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DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

John Wesley Shrum, B. S., M. Ed.

The Ohio State University
1963

Approved by

John S. Richardson
Adviser
Department of Education
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CHAPTER I

THE PROBLEM AND ORGANIZATION OF THE STUDY

Within the past eight years the science curriculum in the secondary schools of the United States has undergone distinct and rapid changes. Each of the three traditional high school science courses - physics, chemistry, and biology - has been drastically altered in a manner without precedent in the history of education. An unparalleled aspect of this curricular change has been the relatively short period of time taken for proposed changes to have an effect upon what is being taught in the science classroom. Two other unique factors in bringing about this change have been: (1) the involvement of college and university scientists, science educators, and high school science teachers; and (2) ample financial support, primarily from the National Science Foundation with some additional support from such organizations as the Ford Foundation and the Carnegie Corporation.

Major projects which have had national significance are the Physical Science Study Committee, the Chemical Bond Approach Project, the Chemical Education Material Study, and the Biological Sciences Curriculum Study. Each of these has produced one or more textbooks, teachers' guides, special equipment, motion pictures, laboratory manuals, and supplementary materials. Each program has been tried two or more years in experimental schools and revised on the basis of information obtained in the trials. Each of the projects has included
a program for the preparation of teachers through summer and in-service institutes so that the new course materials could be used effectively. Each of the projects resulted in reduction of the amount of factual information to be taught, more prominence to laboratory work and processes of inquiry, and organization of the course around the development of selected major concepts of the science field.

In their impact on the schools, the new curriculums have focused attention on the science courses in many schools where none of the new courses have been adopted. Science teachers attending institutes at The Ohio State University have reported that ideas, concepts, teaching procedures, and materials from the new curriculum projects are being utilized in reorganizing their science courses. It may be that such adaptation of the new curriculums will have been their major contribution to improved science teaching when the present is interpreted in historical perspective.

The changes in emphasis in high school science courses have focused attention on improvements needed in junior high schools and elementary schools. Efforts are currently being made to improve the quality of the elementary school science curriculum and to identify the science concepts desirable for inclusion in it. Although these changes are not so widespread as the changes in the secondary school, they have helped create the problem of what science to teach in the ninth grade. Much of the science taught in the ninth grade has been a repetition of science concepts taught in the first eight grades.

Two patterns seem to have developed to solve the problem in the ninth grade. One has been to teach biology at this level and
then offer an advanced course in biology, chemistry or physics in the twelfth grade. The other, and increasingly common, approach has been to provide a year of study in earth science.

The introduction of the earth-science course has presented problems of what content to include, how it should be taught, and how to find teachers academically qualified to teach such a course. In general, the content has been drawn from geology, astronomy, and meteorology. Science teachers with quite limited academic preparation, or none at all, in one or more of these areas have been called upon to teach the new earth-science course. It is, therefore, recognized that steps must be taken to prepare teachers competent to handle the subject matter before there is widespread inclusion of earth science in the secondary school curriculum.

Educators and earth scientists have expressed concern over the relatively rapid growth of earth-science courses in secondary schools. Recognizing the general education value of problem-solving experiences and the acquisition of information and abilities for improving scientific literacy, both groups are convinced of the appropriateness of such courses. Of major concern, however, is the fact that few teachers have adequate preparation for teaching earth science. Opportunities to prepare for earth-science teaching through a planned curriculum have not been generally available to prospective teachers.

**The Problem**

**Statement of the problem.** The purpose of this study has been (1) to propose a curriculum appropriate for the academic preparation
of earth-science teachers; and (2) to adapt the proposed curriculum to the needs and demands of The Ohio State University. In order to accomplish the central purpose, two contributing problems were investigated: a determination of (1) the nature and current status of the developing earth-science course in the secondary school, and (2) the needs of teachers in utilizing earth-science content.

Hypotheses. This study has been carried out on the basis of two hypotheses. (1) The number of schools currently offering, and those which are planning to offer, earth-science courses has created a demand for persons qualified to teach earth science. (2) An academic curriculum can be planned that will adequately prepare an earth-science teacher for his initial teaching responsibility and make provisions for his continued professional growth.

Delimitation of the problem. The study includes only that part of the education of an earth-science teacher which contributes directly to his knowledge of science and his ability to teach earth science. Detailed consideration of other aspects of the curriculum, such as general education, and professional education other than that specifically concerned with teaching earth science is beyond the scope of the present study. These elements would constitute a common need of all secondary school teachers and would be included in the curriculum of the earth-science teacher in a pattern characteristic of a given institution.

Importance of the study. If the hypotheses are proven true that a need exists for qualified earth-science teachers and that these
teachers can be adequately prepared to meet initial teaching responsibilities, the study will fulfill a current need in teacher preparation programs. The proposed curriculum would be helpful to colleges or departments of both education and the academic areas in planning their own curricula for earth-science teachers. Adaptation of the proposed curriculum to one for The Ohio State University serves two functions, first to initiate such a curriculum at this institution and, second, to provide an example that may be used by anyone interested in making a corresponding adaptation in another institution.

The interdisciplinary concepts in earth science are of value in the preparation programs of all science teachers. Appropriate courses emphasizing interdisciplinary aspects have not been commonly available. If such courses were made available in a curriculum for preparing earth-science teachers, a dual purpose would be served by encouraging other science teachers to include them in their curriculum.

**Procedures Used**

The procedures used in achieving the purposes of this study have involved elements of survey techniques, job analysis, and documentary research in the descriptive method of research. The nature of the developing earth-science course has been determined through analyses of currently used textbooks, state and local courses of study, state certification requirements, and the offerings of earth-science summer institutes. Synthesis of these data revealed the needs of teachers in utilizing earth-science content. These needs were subjected to evaluation by ten persons having a responsibility for the preparation of earth-science teachers.
The proposed curriculum for the preparation of teachers competent in the earth sciences has been developed by projecting the areas of content and professional competency found to be needed into a teacher preparation program. The literature and suggestions from experienced professional personnel have also been utilized in designing the proposed curriculum.

The proposed curriculum has been developed into a program for possible use at The Ohio State University by studying the science teacher preparation patterns in existence at this institution and incorporating the proposed curriculum into a similar pattern. This was done within the framework of existing courses, by suggesting desirable modifications for some existing courses, and suggesting needed new courses.

The questionnaires and other instruments used in obtaining data from science consultants and certification officials, from institute directors, and from professional personnel are described at the appropriate point where they are used. The different specific procedures used in analyzing and synthesizing the data are described at the point of use.

**Definition of Terms Used**

**Earth science.** The term "earth science" is defined as the study of the materials and processes of the earth, its atmosphere, its history, including that of its life forms, and its environment in space. This definition is considered to include Stephenson's
definition and extend it to encompass the tools and rules of biology:

Earth science deals with the scientific phenomena of the earth and its environs in space and is composed of a family of interrelated fields of science including geology, geophysics, oceanography, meteorology, and astronomy. Earth science deals with a scientific system composed of the lithosphere, hydrosphere, atmosphere, and space. The tools and rules of chemistry, physics, and mathematics are essential to the study of the earth sciences.1

Earth sciences. In the plural form, the term "earth sciences" is used to refer collectively to the separate sciences, or several of them, that make up earth science rather than the comprehensive meaning of the singular form. The context in which the terms are used should make it clear to the reader which definition is being used.

Secondary school. The term "secondary school" is defined in this study as including the years of schooling from grade seven through grade twelve. The term includes the junior high school, grades seven through nine, and the senior high school, grades ten through twelve.

Curriculum. When used in the broad sense, "curriculum" means all the experiences that a student has under the jurisdiction of the school. The curriculum for the academic preparation of earth-science teachers includes the courses and experiences related to the subject matter of earth science and specific ways of teaching this subject matter.

Professional courses. The term "professional courses" in this study is construed to mean the courses commonly offered in a college or department of education which are oriented toward the development of teaching proficiency.

Philosophy of Science Teaching

The ultimate position taken by anyone in any circumstance is influenced by the individual's philosophy with respect to the consequences of his action or inaction. A philosophy of science teaching, therefore, influences any plan that includes ways of working with students in a variety of situations, determining appropriate learning experiences to accomplish specific purposes, and identifying the areas of scientific knowledge requisite to the ability to teach science in the secondary school.

Objectives of science teaching. A basic element in the philosophy of science teaching is the identification of goals or objectives. When clearly identified and accepted by the teacher, objectives provide the direction necessary in all other aspects of teaching. Objectives enable the teacher to plan his work so as to utilize effective and appropriate learning experiences to achieve these desired outcomes. Objectives of science teaching influence the selection of content to be included in a given science course or sequence of courses and the evaluation techniques and devices that will reliably indicate the extent of achievement.

Science educators are in general agreement on the major objectives of science teaching in our present democratic society.
These objectives may be stated in a variety of ways and in varying detail, but will group into four major categories: development of scientific literacy, preparation for science-related vocations, development of the ability to think critically, and development of an understanding of the social function of science.

Achievement of the goal of scientific literacy is considered to be essential in a society that has become increasingly oriented toward, and influenced by, scientific discoveries and the use of these discoveries through technology. Within the comprehensive goal of producing scientifically literate citizens, science teaching should contribute to the development of student understanding of two major aspects of science, the product of science as a body of knowledge and the process of science as a way of learning and knowing. Science as a body of knowledge has grown tremendously since the beginning of the Twentieth Century both in the discovery of facts, principles, and theories and in the refinement of previous discoveries in the light of additional evidence. The scientifically literate citizen will have learned many of the major concepts of science, be able to recognize the limitations of this knowledge, and be able to understand current scientific advances. The selection of concepts to be included in the science curriculum is thus a problem of identifying the ones that will contribute best to an understanding of the physical and biological environment and the interrelationships between them.

Understanding and being able to use science as a process is the second element in the objective of developing scientific literacy.
Through direct experience with ways that scientific knowledge has
developed and is presently developing, the student will develop such
understanding and ability. These experiences should include such
methods of scientific investigation as observing, experimenting,
interpreting, hypothesizing, concluding, and predicting. Mental
skills such as classifying, forming of mental images, defining,
generalizing, and communicating are abilities in the process of
science that will help develop scientific literacy. Contributing to
an understanding of the process of science such manipulative skills
as using laboratory equipment, graphing, dissecting, collecting,
mapping, and recording should be part of the experience provided in
science teaching.

Experiences such as these are valuable in developing an under-
standing of science as a process in science courses at all levels from
the secondary school through the university. It should not be assumed,
however, that the desired understanding will develop automatically
from the study of science. As a major objective, teaching science as
process would have to be reflected in the variety of experiences pro-
vided, in evaluating the students and in structuring situations to
make certain that students understand both the process being emphasized
and its value to each student as part of his intellectual equipment
for approaching his own problems scientifically.

An additional component of scientific literacy is the develop-
ment of attitudes characteristic of persons who solve problems
scientifically. Through his study in science the student should be helped to develop the following attitudes and attributes:

1. Curiosity about his environment and its phenomena.
2. Accuracy in making observations and interpretations.
3. Tolerance for the viewpoints of others.
4. Being critical of unsupported statements.
5. Open-mindedness in examining hypotheses, viewpoints, and evidence.
6. Desire to know and understand.
7. Withholding of judgments until sufficient evidence is obtained.
8. Disposition to formulate tentative conclusions.
9. Willingness to change conclusions with additional significant evidence.
10. Desire to find cause and effect relationships.
11. Possession of intellectual honesty.
12. Perseverance in intellectual investigations.

Development of these attitudes, as in understanding science as a process, will result only through direct consideration of them as the teacher guides the learning experiences of a science class.

A second major objective of science teaching is the preparation of students for science-related vocations. Relatively few students in a given age group will become professional scientists because of combinations of factors such as interests, ability, opportunity, and the time required for specialized study in a science field. For
these students, science teaching should provide opportunities to explore and deepen interests in science as well as to develop the skills, abilities, and knowledge which will be useful in both their work as scientists and life as citizens.

Many students can expect to be employed eventually in science-related vocations. This is a consequence of the fact that science has been responsible for raising the standard of living and that the technology resulting from scientific discoveries has become significant in providing vocational opportunity. Examples of vocations requiring a science background are abundant in such fields as electronics, aeronautics, astronautics, automation, computer design and construction, agriculture, medicine, and food processing. Opportunities within any of these vocational fields exist for all levels of scientific and technological preparation from that obtained in the secondary school to that in the graduate school.

A third major objective of science teaching is the development of the ability to think critically. This ability strongly supports and contributes to the objective of developing scientific literacy. Basic to critical thinking are the attitudes and mental skills presented as components of scientific literacy. Utilized in critical thinking, these attitudes and skills enable an individual to solve problems in the characteristic manner of a scientist. The ability to think critically should not be restricted to problems in science, but should be developed as far as possible in each student to enable him to apply this thought process to personal, social, and civic problems.
The importance of critical thinking in a democracy is that through this intelligent study each citizen enables himself to arrive at better decisions than could be done otherwise. Critical thinking minimizes the effects of ignorance, prejudice, and self-interest.

The teaching of science should contribute to a fourth major objective, that of developing an understanding of the social function of science. Science has become a central force in our present society through generation of ideas, information, and devices. Application of these through technology has improved the standard of living in American society to an extent that is unequaled in the rest of the world. The interdependence of society and science thus becomes important to all members of the society.

Science is a construct of man's intelligence and cannot be considered apart from its relationship to man. Through the process and products of scientific endeavor, science has become an instrument of society which offers possibilities for continued improvement of the society. Processes of science offer the means of safeguarding gains in understanding and improvement of both the biological and physical environments. Thinking based on truth and logic releases man from the confines imposed by thinking based on fear and superstition.

The products of science have their greatest impact on society through technological development of ideas and devices. Applications of science in the fields of communication and transportation have changed the nature of the relationship among and within the societies of the world. Utilized for the good of mankind, improved communication
and transportation offer hope for the future. Irresponsible utilization of these scientific products may lead to international conflict, depletion of natural resources, and degradation of society. Applications of science in the field of medicine have resulted in the elimination of some diseases, have reduced the harmful effects of other diseases and injury, and have extended the life expectancy of all members of the society.

Through the teaching of science, students should become familiar with the implications of science and technology for society and for their personal lives. Science is dependent upon the support of society; each citizen should be helped to develop an understanding of science so that he can respond intelligently in supporting and using it.

**Bases of the objectives of science teaching.** The values held by our democratic society form the bases of the major objectives of science teaching. Neal has outlined the following values:

1. Respect for the worth of each individual
   a. Through consciousness of the possibility of individual excellence in the future
   b. By conviction that men are more important than things

2. Genuine respect for honest work
   a. By effective workmanship on a job
   b. Through interest in the good workmanship of others
3. High regard for talent and training
   a. By a discriminating sense of high values
   b. By analysis of any success resulting from the skill, persistence, and reliability of a worker

4. Determination to curb racial and group prejudices
   a. Through a realization that emotion as a factor in human relationships must be directed and controlled
   b. Through the practice of tolerance

5. Willingness to utilize personal interests and knowledge for the common good
   a. Through cooperation with others to help bring about scientific progress

6. Desire to live as a worthy member of community, state, and nation
   a. By realizing the values that come from good citizenship and wholesome relations with others
   b. By learning the reasons behind such measures as quarantine, sanitary controls, and immunization requirements.²

These values are basic to a democratic society and find expression in the overall purposes of the schools as well as in the objectives of science teaching. Both the purposes of the schools and the objectives of science teaching are derived from the needs of students, the needs

of society, and the interrelationship of these needs. Individuals need to establish satisfactory relationships with their peers, develop confidence in social situations, understand their body functions and their mental and physical limitations, achieve independence from parents and other adults, develop leadership abilities, and develop a system of values for life in a democratic society. The needs of society include establishing the traditions and customs of the culture, the maximum educational development of all members in the society, an understanding of the responsibilities, rights and privileges of persons living in a democracy, the conservation of human and natural resources, and an understanding of the social and economic aspects of life in a democracy.

The teaching of science to accomplish objectives based on the needs of individuals and society, and on the values held by the society, is mandated by the place of science in our culture. Within the past half-century, science has become a central cultural factor in our society. Science has evolved through a long history of being an academic and avocational interest of a relatively few people to the point of being a necessity in the lives of everyone. An understanding of science not only provides insight and explanation of the universe and man's place in it, but makes possible the technology by which we make use of the materials and energy in the environment.

A major contribution to be made through the teaching of science in the secondary schools is in providing ways of thinking, acting, and investigating that can become an integral part of the students' lives.
Scientific attitudes and modes of thinking provide the means through which conclusions may be safeguarded, time, energy, and resources can be used efficiently, and through which insight may be gained in understanding human behavior. The role of science as a central factor in our culture is that of helping man in his living with those of his own and other cultures and in understanding and making the most effective use of his environment.

**Organization of the Remainder of the Dissertation**

Chapter II is a review of the literature of the areas related to earth science in the secondary school. Pertinent literature is summarized that concerns the preparation of science teachers, the history and recent developments of earth science in the secondary schools, and the contributions of earth science in the curriculum of the secondary school.

The nature of the developing earth science course is treated in Chapter III. Included are original data from state science supervisors, analyses of textbooks and courses of study in earth science, and data from the directors' reports of Summer Institutes for Earth-Science Teachers.

Chapter IV contains statements of the needs of earth-science teachers as obtained through a synthesis of the data from Chapters II and III. An evaluation of these needs by ten persons having responsibility for earth-science teacher preparation is also included in Chapter IV.
The proposed curriculum for preparing earth-science teachers is presented in Chapter V. This curriculum is derived from the findings of the needs of earth-science teachers.

Chapter VI includes a teaching area for the preparation of earth-science teachers at The Ohio State University, as developed from the proposed curriculum. The meeting of certification requirements in the State of Ohio is considered.

The summary and conclusions drawn from the study are included in Chapter VII. Recommendations for developing a teaching area in earth science at The Ohio State University, developing special courses, and modifying certification requirements are made in this chapter. Suggestions for further research related to the preparation of earth-science teachers are made in concluding Chapter VII.

Samples of instruments used, identification of cooperating institutions and individuals, and tabular information not included in the body of the dissertation are found in the Appendixes.
CHAPTER II

REVIEW OF THE LITERATURE RELATED TO EARTH SCIENCE
IN THE SECONDARY SCHOOL

The development of a proposed curriculum for the preparation of earth-science teachers requires an understanding of current practices in teacher education and of factors that pertain to the qualities of, and demands for, such teachers. The National Society for the Study of Education has called attention to additional considerations in the preparation of science teachers. "In order to formulate a plan of education for prospective teachers of science in junior and senior high schools it is advisable first to consider the kinds of positions and responsibilities science teachers generally fill."¹ The acquisition of a background of such understandings and familiarity with special needs of earth-science teachers has been attempted, in part, through a review of the related literature. The literature from four areas - the preparation of science teachers, the history of earth science in the secondary schools, recent developments in earth science in secondary schools, and the contributions of earth science in the science curriculum of the secondary school has been summarized in this chapter.

The Preparation of Science Teachers

"Ultimately the success of any school system depends upon the training and preparation of its teachers. The influx of pupils to the high schools in the last generation, and the necessity of providing adequate accommodations to meet it, have tended to lead to a neglect of the basic element of success." \(^2\) Although written in 1930, this concern for teacher preparation has meaning at the present time.

There is evidence, however, that increasing student enrollments and providing accommodations for them has not continued to lead to neglect of teacher preparation. Individuals and committees representing institutions of higher education, public and private secondary schools, scientific organizations, state and federal agencies, science teacher organizations, and citizens groups have given time and talent to studying the problems of teacher preparation. The interest and participation of such persons and groups has occurred with increasing frequency since late in the nineteenth century. The manner in which their efforts have influenced the preparation of science teachers can be identified from trends established during the present century.

The science courses offered in the secondary schools in the early 1900's were part of a trend that resulted from the work of the "Committee of Ten" in 1893. \(^3\) This Committee had recommended a sequence of secondary-school science courses of physical geography, biology,


physics, and chemistry be offered in the order given. The Committee also made recommendations of methods through which the subjects should be taught, although these were quite general in nature. For example, the recommendation for teaching physical geography was that "every stage of the subject should be naturally introduced and illustrated by the teacher, and the textbook should be kept in its proper place as an aid and not as a master, and mere lesson-hearing should never be allowed to replace actual teaching." Teachers were urged to make extensive use of maps, charts, globes, models, blackboard sketches, common rock and mineral collections, observations, and the keeping of records.

In 1918 the Commission on the Reorganization of the Secondary School published their report giving the "Seven Cardinal Principles" of secondary education. These principles stated that secondary education should be organized around the major areas of health, development of fundamental processes, worthy home membership, effective citizenship, worthy use of leisure, vocational interests, and development of ethical character. A sub-committee of this Commission concerned with science teaching recommended that science be taught so as to contribute to all of the Cardinal Principles except that of the

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4 Ibid., pp. 218-19.

development of fundamental processes. As a result of the publication of the Reorganization Commission and sub-committee reports, a trend was established to implement the Cardinal Principles in the secondary school. Science teachers began to include and emphasize the functional aspects of science.

