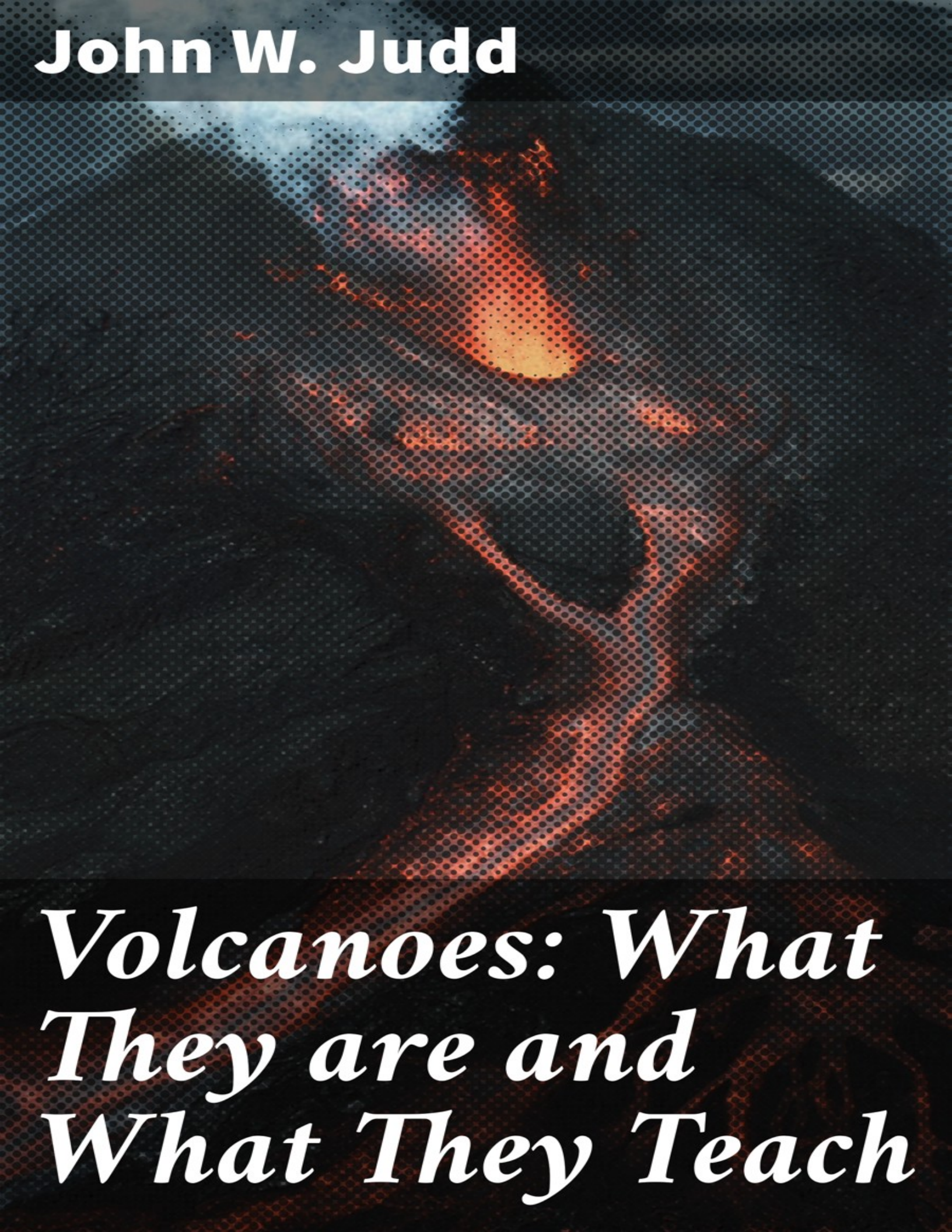


**John W. Judd**



***Volcanoes: What  
They are and  
What They Teach***

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# **Volcanoes: What They are and What They Teach**



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# TABLE OF CONTENTS

PREFACE.

ILLUSTRATIONS.

