EMPLOYMENT OUTLOOK FOR

EARTH SCIENTISTS

UNITED STATES DEPARTMENT OF LABOR
Maurice J. Tobin, Secretary

BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

In cooperation with VETERANS ADMINISTRATION

OCCUPATIONAL OUTLOOK SERIES

BULLETIN No. 1050

Cover picture—Much of the work of earth scientists is carried on in the field.

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Letter of Transmittal

UNITED STATES DEPARTMENT OF LABOR,
BUREAU OF LABOR STATISTICS,
Washington, D. C., November 15, 1951.

The SECRETARY OF LABOR:

I have the honor to transmit herewith a report on the employment outlook for earth scientists. This is one of a series of reports made available through the Bureau's Occupational Outlook Service for use in the vocational counseling of young people in school, veterans, and others interested in selecting an occupation. This study was financed largely by the Veterans Administration, and the report was originally published as a Veterans Administration pamphlet for use in vocational rehabilitation and education activities.

In view of the essential contributions scientists make to the national defense and welfare, it is important that information on employment opportunities in the sciences be made available to young people possessing the necessary aptitudes for, and interest in, such work. The Bureau, therefore, plans to issue a series of reports, of which this is one, on the employment outlook in the natural sciences.

This study was conducted in the Bureau's Division of Manpower and Employment Statistics, Branch of Occupational Studies, under the supervision of Helen Wood. The report was prepared by Cora E. Taylor and Myron F. Lewis, with the assistance of Kevin R. Rohan. The Bureau wishes to acknowledge the generous assistance and cooperation received in connection with the study from the Geological Survey of the Department of the Interior, the Coast and Geodetic Survey of the Department of Commerce, and the Navy Hydrographic Office of the Department of Defense; from the Association of American Geographers, the American Meteorological Society, the American Geological Institute, and the American Geophysical Union; and from other organizations and individuals interested in the earth sciences.

EWAN CLAGUE, *Commissioner.*

HON. MAURICE J. TOBIN,
Secretary of Labor.

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Introduction

Men have always been interested in the nature of the planet on which they live. Since ancient times, traders, explorers, and pioneers have made their way into unknown parts of the earth and have sought to learn more about the lands they discovered. When the early Greeks and Phoenicians began to navigate the open seas, the success of their journeys depended on accurate knowledge of winds and weather, tides and currents, and the location of rocks, shoals, and harbors. The maps and charts used in that era were prepared without the accurate instruments we have today, but they record the progress made thousands of years ago in compiling information on the surface features of the earth.

In ancient times, people knew that valuable metals and precious stones lay under the earth's surface. The discovery of these riches was more or less accidental—they lacked the scientific knowledge which is today basic to the world-wide search for such minerals as coal, oil, and uranium. People in earlier centuries also speculated about the causes of terrifying phenomena such as tidal waves, floods, hurricanes, earthquakes, and volcanic eruptions. But they had no way of finding out the reasons for these occurrences. They thought natural disasters occurred because the gods were angry.

In the course of time knowledge of the earth gradually increased. The earth sciences, however, did not develop as a separate field of systematic study until the nineteenth century, and they have advanced most rapidly during the twentieth century.

Knowledge has now been accumulated to the extent that it is no longer possible for one person to become completely acquainted with all the fields of study encompassed by the earth sciences. Three subdivisions of this broad field have become generally recognized—geology, geography, and geophysics. Each of these subdivisions includes a number of related, narrower specialties. Geologists may specialize, for example, in the study of mineralogy and petrology (minerals or rocks), historical geology, economic geology, or other such closely related fields. Geographers may be experts in political, cultural, economic, or historical aspects of their science. Geophysicists may specialize in the study of volcanoes, earthquakes, the ocean, the atmosphere, the shape, size, and mass of the earth, the waters of the land areas of the earth, or the magnetic forces around and within the earth.

Specific divisions among earth science fields are never clear cut. Each type of earth scientist deals with problems concerning the other types. The close relation between the various specialties is reflected in educational institutions; in some universities, geographers, geologists, and geophysicists receive their training in a single department. The cooperation between specialties is also demonstrated in industry, as in the exploration for oil deposits, where geologists and geophysicists work side by side, each contributing his particular knowledge and skill to the search. Furthermore, there is a close relationship between the earth sciences and the biological and physical sciences, especially chemistry and physics.

Earth scientists divide their activities among basic research, teaching, and the application of research findings to practical problems. Much of the last-mentioned activity is of immediate importance to the defense program. For example, geologists and exploration geophysicists are being called on to assist in providing increased supplies of petroleum and minerals. Meteorologists must furnish more extensive weather data for military Air Force operations. Oceanographers are needed to carry on research connected with submarine operations and amphibious landings. Geographers supply information on foreign countries which is essential in defense planning.

This report is designed to give young people interested in preparing for careers as earth scientists an over-all picture of the main specialties and the employment opportunities they offer. Following a discussion of employment trends and outlook in the earth science fields as a whole, each of the major specialties is given a separate chapter discussing the nature of the work performed, places of employment, training requirements, usual methods of entry, and short- and long-run employment prospects. In addition to chapters on geology, geophysics, and geography, there is a separate section on oceanography, which, in some of its aspects, is a geophysical specialty. This section has been included to allow for a description of marine biology as well as physical oceanography. Meteorology, often classified as one of the geophysical fields, is likewise discussed separately, because in many educational institutions the preparation for this field is entirely distinct from that for other geophysical sciences and because it is also a separate field of employment. The report concludes with a discussion of the earnings of earth scientists and a brief section on sources of additional information.

Size and Growth of the Field

Although many thousands of people in this country have had several college courses in the earth sciences, probably fewer than 25,000 earned their living in 1951 by working professionally in these fields. The total number so employed is difficult to estimate because there are certain border-line fields of technical employment, related in varying degrees to the basic earth sciences. For example, several thousand men and women are doing work related to weather forecasting, yet not all of them are regarded as professional meteorologists because the amount of their formal training in meteorology varies greatly. Much the same situation prevails in relation to exploration geophysicists, who are among the several thousand highly skilled technical workers in the oil fields.

Geologists comprise the largest group of specialists in the earth sciences. About half (approximately 12,000 in 1951) the earth scientists are in geology and the closely related occupational specialties of paleontology, mineralogy, and geological engineering. Geophysicists, including meteorologists, oceanographers, and other related specialists, probably numbered as many as 10,000 in 1951. It is estimated that between 1,500 and 2,000 persons are professional geographers. However, only a part of this field, physical geography, can rightly be considered an earth science; certain aspects of geography belong, rather, to the social sciences.

Most of the earth science fields have grown steadily during the past 30 years, except for the World War II years. Detailed statistical data over a long period are lacking, but there are several sources indicating the growth of the earth sciences. The number of doctoral degrees awarded are shown in chart 1, for geology, geography, and the total earth science field. Because geology forms such a large proportion of the total number in the earth sciences, the trend line is dominated by that field.

The number of doctoral degrees conferred in the earth sciences dropped much lower, proportionately, than in all subject fields during World War II (table 1). On the other hand, the relative increase since the war has been much greater in the earth sciences than in all fields taken together. Over the entire decade from 1940 to 1950 the proportionate increase in doctorates was nearly as great in the earth sciences as in all fields—99 percent and 102 percent, respectively.

TABLE 1.—*Doctoral degrees awarded in all fields and the earth sciences, in selected years*

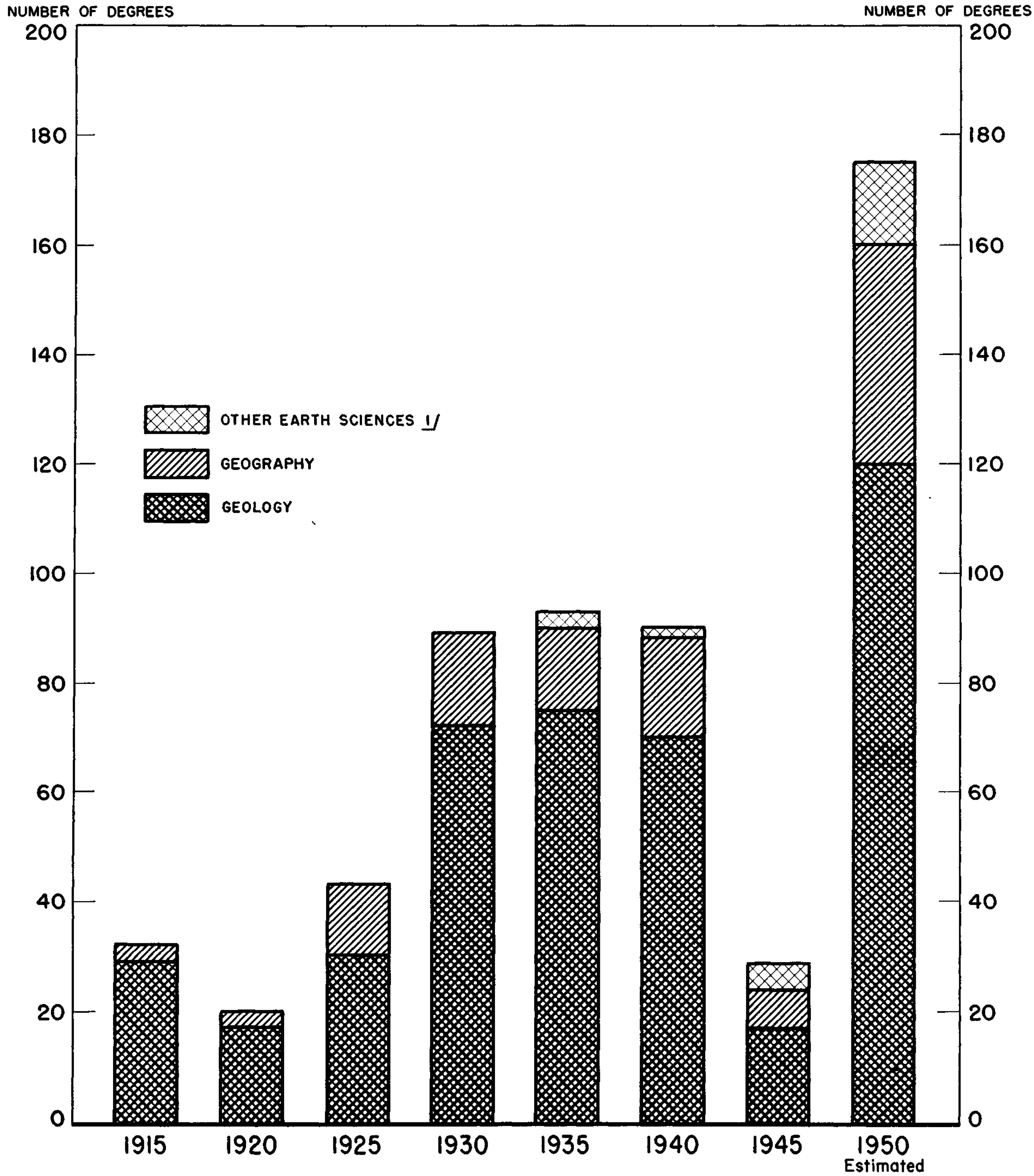
Year	All fields		Earth sciences	
	Number of degrees	Percent change over previous year shown	Number of degrees	Percent change over previous year shown
1940	3,290		90	
1944	2,305	−29.9	38	−57.8
1948	4,188	+77.4	90	+136.8
1949	5,293	+26.4	133	+47.8
1950	6,633	+25.3	179	+34.6

Source: U. S. Office of Education.

Another indication of the growth of the earth sciences is the marked increase in membership of the various related professional societies (chart 2). Society membership does not provide an exact measure of numbers in the various fields. Most scientists belong to more than one society, and the tendency to join professional organizations has become greater in recent years.

Chart I.

DOCTORATES CONFERRED IN THE EARTH SCIENCES BY AMERICAN UNIVERSITIES



1/ Includes geophysics, meteorology, oceanography, and seismology.

Source: National Research Council. 1950 estimate by Bureau of Labor Statistics.

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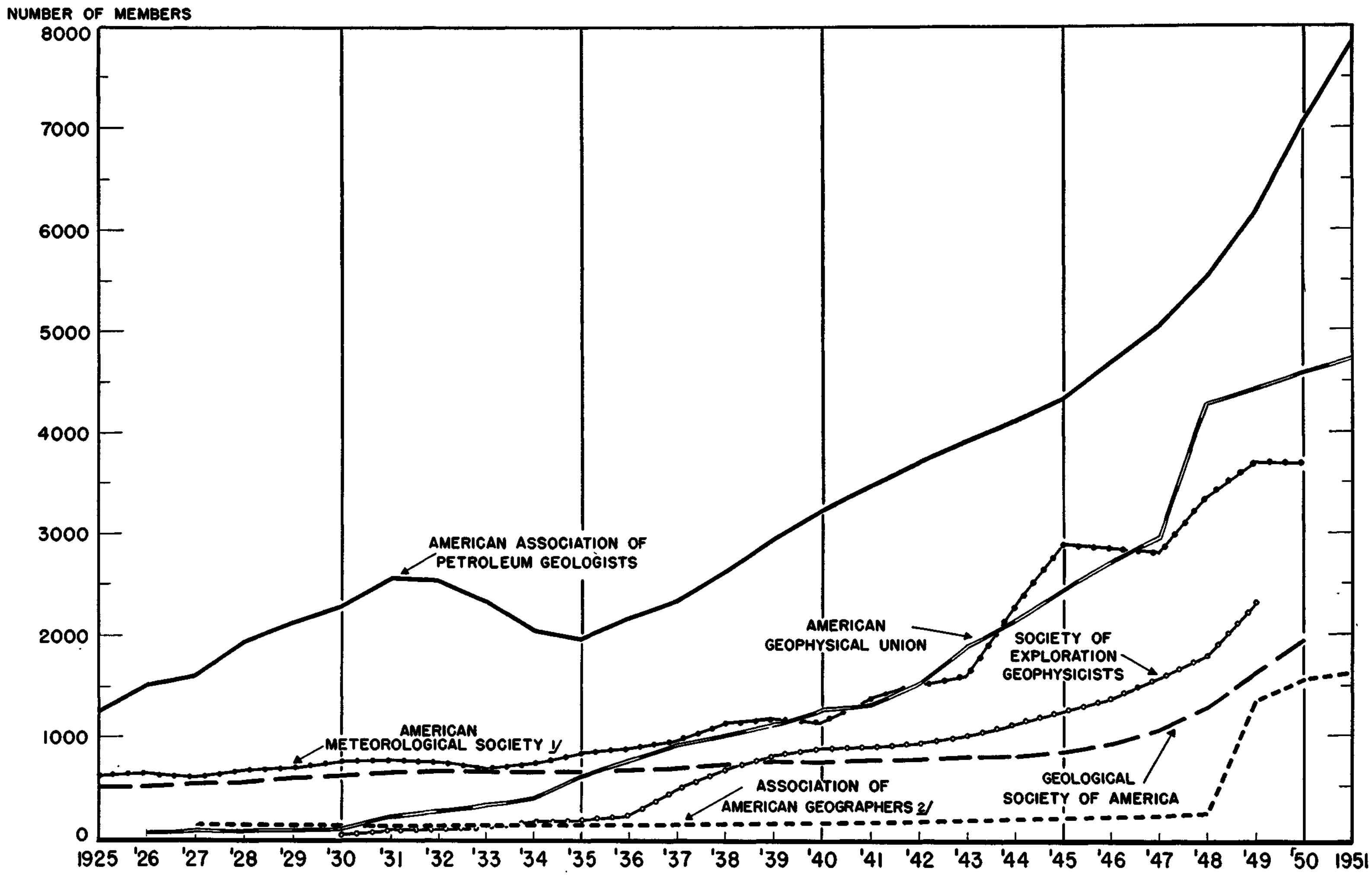
Chart 2.