The trend toward functional use of science principles was enhanced by the Thirty-first Yearbook of the National Society for the Study of Education. The Yearbook recommended that children have experience working with the real things of science and with problems that were real to them. Thirty-eight generalizations were proposed as examples of concepts or principles for use in science teaching. Also proposed was the first organized attempt to establish science as a part of every grade level.

In support of its proposals for teaching science, the National Society for the Study of Education, after reviewing the research on science teaching and studying existing programs, recommended courses for the education of science teachers. The following courses were suggested as comprising minimal preparation.

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8 Ibid., p. 340.
I. **General or Orientation.** A course required of all elementary and secondary-school teachers. The units of this work will be built around those generalizations and principles of science that relate most immediately to the needs and interests of liberally educated people. These will be chosen irrespective of the special field of science to which they may be related (8 or 10 semester-hours of credit).

II. **Beginnings of specialization.** Introductory courses in each of the special sciences - chemistry, physics, and biology. Courses in botany and zoology may be offered instead of biology (18 to 24 semester-hours of credit).

III. **Specialization.**

A. Chemistry

Second-year chemistry (8 hours credit)
Third-year chemistry (8 hours credit)

B. Physics

Second-year physics (8 hours credit)
Third-year physics (4 hours credit)

C. Biology

Second-year biology (8 hours credit)
Third-year biology (8 hours credit)

IV. **Electives.**

A. Geology (4 hours credit)
B. Physiography (4 hours credit)
C. Astronomy (4 hours credit)
D. Bacteriology (4 hours credit)

These recommendations were influential in the development of curricula for preparing science teachers. They may have been the origin of more recent recommendations that at least 50 per cent of the course work taken by a prospective science teacher should be in science courses.
The trend toward teaching science for functional use of scientific concepts was reinforced by the Progressive Education Association. The Report of the Committee on the Function of Science in General Education in 1938 proposed that science teaching should contribute to the needs of youth in four basic areas. These were: (1) personal living; (2) immediate personal-social relationships; (3) social-civic relationships; and (4) economic relationships. The Committee gave special emphasis to teaching science so as to develop the ability to do reflective thinking.

...Young people will be helped to achieve these ways of thinking and acting only by wide successful experience in attacking and surmounting the problems with which novel situations confront them and in adjusting themselves accordingly, and that this adaptability, resourcefulness, and self-criticism will be exhibited mainly in situations similar to those of which they have had previous experience.

The Committee does not specify what content should be in the science curriculum, but gives examples using science content and suggestions for selecting problems and generalizations. From these, it may be inferred that the Committee had a strong faith in the importance of content and in the teacher's ability to select content that would accomplish the aim of functional use of science in the basic

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areas of need. Increased emphasis on teaching science to develop reflective thinking became more common, if not an established trend, as a result of the work of the Progressive Education Association.

Publication of the Forty-sixth Yearbook of the National Society for the Study of Education extended and amplified the trends of teaching science for functional values, including reflective thinking. The objectives, typical courses, and methods of evaluation suggested in this Yearbook emphasized that science must be taught for its values of method, attitudes, and appreciations as well as functional understanding of facts, concepts, and principles. The Yearbook Committee proposed a program for the education of science teachers based on developing such values. This program was similar to that proposed in the Thirty-first Yearbook. Approximately half of the course work consists of science courses.

Recent Emphasis in the Preparation of Science Teachers

In the period of time since World War II the problem of preparing science teachers has been compounded by increasing demands for a greater number of better prepared teachers. More teachers have been needed as a result of the rapid increase in population and the consequent increased enrollment in the public schools. The population in the age group of 14 to 17 years increased steadily from 8.4 million in

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12Supra, p. 23.
From 1950 to 11.2 million in 1960.\textsuperscript{13} During this same period of time, enrollments in the secondary schools increased from 6.5 million to 9.2 million.\textsuperscript{14} Thus, there has been approximately a 33 per cent increase in the 14 to 17 age group and slightly over a 41 per cent increase in the secondary school enrollment.

Problems in the preparation of science teachers. The problem of meeting the demand for greater numbers of science teachers has been recognized as one of many problems in the preparation of science teachers for the secondary schools. A study of science teachers in Minnesota revealed two major problem areas - administrative problems in the schools and problems in the preparation of the teachers. These problem areas were reported by Anderson in 1950. He found that administrative problems consisted of science teachers having too many preparations to make and working with too many pupils per day. These time demands left little time for planning laboratory activities. Laboratory equipment was inadequate in many schools. The inadequate preparation of the science teachers was evident from a variety of factors. The teachers lacked preparation in the sciences, relied heavily on the use of textbooks and laboratory manuals, and had little insight and training in using scientific methods. Field trips and

\textsuperscript{13}National Science Foundation, Statistical Handbook of Science Education (Washington: Government Printing Office, 1960), Figure 2, p. 2.  
\textsuperscript{14}Ibid., Figure 5, p. 5.
visual aids were used infrequently, few science clubs were sponsored, and there was a lack of definite procedures for developing an understanding of principles and scientific attitudes. Teachers lacked professionalism and did not differentiate their instruction for students of varying ability and interests. In reporting such problems, Anderson urged that teacher training institutions and the State Department of Education attack these problems as a means of increasing the quality of science instruction.15

The changes that had occurred in the preparation of science teachers up to 1950 were the basis for recommending needed emphases in teacher preparation. Cahoon and Richardson presented needed emphasis in seven problem areas considered to be worthy of consideration, discussion, and possible investigation:

1. Preparation of teachers in both academic content and professional experience adequate to the aims and purposes of the best schools and to the needs and development of boys and girls in our evolving society.

2. Preparation of mathematics and science teachers in such related fields as conservation, aviation, atomic energy, and consumer problems, of importance in the present or immediate future of boys and girls.

3. The development of more concern with the problems and resources of communities in the preparation of science and mathematics teachers, both in their pre-service and in-service experiences.

4. Provision for the in-service growth and improvement of science and mathematics teachers.

5. More first-hand experience with children and teaching problems and with procedures related to important goals during preparation for teaching.

6. Experience with the professional resources for science and mathematics teachers, including skill in using reading and visual materials, as well as devices and equipment needed by science and mathematics teachers in a modern program.

7. Provision for developing and evaluating competency in the various phases of science and mathematics teaching rather than dependence upon credit hours as an index of teaching preparation or effectiveness.¹⁶

Emphasis such as this and problems of quantity and quality in science teacher preparation were considered at the Conference on Nation-wide Problems of Science Teaching in the Secondary Schools. Held at Harvard University in the Summer of 1953, the Conference participants reviewed research, statistics, and recommendations pertinent to science teaching. The Conference Report suggested that proposals for revised and new teacher-training programs and for certification requirements take into account seven general recommendations. These recommendations were found in reports of proposed criteria for adequate preparation of science teachers:

1. Required programs and the courses composing them insure that the prospective teacher has a scholarly mastery of the fields to be taught.

2. The prospective teacher have a knowledge of education, including such aspects as the nature and development of the child and adolescent learner, testing methods, and evaluation.

3. Skill and competence in teaching be developed as far as possible through realistic experience with actual problems which arise in schools and communities.

4. The prospective teacher have contact with all major areas of human knowledge. Specialization is not enough. The teacher should become aware of the interactions of his major field of study with other fields of human endeavor and creative thought.

5. The five-year college training program for teachers become a mandatory minimum.

6. Nation-wide or at least regional standards for teacher certification be adopted, and better methods of appraising teacher competence be found.

7. During the training process, a sense of self-criticism be instilled in the prospective teacher, so that later he may have the ability to evaluate himself and his work.\(^\text{17}\)

The efforts of other individuals and groups have also been directed towards recognizing and proposing solutions to the problems of preparing science teachers. Evans considered the problems to be centered in the teacher's preparation in science, his knowledge, skill, and understanding of the teaching process, and his liberal education. These problem areas are commonly recognized, but the complexity of the problem requires the development of many "new and experimental programs which will take into account the professional, citizen, and personal needs of the science teacher determined by means of an analysis of the work and responsibilities of the science teacher in the modern school.

and college. The traditional requirement of prescribed courses in
the sciences, humanities, social sciences, and education has not been
satisfactory because of the uncertain and varying quality of the
courses.

The development of a scientifically literate citizenry was con-
sidered by Bryan as being at the focus of the problem of preparing
science teachers. If the goal of scientific literacy is to be
accomplished, teachers of science must be competent in science, under-
stand the value of science in the society, and know the methods of
teaching science so that it becomes part of the life of the student.

The magnitude of the problems confronting those interested in
preparing teachers of science was revealed in a survey made for the
National Science Foundation. Using a stratified random sampling method,
a sample of 3,957 teachers from the U. S. Registry of Junior and Senior
High School Science and Mathematics Teaching Personnel was studied.
Usable questionnaires were returned by 3,012 teachers. Analysis of
the data revealed that opportunities are limited for a teacher to
specialize in teaching one science field. This was especially true of
chemistry and physics where 7 out of 10 and 8 out of 10 teachers
respectively were primarily teachers of other subjects. The problem

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of academic preparation was considered to be critical. If 18 semester hours is assumed to be a minimum preparation in a teaching field, approximately 21 per cent of the classes in biology, 34 per cent in chemistry, and 66 per cent in physics were being taught by teachers with inadequate preparation. 20

**Proposals for the preparation of science teachers.** Recognition of the problems of preparing teachers of science for the secondary schools has led to investigations resulting in proposed and experimental programs for such preparation. As in the case of identifying problems, these investigations have occupied the time and talents of individual researchers and of committees with representatives from organizations with scientific and educational interests. Problems and proposals related to preparing science teachers have received widespread publicity, as have educational problems in general, since the launching of the Russian satellite "Sputnik I" in 1957 and the subsequent developments of foreign and domestic space programs. It should be pointed out, however, that these problems were recognized by educators and scientists long before the public's attention was directed toward the critical state of science and science teaching in the secondary schools by well-meaning but often ill-informed critics.

One group that has long been concerned with the problems of preparing science teachers is the Cooperative Committee on Science Teaching

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of the American Association for the Advancement of Science. Soon after its inception in 1941, this Committee recommended that prospective teachers be prepared in at least three sciences of the following five: biological science, chemistry, earth science, mathematics, and physics. A major of twenty-four semester hours in one subject and eighteen hours in each of two others was recommended. Half of the four-year college program, or sixty semester hours, was considered to be a desirable undergraduate preparation in science which would permit the student to do graduate study in the major science area.21

The AAAS Cooperative Committee has continued to function and publish reports of its recommendations.22,23,24 The most recent report is a re-examination of previous recommendations in the light of events in the interim periods.25 The report made additional recommendations


25 Ibid.
resulting from such changing circumstances as rapid new developments in the sciences, students entering college with advanced standing, a trend of colleges requiring entrance examinations, and the increased complexity of scientific fields. Detailed recommendations were made for the preparation of teachers of biology, chemistry, physics, physical science, mathematics, and general science. Four types of recommendations were made: (1) a description of the science courses to be taken in the major science field; (2) courses to be taken in a fifth year; (3) a description of supporting courses that should be taken; and (4) the inclusion of a science methods course. The total number of credits recommended for the science teaching fields varied from 59 to 66 semester hours in a four-year program. Of these, however, the following 31 hours were considered as common background for all science teachers: biology - 6 hours, chemistry - 8 hours, physics - 8 hours, related science - 3 hours, and mathematics - 6 hours.\textsuperscript{26} The additional course work would be taken in the major and closely supporting fields as would the 26 to 30 semester hours in science courses recommended for the fifth year of study.

The Cooperative Committee recognized that, in addition to science courses, teacher preparation programs should include a science methods course for each of the proposed curriculums. Training in the preparation and planning of materials for use in the laboratory and in demonstrations was also recommended.

\textsuperscript{26}\textit{Ibid.}, p. 1028.
A major change in the 1960 Cooperative Committee report involved an increase in the number of hours in earth-science courses for prospective teachers. Earth science included geology, astronomy, and meteorology, either as separate courses or as a combined course. No recommendations were made concerning the preparation of teachers of earth science as a separate teaching field; it was recommended that all science teachers have courses in the earth-science area.27

Another group that has been interested in science teachers in the secondary schools has made general recommendations for preparation for science teaching. The Joint Commission on the Education of Teachers of Science and Mathematics has suggested:

1. The curriculum in the sciences for prospective teachers needs to be directly designed to prepare science teachers. This means that "...all science courses offered to prospective science teachers should be scrutinized closely to ensure that, both from the standpoint of subject content and of effectiveness in teaching, they are relative to the purposes of teacher education."28

2. The optimum program in the sciences is most likely to result from cooperative analysis by experienced and competent science teachers, scientists, and professional educators. The program should be based on careful job analyses of the work of science teachers and the problems they encounter.

27 Ibid., p. 1025.

3. Credit hours are admittedly an inadequate index of mastery of a subject. Science teachers should have approximately sixty semester hours in science and mathematics as a general rule.\(^{29}\)

The sixty semester hours of science and mathematics courses suggested would consist of an area of concentration of 20 to 24 semester hours in either physics or chemistry for a major, or 36 to 40 hours in the biological sciences for a major. The balance of the 60 hours would be the beginning courses in other science areas and mathematics.

A third cooperative endeavor of the American Association for the Advancement of Science resulted in the publication of guidelines for use in developing programs for the preparation of science teachers. Since the guidelines are almost identical for majors in any science field, but specifically interpreted for each, discussion of them has been included in the part of this review dealing expressly with the preparation of earth-science teachers.\(^{30}\) These guidelines encompass the kinds of recommendations made by the Cooperative Committee and the Joint Commission reports.

General agreement with the recommendations of these cooperative efforts was the position taken by Watson. He pointed out, however, several problems that are not adequately resolved in the proposed

\(^{29}\)Ibid., pp. 24-25.

\(^{30}\)Infra, pp. 49-51.
programs. The potential physics teacher would not be prepared to teach anything else. The concern has been in preparing teachers for a particular field of science rather than preparing science teachers. Little is being done in college science courses to improve the image that science teachers have of scientists and scientific work. The prospective science teacher needs laboratory experience that requires designing the needed apparatus, selecting lines of inquiry, interpreting data, and criticizing himself.31

The National Society for the Study of Education has continued to show a concern for the preparation of science teachers through its yearbooks. In addition to the two previously cited, the Fifty-ninth Yearbook is a comprehensive report on science education. The curriculum for the education of science teachers presented in this volume supported the need for both breadth and depth of preparation in science.32 Breadth of preparation is needed for two major reasons: (1) Because of the interdisciplinary nature of present-day science, the teacher must have a command of the major areas of science; and (2) many teachers can expect their teaching assignments to include two or more science courses. The need for depth of preparation was also supported by two major reasons: (1) Growth in understanding science


is most likely to result from depth of study; and (2) if the teacher is to stimulate his students he needs sufficient depth of study to deal with recent advances in science.

Programs designed to provide for breadth and depth in the preparation of the science teacher have been conceived in empirical patterns. Recognizing the need for breadth and depth and the empirical nature of providing for them, Richardson pointed out the need for research in the field of the academic preparation of science teachers.33

The National Science Teachers Association has suggested the kinds of preparation needed by science teachers through a consideration of the characteristics of an effective science teacher.34 This association indicated that the science teacher needs a knowledge of subject matter encompassing a broad background in science and mathematics with depth of preparation in one or two fields. The teacher must develop an understanding of how ideas and scientific explanations have evolved by studying the history and philosophy of science. The pre-service and in-service teacher needs to work with science in action in order to keep abreast of recent developments in science and continue to develop his own manipulative skills. Teachers need to be continually developing skills and techniques in the teaching process, their

33Ibid., p. 269.

knowledge of psychology, and the learning process. The science teacher should have contact with outstanding teachers, their work with education in action, and the results of their educational research.

Recognition of such needs of science teachers as those suggested by the National Science Teachers Association and in the Fifty-ninth Yearbook have affected proposed and experimental programs for science teacher preparation. Mayor reported on nine studies carried out under the Science Teaching Improvement Program of the American Association for the Advancement of Science. These studies were limited to experimental approaches to the professional education of science and mathematics teachers such as the use of seminars, college teaching experience by college seniors, teaching laboratories, and development of a science teaching center.

A proposed program for science-teacher education was presented by Marshall after considering recent problems and needs of science teachers. The proposed program included 132 to 147 semester hours of course work requiring approximately four and one-half years of study. A basic program of 36 semester hours in science courses would be required of all prospective science teachers. These courses would include 8 semester hours each in biology, chemistry, physics, and mathematics.

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and four semester hours in an integrated physical-biological science course. An additional 26 to 36 semester hours in science would be taken to prepare to teach in such combinations as physics-mathematics, physics-chemistry, and biology-chemistry. Teachers preparing to teach all science subjects would take the basic program of 36 semester hours plus the following additional semester hours of course work: astronomy - 4, geology - 6, meteorology - 4, mathematics - 6, and physics or chemistry or biology - 14. All students would take 30 semester hours in professional education courses and 40 to 45 hours in general education courses.

The limitations of the traditional four-year period for preparing science teachers, recognized in Marshall's proposed program, have also been a major consideration in an experimental curriculum at New Mexico State University. A cooperative program for preparing teachers has been developed which involved personnel from Arts and Sciences and Teacher Education. Roush reported the program for teacher preparation in a science teaching field was built upon a rigorous general education program which included courses in biology, chemistry, physics, and mathematics. The prospective science teacher takes twenty-nine semester hours of course work in a first teaching field and eighteen hours in a second teaching field during the undergraduate preparation which leads to a bachelor's degree. In the fifth year, the teacher qualifies for a master's degree by taking at least eighteen semester hours.

hours of advanced courses in his first teaching field and a minimum of
twelve semester hours in graduate professional education courses.

The desirability of increasing the amount of time available for
the preparation of science teachers has been recognized in these pro-
posed and experimental programs. Coupled with dual-degrees either at
the bachelor's level or a bachelor's degree followed by a master's
degree, programs such as these offer possibilities for improving the
preparation of science teachers. Richardson, Williamson, and Stotler
noted that five years of preparation are now required for permanent
certification in a few states. "With the increasing level of competence
set for the science teacher, it is reasonable to assume that a longer
period of time will be required for his preparation."38

Preparation of Teachers
of Earth Science

The literature pertaining directly to the preparation of earth-
science teachers is found in only a few articles published within the
past four years. The paucity of information, and the recency of that
which does occur, provides evidence for the need of additional research
on preparing teachers for the rapidly developing earth-science course.

An editorial in GeoTimes noted that "the big problem in the trend
toward earth-science courses is the dearth of science teachers with
adequate background in the subject matter."39 Seeking participation

38John S. Richardson, Stanley E. Williamson and Donald W.
Stotler, The Education of Science Teachers, unpublished manuscript,

39"Educators to the Front," GeoTimes, VI (July-August, 1961,
p. 7.
of the geological profession, the editorial continued: "Geologist-educators have been reluctant to recognize this teacher training problem and even more reluctant to do something positive about it. Is the training of school science teachers beneath their station?"\(^{40}\) Indications are found in the literature, however, that some professional scientists and educators have concerned themselves with the problems of preparing teachers of earth science and improving the background of in-service teachers. Studies have been made of the background of in-service teachers who applied for earth-science summer institutes. Other studies have reported the success of institutes in providing for the needs of participants. The results of these studies are considered to have implications and suggestions for the preparation of pre-service teachers as well. Incorporating the needed academic preparation in the undergraduate program is viewed as the logical solution to the long-range goal of adequately prepared teachers of earth science.

The background of 203 teachers of general science who had responsibility for teaching earth science as a part of their work was investigated by Brown. He attributed a lack of student interest in earth science to the inadequate preparation of teachers in this science. Of the 203 teachers applying for a General Science Seminar at Colorado College, 46.2 per cent had no college credit in the earth sciences. A total of 86.1 per cent had fewer than 8 semester hours of credit in

\(^{40}\)Ibid.
earth science. Based on these findings, Brown proposed three courses of action: (1) see to it that institutions preparing teachers recognize the need for including earth science in the curriculum of all teachers; (2) encourage in-service teachers to increase their knowledge of earth science; and (3) encourage institutions to offer special earth-science seminars suitable for teachers.  

Other institutions have been offering special programs of study in earth science through the National Science Foundation Summer Institute Program. An evaluation of such an institute at Temple University was reported by Sarner and Edmund. A random sample of 114 applicants was studied to determine the reasons given for seeking admission to the institute and to what extent the participants' objectives were satisfied. The acquisition of more knowledge of science was the reason for seeking admission stated by 80 per cent of the applicants. The validity of this reason seemed to be established when the science background of these teachers was considered. The mean number of semester hours in earth science was 3.21. Half of the applicants had no earth-science credit.  

