. The same dog has been in use for several years for this purpose, and yet seems in good condition. In the Yellowstone Park in America, there is a valley called "Death Gulch." Animals venturing into it are sometimes suffocated, even in the open air, and the same seems to have been the case at Avernus, a crater lake near Pozzuoli, if we may judge from its name, which means "without birds." (Virgil, *Æn.* vi. 239-242.)

PLATE XVI.

[*To face page* 32.

c

PLATE XVII.

PHLEGRÆAN FIELDS.

The so-called Temple of Serapis, at Pozzuoli, 1888.

The ground at Pozzuoli, in the Phlegræan Fields, near Naples, is plainly shown by this temple to have been subject to variations of level such as occur in other volcanic districts. The ruins are situated near the sea shore,[1] and the temple floor was probably originally a little above sea level. So it may have been in the third century; at a later period, perhaps in the fifth, the temple was ruined; the floor was buried under volcanic ash, the ground sank, and the columns were submerged beneath the Mediterranean to nearly half their height. The parts exposed to the water were eaten into by boring mollusca, some of the burrows of which extend 2 or 3 inches into the stone: the covered lower parts of the submerged columns escaped. At a later period the land again emerged, and about 1752 the accumulations round the columns were removed, and the floor of the temple was again laid bare. The land since then has been sinking again, and the floor would be again submerged, had not a new one been constructed a yard or so above the original pavement, so as to keep a platform above water level.

[1] *See* Lyell, *Principles of Geology*, ch. xxx.

PLATE XVII.

[*To face page* 34.

PLATE XVIII.

ETNA.

Lava of 1886, near Nicolosi.

This lava is of the ordinary scoriaceous type, and is introduced to show how the same lava stream may vary in appearance in different parts.

Three divisions are plainly visible in the plate, though all are certainly due to the same eruption. It is probable that after the part in the foreground had consolidated, it was partly covered by more lava pushing on from behind, and this layer again by a third. The middle layer is seen to consist of much smaller blocks.

PLATE XVIII.

[*To face page* 36.

PLATE XIX.

ETNA.

The Summit Cone, as seen from the Observatory.

The oldest part of the building is better known as the "Casa Inglese," and was built at the expense of some English Naval officers about the beginning of the nineteenth century. The dome and main building are of recent date. The Observatory was not occupied regularly when I visited it in 1888.

The cone contained a very large and deep crater, with precipitous walls. Vapour constantly escaped from numerous openings with a roar as of many boilers blowing off steam. The clouds of vapour prevented me from obtaining a view of the bottom. The general aspect of the crater presented one of the most impressive sights I have ever seen. The arrangement of the beds forming the slopes of the crater resembled that shown in Vesuvius (Pl. ix.), but the crater was much larger, and the sides steeper. The outer slopes extended up to the sharp edge of the precipitous wall of the actual crater, so that I lay down to look over.

PLATE XIX.

[*To face page* 38.

PLATE XX.

LIPARI ISLANDS.

Campo Bianco (*White Field*).

This is a very well-marked example of a breached cone. The crater wall is formed of pumice of very acid composition, *i.e.* containing a high percentage of silica. It is remarkable for its fine-grained vesicular and fibrous character, which are owing to the intimate manner in which the imprisoned vapours were incorporated in it at the time of its eruption, and to this it mainly owes its white colour. Owing to the absence of small embedded crystals, which if present would make it gritty, it is very suitable for employment in the arts, and practically all the pumice used in the world comes from this locality. The dark rocks in the centre which were erupted simultaneously are of the same chemical composition, but being free from vesicles they have consolidated into a dark-coloured obsidian. They form a lava stream which continues down into the sea, and is known by the name of Rocchi Rossi.

The space between the lava stream and the foot of the slopes is a fertile vineyard.

The photograph was taken with a wide angle lens, which accounts for the reduction of the apparent height.

PLATE XX.

[*To face page* 40.

PLATE XXI.

LIPARI ISLANDS.

The Sciara of Stromboli, as seen from the North-east Side.

The word appears to be the southern equivalent of the Northern forms, Skar, Scar, Sguur, and Sguir. The crater of Stromboli is situated not on the summit but on the north-west side of the mountain, at an elevation of about 2400 feet above the sea, and the Sciara extends from that point down to the sea level, forming a slope of about 30°. Its width at the water's edge is about 3000 feet. The Sciara is bounded on each side by two steep cliffs, from one of which the view was taken. They are formed like the Sciara itself, of lava streams, agglomerates, and dykes, in fact of almost every kind of compact volcanic material, chiefly of basic composition. The Sciara itself presents several well-marked ridges of lava, which have flowed either from the crater, or from fissures in the mountain. At the time of my visit red-hot masses of lava were ejected every few minutes, rolled down the Sciara, and disappeared into the sea, with loud hissing noise.

The crater is shown slightly above and to the left of the centre of the plate, and extends a little behind the pointed rock to the left. Further to the left of the point may be noticed the tracks of masses of lava which have been blown out of the crater, and taken this course down to the sea.

PLATE XXI.

[*To face page* 42.

PLATE XXII.

LIPARI ISLANDS.

The Crater of Stromboli, as seen from above.

Owing to the necessity of tilting the camera forward in order to obtain this view, the slopes are much foreshortened, and the perspective is bad. The foreground slope is really very steep. The crater is an elliptical hollow, which is probably 60 or 70 yards in its longer diameter, and at the time of my visit in 1888 it contained two small secondary cones. A considerable amount of vapour escaped steadily from the cone to the right, and also from several fumaroles. Explosions took place from the cone to the left every few minutes. At each eruption the lava at the top of the cone appeared to swell, and then to burst, and a quantity of material was thrown up in a cloud of vapour with a loud roar, though the guide said the explosions were *piccolissima* (very small). Most of the *ejecta* fell back into the crater, but a little fell over its further edge and rolled down the Sciara into the sea.

PLATE XXII.

[*To face page* 44.

PLATE XXIII

LIPARI ISLANDS.

The Cone of Vulcano.

Near the centre is a small old crater, the " Forgio Vecchio," where classical tradition locates the forge of Vulcan, and to the right is a lava stream of obsidian (volcanic glass), probably due to an eruption in 1775, and at any rate geologically quite recent. To the left is the villa of Mr Narlian, where I was most hospitably entertained, behind it is a detached rock, the " Faraglioni." The main crater from which the vapour is ascending is in the summit of the cone.

About six weeks after I obtained this photograph in 1888, an eruption took place, which destroyed the extensive vineyards. During this red-hot stones were thrown out, some of which came through the roof of Mr Narlian's house. He and his family narrowly escaped with their lives.

PLATE XXIII.

[*To face page* 46.

PLATES XXIV. AND XXV.

LIPARI ISLANDS

The Crater of Vulcano, June 1888.

The photographs, which should form part of the same panorama, show the interior of the crater. The beds are seen to dip outwards in the usual way. In the bottom of the crater are many active fumaroles, which were at one time covered in by chambers erected to condense the contained chemicals.

To the right are the remains of a road which led down to the condensing chambers, which were destroyed by an eruption a few years before my visit.

PLATE XXIV.

PLATE XXV.

[*To face page* 48.

D

PLATE XXVI.

LIPARI ISLANDS.

Vulcanello, seen from the Slopes of Vulcano.

To the right of the view in the distance is Vulcanello, a tuff cone with three craters, and showing the "umbrella"-like weathering, usual in volcanic cones.

To the left, also, in the distance, are the hills of the Island of Lipari, which are likewise all volcanic, but are of older date ; and in front of them is a rocky mass, known as the "Faraglione." It is a "neck," the hard central plug of a cone, the softer materials of which have been stripped away by the action of the weather and of the sea. The Faraglione contains extensive caverns from which the ancient Romans extracted alum ; there are also many smaller grottoes which are still inhabited. The inhabitants of these say that the grottoes are warmer in winter and cooler in summer than ordinary houses. Certainly, during an eruption of Vulcano, they proved safer than their more pretentious neighbour, the villa (Pl. xxiii.). The small rock on the shore, a little to the right of the Faraglione, is apparently also a neck.

PLATE XXVI.

[*To face page* 50.

PLATE XXVII.

LIPARI ISLANDS. BASILUZZO.

Near the centre of the group of the Lipari Islands is a cluster of small islets, some of them little more than detached rocks, which appear to be fragments of a great crater ring, breached at many points by the action of the sea. The above photograph was taken from a steamer passing through the midst of the Islands, so that the cliff facing us represents part of the inside wall of the crater. The other side slopes out gradually. The detached rock to the right is Spinazola, another of the smaller islets.

PLATE XXVII.

[*To face p.* 52.

PLATE XXVIII.

AUVERGNE.

The Chain of Puys, looking South from near the Summit of the Puy de Dome.

All the Puys shown are formed of scoria and ashes, and all have craters more or less perfect, though some are breached by the outflow of lava at one side of their base. They have, as may be seen, a generally linear arrangement, though to this there are a few small exceptions. The platform on which they are situated is of granite, concealed in many places by volcanic material. The crags in the foreground are of domite, a kind of trachyte, of which the Puy de Dome is itself composed ; hence the name.

In the distance to the right of the centre is Mont Dore, the wreck of a large volcano of miocene and pliocene age.

PLATE XXVIII.

[*To face page* 54.

PLATE XXIX.

AUVERGNE.

The Chain of Puys, looking Northwards from the Summit of the Puy de Dome.

The broken ground in the foreground forms part of the Petit Puy de Dome, a scoria cone.