GROWTH IN MEMBERSHIP OF PROFESSIONAL ASSOCIATIONS IN EARTH SCIENCES



1/ Paid-up members only for 1925-1944; all members for 1945-1950.
2/ Merged with approximately 900 members of American Society of Professional Geographers in 1949.

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Source: Data provided by the associations.

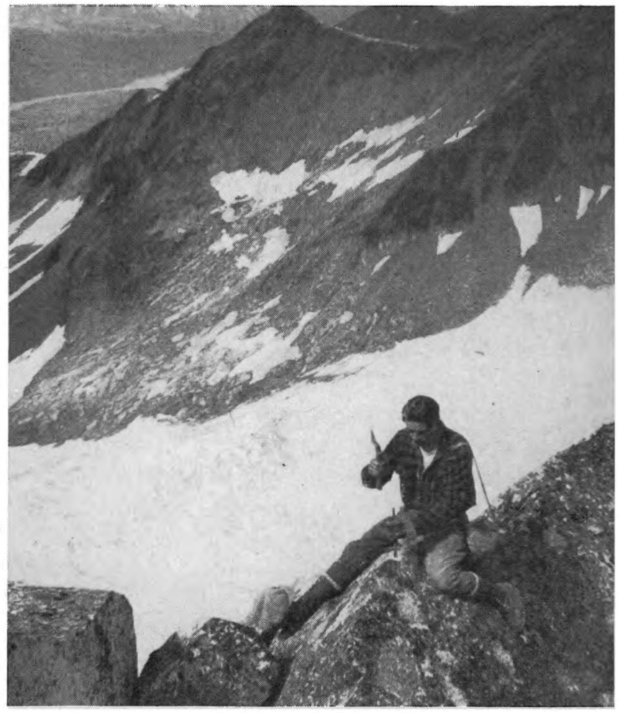
Employment Outlook

Employment prospects are expected to be good in the earth sciences in the early fifties. The defense program is increasing the demand for earth scientists, particularly in the petroleum and mineral industries and in Government service. In certain highly specialized areas, such as research geophysics, the letting of Government contracts has resulted in acute shortages of qualified research personnel. The armed services also need men trained in many of the earth science specialties. Some decline in employment is expected in college and university teaching mainly because of a temporary decrease in enrollments, but even there, new personnel may be required to replace those withdrawing for other jobs or retiring.

The earth scientists in greatest demand are those who are able to organize and direct either research projects or operating programs. Generally, 1 to 2 years of graduate study, in addition to professional experience, is required for such positions. The number of students receiving graduate degrees in the earth sciences has increased considerably since World War II, but the supply is still below the demand. Employers in some fields using earth scientists were lowering requirements for beginning positions in early 1951. As the defense program progresses, it is likely that shortages of highly trained personnel will become more acute. Employment opportunities should therefore improve for those with only the bachelor's degree who apply for professional work.

The long-run outlook is also good for earth scientists with graduate degrees. Scientific activity and employment, in general, have been rising rapidly over the past several decades. Research and development work has advanced in colleges and universities, in Government, and in industry. Private business organizations have extended their use of scientists into many phases of their operations; Government outlays for research, related both to national defense and to public welfare, have increased. Educational institutions have been called upon to assist more and more in the Nation's scientific program. Instead of small research projects undertaken by each student and a supervising faculty member, many universities now have full-scale research programs financed by industry or Government.

Even though petroleum and mineral prospecting will continue to be important, earth scientists in the future are likely to be concerned increasingly with many other problems of land and resource use and conservation, particularly those connected with water resources.



The conduct of geodetic and geologic surveys is a regular operation of the Federal Government, and many young scientists obtain valuable field experience on such work.

Some of the areas of employment which may expand greatly in the future are urban, regional, and river basin planning and development; utilization of the oceans as sources of food and minerals; weather control, rain-making, and irrigation on a great scale; tapping the crust of the earth for metallic ores; and the search for new mineral resources useful in the development of atomic energy. These and many other projects designed to promote human welfare await the skills of earth scientists. In addition to developing these new skills of technological application, members of the earth science professions will continue to conduct basic research on the natural phenomena of the solid earth, its waters, and atmosphere.

Geologists

Nature of Work

Geology is the largest of the fields generally classified as an earth science. About 12,000 professional geologists are now employed in the country. In addition, there are many engineers and scientists in other specialties who have had extensive training in geology and who make use of it in their professional work.

Geology is, broadly defined, the study of the earth's history and structure as they are disclosed by rock formations.[1] During the nineteenth century, when the first truly scientific work in geology began, geological investigations were concerned mainly with the origin and development of mountains, valleys, and other features of the earth; with rocks and minerals; and with the past history of living things as recorded in their fossil remains found in the earth.

As explanations were found for many of the earlier problems relating to the origins of rocks, minerals, mountain ranges, and fossils, the attention of geologists shifted from historical description to a study of the physical processes by which changes in the earth's structure take place. This field of study is known as physical and dynamic geology. Scientists specializing in it are making increasing use of chemistry, physics, and mathematics. Those engaged in the search for needed minerals and fuels—the main practical application of the science—also make much use of engineering techniques.

Functions performed.—The chief functions performed by geologists are field work (including exploration), research, teaching, and consulting. A few men are engaged in administrative and museum work. Although many geologists specialize in one of these functions, their work is seldom limited wholly to a single type of activity.

Most geologists spend a large portion of their time in field work. This requires mastery of the techniques of surveying, map making, note taking, and specimen collecting. The geologist studies the rocks and soils of the area under observation. He explores the surface and subsurface to determine the underground structure of the earth and the kinds of minerals or rocks discovered. He gages the thickness, slope, and direction of rock layers under the earth by observing outcrops of rock and by studying rock cores and cuttings brought up by drills. He may study fossil remains of animal and vegetable life. All the data are recorded in notebooks or on working maps drawn at the site. Among the simpler instruments used in field work are compasses, clinometers, aneroid barometers, hammers, cameras, and pocket lenses. During surveys the geologist collects minerals, rocks, fossils, and other specimens, to be studied later in the laboratory.[2]

Geologist testing a sample of nitrate with portable field outfit.

Although the amount of time spent in studying data in the laboratory depends upon the purpose of the study, all geologists require training in laboratory techniques and methods. They must know how to use the microscope, special instruments, and various chemical tests to identify and tabulate their specimens and determine their characteristics. They may also have to prepare finished maps of the region surveyed, using drafting instruments. When the final map or report on a survey is made, it usually gives a complete geological picture of the region under study.

In colleges and universities, geologists supervise the research of graduate and undergraduate students, direct laboratory and field work courses, and conduct basic investigations in many aspects of geological science. The time spent on research differs materially. In the smaller colleges, where the student body is composed entirely of under-

[1] National Roster of Scientific and Specialized Personnel, Handbook of Descriptions of Specialized Fields in Geology, Washington, D. C., June 1945.

[2] U. S. Civil Service Commission, Classification Standards Series for Geology, Washington, D. C., 1949.

graduates, geologists are likely to carry heavy teaching loads and to devote most of their time to instruction and administrative work. In large universities with funds for research work, geologists, like other scientists, may be able to spend as much as half or more of their time in research, including considerable time away from the campus while doing field work.

The work of the petroleum geologist is a special application of earth science to exploration for oil reserves. Whereas oil was once located by hit-or-miss methods, geologists now search for it with scientific instruments and techniques drawn from the allied sciences of geochemistry and geophysics as well as geology. As a rule, petroleum and mineral deposits cannot be located by surface observations. The petroleum geologist must be skilled in research techniques for locating underground structures (such as faults, anticlines, and salt domes) where oil reserves may be found. When a promising subsurface structure is located, the petroleum geologist, working with the geophysicist and the petroleum engineer, decides where to start drilling. When well-cores are brought up by the drills, the paleontologist and petroleum geologist analyze their fossil content and mineral composition to determine whether to continue drilling at that location.

Some geologists work as consultants for private industry or Federal or State government agencies on a full- or part-time basis. To succeed as a consultant, a geologist must have had long experience.

Fields of specialization.—The field of geology is still developing and a number of geological specialties are currently recognized. The following are the major research and applied fields in which geologists specialize:[3]

1. *Mineralogy* deals with the physical and chemical properties of minerals, their classification, and the way of distinguishing them.

2. *Petrology* deals with rocks, their origin and composition.

3. *Stratigraphy* deals with the arrangement and relationships of earth layers. It is sometimes called *historical geology*, since it is concerned with the chronological succession of rocks. This was one of the first subjects studied by geologists and remains one of their primary interests.

4. *Paleontology* deals with the organic life of past geological periods as revealed by fossil deposits. It is closely related to stratigraphy. Paleontologists must have an extensive knowledge of biology.

5. *Surficial geology or geomorphology* deals with the structure of the earth's surface. It is concerned with forces (such as erosion, glaciation, and sedimentation) causing changes in the landscape.

6. *Economic geology* is concerned with finding and exploiting useful mineral or other deposits and locating desirable sites for such structures as dam foundations. Economic geologists usually specialize in a particular type of deposit such as metallic or nonmetallic minerals, coal, or petroleum. One of the most important branches of economic geology, petroleum geology, is often treated as a separate geological specialty.

The gravity meter is a sensitive instrument used in locating subsurface geological structures.

Where Employed

By far the largest number of trained geologists in this country—about 70 percent—worked for private industry in 1951. Most of them were employed in the petroleum industry.[4] The second

[3] National Roster of Scientific and Specialized Personnel, Description of the Profession of Geology.

[4] American Geological Institute, The Supply and Demand for Geologists, 1949–1950. A report compiled by the Committee on Geological Personnel, National Research Council, Washington, D. C., 1950 (mimeo.).

largest number were employed by the mining industry. A few geologists found employment with construction companies, railroads, public utilities, and manufacturing plants (especially in the metal, stone, and clay products industries).

Colleges and universities employed about 12 percent of the Nation's geologists in 1951. The numbers engaged in teaching increased considerably after World War II because of unprecedented enrollments and the establishment of additional departments of geology. However, not all of these teachers were in departments of geology, because instruction in the earth sciences is a necessary part of the curriculum in mining, metallurgical, and civil engineering. A few persons who have majored in geology teach science in secondary schools.

Some geologists become independent consultants, and about 5 percent of the total number of geologists were so employed by industry or government in 1951.

Federal and State government agencies employ about 13 percent of the Nation's geologists. In the Federal service, as elsewhere, geologists carry on their investigations and research projects in the field, laboratory, and office. Government geologists may be assigned to work in any part of the United States and its Territories and possessions, and also in many allied countries where the need for development of natural resources is urgent. Types of work for which geologists are employed by the Federal Government include petrology, engineering geology, petrography, mineral deposits geology, fuels geology, stratigraphic paleontology, ground water geology, mineral classification, and museum geology. A recent Civil Service Commission examination announcement stated that the work done by persons appointed to professional positions as geologists in the Federal service would include making and recording geological observations; identifying and studying specimens of rock, fossils, and ores; carrying on or assisting in geological mapping; studying mineral deposits to determine their extent and value; studying the occurrence of ground waters; and preparing technical and economic reports for publication.

About 80 percent of the total number of geologists employed in 1950 by Federal agencies were with the Geological Survey of the United States Department of the Interior. The Bureau of Reclamation, also in the Department of the Interior, and the United States Army Corps of Engineers together employed about 16 percent.[5] State agencies employed a few hundred geologists, largely for work on State surveys in cooperation with the United States Geological Survey.

Education and Training

A career as a geologist usually requires four or more years of study, leading to the degree of bachelor of science, in a university, college or institute of technology. The opportunities to acquire equivalent knowledge of geological science by experience and on-the-job training are increasingly rare.

Most people who earn bachelor's degrees in geology obtain them in colleges of arts and sciences. The course requirements differ considerably among institutions. In general, however, the work in geology amounts to about one-fourth of the total semester hours for the 4 years of undergraduate study. About another fourth of the work is likely to be in related natural sciences and in mathematics, and the remaining one-half in general studies—some of which, such as English composition, economics, and foreign languages, provide training important to the profession. In some colleges a special program of studies leading to a bachelor's degree in geology has been set up, allowing as much as one-half of the undergraduate course work to be taken in the major field.[6] Some schools of engineering offer programs of undergraduate study in petroleum engineering and petroleum geology. In such programs as much as 90 percent of the work may be distinctly professional in character, preparing the majority of graduates to begin work without further training.

For entry positions in private industry, the bachelor's degree is often adequate, especially when the applicant's training has included extensive laboratory work, summer field courses, or short periods of apprentice training with industrial concerns. Each year a small number of graduates with only the bachelor's degree obtain

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[5] American Geological Institute, *op. cit.*

[6] Krumbein, W. D., Influence of Geophysics and Geochemistry on the Professional Training of Geologists, American Institute of Mining and Metallurgical Engineers, Technical Publication No. 1327, 1941, p. 11.

government positions. However, in geology, as in other scientific fields, a graduate degree is becoming an increasingly common requirement even for entry jobs. For research or college teaching positions, a Ph. D. degree is often required and is extremely useful in the competition for the more desirable positions (or for advancement in any type of work). The 7 or 8 years of higher education usually required to obtain this degree generally provide thorough academic training in the specialty and also considerable research experience. The preparation of a doctoral dissertation requires extensive independent field and laboratory investigation. In this research work, which may occupy full time for a year or more, the young geologist gains scientific experience equivalent to years of apprentice training on a job. Geologists with doctorates can sometimes start out in responsible positions involving supervision of other geologists with less education.

The importance of graduate training in Government employment was stated as follows in a recent pamphlet of the United States Geological Survey:

> 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 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.[7]

How To Enter

The professors, department heads, and placement officers of the institution where young geologists take their training play an important role in assisting them to find their first positions. Frequently, students make contacts with employers through field work courses, such as assisting in geological exploration work with an oil company in the summer. New graduates with advanced degrees who want college teaching positions usually obtain them through their head professor or research supervisor.

Beginning positions with the Federal or State geological surveys may be obtained after qualifying through a civil-service examination. Upon attaining a certain minimum level of training (usually the completion of 1 year of graduate study), the apprentice geologist may be eligible for membership in one of the national professional societies representing each of the principal fields of specialization in geology. Membership in these organizations, with attendance at their local and national meetings, is one excellent way for young geologists to find out about openings in private industry.

Sometimes new graduates obtain jobs by submitting applications to mining and petroleum companies. When there is a scarcity of geologists, employers often advertise for personnel in the professional journals, published by the geological societies. Company representatives are sometimes sent to the colleges to interview new graduates.

