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EDUCATION IN GEOLOGY—HOW ADVANCE IT?[1]

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THE title of this address is a complex question calling for a number of answers, and I do not pretend to know all of them. In fact, without some definition of scope the question is too large and vague to furnish a hopeful point of attack in a brief discussion. It may be supposed that any one who has devoted a large share of his life to teaching geology would focus on the mechanics of the college curriculum as the chief matter for attention in a search for means to improve geological education. Undoubtedly improvements can and should be made in that quarter. Our subject has had spectacular recent growth in accumulation of critical factual material, in the development of powerful new techniques and in successful application of principles borrowed from other sciences. As a result our fighting front is far flung, and many parts of it are in a fluid condition. An adequate training program requires frequent adjustments and changes of emphasis to insure proper balance in basic preparation on the one hand, and a high degree of specialized skill on the other.

Important as the college curriculum is, however, I prefer to examine some aspects of our educational program that, in my opinion, are even more fundamental and immediately critical. Attention has been strongly focused on some of these matters by Croneis, in a paper which met a general response indicating that the time is ripe for some concerted study and action.[2] Two facets of the general problem deserve particular thought. Both can be approached through questions that are somewhat more specific than the one in our title. (1) How can a larger number of top-rank students be attracted into geology? (2) How can appreciation of geology be widened and deepened among laymen? Although these two matters seem to

[1] Address of the retiring vice-president for 1943 of Section E—Geology and Geography, American Association for the Advancement of Science, Cleveland, Ohio, September 13, 1944.

[2] Carey Croneis, "Geology in War and Peace," *Bull. Am. Assoc. Petrol. Geol.*, vol. 26, pp. 1221–1249, 1942.

be distinct and to call for separate treatment, probably they are so closely related that to a considerable extent they will be found to merge as expressions of one basic problem.

Whether or not geology is getting its fair share of top-flight recruits may be debated at length without a clear verdict, since several variables are involved and convincing evidence is not easy to produce. Many senior-class records suggest that of college students majoring in science, more of honor-grade are likely to be found in physics and chemistry than in geology. Analyses of graduate-record examinations in the few schools that use this form of test tend to support this general conclusion. Regardless of any dispute on the actual comparative figures, there is considerable question as to what constitutes the "fair share" for geology. Analyses have ordinarily started with the tacit assumption that opportunity is equal among these three fields of natural science. "Intellectual opportunity" is perhaps too intangible for a satisfactory appraisal in this regard. However, economic opportunity, perhaps the most potent single influence, is by no means a constant among the fields. Industry every year recruits a particularly large number of young chemists, and the demand for well-trained physicists is by no means inconsiderable. Possibly the present distribution of the ablest students in science can be explained at least in part on this ground. However, it is not an explanation that geologists can accept with complacency. We also are called on to furnish men for industry and, in addition, to continue the attack on research problems that challenge the best minds. Nothing should be left undone that holds any promise of improving the caliber of the young men who choose geology as their vocation.

One disadvantage suffered by geology in the competition for students lies in the late introduction to the subject that is almost inevitable in the present educational program. Geology is almost strictly a college subject, whereas chemistry, biology and physics are taught, after a fashion, in a large proportion of secondary schools. Only a small percentage of students know what geology is when they enter college. Moreover, a large majority of freshmen take chemistry or physics, along with mathematics, and either postpone geology to a later year or omit it altogether. It is by no means uncommon to hear students who elect elementary geology as seniors express regret that they are unable to pursue the subject further. Few who take the introductory course later than the freshman year elect geology as the major subject—understandably enough, since declaration of the major usually is required before the end of the sophomore year, and the student's natural desire is to make his choice and begin shaping his program as early as possible.

There is no easy escape from the serious difficulty presented by this situation. Curricula of secondary schools already are crowded, and few of us would consider it wise to introduce a full-fledged course in geology at the secondary-school level even if it could be arranged. It is conceivable, however, that certain aspects of the subject may profitably form part of a course in general science in high schools. In some sections of the country an elementary study of minerals and rocks now is included in such courses. There are still some advocates of physiography or physical geography, as a valuable study in high schools, although in general this subject, once widely popular, has fallen into disfavor. It has been revived locally, and I know of one preparatory school in which two teachers, defying the general trend, have maintained a high-grade course that continues to interest a goodly number of students. This school has built up an excellent collection of minerals and rocks, has field excursions as a regular part of the course, and every year turns out boys who enter college with a desire to learn more about geology. It would be interesting to know how many schools in the entire country can approach this record.

