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The following Paper was read :—

ON THE INFLUENCE OF GEOLOGICAL REASONING ON OTHER
BRANCHES OF KNOWLEDGE.

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On the installation of the Geologists' Association I was invited to deliver an address, in which were pointed out the several practical objects which the members of the new society might usefully pursue, and thereby accomplish the purpose of the institution. In the course of many years the labours of our colleagues have vindicated the justice of these recommendations by bringing together a mass of valuable facts, and showing what the union of observers can effect, even by means of an organization so unpretending.

Being again invited to address the Association on the opening of a new session, it has occurred to me that it will be less agreeable to dwell on the incidents of our own progress than to deal with some subject of more general influence. This might be found in the growth and history of the science, but such have been often treated, and may be perused in popular works.

There are, however, relations of Geology which have scarcely been considered—those, namely, which, looking beyond its special applications, have reference to its place in the realm of science and its influence on human thought. As a branch of knowledge it is in itself the result of the application of thought, and thus in usual course we are disposed to regard it. This is exemplified in the Influence of Geological Reasoning on other Branches of Science. Inasmuch as Geology is the product of man's influence, so must it react upon him, and, entering on its part in the career of progress, exercise a like function in morals to that which matter once set in motion is destined to perform in the universe, moving and affecting all things, and bringing about other movement and perturbation, even by the cessation of its own action.

It is this direct and indirect action which has given a real vitality to Geology beyond that enjoyed by many other branches of science. Mathematical study does at first sight appear to claim this place, and its value as an instrument of reasoning is great, and

of permanent and constant application, but it does not come home to us with the like power of human sympathy. While Mathematics can claim a direct right to a method of regular reasoning, Geology must be recognised as having fashioned the thought of the age in a general way and in many particulars.

Before the beginning of this century problems of great interest were dealt with wildly. Cosmogony was wild, because it had no facts for its direction, and facts were so handled as to become most assured causes of error. Petrifications gained admission to museums of curiosities, but there they figured as *lusus naturæ*. The accumulation of these showed orders of shells and of plants, but they taught no lesson, and stood as an impediment to research and a hinderance to knowledge. Fossil shells were accounted for by every assignable cause except what truth could determine; they were even supposed to have been placed on mountain tops by the impossible agency of hundreds of pilgrims.

Without entering upon the details of the mode by which a just system was arrived at, it may be remarked that whereas in other cases one man did so much, that mental philosophy was so far indebted to Bacon and that modern astronomy was relatively created by Newton, the science of the earth has been built up by many individuals, to no one of whom can like pre-eminence be assigned. Geology did not pause, for it enlisted a multitude of labourers, and particularly the humblest. There was no waiting for some one to understand the Principia, nor for making the highest reasoning popular and fashionable, in order that it might afterwards be accepted by scientific men. Geology went on as a science of observation ought.

It is as a science of observation that it has exercised a wholesome effect, because it has been shown that observations of facts, even of a trivial nature, will build up truth, correct conjecture, and afford a useful basis for theory. The process has not, however, been the mere collection of a gigantic museum of insects, or of a large herbarium; because each fact has been discussed and tested, so that interest has never flagged, and, consequently, the co-operation of many, without which little true work can be done in science, has never been wanting.

One of the leading results of the collection of observations was the establishment of stratification, and this of itself may be regarded as having exercised a potent effect on modern thought,

because with it were connected the ideas of succession and progression.

These ideas were not of old so well capable of establishment in any other branch of natural science, for classification in the various kingdoms depended on the assignment of groups and regions, and not on succession ; although cryptogamous plants might be regarded as ruder, they could not be assigned as the precursors of the monocotyledonous or of the dicotyledonous. It was a kind of geographical classification on the plane surface of a Mercator's Chart. Not that theories or suggestions of another kind were wanting, but they were unprovided with support.

Notwithstanding the objections of some writers, reasoning by analogy will always prevail in things human, because, after all, as in things human the mind recognises symmetry, so reasoning by analogies is reasoning by probabilities. The admission of stratification was neither more nor less than the introduction of a canon in moral philosophy, and, as the principle became popularised, so has it been extended to various forms of discussion, even to political articles in a periodical journal.