To the right in the middle distance is the Puy de Pariou, a scoria cone, with a very well-preserved crater, behind it Les Goules, another scoria cone, also with a crater, and behind Les Goules, and partly concealed by it, is the rounded form of the Grand Sarcoui, which has no crater. It is one of the most typical of the domitic Puys (see Pl. xxxi.). The pointed mountain to the left, not quite on the sky line, is the Puy Chopine, partly surrounded and concealed by the crater ring of La Goutte (see Pl. xxx.). The rounded cone in front of them without a crater, and marked by light-coloured screes is Cliersou (the bell), another of the domitic Puys. The other cones in the distance are composed of scoria.

For further details see Scrope's *Volcanoes of Central France*, and for a summary of the more modern views about the Volcanic History of the region, consult the *Proceedings of the Geologists' Association*, vol. xvii. pp. 191-269.

PLATE XXIX.

[*To face page* 56.

PLATE XXX.

AUVERGNE.

The Puy Chopine and Puy de la Goutte, from the N.N.W.

The Puy Chopine is mainly formed of domite, but it contains also a remarkable inclusion of a large mass of granite and a smaller one of sedimentary rock. It is partly surrounded by the scoria crater of La Goutte to the right, which, it has been supposed, was first thrown up in the ordinary way by an explosive eruption, at or after the termination of which the action became more tranquil, as the *ejecta* altered in character and consistence. The domite of the Puy Chopine appears to have been sufficiently pasty to remain on the site of the extrusion without running off as a stream of lava, and its consistence seems to have favoured the entanglement and inclusion of the granite and associated sedimentary rocks, which it appears to have brought up with it from below. It is traversed by a dyke of basalt (not shown), and has no trace of a crater.

PLATE XXX.

[*To face page* 58.

PLATE XXXI.

AUVERGNE.

The Grand Sarcoui, from the West.

This is one of the most characteristic of the domitic Puys of Auvergne. The domite of which it is composed was worked by the Romans for sarcophagi, hence its name. It stands between two scoria cones, Les Goules, part of which appears to the right, and the Petit Sarcoui, seen to the left. These cones, it has been suggested, may bear the same relation to it as the Puy de la Goutte does to the Puy Chopine.

PLATE XXXI.

[*To face page* 60.

PLATE XXXII.

AUVERGNE.

The Cone of Tartaret and the Lac de Chambon, looking West from the Castle of Murols.

In the distance is Mont Dore, a much denuded old volcano of miocene and pliocene age. After a long period, during which the Valley of Chaudefour, seen in the half distance to the right, was cut deeply into the mountain mass by ordinary sub-aerial agencies, the scoria cone was thrown up nearly in the bottom of the valley, and from it proceeded a lava flow, shown in the next plate.

The two together blocked the drainage of the upper part of the valley, and the Lac de Chambon is the result. The plateau in the middle distance out of which the valley has been carved, consists mainly of tuff lying upon granitic rocks. The Castle of Murols is built on basalt, perhaps a neck. The photograph, taken in June, shows snow still on Mont Dore.[1]

[1] The horizontal white line is a flaw in the photograph.

PLATE XXXII.

[*To face page* 62.

PLATE XXXIII.

AUVERGNE.

The Lava of Tartaret and the Roman Bridge.

The aspect of the scoria forming the cone of Tartaret and of some parts of the lava-flow is so fresh as to suggest the idea that the eruption took place recently, and the name Tartaret countenances the idea that some action at any rate took place in historic times, but further examination shows that the river Couze has had time to excavate a deep channel through the lava, and that this channel is spanned by a bridge of the type usually constructed down to the fifth century, and supposed to be of Roman workmanship. If so the lava was erupted, and the gorge already excavated, at any rate to a considerable depth, in pre-Roman times.

PLATE XXXIII.

[*To face page* 64.

E

PLATE XXXIV.

AUVERGNE.

A Basalt Neck at Buron, near Coudes.

The crests of many of the hills in Auvergne are formed of beds of basalt, often columnar, which have obviously been poured out as lava-streams, and occupied the floors of the then existing valleys. They have cooled and solidified into beds of compact rock, which resists denuding agencies very much better than the soft deposits (mostly tertiary) on which they rest. The lava has thus protected the parts beneath it, while other parts have been denuded away, and that which was once the floor of a valley remains now as a ridge of a long hill. Such for instance is Gergovia, which has been preserved by a capping of lava resting on soft marls and limestones of fresh-water origin. There are however cases, of which the above appears to be one, where basalt has been erupted from a separate centre and solidified on the spot in the same way as the domitic Puys.

Compare this with the basalt necks in the plates of the Rhine district.

PLATE XXXIV.

[*To face page* 66.

PLATE XXXV.

ARDÈCHE.

The Gerbier de Jonc.

This volcanic neck is one of several of a similar kind which occur south-east of Le Puy en Velay, on the borders between the drainage areas of the Loire and the Ardèche. They consist of phonolite. I suspect they were formed sub-aerially, *i.e.* on the surface, like the domitic Puys, but it is possible they may be laccolites, *i.e.* intrusive masses which have been injected while molten among other strata which have been since removed by denudation.

PLATE XXXV.

[*To face page* 68.

PLATE XXXVI.

VELAY.

The Rocher Saint Michel, Le Puy en Velay.

Le Puy is the capital of the ancient province of the Velay which adjoined Auvergne on the south-east, and is geographically part of the same upland district. This rock is a volcanic neck which appears to have been formed in a slightly different way from the last. Instead of being a homogeneous mass of lava which has solidified quietly in and about the top of a vent, it consists of innumerable fragments of various rocks in which those of volcanic origin preponderate, and which appear to have been churned up and down by a series of small explosions in a chimney, in which they finally consolidated as a mass of "volcanic agglomerate." The scoria cone, which once probably surrounded or crowned the whole, has been denuded away, and the more durable rock forming the "neck" alone remains. The small chapel on the summit is dedicated to St Michel, a saint whose name is generally associated with such elevated situations.

PLATE XXXVI.

[*To face page 70.*

PLATE XXXVII.

ARDÈCHE.

Castle of Pourcheirolles, Valley of Montpézat.

The mountainous region on the right bank of the Rhone below Lyons in the department of the Ardèche, the old Vivarais, extends to the south and south-east of the Le Puy district, and presents many objects of volcanic interest. The mountains are mostly formed of granite and other hard crystalline rocks, which do not weather much, if at all, faster than basalts. Hence the lava-flows often occupy their original relative position in the valleys into which they were erupted instead of capping the tops of hills of soft tertiary rocks (as is not unknown in Auvergne), and the streams whose beds they have usurped have generally re-excavated their channels as deep gorges along the junction of the basalt and granite, which well display the structure of the former. The Castle of Pourcheirolles is situated on a tongue of basalt, left standing at the junction of a small side valley with that of the Fontollière, a tributary of the Ardèche. The almost level top of the lava-flow and its apparent division into different layers (see next Plate) are well shown. The heights in the distance are chiefly granite.

The Gravenne de Montepézat, a scoria cone from which the lava-flow proceeded, is situated on similar heights beyond the left border of the plate.

PLATE XXXVII.

[*To face page 72.*

PLATE XXXVIII.

ARDÈCHE.

The Valley of Jaujac.

The columnar basalts referred to in the last description are seen to the greatest advantage in this valley, and for a mile or two below its junction with that of the Ardèche. Since the occupation of the valley by the flood of lava, the river has excavated for itself a new channel, roughly following the junction of the basalt and granite along the left bank, and has exposed a magnificent section of the lava-stream, 4 or 5 miles long, and from 120 to 150 feet in vertical height. As in many similar cases, there seem to be two beds instead of only one, but closer examination shows that such is not the case. The appearance is produced by the line of junction of the columns of which both portions are composed, and which owe their origin to cracks due to contraction by cooling of the upper and lower surfaces respectively, and their extension inwards till they meet. The upper part, being exposed to the air, has cooled more rapidly and irregularly, and the columns are consequently smaller and more imperfect. The lower portion parting with its heat only to the rock or the soil below, both of which are comparatively bad conductors, has cooled very slowly and uniformly, and the columns are wonderfully regular and perfect.

PLATE XXXVIII.

[*To face p.* 74.

The flat top of the lava-flow has weathered into very fertile soil. Its junction with the granite side of the valley is obscured by material brought down by the rain. The lower surface of the lava where it rests on the rock, or in other places on the gravel of the old stream bed, is usually rough and cindery. The lava proceeded from the Coupe de Jaujac, a scoria cone further up the valley, and was perhaps reinforced by some from the cone of Soulhiol, on the opposite side.

PLATE XXXIX.

GRAN CANARY.

Isleta: A Cone of Single Eruption.

The Isleta is a peninsula which protects the harbour of Las Palmas in Gran Canary. It is entirely formed of volcanic materials, and affords one of the few examples where the effects of volcanoes are useful and not injurious to man. On it are several cones of eruption, the photograph of one of which shows well the general form assumed by loose ashes and scoria, blown out by a continuance of small explosions from a single small vent, and deposited round it as they fell.

The materials lie at the "angle of repose" (like a railway embankment, for example), both on the outside and the inside of the crater. Where there has been no wind at the time of eruption, the form of such cones is sometimes even more regular than that shown in the photograph

PLATE XXXIX.

[*To face page* 76.

PLATE XL.

GRAN CANARY.

Isleta.

In the foreground is a crater with the sides sloping at the angle of repose, as explained in connection with the last plate.

Behind it is a crater where the scoria appear to have been in a sticky and semi-molten condition when thrown out, and to have remained where they fell. The outer slope is therefore rather steeper, and extends up to a sharp lip; the inner slopes of the crater are nearly vertical and have not slipped in towards the centre as soon as the eruptive blast ceased.

