GEOLOGICAL SURVEY CIRCULAR 73

March 1950

TRAINING GEOLOGISTS: A UNITED STATES GEOLOGICAL SURVEY VIEWPOINT

By

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WASHINGTON, D. C.

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PREFACE

Each year the Geological Survey receives numerous inquiries bearing on the question of what constitutes adequate university training for students who desire a career in geology. In the absence of any documented summary of Geological Survey views on this subject, and at the invitation of the American Institute of Mining and Metallurgical Engineers to contribute a paper to its recent symposium on "Training Geologists," H. M. Bannerman and W. T. Pecora prepared a review of the training problem as it affects the Geological Survey. Their original paper, delivered as an address before the Institute in New York City, February 12, 1950, and reproduced here with slight modification as a Geological Survey circular, represents views widely held by geologists of the Survey as a result of many years of professional experience.

W. E. WRATHER
Director

TRAINING GEOLOGISTS

INTRODUCTION

This paper is restricted to a consideration of the requirements deemed essential to a career as a geologist in the United States Geological Survey. As such, it is only incidentally concerned with many of the broad aspects of geology in education that of necessity must be taken into account by the universities and colleges in framing educational curricula. Moreover, the paper makes no attempt to indicate curricula or to outline the courses that should be followed in training geologists, though it undertakes to examine a number of the academic and personal features of the problem insofar as they relate to the responsibilities and activities of the Geological Survey.

RESPONSIBILITIES AND ACTIVITIES OF THE SURVEY

The Survey is primarily a fact-finding and research organization, and its history has been peculiarly one of public service. Currently it is charged by the Congress with such duties as the classification of the public land; the preparation of adequate topographic and geologic maps of the United States, Alaska, and insular possessions; the study of the geologic structure and the appraisal of the mineral and water resources of the national domain; and the administration of Federal mineral leasing laws; and under the "Stockpiling Act," it is directed to make scientific and economic studies of the extent and mode of occurrance of ores and minerals and to conduct explorations for those that are known to be in short supply but which are essential to the security and industrial development of the United States.

It is obvious, therefore, that to discharge the functions inherent in these responsibilities the Survey must employ personnel schooled in most, if not all, of the technical skills known to the geological sciences. We also have to employ geophysicists, geochemists, mathematicians, physicists, chemists, engineers, oceanographers, and botanists.

Currently there are about 900 professional geologists on the staff, of whom some 236 are part-time employees. Roughly they are engaged as follows:

About five percent are involved in high-level planning, in administrative and broad supervisory duties, and in editing or otherwise preparing maps and reports for publication.

Ten percent are engaged essentially in various researches in mineralogy, petrology, and paleontology, though a part of the effort of this group is devoted to identifications for, and consultation with, the geologists in the field service.

Seventeen percent are engaged in ground-water studies, largely in cooperation with State agencies.

Thirty percent are directly concerned with investigations of metallic and nonmetallic mineral deposits in the United States and Alaska.

Sixteen percent are engaged in the investigation of fuels (coal, oil, and gas) in the United States and Alaska.

Nine percent are engaged in military geology. A major part of this activity has to do with the study of permafrost in

Alaska and with general geologic investigations in the islands of the western Pacific.

Five percent are involved in engineering and general geologic studies, primarily with reference to the Federal Government's construction and river-basin development programs.

Four percent are conducting regional studies aimed primarily at the solution of general geologic problems.

Two percent carry on conservational and appraisal studies in connection with the administration of the public-land laws.

Two percent are engaged in minerals investigations in foreign areas under the auspices of the Department of State and the Economic Cooperation Administration.

From this very generalized summation it is obvious that the greater part of the geological work of the Survey is aimed at definite economic objectives. This is, of course, in accordance with the main purpose and intent of the Congress in appropriating funds to the Survey. However, the program is not primarily one of applied geology; instead, it is mainly concerned with work that is more properly termed background or objective research. By far the greater part of it has to do with such activities as regional geologic mapping and broad stratigraphic and structural studies of entire mining districts, of fuels provinces, or of areas that are believed to hold promise for the discovery of minerals or fuels; research aimed at developing or refining techniques that may prove useful in the search for minerals resources; and investigations designed to provide the background data needed for planning and executing the enormous programs of river-basin development that are under way or are being contemplated by the Federal Government. Each unit in the organization is involved in large measure with background research peculiar to its own particular field of activity. In addition, most of the units carry on some research of more basic and fundamental nature. This pattern is in keeping with the traditions of the Survey in that, despite the enormous amount of energy that has had to be expended to meet the day-by-day demands for general services, the Survey has always emphasized the research aspects of its job.

