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THE FUNCTIONS AND IDEALS OF A NATIONAL GEOLOGICAL SURVEY[1]

Introduction.—During the period of unrest and uncertainty through which we are still painfully groping, the many distracting calls upon my time and thoughts have made performance of the duty to prepare a presidential address particularly difficult. In view of these circumstances I may perhaps hope for some indulgence on your part if my effort shows some lack of thoroughness in its preparation and falls somewhat short of the high standard set by some of my distinguished predecessors. The subject of a presidential address to the academy should, I think, be of wider interest and more general character than would ordinarily be an account of work in the speaker's particular branch of science, and this condition I have attempted to fulfill. Although what follows will deal especially with national geological surveys much of it will apply in principle to any scientific bureau conducted as a government organization.

Reasons for the Existence of a National Geological Survey.—In the beginning it may be well to review briefly the reasons for the existence of a national geological survey. Why should the government undertake work in geology while investigations in other sciences are in general left to private initiation and enterprise? The reasons that may be adduced will differ with the point of view. The geologist will suggest that whereas some sciences, such as chemistry, physics or astronomy may be pursued with success with stationary and permanent equipment at any one of a number of localities, geology is regional in its scope and is primarily a field science as contrasted with a laboratory science. Geology, it is true, must avail itself of laboratory re-

[1] Address delivered as retiring president of the Washington Academy of Sciences on January 13, 1920.

sources and methods, but the geologist can not have the greater part of his material brought to him; he must himself seek it afield. Thus it comes that comprehensive geologic problems require for their solution the equipment of more or less expensive expeditions or travel over large areas. Such projects as a rule can not be undertaken by individual geologists or by local organizations. The preparation of a geologic map of a whole country, with its explanatory text, generally recognized as essential fundamental work, is an undertaking that requires consistent effort by a central organization extending over a period of years. Such a map is not likely to result from the patching together of the results of uncoordinated local effort. From a broadly utilitarian point of view, the intelligent layman as well as the geologist must recognize that the development of a country's natural resources in such a manner as to secure their maximum use for the greatest number of its citizens necessarily depends upon reliable information concerning the character, location and extent of these resources and that this information should be available before they are exploited, by those who have eyes only for their own immediate profit, or before they pass entirely into private control or are exhausted. Such information can best be obtained and published by an impartial national organization responsible for its results to the people as a whole. Such a layman will recognize also that knowledge of the mineral resources of a country must rest upon a geological foundation. As Professor J. C. Branner has recently said in his "Outlines of the Geology of Brazil":

> After a life spent chiefly in active geologic work and in the direction of such work, I should be remiss in my duty to Brazil if I did not use this occasion to urge on Brazilian statesmen the serious necessity for the active encouragement and support of scientific geologic work on the part of the national and state governments. Knowledge must precede the application of knowledge in geology as well as in other matters; and unless the development of the country's mineral resources be based on and proceed from a scientific knowledge of its geology, there must inevitably be waste of effort, loss of money, and the delay of national progress inseparable from haphazard methods.[2]

Finally, the citizen of narrower vision will regard as sufficient justification for a national geological survey the fact that he himself can turn to it for information and assistance in the development of particular mineral deposits, to his own material advantage.

As a matter of fact, most of the progressive countries of the world maintain geological surveys so that the desirability of such an organization appears to have been generally recognized, whatever may have been the particular reason or reasons that set in motion the machinery of organization in each country.

Recognizing the fact that most of the principal countries have established geological surveys and granting that there are good reasons for considering the maintenance of such an organization as a proper governmental function, we may next inquire: What should be the ideals and duties of such a geological survey? How may these ideals be realized and these duties performed?

General Legal Functions.—The organic act of the United States Geological Survey specifies indirectly and in general terms the field that the organization should occupy. It states, with reference to the director:

> This officer shall have the direction of the Geological Survey and the classification of the public lands and examination of the geological structure, mineral resources and products of the national domain.

Doubtless the laws or decrees under which other national geological surveys have been established also prescribe to some extent their duties. Such legal authorization, however, is a rule so general as to leave room for considerable latitude in its interpretation. I propose first to discuss the functions of a national geologic survey without reference to legal prescription or definition and afterwards to consider the extent to which some

[2] Branner, J. C., "Outlines of the Geology of Brazil," Geol. Soc. America, *Bull.*, Vol. 30, p. 194, 1919.

of the actual conditions interfere with the realization of these ideals.