Petroleum and mineral industries usually require the beginning professional geologist with a bachelor's or master's degree to start as a field assistant on an exploration party. Successful experience in field operations is required for advancement to supervisory or research work. If the geologist has specialized in paleontology, his first assignment may be the routine testing of rock cores and cuttings from wells to determine the microfossils present. After working in a number of different areas, he may advance into research paleontology, or he may be shifted into subsurface mapping. In every specialty the highest positions to which geologists in industry may be promoted usually involve executive or administrative work. The top executive positions in oil companies are being increasingly filled by geologists with long and varied experience.[8]

Employment Outlook

The demand for geologists' services was much greater in mid-1951 than in mid-1950 because of the mobilization program, and it is expected to increase further in the near future. It is necessary to expand our production of petroleum and

[7] Bannerman, Harold M., and Pecora, William T., Training Geologists: A United States Geological Survey Viewpoint, Geological Survey Circular 73, Washington, D. C., March 1950. pp. 2–3.

[8] Lahee, F. H., The Geologist in Industry, School and College Placement, Vol. 8, No. 2, December 1947, pp. 28–31.

other strategic minerals to meet present defense production goals and to provide stockpiles for a possible greater emergency. Thus the petroleum and mineral industries will require an estimated 500 to 900 additional geologists during the year, ending in June 1952. Any expansion in the mobilization program will increase the demand for geologists still further.

Employment in the petroleum industries, where over half of the Nation's geologists are working, has been on the increase since 1944, following a decline during the first years of World War II. More than 7,000 wildcat or exploratory wells were drilled in 1949 in the United States alone, compared with about 1,800 in 1935.[9] However, this increased number of wells is still not sufficient to serve all the petroleum needs of the country. The spread of exploration activities within this country and to numerous foreign areas will provide an expanding source of employment for economic geologists, at least during the early 1950's.

The defense program is increasing the demand for geologists in the mineral industries also. Geologists specializing in mineralogy and petrology are called upon to devise new and improved techniques for locating scarce mineral deposits in the United States and abroad. In March 1951, the Defense Production Administration allocated $10,000,000 to the Department of the Interior to stimulate a coast-to-coast search for minerals as an initial step in increasing production for defense purposes. This will mean greater employment opportunities for geologists, especially those fully trained, experienced, and ready to take charge of some aspect of geological research or exploration.

The number of professional geologists in civilian positions in the Federal service was approximately 1,300 in early 1951. Budget proposals called for a total of 1,600 positions for the fiscal year 1952, 22 percent more than in 1951; however, the actual number of positions set up depends on congressional appropriations. In addition, about 200 other openings in Federal jobs were expected during 1951–52, largely as a result of withdrawals to the Armed Forces and private industry. A few highly qualified persons in certain geological specialties and in allied sciences were being accepted for commissions in the Armed Forces in early 1951; the Air Force had special need for photomapping and map reproduction officers and for topographic engineers.

A few openings for teachers of geology are expected in the early 1950's despite the anticipated decrease in college enrollments. Teachers will be needed in graduate schools and as replacements for those who enter the Armed Forces, retire, or otherwise leave the profession.

The supply of geologists available in 1951, to offset the prospective increases in demand, included a large number of recent graduates, especially those with only bachelor's degrees. However, the supply of experienced geologists was limited. Because thus far this is a field open largely to men, few persons completed training in the profession during World War II. In 1944, for example, there were only about 16 percent as many students majoring in geology as in 1940. (See table 2.) The return of the veterans to college after the war brought about a sharp increase in enrollments so that by 1950 the number of students majoring in geology was nearly three times as great as in 1940. About 3,650 degrees were granted in geology in 1950 (see table 3), but only about 600 of these were graduate degrees. It is estimated that in 1951 about the same number of graduate degrees were granted; however, the total number of degrees awarded was substantially lower than in 1950.

TABLE 2.—*Number of students majoring in geology in the United States* [1]

Year (January)	Number enrolled				Geology major	
	Undergraduate		Graduate			
	Junior class	Senior class	Master's degree candidates	Doctoral candidates	Total number	Percent of 1940
1940	1,045	812	423	284	2,564	100.0
1941	956	813	413	328	2,510	97.9
1942	722	623	324	256	1,925	75.1
1943	555	474	108	112	1,249	46.7
1944	154	154	65	49	422	16.5
1945	178	129	60	41	428	16.7
1946	402	234	210	142	988	38.5
1947	1,181	567	612	367	3,027	118.1
1948	1,825	1,170	689	433	4,117	160.6
1949	2,659	1,715	885	473	5,732	223.6
1950	2,736	2,623	1,143	512	7,016	273.7
1951	1,770	1,985	1,218	532	5,505	214.7

[1] Data are for students from only 75 schools, and do not fully reflect the postwar increase in geology graduates in colleges not included in the survey.

Source: Levorsen, A. I., Survey of College Students Majoring in Geology, Bulletin of the American Association of Petroleum Geologists, June 1950 and June 1951.

[9] U. S. Department of Labor, Bureau of Labor Statistics, Occupational Outlook Series, Bulletin No. 994, The Employment Outlook in Petroleum Production and Refining, Washington, D. C., 1950, p. 11.

The oversupply in 1950 of new graduates with only the bachelor's degree has been rapidly reduced by increasing defense requirements. New graduates, especially those who have had some field experience in connection with their academic work, will be in demand. Employment opportunities for women geologists will probably continue to improve during the defense mobilization period.[10]

The long-run outlook for employment in geology appears to be good for those with graduate training. Furthermore, so long as there are both junior and senior positions in Government and industry, a small number of persons with only a bachelor's degree will be able to enter the profession each year.

As the world's petroleum resources dwindle, increased efforts on the part of geologists and geophysicists will be required to find new supplies of this highly valuable commodity. There will be systematic resurveys of oil-bearing regions, using improved techniques for locating oil deposits deep within the earth's crust. Exploration and exploitation of undersea areas for petroleum deposits have just begun. Many parts of the world have not yet been surveyed by trained earth scientists.

[10] For a detailed discussion of employment opportunities for women, see The Outlook for Women in Geology, Geography and Meteorology, U. S. Department of Labor, Women's Bureau, Bulletin No. 223-7, 1948. Available from the Superintendent of Documents, Washington 25, D. C.

The utilization of professional geologists in exploration for uranium and other ores used in atomic fission will undoubtedly increase, though the extent of the increase cannot be estimated at this time.

TABLE 3.—*Number of degrees conferred in geology, by type of degree, and number of institutions reporting*

Type of degree	1947-48		1948-49		1949-50	
	Number of institutions reporting [1]	Number of degrees	Number of institutions reporting [1]	Number of degrees	Number of institutions reporting [1]	Number of degrees
Bachelor's	137	1,172	142	1,848	175	3,038
Master's	61	318	84	385	76	493
Doctor's	19	57	22	68	30	113

[1] Differences in number of institutions reporting are due mainly to increase in number of schools granting degrees in geology and partly to failure of some schools to report data on graduates.

Source: U. S. Office of Education.

After the early 1950's when undergraduate college enrollments in the United States are expected to decline temporarily, it is anticipated that the number of students will increase beyond the previous high enrollment of 1949. This means that employment opportunities for geologists who have obtained the doctorate and are prepared for teaching careers will increase moderately by the end of this decade and will continue to increase in the early 1960's.

Geophysicists

Nature of Work

Geophysics is an over-all term embracing a number of sciences dealing with the physical aspects of our planet and their measurement. The geophysical sciences are geodesy, hydrology, terrestrial magnetism and electricity, tectonophysics, volcanology, seismology, oceanography, meteorology, and exploration geophysics.[11]

The origin of geophysics can be traced to early speculations about such phenomena as earthquakes, volcanoes, and the force of gravity. As an integrated science, however, geophysics has developed largely since the First World War. New geophysical discoveries and new applications of the science to practical problems are now contributing greatly to the Nation's defense effort.

Geophysicists apply the principles and concepts of physics and mathematics to the study of the earth and its atmosphere and oceans. They are concerned with the precise measurement and utilization of the earth's forces including magnetic, electrical, gravitational, radioactive, seismic (the force causing earthquakes), and geothermal (resulting from the earth's interior heat and solar radiation). Geophysical scientists study these forces from the standpoint of the physics of solid bodies (the earth), the physics of gases (the atmosphere), and the physics of liquids (the oceans and other bodies of water).

The applications of the geophysical sciences to practical problems are possible because of the advances in basic research, and much of the work is

[11] A separate statement on meteorology is included in the present report. There is also a separate section on oceanography, which includes marine biology as well as the application of geophysical techniques to the study of the ocean.

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pure research. The same scientists who conduct this research, however, are often asked to provide answers to a variety of problems in such fields as civil and electrical engineering, cartography, surveying, radio and telephonic communication, flood control, weather modification work, and underwater transportation.

One of the most important activities in geophysics is the search for petroleum and other mineral deposits. Special techniques and instruments have been devised which yield information to exploration geophysicists about earth structures many thousands of feet below the surface. These techniques are also used in exploration for radioactive and other minerals, to test deep foundations before building, and to make highly precise maps and charts of the earth's surface. Applied geophysics developed rapidly in the last three decades, as geophysical techniques and methods proved their value in yielding specific knowledge about deposits of petroleum and minerals in all parts of the world. Geophysical prospectors, petroleum engineers, and economic geologists work together in the employ of governments and the large oil companies in the search for the supplies of oil so urgently needed for both defense and civilian purposes.

Fields of specialization.—The majority of geophysicists do not call themselves by that name, but use the title of their specialty, e. g., geodesist, volcanologist, hydrologist.

However, the methods and technical applications of physics are employed in common by all these specialized fields of the earth sciences.

Geodesists measure the size and shape of the earth and its gravitational pull, and survey areas sufficiently large to involve consideration of the earth's curvature. Research conducted by the geodesist forms the basis for all accurate mapping of large areas on land and on the oceans.

Seismologists record earthquake vibrations and use the data obtained to determine the time, location, and magnitude of earthquakes. This work requires the use of special instruments, mapping, and surveys of geologic structures in the field. Seismologists provide information used in planning the design of bridges, buildings, and other structures in earthquake regions.

Another large group of geophysicists are concerned with geomagnetism and electricity. These scientists study magnetic and electrical processes in and about the earth, and the influence of the earth's magnetic field. This work includes studies of electrical phenomena in the upper atmosphere (the ionosphere), sunspots and the aurora, and the propagation of radio waves. The findings of these scientists are used in air and sea navigation, in military devices employing magnetic principles, in geological exploration, and in studies of nuclear physics and cosmic radiation.

Volcanologists study the origin, location, and activity of volcanoes, hot springs, and similar phenomena, including the processes by which ore was deposited. They share with physical geologists an interest in the structure of mountain ranges, and in the chemical and physical properties of igneous rocks and minerals.

Tectonophysicists are concerned with both geologic and physical research problems of the earth's structure. They may do field work on such problems as the nature of the earth's crust, the mechanics of glacier flow, and the structure of mountains, plains, and oceans. Tectonophysicists try to find out about the physical forces which cause movements in the earth's crust. In the laboratory, studies are made of minerals and rocks from the viewpoint of physical changes which have taken place in them as the result of heat and pressure.

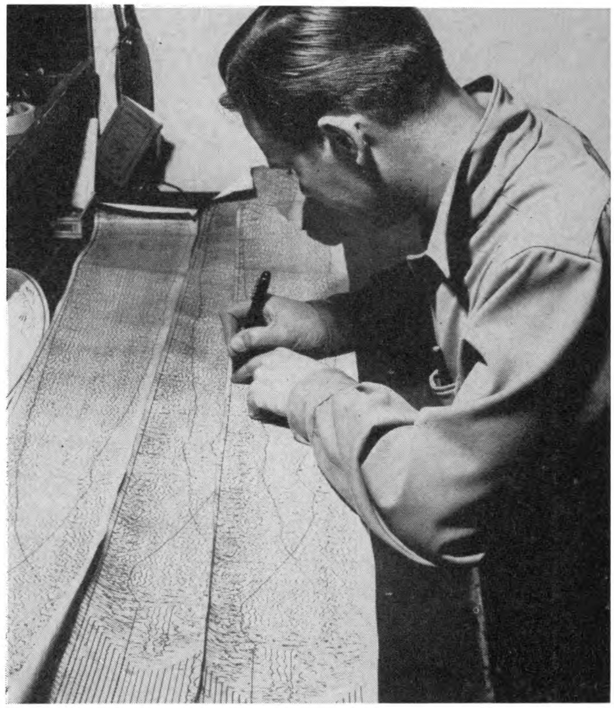
Hydrologists concern themselves with the water supply of the land areas of the earth, and investigate the rate of flow, the volume, mass, and weight of water. Engineering hydrologists (often hydraulic engineers) study flood control, water power, the water supply of cities and towns, and irrigation projects. Other hydrologists, together with geologists specializing in groundwater supplies and their use, work on problems of soil erosion, the effect of crops and grasses on the conservation of water in the soil, and related conservation problems. Some hydrologists specialize in sediment control and the removal of sediment from river beds and harbors. Still others deal with glaciers, snow, ice, their formation and control, and the use of permanently frozen land areas. The majority of hydrologists received their training in such fields as agronomy, geology, and engineering. Many are practicing civil engineers.

The title "geophysicist" is most frequently used by geophysical technologists (exploration or prospecting geophysicists). These scientists conduct or participate in field parties that locate promising sites for oil-drilling activities. Some geophysical technologists work as consultants to oil companies; others supervise petroleum and natural gas production and refining operations, or conduct research on some phase of prospecting. Geophysicists who lead exploration parties usually supervise crews of men, many of whom may not have much knowledge of geophysical methods. Party chiefs with a good background of geophysical and geological knowledge are needed not only to plan the exploration and supervise the work but to bring together and interpret the exploration data. The final interpretations are usually made in the laboratory, after completion of the field work.

Seismic prospecting is the most widely used method of geophysical exploration. The seismograph (originally designed to record earthquakes) measures the rate at which waves created by an explosion of dynamite are transmitted through the earth. As these waves strike rock formations, they are in part reflected back to the instrument. By interpreting the instrument readings which are recorded photographically, geophysicists determine the nature of underground formations. Other methods used in the search for oil are gravity, magnetic and electrical prospecting, all of which require the services of geophysicists and related technologists for the interpretation of findings.

A rough indication of the relative numbers of scientists and technologists interested in the various geophysical specialties is given by the affiliations of the members of the American Geophysical Union. In 1949, the numbers of members affiliated with the various sections were: Geodesy, 485; seismology, 1,256; hydrology, 2,140; meteorology, 1,660; terrestrial magnetism and electricity, 938; oceanography, 872; volcanology, 784; and tectonophysics, 1,101. Because persons with an interest in more than one specialty may be affiliated with several sections, these figures do not accurately represent the total number of professional workers in the specialized fields.

The membership of the American Geophysical Union has increased rapidly in recent years (chart 2). Part of this increase resulted from wartime research and development in several of the geophysical specialties, which brought people into the field from the related sciences. Geophysicists have taken part in the advances made in radiation



Members of geophysical-prospecting crews interpret the data obtained from the seismograph, an instrument used in exploration for petroleum.

