The most extensive demand that the government makes, however, is for entomologists. Large numbers of such specialists are engaged in the study of insect life in all its aspects. A part of this work is done in the laboratories of the Department of Agriculture, but in many cases the field studies constitute a large proportion. Some of the investigations are of the most fundamental scientific value and there are projects for the exhaustive studies of life histories, such as, for instance, that of the honey bee. In this case several men give all their time to investigating, with excellent equipment, the complicated social and biological life of the hive.

As biological science grows, places are made in government departments to take advantage of the latest developments. Within recent years the subject of geneties has undergone rapid development and some of the underlying laws of heredity have become known. To extend our knowledge of these and to make them applicable to animal breeding the Department of Agriculture has established special facilities for the study of genetics and has employed men to investigate breeding problems in the most comprehensive manner. Positions thus opened are very attractive to persons desiring to follow the career of an investigator unhampered by teaching responsibilities.

The states now are also setting up laboratories which require trained zoologists. These may be in their universities and colleges or may be connected with public health departments, biological surveys, entomological commissions, or museums. Among them they offer some variety of choice but, in general, are distinguished from teaching positions by greater contact with the general public and by a larger element of administrative or regulatory work.

Similarly, large cities have established departments of public health in which there is occasional demand for zoologists, principally in entomological or parasitological studies. In some cities also there are municipal museums and zoological gardens which require zoologists trained as collectors, field naturalists and systematists in different groups. Sometimes these positions are very attractive.

Finally there are research institutions on private foundations where opportunities for zoological investigators are of the highest character. The development of these has been due largely to the failure of universities to make adequate provision for research. The rapid growth of science and the expensive equipment required for investigational work, together with the necessity of providing plenty of unhampered time for the student of new problems, has made inevitable and necessary the establishment of research institutes. Since these are well-endowed they offer attractive openings for thoroughly trained zoologists.

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GEOLOGY AS A PROFESSION

INTRODUCTION

"THE geological book—the greatest historical document of the ages . . .," these are the words of one worker after thirty active years of teaching and research. Are the attractions of geology really such that able young men of to-day may expect to be led to similar enthusiastic exclamation after their initiation into the science? To answer this question is the purpose of this paper.

RELATION TO OTHER SCIENCES

The first point which should be understood is that a liking for chemistry, physics, biology, mathematics, astronomy, or economics, excludes no one from becoming a geologist. Geology is not truly an independent science; it is a combination of other sciences directed towards a specific field of study—the earth. One of the greatest deterrents to more rapid progress in geology is the lack of broad training in other sciences; a professor of geology in a well-known university recently remarked that he would rather teach a graduate student well-grounded in other sciences and knowing little geology, than one well trained in geology and knowing little of other sciences. The fact that geology is in many ways not one of the exact sciences by no means indicates that a foundation in these is

not desirable. Many ridiculous hypotheses have been advanced in geologic theory which would never have escaped their authors' minds had some knowledge of the more exact sciences been there to hold their fancies in check. Many of the problems at present most obviously open for investigation are those on the borderland between geology, and physics or chemistry. This matter is stressed because many brilliant students are repelled from geology because of the number of questions to which "probably" or "perhaps" are the only safe answers. The converse of this is also true, that many men with a love of science have been attracted to this field for the very reason that the personal equation can enter in; and by their gifts of accurate observation, deduction and induction, such men have been able to make most important contributions.

OPPORTUNITIES IN GEOLOGY

Without attempting to make geology a sort of scientific catch-all, it is, nevertheless, evident that there is room for men of very diverse scholastic leanings. The same is true for occupational preferences; there are governmental exploring parties whose range of work extends from Alaska to Mexico; there are expeditions to distant or unexplored regions for commercial companies; there are state surveys in 41 of the 48 states; there is the teaching profession; and there is museum work. Lastly, there are opportunities in various endowed institutions, in some museums, and a few universities, for uninterrupted research. Geology not only appeals to men of diverse scientific tastes, but offers each a livelihood in the field of his choice.