Recently I was startled on discovering that even some grade schools present certain aspects of geology in elementary courses of general science. A revelation in one such school raises the question how much misinformation may result from these present efforts. The procedure in the school was to assign a topic to each of several groups of children, who after some days of preparation presented reports illustrated by posters. One group reporting on petroleum had as the most conspicuous poster a large drawing of a dinosaur, which was represented as the source of the all-important fluid! I doubt whether the young researchers actually found this statement anywhere in print. Their mistaken conclusion is a commentary on the power of suggestion. For years the American public has had impressed on its consciousness, by means of billboards, magazine advertisements and labels on oil containers, the image of a dinosaur as the symbol of an oil company. There is no probability that this corporation has had any intention of implanting a monstrous untruth; it merely wants an arresting sign. Nevertheless, the train of thought set going in the mind of the untutored layman is inevitable: Oil got into the ground a long time ago; the dinosaur has long been extinct; great quantities of oil could have come only from the carcasses of huge beasts—that's it, from dinosaurs! Surely the report of the school children does not represent an isolated and chance misconception.

I am not prepared to offer a specific formula for revising pre-college courses of study with a view of serving the best interests of geology. I do suggest that this general subject deserves very serious study by geologists—a study aimed toward some sort of corrective action. We have taken for granted the situation as it exists, accepting the obvious handicap to our training program as if it were fixed by immutable law. Some individuals have seen the problem, but there has been no concerted move even to make a comprehensive study, with the object of learning what the exact situation is, and what changes may be desirable and possible. Even if numerous individual geologists should see a need for action in this matter, how would they proceed? The simple fact is that we are not organized to deal with a far-reaching problem of this kind. We have a number of large and vigorous societies, each of which has developed naturally about a somewhat special focus of interest in the broad field of geologic endeavor. The one with the most comprehensive title—the Geological Society of America—is and has been from its inception a research organization. Its administrative machinery is designed to care for its research program; it is not prepared, nor has it been deputized by the geologic fraternity, to make broad studies leading to policies in education. The American Association of Petroleum Geologists has made some commendable investigations of trends among students in geology and of certain aspects of college curricula. However, it would be altogether inappropriate for the association to assume the heavy responsibility of guiding the entire educational program in geology. We are slowly waking up to a realization that large matters of common interest to all geologists are in danger of going by default, because no existing organization either feels the obligation or has authority to take actions that affect all groups equally. Important societies in earth-science are about as numerous as the original American colonies, and face common problems analogous to those confronting the thirteen political units before they agreed to place their common interests into the hands of a central representative body.

Fortunately there is now under serious consideration the formation of a geological institute or union, to meet the growing need of a central agency to deal with matters of common concern. This need became especially acute under the pressure of problems created by the war; attempts to serve the interests of geology have suffered either from needless duplication among the several organizations or from lack of representatives to act for the entire fraternity on critical occasions. Geologists should make sure, as promptly as possible, that no future emergency shall find us unprepared to act with vigorous and intelligent coordination. There is much more at stake, however, than advance preparation for a possible future war. The situation in geological education constitutes a chronic emergency, which will grow more acute as it is neglected. Other sciences and professions have been more foresighted in this matter. The engineers, for example, have a Society for Promotion of Engineering Education, a progressive and effective organization. Geologists, less numerous and somewhat less heterogeneous than the engineers, do not require a special society to perform this function for their science. However, we might well have an important standing Committee for Promotion of Geological Education. In my opinion, such a committee should be formed and should go to work as soon as the union of geological societies becomes a reality. The committee would give careful attention to all aspects of our educational program. In particular, at an early date it should take up the problem of pre-college training. What is being done, the country over, to give pupils in grade schools and high school some elementary introduction to the subject-matter and the functions of geology? Which of the methods used, in courses that are entitled physiography, physical geography, or general science, seem to be beneficial as elementary preparation for geology or as useful instruction for those who will go no further in this field? What changes, otherwise deemed desirable, appear to be practicable from the viewpoint of the secondary schools? When a blueprint for action is agreed upon by the committee, the weight of the founder societies can be placed behind efforts to put the program into effect. This suggestion is not made with any implication that our plans in this matter, once we have agreed on them, can be carried out with expedition and ease. No doubt the project will involve a long and difficult campaign, with loss of some local battles, revisions of strategy based on hard-won experience, even some changes in objectives as we come to appraise the impact of our efforts on the complex fabric of secondary-school education.