The palæontological relations of simple mineral stratification tended still more to confirm and develop the doctrine of succession, and laid the foundation for that of survival more distinctly than was comprehended by the preservation of strata from denudation, or other influences. Palæontology, however, has had a direct effect on natural history. The groups of existing animals and plants were anomalous and defective, but, as from time to time fossil members were introduced to complete existing groups, as fossil groups intervened to complete series, and as the ruder beings, recognised in the earlier epochs, were found to precede more highly developed forms, so was a more comprehensive view obtained of the whole connexion of natural history. The higher studies of the natural sciences have certainly been greatly acted upon under these circumstances, and thus the naturalist has been made contributory by an unconscious conscription to the militant expeditions of Geology in the development of new regions of investigation.

A consequence of stratification, mineralogical and palæontological, in extension of succession is the acknowledgment of the passage of greater epochs of time than had been heretofore admissible in history or chronology. Thus the range of the infinite

in space, which was extended by the investigation of the fixed stars, and by the determination of the immense minimum of a parallax, was fortified by that element of the eternal in time, which the existence of animal being, of vegetable growth, or of mineral action on this globe showed to be still beyond the computation of eras, in which myriads of years can be involved, and yet figure in their earliest dates as nothing more than later events of long precedent physical action.

The historian of states and empires, and of the evolution of civilization has been compelled to hesitate and to modify his views even before Geology, in its onward march, had furnished him with implements and other records of man in indisputable association with islands and continents which have perished, and with animals extinct before the world's present surface had been bestowed upon it.

This contemplation of time, on the one hand, affected the narration of those passing events in the precarious career of man, but it also gave evidence of fixity, and of a wonderful and long maintained stability in some of the great manifestations of the constitution of the universe. Thus the eye of the trilobite was brought to bear testimony that in the remotest ages of its existence light must have been made sensible under the same conditions as in this day. Geology, indeed, affords us not solely the history of change, not exclusively that of progression, for it gives incontestable lessons that some incidents are immutable, and thus presents us with another aspect of eternity, too little regarded in our philosophy.

The conceptions of the natural philosopher have not only been extended, but have been made more certain by the contemplation of those great operations of water registered in the pebble, or the grain of shingle, of fire penetrating and upheaving the crust of the globe, of magnetic action to which the lines of mineral formation point. The powers of water are understood to include not only stationary and moving fluids, but long protracted, extensive and enormous effects, produced by glaciers and the various forms of ice. Volcanos had been mapped out on the surface, but the philosopher had to work out new problems of spheres of fire and of incandescent metals, and gases preserving their heat during epochs.

It is such contemplation of facts made known which has prepared the way for a bolder study of the solar system, and of that universe, the sparks of which are alone visible to us as yet. The

conceptions of Herschel, corrected and altered, thus assume definite shape, and we begin to deal with the periodic meteors, unexplained comets, and the photosphere of the sun. So, while other branches of science have illustrated the chemical constitution of this, Geology exemplifies the consistency and antiquity of its formation and its operations.

The elements common to the sun, the planets, and as we are led to believe, the universe, have been wrought up in this globe in succession, not of the generations of man, which we have accepted as antiquity, but during the generations of species.

Geography has now to regard these effects of the past, and to consider the connexion of countries by their strata and their mineral relations. Under such circumstances, too, has the distribution of plants and animals taken place. The geographer must look forward to the mapping-out of the ocean, for we know that what now lies at its bottom and in its lowermost depths, has been what we see rising above its shores and shining as snow-capped peaks. There are a vegetation and an animal life now existing in the sea which are the representatives and continuation of what we have embedded in hard rocks, modified by crystallization, or even affected by fire. The fossil marine fauna and flora are the introduction to what is yet to be discovered. Thus Geology anticipates Geography and Natural History, and gains a forecast of events.