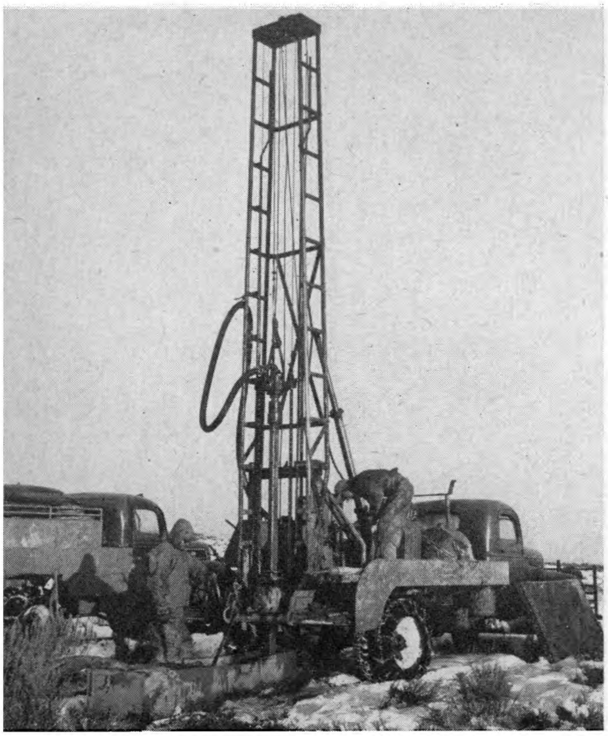
studies, electronics, nuclear physics, and the development of guided missiles and the newer techniques of communication such as radar and sonar.

The Society of Exploration Geophysicists also has received many new members in recent years (chart 2). This organization includes technologists who work in oil-field prospecting and development, and scientists who teach and conduct research in exploration problems and in the sciences basic thereto.

Where Employed

Because the largest number of persons with the job title of geophysicist are engaged in prospecting for petroleum and minerals, the proportion employed by oil and mining companies is high. Probably as many as three-fourths of the exploration geophysicists work for oil companies, either as full-time staff members or as consultants employed on a fee basis. Geophysicists in private industry are concentrated in the southwestern and western sections of the country, where the large oil fields and petroleum refineries are located. Many are employed in foreign countries.

Perhaps as many as 10 percent of geophysicists are employed by colleges and universities to teach



Members of a geophysical exploration crew drill a shot hole. Explosives will be set off in the hole and the earth waves, recorded by the seismograph, will be interpreted to help determine the nature of underground formations.

various aspects of geophysics, geology, or engineering. Teaching is frequently combined with research in the university laboratories and with private consultant work. Research geophysicists in a number of universities have conducted various scientific investigations under contract with the Department of Defense, especially since the beginning of the current defense program. A few specialists conduct projects in private research institutions such as the Carnegie Institution of Washington or one of the oceanographic institutes.

In the Federal service, geophysical scientists find employment in the Coast and Geodetic Survey and the National Bureau of Standards (Department of Commerce); in the Geological Survey and the Bureau of Mines (Department of the Interior); and in the Naval Ordnance Laboratory, the Signal Corps, and the Geophysical Research Division of the Air Force Cambridge Research Center (Department of Defense). Many in the Federal service are classed as geodetic engineers and mathematicians. A number of hydrologists (often under other job titles) work in such agencies as the Forest Service and the Soil Conservation Service of the Department of Agriculture, the Bureau of Reclamation of the Department of the Interior, the Tennessee Valley Authority, and the Army Corps of Engineers.

Employment in the field of geophysics in the Coast and Geodetic Survey involves the following activities, in which engineers and some geophysicists are employed:

1. Surveying and charting the coasts of the United States and its possessions, to insure the safe navigation of coastal and intracoastal waters.
2. Occasional hydrographic and topographic survey of lakes and rivers.
3. Determination of latitude and longitude and elevations to provide information for mapping and engineering survey work.
4. Study of tides and currents in coastal waters and publication of tide and current tables for the use of seamen.
5. Compilation of aeronautical charts, to meet the needs of aircraft pilots.
6. Observations of the earth's magnetism in all parts of the country, to furnish magnetic information essential to the aviator, land surveyor, radio engineer, and seaman.
7. Seismological observations and investigations, to supply data required in designing buildings to reduce the earthquake hazard.
8. Gravitational and astronomical observations, to provide data for geodetic surveys and for scientific investigations of the crust of the earth.

Education and Training

Geophysics is relatively new as an organized subject of instruction leading to degrees. Many students planning to enter research geophysics still obtain their training in geology, physics, mathematics, and engineering, as did many present members of the profession. The trend, however, is toward the establishment of separate departments and curricula in geophysics.

In institutions offering undergraduate training programs the chief aim is to give training in exploration geophysics, under titles such as geophysical technology or geophysical engineering. Some of the colleges with training programs of this kind in 1951 were the Colorado School of Mines (Golden, Colo.), the Pennsylvania State College (State College, Pa.), the New Mexico School of Mines (Socorro, N. Mex.), the University of Utah (Salt Lake City, Utah), the California Institute of Technology (Pasadena, Calif.), St. Louis University (St. Louis, Mo.), and the University of California (Los Angeles, Calif.). Some undergraduate training in exploration geophysics can be obtained also in other colleges with degree programs in engineering geology and petroleum geology. Some students prepare for technical exploration work by combining geology and physics in an undergraduate program.

The other geophysical sciences are almost entirely graduate research specializations (except for meteorology). Except at a very few institutions (e. g., the new Ohio State University Institute of Geodesy, Photogrammetry, and Cartography, and the undergraduate division of the St. Louis University Institute of Geophysical Technology), study in the various geophysical specialties is not possible as a major at the undergraduate level. However, undergraduate work in related sciences such as geology, civil engineering, hydraulic engineering, physics and mathematics, does prepare directly for graduate work in all branches of geophysics.

For graduate study and research specialization in such fields as tectonophysics, geodesy, terrestrial magnetism, and volcanology, the student needs to locate those universities and institutes of technology which have extensive teaching and research staffs in engineering, geology, mathematics, and physics. At these institutions, there will be an opportunity to carry out research problems in one or more of the geophysical sciences. The student's choice of an area of specialization is often determined by the subject of his thesis research for a graduate degree. People with doctorates in geophysics often transfer from one specialty to another, because this shift generally involves a choice of a new area of research activity rather than a change from one profession to another.

How To Enter

The graduate in geophysical technology or petroleum engineering may obtain his first position through the assistance of fellow students or professors intimately acquainted with the petroleum industry. Job vacancies are frequently publicized at meetings of professional societies, in professional journals, or by oil company personnel representatives who often visit college campuses to recruit graduates. A summer job with a petroleum company or geological exploration party improves the student's chances of obtaining professional employment upon graduation.

Young men entering geophysical prospecting with only the bachelor's degree usually spend their first few years of employment in converting theoretical knowledge obtained in college into practical experience. The length of this apprenticeship is often reduced by taking graduate studies; the petroleum industry has shown a preference for persons with 1 or 2 years of graduate work in petroleum geology, geophysics, or engineering geology. The first few years of exploration work provide an opportunity to specialize in a particular type of geophysical technology—for example, to become highly skilled in the use of an instrument such as the seismograph. Following the attainment of such a skill, professional advancement may be rapid and highly remunerative. In the laboratory, the young geophysicist may be assigned to use precision instruments to determine the physical and chemical properties of rock specimens, minerals, and fossils.

A student well-trained in any physical science or in one of several branches of engineering may also be able to obtain a beginning position as a member of a geophysical survey or prospecting crew. Ability to speak a foreign language fluently may be a factor in the entrant's employment, since the larger American geophysical consulting firms obtain contracts for exploration work in many parts of the world. The young scientific or engineering assistant may sometimes learn the methods and techniques of industrial or government geophysical work on the job, if his previous training has not been in geophysics itself.

Most teaching positions for persons with training in geophysics are in schools of engineering or departments of geology and physics, because very few institutions have as yet organized departments of geophysics. For college teaching positions, advanced degrees and research experience are usually required. As departments of geophysical technology are set up, opportunities in college teaching will doubtless increase.

Employment Outlook

Employment opportunities are excellent and are expected to remain so during the early 1950's for persons specializing in geophysics or transferring to this field from other sciences. Employment prospects in the field are closely related to the increased tempo of the world-wide search for petroleum reserves and mineral deposits needed in the defense program. As oil reserves diminish and the search for them is extended to all areas of the globe, more geophysicists will be used in prospecting. Defense plans also call for more research in radioactivity and cosmic and solar radiation; geophysicists are among the scientists concerned with these problems. Much of the scientific methodology used in exploring the ocean is geophysical in nature. All of these areas of investigation are being expanded, because of their bearing on national defense.

The supply of persons with training or experience in geophysics is not great enough to meet the increasing demand. Complete information is lacking on the supply of new geophysicists coming from the colleges because (as already indicated) few institutions have formal curricula in geophysics, and people with training in geology, physics, mathematics, and engineering frequently enter the field. For example, a person with a graduate degree in civil engineering may work in geodetics, a hydraulic engineer may specialize in theoretical and advanced problems in that field and consider himself a hydrologist, a person with advanced training in mathematics and physics may work on problems in the field of terrestrial magnetics and electricity, and a physical geologist may specialize in tectonophysics. In petroleum exploration work, the chief source of new workers is probably the graduates in geological and petroleum engineering.

The separately organized programs of study in geophysical technology have for the most part been set up within the past 10 years, and data on the number of graduates of these courses were not collected until recently. Such information, in most cases, refers to the supply of personnel in exploration geophysics, most of whom are trained in other degree programs. A rough estimate of the numbers graduated from these curricula, plus a partial count of master's and doctor's theses on geophysical subjects, indicates that during 1949–50 about 80 bachelor's degrees, 25 master's degrees, and 15 doctorates were awarded in the geophysical sciences.[12] In addition, there were many other science graduates with some training in the geophysical sciences or in closely related specialties. Estimates indicate that about the same number of degrees were awarded in the geophysical sciences in 1950–51 as in 1949–50. The total number of students graduating from colleges will decline substantially during the early years of the 1950 decade. The great majority of persons who enter the various geophysical sciences are not trained directly in those specialties. The current strong demand for young graduates in physics, engineering, geology, and mathematics who might take up geophysical research may thus reduce the customary number of those transferring to geophysics. As a result, the supply of persons with geophysical training, particularly at an advanced level, will probably continue to be too small to meet the expanding demand as the defense program progresses.

The future developments of the science of geophysics suggest expanding long-run employment opportunities for scientists in this field. Man still has a long way to go before his knowledge of the earth will be sufficient to meet his increasing needs for its hidden resources. Knowledge of the earth's interior through direct observation at widely scattered points extends to only about 3 miles of the 4,000 to the earth's center, and information on the ocean bed is very limited. It is therefore likely that the need for natural resources, now being rapidly depleted in the most accessible places, will necessitate the exploration of greater depths of the earth and ocean areas. Man's needs for water resources and flood control will increase the demand for hydrologists and meteorologists. The general area of communications engineering is a potential source of employment for geophysical scientists. For example, developments during World War II in the field of geomagnetism—including radar, radio-communication disturbances, isomagnetic maps, and improved instrumentation for aerial magnetic surveys—pointed to future employment possibilities in research and development.[13]

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[12] Compiled from a report by J. B. Macelwane, Annual Survey of Geophysical Education 1950–51, Geophysics, 16 : 511–518 (July 1951).

[13] American Geophysical Union Transactions, Education in Geophysics, 26 : 463–476 (December 1945) : 27 : 614–617 (August 1946).

Oceanographers

Nature of Work

Oceanography is the study of the ocean in all its aspects, including its effect on the atmosphere, the sea bottom, and the shores; and the relation between marine animal and vegetable organisms and the environment in which they live.

Collection of data regarding the ocean began long ago, when the problems faced by navigators of sailing ships created a need for information on currents, winds, and ocean temperatures. About 100 years ago, biologists began the systematic study of fish and other marine life, thus opening a new phase in the science of the sea. Realizing that virtually all sedimentary rock originated under the sea, geologists began studies of the sediments accumulating on the sea floor. At the beginning of the present century chemists and physicists also became interested in research relating to the ocean.

Today, these scientists are involved in oceanographic research. Frequently, the scientists performing such research do not call themselves oceanographers, although this title is increasingly common. The varied knowledge and techniques involved in marine research are drawn from other sciences, but form a distinct discipline requiring special training.

Oceanographers' duties may include the conduct of surveys and experiments at sea and ashore, theoretical studies, analysis of samples and data, compilation of special charts and tabulations, preparation of reports, and designing of specialized equipment. Among the topics of research—some physical, some biological—which have concerned oceanographers in recent years are the following:

1. To what distance, and under what pressure can submarine vessels navigate?

2. How does sound travel at various depths beneath the ocean surface?

3. What are the most favorable conditions for the propagation of edible fish?

4. How do coral reefs come into being, and how can food and water be obtained from them?

5. What is the biological and chemical content of ocean floor sediment?

6. What is the location, direction, and force of the principal ocean currents of the world?

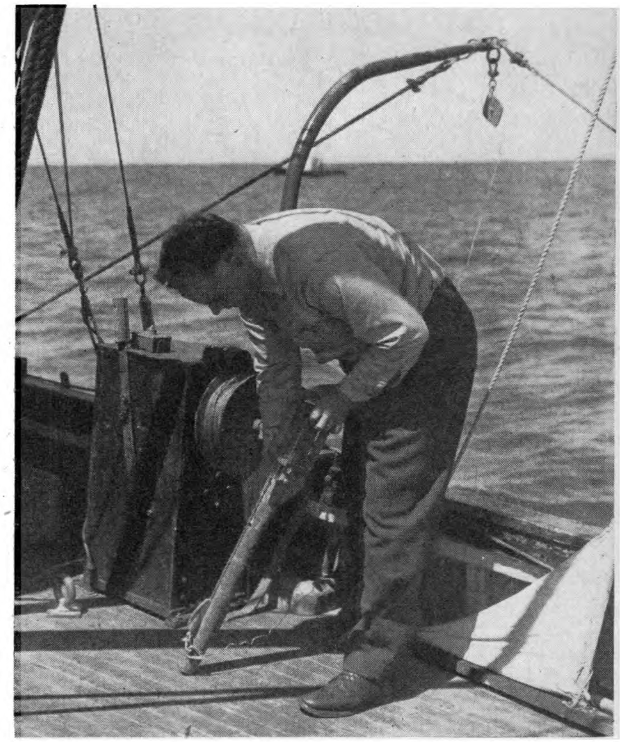
7. Can a forecast be made of the height, roughness, and frequency of the waves at the place and time of a proposed amphibious landing?

8. How far ahead can the location and time of tidal waves be forecast, so as to minimize the damage they produce?

9. What are the best locations for the artificial cultivation of oysters?

10. What are the most efficient ways to drill for petroleum under the ocean?

11. How is sea ice formed, and how does it behave in the spring and summer?



Oceanographers use special instruments such as the bathythermograph to make recordings of the temperature of the sea at various depths.

The importance of oceanography to the national defense is indicated by some of these topics. During World War II, new kinds of vessels and new types of operations, such as amphibious landings and the use of aircraft in rescuing men adrift at sea, required information never before systematically collected or studied. The Government called upon workers in oceanography and related fields to provide the needed data and solve special problems. For example, the Navy Department employed oceanographic laboratories to conduct research on antifouling paints which would prevent barnacles and other marine organisms from attaching themselves to ships. The contributions of oceanographers were of such value to the armed services that provisions were made to continue research and study on a much larger scale than before World War II.[14]

Oceanographers have also been of great assistance in the search for petroleum deposits in tidewater and undersea areas (particularly in the Gulf of Mexico). In constructing drilling platforms, engineers must know the probable maximum height and frequency of the waves, and the strength of the currents at various depths. Because drilling for oil produces waste in large quantities, the oceanographer's knowledge of ocean currents and marine biology is useful in planning ways to prevent the fouling of water which may destroy game fish, oysters, and shrimp.[15]

The projects on which oceanographers work fall into two general categories: basic research, which may be concerned with any data about the sea that will contribute to the understanding of the history of the earth and its life; and the application of this information to practical problems.[16] Many investigations in oceanography are basic theoretical problems. In time of defense emergency, however, the greater part of the work may be shifted to emphasis upon operations research and related technical studies.