The objective of acquiring more knowledge of science was reported as being satisfied by 91 per cent of the 35 participants who

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attended the Institute. Additional objectives satisfied were the learning of many new teaching methods, developing a feeling of confidence in teaching science and a knowledge of how to conduct field trips. Sarner and Edmund concluded that -

1. The applicants to earth science institutes are in need of further academic preparation in subject matter for doing an adequate job of teaching science. They need more content knowledge and they need to know more about methods appropriate for teaching science,

2. The reasons given for seeking assistance appear to be reasonable and commendable, and finally

3. Teachers who have participated in institutes have been satisfied with the instruction received. That is to say, valid objectives held by these teachers have been satisfied in such a way that the teachers will return to their positions with greater enthusiasm and greater competence for teaching earth science.\(^\text{43}\)

A study of 279 applicants to the Earth Sciences Teachers Institute at Franklin and Marshall College also revealed inadequate preparation of teachers of earth science courses. "Although the group averaged a total of 13.4 courses in the areas of math, biology, chemistry and physics, their average in the geology, meteorology and astronomy group was only 1.4 courses."\(^\text{44}\)

A study of the status of earth science in New Jersey revealed inadequate preparation of a high percentage of the teachers. Laux

\(^\text{43}\)Ibid., p. 33.

found that the over-all science preparation of 99 earth-science teachers was adequate, but that 69 per cent had less than nine credit hours in earth science. Pointing out that the effectiveness of an earth-science course is dependent upon the subject matter competence of the teacher, Laux called for additional pre-service education of science teachers in the disciplines of astronomy, geology, meteorology, and oceanography. In addition, the need was apparent for improving the subject-matter background of in-service teachers.45

The preparation of earth-science teachers in Ohio was included in an investigation conducted by Arnold. His study revealed a situation similar to that found in New Jersey and in the various institute studies. Ohio earth-science teachers lacked preparation in the field they were teaching. Of the 34 teachers teaching earth science in 1961-1962, 82.3 per cent had no college training in earth science.46 The minimum requirements for certification as teachers of earth science were not met by 90.9 per cent of these teachers in Ohio.47


47Ibid., p. 73.
Proposed programs for earth-science teachers. The need for better preparation of earth-science teachers in their subject matter field has been clearly established in each of the reported research studies. In conjunction with these studies both specific and general recommendations have been made for the solution to the problem of preparing earth-science teachers. Suggested solutions have also come from other persons who, by virtue of their teaching experience, concern for teacher preparation, or association with committees and projects in earth science, have presented their ideas for consideration.

The value of earth-science institutes in the improvement of the in-service teacher's background was recognized by Moss. But institutes are commonly available only to experienced teachers and cannot be thought of as the answer to the problem of preparing new teachers for teaching earth science. Moss noted that the long-term solution to the problem was in developing curriculums for undergraduate preparation of teachers who would be competent to teach earth science. Franklin and Marshall College reported a tentative program in which a geology student may prepare to teach earth science. The program included nine courses in the earth sciences, astronomy, meteorology, physical geology, historical geology, mineralogy, petrology, paleontology, stratigraphy, and geomorphology. Eight courses were required in the allied sciences, two courses each in mathematics, biology, chemistry, and physics. Five courses were required in education and all students completed thirteen courses in Liberal Arts. Each of these courses was worth four semester hours of credit.48

48Summarized from Moss, op. cit., pp. 43-44.
An entirely different solution to the teacher-preparation problem was seen in the use of geologists to teach ninth grade science. Hill pointed out that "geologists are preeminently qualified to teach general science because their training involves some study of many sciences...." Many geologists could be recruited to teach in the secondary school thereby helping with the scientific education of our society while incidentally reducing unemployment and advancing our profession." While there may be merit in Hill's proposal, a number of concomitant problems were not considered. Would geologists be interested in teaching in the secondary school? Would they understand and be able to work effectively with youngsters of junior high school age? Would they be willing to meet certification requirements by taking additional college courses in education? Would they consider teaching in the secondary school as a temporary and expedient livelihood between positions in the geological profession?

These and similar questions were considered in another proposal that students majoring in geology consider a teaching career in the public schools. Willard considered the desirability of teaching science through direct experience and problem solving methods and concluded that geology majors could become successful science teachers. His proposal differed from Hill's in that the emphasis was on the need


50 Ibid.

for excellent teaching in the secondary school and the ways in which geology majors could qualify for teaching positions during their undergraduate study. The science background of a geology major was considered sufficient for certification in most states; education course requirements would have to be included in their undergraduate study.

Willard called the attention of geology majors interested in teaching in the secondary school to the following points:

1. Forget the idea that schools are desperate to get scientist. They want science teachers who know how to teach. There is a shortage of competent people. There is no shortage of incompetents who do not know how to handle youngsters.

2. The schools do not need surplus C and D college students who couldn't get jobs in industry. As long as there are mediocre teachers with an unsatisfactory background in the subject fields, there will be mediocre salaries for all teachers and the public will be dissatisfied with the schools.

3. Take the required education courses. The number of credit hours required for a temporary certificate in most states is negligible and this will help considerably in obtaining a job....

4. Have a sincere interest in young people and their problems. Recognize that they learn most readily through first-hand experience.

5. In spite of the recent criticism of school curricula, remember that it is generally over-crowded with subjects and administrators are usually reluctant to make changes. If geology is put in, something must go. We must be ready to prove that earth science is better than what is presently being offered.52

52 Ibid., pp. 15, 34.
Having presented these points for consideration by interested geology majors, Willard suggested a five-year program to prepare for teaching earth science. This program would include the required courses for a geology major, a minimum of one year each of biology, chemistry, physics, and mathematics, introductory courses in astronomy and meteorology, the education courses required for certification, and some original scientific research. The research was considered especially important in developing a thorough knowledge of science.53

The problem of preparing earth-science teachers has been of concern to professional organizations as well as to individuals. One such organization, the National Association of Geology Teachers, has recently completed a survey that revealed the viewpoints of educators and earth scientists concerning the manner in which earth-science teachers should be prepared. Matthews reported the results of approximately 200 responses to the survey from departments of astronomy, geology, meteorology, oceanography, and geography in the United States and Canada. These earth-science educators were about equally divided on two means of preparing earth-science teachers. One group favored concentrated training in one of the earth-science disciplines. The other group preferred integrated curriculums involving study in each of the earth sciences.54

53Ibid., pp. 34-35.
NASDTEC - AAAS Guidelines. The subject-matter preparation of science and mathematics teachers for the secondary school has been studied by the National Association of State Directors of Teacher Education and Certification (NASDTEC) in cooperation with the American Association for the Advancement of Science (AAAS). The study originated in December, 1959, and culminated in June, 1961. The results of the study have been published in the form of Guidelines for use in developing teacher-preparation programs.55 Problems of preparing earth-science teachers were not considered until the end of the study. Guidelines for preparing earth and space science teachers were developed, however, and included as an appendix in the published recommendations.

These Guidelines are likely to influence the development of programs to prepare earth-science teachers. On the basis of their potential acceptance and use, the Earth and Space Science Guidelines are included here in their entirety.

Earth and Space Science

GUIDELINE I: The program should include a thorough college-level study of the aspects of the subject that are included in the high school curriculum.

Earth and space science as taught in most schools includes the study of the solid earth, the atmosphere, the hydrosphere, and their relationship to the universe. An earth and space science teacher should, therefore, be well prepared in mathematics and basic sciences (biology, chemistry, and physics) and should have a major or minor in one of the earth sciences (astronomy, geology, meteorology, and/or oceanography) with supporting work in the other three.

GUIDELINE II: The program should take into account the sequential nature of the subject to be taught, and in particular, should provide the prospective teacher with an understanding of the aspects of the subject that his students will meet in subsequent courses.

Emphasis should be placed on the physical and biological aspects of the atmosphere, lithosphere, and their interrelationship early in the preparation of an earth-science teacher. In subsequent years, as his studies become somewhat more restricted to one of these areas, he will then continue to think within the framework of this interrelationship. Regardless of the grade level at which earth and space science is taught, the content affords excellent opportunities to discuss basic concepts of biology, chemistry, and physics that the student may have encountered earlier at a more general level or which he may encounter later at a more sophisticated level.

GUIDELINE III: The program should include a major in the subject to be taught, with courses chosen for their relevance to the high school curriculum.

It is recommended where possible that a major in the broad field of the earth sciences be taken. Where such programs are not available, a major in one of the included sciences (astronomy, geology, meteorology, and oceanography) should be taken with supporting work in each of the other three. The major in earth science should be supported by a minor in either mathematics, biology, chemistry, or physics and should include as a supplementary requirement: mathematics through calculus, at least one year of chemistry, at least one year of physics, and one year of biology.

GUIDELINE IV: The major should include sufficient preparation for the later pursuit of graduate work in one of the earth sciences.

An undergraduate degree in earth science, astronomy, geology, meteorology, or oceanography, should be supported by thorough preparation in the basic sciences to prepare prospective teachers to do graduate work in an earth science other than that in which they have taken their major at the undergraduate level. Broad undergraduate preparation in mathematics, biology, chemistry, or physics, supplemented with some work in earth science, would permit graduate work in any of the earth sciences.

GUIDELINE V: A fifth-year program should emphasize courses in the subject to be taught.

It is recognized that in the preparation of earth-science teachers a substantial amount of the undergraduate program will be taken up by foundation courses in the basic sciences and that only
introductory courses in astronomy, geology, meteorology, and oceanography may be offered in most teacher education institutions. It is, therefore, essential that the prospective earth-science teacher devote most of the fifth year to rounding out his background in the earth sciences. Additional supporting courses in the other sciences are also recommended for the fifth-year program.

GUIDELINE VI: The program should include work in areas relating to the subject to be taught.

In addition to the essential science foundation courses, programs at the fourth- and fifth-year levels should provide an opportunity to develop in some depth the basic science that supports the teacher's major area of interest - physics, for example, if he is primarily interested in meteorology courses. The history and philosophy of science should also be included to round out the preparation of the earth-science teacher.

GUIDELINE VII: The program should include preparation in the methods especially appropriate to the subject to be taught.

Since many earth-science courses are taught at the eighth- and ninth-grade level, it is important that teachers of these courses be familiar with the special problems of junior high school pupils and with methods used in junior high school instruction. The teacher should be acquainted with teaching aids and laboratory equipment appropriate to this level and should be prepared to guide learning by means of demonstration, laboratory experimentation, research, and field studies. High school earth-science teachers should receive preparation in essentially the same areas but for the appropriate grade level. Preparation in these areas is the responsibility of subject-matter specialists as well as education specialists.

GUIDELINE VIII: The program should take into account the recommendations for curriculum improvement currently being made by various national groups.

As is the case in the other sciences, emphasis and interpretation of phenomena studies in the earth sciences are constantly changing. For these reasons and also because earth science is an interdisciplinary science it is important that prospective earth-science teachers be informed of new developments in all of the sciences. Curriculum materials developed by a study group in physics or biology might be as useful and important to an earth-science teacher as it would be to a physics or biology teacher.55

55Ibid.
The seven guidelines for teacher preparation "are held to be common to all the subject fields in science and mathematics." The interpretive paragraphs following each guideline were given as examples of ways in which the guidelines may be implemented in teacher preparation programs.

**History of Earth Science in American Schools, 1751 to 1957**

The teaching of earth science had its beginnings in the science offerings of the forerunner of the American high school, the academy. The Philadelphia Academy for the Education of Youth, founded in 1751 by Benjamin Franklin and considered to be one of the first academies, included a course in natural philosophy in its curriculum. Although this academy soon reverted to the college preparation orientation of the Latin Grammar Schools, the academy movement spread with an emphasis on practical and usable subjects. The language arts, mathematics, and the natural sciences formed the backbone of the academy curriculum.

Within the program of science offerings in the academies there was a wide variation in the particular courses taught. Natural philosophy evolved into physics courses and separate courses in chemistry, astronomy, geography, geology, meteorology, and mineralogy. Natural history gradually changed into separate courses in botany, zoology, anatomy, and hygiene as the academy movement grew. These were not comparable with courses that are currently offered in the secondary school, even those that may have the same or similar course titles. Few textbooks in science existed; the system of giving credits and

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studying each course for a set time period per day, per week or per year was not yet in existence.

The growth of the academy was indicated by Burnett as having increased to over four hundred academies in Massachusetts and over one hundred fifty in both Pennsylvania and New York in 1850. The inclusion of courses in the earth sciences was common in these academies as shown by a summary of the science offerings in 167 academies in New York State in 1853. The following are courses in the earth sciences offered by these 167 academies as selected from a study made by Gifford and cited by Burnett. Both geography and astronomy were offered in most of these academies, thus setting a precedent for including similar courses in the public high schools.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number of Academies Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geography</td>
<td>162</td>
</tr>
<tr>
<td>Astronomy</td>
<td>152</td>
</tr>
<tr>
<td>Geology</td>
<td>56</td>
</tr>
<tr>
<td>Meteorology</td>
<td>17</td>
</tr>
<tr>
<td>Mineralogy</td>
<td>17</td>
</tr>
</tbody>
</table>

The high schools developed in the early nineteenth century during the period in which the academies dominated secondary education. The high school movement originated with the establishment of the


English High School in Boston in 1822 and grew to the point of absorbing most of the academies by the end of the Civil War. As the high school movement spread, the science offerings were strongly influenced by the sciences taught in the academies. Thus, the earth sciences continued to be offered as separate courses in astronomy, geography, geology, meteorology, and mineralogy. These courses were usually taught in a descriptive manner with little or no laboratory work. 59

The variety of courses offered and the variations in quality of teaching in the secondary schools of the late nineteenth century resulted in the establishment of agencies and committees to bring about standardization and uniformity in the high school curriculum. The Committee of Ten, appointed by the National Education Association in 1892, was influential in bringing about more uniform offerings in the earth sciences. Conference Group Nine of the Committee was concerned with the area of geography which was to include physical geography, geology, and meteorology. This Conference Group defined geography even more broadly as embracing:

...not only a description of the surface of the earth, but also the elements of botany, zoology, astronomy and meteorology, as well as many considerations pertaining to commerce, government, and ethnology. "The physical environment of man" expresses as well as any single phrase can the Conference's conception of the principal subject which they wish to have taught. 60


The recommendations of the Committee of Ten included a course in physical geography at the ninth grade level, elective courses of astronomy and meteorology in eleventh grade, and geology or physiography electives in the twelfth grade. The recommendation with respect to the physical geography course was widely accepted, in the form of a common science course offered in the schools at the turn of the century. A summary of enrollments in the various physical science courses, as included in Table 1, showed that physical geography was studied by 121,335 students in the year 1900. This was 23.37 per cent of the high school population at that time.

In the twenty-two year period represented in Table 1, the earth sciences - astronomy, geology, and physical geography - declined significantly in percentage enrollment. These courses were not taught in such a way as to provide adequately for the needs of the increasing number of high school students who were not planning to attend college. The large decrease in numbers of students taking physical geography in the period 1900-1922 reflected dissatisfaction with the value of the course at that time.

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61 Ibid.


63 Ibid., p. 128.
Table 1

Comparison of Enrollments in Physical Science Courses in 1900 and 1922*

<table>
<thead>
<tr>
<th>No. of students in:</th>
<th>1900</th>
<th>1922</th>
<th>% enrollment 1900 to 1922</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School Population</td>
<td>519,296</td>
<td>2,155,460</td>
<td></td>
</tr>
<tr>
<td>Astronomy</td>
<td>14,435</td>
<td>1,474</td>
<td>2.78 to 0.07</td>
</tr>
<tr>
<td>Geology</td>
<td>18,743</td>
<td>3,520</td>
<td>3.67 to 0.16</td>
</tr>
<tr>
<td>Physical Geography</td>
<td>121,335</td>
<td>92,146</td>
<td>23.37 to 4.28</td>
</tr>
<tr>
<td>Physics</td>
<td>98,896</td>
<td>192,380</td>
<td>19.04 to 8.93</td>
</tr>
<tr>
<td>Chemistry</td>
<td>40,084</td>
<td>159,413</td>
<td>7.22 to 7.40</td>
</tr>
<tr>
<td>General Science</td>
<td>not given</td>
<td>130,728</td>
<td>--- 6.06</td>
</tr>
</tbody>
</table>


A criticism is cited here:

Physical geography, offered in the ninth grade, was diluted college geology. Landforms, their genesis and evolution were studied in great detail. Profiles of far away places the pupil could not visualize were made from topographic maps. Detailed but impractical studies of maps were often made. The home landscape, crying for recognition, went largely unnoticed. In the textbooks there was almost no reference to man's relation to his environment and little about its effects on him, and when such material was included in the text, it was ignored by most teachers.64

In addition to the dissatisfaction, or possibly as a result of it, courses in general science were being tried in an increasing number

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64 Ibid., p. 163.
of schools in the middle of the 1900-1922 period. Fairbanks supported physical geography as the only science adapted for teaching in the ninth grade. He maintained that "the only criticism which can have any strength against physical geography as a first year subject comes partly from the results of poorly prepared teachers, and partly from a wrong conception current as to the fundamental basis of the subject."65

The enthusiastic proponents of the "new" general science rallied in defense. Mann refuted Fairbanks' paper and noted:

The battle is not the sham battle between physical geography and general science, as Mr. Fairbanks would have us believe; but a real battle between a vital concrete, significant, worthwhile study of science—not only in the first year, but all through the course—and the formal, abstract, logical, coldly intellectual system of science whose teaching is now attempted in most schools.66

In another refutation of Fairbanks' paper, Rowell pointed out that the purpose of general science was to give students a little scientific knowledge in the limited time available. General science was the only solution, no one science such as physical geography could meet the requirements.67

The advocates of general science were successful in replacing physical geography with general science. During the period 1922-1950,

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physical geography gradually went out of existence in most states. The major exception was in New York State where, in 1939, the name of the physical geography course was changed to "earth science" and, as such, remained in the curriculum as an elective having equal status with biology, chemistry, and physics. 68

The status of earth science in 1948-1949 was indicated by Thurber and Collette in a tabulation showing the secondary school enrollment in science courses for that school year. One semester courses in earth science had an enrollment of 4,828 students and full year courses in it were taken by 15,747 students. Pointing out that earth science was not a popular science offering in 1948-1949, Thurber and Collette noted that the course did have interesting possibilities.

It deals with things which pupils see all about them. It is well adapted for firsthand experience learning. It can be taught entirely on the problem solving basis. It is challenging to all types of pupils. Many schools use it as an alternate elective for physics or chemistry and recommend it to pupils who are interested in science but who would not do well in physics or chemistry. Other schools use it to replace ninth-grade general science for pupils of superior ability. New York State is recommending it for this last purpose.

The greatest handicap to earth science as a popular elective is the domination of the college sciences. Language tends to be unnecessarily difficult. Laboratory exercises are patterned on the college geology courses with hours spent on the identification of purchased specimens, on the reading of topographic maps, and the coloring of geologic maps.

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It can, however, be organized to utilize simple language and to deal with familiar problems. It can answer the need of many schools for an additional science elective. 69

Interest and recognition of earth science was shown by the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science in 1949. The request for representation on this Committee by the American Nature Study Society was approved. "The approval was based on the Committee's need for someone working in the areas of mineralogy, the earth sciences and conservation." 70

Interest in earth science in an individual school was indicated by an experiment in Brooks School, North Andover, Massachusetts, in 1950. Holcombe reported the experimental course in earth science was offered as an elective to tenth grade students. The course emphasized personal observation, laboratory exercises, and field work. Many of the "topics studied in detail are determined largely by what the students can actually see in the field." 71


In suggesting sources of earth-science materials for teachers, the National Science Teachers Association showed both an interest in earth science and that an uncertainty of its future existed in 1951. The disappearance of earth science from the secondary school was decried by some scientists and some science teachers. However, Most science teachers doubt that it will ever return to the high school as a separate course, except possibly in scattered instances or certain special situations. On the other hand, these same educators see the need and the opportunity for incorporating earth science into the program of science for general education all along the line.72

The contribution of earth science to the student's general education was one of the aspects of the course perceived by Richardson. In 1957, he noted that the earth-science course, or units in earth science in other courses, could provide for understandings of basic physical resources, motivation to study underlying science, and appreciation of some aspects of the environment.73 These values, plus the opportunities for laboratory and field studies to provide direct experiences, supported Richardson's statement that earth science "... is apparently increasing in its usefulness to the curriculum."74


74Ibid., p. 46.
Developments in Earth Science in the Secondary Schools Since 1957

Since 1957 there has been increased interest in the teaching of earth science in the secondary schools. Various state and local school systems, scientific societies, government agencies, and individuals have been concerned with problems related to earth-science courses. Such interest and concern have resulted in the publication of viewpoints, reports of actual and proposed courses, efforts of scientific societies, and research studies involving various facets of earth science in the secondary school. This literature has been reviewed as part of an attempt to determine the nature of the developing earth-science course and the extent of its implementation into the science curriculum of the secondary school.