Meteorology, instead of being confined to the registration of the phenomena of the present day, is endowed with a part in the knowledge of vicissitudes and changes of climate, which have left the vestiges of glacial action in the tropics, and planted tropical remains in the polar regions. Thus, while in this temperate land, we can cast our eyes over the green meadows, yet on digging far below we come on fruits and spices, which flourished when the sky was hotter. The adaptation to cold regions of the elephant and other beasts, which we have come to think can live only in the tropics, gives us a new aspect of creation, and opens the way for the idea that in these northernmost parts there may have been black inhabitants, and that a negro skin and woolly hair are not exclusively or necessarily confined to the countries near the line.

As the bonds of restriction of thought by prejudice are loosened, and our grasp gains in freedom, the dreams of the past acquire consistency. Legend takes a nearer approach to history, the old wives' tales which were losing the assent of children, are listened to and gathered up by scholars. Folklore, no longer a miscellaneous

gathering of scraps of superstition, gains interest for its wildest fancies of dragons flying in the air, and of man-eating ogres carrying off their prey to caves. We have seen the dragons which have been hidden under earth for thousands of years, and have found the abodes of the cannibals, and handled their weapons and tools. Thus, in the circle of knowledge, nothing is new under the sun, and in science nothing is childish or trivial, but all hold a just place in the great scheme where the living and the dead succeed each other, and death is the parent of life.

It may be said that an economy of knowledge has been taught to us by Geology, to feel that nothing is waste in matter or in mind, but that it has its timely use. The dung of reptiles, buried for ages, fertilizes our fields, the refuse drift of deserted oceans yields us seams of coal, but by the restoration of past knowledge we no less enrich the mind of man.

The whole teachings of Geology, because they unfold to us the history of the universe, of the globe, and, above all, of mankind, exercise the widest and deepest influence over the vast range of human thought. For the immediate service of Geology there have been enlisted the names of a glorious host of men, whom it is not for us at least to number over, for we daily profit by their work. In the domain of natural history, Geology has given special occupation to Cuvier and Owen. These would have been great without it; they have given a double employment to their discoveries by thus associating them with Geology.

It is in philosophy, including theology, that the effect of geological discussions may most clearly be discovered. Undoubtedly they pervade the whole domain of thought, but they are strongest felt in what are the weightiest subjects. The effect goes beyond the gathering of rocks and fossils, the observation of facts, or their records in scientific journals, because among ourselves more particularly they have become matter of discussion and debate, public and private, and thus have impressed the popular mind. Sharing in their labours with the scientific world, the English on both sides of the Atlantic have more especially promoted the advance of geological studies. These needed in their beginning that freedom of controversy which can alone be enjoyed under free institutions, and which is not compensated by the toleration given to a class of professors, or the indulgence accorded to the creatures of a crown or a court.

The variety of formations in these islands was more favourable

to research than the monotony of the great plains of Europe; and though other countries present the same or more striking phenomena, yet a repressive police or a dominant church did not favour the like expansion of novel and unfavoured ideas.

The study suited Englishmen. The desultory collection of small facts, the dealing with these by piecemeal, agreed with the national instincts. The wider conclusions which arose from these details were forced on conviction after full preparation. More philosophical minds might have waited for the proposition of a complete system, or anticipated it by the promulgation of an embracing theory, which would have been accepted and fought for by a school of students until it was superseded by some other. The present order, as in many things English, has proceeded from the most unsystematic beginnings, being the harvest of what is practical, garnered from the weeds and the chaff. Facts have been tested on the banks of the Thames, the Clyde, and the Shannon, on those of the Mississippi and the St. Lawrence, even on the shores of the Ganges, the Murray, and the Vaal, and wherever wandering men of English blood can wander or settle.

Nowhere but in England and America could the conflict have more usefully taken place with the schools of theological interpretations, which had to conciliate scholastic teaching with the evidences of nature. These evidences were in consequence more severely tested and better established, exposed as they were to the investigation and examination of men compelled to give a reason for their faith, than they would have been by those who reposed their reliance in dogmatic teaching, or even by enthusiasts in Geology, ready to sanctify their own superstitions by an easy belief in what they wished to believe.