Oceanography is related in part to micropaleontology, the study of microscopic fossils; to meteorology, the science of weather and weather forecasting; and to other geophysical fields; and geology in general. It is related to such biological specialties as animal ecology, zoology, and oceanic microbiology. The shifts in professional work among oceanography and related scientific specialties are relatively easy and frequent. For some purposes a fourfold specialization in oceanography is recognized, with the physical, geological, chemical, and biological oceanographer each working on research indicated by his title.

[14] Fleming, R. H., The Science of the Seas, School and College Placement, 7:29–33 (May 1947).

[15] Bates, Charles C., and Glenn, Alfred H., Oceanography in the Offshore Drilling Campaign, World Oil, April 1948.

[16] Fleming, R. H., *op. cit.*

Where Employed

An international directory of oceanographers, published in 1950, listed about 750 persons in many nations who have concerned themselves with marine science.[17] About 280 of these were Americans, composing about two-thirds of the oceanographers in this country.

About 80 of the American oceanographers listed in the directory were on the staffs of marine and oceanographic laboratories which form a principal source of employment in oceanography. Oceanographic research institutions in America are located on Chesapeake Bay (Chesapeake Bay Institute of Johns Hopkins University); on the southern California coast (Scripps Institution of Oceanography of the University of California); on Cape Cod (Woods Hole Oceanographic Institution); and on the coast of the Pacific Northwest (Oceanographic Laboratories of the University of Washington). These seashore laboratories conduct investigations in all aspects of the science. They have the specialized equipment needed for biological, physical, and geological studies of marine phenomena, including oceangoing vessels specially equipped for survey work at sea.

Oceanographers are employed also in several of the larger universities, although there are few teachers of oceanography as such. The 1950 *International Directory of Oceanographers* listed 40 persons associated with biology departments and museums, including several working in fisheries research. About 30 members of departments of geology were listed, these being the Nation's leading specialists in the geology and geomorphology of submarine earth structures. Departments of physics and geophysics, and several laboratories of physical research accounted for some 15 of the scientists listed as oceanographers, 6 were working in departments of meteorology. Altogether, fewer than 100 marine scientists were in American universities in 1950.

The number of oceanographers in private industry is even smaller. The 1950 Directory listed only about 30 geophysicists and geologists working for oil companies interested in undersea exploration or production of petroleum.

[17] An International Directory of Oceanographers, published by the Allan Hancock Foundation, University of Southern California, 1950. 54 pp.

Between 90 and 100 scientists working for the Federal Government were listed in the 1950 Directory. The Department of the Navy, including the Navy Hydrographic Office and the Navy Electronics Laboratory, had 30 oceanographers listed; about 15 more were employed in the Coast and Geodetic Survey. The remainder were scattered among a dozen other agencies of the Federal Government. Except in certain bureaus of the Department of the Navy, only a few of these individuals had the job title of oceanographer.

In 1951 the Hydrographic Office reported the employment of 70 oceanographers including junior scientists whose names did not appear in the Directory. This agency provides information necessary for the safe navigation of civilian and military ships and aircraft. Subjects on which the Office has made surveys include the topography of the sea floor, surface temperatures and currents, wave and swell conditions, the behavior of marine organisms, and the formation of sea ice. The Hydrographic Office has two specially equipped vessels for oceanographic surveys and has pioneered in the development of instruments and equipment for this work. In recent years, particular attention has been paid to studies of the Arctic Ocean. The surveys of the Navy Hydrographic Office, conducted systematically in all parts of the world, result in the collection of basic statistical data on the biology, chemistry, and geology of the seas, besides providing data of immediate importance to the national defense.

Education and Training

There is no 4-year program of study leading to a bachelor's degree in oceanography. The minimum training usually required for professional work in the specialty is either five or more years of study of the related natural sciences, or a bachelor's degree in a science basic to oceanographic work together with two to five years of experience in oceanography under the close supervision of professional oceanographers. Such in-service training is usually in the form of guided research work on some oceanographic problem. In either case, course work alone is never sufficient to prepare for a career in oceanography. In addition to formal instruction, there must be a period of work at an oceanographic laboratory or research institution, or experience at sea on a scientific expedition.

A recommended list of subjects for a training program in oceanography includes mathematics, physics, chemistry, biology, geology, and geophysics.[18] The actual course work in oceanography itself represents only a small fraction of the total scientific training required. A recommended basic program amounts to five full years of study, including a summer field course at an oceanographic laboratory. A second summer of field work in marine biology is recommended for the specialist in biological oceanography. The student's undergraduate major field of study would ordinarily be in one of the basic or related sciences.

The University of California at Los Angeles has the oldest formally organized department of oceanography in the United States. The courses of instruction, leading to M. S. and Ph. D. degrees, are given at the nearby Scripps Institution of Oceanography. Requirements for admission to the department are a college degree with courses in biology, chemistry, mathematics, and physics, or a major in mathematics, meteorology, engineering, or a physical or biological science. The Scripps Institution faculty includes four physical oceanographers, three geophysicists, four submarine geologists, one chemical oceanographer, one marine microbiologist, two marine biologists, and one marine biochemist. Courses are given in each of these scientific fields.

In 1951 Brown University, the University of Miami, Johns Hopkins University, the Texas Agricultural and Mechanical College, and the University of Washington were organizing degree programs in oceanography. Several of the new programs were being developed with funds for oceanographic research provided by the Office of Naval Research and other defense agencies. In Texas, several of the petroleum companies were supporting research on problems of underwater drilling. At the University of Washington, the work in fisheries biology was being expanded into a complete oceanographic research program.

[18] Knudsen, V. O., et al., Education and Training for Oceanographers, Science, III: 700–703 (June 23, 1950).

How To Enter

Opportunities to obtain training in oceanography are limited, because the oceanographic research institutes are too few and small to accept many research assistants at any one time. Beginning appointments in research laboratories or industry are often obtained through the assistance of the university professors under whom the student has carried on his thesis research. Teaching positions are often available in related sciences (physics, geology, biology) for persons who have specialized in marine science and have obtained the doctor's degree. Graduate students soon become acquainted with institutions having organized and subsidized research programs.

Entry positions as oceanographers in the Federal Government are obtained through civil-service examinations. For beginning jobs, the examination requirements have usually not specified courses in oceanography as such, but rather a combination of studies in the physical and biological sciences. A minimum of 1 year of professional experience in oceanographic work also is required. Persons who have done graduate study and research in oceanography can usually substitute such study for part of the required work experience. For responsible positions with government agencies, research institutions, and universities, the requirements usually include a doctor's degree and published contributions to oceanography.

Employment Outlook

A shortage of oceanographers capable of doing research work existed at the beginning of the current mobilization period and is expected to continue for at least several years. The scientists most needed are those with either a doctor's degree in oceanography or extensive experience in the field. It was estimated in 1950 that as many as 30 to 40 additional highly trained research workers were needed in government agencies and on contract research programs at the universities, to lay the foundation for technological advances in military techniques, and to work on such problems as transportation and communication on and under the seas.[19]

[19] Knudsen, V. O., *et al.*, *op. cit.*

The number of persons able and willing to undertake advanced studies in both biological and physical sciences and to carry on thesis research in a marine environment is very small. Moreover, not all students whose research work involves studies in marine biology or in the geology of the ocean are available for oceanographic work. Also, facilities for the training of physical oceanographers are limited. In 1950 only three doctorates (one taken in a department of geophysics) were granted for research work in physical oceanography. Present indications are that the shortage of highly trained scientific personnel for work in oceanographic research will not be met during the present emergency, unless training facilities are increased for degree work or for on-the-job instruction of partly qualified scientists in related fields.

The long-run outlook for employment in oceanography depends largely upon the extent to which investigations in this field are undertaken by Federal agencies or sponsored in the oceanographic institutions and universities by private research grants. Research in oceanography cannot be carried on by single individuals, because it requires special laboratories and equipment. It is expected that a continuing national defense mobilization program will keep the demand at a high level throughout the fifties.

The Navy Hydrographic Office recognizes the need for more extensive work on forecasting oceanic currents, temperature conditions, sea ice, and the behavior of plant and animal life in the ocean. Very little has been determined as to how the efficiency of ship operations might be improved by changes in routes and avoidance of storms. The United States has yet to organize a regular fish forecasting service based upon oceanographic and biological data, though this would be very valuable to fishermen. If these projects and other activities proposed by the Navy Hydrographic Office are carried out, there will be increased opportunities for research oceanographers in the years ahead.[20]

[20] U. S. Department of the Navy, The Oceanographic Program of the U. S. Navy Hydrographic Office, 1946–1949. (Mimeo. speech by Dr. R. H. Fleming, April 21, 1949.)

Meteorologists

Nature of Work

Meteorology is the science of the atmosphere and its phenomena, including weather and climate. Subjects investigated by meteorologists include changes in the temperature, pressure, and moisture of the air, chemical composition of the air, storms, and methods of forecasting the weather, and the winds and their effect on climates.

Like most other earth science specialties, meteorology developed only recently as a systematic science. Many people can remember when the chief sources of information about the weather were the almanac and the farmer's intuition. Weather forecasts were begun on a limited scale in the nineteenth century and proved to be useful to ship captains and others affected by storms. At the present time knowledge of upper air conditions is of immense value in forecasting weather changes for airlines, highway departments, shipping agencies, and agricultural and business operations. Air Force operations also depend greatly on accurate weather forecasts. Nevertheless, meteorology is a relatively small field of work as yet. Probably fewer than 2,500 civilians work in this scientific field in the United States today.

Besides regular weather forecasts, the problems which have been of interest to meteorologists in recent years include the following:

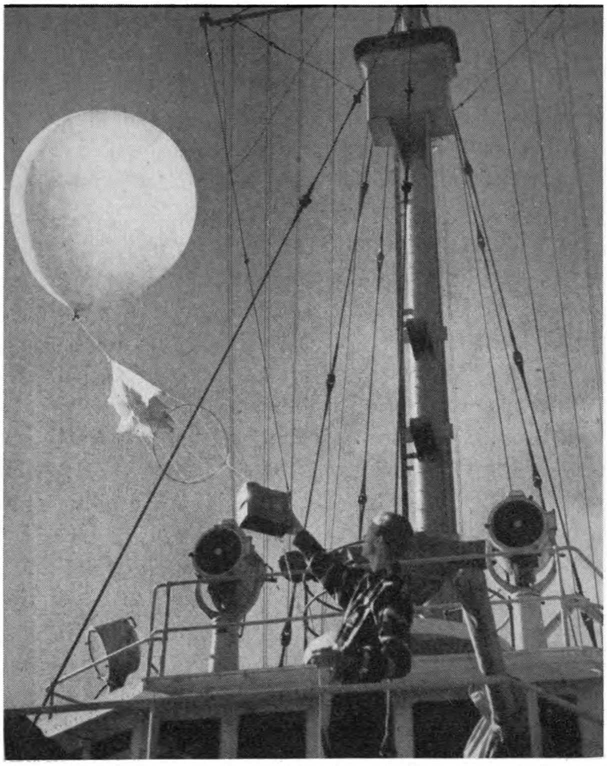
1. How can ice formation on airplanes be controlled?
2. What physical conditions of the upper atmosphere are most favorable for rockets?
3. What kinds of instruments are best suited to use in pilot balloons sent aloft to make weather and radiation observations?
4. What new kinds of radar detection instruments should be constructed in order to forecast and observe the intensity of hurricanes?
5. How can long-range weather forecasting be made more accurate?
6. Is it possible to use sunlight to heat homes?
7. In military operations in polar regions, what are the best ways to cope with permanently frosted terrain and Arctic weather conditions?
8. If atomic bombs were used, how fast, how far, and in what directions, would air currents carry radioactive particles?
9. In a given area, what is the best location for an air base, from the viewpoint of visibility, rainfall, wind, and temperature conditions?

The close relation of many of these problems to national defense is obvious. Much of modern warfare is air warfare, carried on in a realm where meteorologists (together with their geophysicist colleagues) are the scientific interpreters. Meteorologists consider the atmosphere as a gas subject to physical laws, and the science is, therefore, often regarded as a branch of geophysics. Many weather phenomena, as well as cosmic radiation, the aurora, and the ionosphere, are of equal interest and concern to meteorologists and geophysicists specializing in terrestrial magnetism and electricity. Also, many topics studied by geophysicists are of equal interest to hydrologists and oceanographers.

Fields of specialization.—A division of labor has developed among professional meteorologists, and several specialized fields have emerged. Basic or theoretical research claims the attention of some meteorologists, especially those who teach and direct student research projects in the graduate schools. Operating research to improve the efficiency of applied meteorology is especially important in time of war or defense mobilization. The third area of specialization is applied meteorology, i. e., weather forecasting and weather control.

Recognized areas of research specialization are: Physical meteorology, concerned with cloud physics, radiation, atmospheric acoustics, optics, and electricity; dynamic meteorology, concerned with the laws of air movement and the phenomena of temperature and temperature changes; synoptic meteorology, concerned with the problem of interpreting observations and with basic methods of forecasting; and climatology.

Climatologists study the weather in a given area or region through an analysis of past records. They analyze and summarize the records with respect to wind, rainfall, sunlight, temperature, and humidity. Such summaries are of value to many industries and to soil and other agricultural scientists. They also prepare climatic charts and regional classifications of the earth's surface, connecting this work directly to geography. Climatological analyses of the upper air are of particular interest and concern to aviation.


The radiosonde balloon carries an instrument used to obtain meteorological readings in the upper atmosphere.

Weather forecasters apply the principles of synoptic meteorology in preparing and analyzing weather maps (synoptic charts), based on data from observations made simultaneously at weather stations in many different locations. They chart pressure areas, air masses, cross sections of the atmosphere, areas of rainfall, and temperatures in order to create the current weather picture for a given region. Daily weather forecasting involves also the analysis of the daily synoptic charts for the purpose of forecasting the weather up to 5 days in advance. Forecasts are usually made for a given area or air route. Forecasters may specialize in meteorological work for aviation, for marine operations, for agriculture, or for the armed services. Long-range weather forecasting is a more complex specialty utilizing the techniques of daily forecasting and also a detailed study of past trends in the weather and of world-wide interactions in weather conditions; forecasts are made for five or more days in advance.

Radiometeorology is a specialized field of weather observation involving the use of the radiosonde (radiometeorograph), and the analysis of its record. This instrument is sent aloft by balloon to an altitude of 65,000 feet or more. At intervals during its ascent, it sends high-frequency radio signals which can be translated into temperature, humidity, and air pressure data.

The fields most closely related to meteorology are the physical and other earth sciences, including physics, geophysics, geography, oceanography, and hydrology. In the development, construction, and testing of instruments, meteorologists work closely with electrical and aeronautical engineers.