Since the project suggested here is made conditional on formation of the geological union now under consideration, a word concerning this proposed association may be in order. Already a few geologists, with characteristic American distrust of anything savoring of centralization, have voiced fear that a "superorganization" in geology may turn out to be a Frankenstein monster, which will swallow up the autonomy and destroy the cherished independence of the founder societies. It should not be difficult to dispel any such fears. No move is in progress to create a new autonomous unit which will compete with or assume func-

tions of any existing society. There have been some published suggestions—which seem extremely ill-advised—favoring a large new overall organization, in which all interested geologists and laymen might have individual membership, and to which would be entrusted the formulation of policy in all matters of general concern to our science. Even on the assumption that such a new organization would thrive—and there is little probability that it would—surely the consequence would be overlapping and conflict of function, with much more confusion than clarification of our present problems. Progress has been made in developing a more hopeful proposal: that present societies unite in forming an agency—not a governing body—to be manned by representatives from the several participating societies, and to be charged with tasks that concern the interests of all geology and geophysics. Surely one of the prime common interests is the training of replacements for posts of leadership in geologic and geophysical research, teaching, administration, and field application. So vital a matter can not be left any longer to chance or to half-measures if geology is to continue as a virile science. There are additional urgent reasons for close liaison and coordination among organizations in earth-science, as we have come to realize forcibly from experiences during the war. However, even if these other reasons did not exist, the needs of our educational program alone should justify many-fold the cooperative union of societies now in prospect.

The agency planned to coordinate efforts in geology and geophysics looks highly promising "on paper," but an experimental period will be required to test its effectiveness and to repair unforeseen weaknesses in its organizational machinery. During that formative period the founder societies will have to be constantly alert; "eternal vigilance" will be the price of an agency that is to function smoothly and actually meet the major problems for which it is designed. Whatever the theoretical merits of the plan, the personal element will be all-important for successful execution. If the experience of similar coordinating bodies can serve as a basis for forecasting, probably the success of the venture will depend most heavily on finding a wise and devoted executive officer who will guide and stimulate activities of the agency in profitable channels. If the organization can be launched under effective leadership, prospects will be bright for some betterment of our educational situation.

There has been much recent discussion of "public education" in geology, and claims are made that proper attention to enlightening the lay public will provide the key to solution of our outstanding practical problems. Ideas on this subject are so diverse that it is well to make some analysis, in an attempt to determine logical points of departure and sane objectives. On the one hand we are urged, in effect, to throw off our aversion to publicity and to "sell" geology by the most approved commercial methods, with all the eloquence and human appeal of the broadcaster who presents the merits of an oval cake of soap or the "cigar of the hour." The antithesis of this view is the scornful remark of a late dignified gentleman that geology is on too high a plane for the masses, and that attempts to popularize the subject are silly waste of time. Somewhere in the wide area between these extreme viewpoints, some ground for agreement on principle and for practical action may be found. Of course parts of this area have already been explored, and much effective work is being done. The growing tendency to "humanize" scientific knowledge is well expressed in the revised constitution of the American Association for the Advancement of Science, in the statement that a primary object of the organization is "to increase public understanding and appreciation of the importance and promise of the methods of science in human progress."