VOLCANOES.

CHAPTER I. INTRODUCTORY: NATURE OF THE INQUIRY.

CHAPTER II. THE NATURE OF VOLCANIC ACTION.

CHAPTER III. THE PRODUCTS OF VOLCANIC ACTION.

CHAPTER IV. THE DISTRIBUTION OF THE MATERIALS  
EJECTED FROM VOLCANIC VENTS.

CHAPTER V THE INTERNAL STRUCTURE OF VOLCANIC  
MOUNTAINS.

CHAPTER VI. THE VARIOUS STRUCTURES BUILT UP AROUND  
VOLCANIC VENTS

CHAPTER VII. THE SUCCESSION OF OPERATIONS TAKING  
PLACE AT VOLCANIC CENTRES.

CHAPTER VIII. THE DISTRIBUTION OF VOLCANOES UPON THE  
SURFACE OF THE GLOBE.

CHAPTER IX. VOLCANIC ACTION AT DIFFERENT PERIODS OF  
THE EARTH'S HISTORY.

CHAPTER X. THE PART PLAYED BY VOLCANOES IN THE  
ECONOMY OF NATURE.

CHAPTER XI. WHAT VOLCANOES TEACH US CONCERNING  
THE NATURE OF THE EARTH'S INTERIOR.

CHAPTER XII. THE ATTEMPTS WHICH HAVE BEEN MADE TO  
EXPLAIN THE CAUSES OF VOLCANIC ACTION.

INDEX.

# PREFACE.

## Table of Contents

IN PREPARING THIS WORK, I have aimed at carrying out a design suggested to me by the late Mr. Poulett Scrope, the accomplishment of which has been unfortunately delayed, longer than I could have wished, by many pressing duties.

Mr. Scrope's well-known works, 'Volcanoes' and 'The Geology and Extinct Volcanoes of Central France'—which passed through several editions in this country, and have been translated into the principal European languages—embody the results of much careful observation and acute reasoning upon the questions which the author made the study of his life. In the first of these works the phenomena of volcanic activity are described, and its causes discussed; in the second it is shown that much insight concerning these problems may be obtained by a study of the ruined and denuded relics of the volcanoes of former geological periods. The appearance of these works, in the years 1825 and 1827 respectively, did much to prepare the minds of the earlier cultivators of science for the reception of those doctrines of geological uniformity and continuity, which were shortly afterwards so ably advocated by Lyell in his 'Principles of Geology.'

Since the date of the appearance of the last editions of Scrope's works, inquiry and speculation concerning the nature and origin of volcanoes have been alike active, and many of the problems which were discussed by him, now present themselves under aspects entirely new and different from those in which he was accustomed to regard

them. No one was ever more ready to welcome original views or to submit to having long-cherished principles exposed to the ordeal of free criticism than was Scrope; and few men retained to so advanced an age the power of subjecting novel theories to the test of a rigorous comparison with ascertained facts.

But this eminent geologist was not content with the devotion of his own time and energies to the advancement of his favourite science, for as increasing age and growing infirmities rendered travel and personal research impossible, he found a new source of pleasure in seeking out the younger workers in those fields of inquiry which he had so long and successfully cultivated, and in furthering their efforts by his judicious advice and kindly aid. Among the chosen disciples of this distinguished man, who will ever be regarded as one of the chief pioneers of geological thought, I had the good fortune to be numbered, and when he committed to me the task of preparing a popular exposition of the present condition of our knowledge on volcanoes, I felt that I had been greatly honoured.