Compare Pl. lxiv., which shows a crater of similar character in Iceland.

PLATE XL.

[*To face page* 78.

PLATE XLI.

GRAN CANARY.

A Cone of Single Eruption near Las Pálmas, with a Lava Stream.

The cone is composed almost entirely of loose ashes, which have slipped down and covered the explosive vent (which was probably near the telegraph pole); at any rate, no trace of a crater is now visible.

The surface of the lava flow is of the cindery type (compare Plates vii., viii., and lv.), and has already weathered sufficiently to support the scanty vegetation, such as *Agaves* and *Euphorbias*, to which such dry situations are congenial.

PLATE XLI.

[*To face page* 80.

F

PLATE XLII.

GRAN CANARY.

The Peak of Galdar.

A tuff cone, of which there are many in the Canary Islands. I could find no crater, unless the slight depression near the base in front represents one. I imagine it was formed, like the last, of incoherent ashes which have been consolidated into tuff by the rain.

PLATE XLII.

[*To face page* 82.

PLATE XLIII.

GRAN CANARY.

The Caldera of Banadana.

A large and deep crater without any accompanying lava stream, and with the lip very little elevated above the surrounding country. It is a type of the volcanic depression now generally known by the name of Caldera. It would appear that the explosion or explosions which formed it must have been sufficiently violent to distribute the *débris* over a large area, as we know happened in the great eruption of Krakatoa. Otherwise, one might have expected to find a larger accumulation of this round about. I could see nothing to suggest that its formation was due to subsidence. Note the manifest outward dip of the beds of tuff forming its walls. (Compare Pls. lxxxi., lxxxii., and lxxxiii., where crater lakes present similar appearances, and the ejected materials have also been widely distributed.)

PLATE XLIII.

[*To face page* 84.

PLATE XLIV.

TENERIFFE.

The Cañadas, from the Summit of Guajara.

The outer crater of Teneriffe, 8 miles in diameter, appears to have been formed by a great explosive eruption like the Crater of Somma (see Pl. xiv.). The highest point of the ring, Mount Guajara (pronounced Huara), is about 1500 feet above the strip of white sand at its base, to which, I believe, the name Cañadas properly applies. The crater walls are in places even more precipitous than those shown. It was on the summit of Guajara that the late Prof. Piazzi Smyth first established a telescope, and demonstrated the advantages of mountain observatories. Later on he erected his instruments near the summit of the peak of Teneriffe with still better results.

PLATE XLIV.

[*To face page* 86.

PLATE XLV.

TENERIFFE.

The Peak from the Foot of the Pass of Guajara.

Since the excavation of the great crater ring or Caldera, the volcano has been many times active, though not at very frequent intervals, and has built up the great cone which now forms the highest point of the peak. Many lava streams descend its slopes, and those in the middle distance have much reduced the depth of the Cañadas, as the eruptions of Vesuvius are filling up the old crater of Somma. To the left is seen the parasitic crater of Cajorra, which was active in 1798, and to the right some similar smaller cones. The Cañadas, the strip of white sand at the foot of the crater walls, forms a natural highway from one side of the Island to the other over the Pass of Guajara.

PLATE XLV.

[*To face page* 88.

PLATE XLVI.

TENERIFFE.

The Baranco d'Inferno.

The outer slopes of Teneriffe are much seamed by torrents which produce the umbrella-like appearance so characteristic of volcanoes, especially those formed of tuff. Where hard sheets of lava are cut across, bold escarpments are formed, such as are shown in this view.

PLATE XLVI.

[To face page 90.

PLATE XLVII.

ICELAND.

Seydisfjördr, bedded Basalt.

A great part of the north and east coast of Iceland is composed of volcanic rocks. These are probably of miocene age, being apparently contemporaneous with the similar rocks of the Faröe Islands; some parts of the Hebrides, and Antrim in the north of Ireland were probably formed by the same set of outbreaks. At any rate, they date back to before the Glacial Period.

They are composed of almost horizontal beds of basalt, which appear to have been poured out as vast volumes of very fluid lava which have spread over very large areas.

They have suffered much from denudation, and fine sections are exposed both in the sea cliffs and in the walls of the fjords which penetrate deeply into the land.

PLATE XLVII.

[*To face page* 92.

PLATE XLVIII.

ICELAND.

Seydisfjördr, bedded Basalt. Details.

On nearer examination, these rocks are seen to consist of sheets of compact basalt, alternating with softer beds, which appear to represent the soil that accumulated during the periods between the eruption of the different layers. They therefore weather into a series of steps or platforms, whence their name Trap Rocks is derived (from the Swedish *trappa*—a stair).

PLATE XLVIII.

[*To face page* 94.

PLATE XLIX.

ICELAND.

Hafragils Foss, Valley of the Jökulsá.

The Jökulsá which rises under the vast ice-sheet of the Vatna Jokul, in the south-east of the island, runs north through the Myvatus örœfi (desert), and thence into the Axafjordr on the north coast, the earlier part of its course being over the elevated but comparatively level desert. In the northern part of its course it falls rapidly, and has cut a stupendous gorge through the old volcanic rocks of this series. It forms a succession of falls and rapids, of which the above is one of the most picturesque and characteristic examples. The river, as usual with a Jökulsá (glacier river), is very turbid, with finely ground mud from under the ice-sheet. It is too deep and rapid to be forded.

PLATE XLIX.

[To face page 96.

G

PLATE L.

ICELAND.

The Dettifoss.

At the Dettifoss the Jökulsá plunges into a gorge about 400 feet deep, which it has excavated, and in the walls of which the columnar structure of the horizontal basalt lavas is well shown.

It is not probable that every separate layer represents a different eruption (see Pl. xxxviii.).

PLATE L

[*To face page* 98.

PLATE LI.

ICELAND.

The Gorge of the Jökulsá a Fjallum.

The beds of basalt are fewer, more massive, and less distinctly columnar than in the previous plates. The view is, however, quite as typical of the general character of the gorge.

PLATE LI.

[*To face page* 100.

PLATE LII.

ICELAND.

One of the Hljödaklettar.

Near the northern end of the Jökulsá gorge is a very remarkable group of volcanic necks, the Hljödaklettar (echoing cliffs). Some of them are still partly buried in volcanic ash, which obviously formed the mould into which the basalt was injected in a fluid state, from below, and supported the masses in position during consolidation.[1] The river Jökulsá, shown to the right of the plate, has readily undermined and washed away the loose ashes, and exposed the hard basalt, on which it has made very little impression.

[1] Many parts still show a thin selvage of very fine-grained rock, which is owing to the chilling and rapid solidification of the mass where it came in contact with the ashes. It is analogous to the "skin" of an iron casting.

PLATE LII.

[*To face page* 102.

PLATE LIII.

ICELAND.

Another of the Hljödaklettar.

This and the last view show well that the columns are disposed as usual at right angles to the surface of cooling.

These necks, where the explosive stage of the eruption appears to have been over before the fluid lava was injected among the ashes previously thrown out, may be compared with Pls. xxxiv., lxxix., and lxxx., and with Pl. xxxvi., where the neck represents the contents of a volcanic chimney, which had been churned up and down into innumerable fragments by the escape of high-pressure gases, before the mass came to rest and consolidated.

PLATE LIII.

[*To face page* 104.

PLATE LIV.

ICELAND.

Galtalækr, Corded Lava of 1766.

The edge of a lava stream from Hekla.

The fluid lava appears to have been of uniform consistence, and free from imprisoned gases, and to have solidified on the surface to a thickness of a few feet in an almost horizontal position. The deeper part remained molten, and continued to flow. Thus the crust towards the lower end of the stream was raised and broken up into great slabs, of which those at the edge of the flow were tilted up on edge, as shown. Those on the top of the stream are much more horizontal.

PLATE LIV.

[*To face page* 106.

PLATE LV.

ICELAND.

Hekla, Lava of 1766. *Photographed* 1890.

Hekla is a volcano of the Vesuvian type, *i.e.* it consists of a central vent, from which the eruptions habitually take place, and over which a great cone of *débris* has been gradually built up. The explosive eruptions take place from the central crater, with ejection of ashes and scoria, while the fluid lava usually escapes by fissures which form lower down the mountain side. This was the case in 1766, and the plate shows the lava stream descending the hill-side. It is here of the scoriaceous type, having contained much imprisoned vapour at the time of its emission, and in 1890 was beginning to weather, and was covered with lichens. Lower down it appears to have lost its imprisoned vapour, and the lava flowed tranquilly. I believe Pl. liv. shows part of the same stream, but cannot be certain, as bad weather prevented a full examination of the details of the ground. These alternations are not uncommon. The lava of the Skaptár Jökul is slaggy at the upper, and scoriaceous at the lower, part of its course, which is just the reverse of this case.

PLATE LV.

[*To face page* 108.

PLATE LVI.

ICELAND.

Hekla. Dome-shaped Lava.

I have never seen elsewhere the exact counterpart of this curious field of lava. It appears to have solidified quite tranquilly, as its surface is perfectly uniform, and only roughened by small projections, little larger than hob-nails. The rounded domes were probably formed by the contraction of the deeper parts, while the crust was still plastic. I do not think they are bubbles.

The river in the distance is the Vestri Rángá.

PLATE LVI.

[*To face page* 110.

PLATES, LVII. A AND B.

ICELAND.

Reykjalid, a Lava Tunnel.