Professional meteorologists are assisted by weather observers who take routine weather observations and may also plot the data on weather maps, draw weather charts, and keep weather records. The essential tasks of the meteorologist are the analysis and interpretation of the raw data, and the construction of the instruments used to obtain this basic information.

Where Employed

The United States Weather Bureau has long been the principal employer of meteorologists in this country. In 1951 this Bureau had about 2,000 professional meteorologists. These meteorologists supervise hundreds of assistants or aids in the collection of weather observations. Many of the Weather Bureau meteorologists are employed in Washington, D. C., but many more are at weather stations or airports in or near large cities throughout the country. Some are stationed in remote and isolated spots in this country or in such places as Alaska, Wake Island, Hawaii, Puerto Rico, Iceland, and Ireland.

A small number of meteorologists are employed by other Government agencies, chiefly in research work or as consultants. The National Bureau of Standards of the Department of Commerce employs a few in the development of new instruments. The Soil Conservation Service of the Department of Agriculture has a few specialists in climatology who do research on the relation of the climate to crops and soil or water conservation. The Air Force employs some meteorologists in its research laboratories, but other meteorological research for the Department of Defense is done on a contract basis. Meteorologists so employed can often remain in their own university laboratories, where graduate students, working as assistants, have opportunities for practical research experience.

Meteorologists in the Army, Navy, and Air Force perform a variety of tasks, such as making short-range weather forecasts for use in naval and land operations as well as Air Force activities. A few may be engaged in long-range forecasting for military planning.

The commercial airlines had approximately 200 staff members with the title of meteorologist in 1951. These meteorologists analyze weather data and forecast flight conditions for a given sector of the company's routes. They must constantly study weather trends and provide up-to-the-minute information to captains of planes and dispatchers responsible for controlling flights. Some meteorological training is a legal requirement for dispatchers (under the certificate regulations administered by the Civil Aeronautics Administration of the U. S. Department of Commerce). A meteorological background is useful also for positions as dispatchers' assistants and certain other airline jobs.

Approximately 200 meteorologists were teaching meteorology full time in 1949.[21] Since the war, a number of liberal arts colleges have introduced meteorology into the curriculum. However, except in colleges with separate departments of meteorology, instructors in meteorology are expected to teach also other subjects such as physics, mathematics, or geography.[22] Teachers often act as consultants or do research on a part-time basis, and they may have administrative duties.

A few meteorologists work as consultants, advising private business concerns on the contribution of information on weather conditions to their business. On the basis mainly of data from the official Weather Bureau teletype service, these meteorologists make special forecasts to fit an industry's particular needs. Movie companies use such forecasts in deciding when to "shoot" scenes; aircraft manufacturers use them in scheduling test flights; construction companies and highway departments use them in deciding when to call out their workers. Meteorologists' services can be equally useful to other businesses needing weather advice in making decisions. A purchaser of a farm can learn what rainfall and how long a growing season to expect. An insurance company can be informed about storm or flood conditions typical of an area. A company about to build a new plant can learn what temperatures to expect and what insulation and heating equipment will be needed.

Education and Training

A bachelor's degree in meteorology, or some related field with additional courses in meteorology, is the minimum educational requirement for professional work. A few people have been able to enter the profession with less formal training but only after many years of progressive and varied experience. Graduate work is being emphasized more and more and is required for many jobs, particularly in research and teaching.

Students considering a career in meteorology will find that one or two introductory courses in the field are offered at many American colleges. An introductory course in meteorology will help a student determine the extent of his interest in the full-time study of the subject.

Only a few universities and colleges have full-fledged departments of meteorology. In 1950–51, degree programs were available or were being set up at the following institutions:

Cornell University, Ithaca, N. Y.
Florida State University, Tallahassee, Fla.
Massachusetts Institute of Technology, Cambridge, Mass.
New York University, New York, N. Y.
Pennsylvania State College, State College, Pa.
Rutgers University, New Brunswick, N. J.
St. Louis University, St. Louis, Mo.
University of California, Los Angeles, Calif.
University of Chicago, Chicago, Ill.
University of Texas, Austin, Tex.
University of Utah, Salt Lake City, Utah
University of Washington, Seattle, Wash.
University of Wisconsin, Madison, Wis.

Other colleges and universities offer considerable work in meteorology, although they may not grant degrees in the science. At Iowa State College instruction in climatology is provided in the department of agronomy, and a "minor" in meteorology is available in the department of physics. Courses in meteorology are being developed at the Agricultural and Mechanical College of Texas,

[21] Carlin, Albert V., American Occupations, No. 2, Meteorologist, Research Publishing Co., Boston, Mass., 1949, p. 18.

[22] American Meteorological Society, Weather Horizons, Boston, Mass., 1947.

and several of the larger departments of geography in other institutions offer instruction in meteorology as a regular part of their curriculum.

The programs of study differ appreciably among institutions of higher education, though all universities place emphasis on the study of the atmosphere by means of the concepts of mathematics and physics. One institution has a 3-year program, which begins with the third year of college, and leads to a master of science degree. This program includes advanced work in physics, statistics, and mathematics. Eighteen courses in meteorology (representing about two-thirds of the total courses) are required including courses in Meteorological Observations and Instruments, Techniques of Upper-Air Observation, Synoptic Meteorology Laboratory, Fundamentals of Weather Forecasting, Theoretical Meteorology, Physical Climatology, Radiation Physics, Tropical Meteorology, Physics of the High Atmosphere, Condensation Phenomena and Atmospheric Electricity. Advanced courses designed for doctoral candidates in the same department of meteorology include Theory of Instrumentation, Electronics, Problems in Synoptic Meteorology, Advanced Theoretical Meteorology, Applied Climatology, Hydrodynamics of Viscous and Nonviscous Fluids. Both the master's and doctor's degree programs involve extensive application of the concepts of physics and mathematics and the use of scientific papers in foreign languages. Practically all of the courses include extensive laboratory work.

Students with the bachelor's degree who transfer to this or other programs leading to the master's degree in meteorology must often spend two postgraduate years in study and research to obtain this degree. It generally takes 3 or 4 years of postgraduate work to obtain a doctorate.

How To Enter

For a research or teaching career in meteorology, graduate training is essential. The professors who direct thesis research leading to graduate degrees usually assist new graduates in locating positions suited to their interests. Contacts made at local and national meetings of professional associations, such as the American Geophysical Union (meteorological section) and the American Meteorological Society, are often helpful in securing beginning positions. Members of the American Meteorological Society receive monthly listings of current employment opportunities from the employment service of the organization.

A person with only a bachelor's degree and a "major" in meteorology may qualify for a beginning job in the United States Weather Bureau and, occasionally, for industrial meteorological work. The civil-service examination for junior meteorologists is given at irregular intervals, whenever new recruits are needed in the Federal service. The examination for meteorological aids is given more frequently, and persons with bachelor's degrees in meteorology are eligible to compete for appointment to this subprofessional work. Information on employment in the Federal Government may be obtained from the United States Civil Service Commission and the United States Weather Bureau, both in Washington, D. C., and through the American Meteorological Society.

Employment Outlook

Prospects for employment in professional meteorology in the early 1950's are excellent for persons with master's or doctor's degrees, and who are prepared for research careers in scientific work. People with only the bachelor's degree are likely to find increasing employment opportunities in professional positions as the defense program expands. If preparation for air warfare is increased considerably, a shortage of qualified weather forecasters will probably develop. Under full mobilization, several thousand additional weather forecasters would be needed at once, and it might be necessary to train a large number of them at Government expense, as was done during World War II.

The number of meteorology graduates has risen sharply in recent years as new departments have been organized and as veterans (some with wartime training or experience in weather work) have returned to the universities for further study. Before World War II, the number of persons obtaining a doctor's degree in the field was never more than 5 a year; but 8 Ph. D. degrees were granted in 1947, 12 in 1948, 21 in 1949, and 15 in 1950.[23] Data on other degrees are available only

[23] Doctoral Dissertations Accepted by American Universities, 1949–50 (No. 17). Compiled by The Association of Research Libraries, 1950.

for 1950, when 143 baccalaureates and 51 master's degrees in meteorology were granted.[24] At least in the first year or two after VJ-Day, the supply of meteorologists was also augmented from another source—some of the thousands of persons who received wartime training in meteorology sought civilian jobs in this field. This temporary influx into the profession came at a time when the demand for personnel was decreasing, except in teaching. Altogether, during the period from 1946 through 1950 there was an oversupply of persons available for work in weather forecasting.

In early 1951 the defense program was quickly absorbing the available supply of qualified meteorologists. Most of the persons trained in meteorology during World War II had entered other fields of employment and could no longer be regarded as a part of the meteorology labor supply. Furthermore, the number of research meteorologists with graduate degrees was not greatly increased by the war-training programs. When defense mobilization began in 1950, a sufficient number of highly trained meteorologists were not available. By June 1951, plans were again being discussed for training courses for weather forecasters in the Air Force, and consideration was being given to the probable needs of the aviation industry in the event of a more critical emergency. The first civil-service examination for meteorologists since 1949 was opened in the summer of 1951. If an increasing number of reservists are called to duty as weather officers in the Air Force, as expected, many of these men will vacate jobs in the United States Weather Bureau, and replacements will be required.

In the long run, the profession of meteorology will probably continue to grow slowly. Meteorological work, however, is not likely to expand enough to provide civilian employment for the thousands of persons who might be trained for temporary duties in weather forecasting under a full mobilization program. Although the air transportation industry is regarded as a slowly expanding source of employment, the number of meteorologists needed would not increase in proportion to the number of planes in the air. The services of the United States Weather Bureau already cover the Nation rather extensively. Research meteorologists with broad training and experience will undoubtedly continue to find good opportunities. One possible source of future employment for these scientists, the extent of which cannot be accurately estimated at the present time, is in the field of artificial precipitation (rainmaking). In weather-modification activities some meteorologists are already working as consultants on contracts with private organizations. It is expected that further research will be undertaken by government agencies, universities, and private concerns to explore and evaluate the results of artificial precipitation experiments. Until more progress has been made in basic meteorological research, however, the opportunities for employment in applied meteorology will probably remain limited. In the meantime, there is a great deal of interest in industrial meteorology, and advances both in consultation services to industry and in weather-modification activities may be rapid.

Opportunities for the employment of women in meteorology will probably continue to be limited, and they are likely to be in women's colleges, where courses in meteorology are taught along with other scientific subjects. A few positions in the Weather Bureau are especially suited to women, and it is the policy of the Bureau to encourage qualified women applicants.[25]

[24] U. S. Office of Education, Earned Degrees Conferred by Higher Educational Institutions, 1949–50, Washington, D. C.

[25] See U. S. Department of Labor, Women's Bureau, Bulletin No. 223–7, The Outlook for Women in Geology, Geography and Meteorology, *op cit.*, pp. 28–39.

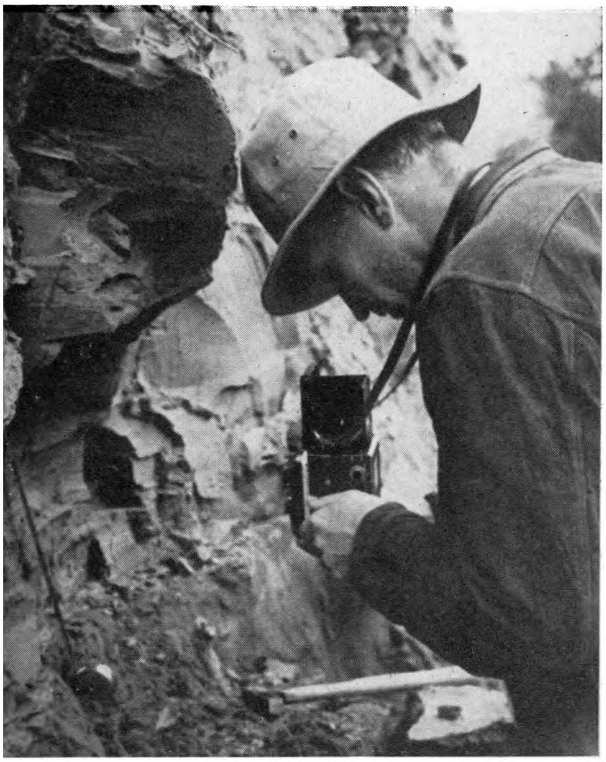
Geographers

Nature of Work

Geography did not emerge as a separate science and occupation until the nineteenth century and did not become fully established until the twentieth. It is still a small profession. The number of professional geographers in the United States in 1951 is estimated to be between 1,500 and 2,000.[26]

[26] Committee on Careers in Geography, National Research Council and Association of American Geographers, Some Basic Facts About Geographers and Geography in the United States, January 1951.

Another 1,500 or more persons are teachers of geography in the public elementary and secondary schools. More than half of this latter group are women.[27] A few women are also in other branches of the profession.



A geographer photographs a clay deposit in Matanuska Valley, Alaska. Geographers are interested in various problems of land use.

Professional geographers scientifically describe the earth's land surface, vegetation, climate, minerals, soil, water supply, and inhabitants and the uses people make of the natural resources at their disposal. Geographers are specialists in regional analysis. The fundamental premise of the science is that regional differences and similarities have a variety of complex physical and cultural causes. To discover these causes and utilize or control them in man's interest, geographers study the diverse physical and cultural processes which have operated to change a mountain range into a plateau or a forest into a farming area. It follows that geography is both a natural and a social science, and most geographers must learn to conduct investigations in both fields.

[27] See U. S. Department of Labor, Women's Bureau, Bulletin 233–7, The Outlook for Women in Geology, Geography, and Meteorology, *op. cit.*, pp. 14–25.

The wide range of topics studied by geographers is indicated by the following sample list of research projects in progress in 1949, which were among those reported by members of the Association of American Geographers in the Association's Annual Directory:

1. Aids for air photo interpretation.
2. Urban land use and the expansion of cities.
3. The geography of Middle East oil deposits.
4. The geography of the State of Mississippi.
5. Bituminous coal strip-mining in the United States.
6. Physiographic history of the Caribbean area.
7. The natural resources of the Soviet Union.
8. Applications of motion pictures to geographic research.
9. The geographical aspects of Europe's food problem.
10. Methods of construction and reproduction of three-dimensional maps.

Where Employed

Colleges and universities.—About 75 percent of geographers were members of college and university staffs in 1950. This constituted a much greater proportion so employed than before World War II, and resulted from the sharp rise since VJ-Day in the number of geography departments and the number of students "majoring" in the subject. In 1950 about 25 of the larger universities, more than twice as many as in 1940, had geography departments offering doctoral programs. Some of these departments have teaching staffs of 10 or more, and extensive facilities and financial aid for research. Most college and university teachers of geography are located, however, in the much larger number of institutions that offer only undergraduate or (less often) first-year graduate training in geography. Many teach in colleges not having separate departments of geography, and so are assigned to departments of geology, economics, or business administration.

Geography is studied by many persons as a part of their general education or as a part of their basic training for various professional fields, including business administration, political science, geology, and other earth sciences. A survey made in 1949–50 indicated that nearly a quarter of a million college students, mainly undergraduates, were enrolled in 3,000 geography courses taught by 1,500 teachers.[28] Only a small number of these students were planning careers in geography. Furthermore, the teachers of these courses included not only professional geographers but also faculty members with training primarily in geology, business administration, or other fields. This information was gathered when college enrollments were at an all-time high. Enrollments were especially heavy in collegiate schools of business, where one or two introductory courses in economic geography are often required of freshman and sophomore students.