Developments in State School Systems

Earth science was practically non-existent in the secondary schools during the late 1940's and early 1950's except as units in general science courses in the junior high school. Stone reported a notable exception in that the earth-science course remained in the curriculum in New York State even though enrollments declined to an all-time low. In 1948, the introduction of an experimental program offering earth science to selected ninth grade pupils resulted in a gradual increase in enrollments in earth-science courses. The success of the experiment is indicated by Stone:

Since that first year in 1948-49, 420 schools have joined the original pilot school in offering earth

science to selected ninth grade pupils, and still more schools will undoubtedly continue to be added each year for some time to come. In addition to the above there are 159 other schools which offer earth science to pupils in grades ten through twelve, thus making a total of 579 schools in the year 1961-62 which teach earth science to more than 33,000 pupils in grades nine through twelve.76

The revival of interest in earth science in the New York schools has been accompanied by increased interest and similar course offerings in other states. Pennsylvania began developing an Earth and Science course in 1958 through the efforts of an advisory committee appointed by Charles H. Boehm, Superintendent of the Pennsylvania Department of Public Instruction. Moss reported five major ideas considered by the sub-committee charged with developing the course philosophy and preparing the syllabus:

First, the original syllabus should be pitched for gifted college-bound students and later adapted to less talented classes (not the reverse as is too often the case). Secondly, the identity of the disciplines of geology, meteorology, and astronomy should be maintained (not an integrated course), although the relationship between the three disciplines should be clearly spelled out. Thirdly, the teaching order: geology-meteorology-astronomy is probably the most logical because the student is taken from his known surroundings outward into space, and the sugar candy of space travel is saved until last. Fourthly, the student should be well exposed to uncertainties and unsolved problems in these sciences and be dissuaded from the idea that science already has solved most of the problems in these fields. Lastly, the students' curiosity should be stimulated by concentrating on explanations of natural phenomena not merely descriptions to be memorized.77

76 Ibid., pp. 13-14.

A composite teaching guide, The Pennsylvania Guide for Teaching Earth and Space Science, was produced. Selecting content from geology, astronomy, meteorology, and oceanography, the guide suggests subject matter organization, teaching techniques, and laboratory procedures. The teaching guide was revised in 1962 "to serve as a vehicle for demonstrating basic concepts in the fundamental sciences." The revised guide also incorporated recent information from the fields of astrophysics, geophysics, astronautics, and space biology.

The growth of the Pennsylvania Earth and Space Science Program was reported in summary by Kosoloski. In 1957-58, nine schools in Pennsylvania taught the course to approximately eight hundred students. By 1961-62, the number of schools offering Earth and Space Science had increased to more than four hundred with thirty-eight thousand students enrolled.

A growth pattern similar to that in Pennsylvania was reported by Laux for earth-science courses in New Jersey. In this state, earth science was offered in twelve schools in 1956-57. In the 1961-62 school year, seventy-two, or one out of every seven secondary schools in the state, were offering earth science. Laux attributed this

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[79] Ibid.

growth to an examination and revision of the secondary school science curriculum since 1958. At that time, changes in the courses of chemistry, physics, and biology and improved science offerings in the sixth, seventh, and eighth grades caused the value of the traditional ninth grade general science course to be questioned. The increased offering of earth-science courses was the result.

**Status of Earth Science in the School Year 1961-62**

A confirmation of the heretofore suspected trend towards increasing popularity of earth-science courses was obtained by Coash in a nationwide status study in 1962. His study revealed the following information for the academic year 1961-62.

1. Earth-science courses were offered in thirty-nine states.

2. Earth science was a part of a well-established program in the majority of schools in New Jersey, New York, and Pennsylvania.

3. Earth science was offered in a significant number of schools and there were plans to increase or improve the course offerings in Colorado, Connecticut, Florida, Idaho, Kansas, Maine, Massachusetts, Montana, New Hampshire, Texas, and Virginia.

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4. Earth science was offered in a few schools in Alaska, Arizona, California, Delaware, Hawaii, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, Missouri, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oregon, Rhode Island, South Carolina, Utah, Washington, and Wisconsin. There was, however, interest in this course in these states for increased offerings in the future.

5. The future of earth science was uncertain and it was offered little or not at all in Alabama, Arkansas, Iowa, Louisiana, Mississippi, Oklahoma, and Tennessee.

6. There was no response to the survey from Georgia, South Dakota, Vermont, West Virginia, and Wyoming.

7. The following states indicated that earth science constituted a major portion of general science courses: Arkansas, California, Florida, Louisiana, Michigan, Mississippi, Nevada, North Dakota, Ohio, and Oregon. [The term "major portion" is used in Coash's report of the survey. If this term implies more than one-half of the course is devoted to earth science, there may be a question of the accuracy of the statement. A "significant portion" would be a more acceptable term to the writer.]
Several efforts to initiate or improve offerings in earth science in local school systems have been reported in the literature of the past seven years. In Norman, Oklahoma, a voluntary summer program in geology was offered to a group of students selected on the basis of achievement test scores. The six-week course was taught to seventh and eight grade students, through lectures and demonstrations utilizing the same materials as the beginning college course in physical and historical geology. The success of the course is reported by Pollack:

I have come away from teaching this course with the feeling that geology can and should be taught at the intermediate school level, if not as a separate subject, then at least as a complementary part of the sciences that are commonly given. Those students who will do well and are interested in the other sciences will probably do well and be interested in geology as well. Geology, with its inherent observational approach, seems particularly well suited for an age group which is naturally curious about its surroundings. I feel that we have tended to underestimate the wide interests of younger students as well as the drawing power of our science.82

Teachers at Amity Regional Junior High School in Orange, Connecticut, reorganized their science curriculum in 1961 after two years of study. They found that traditional general science "failed to provide adequate motivation and challenge, and discouraged too

many students from continuing into the high school science courses." The reorganized curriculum provides earth science in the seventh grade, physical science in the eighth grade, and biology in the ninth grade. Earth science was placed as the first science course in the junior high school because the teachers considered the geological sciences as offering the best structure for synthesizing the different levels of experience of students coming from seven elementary schools. The teachers were also convinced that "Since our primary objective is not to prepare specialists but to provide an opportunity for our students to experience science without the artificial boundaries imposed by the specialized sciences, we feel that the broad field offered by the earth sciences is the most logical foundation on which to build." 

The problems of introducing earth science in the junior high school were studied by Fox and Roberts in their local community. Generalizing on their successful solution to the problem of: (1) obtaining mineral, rock, and fossil specimens; (2) locating suitable materials to show local and world geology; and (3) overcoming the lack of teacher preparation in earth science, they suggested a means of implementation for earth-science courses in suburban schools. The

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84 Ibid., p. 46.

85 Ibid.

basic plan was a cooperative endeavor among interested persons in the community, staff members of a nearby natural history museum, and educators receptive to experimenting with their science curriculum. The teacher and museum geologist developed a program of classroom and laboratory experiences for the study of minerals, fossils, and local geology involving assigned readings, guest lecturers, discussions, library research, demonstrations, classification of minerals and fossils, projects, and field trips. The laboratory sessions were held at the museum.  

Fox and Roberts found that their eighth grade class did slightly better than a college freshman control group on mineral identification tests. The museum geologist held the opinion that many of the eighth grade students did better than some college students in the laboratory study of fossils. The general conclusion was "for little time and money Suburbia Junior High can bring to its new earth-science course meaningful laboratory and field experiences that develop a down-to-earth science."  

Efforts of Scientific Societies, Foundations and Educational Institutions

Various groups of scientists and educators have recently become involved with attempts to improve the availability of information and quality of instruction in earth science. These groups have included

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87 Ibid., pp. 183-187.
88 Ibid., p. 187.
scientific societies, foundations, and educational institutions, often working in cooperation with one another.

Science teachers in the Denver area had an opportunity in 1957 to obtain basic background in geology through cooperative efforts of the Denver Public Schools and the Rocky Mountain Association of Geologists. A seven-week course was offered which included lectures in mineralogy, petrology, structural geology, geomorphology, economic geology, historical geology, and geology of the Denver area. Two field trips were held. The interest in the course was attested by the enrollment. Expectations were that forty teachers would enroll. Actual enrollment was two hundred-sixty students, approximately half of whom were science teachers and the other half were interested laymen. 89

A state-wide program of aid to the schools and of making information available to the general public has been an active and continuing endeavor of the Illinois Geological Survey. Although most of the state geological surveys provide free and inexpensive educational materials such as pamphlets, bulletins, collection sets of rocks, minerals, and fossils, Illinois appeared to have one of the most comprehensive programs. Wilson reported in 1958 that the Illinois Survey was engaged in the following activities:

1. Earth-science field trips were conducted annually in each of six sections of the state. Three trips

were conducted in the fall and three in the spring.
The itineraries prepared for these trips were frequently requested by teachers interested in conducting field trips for their high school classes.

2. Sample sets of typical Illinois rocks and minerals were provided for the cost of postage. In 1957, more than fifteen hundred sets were distributed; a total of seven thousand sets had been distributed as of that year.

3. Maps and an educational booklet series were provided. A list of publications available was sent to the science teachers or principals of all Illinois schools in September of each year.

4. The survey staff provided an identification service for rocks, minerals, and fossils sent to them.

5. Regular press releases helped keep the public informed about latest advances in geology and the work of the survey.

6. Exhibits on Illinois geology and the Survey's work were prepared and shown throughout the state and at professional meetings.

7. Special lectures were prepared and given to interested groups by survey staff members.
8. Materials to help Boy Scouts in their work on the geological merit badge were provided to the thirty Boy Scout Councils of Illinois.

9. The Survey staff was studying the possible use of movies and television in their public information program.\textsuperscript{90}

The teaching of geological sciences in elementary and secondary schools by teachers lacking in formal preparation has been a concern of the Education Committee of the American Geological Institute. This society co-sponsored with the University of Minnesota, Duluth Branch, the "Duluth Conference" for the development of teaching resources in the earth sciences. A grant from the National Science Foundation provided the funds to bring more than thirty science teachers and professional scientists to the Duluth Campus for a six-week workshop during the summer of 1959. The major result of the conference was a preliminary draft of an earth-science sourcebook. This book was to be tested through use by public school teachers in 1959-60 and then revised on the basis of the results of the trial use and recommendations of the teachers.\textsuperscript{91}

Directed by Robert L. Heller, Chairman, Department of Geology, University of Minnesota, Duluth Branch, the Duluth Conference was the


first large-scale attempt to stimulate improved teaching of the earth sciences in the public schools. Stephenson commented in a GeoTimes editorial, "The Duluth Conference was of signal importance in geological education, for never before had such an assemblage of talented people directed its full and undivided attention to the problem of teaching geology."92

The preliminary draft of the sourcebook from the Duluth Conference was revised and has been published as the Geology and Earth Sciences Sourcebook.93 The book contains information on the facts and ideas from the major areas of geology, astronomy, and meteorology. Each topic is accompanied by suggestions to aid the teacher such as methods of presentation, activities, problems, questions, demonstrations, projects, experiments, teaching aids, and references.

Since the 1959 Duluth Conference, increasing numbers of earth scientists have become involved in planned programs to present earth-science information to the public. The Ardmore Geological Society94 (Oklahoma) and the Fort Worth Geological and Geophysical Societies95 (Texas) cooperated with local public libraries in offering extensive


programs of reading and informal instruction. Both programs were considered to be worthwhile and successful. The Houston Geological Society (Texas) has worked with local Boy Scouts in a series of six meetings culminated by a two-day field trip. The undertaking was so successful and worthwhile that the society has been asked to repeat the program for another group of scouts.96

One of the most ambitious efforts to improve earth-science teaching at the local-community level is reported by Hay-Roe.97 The time and talent of twenty-six members of the Tulsa Geological Society were contributed in a year-long refresher course in earth science for Tulsa teachers. The fifty-two science teachers who took the course received in-service training credit for this broad introductory survey of the earth sciences. Each teacher received lecture outlines, bulletins, pamphlets, maps, charts, and a road log of their field trip to representative outcrops in Tulsa County.

As a result of their successful experience with the refresher course, the Tulsa Geological Society plans to hold further courses every two years. Hay-Roe summed up the concern of the society by writing, "the importance of this type of effort by the geological profession lies primarily in its ability to reach the people who count—the junior and senior high school science teachers. We also need to reach the vocational counselors in the high schools."98

98Ibid., p. 27.
Earth-science institutes, workshops and conferences. The apparent increase in numbers of schools offering or planning to offer earth-science courses has resulted in institutes, workshops, and conferences for science teachers and for high school students in the earth sciences. Some of these programs have been financially supported by the host institution with and without the payment of fees by the participants. Most of the institutes, however, have been sponsored by the National Science Foundation through supporting grants made to the host institution.

National Science Foundation sponsored institute programs in the earth sciences for high school teachers have increased in number, apparently paralleling the growth of earth-science courses in the secondary school. One earth-science institute for high school teachers was held in the summer of 1958. In 1961, sixteen such institutes were held and in 1962, the number of institutes increased to twenty-four.\[^{99}\]

Reports of a few of these institutes and of other National Science Foundation sponsored institutes in the earth sciences have recently appeared in the literature. Information on the majority of the institute programs, however, has not been published.

Dolloff reported on the 1960 Summer Institute held at San Jose State College (California) for secondary school students of high \[^{100}\] This Institute was supported by the National Science


Foundation. The forty high school students studied intensively the physics and chemistry of water for one week as an introduction to one week studies of: (1) water and the atmosphere; (2) the hydrosphere; and (3) water and the lithosphere. The staff was impressed with the performance of the students in the successful and worthwhile program.

A workshop for elementary teachers was held at Sul Ross State College (Texas) in the Summer of 1961. It was planned to provide teachers and prospective teachers with a minimum background in earth science. Course outlines and curriculum guides from Texas, Pennsylvania, and New York were used in selecting content for two weeks of study of basic geological principles and a week of study of topics from astronomy, meteorology, and oceanography. The workshop met from 8:00 a.m. to 4:00 p.m. during the three-week period. Matthews, who planned and directed the workshop, set forth the opinion that "it is only by providing our teachers with an understanding of geology and its problems that earth science can effectively take its place in the modern public school curriculum."102

The Colorado School of Mines conducted summer institutes in chemistry and geology for secondary-school teachers in 1961 and 1962. Sponsored by the National Science Foundation, the institutes provided introductory courses in chemistry and geology for participants selected on the basis of limited backgrounds in these areas. The large number

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102 Ibid., p. 28.
of applicants was interpreted as evidence of the need these teachers had for basic courses.\textsuperscript{103}

An in-service institute sponsored by the National Science Foundation was offered by Florida State University in the spring of 1963. Eighty teachers attended forty-two clock hours of class work based on the use of models in "the study of processes and materials of the terrestrial planets."\textsuperscript{104}

The theme of the Ninth Annual Conference for the Advancement of Science and Mathematics Teaching in November 1962 was "Recent Advances in Earth Science." More than 975 high school teachers attended this three-day conference at the University of Texas. Boyer noted that the earth-science theme was particularly timely because many Texas schools are offering or preparing to offer earth science in the eighth grade.\textsuperscript{105}

The Junior High School Science Project. A recent development related to the possibilities for earth-science study has been the Junior High School Science Project. This project was an outgrowth of the Elementary Science Summer Study conducted in the summer of 1962 by Educational Services, Incorporated, of Watertown, Massachusetts. The project has been transferred to Princeton University under the

\begin{itemize}
\item \textsuperscript{103} Harry C. Kent, "Geology Institutes," \textit{GeoTimes}, VII (May-June, 1963), pp. 13-14.
\item \textsuperscript{104} W. F. Tanner, "Florida State Teaches Teachers with Models," \textit{GeoTimes}, VII (May-June, 1963), p. 33.
\item \textsuperscript{105} Robert E. Boyer, "Keeping Our Schools Up to Date," \textit{GeoTimes}, VII (March, 1963), p. 38.
\end{itemize}
direction of Frederick L. Ferris, and with financial support from the National Science Foundation.106

The Junior High School Science Project has developed a new course, *Time, Space, and Matter: Investigating the Physical World*, which was experimentally tried in four schools in 1962-63. The new course will be revised and taught experimentally two or three times before being made available through commercial channels.107 University scientists and secondary school teachers have worked cooperatively in the development and revision of *Time, Space, and Matter*.

The new course places the teacher in the role of a director of research and the students as active scientific investigators. The student records his observations of a series of interrelated open-ended investigations. These data and the conclusions drawn from them are refined and corrected as more experimental evidence is obtained; the resulting record becomes the student's textbook. The investigations, centered upon geology, are structured toward discovery of the nature and history of the earth. Concepts from physics, chemistry, and mathematics are utilized in the two parts of the course, Part I, "Observation and Scientific Investigation" and, Part II, "Classifying Materials: The Search for Regularity."108 The two parts of the course are broadly summarized:

In Part I, the student discovers certain general characteristics of matter. In the course of his

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107 Ibid., p. 23.

investigations, he measures the mass of material, the space it occupies, and the time it takes to change. In Part II . . . the student looks at matter from a different point of view. In these eight investigations, he concerns himself with the different kinds of materials found on earth, the ways in which they occur, and the kinds of change they undergo. Thus, while Part I introduced the student to certain fundamental ideas of physics, Part II takes him into the realm of chemistry as he pursues his study of the earth.109

Earth Science Curriculum Project. A major educational program in earth science for the secondary school has been initiated by the American Geological Institute with financial support from the National Science Foundation. This interdisciplinary effort of earth scientists and science educators is known as the Earth Science Curriculum Project. The project has been planned to develop new text materials, laboratory experiments, demonstrations, teachers' guides, films, monographs, and other learning aids for use at the ninth-grade level.110 The following themes have been proposed as unifying elements in all materials produced for the course:

1. Science as inquiry - observation as a basis of all knowledge.

2. Universality of change.

3. Equilibrium.

4. Uniformitarianism.

109Ibid., p. 16.

5. Significance of components and their relationship in space and time.
6. Conservation of mass and energy.
7. Scale as a frame of reference.
8. Prediction.111

The American Geological Institute has established the goals of the Earth Science Curriculum Project as producing "good sound scientific materials, and to train teachers so that this trend toward earth science in the secondary school will not become a fiasco of pseudo-science taught by ill-prepared teachers."112

Recent Research on Earth Science in the Secondary School

The status study of earth science in the secondary schools by Coash showed a definite increase in the number of secondary schools offering earth-science courses.113 Intuitive recognition of this trend prior to publication of the Coash study may have stimulated research aimed at obtaining reliable information concerning the nature of this course, its effectiveness, and problems involved in its implementation in the science curriculum of the secondary school. Whatever the cause, there has been an increased number of reported studies on earth science in the secondary schools.

111 Ibid., p. 18.
112 Ibid., p. 19.
113 Supra, pp. 64-65.
Laboratory experiences. Laboratory experiences in earth science were studied by Batten through an interpretative and subjective analysis of the topics from commonly used science textbooks. The books included in the analysis were those used in seventh, eighth, and ninth grade general science classes, and in secondary school courses in biology, chemistry, physics, and geography. Units in earth science were found in all the junior high school general science books. Biology textbooks each contained one unit on earth science in the area of conservation. Chemistry textbooks did not contain any units devoted to earth science, but included earth-science topics in the development of concepts in chemistry. Physics books were found to restrict earth-science concepts to those found in units on weather and climate. Geography books included the topics of weather and climate, the earth's surface, the atmosphere, and the earth in space.

Batten proposed eighteen problems for solution in the laboratory in order to develop the following concepts he identified in the analysis of textbooks:

1. The solar system and the universe.
2. Location and time.
3. Weather and climate.
4. Water bodies.

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115 Ibid., summarized from pp. 45-56, 59, 60, 63.
5. Land forms and features
6. Rocks, minerals and soils.\textsuperscript{116}

Field trips. Another type of student experience in earth science was investigated by Benz. A random division of the students in four ninth grade classes into two groups was used to test the effectiveness of field trips and slides taken of the same region. One group was taken on field trips while the other group saw slides of the region under the supervision of a monitoring teacher. Benz concluded there was a significant gain in knowledge of geology as measured by the tests used in both of the treatments and, therefore, either method could be used with confidence. Because of the greater interest engendered in those taking the field trip, such trips were considered to be of superior relative value.\textsuperscript{117}

Content of earth science in secondary schools. A determination of the content in ninth grade earth-science courses has been made by Chapman.\textsuperscript{118} Questionnaires were sent to one hundred forty science teachers in junior and senior high schools. The responses which were obtained from eighty-three schools were the sources of data used in analyzing earth science in the science programs. The returned

\textsuperscript{116}Ibid., pp. 82-83.