Usefulness in Science.—It has been the fashion in some quarters of late to emphasize usefulness as the chief criterion by which to judge the value of scientific research under government auspices. It has been intimated that this or that scientific bureau of the government must do "useful" work if it is to justify its existence and its expenditure of public funds. The statement is usually made with an air of finality, as if a troublesome question had been once for all disposed of and the path of the future made plain. As a matter of fact, however, when it is said that science must be useful in order to receive government support we have really made very little advance. Probably the most idealistic scientific man will admit that ultimate usefulness is the justification for scientific research although that end may not enter into his thoughts when he undertakes any particular investigation with the hope of increasing human knowledge. Men will differ very widely however as to what is meant by usefulness in science. It is well known to all scientific men, although not yet as widely recognized by others as it should be, that the utility of research is not generally predictable. For example, the investigations on electricity for hundreds of years preceding the middle of the nineteenth century had, so far as could be seen, no practical bearing. The experiments of Volta, of Galvani, and even those of our own Franklin, outside of his invention of the lightning rod, were not conducted with any thought of utility and were probably looked upon by the people of the time as diversions of the learned, not likely to have much effect upon human life and progress. How erroneous such a view was it is unnecessary to point out to a generation accustomed to daily use of the trolley car, telegraph, telephone and electric lights. Not only is the utility of science not always predictable but it is of very different kinds. That astronomy has certain practical applications in navigation and geodesy is well known; but important as these applications are they seem insignificant in comparison with the debt that we owe to this science for enlarging our intellectual horizon. This, too, is usefulness which I venture to think is of a truer and higher sort than much that passes current for utility. The classic researches of Pasteur on the tartaric acids, on fermentation, on the anthrax bacillus, on the silkworm disease and on rabies, were so-called applied science of the very highest type, indistinguishable in the spirit and method of their pursuit from investigations in pure science. They were not merely the application of knowledge to industry but were extraordinarily fruitful scientific investigations undertaken to solve particular industrial and humanitarian problems. They are especially interesting in the present connection as probably the most conspicuous example in the history of research of the merging of pure and applied science. Pasteur was doubly fortunate in that he not only enormously enlarged human knowledge but was able to see, at least in part, the practical application of his discoveries to the benefit of humanity. The value of his results measurable in dollars is enormous, yet this is not their only value. Professor Arthur Schuster, in a recent address, remarks:

> The researches of Pasteur, Lister and their followers, are triumphs of science applied directly to the benefit of mankind; but I fancy that their hold on our imagination is mainly due to the new vista opened out on the nature of disease, the marvelous workings of the lower forms of life, and the almost human attributes of blood corpuscles, which have been disclosed.
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> The effect on a community is only the summation of the effect on individuals, and if we judge by individuals there can be little doubt that, except under the stress of abnormal circumstances, pure knowledge has as great a hold upon the public mind as the story of its applications.

Quite independently of any recognized usefulness, investigations that yield results that are of *interest* to the public are willingly supported by the people and this fact is significant in connection with what I shall have to say later on the function of education. As illustrations of this truth may be cited our government Bureau of Ethnology and our

large public museums. Probably few who read the admirable government reports on the aboriginal antiquities of our country and on the arts and customs of the Indian tribes could point out any particular usefulness in these studies but they have to do with human life and their popular appeal is undeniable. The average visitor to a museum probably has little conception of what to a scientific man is the real purpose of such an institution. He gazes with interest at the contents of the display cases without realizing that by far the greater part of the material upon which the scientific staff is working or upon which investigators will work in future, is hidden away in drawers and packing cases. The principal recognizable result so far as he is concerned is that he is interested in what he sees and feels that he is being pleasantly instructed.

In other words, it is as important for man to have his imagination quickened as to have his bodily needs supplied, and in ministering to either requirement science is entitled to be called useful or valuable.

It may be remarked in passing that Pasteur's work had this in common with pure science, or science pursued with the single aim of adding to human knowledge, in that Pasteur himself could not foresee all of the applications that would in future be made of his discoveries.

Enough, I think, has been said to show that the term usefulness as applied to science covers a wide range and that when employed by people of imagination and liberal culture may include much more than when used by those whose only standard of value is the unstable dollar.