Blocks tilted up on each side of a central crack in a manner similar to those shown in the plate, extend for several hundred yards. The surface on each side consists of similar lava, which is undisturbed. Below the tilted blocks is a tunnel by which the still liquid lava continued to flow after the surface had consolidated. As it flowed away, the sides of the tunnel fell together somewhat, so that the blocks on the surface were forced up, as shown. These tunnels are common in most extensive lava-flows, though not perhaps so near the surface as in this case.

For the interior of such tunnels, see Pl. lxxii.

ICELAND.

A Gjá (pronounced Geow), Reykjanes Peninsula.

The lava fields of the Reykjanes Peninsula are extensive. Individual flows are often several miles square, and there are many Gjás, or chasms, of which the above may be taken as a type. There is generally a central depressed part of the flow,

PLATE LVIIa.

PLATE LVIIb.

[*To face page* 112.

separated from the higher at each side by a Gjá, the down-throw rarely exceeding 10 or 15 feet. I did not meet with one in this part extending beyond the limits of a single lava-flow, and they appeared to be formed by the escape of liquid lava from below a crust, as shown in previous figures.

PLATE LVIII.

ICELAND.

The Almannagjá, Thíngvalla, Iceland.

This is one of the best-known Gjás, or chasms, for which Iceland is famous.

A very copious flow of lava from craters to the north-west appears to have filled the pre-existing valley of the Oxerá to the level of the present plain (to the left of the plate), and the whole solidified to a depth of more than 100 feet from the surface. Then the lower and still fluid part of the lava found a vent, presumably by the giving way of the lava wall at the lower end of the flow, and the crust in the centre of the valley was thereby lowered. This part is seen to the right. The broken edge of the depressed part would still in many places accurately correspond with that of the vertical cliff, which is about 100 feet high. The streak in the bottom of the chasm is a horse track. The river to the right is the Oxerá, which falls over the lava cliff further up (see Pl. lx.). There is another chasm corresponding to this on the other side of the valley. The meeting-place of the Icelandic Parliament was beyond the right edge of the picture.

PLATE LVIII.

[*To face page* 114.

PLATE LIX.

ICELAND.

Details of the Upper Edge of the Almannagjá.

The view is taken from the level surface on the plain above, looking over the valley of Thíngvalla, where the Oxerá is shown to the right. A vertical wall of lava, a few feet thick, is seen, separated from the main bulk of the cliff by a deep chasm. It looks as if on the point of falling, but its separation apparently took place while the lower part was still pasty, and it has remained firm ever since the final cooling and consolidation.

PLATE LIX.

[*To face page* 116.

PLATE LX.

ICELAND.

The Falls of the Oxerà, Thíngvalla, Iceland.

The Oxerà is a considerable river, whose old bed has been occupied by the lava, over the surface of which it now flows. The river falls into a chasm, as shown above. Though the lava presents such a fresh appearance, its eruption certainly dates from before the colonization of the Island, about 1000 years ago, and the point of interest about the falls is, that during this period the river has not succeeded in cutting its way back into the hard lava more than a few feet.

PLATE LXI.

ICELAND.

The Logberg (pronounced Lawberg), Thíngvalla.

In the lower plain of Thíngvalla are several Gjás, due to unequal settlement of the crust. In the fork between two of them is the Logberg, on which the Parliament met, and from which the laws were proclaimed, in the early days of the Republic of Iceland.

The rock is almost surrounded by deep Gjás, full of water, which is perfectly clear, fresh, and running. It appears to come

PLATE LX.

PLATE LXI.

[*To face page* 118.

through channels deep in the lava. I could not find any of the tunnels by which the lava escaped; no doubt they are deeper down, and full of water. Criminals were formerly executed here, by drowning.

PLATE LXII

ICELAND.

Ásbyrgi, North Iceland.

Ásbyrgi is a **V**- or **U**-shaped subsidence in the north of Iceland, resembling Thíngvalla in its general character and mode of formation, but differing from it in having a large triangular mass of rock left standing in the centre, like the tongue between the two branches of the **V**. This is represented in the photograph, which is taken with the back of the camera towards the main wall of the subsidence.

The original surface of the lava slopes to the north, but that in the subsidence is practically level, and, at the north end, corresponding to the open end of the **V**, the two are continuous. As we go south, along either arm the cliffs on both sides rise higher, so that the main wall at the apex of the **V** is said to be 300 feet high; owing to the slope of the surface the central mass is perhaps not above 150 feet high. (See for scale the man and white horse in the centre of the plate.)

The rocks are very little weathered.

PLATE LXII.

[*To face page* 120.

PLATE LXIII.

SOUTH ICELAND.

A Crater on the Skaptár Lava.

In 1890 I made a journey, with the special object of visiting the crater, or craters, from which the classical eruption of the Skaptár Jökull took place, in 1783, and which is so graphically described by Lord Dufferin, in his *Letters from High Latitudes.*[1] He states, as did the farmers in the Skaptárdalr, "that the craters had never been visited," so that there was the added charm of a new expedition.

On my return, however, I found that Mr A. Helland, the Norwegian Geologist, had described under the name "Lakis Kratere," a series of craters, which are apparently identical with those I visited. These craters, though not actually on the Skaptár Jökull (Jökull—a snow mountain), are near its base, and the lava from them filled the valley of the Skaptár river, so that I prefer to keep to the old name, which appears in so many books.

Until recently,[2] fissure eruptions were little heard of, and though lava had often been noticed to issue from fissures on Vesuvius,

[1] Letter vii., pp. 111-113.

[2] See Geikie, *Text-Book of Geology*, pp. 192, 222, 255, etc.: Geikie, *Geological Sketches*, p. 278.

PLATE LXIII. [*To face page* 122.

Etna, and elsewhere, they were regarded as of secondary importance. This and the following plates show an example of a copious lava flow taking place from a fissure, unconnected with an habitual vent, and with the formation of a row of comparatively small craters. It has been suggested that some extensive lava-flows, such as the Snake River basalts (Pl. ci.), have been erupted in a similar way, but so quietly, that no cones or craters were thrown up.

PLATE LXIV.

ICELAND.

A Crater, Skaptár lava.

A fissure, averaging perhaps 10 feet wide, but narrower towards the end, extends for about 12 miles across the desert plain, which slopes slightly to the south, and along it is an almost continuous row of small craters, seldom more than 200 or 300 feet high. Some are circular, but most are more or less oval. Those at the upper end of the fissure appear to have given exit to the greater part of the gases, and in the bottom of them the fissure is often well seen, as in the last plate. The scoria from some appears to have been ejected in a plastic condition, so that the fragments adhered where they fell, unless the position was one exposed to the full force of the escaping blast. This accounts for the steep sides and well-marked stratification in the crater shown in this plate.

The outer slope is at the usual angle of repose.

PLATE LXIV.

[*To face page* 124.

PLATE LXV.

ICELAND.

A Crater, lower part of Skaptár Fissure.

Towards the lower end of the fissure, the craters are chiefly breached on one side by the escaping lava, and the fissure is in most places occupied and concealed by the last lava of the eruption.

This photograph is a view looking down the row of craters, and shows the lava solidified as it escaped.

Other cones are seen in the distance, along the line of fissure.

PLATE LXV.

[*To face page* 126.

PLATE LXVI

SKAPTÁR CRATERS, LAVA ESCAPING.

This photograph may be regarded as a continuation of the last, but looking up the lava stream, and showing the great waves of the once liquid material solidified *in situ* as it escaped from the fissure.

PLATE LXVI.

[*To face page* 128.

PLATE LXVII.

SOUTH ICELAND.

A Spiracle on the Skaptár Lava.

The lava appears to have contained but little imprisoned vapour, and the ground near the fissure must have been dry, for the surface of the lava near the craters is very smooth, and of the slaggy type. I noticed only one or two spiracles near the craters, of which the above was the best characterised. It was full of blown desert sand. The size may be judged by the man on the top.

Compare Pl. lxxiv.

PLATE LXVII.

[*To face page* 130.

PLATE LXVIII.

THE SKAPTÁ RIVER, ON THE SKAPTÁR LAVA.

Two great lava streams, 50 and 40 miles long respectively, proceeded from these craters, and occupied the valley of the Skaptá and its tributaries, and of the Hverfisfljot, a river further to the east.

The Skaptá valley was filled in places to a depth of 600 feet,[1] and part of it still bears the name of Eldvatn (fire-water).

The river now flows on the surface of the lava, and there are many islands of lava, with some of washed sand. The channels between them are occasionally full of quicksand.

[1] Henderson, *Iceland*, vol. i. p. 279.

PLATE LXVIII.

[*To face page* 132.

PLATE LXIX.

THE SKAPTÁ RIVER.

After visiting the localities shown in the last photographs, we rode 20 miles further down the valley, till we came to a place near Búlaud, where the Skaptá river spreads itself over the lava in eighteen branches; and, by taking these one at a time, we were able to get across.

The foreground is black volcanic sand.

PLATE LXIX.

[*To face page* 134.

PLATE LXX.

NORTH ICELAND.

The Gardrborgir, near Lake Myvatn.

The mountains on the sky-line are ice-worn, and consequently are older than the Glacial Period. In the middle distance are the Gardrborgir, a range of recent small craters on a fissure, comparable to that of the Skaptá Jökull, and the interiors of the craters are similar to those shown in Pls. lxiii. and lxiv.

This fissure, and its accompanying line of cones, are several miles long, but I had no means of estimating how many.

The foreground consists of blocks of lava, with much blown sand.

The lava stream proceeding from this range of craters appears to have flooded nearly the whole of the basin of Lake Myvatn, and the valley of the Laxá below it, as far as its mouth at the sea near Húsavik.