In order to keep the work within the prescribed limits, and to avoid unnecessary repetitions, I have confined myself to the examination of such selected examples of volcanoes as could be shown to be really typical of all the various classes which exist upon the globe; and I have endeavoured from the study of these to deduce those general laws which appear to govern volcanic action. But it has, at the same time, been my aim to approach the question from a somewhat new standpoint, and to give an account of those investigations which have in recent times

thrown so much fresh light upon the whole problem. In this way I have been led to dwell at some length upon subjects which might not at first sight appear to be germane to the question under discussion;—such as the characters of lavas revealed to us by microscopic examination; the nature and movements of the liquids enclosed in the crystals of igneous rocks; the relations of minerals occurring in some volcanic products to those found in meteorites; the nature and origin of the remarkable iron-masses found at Ovifak in Greenland; and the indications which have been discovered of analogies between the composition and dynamics of our earth and those of other members of the family of worlds to which it belongs. While not evading the discussion of theoretical questions, I have endeavoured to keep such discussions in strict subordination to that presentation of the results attained by observation and experiment, which constitutes the principal object of the work.

The woodcuts which illustrate the volume are in some cases prepared from photographs, and I am indebted to Mr. Cooper for the skill with which he has carried out my wishes concerning their reproduction. Others among the engravings are copies of sketches which I made in Italy, Hungary, Bohemia, and other volcanic districts. The whole of the wood-blocks employed by Mr. Poulett Scrope in his work on Volcanoes were placed at my disposal before his death, and such of them as were useful for my purpose I have freely employed. To Captain S. P. Oliver, R.A., I am obliged for a beautiful drawing made in the Island of Bourbon, and to Mr. Norman Lockyer and his publishers, Messrs. Macmillan &

Co., for the use of several wood-blocks illustrating sun-spots  
and solar prominences.

J. W. J.

LONDON: *May 1881.*





# ILLUSTRATIONS.

## Table of Contents

Sections of igneous rocks illustrating the passage from the glassy to the crystalline structure Frontispiece

FIG.		PAGE
1.	Stromboli, viewed from the north-west, April 1874	<i>tofacep.</i> 10
2.	Map of the Island of Stromboli	11
3.	Section through the Island of Stromboli from north-west to south-east	13
4.	The crater of Stromboli as viewed from the side of the Sciarra during an eruption on the morning of April 24, 1874.	14
5.	Vesuvius in eruption, as seen from Naples, April 26, 1872. ( <i>From a photograph</i> )	<i>tofacep.</i> 24
6.	View of Vulcano, with Vulcanello in the foreground—taken from	43

- the south end of the Island  
of Lipari
7. Minute cavities, containing liquids, in the crystals of rocks. (*After Zirkel*) *tofacep.60*
  8. Minute liquid-cavity in a crystal, with a moving bubble. (*After Hartley*) **63**
  9. Cavity in crystal, containing carbonic-acid gas at a temperature of 86° F., and passing from the liquid to the gaseous condition. (*After Hartley*) **64**
  10. Monte Nuovo (440 ft high) on the shores of the Bay of Naples. (*After Scrope*) **76**
  11. Map of the district around Naples, showing Monte Nuovo and the surrounding volcanoes of older date **78**
  12. Outlines of the summit of Vesuvius during the eruption of 1767. (*After Sir W. Hamilton*) *tofacep.80*
  13. Crater of Vesuvius formed during the eruption of 1822 (*After Scrope*) **82**
  14. Crater of Vesuvius in 1756, **84**

- from a drawing made on the spot. (*After Sir W. Hamilton*)
15. The summit of Vesuvius in 1767, from an original drawing. (*After Sir W. Hamilton*) 85
16. Summit of Vesuvius in 1843 86
17. Outlines of Vesuvius, showing its form at different periods of its history 87
18. Cascade of lava tumbling over a cliff in the Island of Bourbon. (*After Capt. S. P. Oliver, R.A.*) 93
19. Lava-stream (obsidian) in the Island of Vulcano, showing the imperfect liquidity of the mass 95
20. Interior of a rhyolitic lava-stream in the Island of Lipari, showing broad, sigmoidal folds, produced by the slow movements of the mass 96
21. Interior of a rhyolitic lava-stream in the Island of Lipari, showing the 96

complicated crumplings  
and puckerings, produced  
by the slow movements of  
the mass

22. Vesuvian lava-stream of  
1858, exhibiting the  
peculiar 'ropy' surfaces of  
slowly-moving currents. *tofacep.98*  
(*From a photograph*)

