described by Kentmann, and in 1664 the existence of leaf-impressions in true rock was for the first time published by Major. In 1699, Lhywd, a Londoner, figured and described a number of ferns from the Coal-Measures, which can even now be recognised. These he was inclined to consider due to the *succus petrificus*, a petrifying juice whose action was controlled by the *vis lapidifica*, both petrifying forces having been invented by Kircher in 1655, when he propounded his theory of *seminaria de corpuscula salina* as the true faith regarding petrifactions. Sperling believed in a special stone-making spirit, and Camerarius (1712) held that in the beginning God had supplied the earth's interior with these varied forms, just as he had placed grass and herbage on its surface. Still others were content to regard fossils as mere freaks of Nature. Such-like ideas held the field, and only began to give way during the early years of the eighteenth century, for we find that, as late as 1733, infinitesimal particles were believed by a Dr. Arnold to have been brought together at the Creation to form dead outlines or images of all the living creatures upon or within the world. During all these dark ages, however, there were not wanting writers who held more rational views as to the nature of fossils, and even combated the supernatural explanations of the dominant schools. It was due to fossil vegetables, according to Brongniart, that these crude ideas came to be abandoned. All these theories were swept away by the "Flood theory," the first germ of which is apparently to be found in Luther's commentary on Genesis, where he expresses the belief that surviving indications of the Deluge would be found in the form of wood hardened into stone around the mines and smelting-mills. Several writers between Luther's time and the close of the sixteenth century held the same view, but the Flood theory was for a time drowned in the more fantastic speculations then in vogue, not to come to the surface again until another century had passed. In 1695 Woodward published a work on fossils, in which he maintained that all the solid parts of the earth's crust were loosened by the Flood and mingled promiscuously in its waters, and that at its close everything sank back to the surface according to its specific gravity, the remains of animals and plants assuming the positions in which they are found petrified. The chiefest expounder of this hypothesis, however, was Scheuchzer, whose great work on fossils, in 1709, laid the foundations of palæobotany, though he subsequently rendered himself even more notorious by describing a large fossil Salamander as *Homo diluvii testis*. His work, however, aroused so deep an interest that for many years collectors and writers were busy searching for and describing fresh evidences in support of the Diluvial theory. It had indeed for some time no serious rival, and remained all but universally accepted down to the second half of the eighteenth century, when dissentients first ventured to make themselves heard. The last two decades of the eighteenth century were destined to witness a collapse of the Diluvial theory as rapid as its rise in the first decade, though Hugh Miller even found supporters of it in our own time.

During the seventeenth century the occasional protests of the rational minority, among whom we find Steno, made few disciples; but during the eighteenth their arguments were felt with increasing force. The Deluge hypothesis, faulty as it was, was a great actual advance, for it at least recognised the real nature of the objects, and turned discussion towards the means through which fossils came to be embedded. Though several authors wrote in a truly scientific spirit during this century, it was Blumenbach who first taught with authority that the beings to whose former existence these fossil forms were due were not only antediluvian, but pre-Adamitic, and that, moreover, there had been a series of faunas and floras inhabiting the earth before the age of man. The change in opinion, however, had long been preparing, and prominent among the questions that led up to it were: Are these the remains of the same kind of plants that are now found growing upon the earth? and, When did the originals live that have been preserved by changing into stone? Only two generations since the answers would have been universally that they were plants that grew but a few thousand years ago, and that they either grew where found, or had been brought from other countries by some such agency as the Flood, or else had been destroyed by these agencies and become extinct. Scheuchzer regarded them as plants which could still be found living, citing a number of genera as examples. Among many others who embraced this view was Lehmann (1756), who laboured hard to prove that the impressions of *Annularia sphenophylloides* were flowers of *Aster montanus*, caught in full bloom, and petrified *in situ*. The exotic theory, as it may be called, first appears in a note of Leibnitz, 1706, on the occurrence of impressions of Indian plants in Germany; and in 1718 Antoine de Jussieu discussed the resemblances of the coal plants of St. Chaumont to ferns of the tropics. Parsons (1757) stated that the Sheppey fruits were absolutely exotic, and Dulac soon after compared the coal plants of St. Etienne to American species. These instances are only a few among many, for similar views became commonly held. Volkmann (1720) and others held what may be described as a degeneration theory, believing that antediluvian vegetation was of a higher order, and free from thorns, thistles, and other scourges, while comprising many fruit-bearing trees of which our modern ones are the degenerate representatives. The same authors held at the same time mixed views, thinking that many of the petrified plants might have become extinct during the Deluge or other physical changes, and it was probably this idea that led to the more critical investigation of the stratified rocks, and brought the question as to when the originals lived within the region of practical science.