Federal Government agencies.—More than 200 professional geographers were employed by the Federal Government in 1950, mainly in the Departments of Defense and State. Probably not more than a fourth of these are officially called geographers; the others have various job titles such as economic analyst, intelligence specialist, cartographer, and area specialist.[29]

Regardless of the job-title used, about half of the geographers in the Federal Government are working on the oldest aspect of the profession—maps, including the collection of data for map making and the interpretation of maps. The other half are engaged in various kinds of research and administrative work. In any case, the work of the Government geographer is likely to require specialized knowledge of some region of the earth, some phase of the economy of a country, or the utilization of some natural resource such as water power, oil, or coal.

In addition to the 200 professional geographers in the Federal service in 1950, many other Government employees have had some training in the science. The United States Civil Service Commission recognized the value of advanced geographical studies in the work of foreign affairs officers and intelligence research specialists by including them among the educational prerequisites for the examinations for these positions in 1950.

Except for the Department of State and the defense and intelligence agencies, the Federal agency employing the most geographers is the Department of Commerce. In this Department the Bureau of the Census has a Division of Geography which works on all censuses of population, housing, manufactures, and agriculture. Census Bureau publications often contain outline maps of the areas covered. In preparation for the 1950 census of population, the Division of Geography drew up official descriptions of the boundaries of each metropolitan area based upon studies of population clusters around large cities. Other geographers work in the Department's Office of Foreign and Domestic Commerce and Office of International Trade.

The Board of Geographic Names of the Department of the Interior serves as a review agency for decisions on official place names of both natural features (mountains, lakes, and rivers) and localities. Because the Federal Government is the world's largest map publisher, and because exploration and resurveys of isolated areas are still adding to geographic knowledge, the geographers employed by this Board have an important part in place-name geography (toponymics). A few geographers do highly skilled map compilation work in the United States Geological Survey, which is also in the Department of the Interior. A few are employed in the Soil Conservation Service of the Department of Agriculture and in other agencies making extensive use of maps. The Federal Government also employs some geographers as map librarians and curators of map collections, as in the Library of Congress, which has one of the world's largest map collections.

Private industry.—Although the number of geographers employed by private business concerns is small, employers are beginning to recognize the value of geographic information and interpretation. A manufacturer building a large plant must select a location accessible to both the sources of his raw materials and the markets for his products. Geography and economics combine to supply industry with answers to problems such as the above. Economic geography, now a well-established field of specialization, is the study of the distribution of economic activities and relationships between resources, localities, markets, and other economic factors.

An important phase of geographic work in industry is in foreign trade and foreign area analysis. The great corporations in the oil, rub-

[28] Schwendeman, J. R., Survey of the Status of College Geography in Institutions of Higher Learning in the United States (mimeo.). Department of Geography, University of Kentucky, Lexington, Kentucky, 1951.

[29] Taylor, Griffith, ed., Geography in the Twentieth Century, New York, The Philosophical Library, 1951 (esp. Ch. 24, Rose, John Kerr, Geography in Practice in the Federal Government, Washington, D. C., pp. 566–586).

ber, metal, chemical, food products, and other industries require detailed knowledge of many aspects of their foreign markets. Economic geographers both in government and in private industry bring together information on foreign areas in order to help the United States expand its world markets and find raw materials for its industries.

Secondary and elementary schools.—Geography has long been a regular subject of instruction in elementary and secondary schools. By studying geography, children learn about other lands and peoples and also about commercial relationships between city and country, the effect of the location of war materials on the development of American industry, and other geographic factors of great importance in national and international affairs. In elementary schools teachers do not specialize in geography but cover a wide range of subjects and activities, working with one group of pupils during the entire day. On the other hand, geography teachers in junior and senior high schools have considerable training in the science as well as in teaching methods. Even in such schools, however, these teachers must often give instruction in subjects such as history, civics, or some other natural or social science, in addition to geography.

Many of the 1,500 public-school teachers of geography have not obtained advanced degrees in geography and, therefore, are not qualified for research or college-teaching positions in professional geography. They are likely to regard themselves primarily as teachers, rather than scientists, and they have a separate association of their own—the National Council of Geography Teachers.

Education and Training

To qualify as a professional geographer one must generally have graduate training, although it is sometimes possible for persons with only the bachelor's degree to obtain full professional status after several years of work experience. Undergraduate studies usually provide only a general introduction to geographic knowledge and research methods, and often do not include the field studies necessary for professional competence. Students planning to work as professional geographers should, therefore, secure at least the master's degree. (This degree, or a bachelor's degree and 2 years of professional experience, is required for professional membership in the Association of American Geographers.)

Young people considering careers in geography would also do well to inquire about the types of courses offered and the specializations possible in the various colleges and universities. The following sample list of undergraduate and graduate courses offered in different geography departments suggests the range of subjects covered. Although no institution offers all of these courses, the larger departments have many not included on this list:

Systematic Geography

Economic Geography
Principles of Geography
Climatology
Land Resources
Earth Features
Political Geography
Meteorology
Human Geography
Historical Geography
Industrial Geography
Trade Geography
Urban Geography

Regional Geography

World Geography
Regional Geography
North America
South and Middle America
Europe
Asia
Africa
Australia and Pacific Area
U. S. S. R.
China
Polar Geography

Methodology

Cartography
Field Techniques
Geography in Education
Source Materials
Map Interpretation
Aerial Photography

Three sample course descriptions are given below to suggest the content of college courses in geography:

1. *Cultural Geography of East Asia.*—A comprehensive and systematic survey of the geographical distribution and interpretation of the major racial groups and cultural patterns of China, Japan, and Korea. Special emphasis will be placed upon the unique characteristics of the

peoples of these areas, their basic cultural institutions, outlooks on life, contemporary problems, and trends of cultural change. Designed specially for students of the social sciences and those preparing for careers in foreign service, foreign trade, education, and international relations.

2. *Problems of Map Evaluation.*—A review of the status of topographic mapping with consideration of important schools of topographic concepts and practices. Theoretical and practical means of determining map reliability and utility, including studies of map coverage. Emphasis on methods of preparation of data for compilation purposes, including a study of types of source materials. Methods of map cataloging and bibliography will be considered.

3. *Summer Field Course.*—Intensive training in methods and techniques of geographic field observations and recording. Practical experience in conducting land utilization surveys and the preparation of reports. Field study of the location and site factors affecting selected industrial establishments. Water-use problems. For geography majors and for those preparing for careers in regional planning. Requires 6 weeks' residence in a selected nonurban field area.

During the freshman and sophomore years the college student can usually take only introductory courses in geography. Specialized work in the chosen major field normally begins in the junior year. For those who plan to take doctorates, the junior year is the beginning of a 5- or 6-year program of study and research. Graduate study for the master's and doctor's degrees involves geographic field work and laboratory work as well as classroom studies. The student's thesis is based upon field work, and is usually his first independent experience in collecting and organizing earth science data. Skills in geographic research methods obtained in field work are the distinguishing marks of the professional geographer. It is often desirable for students to interrupt their studies with periods of employment related to their field interest. Instructors can often guide students to jobs that contribute to their professional knowledge and maturity.

A doctor's degree is particularly important for a career in college or university teaching. It may be required for appointment even to a position as instructor and is especially necessary for advancement. In the university department, advancement from instructor to full professor is relatively slow and may depend as much upon the quality and quantity of published research as upon performance in teaching.

Individuals with the bachelor's degree in geography sometimes qualify for positions as cartographic aids, if their training includes the required technical courses. They may also qualify for a few junior professional positions as geographers in the Federal service, and occasionally for junior positions on the staffs of State and city planning boards. If they have taken the required courses in professional education, they can qualify for teacher's certificates and become eligible for positions in secondary-school teaching.

The qualifications required for geographer positions in the Federal Government are set forth in the United States Civil Service Commission's examination announcements. An announcement issued in May 1951 for the grade of position above the junior level stated that applicants must have either a master's degree or a bachelor's degree with an acceptable major in geography plus one full year of professional experience. Persons with doctorates or additional experience in geography were eligible for higher-level positions. At all levels, it was possible to substitute experience of the following types for advanced graduate study:

(1) Geographical research in Government; (2) land planning research as an analyst or consultant; (3) military, air, or naval intelligence research; (4) business or industrial research as a technical advisor, analyst, or consultant; or (5) college teaching as an instructor or professor of geography.

How To Enter

New graduates who enter college teaching usually obtain their first positions through the department heads and placement officers of the institutions from which they graduated. Entry into college teaching jobs is sometimes possible on a part-time basis while the student is completing his advanced graduate studies. Beginning teaching positions in the public schools may be obtained through college placement officers, teachers' agencies, or direct contacts with school principals.

Information on certification and other requirements may be obtained from the State departments of education or from superintendents or principals of specific school systems.[30]

Employment in the Federal Government in the field of geography is usually secured by passing a civil-service examination. Students soon to complete their formal education are well advised to watch for announcements of such examinations in the fields of work for which they may be qualified. New graduates with only the bachelor's degree sometimes start in Government work by taking jobs as cartographers or cartographic aids.

At present geographers who wish to work for private commercial firms must "sell" their services to these companies, because geographic service to business has not been widely developed. It is suggested that efforts of this kind be made by students in connection with their thesis research.[31] Students seeking positions with concerns having foreign interests might profitably study foreign market problems on which information would be valuable to these firms. As an approach to a firm doing business within this country, the student might ask to make a study of the firm's marketing operations or manufacturing processes insofar as these are influenced by factors of location. Urban land-use studies have sometimes led to positions with city and State planning boards. Contacts made with fellow members of professional scientific societies are often helpful in obtaining beginning positions in teaching and government work as well as private industry.

Employment Outlook

Employment opportunities for professional geographers will probably continue to expand. In the early 1950's, an increasing number of geographers, particularly those with specialized knowledge of certain foreign areas, will probably be employed by the Federal Government in activities related to international relations, international trade, the technical assistance program for underdeveloped areas, and military planning. Often, a high level of scientific knowledge and skill, obtainable only through a combination of advanced training and specialized experience, is required for such employment.

During World War II, the rise in employment of geographers in civilian government agencies and the Armed Forces was great, in relation to the size of the profession. The number of civilian geographers on the Federal payroll increased from a prewar figure of around 50 to as many as 500 in 1945.[32] At the war's peak in 1945, more than 300 geographers were serving in the Armed Forces; of that group, some 75 percent used geographic skills in their military assignments.[33] Approximately 800 members of the profession taught in military programs at some time during the war.[34] However, many of these teachers were included also in the figures on Federal employees and members of the Armed Forces just cited.

It appears likely that similar movements in geography personnel will take place during the next few years beginning in mid-1951. Some faculty members will probably move to Government employment as enrollments decrease and the defense program advances. The normal demand for geographers as teachers in colleges and universities may be temporarily limited to necessary replacements. In the immediate future opportunities in high-school teaching will result largely from the current high turn-over rates among school teachers.

Since June 1950 the civil-service roster of persons eligible for appointment to Government positions as geographers has been exhausted, indicating that opportunities for employment in the Federal Government have increased sharply. Shortages of experienced geographers developed by early 1951 in the Army Map Service and in other units of the Department of Defense carrying on intelligence research. Prospects in cartographic work, intelligence, logistics, and foreign area analysis are good for persons with the requisite experience. In addition, a small number of well-qualified new graduates are being selected for assistants to experienced scientists.

[30] U. S. Department of Labor, Bureau of Labor Statistics, Bulletin No. 972. Employment Outlook for Elementary and Secondary School Teachers. Government Printing Office, Washington, D. C., 1949. *See also* Supplement (1951) to Bulletin No. 972.

[31] National Research Council, Division of Geology and Geography, Foreign Research Opportunities for Graduate Students in Geography, Washington, D. C., December 1949 (mimeo.).

[32] Taylor, Griffith, *op. cit.*

[33] Deasy, George F., War-Time Changes in Occupation of Geographers, The Professional Geographer, 7: pp. 33–41 (April 1948).

[34] Miller, E. Willard, Geography in the Army Specialized Training Program, The Professional Geographer, 3: Nos. 3–4 (May–June 1945).

The supply of geographers has increased considerably since World War II, although geography remains a relatively small field. The number of Ph. D. degrees granted annually in geography averaged about 12 during the period 1930–46 but increased to 40 in 1949–50 (see table 4).

The relative increase in degrees granted has been much greater in geography than in all fields since World War II. The number of graduates with "majors" in geography was more than 40 ably continue high during the next few years. whereas the total number of college graduates rose by only 18 percent. This increase in geography graduates was probably due to heightened interest in the subject on the part of veterans who had been sent to other countries during the war or who had had opportunity to see the practical uses of geography in intelligence work and military planning. Furthermore, the number of colleges offering training in geography, especially at the graduate professional level, increased sharply during the past 5 years.

The number of bachelor's degrees granted in geography (as in practically all other fields) is expected to decrease in the early 1950's. However, the number of graduate degrees will probably continue high during the next few years. Very good employment opportunities should await geographers with doctorates, and the prospects for those with only the master's degree are reasonably good. As previously noted, the bachelor's degree is not sufficient to qualify one for most positions in professional geography.

In the long run, the principal field for professional geographers will probably continue to be college teaching, assuming that the country does not enter into full mobilization. Opportunities for geography teachers in secondary schools are expected to expand in the latter part of the decade, when the large numbers of children born during World War II reach high-school age. As these young people graduate from high school in the late 1950's and the 1960's, there will be a sharp increase in the college-age population. Furthermore, the proportion of young people attending colleges in the United States is increasing steadily. Research in geography in colleges and universities will probably obtain greater support. These and other factors point to good long-run employment prospects for persons desiring to train themselves for academic careers in geography.

TABLE 4.—*Number of degrees granted in geography, 1948–50*

Academic year	Bachelor's degree		Master's degree		Doctor's degree	
	Number	Percent change over previous year	Number	Percent change over previous year	Number	Percent change over previous year
1947–48	357		157		17	
1948–49	511	+43.1	138	−12.1	28	+64.7
1949–50	757	+48.1	203	+47.1	40	+42.9

Source: U. S. Office of Education.

Utilization of professional geographers in industry, trade, market analysis, and other phases of business enterprise has just begun. This field should continue to offer good opportunities for small numbers of experienced geographers who can convince employers of the economic advantages of employing a consultant or specialist in geographic analysis as applied to their particular business.

Demand for geographers in Government service is likely to decline if defense activities slacken. However, a limited number of geographers will continue to be employed in agencies where maps are compiled, where a knowledge of foreign areas is valuable, and where evaluation of American and foreign natural resources is undertaken.

Earnings

Starting Salaries

The general range of entrance salaries received by earth science graduates in research and development laboratories is suggested by a survey covering 27,000 scientists in such laboratories in 1950.[35] The average monthly salary for beginners with the bachelor's degree was found to be $279. In the petroleum industry, which no doubt em-

[35] Los Alamos Scientific Laboratory of the University of California, 1950 National Survey of Professional Scientific Salaries, Los Alamos, N. Mex.

ployed most of the relatively few earth scientists included in the survey, inexperienced persons with only the bachelor's degree had an average monthly salary of $291. Average salaries among Ph. D.'s ranged from about $450 a month for those who had received the bachelor of science degree 3 years earlier to more than $700 for those with more than 20 years' experience since their baccalaureate.