It presents several peculiarities, which are shown in the following plates.

PLATE LXX.

[*To face page* 136.

PLATE LXXI.

NORTH ICELAND.

The Dimmuborgir, near Lake Myvatn.

Before it reaches the lake, the lava-stream exhibits a large subsidence, and a considerable number, probably above a hundred, projecting borgir (castles). The rock of which these consist appears to have been sufficiently solidified to remain standing when the crust round them sank, owing to the liquid lava running out from below it.

They are thus analogous to the great central mass in the Ásburgi (Pl. lxii.) but on a much smaller scale.

They are chiefly interesting as showing vertical marks like slickensides, where the subsiding part of the crust has rubbed against and scratched the wall in its descent. They also present horizontal marks, where the crust has halted long enough to become attached to the still plastic mass.

PLATE LXXI.

[*To face page* 138.

PLATE LXXII.

NORTH ICELAND.

Myvatn, a Lava Cave.

This cave is situated at the lower end of the lake, and is part of one of the channels by which the lava escaped from under the crust. The formation of the roof, with its small knobs of lava, like icicles or stalactites, is worthy of notice. The stalactites mostly showed a metallic lustre, were about a quarter of an inch in diameter, and some of them as much as 2 or 3 inches long. They appeared to have formed as drops when the lava was in a treacly, half-molten condition.[1] The cave was about 8 feet high in the centre, and contained sand, which seemed to have been washed in. This may account for my not noticing any stalagmites on the floor. The stones are artificially arranged, so as to form a manger for farm stock.

[1] For a description of some remarkable lava stalactites, see Bonney, *Volcanoes*, p. 87, *et seq.*

PLATE LXXII.

[*To face page* 140.

PLATE LXXIII.

CRATERS, LAKE MYVATN, NORTH ICELAND.

The basin of Lake Myvatn is studded with craters of all sizes, from small "spiracles," such as those shown in the next plates, to hills over 100 feet high, and all situated on the surface of the lava sheet, with which the lake basin has been flooded.

I saw no spiracles on its surface at any point above where it reached the lake. The region seems to have been a depression containing water before it was invaded by the lava, and, no doubt, there would be much water in the mud and in the fissures in the bottom, which would be converted into steam by the hot lava. This in rising through the latter would entangle portions of it, and on escaping through holes in the crust would form cones on its surface indistinguishable from small ordinary cones of eruption. I found every gradation between the little "hornitos" scarcely larger than bee-hives, and craters above 100 feet high, and believe they all had the same origin. The larger ones form islands in the lake, or are situated near its margin, the smaller are studded over the lava plain which extends down the valley below the lake; just as might be expected if the above be the right explanation.

PLATE LXXIII.

[*To face page* 142.

PLATE LXXIV., A, B, AND C.

MYVATN LAVA. NORTH ICELAND.

Details of craters and spiracles mentioned in the description of the last plate.

(A.) A crater on one of the small islands in the lake, taken from the same spot as the last plate, but looking in the opposite direction.

(B.) A spiracle or blow-hole on the lava beyond the lower or north-west end of the lake.

I have seen similar spiracles and small cones on lava streams elsewhere, but none forming such a fine series as those in this district.

(C.) One of a group of about a dozen craters behind the Parsonage of Skútustadir, at the south side of the lake. The figure to the left is the Dean, Sira Arni Jonson.

PLATE LXXIVA.

PLATE LXXIVB.

[To face page 144.

PLATE LXXIV c.

[*To face page* 144.

K

PLATE LXXV.

NORTH ICELAND.

A Crater of Leirhnúkr, north-east of Myvatn.

This volcano is situated on a prolongation of the line of the Gardrborgir, illustrated in Pl. lxx., and as in that case, consists of a series of small craters along the line of a great fissure extending several miles north and south. Most of them are breached on one side, where the lava has escaped, and the photograph is a characteristic example.

There are many Gjás in this region, all more or less north and south in direction, some having given vent to eruptions, and some apparently being at the edges of subsidences in lava fields, as in the case of Thíngvalla.

This appears to be the crater figured by Sartorius Von Waltershausen (*Geologischen Atlas von Island*, 1853), Pl. xxi.

The great Rift Valley shown in the next plate is quite near, but is concealed by a small ridge, from which the next photograph was taken. It is remarkable that Von Waltershausen should have been so near, and yet have been out of sight of and missed the most remarkable object in the district.

PLATE LXXV.

[*To face page* 146.

PLATE LXXVI.

NORTH ICELAND.

A Great Rift Valley, near Leirhnúkr, north-east of Myvatn, view looking south-east from a Cross Ridge near its Western Wall.

By far the greater number of subsidences in Iceland are clearly due to the escape of lava from under a crust which has sunk down in consequence, but the instance represented in this photograph differs from the ordinary cases, which are confined to one bed of lava in that the fault cuts all the strata impartially. The plate shows to the left a bed of columnar basalt, which has filled up a hollow. Almost in the centre is a mass of older rock, apparently some sort of tuff, reaching up nearly to the surface of the lava. Further to the right the tuff comes in again, and continues to the limit of the plate. The whole, however, has been uniformly cut through by the great fault. There is a parallel face, against the top of which the man is standing, but the structure is obscured by talus, and the rock which formerly occupied the whole space between the two has apparently sunk. The subsidence extends visibly for two or three miles. A small portion, about mid-way in its length,

PLATE LXXVI.

[*To face page* 148.

has not sunk so deeply, and from the top of this the photograph was taken. Much of the floor of the subsidence, especially to the north of this ridge, is concealed by a recent lava flow from Leirhnúkr.

PLATE LXXVII.

KOTLUGIÁ

The Myrdals Jökul is a great ice-sheet in the south of Iceland, under which is situated the crater of Kotlugiá. This is the most dreaded of all the Icelandic volcanoes. When it has an eruption an enormous volume of boiling water overflows the surrounding country, holding in suspension volcanic ejecta, and with masses of ice floating in it. The Myrdalssandr, which is the track taken by these débacles on their way to the sea, is utterly desolate, and fully half a day's ride across. The eruption of 1755 extended the shore line 5 miles out to sea. There was also a severe eruption in 1866.

The photograph, which is from the Fjallabaksvegr on the north, shows the ice-sheet with a few small crevasses and with dirt bands of blown sand. The foreground is sand, and extends under the ice-sheet. The largest river which issues from under this sheet is the Fúlilækr on the south side. It frequently shifts its course among the sands, and is often dangerous to cross, owing to quicksands in its bed.

Its smell is caused by sulphuretted hydrogen, probably from subglacial fumaroles.

PLATE LXXVII.

[*To face page* 150.

PLATE LXXVIII.

EIFEL, RHENISH PRUSSIA.

The Käsekeller, Bertrich.

A thin lava bed of basalt, which has as usual behaved differently in its upper and lower parts. The upper, which would cool more rapidly, is massive; the lower is sub-columnar, and has broken up into short joints, which weather into forms not unlike Dutch cheeses; hence the name. It is chiefly interesting from the historic point of view, as having lent countenance to the idea now abandoned, that basalt columns were formed by the mutual pressure of originally separate globular masses of half-molten lava, instead of by the contraction and splitting of a solid mass.

The authorities of Bertrich, having had their village made known all over the civilised world by its association with the "Käsekeller," have thought fit to rename it, "Elfin Grotto."

PLATE LXXVIII.

[*To face page* 152.

PLATE LXXIX.

RHENISH PRUSSIA.

The Hummelsberg, near Linz.

In this district, which is not far from the old volcanoes of the Eifel and the Sieben Gebirge, are several necks of basalt, which are now extensively quarried. The columns are exported to Holland, where they are used in the construction of dykes. Where not thus artificially removed, they now form hills which cannot ever have been much higher than at present, as shown by the persistence of the irregular columnar layer on the top. The ground around must have been since removed by denudation.

PLATE LXXIX.

[*To face page* 154.

PLATE LXXX.

RHENISH PRUSSIA.

The Mindeberg, Linz.

The disposition of the columns in the Mindeberg shows that the cooling took place from the top, and not from the sides of the hill, which would be protected from loss of heat by a covering, since denuded away.

It is of course conceivable that the molten lava might have been erupted over the surface in a pasty condition and solidified there, as is supposed to have happened in the case of the domitic Puys in Auvergne (see Pl. xxxi.), but if that had been the case, we should have expected the columns to have converged inwards from the surface of the hill. I have noticed the same arrangement in other basalt necks (see Pl. xxxiv.).

PLATE LXXX.

[*To face page* 156.

PLATE LXXXI.

EIFEL, GERMANY.

The Pulvermaar, near Gillenfeld.

There are many crater lakes in the district of the Eifel, of which this is one of the most characteristic. A nearly circular hole seems to have been punched as it were, by an explosion, through the slaty rocks of the district, here of Lower Devonian age, and the *débris* widely distributed over the neighbourhood, mixed with a smaller quantity of volcanic ash.

The slopes of many, perhaps most, of these crater lakes are now clothed with trees.

The hill in the distance is also a crater.

PLATE LXXXII.

CENTRAL FRANCE.

The Lac D'Issarlès.

I have seen several crater lakes in the volcanic district of Central France, and the above, which is one of the most characteristic, is situated south of Le Puy, near the boundary of the old provinces of Velay and Vivarais, both of which contain volcanic remains.

PLATE LXXXI.

PLATE LXXXII.

[*To face page* 158.

Like the crater lakes of the Eifel, it appears to have been formed by a single explosive eruption without emission of lava. As in their case also, the ejecta consist largely of the bed-rock of the country, which is here "granite gneissique," the amount of volcanic material being comparatively trifling. These lakes have been supposed to be due to volcanic subsidences, but the phenomena in such cases are altogether different (see Pls. lviii., lxii., and lxxi.).