\textsuperscript{117}Grace Benz, "An Experimental Evaluation of Field Trips for Achieving Informational Gains in a Unit on Earth Science in Four Ninth Grade Classes," Science Education, XLVI (February, 1962), pp. 43-49.

questionnaires came from thirty-five schools in Illinois, four schools each in Pennsylvania and Michigan, and fewer than four schools from each of twelve other states.\textsuperscript{119}

The responses from the participating schools in which earth science was taught revealed that the following topics were receiving great emphasis: "erosion," "astronomy," "space travel," and "the atmosphere."\textsuperscript{120} Relatively little emphasis was found on the topics of "geologic history of the earth," "the chemistry and physics of astronomy" and "the scientific aspects of conservation." The very small sample used - only eighteen of the eighty-three participating schools had a one year earth-science course - lends credence to the observation that "it is apparent that curriculum studies are needed on a national basis pertaining to the growth and development of effective earth-science courses in the secondary school science pro-
grams."\textsuperscript{121}

\textbf{An evaluation of the earth-science course.} The Earth and Space Science course was evaluated by the Pennsylvania Department of Public Instruction. Ninth grade students who had received instruction for

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{119}John M. Chapman and Loren T. Caldwell, "A Content Study of Earth Science Courses in Selected Secondary Schools," mimeographed manuscript submitted for publication, p. 3. This manuscript has been made available through the courtesy of Professor Loren T. Caldwell, Head, Department of Earth Sciences, Northern Illinois University.
\item \textsuperscript{120}Ibid., pp. 5-7.
\item \textsuperscript{121}Ibid., pp. 5-8.
\end{itemize}
\end{footnotesize}
one year in an Earth and Space Science course were compared with a
similar group in a regular general science program. These students
were enrolled in a random sample of nineteen schools. The comparison
was made on the basis of scores from a test constructed by a teacher
of Earth and Space Science.\textsuperscript{122}

Earth and Space Science students were found to be superior to
General Science students in their performance on the test instrument.\textsuperscript{123}
It should be noted, however, that the test items as reported in
Kosoloski's article appeared to draw extensively from the Earth and
Space Science course and may or may not be a part of the General
Science course. The following topics appeared to involve concepts
that were best understood by the students:

- earth changes in formation
- meander and oxbow lakes
- location of common earthquake faults
- ages of rivers
- igneous rocks
- vertically developed clouds
- overcast rain\textsuperscript{(sic)}
- cirrus clouds
- planet revolutions
- planet location
- planet temperature\textsuperscript{124}

Topics that appeared to be least understood were:

- characteristics of sandstone
- definition of rocks
- fault by tension

\textsuperscript{122} Kosoloski, \textit{op. cit.}, p. 15.

\textsuperscript{123} \textit{Ibid.}, p. 17.

\textsuperscript{124} \textit{Ibid.}. 
Summary of Recent Developments

Earth-science courses have been introduced into the science curriculum of secondary schools at a rapidly expanding rate. This growth has been most rapid in the schools of New York, Pennsylvania, and New Jersey where earth science is now a part of a well-established science program in the majority of the schools. Earth-science courses were being offered in thirty-nine states in 1961-62.

Dissatisfaction with the science curriculum in the junior high school has resulted in reorganization and experimentation which includes earth-science offerings at these grade levels. Local schools have received help in obtaining materials and additional preparation for teachers from geological societies and associations, libraries, and museums. Colleges and universities, independently and with financial support from the National Science Foundation, have responded to the increased interest in earth science by offering institutes, workshops, and conferences designed to improve the subject-matter competency of earth-science teachers.

Two course content improvement projects, the Junior High School Science Project and the Earth Science Curriculum Study, have been initiated. The project staffs are currently involved in developing

\[125^{\text{Ibid.}}.\]
new materials and organizational patterns of content and methods to be used in earth-science courses.

Research studies have been reported on the development of laboratory experiences, the effectiveness of field trips, the content of earth-science courses, and an evaluation of the Earth and Space Science course in Pennsylvania.

The Contribution of Earth Science in the Science Curriculum of the Secondary School

Any course in the science curriculum of the secondary school must be defended in terms of positive values that may be accomplished through such a course. The earth-science course is no exception. The curriculum in the secondary school is already overcrowded and subject to pressures of time and special interests in both academic and non-academic areas of study. For earth science to be introduced, as is being done in an increasing number of schools at the present time, the values derived from the course must be important enough to displace an existing part of the science curriculum.

Prior to the renewed interest in earth science in the late 1950's, Wilson pointed out values he saw in an earth-science course. The breadth of earth science including such subjects as physiography, geography, meteorology, and geology was considered as offering content that can be one of the most interesting areas in the entire curriculum. The fact that earth-science topics lend themselves for study in any and every local situation has potential for great carry over into the
student's actual living experience. In addition, earth science offers the student the opportunity to become more fully acquainted with the earth as his home and source of all food, shelter, raiment, and industrial raw materials.126 Wilson summarized by saying:

Is it not natural to assume, then, that anyone who goes through life without a true understanding of all this and how it came about, must be unnecessarily handicapped in his thinking and in the method of his attack on and solutions of the problems of life? This alone is reason enough for the universal adoption of an elementary course in earth science in all secondary schools.127

In a faculty workshop in Joliet Township High School (Illinois), the question of the major contributions of earth science to the curriculum was raised. Wilson reported the following comments made by the faculty:

1. Earth science is the only science course that contacts all students since it is required of all high school freshmen (in Joliet Township High School).
2. Earth science introduces the student to science courses offered later in high school.
3. Earth science stimulates an interest in chemistry through simple experiments, use of apparatus, use of a few chemical symbols and equations.


127 Ibid., p. 621.
4. Earth science simplifies the teaching of physics.

5. Earth science is the basis for understanding geography and interpreting history.

6. Earth science offers a contribution to English and mathematics.

7. Earth science offers an opportunity to teach use of statistics and graphing.

8. Earth science classes are taught how to set up reports (of significant value to other classes).

9. Earth science encourages the questioning "why?" (Scientific thinking.)

10. Earth science develops interest in leisure-time activities.

11. Earth science develops an interest in nature—environment.

12. Earth science teaches living on earth not teaching to live.

13. Earth science adds through study of new terms, an appreciation of languages.

14. Earth science adds to enriched appreciation of the world in which we live.

15. It is a stimulus to "rationalized living" and confines our work to things which are tangible.128

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128 Ibid., pp. 622-623.
The earth-science course was thus considered as contributing to the general education of students, the development of interest in and preparation for study of other sciences, and as having a significant relationship to other areas of study in the secondary school.

Values of earth science in general education. The need for all citizens to become scientifically literate has been a frequently expressed reason for including science courses in the curriculum of the secondary school. Democratic citizenship in the present scientific and technological age requires an understanding of scientific phenomena, scientific methods, and scientists and their work. McGrath has stated this goal of science in general education as being to "show what science is like, what scientific procedure is like and what scientists are like."\(^{129}\)

Delo expressed the view that a goal such as the one stated by McGrath "is much too limited a goal for the times in which we live and the long range developments that present trends portend."\(^{130}\) He proposed the goal of giving all students a scientific foundation that would develop a liking for science and "... give them a scientific basis for citizenship in the disturbed and confusing world. ..."\(^{131}\)


\(^{131}\)Ibid.
The study of earth science was viewed as contributing uniquely to this goal because "the basic factors in their daily lives are those which compose the physical environment." Problems of national significance with which our future voters and legislators will be concerned call for scientific bases that can best be developed in earth-science courses. These are some of the problems:

1. Our national use of the land.

2. The distribution of production (which in the last analysis is dependent on raw resources).

3. The preservation and use of timber resources, and reforestation.

4. Effective utilization of our national regions of differing climate and productivity as one homogeneous national unit.

5. The water problem: control of rivers and drainage systems to prevent floods, produce usable power, and assure maximum productivity of drainage areas; measures to cope with the depletion of underground water, which is now becoming a national concern.

6. More effective and more stable use of such areas as the Great Plains.

7. The soil problem: prevention of erosion and depletion; renewal of areas that have been partially exhausted and more effective use of marginal lands.

132 Ibid.
8. The problem of mineral resources: more accurate information concerning supply and demand; utilization of "marginal" deposits; a realistic national policy concerning importation of scarce raw materials to prevent peacetime exhaustion of domestic deposits which may be essential during war.\textsuperscript{133}

The goals and problems in earth science stated by Delo seemed to be consistent with the viewpoint of the place of science in education expressed by Glass:

Human life is now permeated with science; civilization rests upon scientific foundations. The sciences are the greatest educational forces in generating true freedom of the mind, and thus must in fact constitute the heart of truly liberal education. Yet the vast majority of our people have little understanding of science as a way of thinking or a method of seeking answers to problems.\textsuperscript{134}

The fact that earth science is being taught predominantly at the junior high school level places a heavy burden of responsibility for developing an "understanding of science as a way of thinking or a method of seeking answers to problems." For many of the students, the ninth grade science course, be it earth science or general science, has been or will be the termination of science course work. For other students who study science in later high school or college years, this same

\textsuperscript{133}Ibid., pp. 59-60.

\textsuperscript{134}Bentley Glass, Science and Liberal Education (Baton Rouge: Louisiana State University Press, 1959), p. 68.
understanding of science has long been considered as an important goal of ninth grade science courses. A recent National Science Teachers Association publication restated the goal of "a basic knowledge of the scientific enterprise" as one of the desirable outcomes that should be achieved by ninth grade science students.\textsuperscript{135}

Earth science has been regarded as especially adaptable to teaching science as a process involving various modes of scientific thought. Lokke indicated a number of such possibilities through individual student participation with observations such as temperature and humidity readings, construction and interpretation of charts, and descriptions of rock outcrops; measurements, comparisons, conclusions, and discussions to duplicate research procedures; the use of fascinating events from appropriate literature to add to the story of science in action the processes not available as personal experience.\textsuperscript{136}

In addition to achieving a basic knowledge of the nature of the scientific enterprise, the National Science Teachers Association recommended that a ninth grader should achieve:

An increase in the mathematical, observational, and experimental skills.

Understanding related to the interrelations of science and society.


Increased understanding of the concepts and theories which describe and unify the fields of science.

Career opportunities.\textsuperscript{137}

These goals have been developed to be consistent with the definition of science set forth by the Association.

Science, ..., is a human enterprise including the ongoing process of seeking explanations and understanding of the natural world, and also including that which the process produces - man's storehouse of knowledge. Science is a process and product.\textsuperscript{138}

A variety of potentialities for earth science in the school science program that may lead to the goals expressed above were designated by Willard. The environmental scope of earth science can develop increased student understanding and appreciation of the natural environment. Studies in astronomy can arouse interest in the principles of light, optics, and radiant energy involved in the use of the telescope. Ecological studies lead to the relationship of ancient and modern life to the physical environment. Chemical and physical properties and the behavior of atoms, molecules, and ions develop chemical concepts in the study of rocks and minerals. Recent information on the International Geophysical Year and continuing studies of earth and space exploration can be used to develop understandings of radioactive contamination in the atmosphere, mineral resources of the ocean, and conservation of natural substances.

\textsuperscript{137}Planning for Excellence, op. cit., pp. 40-41.

\textsuperscript{138}Ibid., p. 15.
Opportunities for club and hobby activities include weather observation, telescope construction, and collections of minerals, rocks, and fossils. The interdependence of science fields can easily be demonstrated through application of physical and chemical principles, study of fossil evidence for evolution, and study of earth substances used by man. Studies of natural resources, effect of climate on plant and animal life, dangers of radiation, and impact of earth-science discoveries on society afford opportunity for integration with other courses in the curriculum. Indoor and outdoor laboratory experiences are available in all areas of earth-science study.\textsuperscript{139}

Caldwell considered topics and the organization of scientific ideas similar to those expressed by Willard and concluded that a ninth grade earth-science course had great value to the student. Information would be obtained to help the student decide whether to specialize in one of the sciences. The relationship between good citizenship and knowledge of the sciences would be evident. The door would be opened for many students to obtain a hobby interest. And perhaps most important, students of earth science would learn to view the human culture as a scientific whole with a resultant understanding of the social implications of science.\textsuperscript{140}


Geology, a significant part of earth-science courses, is considered by Gilluly as the source of three powerful and important ideas about the world in which we live. First, the age of the world must be measured in terms of billions of years, perhaps as many as five billion and certainly more than three billion years. Secondly, conditions on the earth have remained much like those of the present for the last billion years or longer. Temperatures have changed slightly with resultant building or melting of glaciers, the atmosphere has been about the same in composition, and the sea has existed throughout this time although not always within its present boundaries. The third powerful lesson taught in geology is that man is the surviving product of a vast history of evolution.¹⁴¹

Geology thus teaches us of the great antiquity of our globe and the life upon it. It teaches of a persistence of conditions much like those of our own day. But quite as insistently, it teaches that the "everlasting" hills are not everlasting, that the mountains wear down to the level of the plains and must be rebuilt either by renewed uplift or in new sites. Ours is a world always much the same but always changing. . . . The placing of men in nature as the culmination of so long a history is the contribution to man's thinking that geology has made in the last three generations.¹⁴²

Suggesting that earth science should be equated with geology, Perry viewed earth science as destined to become more prominent in high school curricula than it has in the past. Two major reasons were


¹⁴² Ibid., pp. 16-17.
mentioned: (1) drawing heavily from concepts of physics, chemistry, and the life sciences in explaining geologic phenomena and processes, the close interrelationships in earth science unifies all fields of science; and (2) geologic concepts add immeasurably to understanding of observable natural phenomena and a better appreciation of the present environment as well as that of the past millions of years.\textsuperscript{143}

Summary of the Contribution of Earth Sciences

The inclusion of an earth-science course in the secondary school has been justified on the basis of the actual and potential contributions of the course in the educative process. Since the topics studied in such a course are concerned with the materials and processes occurring in the student's environment, the course has been considered as intrinsically interesting and readily related to the life experience of students.

Earth-science courses offer many opportunities for developing scientific literacy through an understanding of scientific phenomena, scientific methods of problem solving, and the work of scientists. Understanding of the environment and the development of scientific literacy are accomplished by studying chemical, physical, and biological principles with the added perspective of change through geologic time.

The earth-science course contributes to the commonly accepted objectives of science in the secondary schools through opportunities to: teach scientific processes; increase mathematical, observational, and experimental skills; interrelate science and society; interrelate or unify the fields of science; and provide career information to students. The achievement of these goals within the framework of the facts, principles, and concepts of earth science would contribute materially to developing a scientific basis for citizenship. Earth science is thus seen as making a significant contribution to the general education of all secondary school students who take such a course.
CHAPTER III

THE NATURE OF THE DEVELOPING EARTH-SCIENCE COURSE

An essential component in planning a curriculum for the preparation of teachers is a determination of the responsibilities, knowledge and other competencies required in the positions to be filled. These factors have been determined through collecting, analyzing, and interpreting data from sources that would yield reliable and recent information. There have been four sources of these data: state science supervisors or certification officials, earth-science textbooks, courses of study and curriculum guides from state and local educational systems, and the directors' reports from Summer Institutes for Earth-Science Teachers.

The variety of sources and nature of these data have required different procedures of obtaining and analyzing them. The procedures used with each source of data are explained immediately preceding the presentation of the data.

Current Status of Earth Science in the Secondary Schools of the United States

The review of the literature in the field of secondary school earth science included only a few reports of the status of earth-science courses, notably in the states of New York, New Jersey, and Pennsylvania. The only information obtained and reported on a national basis was a
survey completed by Coash for the school year 1961-62.¹ Current information concerning the status of earth science as a part of the secondary school curriculum was considered to be essential in the present investigation. Information was needed in order to determine and to verify the demand for earth-science teachers, the grade levels in which earth science was being taught, the number of schools offering earth-science courses, certification requirements for earth-science teachers, textbooks in use, and the special problems encountered in the various states in the implementation and operation of earth-science courses. In order to obtain such information, a questionnaire and a covering letter were prepared and sent to the science supervisor or consultant in each of the states, the District of Columbia, and New York City. New York City was included separately from the state of New York when it was learned that certification requirements are different for each and that the enrollment figures are compiled independently.² A copy of the original questionnaire and covering letter have been placed in Appendix A.

In those states not having a science consultant, the information form was sent to the person responsible for Title III of the National Defense Education Act or to a state certification officer. The names

¹Coash, "Earth Science in the Secondary Schools," loc. cit. Results of this survey have been presented in Chapter II, pp. 64-65.

²The suggestion of obtaining separate information from New York City was made by Dr. Hugh Templeton, Supervisor of Science Education, State Education Department, Albany, New York.
of these persons and the science consultants were obtained from the
mailing list of persons responsible for the area of science or science
education in the various states compiled by the United States Office
of Education.3

Officials in thirty-eight states, the District of Columbia,
and New York City responded to the original request for information.
Those in seven other states responded after a follow-up letter was
sent, while the remaining five state officials returned the completed
questionnaire after a second follow-up letter was sent.4

Analysis of Earth Science in the
United States in 1962-63

The information concerning earth-science courses obtained by
means of the questionnaire was not complete in all cases. Several
states did not have compiled data on some of the items asked for, but
supplied information for those items upon which they did have data.
Two state officials replied that they had no information available.
Usable information was received from fifty sources. The four tables
in Appendix B of this study summarize the responses from all fifty-two
respondents.

In this analysis, the District of Columbia and New York City
are included in the term "states" except where it is desirable to

3United States Office of Education, "State Specialist Super-
visors for Science" and "Mailing List for Science--States and
Territories Having No Specialist Supervisor for Science," mimeographed
mailing lists, October, 1962.

4Copies of the follow-up letters are found in Appendix A.
identify them specifically. The analysis has been made in the following ten categories.

Category 1: **Length of Time Earth-Science Courses Have Been Offered in the Various States**

The information form requested an indication of the number of years earth science has been offered in each state. This item was included to attempt to test the general opinion that earth-science course offerings have increased within recent years.

Earth-science courses have been offered in nine states for periods ranging from ten to more than one hundred years. In four states earth-science courses have been offered for "many" years. Earth-science courses have been included in the secondary school curriculum of 14 states within the past ten years; in ten of these states earth science has been included within the past four years.5 Two states, Kentucky and Louisiana, had tentative plans to offer earth science for the first time in the 1963-64 school year. In three states earth science has been offered for "several" years.

Twenty state officials were unable to supply information as to how long earth-science courses have been taught. Of these, 13 reported that earth science is taught currently in the state in from one to 51 schools.

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5Use of numerals. Because of the frequent use of numerals in this analysis, the policy is to use Arabic numerals for numbers greater than ten. Exceptions occur when a numeral is used to begin a sentence and in the case of one hundred.
These figures, summarized in Table 2, indicate there has been a significant increase in the number of states offering earth-science courses in the last ten years, especially in the past four years. In three states, New Jersey, North Dakota, and North Carolina there has been renewed interest in earth-science courses within the past two years. Committees in North Dakota and North Carolina were working on curriculum materials for contemplated state-wide adoption of an eighth grade earth-science course.

Table 2

Number of Years Earth Science Has Been Offered in Various States

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<thead>
<tr>
<th>Number of Years Earth Science Has Been Offered</th>
<th>Number of States Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 or more</td>
<td>1</td>
</tr>
<tr>
<td>76 to 99</td>
<td>1</td>
</tr>
<tr>
<td>51 to 75</td>
<td>1</td>
</tr>
<tr>
<td>26 to 50</td>
<td>2</td>
</tr>
<tr>
<td>10 to 25</td>
<td>4</td>
</tr>
<tr>
<td>5 to 9</td>
<td>4</td>
</tr>
<tr>
<td>1 to 4</td>
<td>10</td>
</tr>
<tr>
<td>0 (plan to offer earth science in 1963-64)</td>
<td>2</td>
</tr>
<tr>
<td>several</td>
<td>3</td>
</tr>
<tr>
<td>many</td>
<td>4</td>
</tr>
<tr>
<td>no information</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>52</strong></td>
</tr>
</tbody>
</table>
Category 2: Grade Level(s) at Which Earth-Science Courses Are Taught

In response to the question asking for the grade level(s) at which earth science is taught, 44 state officials indicated that earth science was taught at one or more grade levels. In addition, personal communication with individuals in Michigan, and the information obtained by Coash for Michigan and Arizona, indicate that earth science was taught in at least a few schools in these states. Earth science was, therefore, offered as a separate course in 46, or 88 per cent, of the 52 areas in the survey.

Schools in 18 states generally offered earth science at more than one grade level. The grade level at which the course was offered varied within the state, or the course was available on an elective basis to students in several grades. In 16 states earth science was generally offered at the ninth grade level and in three states at the eighth grade level.

The grade levels at which earth science was taught and the number of state reports specifying these grade levels are summarized in Table 3. The duplication of grade levels in Table 3 results from the fact that these were the groupings as listed by the various state reports.

A study of Table 3 reveals that in 37 of the 46 states earth-science courses were offered at the junior high school level. In 14 of these 37, the course was also offered in the senior high school. Schools

6Coash, loc. cit.
in at least 23 of the 46 states offered earth science at the junior high school level only. The grade level at which earth science is offered in nine states was not reported.

Table 3
Offerings in Earth Science by Grade Level

<table>
<thead>
<tr>
<th>Grade Levels</th>
<th>Number of States Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>7, 8, 9</td>
<td>4</td>
</tr>
<tr>
<td>7, 8, 9, 10</td>
<td>1</td>
</tr>
<tr>
<td>7, 8, 9, 10, 11, 12</td>
<td>1</td>
</tr>
<tr>
<td>8, 10, 11, 12</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>9 and 10</td>
<td>6</td>
</tr>
<tr>
<td>9 and 12</td>
<td>1</td>
</tr>
<tr>
<td>9, 10, 11, 12</td>
<td>4</td>
</tr>
<tr>
<td>Grade level not specified</td>
<td>9*</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>46</strong></td>
</tr>
</tbody>
</table>

*Includes Arizona and Michigan for which the information was obtained through personal communication and Coash's study, loc. cit.

