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CONTENTS

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GEOLOGY AND THE WORLD AT LARGE[1]

I HAVE no new discovery to announce nor shall I follow the precedent of reviewing the history of geology in part or in whole. Rather I shall ask you to step out of the procession and with me watch it go by. In brief, we shall try to see ourselves as others see us. Frankly, the picture is not flattering. To the world at large geology has taken a back seat. She has lost prestige as compared with other subjects of human thought, and is serving neither herself nor the world as she can and ought. I believe the situation is a challenge to geologists to take stock of where they stand and to again get into the procession in a place commensurate with the large human interest of the subject they represent.

For the past eight years my associations have been mainly and very close with men outside the profession—bankers, merchants, lawyers, judges, manufacturers, bakers, butchers and candlestick-makers. Hundreds of these men call me by my first name and have told me how much they don't know about geology and why.

I live in a town where most of the leading men of all professions are conservative, in theology and otherwise. I do not think that they differ greatly from the leading business and professional men of other towns, and I feel that these men would be vastly enriched in their thinking by a clear knowledge of the larger findings of science in general and of geology in particular.

How many members of your home chamber of commerce or your Rotary or Kiwanis or other service clubs, for example, have any clear idea of geologic time, a conception in which years and centuries sink into insignificance that puts human history in its proper setting, or of the vast geologic changes the earth's surface has undergone or of the story of life's marvelous unfolding up the geologic ages as read in the rocks? My own conclusion is that not one in ten of the big men of my town, the men who own the big stores or manufacturing plants, who dominate its politics, who in a large measure have built and made the town what it is, have more than the vaguest idea

[1] Address of the vice-president and chairman of Section G—Geology, American Association for the Advancement of Science, Nashville, December, 1927.

of these things. They are not real and actual to them. They do not affect their thinking.

More astonishing still I am convinced that the average man of culture of fifty years ago had a better knowledge of these things than the man of culture to-day. Then, every person of culture had some knowledge of geology. It was widely taught in the "academies" of that day, using Dana's "Briefer Story," Steele's "Fourteen Weeks," and other works, and, here in Tennessee, Safford's "Elements of Geology." The fascinating writings of Hayden, Shaler and King, the memories of Lyell, the discussions and disputes of Marsh and Cope, were public property. Geology held a leading place in the museums. Some museums had little else than geologic material, partly because of the activity of Henry Ward in supplying this material. We were a new country with little knowledge of our own mineral resources, and the men who explored this new country and told us of its mineral wealth and earth secrets loomed large in public affairs.

To-day geologic text-books have practically disappeared from high schools and only a small proportion of those who go to college are exposed to this line of knowledge, and I am astonished to find how many of these appear to have missed inoculation and have forgotten about all they knew. Apparently, from what I have gathered from them, our text-books have become so largely a catalogue of facts that the great truths have been lost in the multitude of findings.

Individually most of us are so engrossed in the necessary details of our work that we have all but lost sight of these great truths of which the world at large is blissfully ignorant and of which the world is woefully in need. Our work is no longer spectacular as once it was. It is slow, patient, plodding work, as of the research engineer or surveyor. And when our work does lead out into something interesting or thrilling, we feel that the world at large would not understand, and that by the time we had explained the whole matter so that it would understand the thrill would have worn itself out and become only a shiver. So we content ourselves by telling our fellow workers, conscious that most of them are too busy to read our story after we write it.

The result of all this is that the world at large has lost interest and in large measure even lost track of us. In the field we seldom speak of ourselves as geologists but as mineral surveyors, as that designation is at least partly understood, but not geologists. Geology in the minds of most people is associated only with the finding of mineral deposits, water and fossils. We are often classed with the mineral prospector and in the minds of many have faded out with that picturesque but worthy, if usually impecunious, individual. We hear of great foundations and laboratories for the study of medicine, physics, chemistry, archeology and other sciences, and of expeditions to other lands. We see physics and chemistry and perhaps biology being studied in practically all high schools but what of these have we in geology? A few of our museums feature the bones of giant reptiles. But all too many of them have relegated geology to back rooms and galleries.

So to-day when we are faced with the most stupendous problems facing any science we are handicapped by lack of funds and lack of interest. Geology to-day is breaking away from its old moorings, whether for better or worse. Great fundamental problems face us. Is isostasy true, and, if so, what are its causes and laws? Do the continents float around at will? Did Mesozoic time begin 25 or 250 million years ago? How came our mountains to be? Is there likely to come another ice age, a state-wide lava flow, a continental flooding, such as has often occurred in the past? All of these problems are being approached from new angles. The very foundations of the deep are being stirred; but the world at large knows little of it, would not understand it if told, and so has little interest and is not inclined to be sympathetic to our call for help.