Probably few students of geology would have any sympathy with the exclusive attitude of the departed gentleman mentioned above. Scientists who stay aloof from programs of popular education usually do so because they are deeply absorbed in their own work, and not from any conviction that popularization is either wrong or futile. Surely a large majority of geologists will agree, at least academically, that many aspects of our subject have inherent popular interest and that a wholesome public-relations program will benefit both the science and the public. There is general agreement also that nearly all geologic literature is not only unattractive but indigestible to the average man in the street. The same statement applies to the literature of any other science, and of course the explanation involves much more than insulating jargon, as any scientist will testify when he undertakes to read a technical treatise on a subject remote from his own special field. The area of general agreement, then, will include the proposition that only selected aspects of geology are suitable for serving to the general public, and that the selected diet should be prepared in somewhat special form. Opinions differ widely regarding the scope and aims of public education and the machinery to be employed. At what segments of the population should our efforts be particularly directed? Should the chief objective be wider recognition and employment of geologic services or merely altruistic extension of geologic knowledge for its own sake? Shall we leave efforts altogether to individual enterprise, or design a sys-

tematic program through national societies and other organizations? If there is to be an organized plan, what part of our total energy and resources can it fairly claim?

From time to time one or another group is brought sharply into focus as an element of the public claiming our interest. In 1928, failure of the St. Francis dam in California directed attention of geologists to public officials and engineers who have charge of building large structures involving bedrock. Probably that disaster established the value of geology in engineering more effectively than years of organized propaganda could have done. During the present war the responsible officers of our armed forces are a part of the public with which we are especially concerned. This is not to say that the Army has ignored geology. Early in the war the Corps of Engineers revealed a well-conceived plan to use geologists for preparing terrain intelligence reports of possible combat areas, and a large civilian organization in Washington has been performing this function with admirable skill and thoroughness. If we had only the accomplishment of this special unit to cite as the contribution of geology to the war effort, the record of our science would be distinguished. The opinion has been widely expressed that this commendable use of geology should have been supplemented by employment of many geologists in the field armies, as there is reason to believe our enemies are doing, to aid in solution of terrain problems as they arise, and to make the terrain intelligence reports prepared in the office more effective by interpretation and constructive modification on the ground. Whatever the merits of this viewpoint, it is probable that geology in its applications to warfare has been employed in the present conflict as fully as this aspect of the science has been clearly defined in the minds of geologists themselves and intelligently presented to military men. If in our view these men have failed to recognize the full potentialities of geology as a basis of military terrain study, a little introspection reveals that geologists gave this important matter only casual and sporadic attention in the interval between the two great wars. We should now profit from this experience; the record of geologic participation in this war should be fully compiled, and the results should be analyzed with the aim of better understanding on the part of geologists as well as military leaders.

Efforts to realize the most effective use of geology in the war have brought conviction that the science will come to be accepted and utilized in special situations in proportion to increase of knowledge and appreciation of its broad concepts among intelligent people everywhere. If this view is correct, our basic problem reduces to fairly simple terms, although its magnitude is undiminished. Even from a long-range viewpoint of self-interest, the most hopeful program of public education in geology looks beyond government officials, military leaders and other important special elements of society. Our goal should be the widest possible dissemination of geologic information that can be made intelligible to laymen without a technical background. Each of us counts among his acquaintances amateurs who have mastered certain aspects of the subject and some who have remarkable grasp of geologic principles. If this comparatively small number were greatly multiplied, public enjoyment of outdoor nature would be increased, geology would have more friends in practical situations, and probably there would be a larger number of worthy candidates for professional study. With these rich returns in prospect, we could justifiably devote a considerable share of our energy and resources to this boundless educational program. There remains the important question of how and by whom the task is to be attempted.

Some have already suggested an answer to this question. They point out that the modern instruments of communication are radio and the printed word. What is required, they say, is an agency to supply talent and funds for regular broadcasts, news stories and magazine articles on geological subjects. It is even suggested that our wealthiest society for research should revise its entire organization and program to become the principal sponsor of this educational experiment. The suggestion might have merit if we could believe that the proposed investment would bring an adequate return. Geologists know, however, that real appreciation of geology is more likely to come from field observation than from clever expositions, either spoken or written. A dweller near the bluffs of the upper Mississippi River may be entertained by well-phrased descriptions and explanations of the Rocky Mountains and the Sierra Nevada, but he will find more genuine pleasure and enduring knowledge by examining the marine strata and the glacial drift in his own neighborhood. Before we experiment by turning a research institution into a chamber of commerce it will be best to explore other and more promising means of geologic instruction. Radio and newspaper publicity are valuable aids in any wide educational movements. However, to rely on these methods as the chief remedies for widespread ignorance of geology would be comparable to the use of an external salve in trying to cure an organic disease.