PLATE LXXXIII.

CRATER LAKE, OREGON, U.S.A.

The Cascade range of mountains stretches parallel to the Pacific Coast from California, far up into the British Territory. It presents at intervals of from 20 to 100 miles a series of extinct volcanoes, varying from 9000 to 14,000 feet high. Shasta, in California, and Tacoma, within view of the city of that name, are prominent examples, and tower many thousand feet above anything in their neighbourhood.

Crater Lake appears to have been such a mountain, the product of many eruptions, and, like them, extending far enough above the snow line to be clothed with glaciers, some striæ caused by which still remain.

An explosive eruption of enormous magnitude has removed several thousand feet of the summit, and distributed the material over the surrounding country. The result is a crater about 8 miles by 6 miles in size, the rim of which reaches a height of about 8,000 feet above the sea. The cliffs rise about 2,000 feet above the surface of the lake, which is in places 2,000 feet deep. It contains a small island, with a crater like those shown in the crater of Stromboli, but on a larger scale. If it had been still larger, it would have been comparable to the Peak of Teneriffe Pl. xlv.), which is surrounded by an old crater ring of about the same size.

PLATE LXXXIII.

[*To face page* 160.

L

PLATE LXXXIV.

CRATER LAKE, OREGON.

Volcanic Agglomerate.

The rocks forming the walls of the crater consist mostly of beds of lava and tuff comparable to those of Somma, and arranged like them, dipping away from the former axis of the mountain. They are evidently the lower and outer portions of the former mountain, practically undisturbed. I looked for any structures that could throw light on the mechanism of the explosion, and was fortunate enough to find a mass of agglomerate, shown in the plate. It is within the crater's lip, and of different appearance from the undisturbed beds near it. It seems to me certainly part of a mass which was formed by consolidation of materials, that fell back after the explosion or during the series of explosions that formed the crater. A subsequent explosion, or continuance of explosions, removed part of it again, and left the precipice facing the lake.

If, as has been supposed, the crater was once habitually full of molten lava, like Kilauea in Hawaii, and has since been emptied by escape of the lava, I should have expected some remains, such

PLATE LXXXIV. [*To face page* 162.

as lava terraces or beaches, inside it, similar, but on a larger scale, than shown in plate lxxi., but I could find nothing of the kind.

I am therefore satisfied that the lake was formed explosively, and not by subsidence.[1]

[1] For the views of Messrs Diller and Dutton, who advocate a series of explosions and engulfments, and from whose authority I feel it almost presumptuous to differ, see Bonney, *Volcanoes*, p. 129.

PLATE LXXXV.

ON THE ANTRIM COAST. NORTH IRELAND.

For many miles along the coast of Antrim, a series of magnificent sections of volcanic rocks is to be found.

They consist chiefly of almost level beds of basalt, dolerite, and other basic rocks, some of which appear to have been erupted on the surface as beds of lava, while others are intrusive sheets. The platform on which they rest is in part below sea level, but, where visible, it consists chiefly of chalk, with here and there other Secondary rocks.

This plate shows beds of basalt resting on chalk. To the right the whole series is faulted down by a land-slide.

PLATE LXXXV.

[*To face page* 164.

PLATE LXXXVI.

PLEASKIN HEAD. ANTRIM, NORTH IRELAND.

This cliff is about 400 feet high, and consists of many sheets of columnar basalt, with beds of softer material between them. These represent the soils which accumulated on the surface in the intervals between the eruptions.

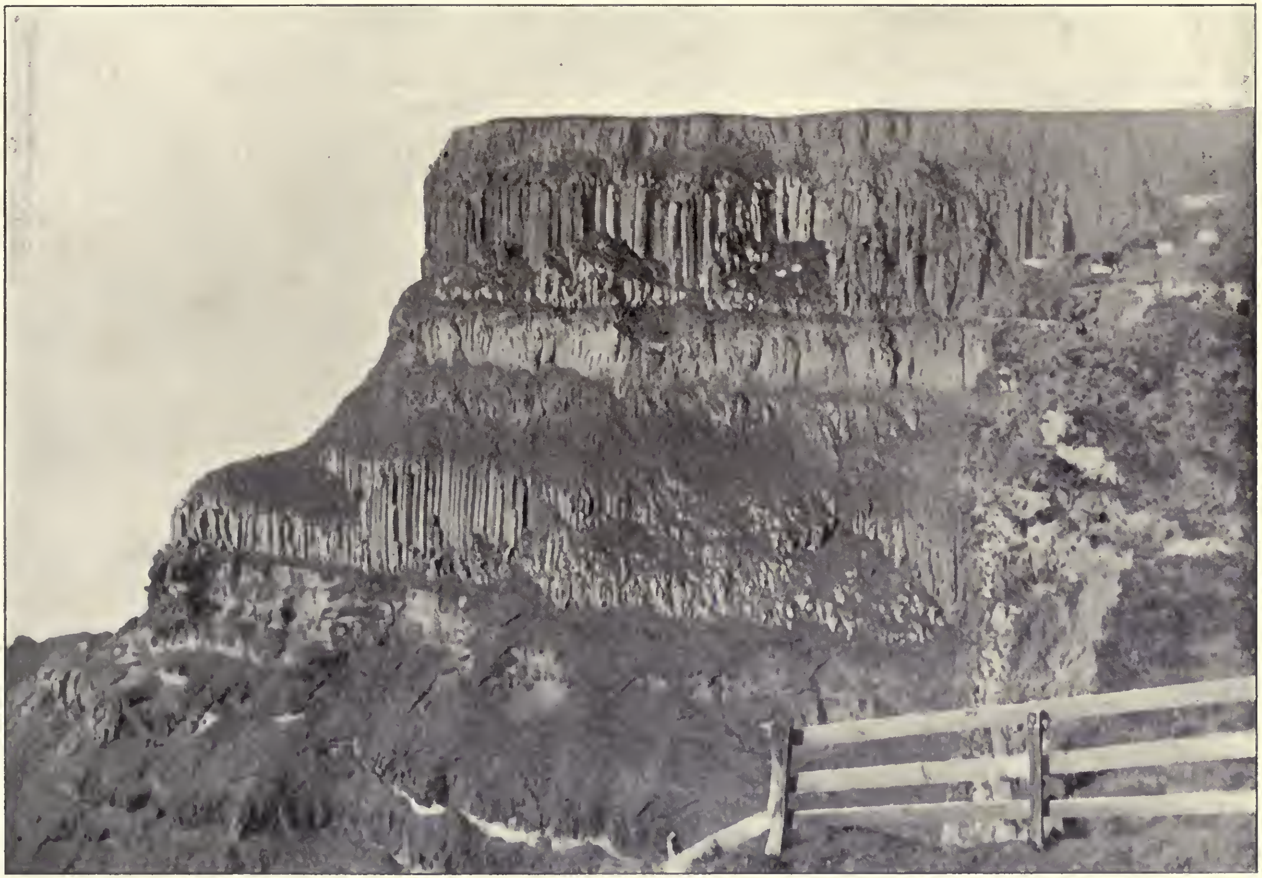

PLATE LXXXVI.

[To face page 166.

PLATE LXXXVII., A AND B.

THE GIANT'S CAUSEWAY. ANTRIM, NORTH IRELAND.

This bed of basalt is near sea level, and has been dissected by the waves, so as to show the arrangement of the columns. They are mostly hexagonal, but where the structure is not very regular, examples occur with more or fewer sides. The cross joints are mostly slightly concave and convex. The Pleaskin shown in the last plate is about a mile beyond the promontory in the background, and the cliffs are continuous between the two.

PLATE LXXXVIIA.

PLATE LXXXVIIB.

[*To face page* 168.

PLATE LXXXVIII.

KINBANE HEAD. ANTRIM, NORTH IRELAND.

The foreground consists of chalk, with the usual beds of basalt capping the whole. The anticline near the centre consists of oolite, lias and chalk, and under it is an intrusive mass of basalt. This locality is classical, as having helped to settle the controversy about the igneous nature of basalt. In the earlier part of the nineteenth century some persons held a theory that it was formed by "aqueous precipitation," but the presence of this mass, which is clearly intrusive, is incompatible with this view.

PLATE LXXXVIII.

[*To face page* 170.

PLATE LXXXIX.

ANTRIM, NORTH IRELAND.

Rocks at Carrick à Raide.

The question of the situation of the crater or craters from which issued the volcanic sheets of Antrim has been much debated. It is clear that what now remains is only a fragment of a formation, which once extended further north, and was part of a volcanic region which included the Hebrides, the Faröe Islands, and Iceland. It is possible that some of the vents may have been situated where the sea now flows. The plate shows chalk in the distance overlain by beds of lava and volcanic ash arranged nearly horizontally, and thinning out as they recede from this centre, while in the foreground the rocks are unstratified and massive, and are supposed to represent a neck, or plug filling up what was once a main vent of eruption. They consist of "coarse greyish volcanic agglomerate, enclosing large, irregular masses and smaller fragments of basalt, basalt bombs of all sizes, and chalk pieces occasionally. Numerous veins and irregular dykes of compact black basalt penetrate the ash in all directions, some of them being columnar in structure."[1]

[1] *Survey Memoirs*, Nos. 7 and 8, p. 31.

PLATE LXXXIX.

[*To face page* 172.

There is no trace of a built-up crater, but Pl. ci. A and B show that enormous lava flows may take place without any large cone or crater, and even if there has been any in this case, it might have been removed by the sea and other denuding agents.