EDUCATIONAL BACKGROUND

Nearly all the geologists of the Survey have permanent Civil Service status. This means that they have been recruited from a register of eligibles established by the Civil Service Commission on the basis of competitive examinations of one kind or another. The minimum educational requirements for men and women entering the service in a professional capacity are 30 semester hours of geology or an alternative of 24 semester hours in fundamental geology courses with 6 hours in advanced courses in related sciences.

We will not presume to advise students or universities as to what curriculum of studies should be followed to qualify for appointment or to insure a fully productive career in the Geological Survey, for it is doubtful if we would find agreement even among ourselves as to the specific course patterns best suited to the purpose. Moreover, the records show that the more successful men in the Survey have followed various paths of education. A few generalizations as to basic requirements and personal attributes seem justified, however, and may prove helpful.

It has become increasingly evident that undergraduate training alone is rarely adequate for a satisfactory career with the United States Geological Survey, even though it may suffice to pass the Civil Service examination. Only the unusual 4-year student can compete favorably in Survey professional circles with those

who have had the advantages of postgraduate training. The Survey does not require a doctorate, nor do the records indicate that the Ph.D. is necessary to a successful career with the Survey; yet the intellectual discipline, the intensive training, and the research habits instilled by the graduate-school environment are of paramount importance to a Survey geologist. We recommend, therefore, that college seniors aiming at a career in the Survey plan to devote at least 2 years to postgraduate studies and, if reasonably possible, that they complete the course requirements for the doctorate. To this end we have in the past 4 years encouraged young geologists who joined the staff during the war and who had not completed their graduate training to take a furlough and return to the university for further training. Wherever possible within the framework of the projects on which they were working, we have also encouraged them to prepare and submit appropriate reports on parts of the geologic problems in which they were engaged as dissertations in partial fulfillment of the requirements for an advanced degree. Currently some 80 geologists are on furlough from the Survey staff in pursuit of advanced university training; 18 of these are using results of their Survey investigations as theses.

For a number of geologists, who for various reasons are unable to return to the university just now, the Survey has recently devised a course of lectures and seminars in Washington by arrangement with the Graduate School of the Department of Agriculture. These courses, given at off-duty hours, are organized and guided by experienced Survey geologists. They are aimed at broadening professional horizons in the younger employees and at developing research incentives. As far as we are able to judge to date, they are proving successful; however, they are not a satisfactory substitute for university graduate training, nor are they so intended.

TECHNICAL DISCIPLINES

Survey experience shows that in general the student who is well grounded in each of the fundamental geologic disciplines and in the basic sciences (physics, chemistry, mathematics, and biology) before concentrating on any specific field in geology proves to be more suited to a Survey career than the one who turns to specialization in the early stages of his training. This is so partly because a reasonable facility with a considerable range of geologic skills is required by the diverse activities to which men on the Survey are likely to be assigned in their early years with the organization. More important, however, the broader training leads to a more comprehensive understanding of the over-all problems with which one must deal and quickens the versatility needed to do an all-round job. It also leads to a freer interchange of ideas with one's colleagues, which in turn tends to develop leadership qualities and high *esprit de corps*.

Accordingly, it is our view that--irrespective of the specialties they may eventually follow--students should have a sound training in mineralogy, petrology and petrography, paleontology, stratigraphy, structural geology, geomorphology, map interpretation, and map construction, including the elements of surveying, photogrammetry, and drafting. We recognize, too, that a geologist is first of all a scientist. We therefore feel that he should thoroughly understand the scientific method and, within the limits of his experience, know how to apply scientific principles to the solution of geologic problems. Moreover, as each of the geologic sciences is based in large measure on one or more of the basic sciences and

on the border-line sciences, especially geophysics and geochemistry, and as geologic field techniques are based in part on the principles of engineering, we believe that appropriate combinations of these disciplines should be included in a geologist's early training. He should also have a reading and writing acquaintance with some foreign languages, a sound training in the use of English, and an appreciation of the principles of logic as opposed to argumentation, and he should understand the need for careful documentation in scientific writing and know how to use geologic literature as an instrument of research.

PERSONAL ATTRIBUTES

In addition, certain personal attributes must be taken into account in selecting geologists for the permanent staff of the Survey. For example, we believe personal integrity is of first-order importance in all persons who aspire to any sort of scientific career and especially in those engaged in scientific work for the Government. We also have to keep in mind the fact that we are a public agency devoted to public service. Each of our geologists is in some measure an emissary of the Survey. The reputation of the organization and the success of his own mission depend to some extent upon his capacity to meet and to deal wisely and well with the people with whom he comes in contact. This is largely a matter of personality, tolerance of the views of others, judgment, and common sense.