I said the world at large needs geology. Let me take a single example. Some time ago biology stirred up a pretty rumpus over a little matter called evolution. Unfortunately, evolution was not content to remain simply a theory of the biologist. It insisted on getting mixed up with geology and astronomy, with physics and chemistry, with history and archeology, with philosophy and theology, and right there is where it ran afoul of a very real opposition; for nearly everybody holds some kind of theologic belief and evolution said that much theologic belief failed to fit the facts. Biology, of course, came back with "Here are the facts, see for yourselves." Unfortunately the biologic facts are a little difficult to display. For example, it is hard to show a man his strange embryonic development before he saw daylight and said "Hello, folks." It is difficult to demonstrate to him his vestigial reminders of other days when he was only a monkey, a reptile or a fish. It is difficult to bring home to him the bearing of the facts of geographic distribution.

On the other hand, geology deals with mountains and mastodons and other big things you can see. The slow seaward movement of the land is common knowledge when attention is called to it. The progress of life as revealed in the rocks can be easily shown in museums. Nearly any one can go out and collect fossils. Seashells or shark's teeth in the rocks form-

ing mountain tops compel the thoughtful consideration of any thinking man. Even Mr. Bryan felt impelled to admit that the world was not made in six days. So clear and so wide-spread is geologic evidence that if properly handled it should not be difficult to convince any one, except a certain unnamed person, of the magnitude of geologic time, of the long and involved series of events that has led up to the present shape of our landscapes, of the unfolding progress of life as revealed in the rocks.

It is my personal belief that the world at large needs to know these facts and that if properly presented they will be accepted and that the acceptance will create an open mind toward other great facts. Believing this, are not we geologists in duty bound to give most serious consideration to the problem of how to make these facts a part of the stock of knowledge of the world at large and his wife and children?

How shall we go about it?

First, I suggest we make geology a science. At present geology is hardly more than a collection of facts and a collection of facts is not generally considered to be a science. To be a science facts must lead to hypotheses, theories, laws, by which we guide our action or predicate future results from present causes. Physics and chemistry have a foundation of laws. But what laws can you find in our geologic text-books?

Second, we need to revamp our text-books and teaching. Even though we are not prepared to state laws, our facts are of different orders of value. To-day our text-books are little more than catalogues of facts, all on a dead level. They are like a variety-store window. We need to inject some high lights, some mountains, some foreground and background, to set out our star performers and turn the spotlight on them, having in mind the value of these facts in the after life of the student.

Third, we need to get together on some of our larger facts. When one of us declares our giant reptiles were here six million years ago, and another says sixty million years ago, what is the world at large to think of us? No two text-books to-day use the same major units for a time scale. Most trades are getting together on codes and standards of practice. Are lumbermen and furnace men any more reasonable or fair-minded than we geologists? There is, I find, a wide-spread belief among the younger geologists that business or the church have nothing on geology for conservatism.

Fourth, it is time to distinguish sharply between public and professional papers and reports. We publish, let us say, 3,000 copies of a report for the public at public expense. We may estimate that five hundred of these go to libraries, five hundred reach men who can read them intelligently, leaving two thousand to go to people who can find neither pleasure nor profit in the average geological report. At least that is the reaction I get from talking to many people I meet in the field who have sent for our reports or those of other surveys. Recently I went over the manuscript of a detailed areal report intended to inform the people of the area covered, or others interested, of its geology and mineral resources. I listed about seventy-five words, most of them used many times, that might as well have been written in Hindu so far as conveying any meaning to most of its readers, enough to destroy a large part of the value of the report and to explain why we have difficulty in getting rid of 3,000 copies, while a writer in another science on our same floor can not supply the demand for his books with five editions of 10,000 each.

Fifth, recognizing that the average scientist is not qualified by temperament or otherwise, as will be testified by any lawyer or judge, to make a simple, appealing presentation of scientific facts, let us honor rather than discourage the man, whether scientist or not, who can and will put our findings in popular form. Federal and State Surveys might well make the popularization of geologic facts an important part of their work. The Pennsylvania Survey is at present running carefully prepared articles each month in the State school journal, planning road signs wherever there are geological features on the highway, taking and making opportunities to give popular illustrated talks wherever possible.