23. Vesuvian lava-stream of  
1872, exhibiting the rough  
cindery surfaces  
characteristic of rapidly  
flowing currents. (*From a  
photograph*) *tofacep.96*

24. Concentric folds on mass  
of cooled lava. (*After  
Heaphy*) 100

25. Mass of cooled lava formed  
over a spiracle on the  
slopes of Hawaii. (*After  
Dana*) 100

26. Group of small cones  
thrown up on the Vesuvian  
lava-current of 1855. (*After  
Schmidt*) 101

27. Natural section of a lava-  
stream in the Island of  
Vulcano, showing the  
compact central portion 104

- and the scoriaceous upper  
and under surfaces
28. Section of a lava-stream  
exposed on the side of the  
river Ardèche, in the south-  
west of France. (*After*  
*Scrope*) 106
29. Portion of a basaltic  
column from the Giant's  
Causeway, exhibiting both  
the ball-and-socket and  
the tenon-and-mortise  
structure 107
30. Vein of green pitchstone at  
Chiaja di Luna, in the  
Island of Ponza, breaking  
up into regular columns  
and into spherical masses  
with a concentric series of  
joints. (*After Scrope*) 108
31. Illustration of the 'perlitic  
structure' in glassy rocks 109
32. Transverse section of a  
lava-stream 111
33. The Kammerbühl, or  
Kammerberg, Bohemia (as  
seen from the south-west) 113
34. Section of the Kammerbühl  
in Bohemia 114

35. Natural section of a volcanic cone in the Island of Vulcano 116
36. Section in the side of the Kammerbühl, Bohemia 118
37. Experimental illustration of the mode of formation of volcanic cones, composed of fragmental materials 120
38. Natural section of a tuff-cone, forming the Cape of Misenum, and exhibiting the peculiar internal arrangement, characteristic of volcanoes composed of fragmentary materials. (*After Scrope*) 121
39. Section of a small scoria-cone formed within the crater of Vesuvius in the year 1835, illustrating the filling up of the central vent of the cone by subsequent ejections. (*After Abich*) 122
40. Volcanic cones composed of scorizæ, and breached on one side by the outflow of lava-currents. (*After Scrope*) 128

41. Campo Bianco, in the Island of Lipari. A pumice-cone breached by the outflow of an obsidian lava-stream *tofacep.*124
42. Volcanic cones in Auvergne, which have suffered to some extent from atmospheric denudation. (*After Scrope*) 124
43. Experimental illustration of the mode of formation of volcanic cones composed of viscid lavas. (*After Reyer*) 126
44. The Grand Puy of Sarcoui, composed of trachyte, rising between two breached scoria-cones (Auvergne). (*After Scrope*) 126
45. Volcanic cone (Mamelon) composed of very viscid lava (Island of Bourbon). (*After Bory de St. Vincent*) 127
46. Another Mamelon in the Island of Bourbon, with a crater at its summit. (*After Bory de St. Vincent*) 127
47. Cliff-section in the Island of Madeira, showing how a 125

- composite volcano is built up of lava-streams, beds of scoriæ, and dykes. (*After Lyell*)
48. Section seen at the cascade, Bains du Mont Dore. (*After Scrope*) 130
49. Section in the Island of Ventotienne, showing a great stream of andesitic lava overlying stratified tuffs. (*After Scrope*) 130
50. Cliff on the south side of the Island of San Stephano 131
51. The headland of Monte della Guardia, in the Island of Ponza 131
52. Western side of the same headland, as seen from the north side of Luna Bay 132
53. Sea-cliff at Il Capo, the north-east point of Salina, showing stratified agglomerates traversed by numerous dykes, the whole being unconformably overlaid by stratified, aqueous deposits 137
54. Section observed in the Val 138