The data in Table 3 suggest that the ninth grade is the level at which earth science is most likely to be offered. In 32 states earth science was offered in the ninth grade, 15 in the tenth grade, 11 in the eighth and twelfth grades, ten in the eleventh grade, and two in the seventh grade. In nine states offering earth-science courses the grade
level was not reported. The comparison of the numbers of states in which earth science was offered at each grade level is presented in Figure 1.

Figure 1

Comparison of the Number of States Offering Earth Science at Specified Grade Levels
(Total states reporting = 46)

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Number of States Offering Earth Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>32</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>NR*</td>
<td>0</td>
</tr>
</tbody>
</table>

*Grade level not reported.

The responses from the various states indicate that earth-science courses are becoming an integral part of the secondary school science curriculum. Such courses are most frequently offered in the ninth grade. This fact lends support to a statement made by Caldwell that,

Dissatisfaction seems to be most intense in the junior high school and particularly the ninth grade where general science courses have been most commonly offered. Many school systems are hunting for either a revision of their general science program or a new sequence of learning experiences which might challenge the growing mind of the ninth grade students in such a way that the
student can see the significance of continuing to study in selected fields of the sciences.7

Category 3: Grade Level and Courses Including Earth Science as a Part of Another Science Course

Content from the earth sciences is included in other science courses in 32 states. In five states earth-science topics are generally included in general science at the ninth grade level, two states include earth science in seventh and eighth grade general science, and in 19 states responses indicated concepts from the earth sciences are included in the general science sequence in the seventh, eighth, and ninth grades.

Three respondents made comments in explanation of their answers to the question of the inclusion of earth science in other courses. New York City schools were conducting an experimental program of including eight-week earth-science units each year in seventh, eighth, and ninth grades. Some schools in Connecticut gave earth-science topics a major emphasis in seventh or eighth grade general science. Schools in Georgia did not treat earth science as a separate course, but included earth-science concepts in grades one through eight.

In the senior high school, earth science was included in tenth, eleventh, or twelfth grade physical science in six states. One state official reported that earth-science topics are taught in the eighth, eleventh, and twelfth grades, but did not report the course names. One

---

other report included earth science in other courses, but course names or grade levels were not specified.

Twenty states did not respond to the question of including earth science in other courses. In 18 of these states, earth science was taught as a separate course. No information was available in the other two states.

The information concerning the extent that earth science was included in other courses is compiled in Table 4. In this table, the total number of responses is greater than 52 because in several states earth-science topics were included in more than one of the categories used.

The responses to the question of earth science being offered as a separate course and as a part of other courses revealed that it occurred both separately and in combination with other science courses in 26 states. Earth science occurred only as a separate course in 18 states and only in conjunction with other courses in six states.
Table 4

Courses in Which Earth-Science Topics Are Included

<table>
<thead>
<tr>
<th>Course</th>
<th>Grade Level(s)</th>
<th>Number of states Reporting*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary school science</td>
<td>1 through 8</td>
<td>5</td>
</tr>
<tr>
<td>General science</td>
<td>7 and 8</td>
<td>2</td>
</tr>
<tr>
<td>General science</td>
<td>7, 8, 9</td>
<td>19</td>
</tr>
<tr>
<td>General science</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Physical science</td>
<td>10, 11, 12</td>
<td>6</td>
</tr>
<tr>
<td>Course not specified</td>
<td>8, 11, 12</td>
<td>1</td>
</tr>
<tr>
<td>Course not specified</td>
<td>not specified</td>
<td>1</td>
</tr>
<tr>
<td>No response (earth science</td>
<td>-----</td>
<td>18</td>
</tr>
<tr>
<td>is a separate course)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No information available</td>
<td>-----</td>
<td>2</td>
</tr>
</tbody>
</table>

*Total response is greater than 52 because in some states earth science is included in more than one category.

From these data it is apparent that academic preparation in the earth sciences needs to be included in programs designed to prepare not only earth-science teachers, but in those programs preparing teachers of general science, physical science, and elementary school science. The teachers in the latter three categories can generally expect to be working with earth-science concepts.

Indications that earth science was not offered in a given state. If earth science was not a separate course or a part of another science course, the respondents were asked to indicate that earth science was
not offered in this state." All of the responses except for the two which indicated that no information was available showed that earth science was offered as a separate course and as a part of other science courses.

Category 4: Enrollment Statistics for Earth-Science Courses in the United States, 1962-63

In order to obtain current statistics concerning the status of earth-science courses and enrollments, the information form requested the state respondents to supply the following information:

a. Total number of schools offering earth science,
b. Total number of sections of earth science,
c. Total number of students enrolled in these courses,
d. Total number of teachers teaching these courses,
e. Total number of teachers in d. who are certified to teach earth science, and
f. Is the information above based on "actual" or "estimated" numbers?

The information obtained from the 52 returned forms is presented in Appendix B. A summary of the responses indicates the status of earth-science courses in the school year 1962-63.

Number of schools offering earth-science courses. Forty states reported that earth science was taught in 1962-63 in a total of 3,052 schools. Earth science was not offered as a separate course in six states, although it should be noted that in two of these, Kentucky and Louisiana, plans were under way to offer earth science in the 1963-64
school year. In six of the states in which earth science was taught as a separate course, a report of the number of schools offering this course was not available.

Of the 40 state reports including the number of schools teaching earth science, four account for 61 per cent of the 3,052 schools reported. In New York, earth science was offered in 570 schools; Pennsylvania reported 400 schools, Texas estimated 500 schools, and Virginia estimated 400 schools offered earth science.

The 3,052 schools offering earth-science courses was considered to be a minimum number. The reason is twofold: (1) the respondents are state education officials with a special concern for science courses in their states and, consequently, they are able to make as valid an estimate as can be obtained; and (2) in six states earth science was taught as a separate course, but since no figures are available for these states, they are not included in the total. The same reasoning applies to the statistics in the following parts of this section.

**Number of sections of earth science being taught.** In the 3,052 schools reported by 40 states as teaching earth-science courses, there were a total of 6,839 sections or separate classes of earth science. The number of sections was considered as minimum for the reasons given above and, in addition, because ten states did not include data on the number of sections. The investigator recorded these states as having one section of earth science per school or per earth-science teacher in the school using the larger number in each case. A reasonable assumption is that there are some schools in these ten states that had more than one section of earth science in their schedules.
Number of students taking earth science. The total number of students taking earth-science courses in the United States in 1962-63 as tabulated from the replies of 40 states was 190,418. The four states of New York, Pennsylvania, Texas, and Virginia accounted for 111,101 students, or slightly more than 58 per cent of the total reported for the 40 states. Pennsylvania appeared to be the state in which earth-science courses were best established—68,000 students were reported as being enrolled in such courses in 1962-63.

Number of teachers of earth science. The 40 states responding to the question of how many teachers were teaching earth-science courses indicate there were 4,195 such teachers in 1962-63. Of these teachers, 2,800 or 67 per cent were in the four states of New York, Pennsylvania, Texas, and Virginia.

Number of teachers who are certified to teach earth science. Twenty-seven of the 40 states supplying figures for the preceding sections did not include information on the number of teachers who were certified to teach earth science. The lack of response to this item suggests that: (1) they did not obtain this information; (2) they did not have sufficient personnel to tabulate any available data; or (3) earth-science teachers were certified as physical or general science teachers. Such factors were mentioned in some replies. They perhaps applied to other states as well.

The 13 states that supplied the number of teachers certified in earth science reported 421 certified teachers. A total of 633 earth-science teachers was reported in these states. Approximately
two out of three of the earth-science teachers in these 13 states were
certified to teach the subject.

The use of "actual" and "estimated" figures. The persons
completing the information forms were asked to indicate whether they
were reporting actual figures for the statistical information or if
the figures were being estimated. Of the 40 states supplying statist-
tics, nine used actual figures, 18 estimated the numbers, 12 used a
combination of actual and estimated figures, and one state did not
indicate how the figures were determined.

Summary of enrollment statistics in 1962-63. Forty states re-
ported that earth-science courses were taught in 3,052 schools with
6,839 sections or separate classes being taught. There were 4,195
teachers teaching 190,418 students in these schools. Thirteen states
reported that 66\(\frac{1}{2}\) per cent of the earth-science teachers were certi-
fied to teach the earth-science course.

Category 5: Certification Requirements for Earth-Science Teachers

The respondents to the information form were asked to indicate
if their states had definite certification requirements, no certifi-
cation requirements, or if they were planning such requirements for
earth-science teachers. In the latter case, the date the certification
requirements would become effective was requested. Forty-nine reports
contained a response to these questions.

Thirteen state officials listed definite certification require-
ments for earth-science teachers. The report from one state, Illinois,
indicated there were requirements for certifying geology and physical geography teachers. Thirty-six state reports specified there were no definite requirements for the certification of earth-science teachers. There was no information available for three states.

Four states included in the 36 which had no definite earth-science certification reported that they had planned or were planning such requirements. New York and Kentucky officials had planned a certification area in earth science to become effective upon adoption by their state certification agencies, probably in September, 1963. Texas was planning requirements to become effective in 1965 and North Carolina was proposing requirements for adoption in 1967.

Two state officials from Kansas and Pennsylvania reported that their current certification requirements for earth-science teachers had been restudied. Changes in requirements in both states were to become effective in the 1963-64 school year. In New Jersey, earth-science requirements were to be modified, but a time for the change to become effective was not specified.

The status of certification requirements for earth-science teachers in the United States is shown in Table 5.
### Table 5

Status of Earth-Science Certification Requirements in the United States

<table>
<thead>
<tr>
<th>Status</th>
<th>Number of States Reporting</th>
<th>Per cent in the Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have definite certification in earth science</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>No certification requirement in earth science</td>
<td>36</td>
<td>69</td>
</tr>
<tr>
<td>No information available</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>52</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Certification requirements planned to be effective:
- September 1963: 2
- 1965: 1
- 1967: 1

Changing present requirements, planned to be effective:
- 1963-64 school year: 2
- unspecified future date: 1

---

**State certification requirements.** Thirty-six of the replies indicated there were no certification requirements in earth science in the respective states. Twelve of these included a notation that teachers of earth science were certified in such areas as physical science, comprehensive science, general science, and junior high school science, or that there was a minimum number of semester hours of academic preparation required in the subject being taught. Earth science was taught in 30 of the 36 states where there were no definite certification requirements for earth-science teachers. The assumption is made that in 18 additional states earth-science teachers were certified in areas similar to those indicated by the 12 state reports. These
18 responses, however, did not specify how earth-science teachers were certified and, therefore, cannot be included as having definite provisions for such certification.

The state reports that cited regulations for the certification of teachers of earth science included 13 states having definite certification requirements and 12 states which required certification in another science area and/or a minimum number of hours of academic credit in the subject taught. Thus, 25 of the 52 responses, or 48 per cent, were from states having definite certification requirements. If two states which were planning earth-science requirements are added, there were 27, or 52 per cent, of the 52 areas in the survey which had or were definitely planning means through which earth-science teachers may be certified. Only two of the four states where earth-science requirements were planned can be included in the above 52 per cent because two states, New York and Texas, were included in the 12 states requiring earth-science teachers to be certified in other science areas.

Category 6: Academic Requirements for Certification of Earth-Science Teachers

Twenty-seven states reported that they had currently effective or planned regulations for the certification of earth-science teachers. These requirements vary so widely that each state needs to be considered separately. The state reports that indicated there were no certification requirements for earth-science teachers and not listing
any means through which these teachers could be certified are not included in the following account of state certification requirements.

States Reporting Definite Requirements for Earth-Science Teachers

Certification requirements were reported from the following states as applying specifically to earth-science teachers. All course requirements are given in semester hours of credit.

1. Colorado. The information form from Colorado indicated definite certification requirements for earth-science teachers in this state, but did not include a copy of the requirements. Armstrong and Stinnett reported the requirements for teaching an academic area in Colorado as being the completion of an "approved course" and having a bachelor's degree.8 Woellner and Wood reported the same requirement.9

2. Connecticut. In Connecticut earth-science teachers were certified by requiring a minimum of 30 hours in one or two fields of concentration in the sciences. Eighteen hours in earth sciences constituted a teaching major. Twelve hours were required for a minor.

---


3. **Indiana.** Indiana had definite certification requirements for earth-science majors and minors which indicated the number of hours required in specified and elective courses. These requirements were listed as:

<table>
<thead>
<tr>
<th>Course name:</th>
<th>Number of semester hours for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Major</td>
</tr>
<tr>
<td>Historical and Physical Mineralogy</td>
<td>9</td>
</tr>
<tr>
<td>Advanced Geology</td>
<td>3</td>
</tr>
<tr>
<td>Astronomy</td>
<td>3</td>
</tr>
<tr>
<td>Physical Geography</td>
<td>3</td>
</tr>
<tr>
<td>Meteorology</td>
<td>3</td>
</tr>
<tr>
<td>Conservation</td>
<td>3</td>
</tr>
<tr>
<td>Regional Geology</td>
<td>2</td>
</tr>
<tr>
<td>Field Techniques in Earth Science or Cartography</td>
<td>2</td>
</tr>
<tr>
<td>Paleontology</td>
<td>3</td>
</tr>
<tr>
<td>Physical Anthropology or Anthropogeography</td>
<td>3</td>
</tr>
<tr>
<td>Electives - from above or mathematics or biology</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total Hours Required</strong></td>
<td>40</td>
</tr>
</tbody>
</table>

4. **Kansas.** An earth-science teacher in Kansas needed 24 hours in the field of science with six hours in the earth sciences for a major on a standard certificate. Eighteen hours in science with five hours in earth science constituted a minor. Kansas made the further requirement that the science courses must have been taught in a science department.
5. **Mississippi.** Thirty-two hours in science with a minimum of 16 hours in each subject taught were required for certification of a science teacher.

6. **Montana.** The certification of an earth-science teacher in Montana depended upon the completion of an approved course of study at an accredited institution. By endorsement of an institution's program, the Montana State Department of Public Instruction approved the graduates for certification.

7. **New Hampshire.** Earth-science teachers in New Hampshire were certified within the requirements for all science teachers. For those teaching a subject for more than 50 per cent of the school day a major in the teaching area of 30 hours was required. If teaching a subject for less than 50 per cent of the school day, a minor was required that consisted of 12 hours in the teaching area with six hours in the subject being taught.

8. **New Jersey.** Certification requirements for earth-science teachers in New Jersey were 18 hours distributed over geology, meteorology, astronomy, and an optional requirement in oceanography. The respondent indicated that these requirements will probably be modified.

9. **New York.** Earth-science teachers in New York were certified as physical science teachers. New requirements were to become effective September 1, 1963. For provisional certification, an earth-science teacher will need 42 hours in mathematics and science including a full year course or its equivalent in each area of mathematics, chemistry, physics, and biology and two full-year courses or the equivalent in the area of earth science. A permanent certificate requires
a total of 57 hours in mathematics and science including the requirements for the provisional certificate plus an additional year's work in earth science. Either certificate holder is required to become proficient in laboratory demonstrations and techniques.

10. **North Carolina.** Certification requirements for earth-science teachers have been prepared and will be come effective in 1967. The prospective earth-science teacher will need one year of study in three of the four areas of biology, chemistry, physics, and earth science. Advanced study amounting to one-sixth of the total undergraduate program is required for depth of preparation in earth science. This advanced study should include concepts from the major geologic sciences of paleontology, mineralogy, structural geology, economic geology, petrology, and geomorphology.

11. **Ohio.** A teacher may be certified to teach earth science in Ohio with the academic requirement of 15 hours including appropriate courses in geology and geography.

12. **Oklahoma.** Earth-science teachers were certified in Oklahoma by obtaining a science certificate or by having a minimum of 18 hours in science with a certificate in another area. The information sent by the Oklahoma respondent did not specify the requirements for a science certificate. As reported by Woellner and Wood, these requirements are 36 hours in science with both physical and biological science required.\(^\text{10}\)

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13. **Pennsylvania.** Effective October 1, 1963, Pennsylvania requires earth-science teachers to have a minimum of 24 hours in science including astronomy, geology, meteorology, physical geography, and related sciences.

14. **Wyoming.** A major in a science teaching field in Wyoming required 24 hours in a balanced program of science courses with at least 10 hours in the subject taught.

15. **New York City.** Earth-science teachers in New York City were certified to teach earth science if they had 36 hours of approved science courses including the following: 18 hours in earth science, six hours in each of two other areas of science (chemistry, physics, or biology), and six hours in any of the other science areas (chemistry, physics, biology, or earth science).

**States Reporting General Requirements Within Which Earth-Science Teachers Are Certified.**

The following states certified earth-science teachers within the requirements for a teaching certificate in general science or physical science. The course requirements are given in semester hours of credit.

1. **Florida.** Earth-science teachers were certified in Florida either in junior high school science or in general science. These areas required a minimum of 18 hours of science courses including laboratory courses in biology and physics or chemistry, and earth-science courses including astronomy, geology, and meteorology or physical geography.

2. **Georgia.** Teachers holding general or physical science certificates in Georgia were considered qualified to teach earth science.
The requirements for such certification included 30 per cent of the undergraduate work in physics and chemistry and 25 per cent in natural science and mathematics with an emphasis on geology, meteorology, and astronomy.

3. **Hawaii.** In the State of Hawaii the requirements for a physical science certificate qualified the teacher in the area of earth science. The returned information form did not include these requirements. Armstrong and Stinnett reported that 32 hours in science courses plus a course in the teaching of science were required for a science certificate in Hawaii.¹¹

4. **Idaho.** The general science certificate was used in Idaho for certifying earth-science teachers. These requirements were not included with the information form. Armstrong and Stinnett reported that Idaho required a minimum of 15 hours in each of two teaching fields for certification.¹²

5. **Illinois.** Illinois had certification requirements for geology and geography teachers, but no definite ones for earth-science teachers. The requirement for a geology certificate was 24 hours in physical science including eight hours in geology. A geography certificate required 24 hours in social science with a minimum of eight hours in geography.

¹¹Armstrong and Stinnett, op. cit., p. 80.

¹²Armstrong and Stinnett, op. cit., p. 82.
6. **Iowa.** An earth-science teacher was certified in Iowa by having at least a science minor with a minimum of six hours in the subject to be taught.

7. **Kentucky.** A committee was working on earth-science certification requirements for Kentucky. The tentative plans were that the requirements would be established, approved, and in effect by September, 1963.

8. **Texas.** There were no specific requirements for earth-science teachers in Texas. Such teachers usually qualified to teach earth science in one of two ways, either by having a science major with six hours in the specific course taught or by having a composite teaching field in the sciences. The composite teaching field required a balanced program of 48 hours in the earth sciences, life sciences, and physical sciences.

9. **Utah.** Utah had no requirements for earth-science teachers, but the notation was included on the information form that "most are academically prepared in earth science."

10. **Virginia.** General science certification consisted of 24 hours of biology, chemistry, and physics which qualified the individual to teach earth science in Virginia.

11. **West Virginia.** Earth-science teachers in West Virginia must have a physical science certificate. The requirements for a physical science certificate, as given by Woellner and Wood, were 24 hours in the physical sciences.\(^\text{13}\)

\(^{13}\)Woellner and Wood, *op. cit.*, p. 137.
12. **Wisconsin.** A comprehensive science certificate qualified a person to teach earth science in Wisconsin. This certificate required 54 hours in science with a minimum of 22 hours in one science and one year each of biology, chemistry, physics, and earth science.

The minimum semester hour requirement for a teaching major in earth science was specified in the replies from 19 states. The range of these requirements was from 15 to 54 semester hours. The modal and median values were both 24 semester hours. A mean of 29.6 semester hours was required.

Officials in 11 states reported the semester hour requirements for a minor in the earth-science teaching field. This group was bi-modal at 12 and 18 semester hours for a minor area in a range of eight to 24 semester hours credit. The median was 15 hours, the mean was 15.5 semester hours for these 11 states.

**Category 7: Earth-Science Textbooks in Use**

The person completing the information form for each state was asked to indicate the textbooks that were used in his state and the extent of use of each textbook. The four textbooks known to the investigator to be used in secondary school earth-science courses were listed on the information form. These four textbooks are:


Space was provided for the respondent to indicate any other textbooks that were being used in the state. The information from the individual states has been tabulated in Appendix B. The information concerning the textbooks used in the various states is summarized according to the amount of use in Table 6.

Thirty-one of the 52 respondents indicated one or more textbooks that were used. Twenty-one respondents did not supply information on this item. Of these 21 states, six states did not offer earth science as a separate course.

The information summarized in Table 6 reveals that *Earth Science, The World We Live In* was the textbook used in the greatest number of states. It was used in 19 states as either the first or second in amount of use. *Modern Earth Science* was used in 13 states, *Earth Science* in 11 states, and *The Earth and Its Resources* in two states as either the first or second in amount of use. In Oklahoma the introductory college textbook, *Introduction to Geology*,\(^\text{14}\) was used as well as the other textbooks mentioned. In Texas and Virginia, other science textbooks including general science was adapted for use in earth-science courses.