Sixth, contact with some of those who have been active in propaganda against science teaching leads me to believe that science herself or rather a very few of her disciples have been primarily responsible for this state of mind. A study of attempts to pass inhibiting or controlled legislation in other lines of work shows invariably a failure on the part of a few of those to be curbed to play the game fairly. So here I believe the irritating cause has been the unguarded speech of a very few people who publicly expressed their private views, ridiculing the religious beliefs of their students or neighbors. I do not propose a gag for such people, but would remind them, recalling that they live in a land in which eighty-five per cent. of the people are conservative, that this country started out with "a decent respect for the opinions of mankind," and that a large proportion of the leading scientists of the country, while they may have exchanged their old theology for a new, find their science no bar to themselves taking an active part in the religious exercises and life of the day.

In conclusion, I believe geology to-day faces the

task of taking the world at large into its confidence and friendship in a very real way, first by simplifying and popularizing or making fully intelligent to the public, all public, but not professional, reports. Second, by rearranging our geologic facts so as to bring into the foreground and limelight the great fundamental truths that all persons should know and recasting our text-books and teaching accordingly. Third, by striving to change geology from a history to a science, by the correlation of our facts into generalizations and, if possible, into definitely stated theories and laws. Fourth, by eliminating as far as possible all differences of interpretation and statement. Fifth, by encouraging the man who can dress our science up so as to attract and hold the interest of the world at large. Sixth, by following the Declaration of Independence in having "a decent respect for the opinions of mankind." That is the challenge. Will we meet it?

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PURPOSIVE ACTION[1]

IT is the purpose of this address to suggest certain directions in which a mechanistic explanation may be sought for the purposive behavior of animals, which has been by some authorities regarded as a unique phenomenon, irreducible to those laws which govern the rest of the universe.

Since I shall have occasion to speak of the motives or drives underlying behavior, it is not inappropriate to say that the drive which lies back of my present purpose is a hearty dislike of the doctrine of emergent evolution, which was so warmly endorsed at the last meeting of this association by Professor Jennings,[2] the retiring chairman of the Zoological Section. This doctrine, as you all know, holds that from time to time something entirely new emerges in the course of evolution. It is considered to be opposed to the doctrine of mechanism, which holds that from the beginning the material universe has been governed by a set of unchanging laws. Now as I read expositions of the doctrine of emergent evolution, it seems to mean either something with which all mechanists will agree, or something which involves the negation of scientific thinking and a return to more primitive modes of thought. First, it may mean that new phenomena make their appearance from time to time: new chemical combinations, new species of living beings. Who would doubt it? This is evolution: there is no need for the distinguishing adjective "emergent." Secondly, it may mean that new fundamental laws of the material universe have been discovered from time to time. Who would doubt this, or that others may yet be discovered which have been operating from the beginning but which our imperfect methods of observation have not previously been able to detect? Thirdly, it may mean that the fundamental laws of the universe modify each other when they enter into new combinations. Who would doubt it, or imagine that we have yet observed all the combinations of those laws which have existed from the beginning? Fourthly, it may mean that from time to time new fundamental laws of the physical universe have come into existence, and may at any time in the present or future do so. Professor Jennings complains that without emergent evolution there is no fun in experimenting. According to the mechanistic theory, he says, "from a sample of the universe we ought to be able to reason out the rest; the experimenters are those of us who can't"; and he goes on to say that this must naturally make the experimenter feel deeply inferior. But what would cheer the experimenter? The thought that he may at any moment observe a new combination and have the fun of showing that it is really reducible to already known laws? The mechanist gets a good deal of enjoyment from such an experience. Or the thought that he may at any moment discover a law which has been in operation always but has hitherto escaped observation? This is a joy for which the mechanist may always hope. Or is the only possible thrill for the experimenter to be derived from the chance that at any moment a new law of nature may *come into existence* and he be there to see? But what ought to discourage an experimenter more finally than such an expectation as this? He is trying to discover a law of nature, but what if at any moment it may be interfered with by a new one that has come into existence? If the universe can not be relied upon to stay on the tracks, why try to find out where the tracks lie? Professor Jennings sees in emergent evolution the only salvation from the dire practical consequences of mechanism. "Mingle," he says, "this perfect doctrine of mechanism with equal parts of the perfect doctrine of natural selection and you get a potion, a cocktail, with a kick that is warranted to knock out ethics and civilization." But if we believe that new laws of nature may at any moment begin to act, in the paralysis of science that would result from the drinking of *this* cocktail, I would give still less for the chances of ethics and civilization.

The mechanist then believes that whatever may be the ultimate truth of the matter, an inclination to

[1] Address of the vice-president and chairman of Section I—Psychology, American Association for the Advancement of Science, Nashville, December, 1927.

[2] SCIENCE, 65, 1927, pp. 19–25.