Likewise, we must give attention to such attributes as personal initiative and willingness to cooperate. The program of the Survey requires close teamwork on the part of many individuals possessed of various skills and often of diverse points of view. Geology is becoming so specialized that group research is rapidly taking the place of the erstwhile lone worker who tried to do the whole job himself. In these circumstances a man should have the ability to cooperate with others--including his colleagues. We have, and we hope we always will have, a place in the organization for individualists, because individual initiative is the mainspring of scientific achievement, but the extreme individualist who always insists that this or that must be done "my way or else" and is intolerant of the ideas of others has to be exceedingly good to make up for the worry and hard feelings he engenders in the organization and for the excessive amount of time and energy that his supervisors have to devote toward keeping him and his associates happy. By contrast, a geologist endowed with a large capacity for original and independent thinking, who has a high degree of personal initiative and self-reliance and has been trained to maintain a keenly critical but well-balanced and constructive outlook, is of inestimable value to the organization.

DEFICIENCIES IN TRAINING

As a general rule we find that the young geologists who join the permanent staff of the Survey are well equipped academically to enter upon their duties. However, a few deficiencies in training have been rather apparent, from our viewpoint, among those who have come to us in the past few years. For example, many recent recruits seem to have had no instruction in report writing. A considerable number also lack training in the use of geologic literature in research and show little appreciation of the need for careful documentation in scientific writing. Likewise we find that some are not sufficiently trained in the use of the microscope to enable them to tackle the petrographic problems that beset every field geologist; others lack training in surveying and apparently have had little instruction in field geology and no practice in preparing maps from original data.

Perhaps, in comparison with the past, these deficiencies may be more apparent than real, for in recent years we have had to recruit a relatively large number of inexperienced personnel--among them, several men and women selected at an earlier stage in the educational process than was our custom in the days when postgraduates were willing to accept junior appointments. In part, however, the inadequacies seem to stem from the speed-up system and the overcrowding of facilities that have afflicted the universities in the postwar years. Whatever the cause, the deficiencies have created a situation for which corrective measures must be found; for the library habit is utterly essential to sound scientific research, the microscope is still the main laboratory tool of the geologist, proficiency in making a good map is still fundamental to doing good field work, and geologists who do not know how to prepare acceptable reports are not quite ready for professional status.

TRAINING FOR THE FUTURE

Current trends in the Survey program suggest that more and more quantitative data and greater skill in compiling and interpreting them will be demanded of the geologists of the future. We expect, therefore, that Survey geologists will be called upon to make much greater use of precise mineralogic and geochemical techniques in studies in petrology and mineral exploration. We also expect to place more emphasis on certain phases of geophysics in the determination of concealed geologic structures, in the search for mineral deposits, and in problems in ground-water and engineering geology. There is a similar need for the application of these skills and for improved mapping techniques in the study and interpretation of soils and other surface deposits, not only as they relate to problems in construction engineering and ground water, but also in the highly important field of soil conservation and land use. Moreover, we see a need for more emphasis on fundamental research. As examples, we might cite the need for detailed ecologic studies of living organisms to establish a firmer base and make more meaningful our interpretations in paleontology, sedimentation, and stratigraphy; and the need for the adaptation of appropriate skills from nuclear physics and geochemistry to the study of such problems as mineral genesis, the origin and circulation of aqueous solutions, the rate and process of oxidation and rock decay, and the determination of geologic age relations. Researches of this kind are a bit beyond the experience of the beginner, but we believe they are bound to become a necessary part of our future program. The student of today may well be called upon to take part in them tomorrow. This means that Survey geologists of tomorrow will need more mathematics and physics, more chemistry and mineralogy, more biology, and more training in the borderline sciences. They probably will also need more proficiency in the application of statistical techniques. If this is so, somewhere along the line the purely geologic curriculum now offered in undergraduate training will have to become more concentrated, for the educationists tell us that there is no time for additional courses.

How these educational goals are to be achieved and how the fundamentals that we deem essential can best be taught are questions that we cheerfully and confidently leave to our friends in the universities. As an agency concerned with research in almost every field of geology, the Survey wants geologists who are thoroughly trained in the fundamental geologic disciplines and who have the capacity to develop into specialists. We do not know of any simple formula by which these educational objectives can

be reached. We are inclined to doubt that there is one. If we succeed in identifying the jobs to be done, however, and if--continually appraising the skills required to do them--we insist upon high standards, both in training and at the various professional levels, we are certain that adequate skills will be developed to achieve our aims. The history of science is comforting in this respect.