POSSIBLE LINES OF INVESTIGATION

Some types of geologic investigation are described below:

First, there is investigation on the borderland between physics, chemistry, and to a certain extent astronomy, and geology. A good idea of the type of problem attacked in this field may be obtained from the list of publications of the Geophysical Laboratory of the Carnegie Institution. Here are such headings as:

Contributions to Cosmogony and the Fundamental Problems of Geology. The Tidal and Other Problems.

An Investigation into the Elastic Constants of Rocks . . .

Significance of Glass-making Processes to the Petrologist.

Methods of Petrographic Microscopic Research.

If a more detailed picture of the overlap of geology and chemistry is desired, the student need only glance through "The Data of Geochemistry," Bulletin 616, United States Geological Survey, where the almost endless inter-ramification of the two sciences is well illustrated.

Second, there is that great mass of research on the borderland between biology and geography. Types of recent topics are:

The Fossil Turtles of North America.

Iron-bearing Bacteria and their Geologic Relations.

Human Remains and Associated Fossils from the Pleistocene of Florida.

Distribution of Fossil Plants in Time and Space.

Such investigations have been carried out under the auspices of government museums, privately endowed museums, privately endowed research institutions, the United States Geological Survey, State Geological Surveys, and universities, and by teachers utilizing their spare time for independent research.

Third, there is the decided trend of many geologists toward research on the borderland between geology and economics, a useful field if competently filled. Of a recent book "Coal, Iron and War," written by a geologist, a reviewer has said that it "cuts under political and social facts" to the material influences which create them.

Fourth, there is research in commercial geology. There are two classes of commercial workers—the consulting geologist and the geologist in the employ of a single company. The first to a certain extent controls his time and has opportunity to devote considerable

energy to research. Such men have taken an active part in the development of their phase of geology and have made many valuable contributions to the subject. Those employed by a definite company have less control of their time and therefore less independence in the direction their studies take. In both cases the research is likely to contain an element of secrecy—and results of research which can not be published, no matter how good they may be, can not contribute to the advancement of the science. Recent studies show an actual decrease of published matter occurring at just about the time the call for oil geologists became pronounced. This is no indication that geologists should not go into professional geologic work, but it does point out that if a man feels he would enjoy the publication of the results of his research, there are far better openings than commercial work in his particular case.

There seems to be no need of discussing the various fields of what is more commonly considered geology. The sources of support are the same as above and the opportunities for subjects of study as endless as the topics of the text-books. Stratigraphy, physiography, economic geology, dynamical, and historical geology, with their accompanying theoretical aspects, all offer their attractions according to the taste of the investigator.

COMPENSATION

Compensation is unquestionably of two sorts—material and mental. In material compensation, there can be no doubt that the practising geologist leads. He also has the satisfaction that comes from active participation in the development and winning of material wealth. There is, however, a field of research where the results are not utilitarian and are of no apparent practical value. Here the financial reward is less, but there comes instead what to many men is the greatest joy of life—the personal discovery of new facts and the increase of human knowledge. A geologist said recently "I am doing just what I would do if I had a million dollars." The true research spirit has in it also an underlying motive of service to humanity. The reading of biography or personal observation will surely verify this statement.

> Great advances of the future are not dependent upon having every man do everything as an expert, but they will rest upon a wide appreciation of the importance of constructive thought, of organized knowledge, and of the continuous advance of knowledge.[1]

If a man's inclination is to add to this "continuous advance of knowledge" by personal effort, he may be sure that he will eventually feel well paid.

GEOLOGY AS A PROFESSION[2]

Why enter geology as a profession? The reasons are most diverse and will make varying appeals according to the likes and dislikes of the individual. No claim is made that the facts advanced are all peculiar to geology, but the combination of advantages is certainly hard to match elsewhere.

For the sake of clarity these reasons will be discussed under numerical headings.

