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THE RELATIONS OF THE STATE AND NATIONAL GEOLOGICAL SURVEYS TO EACH OTHER AND TO THE GEOLOGISTS OF THE COUNTRY.[1]

INVESTIGATIONS undertaken in the course of instruction are often carried on in college laboratories, but it is rarely that individuals or institutions, other than the State and National surveys, have undertaken extensive and expensive geological operations. We must except, of course, in this statement those of an economic nature.

The reason of this is that individuals seldom, and commercial organizations never, devote their means to purely scientific investigations; and inasmuch as these investigations require large sums of money, and as they are conducted largely with a view to increasing human knowledge, the expense of them must be borne by the public treasury.

With our official organizations, most of the working geologists of the country, excepting those called consulting geologists, are connected either as salaried assistants, permanent or temporary, or as volunteers. But these organizations carry on their work independent of each other, indeed, without any regard to one another's existence, while individual investigators go each his own way, pretty much as if he had the whole world of geology to himself.

[1] Abstract of an address before the Section of Geology and Geography of the American Association for the Advancement of Science, at Indianapolis, Ind., on Aug. 20, 1890, by John C. Branner, vice-president of the section.

Practically the United States Geological Survey has *carte blanche* to carry on geologic investigations over the whole territory of the United States, and in every branch of scientific work directly related to geology, such as geography, topography, paleontology, physics, chemistry, and statistics.

Now, over this same area, though limited to the States carrying them on, we have our several State geological surveys; while private individuals, educational institutions, scientific societies, and commercial corporations are at liberty to carry on such investigations as they see fit, and all regardless of each other.

In the earlier work carried on by the Federal Government, however, the various Territories were the specified areas to which the National surveys were confined, and now that the whole area of the United States is open to this work a broad-minded and co-operative direction seeks to aid and strengthen the State organizations instead of antagonizing or annihilating them.

But I wish to emphasize the fact that the classification of the geologists of the country, the work within the domain of the National survey, the work within the domain of the State surveys, and that which can be or will be accomplished by private institutions, corporations, or individuals, demand that there should be some definite and better organized co-operation or co-ordination in all this work and among all these men.

The statement has been made that the United States Survey does co-operate with nearly every State survey in the country, but the fact is that the National survey does not know what the State surveys are doing except in a very general way, and that the State surveys know but little or nothing of what the National survey is doing, except, perhaps, as it may happen to be picked up in private conversations and in private correspondence between personal friends.

Please bear in mind that this is not intended as reflecting upon the Director of the United States Survey; co-operation can only exist by the common consent of all the parties concerned, and it is quite as much the fault of the State surveys that there is no such co-operation as it is that of the United States Survey.

What I have to say, however, refers to the internal arrangements and the working of geologists as affected by our own bearing toward the official surveys, toward each other, and toward the science, rather than toward official relations and toward legislation. For these are not matters to be fixed by laws: laws would interfere with that freedom of movement that gives health, vigor, and activity to our scientific bodies and to our scientific men; they can only be determined by common consent and by usage.

The United States Geological Survey stands at the official head of all our surveys and of all our geological work. National work encourages and stimulates State work, and State work re-acts in favor of national work, and both stimulate private enterprise and investigation. The return from all this no man can measure, for it is both material and intellectual, and in both these senses it is felt in every nook and corner of the land.

The National survey is thus doing a work that no other institution can do, and it is able to maintain an organization of geologists that no other institution could maintain. For nowhere, in no country, is there, and at no time has there been, a corps of working geologists superior to that of our present National survey—a body of geologists of which every scientific man, and, indeed, every citizen of this country, may well be proud.

Having no connection with that organization, either present or prospective, I feel at liberty to express this a frank, disinterested and independent judgment.

With its splendid equipment of men and means, what can the National survey best do, and best leave to State surveys and to private enterprise? The question is not asked as implying that the officers of that body are not perfectly competent to decide these matters, but because we feel that a more effectual co-operation can be brought about to the great advantage of every one concerned. So long as more than one organization must occupy the same field, some understanding can certainly be arrived at that will prevent the duplication of work and the waste of energy and of funds. The appliances, libraries, laboratories, equipments, and the large number of special assistants required by a National survey, are quite beyond the means of our modest State surveys.

The great size of our country, the wide sweeping character of its general geologic structure, and the limits placed by civil boundaries on State work, must throw most of the important general questions into the hands of the National survey. Local details can and should be worked out by the State surveys, and these results should be placed as soon as possible at the disposal of the specialists of the National survey. It is self-evident that problems that can be solved only after a wide experience and acquaintance with the whole country can not be satisfactorily undertaken by the State surveys, but that they must be solved by the larger and stronger organization.