THE RECENT EARTHQUAKES AND VOLCANIC ERUPTIONS

TERRIBLE as has been the tale of destruction to life and property during the last six years owing to the exceptional activity of the subterranean forces in nearly every part of the globe, we cannot avoid the reflection that scientific men in the future will feel that there have been at least some compensating advantages for these sad losses. Never before, perhaps, have greater opportunities been afforded to us for collecting the real facts, and for testing, verifying, or correcting hypotheses concerning these interesting phenomena; and never, certainly, have such organised efforts been made to deal adequately with the great opportunities which have been afforded to us.

After the earthquakes at Agram, a Commission appointed by the Hungarian Government was sent to examine the district, and the result was a Report of great value and interest, in which the exact details of the actual phenomena observed were carefully sifted from the mass of vague rumours and gross exaggerations with which they had become involved. Admirable monographs on the terrible earthquakes of Ischia in 1881 and 1883 have been prepared by Prof. Mercalli, of Monza, and by our own countryman, Dr. Johnston-Lavis. The tremendous catastrophe which occurred in the Sunda Straits three years ago has already given rise to a vast mass of literature bearing on the subject. Commissions, including very competent observers, were sent to the district by the Dutch and the French Governments, and the former of these has already completed and published its very valuable Report. We may be certain, too, that the more

recent events, in New Zealand and Charleston respectively, will not be allowed to sink into oblivion until every effort has been made to gather to a focus all the light which they are capable of affording to us on the great problems of vulcanology and seismology.

No one can have studied the reports of the late eruption of Tarawera in New Zealand without being impressed by the energy and enterprise exhibited by the local Press of the colony. The first mail after the outbreak brought us very full and detailed accounts collected by correspondents who, braving no inconsiderable risks, travelled over the scene of the catastrophe to collect information, and these accounts were amply illustrated by maps, sketches, and photographs. It must always be remembered, however, that the requirements of journalism and science are different, and to some extent antagonistic: the former demands, above all things, speed; the latter, accuracy. It is often only when the work of the newspaper correspondent is well-nigh forgotten that the scientific man finds himself in a position to deal with the vass mass of unsifted materials—good, bad, and indifferent—which is poured out before him in such wonderful profusion; to him relations of events can never be "stale" if they are capable of being authenticated and of supplying accurate data for the legitimate inductions of science.

In the case of the Tarawera eruption, as in that of Krakatâo, it must be always a subject of regret that the topographical and geological surveys of the scene of the outbreak which were made prior to the event appear to have been far from perfect. Tarawera is situated in the midst of a barren region, in the very heart of the native reserve, and it was moreover most jealously guarded from the intrusions of white men by the superstitious Maoris, who used it as the place for depositing their dead. Dr. Hector, the accomplished Director of the New Zealand Geological Survey, confesses that he had never been able to ascend the Tarawera Range, but that from an examination of its flanks he concluded that it was composed of highly acid (rhyolitic) lavas in *coulées* and dykes, and that large quantities of obsidian and pumice were also present. He was thus led to conclude that Von Hochstetter was right in mapping the mountain as belonging to his recent volcanic series. Mr. Percy Smith, the Assistant Surveyor-General of New Zealand, who like Dr. Hector was upon the spot within a few hours of the outbreak, had been more fortunate in obtaining some knowledge of the upper part of the mountain before the eruption. In the year 1874 he ascended the mountain three times, and found its summit to be destitute of any trace of a crater, but to consist of a table-land about three miles long by half a mile wide, divided into two portions by a saddle, and covered by angular fragments of rhyolite, apparently shivered by the action of frost.

There unfortunately still exists some doubt upon the question as to whether Tarawera has ever been in eruption during the period that New Zealand has been occupied by the Maoris. On the one hand, it has been asserted that no traditions of any previous outbreak are preserved among the natives; but, on the other hand, the names given to the parts of the mountain are said to indicate a knowledge on the part of those who first applied them of its volcanic character, and moreover the extreme sacredness attaching to the locality seems certainly to point to the conclusion that there had been something remarkable in its past history.