Every State in the Union has colleges equipped with departments of geology. Many States have also active

Academies of Science which already are giving attention to public education in the sciences, including geology. A number of museums, irregularly distributed, have excellent geologic exhibits and conduct programs designed for laymen interested in geology. Moreover there are numerous local geological societies, especially in States that have large populations of geologists engaged in commercial work. Staffs of these various organizations are not made up of persons of leisure; nevertheless, they are the nuclei of frontline troops that any additional program of public education must call to duty. In many localities they are reinforced by men and women in many vocations, including teachers in secondary and grade schools, who have had training in geology and who continue to follow the subject as a hobby. Opportunities to arouse and foster popular interest are ready made in many communities. Mineral clubs and hiking clubs are numerous and perennial, even in the movie-infested cities. Participation in such organizations by one or more persons who know the local geology often furnishes the spark that turns mild interest into enthusiasm. Possibly the greatest single impetus to the study of local geology is publication of guidebooks that explain the bedrock units and the land forms, and give detailed directions to points of particular interest such as road cuts, quarries, glacial features, mineral localities and the numerous other types of geologic exhibits that nearly every district affords. Obviously some sections of the country offer better material than others for such guidebooks. However, every considerable area has a wealth of geologic features, even though some of the more spectacular types are lacking.

Two obvious comments will be evoked by the foregoing suggestions. First, it will be pointed out that numerous members of teaching departments and of other geological units are already engaged in some of the activities mentioned. This of course is true. I know a number of geologists who are doing yeoman service in popular education by supporting local clubs, giving lectures to amateur groups and making other time-consuming contributions. The success of these individual efforts is the chief basis for encouraging a more extensive program of the same sort. It will be said also, with justification, that mere optimistic talk about large expansion of these local volunteer activities has a "pollyanna" flavor. Large areas in the country have no geological organizations, or at best have only small units with overworked staffs. Preparation of an adequate guidebook is a formidable task, and in many communities there are no resources for publishing such altruistic literature. Schemes for universal missionary work in geological education are impractical unless they make provision for substantial cooperative aid.

Any comprehensive plan must start with an inventory of all effective facilities. A strategic unit is the State Geological Survey. Such surveys exist in a large majority of the States, although they vary between wide limits in size and strength. Some of the more progressive surveys are already showing the way in organized programs of public education. At least one has for this purpose a special division, which supplies mineral study-sets and other geologic materials to schools and amateur clubs, organizes field trips for teachers, furnishes illustrated lectures on request, publishes nontechnical bulletins on the mineral resources and geologic features of the State, and contributes in other ways to a well-integrated educational program. No doubt this and other surveys would cooperate also with local plans of college departments, Academies of Science and local societies, perhaps to the extent of facilitating publication of guidebooks. Integration and mutual stimulation of all agencies within a State would be the ideal arrangement, since the State makes a convenient and manageable unit, and the governmental machinery already developed for educational purposes can be utilized. The Association of College Geology Teachers, a growing organization that has public education as a leading objective, may come to play an important part in State programs.

Geological Surveys vary in strength more or less directly with the value of mineral resources in the States, and a fairly large number of States have either weak Surveys or none at all. Colleges with departments of geology also are few and small in some large sections of the country, and wherever this scarcity coincides with weakness of State Surveys the local facilities for public education are discouragingly small. In these situations the national societies will have to take a hand, if we are to have a nationwide program of public education. This may be another major problem for the geological union, if and when it takes form. Conceivably this body, after appropriate study of the problem, should sponsor a general plan, which would aim to stimulate efforts in public education in all parts of the country. The general principle should be to leave actual operations to local individuals and organizations, and to go no farther than local interest seemed to warrant; to encourage, and in no case to dictate or to supply all facilities. Aid in publication of some local guidebooks might be the chief financial contribution from the societies.