Functions under an ideal Autocracy.—If government were in the hands of a wise and benevolent autocracy a national geological survey would be so conducted as to be useful to the people whose taxes go towards its support; but it would probably be useful in the broader sense that I have outlined. It would give the people not perhaps what they think they want but what, in the wisdom of their government, seems best for them. I believe that a survey so directed would aim to encourage and promote the study of geology by undertaking those general problems and regional investigations that would be likely to remain untouched if left to private enterprise. It would lay the foundation for the most economic and efficient development of the natural resources of the country by ascertaining and making known the location, character and extent of the national mineral resources. As an aid to the intelligent utilization of these resources, and to the discovery of deposits additional to those already known, it would properly occupy itself with problems concerning the origin and mode of formation of mineral deposits. Last, but not least, it would accept the responsibility, not only for making known the material resources of the country but for contributing to the moral and intellectual life of the nation and of the world by seeing to it that the country's resources in opportunities for progress in the science of geology are fully utilized. I may illustrate my meaning by examples taken from the publications of the U. S. Geological Survey. In my opinion such works as Dutton's Tertiary History of the Grand Canyon, Gilbert's Lake Bonneville, and the investigations of Marsh, Cope, and their successors, on the wonderful series of reptile, bird and mammal remains found in the Cretaceous and Tertiary strata of the west are fully as adequate and appropriate a return for the expenditure of public funds as a report describing the occurrence of a coal bed and giving the quantity of coal available in a given field. Many years ago when the United States Geological Survey was under heavy fire in Congress one member of that body in some unexplained way learned that Professor Marsh had discovered and had described in a government publication a wonderful fosssil bird with teeth—a great diver up to 6 feet in length. He held this up to ridicule as a glaring example of the waste of public funds in useless scientific work, quite unaware of the light that this and similar discoveries threw upon the interesting history of the development of birds from reptiles and upon

evolution, or of the intellectual value of such a contribution to knowledge. The representative of a people educated in the value of geologic science would, by such an exhibition of ignorance, discredit himself in the eyes of his constituents.

Functions in a Democracy.—Our government, however, is not an all-wise benevolent autocracy but is democratic in plan and intent and suffers from certain well-known disadvantages from which no democracy has yet been free. The wishes of the politically active majority control and these wishes may or may not coincide with those of the wisest and most enlightened of the citizens. The funds for government work in science must be granted by Congress and the vote of each congressman is determined by the real or supposed desires of his constituents. A national scientific bureau, if it is to survive, must have popular support, and to obtain and hold such support it must do at least some work that the majority of the people can understand or can recognize as being worth the doing. Here evidently compromise with scientific ideals is necessary. Something must be sacrificed in order that something can be done. Such concessions and compromises are inseparable from democratic government and the scientific man of high ideals who is unable to recognize this fact will inevitably fail as a director of the scientific work of a government bureau. Such a man is likely to insist that no concessions are necessary and that the public will support science that is not interesting to it or from which it can see no immediate resulting material benefit. One very eminent geologist with whom I was once conversing held this view. He said that he had always found that he could go before a legislative body and secure appropriations for scientific research by being absolutely frank and making no attempt to show that the results of the work would be what the average man would term "useful" within the immediate future. His confidence was possibly well grounded, but I am inclined to think that the success gained by him was rather a tribute to his earnest eloquence and winning personality than a proof that the people are yet ready to contribute their taxes to the support of investigations that, so far as they can see, are neither useful nor interesting.

Character of Compromises.—Lest it be supposed that I am advocating the surrender of the high ideals of science to the political business of vote-getting I hasten to point out that surrender and compromise are not synonymous and may be very far apart. Some compromise there must be, but in my opinion the most delicate and critical problem in the direction of a national scientific bureau is to determine the nature and extent of this compromise so as to obtain the largest and steadiest support for real research with the least sacrifice. Complete surrender to popularity may mean large initial support, but is sure to be followed by deterioration in the spirit of the organization and in the quality of its work, by loss of scientific prestige, and by final bankruptcy even in that popular favor which had been so sedulously cultivated.

The extent to which concessions must be made will depend largely of course on the general level of intelligence of the people and upon the degree to which the less intelligent are influenced through the press and other channels by those who are able to appreciate the value of science. The more enlightened the people the more general and permanent will be their support of science.

Importance of Popular Education in Geology.—This leads us to the consideration of what I believe to be one of the most important of the functions of a government scientific bureau, namely, education. Of all forms of concession, if indeed it is really a concession, this is the least objectionable and most fruitful. Its results are constructive and cumulative. It is not, like other concessions to popularity, corrosive of the scientific spirit of an organization and in so far as it calls for clear thinking and attractive presentation on the part of those puting it into practise as well as the ability to grasp and expound essentials, its educational effect may be subjective as well as objective. Whatever may be true of other sciences, geologists in this