There are certain classes of work that, of necessity, fall upon a National rather than upon the State surveys; such are triangulation, precise levels, topography, paleontologic work, almost all investigations falling under the head of what is usually known as pure science, and all those investigations requiring much time and labor and money and many specialists. The reasons why State surveys can not do work of this class are not far to seek. The men with whom the National survey has to deal are our broadest minded statesmen,—men who comprehend the scope and importance of purely scientific work, while, as a rule, State legislators look to immediate and what they call practical results. Such men can not be convinced of the importance of any work that looks not to the immediate material prosperity of the State, while they are but little concerned, as a rule, with the intellectual income from it.

It is entirely beyond the means of any State survey to make a topographic map of the entire area of the State: the best it can do is to select a few typical areas and map those. But maps are absolutely essential to satisfactory geological work, and map making has come to consume a constantly increasing share of the money appropriated for geological surveys, both State and National. The National survey, however, having large appropriations for topographic work, and contemplating as it does the mapping of the entire area of the United States, ought to do this work.

That these maps must meet various demands, and must therefore be constructed with varying degrees of accuracy and detail, every one will admit. As a matter of fact, however, the maps made are usually, as they should be, parts of a plan, and upon a scale for mapping the whole of the United States. This plan and scale may be perfect for that particular purpose, but it often happens that neither the plan nor the map is adapted to the purposes of the State surveys. And certainly nothing can be plainer than that the maps made by a geological survey ought to be available for geological work, or that, failing to meet the demands of geology, there is no geological excuse or reason for their existence.

Geodetic work can not be carried on by the States, because States are but small parts of and furnish but few points in geodetic questions. European countries have even been obliged to unify their work. In the United States work of this character must be left to some institution of the general government. That paleontologic work should be relegated to the National survey seems to me scarcely to admit of question.

It might be urged against these reasons that the States of Illinois and New York afford striking examples of the fact that States may and can and do carry on a high grade of paleontologic work. But it should be remembered that the conditions under which these excellent results have been obtained have passed or are about to pass away. For, while the States of Illinois and New York have grown in wealth and intelligence since their surveys were begun, the Legislatures of those States could not to-day be induced to take up and carry forward works of so purely a scientific nature; and if those States could have seen the end from the beginning it may well be doubted whether they would have undertaken the great paleontologic investigations carried on so long and so successfully by Hall and by Worthen.

Another point which I must insist upon is that it is the place of a State geological survey to do what is wanted in the State, and as a rule economic results are wanted. The people are entitled to what they pay for. Not that the survey must go on every wild-goose chase suggested and examine every prospect and claim in the country, but the problems which the people wish to have solved should be solved if they can be solved.

These very demands define the work of the State surveys, and separate it pretty sharply from that of the Government survey. If we are to be perfectly honest with ourselves, we must confess that State surveys have, as a rule, failed to do what the people have expected of them, and one of the principal reasons for these failures is that the geologists have not had the counsel and the co-operation of a National survey. The geologists who have encouraged the making of appropriations for the work have invariably held out the hope that these surveys would be devoted to economic geology, while members of Legislatures who have supported such bills have invariably done so in the expectation that they would do something of direct economic importance. But there are but few exceptions to the rule that these State appropriations have been devoted to paleontologic problems and to pure science, while economic problems have been entirely lost sight of.

These economic problems, or such of them, or rather, perhaps, such phases of them as can safely be dealt with by a State, should be the special province of the State surveys, while the broader questions which can be satisfactorily studied and safely discussed only over wide areas should be left to the National survey.

It is true that economic and purely scientific problems cannot be entirely separated, and there is no necessity that they should be, but geologic work may give preference or prominence to one or the other phase of the question as the case may demand. I have said that economic problems should, in so far as possible, be left to the States. There are cases, however, in which this cannot be done, for there are often those which, requiring study over a wider area, cannot be solved in a single State. These should be studied in part or entirely, as the case may demand, by the National survey.

It seems plain, in so far as the relations between the National and the State surveys are concerned, that the National survey should leave all that it can safely leave to private enterprise and to State surveys, and it should deal with those problems which State surveys and individuals will not or can not satisfactorily deal with.

It is my opinion, also, that the National survey, being better informed of what is going on in the way of geologic work than the State geologists, and being in every respect the strongest of our organizations, should hold out a helping hand to the State surveys, and from their wider and more valuable experience, give advice and encouragement to State work. In this way State aid to scientific work would be encouraged and the National survey would widen its helpful influence.