The salary levels for new graduates trained as petroleum engineers or geophysical technologists are suggested also by a survey of beginning salary rates for approximately 11,000 engineering graduates in 1950.[36] The median monthly salary of these graduates was about $265. Salaries varied somewhat depending on the region in which the young engineers were employed. The medians ranged from about $250 monthly in the South Atlantic States to $275 in the Pacific States.

Earnings of Ph. D. Scientists [37]

Information on the earnings of earth scientists with Ph. D.'s is available from a study of persons listed in the 1949 directory of "American Men of Science." [38] In interpreting the data on earnings of Ph. D.'s, it must be noted that holders of doctorates tend, in general, to have higher earnings than members of the same profession with less academic training. This has been shown by many studies of professional earnings. There has also been a general upward trend in earnings in this country, since the time of the survey in mid-1948.

The median annual salary of earth scientists with Ph. D.'s was about $5,710 in mid-1948. One out of four of these scientists made over $7,130, and three out of four, over $4,650. The scientists employed in private industry had a much higher median salary ($7,780) than those employed solely in Government ($6,120) and those working only for educational institutions ($5,200).

Scientists specializing in geophysics tended to have higher salaries than other earth scientists included in the survey. This was probably due to the high proportion of geophysicists employed in private industry (table 5).

TABLE 5.—*Median annual salaries of earth scientists with Ph. D. degrees and percent of scientists working for major types of employers, 1948*

Field of specialization	Median salary	Percent of scientists employed solely in—		
		Education	Government	Private industry
All earth sciences	$5,710	29.9	26.6	16.3
Geophysics	6,780	15.7	31.4	30.0
Geography	5,670	68.7	11.1	1.1
Geology	5,630	25.7	26.3	17.4
Meteorology	5,670	30.0	48.6	5.0

Only half the earth scientists in the survey reported supplementary professional income in addition to their regular salaries. The median added income was $1,100. As shown in table 6, the proportion with added income was largest among the scientists with the lowest salaries—many of whom were college faculty members who taught summer school classes or did other work during the summer vacation. In terms of the amount of added income received, however, these lower paid scientists did not fare as well as those with higher salaries—who were often in a position to render highly paid counseling services to private industry or Government agencies.

TABLE 6.—*Added professional income of earth scientists with Ph. D. degrees, by amount of regular annual salary, 1948*

Regular salary	Median added income	Percent reporting added income [1]
Total	$1,100	52.9
$3,000–$3,999	1,010	76.2
$4,000–$4,999	920	64.0
$5,000–$5,999	1,120	57.2
$6,000–$6,999	1,400	46.4
$7,000–$7,999	1,300	39.7
$8,000–$8,999	1,250	36.2
$9,000–$9,999	(2)	40.0
$10,000 and over	1,880	27.6

[1] Percentages based only on scientists reporting regular salary.
[2] Insufficient reports to compute median.

[36] American Society for Engineering Education in cooperation with Engineers' Joint Council, Survey of Employment Status of 1950 Engineering Graduates. Mimeo.

[37] All data in this section are from Bulletin No. 1027, Employment, Education, and Earnings of American Men of Science. Prepared by the U. S. Department of Labor's Bureau of Labor Statistics in cooperation with U. S. Department of Defense. Government Printing Office, Washington, D. C., 1951.

[38] These data cover a large and important segment of the earth science professions, because the proportion of scientists with doctorates is high in a number of specialties—particularly among those engaged in research or college teaching. In applied fields such as exploration geophysics and geology, however, the majority of scientists have only bachelor's degrees, and there are some persons without doctorates in all major specialties.

Salaries in College and University Teaching

The average salaries of college faculty members of different ranks indicate the general range of salaries received by earth scientists in this field of employment, although separate figures are not available for these scientists.

A sample study made by the United States Office of Education showed that in 1947–48 the average salary for the academic year for professors was $5,758; associate professors, $4,594; assistant professors, $3,892; and instructors, $2,950. The overall average for all college teachers studied was $4,147. Important differences in earnings levels were found when faculty members were classified by age, sex, degree held, and length of teaching experience.[39]

More recent data on the salaries paid by a selected group of 41 colleges and universities are available from a survey made by the American Association of University Professors. It is probable that the colleges studied paid salaries somewhat higher, on the average, than those paid by all institutions of higher education in the country. The average salaries received by faculty members of these institutions in 1948–49 and 1949–50 are shown in table 7.

Figures on faculty earnings in 1950–51 are available for 200 teachers' colleges.[40] These colleges included on their teaching staffs a number of geographers, but relatively few other earth scientists. In the institutions reporting, the median salaries in 1950–51 were, for instructors, $3,400; assistant professors, $4,000; associate professors, $4,300; and full professors, $5,000. The range of salaries was from $1,350 for the lowest paid instructors, to $11,000 for some professors.

The data presented above indicate the range of earnings in the field of college and university teaching which may be expected by persons planning for careers in such work. Although earnings of college teachers are not usually as high as those obtained by professional workers in industry and Government, certain advantages (such as tenure, long vacations, opportunity for independent research) make college teaching attractive to many persons.

[39] Kelly, F. J., Salaries of College Teachers, Higher Education, 5 : 187 (April 15, 1949).

[40] American Association of Colleges for Teacher Education, The Committee on Studies and Standards, Salary Schedules and Salaries Paid in Colleges for Teacher Education, 1950–1951. 7 pp., mimeo.

TABLE 7.—*Average annual salaries of college teachers in selected institutions, 1948–49 and 1949–50*[1]

Academic rank	Average salary		Percent increase
	1948–49	1949–50	
Professors	$6,753	$6,899	2.2
Associate professors	5,138	5,189	1.0
Assistant professors	4,099	4,177	1.9
Instructors	3,154	3,287	4.2

[1] Instructional Salaries in 41 Selected Colleges and Universities for the Academic Year 1949–50, Bulletin of the American Association of University Professors, Vol. 35, No. 4, Winter, 1949.

Federal Government Salaries

Since the salary scales for Federal employees are fixed by law, much more detailed information is available on the salary levels of earth scientists in Government jobs than of those in other fields of employment. Federal salaries are graduated in relation to the degrees of responsibility involved in the given position. In addition, periodic increases, above the base salary for each grade, are given to workers whose job performance is satisfactory.

New graduates with only the bachelor's degree began professional positions at a yearly salary of $3,410 in late 1951; those with a master's degree or a baccalaureate and 1 year of qualifying experience, began at $4,205, and those with a doctor's degree or an equivalent combination of education and experience, at $5,060. Only a small number of persons with the minimum professional education (bachelor's degree) and no previous work experience in their chosen field are hired during any given year; more earth scientists start with the Government at a salary of $4,205 than at $3,410.

Persons with sufficient education, on-the-job experience, and a record of professional attainment can qualify for positions with base salaries of $5,940, $7,040, or more. Opportunities for initial appointment to positions with salaries above $5,940 are infrequent, however. These high-level positions are usually supervisory or administrative in nature and are filled, as a rule, by promotion of persons already with the agency.

Where To Get Further Information

Professional Associations

Information on the various earth science fields can often be obtained from the professional societies which have been formed by groups of scientists with common interests in one of the specialized fields of work. Many of the societies maintain permanent offices, with a full-time secretary or other official. The societies stipulate the requirements for membership, setting different standards for associate and other types of membership. Their definitions of the amounts of education and experience needed for professional membership have an important effect upon the college courses of study set-up for training purposes. The societies interpret their profession to the public at large and serve as sources of information about employment opportunities, training facilities, and other subjects of interest to prospective entrants. They usually publish professional journals and research papers, and hold national, regional, and local chapter meetings. Some of the societies maintain a placement service for members.

The American Geological Institute, 2101 Constitution Avenue NW., Washington 25, D. C., is a federation of 12 professional societies, each of which represents a special field of interest within the earth sciences. Each group publishes its own journal, and often a newsletter or bulletin as well. Most of the organizations have State or local chapters. Further information on the associations may be requested from the Institute. The following organized groups made up the membership of the American Geological Institute in 1951:

- American Association of Petroleum Geologists.
- American Geophysical Union.
- American Institute of Mining and Metallurgical Engineers.
- Association of American State Geologists.
- Geological Society of America.
- Mineralogical Society of America.
- Paleontological Society.
- Seismological Society of America.
- Society of Economic Geologists.
- Society of Economic Paleontologists and Mineralogists.
- Society of Exploration Geophysicists.
- Society of Vertebrate Paleontology.

The American Meteorological Society maintains permanent offices at 5 Joy Street, Boston, Mass. It publishes a bulletin (10 issues each year) and a bimonthly Journal of Meteorology. In 1951 the Society had about 4,000 members, about half of whom were professional members, viz., persons who met the education and experience requirements set up to define this classification.

Membership in the Association of American Geographers is limited to professional geographers. Its publications are the Annals of the Association of American Geographers and The Professional Geographer. Annual meetings, devoted to the presentation of research papers, are sponsored by the association, which is organized into branches permitting frequent meetings of geographers in a local area. The central office of the association is located in the Division of Maps of the Library of Congress, Washington 25, D. C.

The National Council of Geography Teachers fosters geographic education and seeks to increase the effectiveness of geography teaching. It publishes the Journal of Geography and two irregular series of publications known as the Professional Papers and the Geographic Education Series. The secretary of the Council is Miss M. Melvina Svec, State Teachers College, Oswego, N. Y.

Government Sources

Announcements of United States civil-service examinations for positions in the earth sciences are available from the central office in Washington, D. C., and also from 12 regional offices of the Commission, and are posted in all first- and second-class post offices. Examinations are opened annually for some of the earth science fields. For others, announcements are issued irregularly, according to the needs of the service for particular kinds of scientific personnel. In addition to the examination announcements, the United States Civil Service Commission issues general informational bulletins describing Government work.

A few agencies employing large numbers of earth scientists (such as the Geological Survey, the Weather Bureau, and the Navy Hydrographic Office) publish descriptive pamphlets about their work, and these usually contain information about the professional duties required of earth scientists in the Federal service. The United States Weather Bureau, Washington, D. C., should be consulted directly for information on positions with that agency, as well as on the student-aid program for prospective meteorologists.

Occupational Outlook Publications of the Bureau of Labor Statistics

Studies of employment trends and opportunities in the various occupations and professions are made available by the Occupational Outlook Service of the Bureau of Labor Statistics.

These reports are for use in the vocational guidance of veterans, in assisting defense planners, in counseling young people in schools, and in guiding others considering the choice of an occupation. Schools concerned with vocational training and employers and trade-unions interested in on-the-job training have also found the reports helpful in planning programs in line with prospective employment opportunities.

Two types of reports are issued, in addition to the Occupational Outlook Handbook:

Occupational outlook bulletins describing the long-run outlook for employment in each occupation and giving information on earnings, working conditions, and the training required.

Special reports issued from time to time on such subjects as the general employment outlook, trends in the various States, and occupational mobility.

These reports are issued as bulletins of the Bureau of Labor Statistics. Most of them may be purchased from the Superintendent of Documents, Washington 25, D. C., at the prices listed with a 25-percent discount on 100 copies or more. Those reports which are listed as free may be obtained directly from the United States Department of Labor, Bureau of Labor Statistics, Washington 25, D. C., as long as the supply lasts.

Occupational Outlook Handbook

Employment information on major occupations for use in guidance. Bulletin 998 (1951 revised edition). $3.00. Illus.

Includes brief reports on more than 400 occupations of interest in vocational guidance, including professions; skilled trades; clerical, sales, and service occupations; and the major types of farming. Each report describes the employment trends and outlook, the training qualifications required, earnings, and working conditions. Introductory sections summarize the major trends in population and employment, and in the broad industrial and occupational groups, as background for an understanding of the individual occupations.

The Handbook is designed for use in counseling, in classes or units on occupations, in the training of counselors, and as a general reference. Its 600 pages are illustrated with 103 photographs and 85 charts.

Occupational Outlook Bulletins

	Price
Aviation Occupations, Employment Opportunities in, Part II—Duties, Qualifications, Earnings, and Working Conditions	
Bulletin 837-2 (1946). Illus	30 cents
Foundry Occupations, Employment Outlook in	
Bulletin 880 (1946). Illus	15 cents
Business Machine Servicemen, Employment Outlook for	
Bulletin 892 (1947). Illus	15 cents
Machine Shop Occupations, Employment Outlook in	
Bulletin 895 (1947). Illus	20 cents
Printing Occupations, Employment Outlook in	
Bulletin 902 (1947). Illus	20 cents

	Price
The Plastics Products Industry, Employment Outlook in Bulletin 929 (1948). Illus	20 cents
Electric Light and Power Occupations, Employment Outlook in Bulletin 944 (1948). Illus	30 cents
Radio and Television Broadcasting Occupations, Employment Outlook in Bulletin 958 (1949). Illus	30 cents
Railroad Occupations, Employment Outlook in Bulletin 961 (1949). Illus	30 cents
The Building Trades, Employment Outlook in Bulletin 967 (1949). Illus	50 cents
Engineers, Employment Outlook for Bulletin 968 (1949). Illus	55 cents
Elementary and Secondary School Teachers, Employment Outlook for Bulletin 972 (1949). Illus	40 cents
Petroleum Production and Refining, Employment Outlook in Bulletin 994 (1950). Illus	30 cents
Men's Tailored Clothing Industry, Employment Outlook in Bulletin 1010 (1951). Illus	25 cents
Department Stores, Employment Outlook in Bulletin 1020 (1951). Illus	20 cents
Accounting, Employment Outlook in Bulletin 1048 (1951). Illus	(In press)
The Merchant Marine, Employment Outlook in Bulletin 1054 (1951). Illus	(In press)

Occupational Outlook Supplements

Effect of Defense Program on Employment Outlook in Engineering (Supplement to Bulletin 968, Employment Outlook for Engineers) (1951)	15 cents
Effect of Defense Program on Employment Situation in Elementary and Secondary School Teaching (Supplement to Bulletin 972, Employment Outlook for Elementary and Secondary School Teachers) (1951)	15 cents

Special Reports

Occupational Data for Counselors. A Handbook of Census Information Selected for Use in Guidance Bulletin 817 (1945) (prepared jointly with the Occupational Information and Guidance Service, U. S. Office of Education)	20 cents
Factors Affecting Earnings in Chemistry and Chemical Engineering Bulletin 881 (1946)	10 cents
Occupational Outlook Information Series (By States) VA Pamphlet 7–2 (1947) (When ordering, specify State or States desired) (each)	10 cents
Employment, Education, and Earnings of American Men of Science Bulletin 1027 (1951)	45 cents
Fact Book on Manpower (1951)	Free
Employment Opportunities for Student Personnel Workers in Colleges and Universities (1951)	Free
Elementary and Secondary School Principalships—Chief Advancement Opportunity for Public School Teachers (1951)	Free
Employment Opportunities for Counselors in Secondary and Elementary Schools (1951)	Free

Occupational Outlook Mailing List

Schools, vocational guidance agencies, and others who wish to receive brief summaries of each new Occupational Outlook report, usually accompanied by a wall chart, may be placed on a mailing list kept for this purpose. Requests should be addressed to the Bureau of Labor Statistics, United States Department of Labor, Washington 25, D. C., specifying the Occupational Outlook Mailing List. Please give your postal zone number.

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