1. *The science is young.* Any man of good ability may hope to make worth while contributions to it. The joy of discovery, already alluded to, is open to all.

2. *The range of possible employment is large.* The three most open to the beginner are teaching, work under government or state bureaus, and commercial employment. If one type of work proves distasteful, there are opportunities to utilize the same training in a different occupation. This fact has been amplified on a preceding page.

3. *The investigator may feel that his work has an intimate relation with the winning and best utilization of the raw materials which contribute to national and world prosperity.* This is often true even if his tastes lead him in fields which seem to have no relation to the practical needs of man. Berry,

[1] Address by J. C. Merriam. See SCIENCE for November 19, 1920.

[2] The writer wishes to acknowledge indebtedness to a splendid paper by R. D. Salisbury, in SCIENCE, April 5, 1918, for much that is good in the following discussion.

in reviewing a recent work on foraminifera, has pointed out that these microscopic animals "have lately been shown to be of profound significance in the location of oil sands . . . in the Texas oil fields."

4. *The geologist has the pleasure of realizing close bonds with many kinds of people and many fields of human interest.* The successful operation of the federal leasing law depends on the work which many young geologists have been doing in the different sections of the country in past summers. In the settlement of post-war problems in economics, the word of the geologist (and geographer) carried much weight. In matters of conservation and the establishment of national parks he holds an honorable place. And his influence on religious thought has been and still is great.

Geology means contact with people. The geologist in his field work often meets woodsmen, Indians, cowboys, pioneer agriculturalists, prospectors and miners; in consulting work, he deals with "big business"; in classroom or office, with highly trained university men; often his lot is cast with all three types many times in the course of a year. He must develop tact, an understanding and appreciation of people of various kinds, and an ability to adapt himself to varying conditions of life. Incidently, he will probably keep alive the "milk of human kindness." Geology may not be a humanistic subject, but it is a thoroughly human subject.

5. *The character of the science is such as to develop the quality of good judgment.* Geology being young and many theories still debatable, the first duty of the geologist is to consider the evidence and accept those theories according best with the known facts. Due, perhaps, to this and the preceding fact, many geologists have filled positions as college presidents, executive officers, and public servants with exceptional tact, skill, and integrity.

6. *The geologist derives great reward from his intimate understanding of nature.* No journey is so long, no desert so drear, no mountain so forbidding, no streamlet so small, no life so insignificant, that it does not bring with it some intimate revelation and fellowship. As is often said of religion, this is something which needs to be experienced to be understood. It is a wonderful possession to have and a wonderful gift to impart to others as teacher and as investigator. The geologist may not express his thoughts in a "Psalm of Life" as did Longfellow after viewing a fossil foot-print, but his inspiration may be even greater from his fuller understanding of its meaning.

7. *Geology is an invigorator—physically.* The researches of the active geologist will take him into the open, far away from the contaminated air of city and laboratory, for several weeks or months, each year. Few other learned professions can offer this inducement to their votaries. The geologist must love the out-of-doors and from this love he will draw physical fitness. Geology is pre-eminently a profession for the red-blooded, athletic type of man.

8. *Geology is an invigorator—morally and spiritually.* Consider the title of papers by some of the present-day leaders—J. M. Clarke, "The philosophy of geology and the order of the state"; T. C. Chamberlin, "A geologic forecast of the future opportunities of our race"; G. O. Smith, "Geology and the public service"; read the concluding paragraphs of text-books on geology; consider the closing words of a recent address before an important gathering of geologists—

> The student of earth sciences was once a contributor to the wider philosophy of nature. It may be his duty now to make sure, not only that his influence is felt in advancement of material welfare, but that he serve also to point out the lesson of the foundations of the earth, and to show that strength may still come from the hills.

In conclusion, for one who has scientific leanings, who cares for investigation, and who has ability, geology offers health, an optimistic outlook on life, human intercourse, abundant opportunity for research, and withal, a livelihood.

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