PLATE XC.

ANTRIM.

A Dyke on the Shore at the Giant's Causeway.

A fissure in the rock has been filled up with molten lava, which has solidified and has broken up as usual into prisms at right angles to the surfaces of cooling. The rocks on each side of the fissure have been removed by the sea, while the more durable mass of igneous rock, forming the dyke, now stands up like a wall. In Iceland such dykes are called Giant's walls.

PLATE XC.

[*To face page* 174.

PLATE XCI A.

YORKSHIRE.

The Great Cleveland Dyke, Goathland.[1]

This dyke is first visible on the hills near Robin Hood's Bay, between Scarborough and Whitby on the Yorkshire coast, and extends in a nearly straight line across the Moorland Hills to Ayton, near Stokesley, in Cleveland. It is lost sight of under drift deposits in the Vale of York, but probably continues further and forms part of the same intrusive system as the Whin Sill in the Teesdale district. It is composed of basalt, and is largely quarried for road metal. Our picture shows the work in progress. The abandoned workings stretch for miles across the moors. At Goathland the dyke is from 20 to 30 feet wide; in Cleveland it is sometimes as much as 50 feet. The rocks through which it runs are Jurassic grits and limestones, with occasionally thin beds of "moorland coal." They all show signs of having been acted on by the heat, the last being turned to cinders.

[1] For a very complete description of this dyke, see J. J. H. Jeall, *Quar. Jour. Geol. Soc.*, vol. xl. (1884), p. 209.

PLATE XCI B.

ARIZONA DESERT.

A Butte with Volcanic Dyke. Arizona.[1]

The district of the Grand Cañon of the Colorado in the Arizona Desert presents many examples of volcanic activity.

The rocks shown here are of Triassic age, and the dyke has been formed in the manner described on page 174.

[1] For further particulars see a paper by the Author in the *Alpine Journal* for May 1901, No. 152.

PLATE XCIA.

PLATE XCIB. [*To face page* 176.

M

PLATE XCII.

TEESDALE, ENGLAND.

The High Force.

The Whin Sill is a great intrusive mass of basalt, which has been injected into the Carboniferous rocks of the north of England, and extends over an area of at least 400 and probably 1000 square miles. It averages 80 to 100 feet in thickness.[1] Though preserving a roughly horizontal position for miles at a time, it is found when traced through longer distances to alter its position with regard to the beds among which it lies, and for this and other reasons its intrusive character is considered to be fully proved.

At the High Force the upper part of the section consists of the Whin Sill separated into two beds at about the level of the top of the fall by a band of altered shale; below this is another layer of altered shale, and the whole rests on limestone of Carboniferous age. The fall is 69 feet in height.

[1] See A. Geikie, *Volcanoes of Great Britain*, vol. ii. p. 2, *et seq.*, and Clough, *Quart. Jour. Geol. Soc.*, 1876, p. 466.

PLATE XCII.

[*To face page* 178.

PLATE XCIII.

SKYE.

A Composite Dyke on the Slopes of Sguir na Gilean.

Many of these dykes consist of several parallel layers, representing successive injections of molten lava. In some cases this may merely represent successive stages of one operation, the first portion injected having solidified before the fissure had attained its full width, but in others, some of the layers consist of a totally different rock, as, for instance, an acid granophyre[2] between layers of basalt; and cases even occur of such a dyke forming branches into which the different kinds of rock are separated. In these cases it is obvious that the fissure must have been re-opened subsequently to its first formation, and perhaps at widely-distant epochs.

[1] See Judd, *Quart. Jour. Geol. Soc.*, xlix. 436; A. Geikie, *op. cit.* ii. 159.

[2] A name given a granitic rock, in which the material between the larger crystals forms a sort of rude network or mosaic of quartz and felspar.

PLATE XCIV.

EAST COAST OF SKYE, SCOTLAND.

Intrusive Sills between Portree and Uig.

The light-coloured beds are sedimentary rocks of Jurassic age; the dark bands are intrusive sheets of basalt of later date.

PLATE XCIII.

PLATE XCIV.

[*To face page* 180.

Their intrusive nature is shown by their breaking through the sedimentary beds, so as to appear above and below the same bed at different places. Having consolidated under pressure, they do not show the scoriaceous upper and lower surfaces presented by some varieties of lava, which flowed sub-aerially (see Pls. vii., viii., and lv.). When such surfaces are present, the bed in question is presumably not an intrusive sheet.

The lake in the middle distance is Loch Mealt, and the high ground behind it is the basaltic plateau of the Quiraing.

PLATE XCV.

NAMASKARD, NORTH ICELAND.

A Mud Cauldron.

The hot springs of Iceland are very numerous. In one class, such as the great Geysir of Haukadalr, and the Uxahver near Husavik, the boiling water is clear and limpid, and is subject to outbursts at regular or irregular intervals; it contains silica in solution, and deposits a white siliceous sinter. Unfortunately, the great Geysir did not erupt while I was there.

Another class, such as that of Namaskard, near Reykjalid in the north, and several groups on the Reykjanes peninsula in the south-west, contain boiling mud of the consistence of porridge. In some the mud is white, in others coloured yellow, red, or blue by the presence of oxides of iron. These do not explode, but are constantly boiling and spluttering out pats of mud, which build up a sort of crater round them. The crust thus formed is often thin, and unsafe to walk on, and the active part is apt to be transferred from one spot to another in the vicinity.

The exposure of the photograph has been sufficiently rapid to show the boiling of the mud.

PLATE XCV.

[*To face page* 182.

PLATE XCVI.

YELLOWSTONE PARK, U.S.A.

The Paint Pots, Middle Geysir Basin.

All the phenomena of boiling springs can be studied, on the largest scale, in the Yellowstone Park.

The "Mud Puffs," or "Paint Pots," shown above, are similar to, but larger than, that shown in the last plate. The craters built up by the pats of mud vary from a few inches to a few yards in diameter, and the mud as it dries cracks in a very characteristic manner.

PLATE XCVI.

[*To face page* 184.

PLATE XCVII.

YELLOWSTONE PARK, U.S.A.

A Sinter Terrace, Mammoth Hot Springs.

In the Yellowstone Park, the Mammoth Hot Springs present many sinter terraces similar to the above. The boiling water is clear and limpid, but is strongly charged with silica, which it deposits where it comes in contact with air. This deposit may be merely due to cooling, but is more probably connected with the presence of some micro-organism.[1] At any rate, it takes place more rapidly where the water flows over the surface of the deposit than in the pools behind, so that the edges tend to rise, and the pools to grow deeper, till encroached upon by the growth of other terraces behind. The trees shown have been surrounded and killed by the "formation." The variegated colours of some of the terraces is due to the presence of traces of peroxide of iron. The pink and white terraces of Rotomahana in New Zealand which were unfortunately destroyed some years ago by a volcanic eruption, were of this class.

[1] See W. H. Weed, *Ninth Annual Report of Geological Survey*, U.S.A., p. 619.

PLATE XCVII.

[*To face page* 186.

PLATE XCVIII.

YELLOWSTONE PARK, U.S.A.

The Lone Star Geysir.

The geysirs in the Yellowstone Park are very numerous, and all agree in being springs that pour out boiling water containing silica in solution. The overflow as it cools deposits a formation similar in appearance and composition to that shown in the last plate.

The Lone Star is chosen for this illustration as exhibiting a formation of great regularity and beauty. In all these geysirs the water is not only boiling, but the temperature of the rocks below appears to be above the boiling point. The water is thus superheated, and only kept from being converted into steam by the pressure of the column above. Directly any considerable portion begins to boil and run over the orifice, the pressure below is somewhat relieved, and a great part of the water there is converted into steam and drives that above it out with great violence. Some of the geysirs throw out the water to a height of 180 or 200 feet. This explanation applies to other geysirs, such as those in Iceland.

PLATE XCIX.

YELLOWSTONE PARK, U.S.A.

The Beehive Geysir.

This geysir situated at the Upper Geysir Basin, is so called because its cone is so regular as to resemble a beehive in size

PLATE XCVIII.

PLATE XCIX.

[*To face page* 188.

and shape. It erupts at intervals of about 6 hours, and then presents the appearance shown. It has been found that soap thrown into a geysir will often bring on an eruption, but the geysir then takes a longer time than usual to recover, before it again erupts. The use of soap is therefore now prohibited. Its action was discovered accidentally by a Chinaman in the Yellowstone Park, who erected a shed for a laundry over a boiling spring, which had never been known to act as a geysir. He emptied some soap-suds into the basin of the spring, and produced an eruption, which blew up his shed.

PLATE C.

YELLOWSTONE PARK, U.S.A.

The Riverside Geysir.

This is one of the most picturesque of the geysirs. It is situated close to the bank of a stream of cold water.

Both this and the Beehive Geysirs have "indicators," *i.e.* small holes near the main mouth from which steam and water begin to escape a few minutes before each principal eruption. It seems likely that this escape is really the preliminary boiling which relieves the pressure, and sets the geysir in action.

PLATE C.

[*To face page* 190.

PLATE CIa.

IDAHO, U.S.A.

The Snake River Cañon.

In the far west of America, in the states and territories of Oregon, Washington, California, and Idaho is a vast plain larger in area than Great Britain and France combined, which has been flooded with molten basalt to a depth averaging 2,000 feet. The lava is supposed to have issued from fissures in a manner comparable to the great eruption of the Skaptá Jokull (see Pls. lxiii.-lxx.), but there are less traces of craters. The Snake River has cut for itself a cañon in the lava, said to be in places 4,000 feet deep. I roughly estimated the thickness of the basalt at 500 to 600 feet at the place where I took this photograph, above the Shosone Falls.[1]

[1] See Geikie, *Text-Book of Geology*, Book III. part i. sec. ii.