- del Bove, Etna, showing a basaltic dyke, from the upper part of which a lava-current has flowed
55. Basaltic dykes projecting from masses of stratified scoriæ in the sides of the Val del Bove, Etna 134
56. Sheets of igneous rock (basalt) intruded between beds of sandstone, clay, and limestone (Island of Skye) 137
57. Plan of the dissected volcano of Mull in the Inner Hebrides *tofacep.*142
58. Section of the volcano of Mull along the line A B "142
59. Summit of the volcano of Monte Sant' Angelo, in Lipari, exhibiting a crater with walls worn down by denudation 158
60. Outlines of lava-cones 160
61. Diagram illustrating the formation of parasitic cones along lines of fissure formed on the flanks of a great volcanic mountain 162

62. Outline of Etna, as seen from Catania 162
63. Outline of Etna, as seen from the Val del Bronte 163
64. Plan of the volcano forming the Island of Ischia 163
65. A primary parasitic cone, with a secondary one at its base—Ischia 164
66. Scoria-cone near Auckland, New Zealand, with a lava-current flowing from it. (*After Heaphy*) 165
67. Section of rocks below the ancient triassic volcano of Predazzo in the Tyrol 165
68. Cotopaxi, as seen from a distance of ninety miles. (*After Humboldt*) 168
69. Citlaltepētēl, or the Pic d'Orizaba, in Mexico, as seen from the Forest of Xalapa. (*After Humboldt*) 169
70. Lac Paven, in the Auvergne. (*After Scrope*) 171
71. The crater-lake called Lago del Bagno, in Ischia, converted into a harbour 172

72. Lake of Gustavila, in Mexico. (*After Humboldt*) 172
73. Peak of Teneriffe, surrounded by great crater-rings. (*After Piazzzi-Smyth*) 175
74. The volcano of Bourbon, rising in the midst of a crater-ring four miles in diameter. (*After Bory de St. Vincent*) 176
75. The volcano of Bourbon, as seen from another point of view, with three concentric crater-rings encircling its base. (*After Bory de St. Vincent*) 176
76. Vesuvius as seen from Sorrento, half encircled by the crater-ring of Somma 177
77. Outlines of various volcanoes illustrating the different relations of the craters to cones *tofacep.*178
78. Island thrown up In the Mediterranean Sea in July and August, 1831. (*After the Prince de Joinville*) 179
79. Sinter-cones surrounding 183

	the orifices of geysers	
80.	Diagram illustrating the mode of formation of travertine- and sinter-terraces on the sides of a hill of tuff	185
81.	Map of the volcanic group of the Lipari Islands, illustrating the position of the lines of fissure upon which the volcanoes have been built up	192
82.	The Puy de Pariou, in the Auvergne, illustrating the shifting of eruption along a line of fissures	193
83.	Ideal section of the Puy de Pariou	194
84.	Fissure formed on the flanks of Etna during the eruption of 1865. ( <i>After Silvestri</i> )	194
85.	Plan of the Island of Vulcano, based on the map of the Italian Government	196
86.	Vulcanello, with its three craters	197
87.	Section of basalt from Ovifak, Greenland, with	319

- particles of metallic iron  
diffused through its mass
88. Diagram illustrating the relations between the terrestrial and the extra-terrestrial rocks *tofacep.*322
89. A group of sun-spots. (*After Secchi*) 362
90. A sun-spot, showing the great masses of incandescent vapour rising or falling within it. (*After Secchi*) 363
91. The edge of a sun-spot, showing a portion of the prominent masses of incandescent gas (A) which detached itself at B and floated into the midst of the cavity. (*After Norman Lockyer*) 363
92. Drawing of a solar prominence made by Mr. Norman Lockyer, March 14, 1869, at 11 h. 5 m. A.M. 364
93. The same object, as seen at 11 h. 15 m. on the same day. (*After Norman Lockyer*) 365
94. Drawings of a solar 366

prominence at four  
different periods on  
September 7, 1871. (*After  
Young*)

95. A group of Lunar craters  
(Maurolycus, Barocius,  
&c.), the largest being  
more than sixty miles in  
diameter 368

# **VOLCANOES.**

## **Table of Contents**

# **CHAPTER I.**

## **INTRODUCTORY: NATURE OF THE INQUIRY.**

### **Table of Contents**

'WHAT IS A VOLCANO?' This is a familiar question, often addressed to us in our youth, which 'Catechisms of Universal Knowledge,' and similar school manuals, have taught us to reply to in some such terms as the following: 'A volcano is a burning mountain, from the summit of which issue smoke and flames.' Such a statement as this, it is probable, does not unfairly represent the ideas which are, even at the present day, popularly entertained upon the subject.

