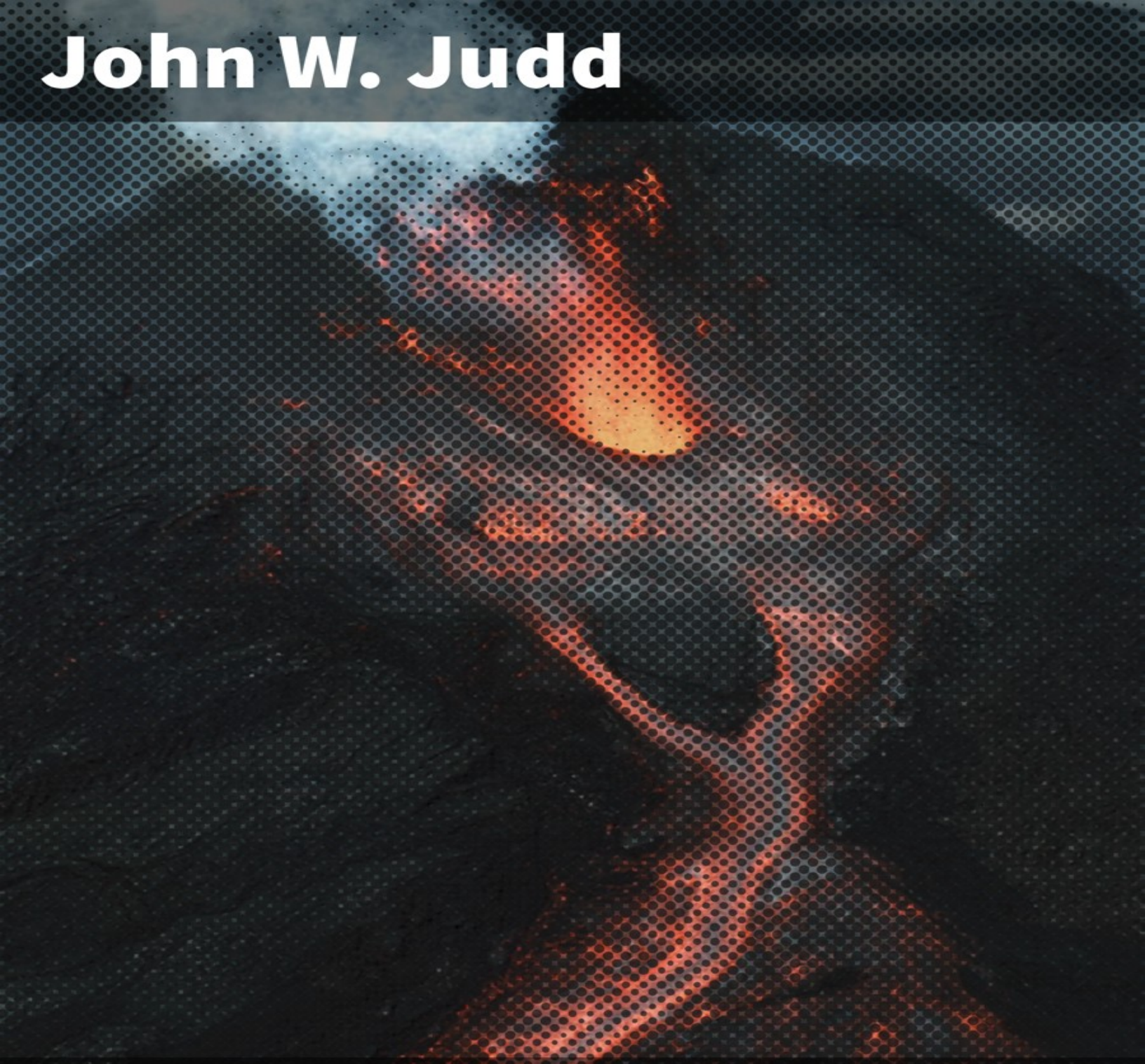
John W. Judd



Volcanoes: What They are and What They Teach

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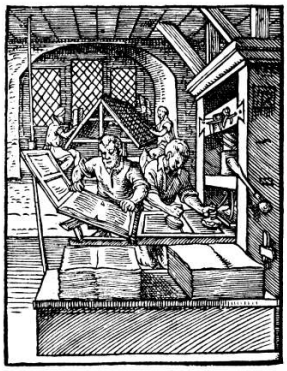

Published by Good Press, 2022

goodpress@okpublishing.info

EAN 4064066427313

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PREFACE.

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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.

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VOLCANOES.

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CHAPTER I.
INTRODUCTORY: NATURE OF THE INQUIRY.

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'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.

IDEAS OF THE ANCIENTS.

The ancients were acquainted only with the four or five active volcanoes in the 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 £act 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.

CHARACTER OF MODERN RESEARCHES.

The first attempt, however, to frame a satisfactory theory of volcanic action, and to show the part which volcanoes have 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.

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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