Certain it is, however, that, up to June 10 last, Tarawera was not by any means regarded as a spot upon which a volcanic outburst might be expected to break out. But after a series of violent earthquakes occurring on the midnight preceding that day, and lasting for about three-quarters of an hour, a great fissure opened, beginning with an orifice on its northern summit and gradually extending south-westwards to a distance of four miles during the next hour and a half; distinct ejections took place from at least seven vents along this line of fissure. The highly heated condition of the materials thrown from these vents, which set on fire trees at a great distance around the mountain, certainly points to the conclusion that molten lava was ejected from the volcano during this its earliest stage of eruption. But that this lava rapidly became consolidated and no longer incandescent on its surface appears to be clearly established by the observations of Dr. Hector, who, watching the steam cloud on two successive clear nights, was unable to detect any trace of a reflected glow upon it. After the first tremendous outburst, this eruption appears to have been almost entirely a hydrothermal one, and to have slowly but gradually declined in intensity.

Immediately after the completion of the first fissure, there opened a second one throwing out enormous volumes of steam. This second fissure, which eventually attained a length of nearly eight miles, running in a nearly north-and-south direction, was that which passed through the famous lake of Rotomahana. Its ejections seem to have been purely hydrothermal in character, and by the masses of ash and mud thrown out, the beautiful sinter terraces have been apparently converted into mud-volcanoes. There still remains some doubt as to whether the second fissure is not to be regarded as a branch of the first-formed one. The eruptions from a number of vents formed along this second fissure have also been gradually diminishing in intensity; but the quantity of steam and of more or less finely comminuted rock ejected from them has been enormous.

According to the latest accounts which have reached us from the district, the ash, which covers the whole country like a great mantle of snow, effectually prevents the completion of the necessary geological observations upon the scene of the eruption. Indeed, Dr. Hector, after a preliminary survey, felt that no useful detailed work could be done until the rains have removed this covering of loose dust and rendered the country more easily accessible. Mr. Percy Smith has, however, ascended Tarawera, and reports the existence of a great fissure four miles long and five hundred feet wide, of which there seems to have been no trace when he ascended the mountain on former occasions.

It is evident from this brief outline that a number of problems of the greatest interest await solution in connection with the recent display of volcanic energy in New Zealand. Never before, perhaps, have better opportunities been afforded of studying the phenomena attending the formation of the fissures along which volcanic ejections take place. It is remarkable, too, that, although the quantity of materials erupted was very great, there were few if any regular cones of the ordinary pattern built up along the fissures. There also remains much to be learnt concerning the actual nature of the materials ejected at different stages of the outburst, and the way in which they were distributed: all the materials at first thrown out still remain buried under the later ejectamenta.

Upon these and many other problems of the greatest importance we may rely on the geologists of New Zealand, both officials and amateurs, for obtaining all possible evidence during the next few months; and when their researches have been completed the New Zealand eruptions of 1886 can scarcely fail to prove among the most instructive which have ever come under the observation of vulcanologists.

That the terrible catastrophe at Charleston will be similarly utilised by the numerous and able geologists of the United States we cannot for a moment doubt. The telegram despatched by Major Powell during the recent meeting of the British Association at Birmingham shows how fully alive he was to the importance of carrying on systematic observations in the district; among his staff of excellent geologists constituting the United States Geological Survey he will experience no difficulty in

selecting observers admirably qualified for this investigation; nor need we fear that the United States Government will be wanting in their accustomed liberality in publishing the Reports on the subject when they are prepared. Nor will the unofficial geologists of the country and private associations be behindhand in contributing to the mass of information gradually accumulating upon the question of the nature and origin of the terrible event.

ON LION-BREEDING[1]

THE Gardens of the Royal Zoological Society of Ireland have become famous among zoological gardens for their breed of lions. While here and there among the zoological gardens of the world a lion cub is born, none save those of Dublin can boast of a period of lion-cub production of nearly thirty years' duration, or of the extraordinary success of the birth of 131 cubs. This being so, we are indebted to Mr. V. Ball for a history of the subject, which has been published in a recent part of the *Transactions* of the Royal Irish Academy. The subject is one of interest in several ways, and the following short abstract of the details will call our readers' attention to it.

In 1855 a pair of lions from Natal were purchased for these Gardens. The exact relationship of these appears to have been unknown, but their first litter was born in 1857. From 1857 to 1885 we find a total of 131 cubs born, of which twenty-one were either born dead or died shortly after birth, and 110 were reared, eighty-six of these latter being sold, greatly to the profit of the Society and to the advantage of very many of the zoological gardens of Europe, Asia, and America. These 131 cubs were the offspring of nine lionesses and four lions; of the latter, one, "Natal," was the father of forty-two cubs; and another, "Old Charley," who was a son of "Natal's," was the father of forty-six; while of the former, one, "Old Girl," who was born in the Gardens in 1859 as one of a litter of five, was the mother of no less than fifty-five cubs, of which forty-nine were reared. This prolific lioness died at the age of 16 years, apparently of old age.