But in this, as in so many other cases, our first step towards the acquirement of scientific or exact knowledge, must be the unlearning of what we have before been led to regard as true. The description which we have quoted is not merely incomplete and inadequate as a whole, but each individual proposition of which it is made up is grossly inaccurate, and, what is worse, perversely misleading. In the first place, the action which takes place at volcanoes is not 'burning,' or combustion, and bears, indeed, no relation whatever to that well-known process. Nor are volcanoes necessarily 'mountains' at all; essentially, they are just the reverse—namely, holes in the earth's crust, or outer portion, by means of which a communication is kept up between the surface and the interior of our globe. When mountains do



exist at centres of volcanic activity, they are simply the heaps of materials thrown out of these holes, and must therefore be regarded not as the causes but as the consequences of the volcanic action. Neither does this action always take place at the 'summits' of volcanic mountains, when such exist, for eruptions occur quite as frequently on their sides or at their base. That, too, which popular fancy regards as 'smoke' is really condensing steam or watery vapour, and the supposed raging 'flames' are nothing more than the glowing light of a mass of molten material reflected from these vapour clouds.

It is not difficult to understand how these false notions on the subject of volcanic action have come to be so generally prevalent. In the earlier stages of its development, the human mind is much more congenially employed in drinking in that which is marvellous than in searching for that which is true. It must be admitted, too, that the grand and striking phenomena displayed by volcanoes are especially calculated to inspire terror and to excite superstition, and such feelings most operate in preventing those close and accurate observations which alone can form the basis of scientific reasoning.

The ancients were acquainted only with *IDEAS OF THE* the four or five active volcanoes in the *ANCIENTS*. Mediterranean area; the term 'volcano' being the name of one of these (Vulcano, or Volcano, in the Lipari Islands), which has come to be applied to all similar phenomena. It is only in comparatively modern times that it has become a known fact that many hundreds of volcanoes exist upon the globe, and are scattered over almost every

part of its surface. Classical mythology appropriated Vulcano as the forge of Hephæstus, and his Roman representative Vulcan, while Etna was regarded as formed by the mountains under which a vengeful deity had buried the rebellious Typhon; it may be imagined, therefore, that any endeavour to more closely investigate the phenomena displayed at these localities would be regarded, not simply as an act of temerity, but as one of actual impiety. In mediæval times similar feelings would operate with not less force in the same direction, for the popular belief identified the subterranean fires with a place of everlasting torment; Vulcano was regarded as the place of punishment of the Arian Emperor Theodosius, while Etna was assigned to poor Anne Boleyn, the perverter of faith in the person of its stoutest defender. That such feelings of superstitious terror in connection with volcanoes are, even at the present day, far from being extinct, will be attested by every traveller who, in carrying on investigations about volcanic centres, has had to avail himself of the assistance of guides and attendants from among the common people.

Among the great writers of antiquity we find several who had so far emancipated their minds from the popular superstitions as to be able to enunciate just and rational views upon the subject of volcanoes. Until quite recent times, however, their teaching was quite forgotten or neglected, and the modern science of Vulcanology may be said to have entirely grown up within the last one hundred years.

The great pioneer in this important branch of research was the illustrious Italian naturalist Spallanzani, who, in the

year 1788, visited the several volcanoes of his native land, and published an account of the numerous valuable and original observations which he had made upon them. About the same time the French geologist Dolomieu showed how much light might be thrown on the nature of volcanic action by a study of the various materials which are ejected from volcanic vents; while our own countryman, Sir William Hamilton, was engaged in a systematic study of the changes in form of volcanic mountains, and of the causes which determine their growth. At a somewhat later date the three German naturalists, Von Buch, Humboldt, and Abich, greatly extended our knowledge of volcanoes by their travels in different portions of the globe.