country have shown little interest in popularizing their science or in encouraging its pursuit by amateurs. Such attempts as have been made have often been inept and unsuccessful and the professional geologists have looked with more or less disdain upon those of their fellows who have tried to expound their science to the people. They have felt that men with unusual ability for research should devote all of their energy to the work of enlarging the confines of knowledge rather than to dissemination and popularization of what is known to the few. There is undoubtedly much to be said for this view and when applied to certain exceptional men it is strictly correct. When, however, we think of Darwin and compare the magnitude of his achievements with the pains that he took to make his conclusions comprehensible by the multitude, we are inclined to feel that only by extraordinary ability and performance in certain directions can an investigator in natural science be altogether absolved from the duty of making himself intelligible to more than a few specialists in his own line. There are undoubtedly many scientific men, thoroughly and earnestly convinced of the importance of their researches, who would in the long run be doing more for humanity and perhaps for themselves if they would spare some time to tell us as clearly and attractively as possible what it is that they are doing. While I believe this to be true of scientific men in general, it is particularly true of those who are officially servants of a democracy. A democratic government might almost be characterized as a government by compromise, and this is one of the major compromises that confronts scientific men in the service of such a government. The conclusion that a very important function of a national geological survey is the education of the people in geology and the increasing of popular interest in that science, appears to be unavoidable, yet it is surprising how little this function has been recognized and exercised. The results of such education are cumulative and a direct and permanent gain to science whereas, on the other hand, the consequences of prostituting the opportunities for scientific work to satisfy this and that popular demand for so-called practical results in any problem that happens to be momentarily in the public eye, is a kind of charlatanry that is utterly demoralizing to those who practise it and that must ultimately bring even popular discredit on science. A bureau that follows such a policy can neither hold within it nor attract to its service men animated by the true spirit of investigation.

Methods of Education.—It is not practicable in the present address to discuss in detail the many possibilities of educational work in geology. Only a few general suggestions can be offered.

In the first place the importance of education by a national geological survey should be frankly recognized and the idea that it is beneath the dignity of a geologist to participate in this function should be discountenanced. A geological survey should include on its staff one or more men of high ability who are especially gifted in interesting the public in the purposes, methods and results of geologic work—men of imagination who can see the romance of science; men of broad sympathy who know the hearts and minds of their countrymen from the Atlantic to the Pacific; men imbued with the truthful spirit of science; and finally, men skilled in the art of illuminating the cold impersonal results of science with a warm glow of human interest.

It should be the duty of these men to see that so far as possible all of the results of geologic work are interpreted to the people so that every citizen can benefit to the limit of his individual capacity. Magazines, the daily papers, moving pictures, and all possible means of publication should be utilized. There should be close contact with educators and special pains taken to prepare material for use in schools and colleges. Carefully planned courses at university summer schools and elsewhere might be given by members of the educational or publicity staff, or by certain selected geologists from the field staff.

Geologists in preparing papers and reports should consider with particular care the ques-

tion "Who may be reached by this?" Some scientific results can not be popularized and these may be written in the concise accurate language of science. Others, however, may by taking sufficient care and trouble, be made interesting to more than a small circle of scientific colleagues. Every effort should be made to enlarge this circle by simple and attractive presentation. In some cases I am inclined to think that a geologist might issue separately or as a part of his complete report, an abstract or résumé in which all effort is concentrated on an endeavor to be interesting and clear to as many people as possible. If this were done, I am sure that the writer would be in a position to appraise more truly the value of his complete report and might proceed to rewrite some portions of it and to omit others, without loss to science and at a saving in paper and printing.

Relations with Universities.—In connection with the subject of education attention may be called to the fundamental importance of establishing and maintaining close and cordial relationship between a government scientific bureau and the universities. The advantages of such a relationship are so many that it is difficult to enumerate them all but it may be pointed out that any plan of popular education in science will be seriously crippled if the professional teachers, whose influence in molding the thoughts and determining the careers of the young men and women of the country is so great, are out of sympathy with the government organization that is attempting to quicken the interest of the people in a particular branch of science. Moreover, it is vital to such an organization that it should attract to its service young men of exceptional ability in science. This it is not likely to do if professors of geology feel that they must conscientiously advise their most promising graduates to avoid government service. Doubtless some teachers of geology in the universities fail to realize the necessity for some of the compromises inevitable in a government bureau, or in their impatience at some of the stupidities of bureaucratic procedure are inclined to place the blame for these where it does not belong; a few may cherish personal grievances. No class of men is without its unreasonable members and neither rectitude nor tact can prevent occasional clashes; but if a national geological survey can not command the respect and hearty support of most of the geological faculties of the universities the consequences to the progress of geology must be deplorable. Any approach to such a condition demands immediate action with less emphasis on the question "Who is to blame?" for in all probability there is some fault on both sides, than on "What can be done to restore relations of mutual regard and helpfulness?"