The list of organizations to participate in the close-knit national effort has omitted, up to this point, the U. S. Geological Survey. In general its activities are

subject to budgetary stipulations, and perhaps it could play no leading official part in organizing the proposed educational program. However, many of its members would lend sympathetic support, and no doubt the program would in time receive aid in many forms from the Survey. I am informed that the Survey now has plans for the preparation of abundantly illustrated geologic guidebooks for a number of our transcontinental highways. These will be written in lay language and an attractive style. Comparable guidebooks for the transcontinental and other principal skyways are also being planned, but these would be illustrated primarily with airplane photographs and geologic maps superposed on airplane-photograph mosaics. Modernized railroad guides also are contemplated in this series. The highway guides hold particular promise. In the decade before the war the volume of tourist travel between East and West reached enormous proportions. Prospects are for a large increase of such travel when peace returns. It is true that to some of these tourists the chief objective, at any point on the road, is to reach the next town in the shortest possible time. A large proportion, however, are thoughtful people, curious to know the scientific explanation of natural features along the route. Available road maps guide them to the chief scenic localities, but except for some of the national parks and monuments they find no adequate geologic explanations. Well-designed guidebooks would correct the impression that a few scenic areas in the country are separated by vast spaces devoid of interest. The wide inland seas of Paleozoic date, the glaciers of the Ice Age and other features of the geologic past for which there is abundant roadside evidence, could be made to relieve monotonous modern scenery. Locations of coal fields, oil pools and other mineral deposits, with significant facts of their geologic setting, would be welcome information to many travelers. If only a small fraction of our touring throngs actually used the guidebooks for serious study, the net result would be increased understanding of landscapes in terms of their geologic history and a wider appreciation of geology as a science that is serviceable and not merely entertaining. A large number would use the books to excellent advantage if they were made as informative and attractive as the available subject-matter warrants.

There is increasing evidence that busy geologists are accepting an obligation to contribute time and energy to the large task of interpreting their science to the public. The latest number of the *Geological Magazine* to reach this country contains reviews of three books entitled "Teach Yourself Geology," "Geology for Everyman" and "Geology in the Service of Man." Several books of similar character have appeared in this country within recent years. Unless geologists take the trouble to supply the growing demand for such literature, amateurs will undertake the task, with results that we shall not like. If geologists are to assume the burden, some organization of effort will distribute the load and make the effort far more effective. This suggestion does not point to "regimentation," or any stifling of individual incentive. A project like that of the proposed guidebooks can be accomplished only through coordination of all available facilities—local, State and national.

We ought eventually to have in this country an organization similar to the Geologists' Association in England, designed to serve the common interests of professional and amateur geologists. If such an organization can wax strong on a nationwide scale, it will have a powerful influence in further extension of geological education to the public. Probably growth of an American Geologists' Association will be gradual, perhaps by merging of initial local organizations in parts of the country where amateur interest is particularly strong. Because of the great size of this country, as compared with the compactness of England, no doubt our association of amateurs would operate most effectively in a considerable number of sections, each of which would have an annual field excursion and convention. Basic units would be subdivisions of regional sections, small enough to permit more frequent meetings for field study and discussion. College departments would be active elements in the smaller units, and the entire movement would be a logical development from small beginnings stimulated by local guidebooks in college communities. Any attempt to start such an organization "in reverse," by setting up a national framework before local foundations are laid, would be artificial and probably futile.

At the close of this brief discussion some may feel that Hamlet has been left out of the play, since the large problems of technical training in geology are omitted. No doubt some will see undue emphasis on public education, since the chief function of the geologist is not to entertain the public. However, if we may borrow a phrase from the politician, the "grass-roots" merit our serious attention. Geology has a large asset in the widespread appeal of visible geologic features. Cultivation of this natural interest will be a valuable contribution to cultural education in a materialistic age, and may prove to be the most effective means of insuring a flow of high-grade recruits into our professional ranks. When geologists are ready to give unified and systematic attention to this large and important problem, they will demonstrate that the science in this country is really coming of age.