Table 6

Incidence of Earth-Science Textbook Use

<table>
<thead>
<tr>
<th>Textbook</th>
<th>Most Used</th>
<th>Next in use</th>
<th>Least Used</th>
<th>Used, but Not Ranked</th>
<th>Total States Using</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Earth and Its Resources</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Earth Science</td>
<td></td>
<td></td>
<td>4</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Earth Science, The World We Live In</td>
<td></td>
<td></td>
<td>16</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Modern Earth Science</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Introduction to Geology</td>
<td></td>
<td></td>
<td></td>
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<td>1</td>
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<tr>
<td>Other science textbooks adapted</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

The information on the number of states using the various textbooks is presented in graphic form in Figure 2. From this graph and the summary of the states using the various textbooks above, it would seem that three textbooks: (1) Earth Science, The World We Live In; (2) Modern Earth Science; and (3) Earth Science, would determine the earth-science concepts included in the typical secondary school course in those schools wherein the course is textbook oriented.
Figure 2
Most Used Earth-Science Textbooks

The Earth and Its Resources
Earth Science
Earth Science
The World We Live In
Modern Earth Science

Category 8: The Inclusion of Laboratory Work in Earth-Science Courses

Each respondent was asked to indicate whether or not laboratory work was typically a part of the earth-science course in his state. If the course usually has a laboratory, the respondents were asked to indicate what laboratory manuals were used. The 52 responses indicate that the following situation prevailed during the 1962-63 school year.

In 14 states laboratory work was typically a part of the earth-science course. In 22 states, laboratory work did not form a significant part of the course. No data for this item were given by 16 respondents. The laboratory was, therefore, a significant part of the course in 14 or 30 per cent of the 46 states offering earth science as a separate course. The information from New Jersey, contained the
notation that they were working very hard to bring about the acceptance of earth science as a laboratory science in that state. Four other respondents indicated a concern for the amount of laboratory work in their earth-science courses. These concerns indicated that laboratory work may form a more significant part of earth-science courses in the future than it has in the past.

In response to the question of what laboratory manuals were used in their state, only four of the 14 states in which the laboratory was a significant part of the course indicated that a laboratory manual was being used. The manuals used in these four states were those that accompanied the textbook.

**Category 9: States Desiring Curriculum Help**

The respondents were asked to indicate if they would find it helpful to have a panel or committee of area geology teachers review their earth-science curriculum or the related parts of other science courses and offer suggestions for their consideration. This was done in cooperation with the National Association of Geology Teachers. This association proposes to secure such area geology teachers to do this review in those states that indicated interest in having it done. The responses are summarized here to indicate the extent of interest in the various states.

Twenty-six replies stated that officials in these states would favorably receive such help as could be offered in the earth-science curriculum. There were 14 negative responses to the help suggested.
Four negative replies explained that curriculum development took place at the local level in their states and that such help would also have to take place at the local level. The information form from 12 states did not contain a reply to the question of the desirability of help with the earth-science curriculum.

The 26 replies indicating earth-science curriculum help would be desirable suggest uncertainty on the part of the state officials as to what should be included in their curriculums. At the same time, this response would seem to indicate that state supervisors recognize that earth science is coming into the secondary school curriculum and that help from professional earth scientists would be useful in determining the future of the course in their state.

Category 10: Special Problems in the Implementation and Operation of Earth-Science Courses

Space was provided on the information form for each respondent to indicate any problems encountered in the implementation and operation of earth-science courses in his state. This information was requested in order to identify problem areas that might be alleviated through teacher preparation, the providing of curriculum materials, or other aid that could be given by professional groups such as state geological surveys or teacher associations. Another purpose for asking this question was to discover problem areas which might be suggestive of further research.

Special problems were listed on 26 of the information forms. Several contained statements of more than one problem encountered in
the implementation and operation of earth-science courses. The responses to this question are tabulated in Appendix B. A summary of this information indicates that a number of problems are common to several states.

The problem most commonly mentioned was the need for qualified teachers of earth science. This problem seemed to be as acute in those states where earth science was well established, such as Pennsylvania, New York, and New Jersey, as in states such as Minnesota, Florida, and Indiana, where earth science is just becoming a part of the curriculum.

Each of the following problem areas was mentioned by five of the respondents: acceptance as a laboratory course; the need for good textbooks and curriculum materials; and scheduling problems such as are involved in providing for laboratory time and in taking field trips. Four respondents indicated that providing adequate equipment and materials for the schools was a problem. Each of the following problems was listed by one state official: (1) grade placement of earth-science courses; (2) utilization of resource persons; (3) lack of accurate information; (4) the inertia to change; (5) the acceptance of the course in the secondary school by the community.

From this summary, it is apparent that the most pressing problem in the implementation and operation of earth-science courses was the need for qualified teachers. Partially related to the teacher problem was the acceptance of earth science as a laboratory course and the scheduling of the laboratory and field trips. These are also administrative problems.
The problems mentioned above that were listed by only one respondent are largely problems confined to a local situation. One problem, however, that of grade placement for earth-science courses, may be more general than the one response would indicate. The discussion under Category 2 pointed out that although earth science is most likely to be taught at the ninth grade level, it is taught at various grade levels from the seventh to the twelfth grade in the 46 states where it is a separate course.

**Topical Analysis of Earth-Science Textbooks**

*Used in Secondary Schools*

One of the generally accepted indices of what subject matter is included in secondary school science courses has been the topics included in textbooks used in the courses. By virtue of being published and used as either a basic textbook or a source of reference, the textbook reflects content being taught in the classroom. Analyses have been made of the topics included in secondary school science courses by Blanc,\(^\text{15}\) Carnez and Colbert,\(^\text{16}\) Davis,\(^\text{17}\) Klopp,\(^\text{18}\)

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Richards, Simmons, Webb, and Weckel. None of these is specifically concerned with the topics included in the secondary school earth-science courses. Further search of the literature failed to disclose any studies that analyzed the topics included in earth-science textbooks. An analysis of such topics was considered desirable in determining the nature of existing earth-science courses and was, therefore, planned and carried out in the following manner.

**Procedure**

A study of the methods of topical analyses cited above for general science, biology, and chemistry textbooks revealed such procedures as word counts devoted to topics, emphasis on topics in the opinion of the investigator, and gross number of pages devoted to major topics expressed as a percentage of each book. Considering the nature of the problem of determining what major topics are included in earth-science textbooks and the relative emphasis placed upon these topics by the authors, a modified page count of topics was considered to be the simplest and most accurate method of content analysis.

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Criteria for selecting the textbooks and identifying major topics were developed. Procedures for analyzing the textbooks and determining the relative emphasis of the topics were established.

**Criteria for selecting textbooks.** The following three criteria were used in identifying the textbooks to be analyzed:

1. The textbook must be devoted exclusively to earth science for secondary school courses.

2. All known textbooks in use must be included.

3. The most recent edition of each book as of January, 1963, must be used.

Four textbooks were identified as satisfying the established criteria:


The identification was verified by the fact that the four books were those reported as being used in the United States by the respondents to the questionnaire in Part I of this chapter.

**General considerations for analyzing the textbooks.** In order to select the major topics objectively and determine the relative emphasis given to these topics in each textbook, definite procedures
had to be established. Each of the four textbooks was briefly surveyed to determine possible problems in making an analysis of the major topics in each book.

Several points of difference among the books became apparent. Three of the four textbooks used a double-column format with the same length of lines of type. One book used a single-column format with the length of lines 3.3 centimeters shorter than that of the other three books. Type size, and consequently the number of lines per page, varied slightly in the four texts. There was considerable variation in the number, size, and type of illustrations used in the books as well as the amount of space given at the end of chapters to such items as suggested activities, study questions, suggestions for further study, exercises, and recommended readings. Two of the books presented an overview of the earth-science course in an introductory chapter with no development of topics at that time. Variation was also noted in the appendixes of the books with respect to the amount and type of information presented.

The differences among the textbooks were the basis of general considerations in determining the relative emphasis placed upon major topics in each book. The decision was made that the amount of space devoted to each topic identified should be determined from the printed portion and be expressed as a percentage of the total printed portion of each book. Such a procedure eliminated discrepancies due to the differences in length of lines, size of print, and number of lines per page in the four books.
The decision was made to exclude the illustrations and end-of-
chapter inclusions from the analysis of topics on the basis that the
amount of space devoted to them reflects differences in publication
practices and the availability of suitable illustrative examples for
a given topic. The value of these in the text and to the development
of the topic has not been judged, nor is it denied in any way.

Criteria for identifying major topics. The identification of
major topics was carried out by employing the following criteria in
the initial selection of topics:

1. A topic must be a subjective word or phrase.

2. A topic must be suggestive of related scientific con-
cepts to be treated in the textbook.

3. The author of the textbook must develop the topic through
the use of sub-topics or related scientific concepts that contribute
to an understanding of the topic.

Analytical procedures for determining major topics. The follow-
ing procedures were formulated and followed in analyzing each textbook
for the major topics included:

1. Topics were determined by examining the book page by page.

2. Topics meeting the established criteria were recorded
on 3x5 file cards along with the name of the book, appropriate sub-
topics, and scientific concepts developed.

3. The number of pages of text supporting the topic was re-
corded on the file card to the nearest one-half page. In counting
the pages of text, the amount of space occupied by illustrations
was subtracted so that the number recorded represented the total number of full pages of text devoted to each topic.

4. The amount of space devoted to tables such as rock and mineral keys, geologic time scale, and characteristics of the members of the solar system was included as an equivalent amount of text.

5. Prefaces, general introductions, glossaries, indices, and parts of appendixes not contributing to the development of a major topic were excluded from the page count.

6. The major topics identified in the total sample were studied. Those topics common to two or more books were reworded where necessary to be inclusive of each book.

Procedures for determining emphasis given to topics. With the major topics identified according to the established criteria and procedures, the emphasis given to these topics was determined in the following way:

1. The major topics were grouped according to the branches of science from which the topics are drawn. These branches are geology, oceanography, astronomy, meteorology, and conservation.

2. The topics were tabulated along with the pages of text devoted to each topic in the four books.

3. The total number of pages given to all topics in each book was determined.

4. The per cent of space given to each topic in each book was calculated.

Limitations of the analysis. The purpose of this analysis of earth-science topics has been to determine the content nature of existing earth-science courses as indicated by the textbooks used.
There has been no attempt to judge or compare any of the textbooks with respect to accuracy of treatment, sequence of topics, effectiveness of presentation, or the value of illustrations. All of the textbooks known to be in use are included in the analysis in order to determine the major topics being taught in courses based on these textbooks.

Major Topics in Earth-Science Textbooks

The currently used earth-science textbooks contained 25 major topics. The respective authors appear to be in general agreement as to what should be included in an earth-science textbook for the secondary school. Twenty-one of the 25 major topics are found in all four books and two of the remaining four topics, "earth chemistry" and "conservation of our resources," are included in all books either as a major topic or integrated into appropriately related sub-topics without major topic emphasis. Twenty-three, or 92 per cent, of the major topics are, therefore, common to all four earth-science textbooks. Two topics, "the stars and galaxies" and "space travel," were treated as major topics in two books and received very little or no treatment in the others.

The major topics, typical sub-topics, and number of books including them, are summarized in Table 7. Sub-topics are included to clarify the meaning of each major topic and should not be interpreted as limiting the scope of the major topic to the sub-topics listed or as indicating any preferred sequence of development.
<table>
<thead>
<tr>
<th>Major Topic</th>
<th>Typical Sub-topics</th>
<th>Number of Books Including the Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials of the earth's crust</td>
<td>rocks, minerals, economic rocks and minerals</td>
<td>4</td>
</tr>
<tr>
<td>Weathering and erosion</td>
<td>process, agents, products, soil formation and conservation</td>
<td>4</td>
</tr>
<tr>
<td>Earth chemistry</td>
<td>elements, compounds, atomic structure, oxidation, carbonation, hydration, solutions</td>
<td>1</td>
</tr>
<tr>
<td>Maps and map reading</td>
<td>topographic, geologic, map projections</td>
<td>4</td>
</tr>
<tr>
<td>Work of running water</td>
<td>ground water, surface water, landforms, floods and flood control</td>
<td>4</td>
</tr>
<tr>
<td>Water resources of the land</td>
<td>lakes, springs, swamps, wells</td>
<td>4</td>
</tr>
<tr>
<td>Glaciers and their landforms</td>
<td>alpine, continental</td>
<td>4</td>
</tr>
<tr>
<td>Volcanoes and vulcanism</td>
<td>features, extrusion, intrusion, distribution</td>
<td>4</td>
</tr>
<tr>
<td>Earth movements</td>
<td>diastrophism, folding, faulting, earthquakes</td>
<td>4</td>
</tr>
<tr>
<td>Plains, plateaus and mountains</td>
<td>structure, history</td>
<td>4</td>
</tr>
<tr>
<td>Physiographic provinces</td>
<td>locations, characteristics</td>
<td>4</td>
</tr>
<tr>
<td>Earth history</td>
<td>rock record, fossil record, geologic eras, early man</td>
<td>4</td>
</tr>
<tr>
<td>Conservation of our resources</td>
<td>soil, water, air, forests, wildlife, minerals, fuels, natural wonders</td>
<td>2</td>
</tr>
<tr>
<td>Major Topic</td>
<td>Typical Sub-topics</td>
<td>Number of Books Including the Topic</td>
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<tr>
<td>The oceans</td>
<td>extent, distribution, composition</td>
<td>4</td>
</tr>
<tr>
<td>Waves, tides and currents</td>
<td>shores, shoreline features</td>
<td>4</td>
</tr>
<tr>
<td>The stars and galaxies</td>
<td>star classification, constellations, instruments used in astronomy</td>
<td>2</td>
</tr>
<tr>
<td>The solar system</td>
<td>origin theories, sun, moon, planets</td>
<td>4</td>
</tr>
<tr>
<td>Planet Earth</td>
<td>structure, shape, motion, seasons, location and navigation, keeping time</td>
<td>4</td>
</tr>
<tr>
<td>Space travel</td>
<td>artificial satellites, orbits, rockets, Man in space</td>
<td>2</td>
</tr>
<tr>
<td>Nature of the atmosphere</td>
<td>composition, layers, light and color temperature changes, pressure changes, lightning</td>
<td>4</td>
</tr>
<tr>
<td>Changing winds</td>
<td>Coriolis effect, wind belts, local winds</td>
<td>4</td>
</tr>
<tr>
<td>Water in the atmosphere</td>
<td>evaporation, condensation, precipitation</td>
<td>4</td>
</tr>
<tr>
<td>Weather</td>
<td>air masses, fronts, cyclones, anticyclones, thunderstorms</td>
<td>4</td>
</tr>
<tr>
<td>Climate</td>
<td>factors, climates of the world</td>
<td>4</td>
</tr>
<tr>
<td>The Weather Bureau</td>
<td>weather maps, forecasting</td>
<td>4</td>
</tr>
</tbody>
</table>
For the purpose of analyzing the major topics, they are grouped into the science areas from which the content has apparently been selected. Twenty-four of the 25 major topics were considered to be derived from the sciences of geology, oceanography, astronomy, and meteorology. The one additional major topic, "conservation of our resources," is treated separately because it involves each of the four science areas of the other topics plus additional sciences such as botany and zoology.

**Geology topics.** Major topics from geology received the greatest emphasis in the amount of space devoted to them in the currently used earth-science textbooks. Twelve major topics from geology received an average of 52.9 per cent of the total text space in the four books. There is, however, considerable variation in the emphasis given to individual geology topics among the books. The major topics, the amount of space given to them in each textbook, and the total for all four books are recorded in Table 8.

The topic "materials of the earth's crust" received the greatest emphasis with 10.3 per cent of the total space in the four books devoted to this topic. Three other geology topics, "earth history," "work of running water," and "plains, plateaus and mountains," had 7.8, 7.2, and 5.6 per cent of space given to them respectively. "Weathering and erosion" received 4.6 per cent of the text space, "water resources of the land" and "glaciers and their landforms" each 3.5 per cent, and "earth movements" 3.0 per cent of the space in the four textbooks. The other four topics, "volcanoes and vulcanism,"
<table>
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<tr>
<th>Topic</th>
<th>Textbook</th>
<th>Total in All Books</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>%</td>
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<td>GEOL OGY TOPICS:</td>
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<td>Materials of the earth's crust</td>
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<tr>
<td>Earth chemistry</td>
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<td>Maps and map reading</td>
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<td>Water resources of the land</td>
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<td>Volcanoes and vulcanism</td>
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<td>Glaciers and their landforms</td>
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<td>Plains, plateaus, and mountains</td>
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<td>Stars and galaxies</td>
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<td>11</td>
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<td>5.4</td>
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<td>Nature of the atmosphere</td>
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<td>Conservation</td>
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*Included in related major topics, but not given major topic emphasis.
"physiographic provinces," "maps and map reading," and "earth chemistry," ranged in emphasis from 2.4 down to 0.7 per cent of the space in the four books.

The fact that "earth chemistry" appeared as a major topic in only one book does not mean that earth chemistry was not included in the other three books. This topic was included in the other textbooks but it was integrated into the other major topics without receiving major topic emphasis.

Oceanography topics. Two major topics were identified that involve concepts from the scientific area of oceanography. Both topics, "the oceans" and "waves, tides and currents," occurred in all four books, receiving an average of 7.3 per cent of the text space.

Astronomy topics. The major topics from astronomy identified in the textbook analysis were "the stars and galaxies," "the solar system," "Planet Earth," and "space travel." These four topics received 12.1 per cent of the space in the combined total for all books. A variation of from 3.6 to 19.0 per cent of the space in the individual books occurred for the astronomy topics. Part of the variation was a result of the topics "stars and galaxies" and "space travel" not being included in two of the textbooks.

Meteorology topics. A total of 25.4 per cent of the text in the four earth-science textbooks was drawn from the science of meteorology. The topics "climate" and "nature of the atmosphere" received 6.7 and 6.4 per cent respectively of the space in the books. The other topics which accounted for 3.9 to 1.9 per cent of the space
were "water in the atmosphere," "weather," "changing winds," and "the
Weather Bureau."

**Conservation as a topic.** Two of the earth-science textbooks
included "conservation of our resources" as a major topic with 4.3 and
4.9 per cent of the space devoted to the topic. The total space for
all four books was 2.3 per cent, the lower figure resulting from
conservation not being included as a major topic in two of the books.
Conservation was treated at appropriate points, however, in other
major topics in the two books where it was not treated as a separate
major topic.

**Summary of topics found in earth-science textbooks.** The four
earth-science textbooks included 25 major topics drawn from the science
areas of geology, oceanography, astronomy, meteorology, and conserva-
tion. Geology received a total of 52.9 per cent of the space in the
books; 7.3 per cent of the textbook concerned oceanography topics;
12.1 per cent of the textbook was devoted to topics from astronomy;
meteorology topics received 25.4 per cent of the textbook space; and
major topic emphasis from conservation was 2.3 per cent. The number
of pages of text, the percentages for each book, and the total for all
four books are summarized in Table 9.

If each of the 25 topics in the textbooks had been given equal
emphasis by the authors, each topic would involve four per cent of the
textbook. From Table 8, it is apparent that the following topics re-
ceived greater than four per cent of the textbook space:

1. Materials of the earth's crust  (10.3%)
2. Earth history  (7.8%)
Table 2

Emphasis of Earth-Science Textbooks According to Branches of Science Involved

<table>
<thead>
<tr>
<th>Major Topics From:</th>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>Total All Books</th>
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<tr>
<td></td>
<td>Pages</td>
<td>%</td>
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<td>%</td>
<td>Pages</td>
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<tr>
<td>Geology</td>
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<td>195.5</td>
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<td>22.5</td>
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<td>14.6</td>
<td>64</td>
<td>19.0</td>
<td>39.5</td>
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<td>16.4</td>
<td>90.5</td>
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<td>Conservation</td>
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<td>15.5</td>
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<tr>
<td>Totals</td>
<td>304.5</td>
<td>99.9</td>
<td>337.5</td>
<td>99.9</td>
<td>359</td>
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</table>
3. Work of running water (7.2%)
4. Climate (6.7%)
5. Nature of the atmosphere (6.4%)
6. Plains, plateaus and mountains (5.6%)
7. Planet Earth (5.3%)
8. Weathering and erosion (4.6%)
9. Solar system (4.5%)

These nine major topics comprised 58.6 per cent of the total space in the four textbooks.

Implications of the analysis of major topics. Ninety-two per cent of the 25 major topics was found in all of the four textbooks, although the amount of emphasis given to the topics varied considerably. For example, "materials of the earth's crust," the topic that received the greatest percentage of space in all four books, ranged from 6.3 per cent to 13.6 per cent of the space in the individual books. It may be assumed that the major topics presented by the textbook authors would determine to a large extent what is taught in earth-science courses in the secondary schools if a textbook is being used.