The Amateur in Geology.—In the present age of specialization we are apt to forget how much geology owes to amateurs, particularly in Britain and France. Sir Archibald Geikie in the concluding chapter of his "Founders of Geology" dwells particularly on this debt. He says:

> In the account which has been presented in this volume of the work of some of the more notable men who have created the science of geology, one or two leading facts stand out prominently before us. In the first place, even in the list of selected names which we have considered, it is remarkable how varied have been the ordinary avocations[3] of these pioneers. The majority have been men engaged in other pursuits, who have devoted their leisure to the cultivation of geological studies. Steno, Guettard, Pallas, Füchsel, and many more were physicians, either led by their medical training to interest themselves in natural history, or not seldom, even from boyhood, so fond of natural history as to choose medicine as their profession because of its affinities with that branch of science. Giraud-Soulavie and Michell were clergymen. Murchison was a retired soldier. Alexandre Brogniart was at first engaged in superintending the porcelain manufactory of Sèvres. Demarest was a hard-worked civil servant who snatched his intervals for geology from the toils of incessant official occupation. William Smith found time for his researches in the midst of all the cares and anxieties of his profession as an engineer and surveyor. Hutton, Hall, De Saussure, Von Buch, Lyell and Darwin were men of means, who scorned

[3] *Vocations* would seem to be the right word here. F. L. R.

a life of slothful ease, and dedicated themselves and their fortune to the study of the history of the earth. Playfair and Cuvier were both teachers of other branches of science, irresistibly drawn into the sphere of geological inquiry and speculation. Of the whole gallery of worthies that have passed before us, a comparatively small proportion could be classed as in the strictest sense professional geologists, such as Werner, Sedgwick and Logan. Were we to step outside of that gallery, and include the names of all who have helped to lay the foundations of the science, we should find the proportion to be still less.

From the beginning of its career, geology has owed its foundation and its advance to no select and privileged class. It has been open to all who cared to undergo the trials which its successful prosecution demands. And what it has been in the past, it remains to-day. No branch of natural knowledge lies more invitingly open to every student who, loving the fresh face of Nature, is willing to train his faculty of observation in the field, and to discipline his mind by the patient correlation of facts and the fearless dissection of theories. To such an inquirer no limit can be set. He may be enabled to rebuild parts of the temple of science, or to add new towers and pinnacles to its superstructure. But even if he should never venture into such ambitious undertakings, he will gain, in the cultivation of geological pursuits, a solace and enjoyment amid the cares of life, which will become to him a source of the purest joy.

In this country at the present time, as Mr. David White in an as yet unpublished address, has I believe pointed out, the amateur geologist, due partly to the way in which the subject is taught, is rare and few indeed are the contributions made to the science by those who follow geology as an avocation or hobby. This is unfortunate and an improvement of this condition should be one of the major objects of the educational program of a national geological survey. The science lends itself particularly to its pursuit as a recreation by men of trained intellect who must find in the open air some relief from sedentary professions. In a country still so new as ours geologic problems lie on every hand and many of these can be solved wholly or in part without elaborate apparatus or laboratory facilities. The standards for the professional geologist should be high, but there is no necessity that maintenance of such standards should be accompanied by a patronizing or supercilious attitude toward the work of the amateur. Rather, let the professional geologist cultivate sympathy, tolerance, and generosity toward all who are earnestly seeking for the truth; let him help by encouragement instead of deterring by disdain. There is no better evidence of a wide interest in geology than the existence of numerous amateur workers and it is decidedly to the advantage of the professional geologist and to the science to encourage in every way possible the efforts of such workers and to increase their number.

F. L. Ransome

(To be concluded)

GEORGE MACLOSKIE

George Macloskie was born in Castledown, Ireland, in 1834. He studied at Queens' University, Ireland, receiving the degree of A.B. and A.M. Later, at the University of London, he took the degrees in course of LL.B. and LL.D. He was three times gold medalist. After he had been some years in America the University of Ireland granted him the honorary Sc.D.

He was for 13 years (1861–'74) pastor of the church of Ballygoney, Ireland. During his student life and while discharging his pastorial duties he was actively interested in the study of natural history. This interest had attracted the attention of his friend and one-time teacher, Dr. McCosh, the new President of Princeton College, who called him in to occupy the chair of natural history in the recently established John C. Green School of Science, at Princeton.

In this chair, later termed biology, with unfailing devotion he served the college and university for 31 years, retiring in 1906 as professor emeritus. During this period, in addition to his teaching and executive duties, he wrote his "Elementary Botany with Student's guide to the Examination of Plants" published by Henry Holt & Company, 1883, which for several years was used in his classes. He published also a number of papers on botanical subjects, chiefly in the *Torrey Bulletin* and entomological papers, in