It goes without saying that State and National surveys should not ride rough shod over each other just because there is no law to prevent their duplicating each other's work or their doing work that will interfere with each other's plans or efficiency. It would be easy for a Government survey to discredit and embarrass a State survey to such a point that the State would put a stop to its own work. Fortunately, our National survey has been conducted rather with a view to aiding the State surveys. But this aid can be made much more effectual than it ever has been, and I have no doubt it will be made so whenever we are all ready for such co-operation.

What must a man's feelings be when he brings his contribution, to find that it is in the wrong place, or that it is not wanted. Mistakes of this sort are constantly being committed in geologic work, and in abundance too, all because we have no recognized directing head for the work done outside of the United States Geological Survey.

The bulk of geologic literature must yearly become greater, and unless it becomes at the same time better, we must expect a day to arrive when geologists may well stand appalled before it. Much of the literature is practically worthless; it is an encumbrance rather than a help to the progress of science, and we should feel grateful to any method that would deliver us and geology from an evil which is coming to be a more and more serious one.

In one of the States in which the United States Survey has been doing topographic work, an area of 3,000 square miles that had already been surveyed had to be remapped by the State survey to meet its own demands. Here, I think, no one will have any diffi-

culty in understanding the necessity of co-operation between the State and the National surveys.

Take as another example the chemical analyses made for geological purposes. The chemists of State and National surveys have thrown upon them a vast amount of heterogeneous work, while but little or no time is left them for original investigations. A great many of their analyses are duplicated elsewhere, or may be duplicated in any number of laboratories, so that investigations that might otherwise have been possible are prevented, and both chemistry and geology are hindered.

The errors made by geologists not connected with the surveys are mainly due to haste, or, in other words, to expression of opinion based upon too limited observations. But only limited observations are possible to men of limited time for the work, and limited means to work with, a limited area to work in, limited acquaintance with field geologists, and limited opportunities for publication. There are many young geologists and men of but little experience—amateurs—whose efforts are not so directed as to be of as much service as they might be. They lack neither zeal nor means in many cases, but they do lack some one to guide their tottering footsteps. Their want of experience gives them but a restricted view of the field in which they are laboring. Their labors can not, therefore, unless directed by some one who has a sufficiently broad view of the whole field, be of any value to geology. Who will direct them? Or shall they go on piling higher their wasted energies, and find themselves when they have come to the end with the mortification of knowing that, though they have worked hard and faithfully, they have, in reality, contributed nothing to the sum of human knowledge?

If we could have some sort of co-operation, a man at work upon a particular subject would have some assurance that his field of operations would be, within all reasonable limits, left to him. As matters now stand a geologist is often obliged to mount guard over his own grounds and his own work to keep the unscrupulous and unbridled camp-followers of science from walking off with and getting the credit for the results of his labors.

Co-operation would enable each one to concentrate his efforts upon that line of work or that investigation in which he is especially interested. As matters have gone heretofore, no State survey and no man on a State survey has been able to take up any one subject in a systematic and thorough manner unless it has happened that some one group of facts has been available in his own State alone. Take any topic you may choose for a test, and you will find this to be an invariable rule.

Do the best we may, there is not one of us who may not be benefited more or less by a friendly criticism. And it is of great importance to the science that these criticisms be made before our results or observations are published. In this way we may avoid adding to that vast talus of geologic trash beneath which the science of geology is buried more and more each year. Such criticism is not possible except under conditions that enable us to know the lay of the land with reference to other geologists and to what they have done and are doing.

It should be distinctly understood from the outset that such work is to be, not subordination, but co-ordination, and above all, co-operation. The demands of scientific work do not require, and the conditions and peculiarities surrounding scientific ambition and devotion do not admit of the most successful and satisfactory work being done by machinery.

I would not by any means destroy the autonomy of local societies or of independent workers not formally connected with the public surveys. Certain independence of thought and action is essential to scientific advancement, and friendly rivalry is not only not injurious, but it is extremely helpful, and in many cases absolutely essential. I have no idea that a "perpetual motion" sort of a geological machine can be devised, or that any arrangement or adjustment of parts is possible which will entirely do away with friction.

It is scarcely possible that any device that can be made or suggested would be perfectly satisfactory, but it certainly is reasonable to expect that some system of co-operation can be devised and put into practical operation. If ever such co-operation should be brought about, several points must be kept in mind by us all. As much latitude as possible would have to be allowed individuality. Men are not like pieces of coal to be separated and classified by sizes or by specific gravity.

Administrative methods devised for scientific work, like those of diplomacy, are often a series of compromises, and good sense must make up for the defects of any system.