PLATE CIb.

IDAHO, U.S.A.

The Shosone Falls, Snake River.

At the Falls the cañon has been cut through the basalt into the Archæan rock below, and the river plunges over the latter

PLATE CIa.

PLATE CIb. [*To face page* 192.

to a further depth of about 200 feet. The fall has been called the Niagara of the West. The volume of water is so much less that the title is scarcely deserved, but it must be admitted that the Shosone is much more picturesque, if less imposing, than its Eastern rival. There is an old river-bed (not shown), parallel to the present one, but at a higher level, which presents some dry falls and other objects of interest to the physical geographer.

PLATE CII.

ST VINCENT, WEST INDIES.[1]

The Wallibu Valley, June 1902.

The island of St Vincent is oval, about 18 miles long and 11 miles broad. A ridge of volcanic mountains forms its backbone from north to south, but all have long been extinct except the Soufrière which occupies the north end of the Island. Just to the south of the volcano a deep depression runs across the Island and separates the Soufrière from Morne Garu, the next mountain of the chain. The western part of this depression forms chiefly the Valley of the Wallibu, and the eastern portion that of the Rabaka, with their respective tributaries.

It is a peculiarity of this volcano and Mont Pelée that in the recent, and apparently in several former, eruptions, no true lava has been discharged, but an enormous amount of very hot sand and scoria mixed with much superheated steam and sulphurous gases has rushed down the mountain-side in a sort of

[1] For further information on the subjects illustrated in this and the three following Plates, see "Preliminary Report on the Recent Eruption of the Soufrière, in St Vincent, and of a Visit to Mont Pelée in Martinique," by Tempest Anderson, M.D., B.Sc., F.G.S., and John S. Flett, M.A., D.Sc., F.G.S. Communicated by the Secretaries of the Royal Society. Received August 11, 1902 (Plates xi.-xiii.).—*Proceedings of the Royal Society*, vol. lxx., No. 465, p. 423, August 22, 1902.

Part I. of the Full Report on the same subject was read before the Royal Society, November 20, 1902, and is now (December 1902) in the hands of the printer. It deals with the Topography and general Volcanic Phenomena.

PLATE CII.

[*To face page* 194.

incandescent avalanche, destroying every living thing in its path. The outskirts of this avalanche, where it was mixed with air, constituted the "Black Cloud" or "Hot Blast" so frequently mentioned by the Press. In the case of the Soufrière an enormous quantity of this incandescent material descended into the above-mentioned valleys, and filled them to depths reaching in some places to as much as 200 feet.

At the time of our visit, about a month after the first eruption, the rainy season had set in with unusual violence, as much as five inches of rain having been measured in one day, and this enormous amount of water rushing down and meeting with the still hot sand caused explosions of steam and dust on a large scale, which at first were supposed to be due to genuine volcanic eruptions.

The photograph shows the valley deeply filled with sand, which was hot enough to steam wherever it came in contact with moisture, and in places to burn the bare feet of our porters. In the foreground is the Wallibu River, which has already cut for itself a deep channel. The banks show many portions of circular hollows where explosions of steam took place when the water ran at a higher level. The sand is dark coloured where it has been exposed to the rain and got wet. The light patches in the foreground show where fresh surfaces of dry ash have been exposed by water undermining the bank and causing land-slides. In the distance are the slopes of Morne Garu, with its trees killed by the hot blast and its surface coated with a thin covering of sand which is being sculptured by rain rills.

PLATE CIII.

ST VINCENT, WEST INDIES.

Rozeau Dry River flowing with Boiling Mud.

This is a small stream in the Wallibu Basin. When the water undermines the banks and the hot ashes fall into the river, as described in the last instance, the stream is often temporarily dammed up, and the giving way of the obstruction is associated with a great discharge of boiling mud. In one of our ascents of the Soufrière we had crossed the Rozeau Dry River without difficulty in the morning when the weather was fine, but heavy rain had fallen before our return in the afternoon, and the river was full of boiling mud, coming in gushes, as shown in the Plate. After some trouble our men cut down two trees which had been killed by the eruptions, and made a bridge by which we crossed. The banks show the characteristic erosion by the rain rills.

PLATE CIII.

[*To face page* 196.

PLATE CIV.

ST VINCENT.

A Devastated Plantation. (Lot 14).

On the eastern or windward side of St Vincent all the Plantations on the slopes of the Soufrière were devastated and most of the inhabitants killed.

The photograph shows Lot 14—the highest plantation on the mountain along the old Carib track, which led to the summit. Here the trees were stripped of their leaves and killed, the shrubs and growing crops destroyed, the mill was unroofed and the machinery wrecked. The inhabitants were all killed except a few who took refuge in the cellar, and closed every outlet. A little higher up the devastation was even more complete; great trees were uprooted or broken off short, and the remaining fragments were all deeply charred on the side next the mountain.

PLATE CIV.

[*To face page* 198

PLATE CV.

MONT PELÉE IN ERUPTION.

Taken from a Sloop off St Pierre on the afternoon of July 9, 1902.

It shows the "cauliflower" shapes assumed by the clouds of dust and steam as they drifted westward out to sea. The lighter-coloured cloud to the east (or right) is the trade-wind cloud which so constantly covered the summit. A small light-coloured patch just below the western end of this indicates the fissure from which the chief discharges proceeded. The eruptive "avalanche" of volcanic material which destroyed St Pierre descended the slopes in the centre of the foreground, the town itself lying to the right and outside the picture.

PLATE CV.

[*To face page* 200.

BIBLIOGRAPHY

It would be foreign to the scope of this work to attempt a copious Bibliography. The student should procure one of the three text-books first mentioned, study the photographs in this book with it as circumstances will allow, and then proceed with monographs on the districts he proposes to visit.

TEXT-BOOKS

BONNEY.—*Volcanoes, Their Structure and Significance.* By T. G. Bonney, D.Sc., LL.D., F.R.S. Progressive Science Series. Large 8vo. London: John Murray. New York: Putnam, 1899.

JUDD.—*Volcanoes.* By John W. Judd, F.R.S. International Scientific Series. 8vo. Third edition, 1885. Kegan, Paul, Trench & Co.

HULL.—*Volcanoes, Past and Present.* By Edward Hull, M.A., LL.D., F.R.S. Contemporary Science Series. 8vo. Walter Scott, Limited, 1892.

DAUBENY.—*A Description of Active and Extinct Volcanoes.* By Charles Daubeny, M.D., F.R.S. 8vo. Second edition. Taylor, London, 1848. (Still interesting, and contains notes of many little-known Volcanoes, a Bibliography, and some good plates.)

SCROPE.—*Volcanoes, and the Character of their Phenomena.* By G. Poulett Scrope, F.R.S., F.G.S. 8vo. Second edition. Longmans, 1872. (Still interesting; mentions many out-of-the-way Volcanoes, but is perhaps hardly equal to his work on Central France.)

There are also good articles on Volcanoes in—

GEIKIE.—*A Text-Book of Geology.* Sir A. Geikie, LL.D., F.R.S.

LYELL.—*Principles of Geology.* By Sir Charles Lyell, F.R.S.

MONOGRAPHS

HAMILTON.—*Campi Phelgræi.* By Sir William Hamilton, K.B., F.R.S. 2 vols. folio. Naples, 1776. (Rare.) A magnificent work, with many beautiful hand-painted plates which are feebly copied in the modern books.

HAMILTON.—*Observations on Mount Vesuvius, Mount Etna, and other Volcanoes.* By Sir Wm. Hamilton, K.B., F.R.S. 8vo. London, 1773. An earlier and smaller work, with curious old plates.

SCROPE.—*The Geology of the Extinct Volcanoes of Central France.*—By G. Poulett Scrope, F.R.S. Large 8vo. Second edition. John Murray, 1858. A monumental work, pleasantly but accurately written, with excellent but rather diagrammatic plates, and still the best guide to that very interesting region.

PHILLIPS.—*Vesuvius.* By John Phillips. 8vo. Clarendon Press, 1869. Should be read by all visiting Vesuvius for the first time.

LOBLEY.—*Mount Vesuvius.* By J. Logan Lobley, F.G.S. 8vo. Roper & Drowley, 1889.

JOHNSTON LAVIS.—*South Italian Volcanoes, being the Account of an Excursion by the Geologists' Association of London.* By H. J. Johnston Lavis, M.D., and others. 4to. Furcheim. Naples, 1891. Contains several good photographs and a bibliography of 340 pages.

JUDD.—*Contributions to the Study of Volcanoes.*—By J. W. Judd, F.G.S. Geological Magazine, 1875. An excellent account of the Lipari Islands, with a map and plates. I found it a most useful guide during my visit.

DANA.—*Characteristics of Volcanoes.* By James A. Dana. Large 8vo. Sampson Low (about 1890). A most important work, dealing chiefly with the Hawaiian Volcanoes.

GEIKIE.—*The Ancient Volcanoes of Great Britain.* By Sir Archibald Geikie, F.R.S. 2 vols. large 8vo. Macmillan, 1897. This great work contains a digest of researches by the Author and his Colleagues on the Geological Survey previously scattered through many papers, and now incorporated with much original matter. It is profusely illustrated with reproduced photographs as well as sketched plates, and is indispensable to the student.

PRINTED AT THE EDINBURGH PRESS
9 AND 11 YOUNG STREET.