The first attempt, however, to frame a *CHARACTER OF* satisfactory theory of volcanic action, and *MODERN* to show the part which volcanoes have *RESEARCHES*. played in the past history of our globe, together with their place in its present economy, was made in 1825, by Poulett Scrope, whose great work, 'Considerations on Volcanoes,' may be regarded as the earliest systematic treatise on Vulcanology. Since the publication of this work, many new lines of inquiry have been opened up in connection with the subject, and fresh methods of research have been devised and applied to it. More exact observations of travellers over wider areas have greatly multiplied the facts upon which we may reason and speculate, and many erroneous hypotheses which had grown up in connection with the subject have been removed by patient and critical inquiry.

We propose in the following pages to give an outline of the present state of knowledge upon the subject, and to indicate the bearings of those conclusions which have already been arrived at, upon the great questions of the history of our globe and the relations which it bears to the other portions of the universe. In attempting this task we cannot do better than take up the several lines of inquiry in the order in which they have been seized upon and worked out by the original investigators; for never, perhaps, is the development of thought in the individual mind so natural in its methods, and so permanent in its effects, as when it obeys those laws which determined its growth in the collective mind of the race. In our minds, as in our bodies, development in the individual is an epitome, or microcosmic reproduction, of evolution in the species.

## **CHAPTER II.**

### **THE NATURE OF VOLCANIC ACTION.**

#### [Table of Contents](#)

THE dose investigation of what goes on within a volcanic vent may appear at first sight to be a task beset with so many difficulties and dangers that we may be tempted to abandon it as altogether hopeless. At the first recorded eruption of Vesuvius the elder Pliny lost his life in an attempt to approach the mountain and examine the action which was taking place there; and during the last great outburst of the same volcano a band of Neapolitan students, whose curiosity was greater than their prudence, shared the same fate.

But in both these cases the inquirers paid the penalty of having adopted a wrong method. If we wish to examine the mode of working of a complicated steam-engine, it will be of little avail for us to watch the machinery when the full blast of steam is turned on, and the rapid movements of levers, pinions, and slides baffle all attempts to follow them, and render hopeless every effort to trace their connection with one another. But if some friendly hand turn off the greater part of the steam-supply, then, as the rods move slowly backwards and forwards, as the wheels make their measured revolutions, and the valves axe seen gradually opening and shutting, we may have an opportunity of determining the relations of the several parts of the machine to one another, and of arriving at just conclusions concerning the plan on which it is constructed. Nor can we doubt that the parts of the machine bear the same relation

to one another, and that their movements take place in precisely the same order, when the supply of steam is large as when it is small.

Now, as we shall show in the sequel, a volcano is a kind of great natural steam-engine, and our best method of investigating its action is to watch it when a part of the steam-supply is cut off. It is true that we cannot at will control the source of supply of steam to a volcano, as we can in a steam-engine, but as some volcanoes have usually only a small steam-supply, and nearly all volcanoes vary greatly in the intensity of their action at different periods, we can, by a careful selection of the object or the time of our study, gain all those advantages which would be obtained by regulating its action for ourselves.

Spallanzani appears to have been the first to perceive the important fact, that the nature of volcanic action remains the same, however its intensity may vary. Taking advantage of the circumstance that there exists in the Mediterranean Sea a volcano—Stromboli—which for at least 2,000 years has been in a constant and regular, but not in a violent or dangerous, state of activity, he visited the spot, and made the series of careful observations which laid the foundation of our knowledge of the 'physiology of volcanoes.' Since the time of Spallanzani, many other investigators have visited the crater of Stromboli, and they have been able to confirm and extend the observations of the great Italian naturalist, as to the character of the action which is constantly taking place within it. We cannot better illustrate the nature of volcanic action than by describing what has been witnessed by numerous observers within the