No plan of co-operation can succeed if we do not all take a broad and unselfish view of science and its functions. Local talent should be utilized. It would in many cases save a good deal that now goes to pay travelling expenses, to say nothing of the importance of keeping all the geologists of the country actively interested in geological work.

Now, if geologic work can be improved by being under the nominal direction of those best fitted to direct, where are we to find our directors? The men who have done most to popularize the science of geology in this country are our professional geologists, and it is not unnatural that we should turn to them. But the teachers of a science are not necessarily the best directors of research, while they are probably in no case thoroughly conversant with the work being done by the various State surveys and by the National survey.

The direction of work over the whole country would be quite as impossible, or even more so, from the States.

The National survey, standing as it does at the head of all the geologic work done in the country, having the whole national domain as its field, and composed, as it is, of our best geologists, and having the most thorough organization, is, or should be, the natural head and director of all geological work in this country. I have no doubt that the National survey would be glad to help, in so far as it can, to unify and give useful direction to this work.

I take this ground in the face of the statement of the distinguished Director of the United States Geological Survey, who has said that "all of this scientific research under National, State, or local patronage cannot be controlled by some central authority as an army by its general, from the fact that scientific men, competent to pursue original research, are peculiarly averse to dictation and official management. Scientific men spurn authority, but seek for co-ordination."

Such a statement as this must necessarily be taken with some allowance. The function of a director or of a superior, in science at least, is not, to be sure, that of a commander ordering here and there men who must act like machines, who must have no independent opinions or plans of their own; he must rather be a helper, a man to encourage, to suggest, to fire with enthusiasm those under him, and to unify the work of the organization of which he is the head. Scientific men do not spurn authority if there is any reason for it, and as a proof of it we may cite the United States Geological Survey itself, as well as all the State Geological Surveys in this country, or, for the matter of that, in the world. The members of these surveys submit to all reasonable authority, but they are also put upon congenial work, and they are permitted to do that work pretty much in their own way. Now, why can there not be an organization of all geologists, more or less similar to this?

We may disabuse our minds of the thought that there is a probability or even a possibility of the Government monopolizing geology. It can't do it; geology belongs to the geologists, whether the Government helps carry on geologic investigations or not.

My conclusions are:—

1. That the great and valuable contributions to geologic knowledge must be made by our official surveys, for they alone have the means for producing them—for gathering the facts, giving the necessary time to philosophical thought and discussion, and for furnishing the necessary illustrations and distributing the publications.

2. That economic problems should be left, in so far as it is possible, to the State surveys, while the National survey should deal with those requiring larger means and a wider range of observations.

3. That all the working geologists of the country should be brought into official or quasi-official relations with the State and National surveys, and their efforts and skill thus utilized.

I am free to admit, however, that no plan of operation or co-operation can be devised that will work to the complete satisfaction of everybody. We sometimes have men to deal with who are not amenable to either law or reason.

In his presidential address before the American Association at Cleveland, Professor Langley compared the advance made by scientific men in their search after truth to that of a pack of hounds following a trail. Permit me to carry this simile still further. Hounds understand that it is their business to follow the game, and, when left to their own instincts and wishes, they will follow it. Now imagine a bull dog seized with the ambition to become a hunter and joining the pack of hounds. Every one knows that the bull dog will, in spite of any thing that can be done, have a fight with half a dozen, or, more likely, with the whole pack of hounds, by the time the chase is well under way.

It is not a pleasing reflection to remember that the great search after truth, in which every genuine man of science is engaged, heart and soul, is often interrupted in this same fashion by the pugnacious disposition of some companion.

Let me recapitulate some of the benefits to be derived from voluntary and cordial co-operation between all geologists and all geologic organizations in this country:

1. Geologic research being under the nominal direction of the leading investigators, would be so conducted as to be of the greatest utility to the largest number.

2. When a piece of work was done by one it would be done for all, and duplication by State surveys and by individuals and the consequent waste of energy, time, and money would cease.

3. The functions and fields of official organizations being better defined, State and National surveys and individuals could so direct their efforts as to serve the purposes of others without neglecting their own immediate aims and without infringing upon each others' grounds.

4. National and State surveys would be strengthened, and local organizations and individual effort encouraged.

5. It would give us a better geologic literature, better instruction, better geologists, and more thorough specialists.

6. And finally, we trust, it would put a stop to those oracles of science who are so ready to prophesy in its name. This ideal state of affairs may never be brought about, but it is none the less desirable that we should aim at it. For the more nearly we approximate to it the more rapid will be the progress of science, and the progress of science is the progress of civilization.