The facts given by Mr. Ball in one of his very carefully compiled tables seem to indicate two periods of the year at which lionesses in a state of semi-domestication produce their young. While the absence of any well-authenticated information as to the period of the year in which lion cubs are born when in a state of nature is quite remarkable, yet Mr. Ball ventures the fairly safe surmise that considering the period necessary for the rearing and education of a cub to be at the least a year, for the cub is often learning to kill its prey when over a year old, it is most improbable that lionesses have more than one litter in a year when in a wild state; but he thinks it probable that the geographical surroundings of the parents may alter this period, and that it may be in the autumn season in the tropics, when the great heats and droughts of summer are over, and in the spring season in more temperate climes, where the summer warmth would be of service to the young offspring; and he very ingeniously speculates that the two periods of maximum production, as observed in the lionesses in the Dublin Gardens, may have been inherited from two corresponding periods, the result of climatal conditions in a wild state. Another remarkable phenomenon comes to light on comparing the curves of production, when modified into curves of conception, with the monthly curves of temperature for Dublin. In doing so, the maximum curve in the one case is found to closely approximate to the maximum curve of temperature, *i.e.* June and July; and the second maximum curve corresponds to the period of lowest temperature, *i.e.* December and January: but it will be remembered that then the animals are kept in well-heated houses, so that this period, as to temperature, may, though the temperature be artificial, be compared to the other, when it is natural.

The cubs when born are noted as distinctly spotted with dark brown on a ground colour which is rather light brown than fulvous; from about one to three months they are perhaps most distinctly defined; and, though along the back the spots are somewhat quadrangular in shape, there is no indication of actual bars or bands.

In reference to the sexes of the cubs, Mr. Ball is able from accurate information to record the sex of 130 of the cubs, and we find 74 were males and 56 females, giving a majority of 14 males in every 100 cubs. This is an interesting and novel addition to our knowledge of the natural history of the large Carnivores.

No lion or lioness lived in the Gardens for a longer period than 16 years, and it seems probable that 12 to 14 years is the average duration of lion life. The cases so often referred to of lions living to an age of 20 to 30, or the case of "Pompey," who died in the Tower in 1760 at the age of 70, stand on no scientific or even reliable evidence.

Under the heading of "The Cause of Success in Breeding," we find some valuable suggestions as to the keeping of these splendid Carnivores; but we searched in vain for the secret of success. Horse-flesh is evidently not dear in Dublin, as the annual cost of the food of an adult lion, being for the most part horse-flesh, only came to 15*l.* in 1885. A series of tables accompanies the memoir, and some illustrations of the cubs of the lioness "Queen," born April 1885, from drawings by Mr. Thomas.

[1] "Observations on Lion-Breeding in the Gardens of the Royal Zoological Society of Ireland," by V. Ball, M.A., F.R.S., Director of the Science and Art Museum, Dublin, and Hon. Sec. of the Royal Zoological Society of Ireland. *Transactions* of the Royal Irish Academy, vol. xxviii. Part 24, August 1886.

NOTES

AN article in NATURE for May 6 (p. 7) drew attention to the fact that this present year is the tercentenary of the introduction of the potato into England, and discussed some of the points of its history. Apart from the purely historic aspects of the question, "Whence did our potato first come?" it was shown that in connection with the suggestion of cross-breeding to strengthen against disease it is very important to know which is the species that for three hundred years we have been cultivating. With a view to drawing the attention of cultivators to the subject, it is proposed to hold a Tercentenary Potato Exhibition at the St. Stephen's Hall, Westminster, from Wednesday, December 1, to Saturday, December 4, and to appoint one of those days for a Conference, when some of the unsettled questions may be discussed. The Exhibition will consist of four sections:—(1) An historic and scientific collection, to include early works on botany, in which the potato is figured; maps showing the European knowledge of the New World three hundred year ago, and the proximity of potato-growing districts to the ports most frequented; early books on travel and voyages in which references to the potato occur; works and papers in which attempts to define the different species are made; illustrations of the species and varieties; contemporary references to the voyages of Hawkins, Drake, Grenville, and Raleigh. (2) Illustrations of potato disease, and works on the subject. (Sections 1 and 2 will be arranged under the advice of a committee of scientific gentlemen who have consented to give their co-operation.) (3) Methods for storing, preserving, and using partly diseased potatoes, &c. (4) A display of tubers of all the various varieties grown. (In this section gold, silver, and bronze medals will be awarded. Each exhibit must be accompanied by a statement of date of planting, locality, nature of soil, &c.)