Clergy and laity were compelled to study geological facts, and, on the other hand, undoubtedly they had to engage in a harder examination of the Scriptures, and many a one was driven to a closer knowledge of the Hebrew language. Indeed, this department of Oriental learning has been as much promoted by the cause referred to as by any other, not but that a greater activity of the human mind has sharpened all incentives to study.

In theology a breadth has been given to interpretation of historical portions of the Scriptures, which has had a most valuable influence on theology and science. That canon has been confirmed, which, dividing the domain between the two, abandons the prero-

gative of theology over science. Theology must undoubtedly be strengthened by its disembarassment from the dogmatic teaching, as incontrovertible articles of faith, of what was beset with natural doubts. Many a man must have been brought within the pale of religion in recent days, whose unconquered doubts were condemned by the constituted authority of ignorance and intolerance. On some this salutary lesson must have been enforced—that the bounds of human knowledge are narrow, and its acquirements uncertain.

It happened, in the nature of things, or rather in the nature of the human mind, that the discoveries of Geology affected those inclinations which, in all ages, have swayed belief, and given rise to interminable controversy. Those who accepted a perpetual succession of matter were eager to apply a system which, even in its gestation and its infancy, gave them the elements of succession and progression. Thus the book known as “*The Vestiges of Creation*” was earnestly perused, and had its day of votaries. The more serious labour of a great student, Charles Darwin, have had a wider effect, because the intellect of Europe awaits each volume of his investigations to decide on acceptance of his doctrines, on confirmation of dissent, or even on suspension of opinion.

These controversies penetrate into the remotest regions, as far as sight can be pushed on by the telescope, or strained in the microscope, and the elements of matter and the beginnings of life are eagerly canvassed. In discovering vitality in its minutest germs and atoms, where the vegetable and the mineral await but transformation to become instinct with thought, Huxley, Bastian, and others, have to confront the most responsible problems, and within the limits of sight—and on the verge of sight—where life is on the point of being born, still to find life a phenomenon intimately connected with matter, and yet beyond it.

All these considerations tend to invest Geology in its highest relations with interest, but they will not authorise us to judge in such controversies. Men of brightest intellect and purest thought will go on, as others have done, to seek in the far past a perfect organisation of matter, which may appear self-sufficing for the economy of the universe. Others, of lower minds, and of lower motives, will follow them in the hope that the sense of responsibility being abolished, the bounds between virtue and vice, good and evil, artificial or divine, as they may deem it, may yet be abolished.

Such is, unfortunately, the inducement to many who peruse geological books, not to acquire truth, but to cultivate doubt. Ethics, however, remain unaffected by physical teaching, and a circle of reasoning brings the experimentalist, whether starting from grounds of simple utility or under the inspiration of moral considerations, to the same result, that what is held to be vice is incompatible with the welfare of mankind.

To the other school, of those who acknowledge evidences of design, Geology offers, in its facts, abundant confirmation, and, by its means, many a man has been strengthened in such convictions. This thing, too, is very certain, that no man, by our studies, has been made less virtuous.

From man in his intellectual aspirations to the science of man in general, is but a step in due course. Ethnology, an earlier science in its traditions, has been greatly favoured by the advance of Geology, and is thereby acquiring the claims of an exact and recognised department of science. Ethnology, in its subject of man, is the nobler science, and has the more distinguished inheritance, but, whatever its development, the mode of reasoning adopted must long be acted upon by that worked out in Geology. We must, for a time, accept strata or epochs of men in the prehistoric and protohistoric periods, we must account for the phenomena of denudation and survival, and even in language, as in the upper strata we recognise the percentage of older fossils, so shall we calculate the persistence of remotest and oldest roots and words.

In due course we shall expect the reaction of Ethnology on Geology, and perhaps obtain new modes of discovery, or, at all events, of illustration. Whatever may be the immediate results of our studies, we shall nevertheless have this inducement to persevere, that all knowledge is general knowledge, that its relations are with the past as well as the present, that from a flint we may make known the annals of a race of men, or by a fossil point out the extension of unexpected stores of mineral wealth, and that, while no labour of the meanest student is idle or worthless, so there is no fleeting moment of time but may witness the birth of the greatest discovery.