To paraphrase a recent utterance of Bishop Potter, "It would be a monstrous conception of science if any one of us were to esteem it only as a selfish weapon with which he was to carve his way to personal fame and fortune." It has often been used for just that purpose. Higher ideals will give us nobler motives.

ON CERTAIN PHENOMENA OF GROWING OLD.[1]

AFTER a few introductory remarks on the choice of a subject, Dr. Minot said that he had been guided in his selection by the idea of taking a subject which would be of general interest and indicate, if possible, the new directions in which biology is developing. For this reason he had chosen the subject as announced in the title of the address. He spoke first of the law of variations as connected with the age of the living organism. When variations occur which are due simply to chance, it is found that they are distributed according to a regular curve on either side of a maximum; but when we study the variations which occur in the living organism we find that there the curve is irregular, and that there is a certain point of maximum which occurs at a definite age, and that the ascent of that curve toward the maximum is steeper upon the young side than upon the older. The speaker presented a number of examples of this taken from the age at which Harvard students enter college, from the growth of children, from the age at which maturity is attained in the female sex, from the age of mothers and the number of children which they have had at each age, and giving other examples, without, however, presenting them in statistical form. In all of these cases the same peculiarity of the curve being steep on the young side, and less steep upon the old side, recurs. But in all these cases the maximum occurs at a comparatively early period of life. In other cases, as, for instance, when we discuss the relation of suicide to age, we find that the maximum frequency occurs at a much more advanced period, and in this case the curve becomes steep upon the old side, so that there is here a large field of statistical inquiry which is to be worked out, and there is a large amount of material which might, if properly put into shape, yield valuable results. We might study from this point of view the relation of various diseases to age, the relation of the birth of the first child to the age of the parent, of the acquisition of fame, the age of second marriage, the age at which distinguished authors have published their first book, the age of entering the United States Senate, etc. All these and other similar data might be utilized for the purpose of the biologist to study the law of variation in connection with age. At the present time there is not sufficient work done in this direction to enable us to draw any more general conclusion than that which has been presented above.

The peculiarity of the curve of variation is unquestionably due to what may be called senescence, or growing old. This senescence shows itself in the fact that toward the younger period the same range of alteration takes place as toward the older period in more advanced age. This is particularly well illustrated by a series of elaborate experiments upon guinea pigs and their growth made by the speaker. These experiments, which were interrupted by an accident which destroyed the whole stock of animals, show that the loss of vital power commences with birth, and that in order to add a given percentage to the weight of an animal a much longer period is required when it is old than when it is young. This was illustrated by statistics and diagrams. The general result may best be expressed by saying that the older an organism is, the more time it requires to produce a given change, and this indicates that there is a progressive loss of vitality. The difference between this view and the current one is that, in the speaker's opinion, there is, scientifically speaking, no period of development, but only a steady decline from birth onwards.

The speaker then turned to the second part of his subject, and discussed how far anatomical peculiarities can be found to be correlated with this progressive line of vitality. He took up the various tissues of the body, considering them one after another in their order of development, and showed that in each one of the principal tissues and organs the cells composing them exhibit the same peculiarity; namely, that in their young condition they contain only a small amount of protoplasm, and in their adult condition a very much larger amount, so that the proportion of protoplasm to the nucleus increases with the age of the organism. This fact, which can be readily verified in the case of the higher animals, finds also certain support in the development of many of the lower forms, which were also briefly discussed. Hence the conclusion that the development of protoplasm is associated with the loss of vitality, and that instead of speaking of protoplasm as the physical basis of life, we might speak of it as the physical basis of advancing decrepitude; or, since the changes involved in growing old lead to death, we might designate it as the physical cause of death. These definitions of protoplasm are too dictionary-like, and might be misleading if taken strictly, but they can at least teach us that protoplasm is by no means a simple jelly which explains in a simple manner all the phenomena of life, but it is in reality an extremely complex substance, as complex as life itself. We see in this problem of age a series of phenomena which are not especially associated with any organ or any system of organs of the body, but something which involves all parts alike. Such a study as this goes, strictly speaking, in the direction of general biology. Hitherto we have had comparative anatomy and physiology, but of general biology extremely little. The speaker expressed his belief that the future of biology would lead in this direction, and that the study of the organism as a whole would supercede in the near future to a large extent the present study of the separate organs, both in their physiological and morphological aspects.

There is a great deal to be done, for it is only in the domain of

[1] Abstract of an address before the Section of Biology of the American Association for the Advancement of Science, at Indianapolis, Ind., Aug. 20, 1890, by Charles S. Minot, vice-president of the section.