The teacher of earth science, on the basis of this analysis, needs to be competent in teaching concepts from the science areas of geology, oceanography, meteorology, and astronomy. In geology, the major topics are derived from such specialized areas as mineralogy,
petrology, geomorphology and physical geography, structural geology, and paleontology. The oceanography concepts needed by earth-science teachers are largely the physical oceanography topics of composition, extent and distribution of the oceans, and the mechanics and effects of waves, tides, and currents. Astronomy concepts most needed by teachers using any of the textbooks are those related to the solar system with special emphasis on the earth as a planet. Minor attention is given to "stars and galaxies" as a topic and to the astronomy-related topic of "space travel." From the area of meteorology, the earth-science teacher would need a comprehensive understanding of the nature of the atmosphere, cause and effect factors in weather phenomena, and the contributing factors and distribution of world climates.

A further implication of the analysis of major topics is that the earth-science courses using any of the textbooks would tend to be taught for the school year with fractional parts of the time devoted to study of the topics from each science area. Geology would thus be the science studied for about one-half of the total time, meteorology would involve about one-fourth of the time, and astronomy, oceanography, and conservation topics would be of concern in the remaining one-fourth of the course.
Topical Analysis of State and Local Courses of Study in Earth Science

The identification and analysis of major topics found in currently used earth-science textbooks was considered to be a source of evidence concerning the nature of the developing earth-science course in the United States. Another source of evidence was the topics included in courses of study in earth science for various state and local school systems. These courses of study have resulted from curriculum studies made by committees of the school systems involved. Available in published or mimeographed form, they may be known as courses of study, curriculum guides, teaching guides, or course outlines. The term "course of study" has been interpreted and used in this analysis as a general term that includes the other terms given.

Courses of study indicated the subject-matter to be taught in the state or local area concerned and may contain topical emphases not included in textbooks. If topics are being included in courses of study that are not found in the available textbooks, a determination of these topics would reveal significant evidence lacking in the textbook analysis. This additional evidence could indicate trends in the nature of the developing courses with implications for the concepts needed by the teacher of earth science. The following analysis was planned and carried out in order to secure evidence that could be compared with and possibly extend the evidence found in the textbook analysis of the topics included in earth-science courses.
Procedure

The available courses of study in earth science were identified by consulting the United States Office of Education bibliography of state curriculum guides, the curriculum materials displayed at the 1963 National Science Teachers Convention, and by communication with individuals concerned with earth-science curriculum development in the secondary schools. Courses of study were requested and obtained from science supervisors in New York, Pennsylvania, Vermont, North Dakota, Texas, Oklahoma, Allegany County Public

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26Teaching Guide for the Earth and Space Science Course (Harrisburg, Pennsylvania: Department of Public Instruction, 1959).


28"Outlines for 7th and 8th Grade Science" (Bismarck, North Dakota: Department of Public Instruction, 1963), mimeographed.


Schools in Maryland,31 and Lakewood Public Schools in Ohio.32

The major topics included in the courses of study were determined by establishing criteria that were used in the identification. Procedures for analyzing the topics were developed and used in an effort to make the analysis as objective as possible.

Criteria for identifying major topics. The initial identification was accomplished by employing the following criteria:

1. A topic must be a subjective word or phrase.
2. A major topic must be suggestive of related scientific concepts that could be included in a study of the topic.
3. A major topic must be supported by the inclusion of sub-topics or related concepts that contribute to an understanding of the major topic.

These criteria are practically identical to the criteria used in identifying the major topics in earth-science textbooks since the nature of a major topic is considered to be the same in either a textbook or a course of study. In addition, consistency in identification of major topics facilitated a comparison of topics found in both sources.

31“Teaching Guide for Earth Science” (Cumberland, Maryland: Allegany County Public Schools, 1961), mimeographed.

Analytical procedures for determining major topics. The following procedures were used in analyzing the major topics in state and local courses of study in earth science:

1. Topics were identified by using the established criteria in a page by page examination of each course of study.

2. Topics were recorded on strips of paper approximately three inches wide with space between topics so that the individual topics could be separated for analysis. The name of the state or local area was recorded on each paper strip as well as representative sub-topics or scientific concepts supporting the major topic.

3. The major topics identified in the total sample were placed on large sheets of paper ruled into eight parallel columns, one column for each course of study in the sample.

4. Major topics were arranged so that those common to two or more courses of study were in the same horizontal position in the columns for the appropriate course of study.

5. The major topics found in all sources were studied. Topics common to two or more courses of study were reworded where necessary to be representative of the topic from each source.

6. The major topics from all sources were tabulated by listing the topics and indicating the courses of study which included each topic.

7. The emphasis given to major sections of the earth-science courses was determined by analyzing the amount of time recommended for groups of topics in the course of study giving this information.
Limitations of the analysis. The analysis of earth-science topics included in state and local courses of study is limited by the number included in the analysis. There may be additional courses of study produced by state and local school systems which were not identified in the sources of information used. However, the courses of study included in this analysis are representative of the earth-science courses offered in 1962-63. Data summarized in Appendix B and used in determining the status of earth-science courses in the United States revealed that the states represented in this analysis of courses of study, New York, Vermont, Pennsylvania, North Dakota, Texas, and Oklahoma, account for 1,567 of the 3,052 schools offering earth-science courses and 105,968 of the 190,418 students taking these courses in 1962-63.

The courses of study have been analyzed for the purpose of determining the major topics included in the earth-science courses represented. No attempt has been made to compare or judge the courses of study in terms of accuracy of treatment, sequence of topics, or effectiveness of presentation.

Major Topics in Courses of Study in Earth Science

Thirty-six topics were treated as major topics in one or more of the courses of study. From Table 10, in which the major topics are summarized and the courses of study including them are indicated, it is apparent that earth-science courses taught from these courses of study have much in common. Sixteen of the 36 topics are found in all
Table 10

Major Topics in Earth Science From State and Local Courses of Study

Code:  X = included as a major topic  
       i = included in a related major topic

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<td>X</td>
<td>X</td>
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<tr>
<td>The oceans</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>i</td>
<td>X</td>
<td>i</td>
<td>i</td>
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<td>Waves, tides, and currents</td>
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<td>X</td>
<td>i</td>
<td>X</td>
<td>i</td>
<td>i</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>The ocean floor</td>
<td>i</td>
<td>i</td>
<td>X</td>
<td>i</td>
<td>X</td>
<td></td>
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<td>Ancient sea level changes</td>
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<td></td>
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<tr>
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<td>i</td>
<td>i</td>
<td>i</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Matter and energy</td>
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<td></td>
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<td>ASTRONOMY TOPICS:</td>
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<td></td>
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<tr>
<td>Stars and galaxies</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>i</td>
<td></td>
<td>X</td>
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</tr>
<tr>
<td>Solar system</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Planet Earth</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>8</td>
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</tr>
<tr>
<td>Space travel</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
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<td>7</td>
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<tr>
<td>The Universe</td>
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<tr>
<td>Instruments in astronomy</td>
<td>X</td>
<td>i</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Astronomy as a vocation or hobby</td>
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<tr>
<td>Law of universal gravitation</td>
<td>i</td>
<td>i</td>
<td>i</td>
<td>i</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Earth's atmosphere</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8</td>
</tr>
<tr>
<td>Solar energy</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8</td>
</tr>
<tr>
<td>Air pressure and air motion</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8</td>
</tr>
<tr>
<td>Moisture in the air</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8</td>
</tr>
<tr>
<td>Weather</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8</td>
</tr>
<tr>
<td>Optical phenomena</td>
<td>X</td>
<td>i</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Climate</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>i</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>7</td>
</tr>
<tr>
<td>The Weather Bureau</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>i</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>
eight courses of study. Three additional topics are included in seven of the sources, six topics in six of the sources, one topic in five sources, and three topics in four of the courses of study. Twenty-five of the thirty-six topics are, therefore, common to one-half of the courses of study.

The topics common to two or more of the sources of study did not receive major topic emphasis in all cases as indicated by the notation "i" in Table 10. This notation is included to show that the topic is included in the course of study in some way other than as a major topic, usually as a sub-topic or scientific concept related to a major topic. The blank spaces in any column in Table 10 should be interpreted as meaning that the topic did not appear either as a major topic or as a sub-topic contributing to a major topic.

The major topics presented in Table 10 are grouped into the science areas from which the topics are derived. Such grouping occurs in the Texas, North Dakota, and Lakewood, Ohio, courses of study and is referred to in introductions, references cited, and appendixes in the others.

**Geology topics.** Twelve, or one-third of the 36 major topics identified in the state and local courses of study, were from geology. The following topics were common to all the sources analyzed: "the earth's crust," "rocks and minerals," "weathering and erosion," "earth movements and resulting landforms," "landforms produced by wind, water, and ice," "volcanoes and vulcanism," and "geologic history of the earth."
Three topics, "earth's interior structure," "the waters of the land," and "geology of state and local areas," were common to six of the courses of study. The topics "maps and map reading" and "physiographic regions" were found in five and three of the courses of study, respectively.

**Oceanography topics.** Six topics in oceanography were included in the courses of study. Two of these, "the oceans," and "waves, tides, and currents," were found in all eight sources, and one topic, "the ocean floor," was found in six of the sources. Each of the remaining three topics, "origin of islands," "ancient sea level changes," and "habitat for plants and animals," was a major topic in one course of study.

**Astronomy topics.** Eight major topics in astronomy were found in the courses of study. Two topics, "solar system," and "Planet Earth," were common to each of the eight courses of study. Seven courses of study included two additional topics, "stars and galaxies" and "space travel." Three topics, "the universe," "instruments in astronomy," and the "law of universal gravitation," were included in four of the courses of study. One course of study included the topic "astronomy as a vocation or hobby."

**Meteorology topics.** Eight major topics in meteorology were found in the courses of study. Five of the eight, "earth's atmosphere," "solar energy," "air pressure and air motion," "moisture in the air," and "weather," were found in each course of study. "Climate" as a topic appeared in seven of the sources, "the Weather Bureau" was
included in six sources, and "optical phenomena" was a major topic in three courses of study.

Conservation topic. One conservation topic, "conservation of earth's resources," was found to be included in six of the courses of study, in three as a major topic and in three in conjunction with one or more of the major topics to which conservation may be related.

Physical science topic. One course of study included the physical science topic "matter and energy" as the introductory unit in a seventh grade science course that was otherwise devoted to topics in earth science.

Emphasis on Earth-Science Areas

The analysis of major topics in state and local courses of study did not reveal what emphasis would be placed upon a given topic in the course. Six of the courses of study included a suggested schedule giving recommendations for the allocation of time in the earth-science course. These recommendations are given in terms of the amount of time to be devoted to major topics, units, or other subdivisions of the course. For example, the New York Course of Study suggests the following time allotment:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>The earth's surface</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Destructional forces</td>
<td>6 weeks</td>
</tr>
<tr>
<td>Constructional forces</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Age of the earth</td>
<td>2 weeks</td>
</tr>
<tr>
<td>The earth in space</td>
<td>6 weeks</td>
</tr>
<tr>
<td>The atmosphere</td>
<td>5 weeks</td>
</tr>
<tr>
<td>Air masses and fronts</td>
<td>5 weeks</td>
</tr>
</tbody>
</table>

The first four of the above sub-divisions included the major topics from the science areas of geology and oceanography; the sub-division "the earth in space" included the astronomy topics; the remaining two sub-divisions were concerned with the topics from meteorology.

Time allotment recommendations were also found in the courses of study from Lakewood, Ohio, North Dakota, Pennsylvania, Texas, and Vermont. The information from all six sources has been summarized in Table 11 by grouping the recommended periods of time for the sub-divisions of the course into the science areas from which they are derived. In each case, these periods of time were expressed as the percentage of the course from the indicated science area.

Considerable variation in the amount of emphasis given to the science areas in the six courses of study is noted in studying Table 11. Emphasis on geology topics ranges from 28.6 to 51.6 per cent in the six sources. Topics in oceanography were not found in one course of study, but made up 22.8 per cent of the course in Texas and less than

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35 North Dakota Course Outline, op. cit.
37 Texas Curriculum Guide, op. cit., from time allotment listed in the Table of Contents.
Table 11

Emphasis of Earth-Science Courses of Study According To Branches of Science Involved

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Geology</td>
<td>44.3</td>
<td>50.0</td>
<td>51.6</td>
<td>34.4</td>
<td>28.6</td>
<td>50.0</td>
</tr>
<tr>
<td>Oceanography</td>
<td>6.6</td>
<td>*</td>
<td>*</td>
<td>9.4</td>
<td>22.8</td>
<td>*</td>
</tr>
<tr>
<td>Astronomy</td>
<td>24.8</td>
<td>18.8</td>
<td>25.8</td>
<td>28.1</td>
<td>28.6</td>
<td>18.8</td>
</tr>
<tr>
<td>Meteorology</td>
<td>22.1</td>
<td>31.2</td>
<td>22.6</td>
<td>28.1</td>
<td>20.0</td>
<td>31.2</td>
</tr>
<tr>
<td>Conservation</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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</tr>
</tbody>
</table>

*Oceanography topics are included as a part of the geology section in the course of study from the state indicated at the heading of the column.

10 per cent in each of the other courses of study. The astronomy and meteorology topics had a narrower range of emphasis in the courses of study represented than was the case in geology and oceanography. Astronomy topics ranged from 17.8 to 28.6 per cent and topics from meteorology ranged from 20 to 31.2 per cent of these six courses of study. One course of study, that from Lakewood, Ohio, included a recommended time allotment for conservation topics, 2.2 per cent of the course.

Comparison of Emphasis in Textbooks and Courses of Study

The emphasis given to the presentation of topics from geology, oceanography, astronomy, meteorology, and conservation has been
summarized in Table 9, page 144, for the earth-science textbooks and in Table 11, page 159, for six state and local courses of study. A comparison of the emphasis given to each science in the textbooks and courses of study has been made in order to determine similarities and differences in viewpoint between textbook authors and the writers of state and local courses of study in earth science.

The comparison is made with the realization that an assumed direct relationship exists between the emphasis as indicated by the amount of space devoted to each science area in textbooks and by the recommended time for each science area in the courses of study. To the extent this assumption is true, the comparison is valid. The data of this study do not furnish evidence to verify or negate the assumption, so the principal value of the comparison is considered to be the indication of possible trends and changing emphases in earth-science courses.

The comparison of emphases is illustrated in Figures 3, 4, 5, and 6. The data for these figures were taken from Table 9, page 144, for the textbooks and Table 11, page 159, for the courses of study.

Geology emphasis. Emphasis given to geology topics in the textbooks and courses of study, as illustrated in Figure 3, indicated that four of the courses of study were in general agreement with the amount of emphasis given to geology topics in the textbooks. Three of the textbooks equalled or exceeded the emphasis on geology topics in any of the courses of study. Two of the courses of study, those from
Pennsylvania and Texas, recommended much less emphasis on geology topics than either the textbooks or other courses of study.

Three courses of study, those from New York, North Dakota, and Vermont, included oceanography topics in the time allocated to the geology portion of the course. The oceanography topics as presented in Table 8, page 139, for the textbooks are essentially the same as those found in the courses of study for these three states as summarized in Table 10, page 152. No comparison of the emphasis on oceanography can be made for the three courses of study except to note that by combining the emphasis on geology and oceanography topics of the textbooks in Figures 3 and 4, the combined emphasis in each of the textbooks was greater than the time allocation emphasis in the New York, North Dakota, and Vermont courses of study.

**Figure 3**

Emphasis on Geology Topics in Textbooks and Courses of Study
Figure 4
Emphasis on Oceanography Topics in Textbooks and Courses of Study

Figure 5
Emphasis on Astronomy Topics in Textbooks and Courses of Study
Oceanography emphasis. The textbook emphasis on oceanography topics ranged from 4.9 to 10.6 per cent while the emphasis in three courses of study which included a separate time allocation for oceanography ranged from 6.6 to 22.8 per cent. These emphases, illustrated in Figure 4, indicated that oceanography topics were seen as a relatively minor area of study in earth-science courses, generally less than 10 per cent. One exception was clearly evident. The Texas course of study allocated 22.8 per cent of the course time to oceanography, more than double the emphasis in the other courses of study or any of the textbooks.
Astronomy emphasis. Astronomy topics, as shown in Figure 5, received more emphasis in the courses of study than in three of the earth-science textbooks. The textbook with the most space devoted to astronomy had approximately the same emphasis as the New York and Vermont courses of study, the two courses of study having the least emphasis on astronomy. The courses of study as a group, therefore, placed more emphasis on astronomy than did the textbooks.

Meteorology emphasis. The emphasis on meteorology varied considerably among the textbooks and the courses of study. Figure 6 shows this variation to range from 16.4 to 34.8 per cent in the textbooks and 20 to 31.2 per cent in the courses of study. There appeared to be agreement in three of the courses of study at approximately 20 to 22 per cent of the course emphasis, and in the other three at approximately 30 per cent of the course. Between these two groupings, an emphasis of 25 to 26 per cent was included in two of the textbooks. The other two textbooks formed the extremes in the range of emphasis for both the textbooks and courses of study.

Conservation emphasis. There was little basis for comparison of the conservation topics in the earth-science textbooks and the courses of study. The Lakewood, Ohio, course of study emphasized conservation to the extent of 2.2 per cent of the time allocation for the course. Although conservation topics are included in the other courses of study, they are developed in conjunction with appropriate major topics and were not allocated an identifiable block of time. Two of the textbooks followed the pattern of developing conservation topics as a part of the related major topics while the other two devoted 4.3 and 4.9 per cent of the text space to conservation as a topic.
The inclusion of conservation in the development of other topics indicated a degree of general agreement between the authors of two of the textbooks and the writers of the state courses of study.

Possible Trends and Changes in Emphasis

The comparison of the emphases in textbooks and courses of study indicated several possible trends in the earth-science courses being taught in secondary schools. There appears to be a trend toward:

1. State and local areas placing less emphasis on geology topics than do textbooks.

2. Oceanography topics receiving more emphasis in some areas, notably Pennsylvania and Texas, than is generally the case in textbooks and courses of study from other states.

3. State and local areas including more emphasis on astronomy topics than is found in the currently available textbooks.

4. Including the concepts of conservation as integral parts in the development of major topics in geology, oceanography, meteorology, and astronomy rather than in a separate study of conservation.

5. Continuing the trend established in the textbooks of treating the earth-science areas of geology, oceanography, astronomy, and meteorology as separate divisions of the course.
Analysis of Earth-Science

Institute Programs

The Summer Institute program of the National Science Foundation has provided opportunities for many science teachers to strengthen their background in the subject matter they teach. Until recently very few of these institutes were designed for the needs of earth-science teachers. During the summer of 1962, however, 23 programs designated as Earth Science Institutes were held at various institutions of higher learning in the United States. Each of these institutes was designed by interested personnel in a host institution to improve the subject matter competency of the teachers who would be attending. Proposals were submitted to, and approved by the National Science Foundation who provided funds for financial assistance to the institution and the participating teachers.

Following the completion of each institute, the director submitted a three-part report to the National Science Foundation. These reports, standardized as to format and type of information requested, are considered privileged documents and are not released by the National Science Foundation. The individual director may make his report available at his own discretion. After a study of the kinds of information the reports would contain, it was decided to request copies of selected pages of the Earth Science Institute reports from the directors concerned.

The selected pages requested from each director contained information on the kinds of courses offered, selection criteria, problems
with content level, reactions of participants to the program, plans for continued individual development, reaction of staff to the program, and ways of improving the institute program on the local and regional levels. A copy of the report pages requested from each director has been placed in Appendix C. The names of the directors and institutions where institutes were held were obtained from the National Science Foundation brochure, "Summer Institutes for Science, Mathematics, and Engineering Teachers, 1962." The list of institutes and directors participating in this study is included in Appendix C.

The requested sections of the reports were concerned with participant qualifications and the experience the participants had in the institute. Through analysis, the value and need of certain kinds of experiences for earth-science teachers may become apparent that would have implications for experiences to be included in a teacher preparation program. The analysis which follows combines the reports from all of the participating institutes. Individual institutes and their programs are not identified because of the confidential nature of each report.

The analysis is in the form of a subjective description of the institute programs, as compiled from the directors' reports. These reports were predominantly in narrative style. Information pertaining to the value and need of various kinds of academic preparation and desirable learning and teaching experiences has been selected from the reports for this analysis. Included is information from 20 of the 23 Earth Science Summer Institutes held in 1962, as furnished by
the directors of these institutes. The analysis, therefore, represents 86.9 per cent of the earth-science institutes held in 1962. The information from 3 institutes was not made available.

Courses Offered and Participants Enrolled

The 20 institutes included in this study offered a total of 43 separately identifiable courses to a combined total of 760 secondary school science teachers during the summer of 1962. There was considerable variation in course titles among the different institutes, but these grouped easily into ten generalized course titles. For example, Physical Geology, Topics in Physical Geology, and Geological Processes are considered as Physical Geology. Some institutes offered courses similar in title to Physical and Historical Geology. In the description which follows, the numbers of participants taking such courses are included as taking both Physical Geology and Historical Geology so as to obtain information concerning how many teachers were concerned with concepts from each area.

The 20 institutes listed a total of 37 courses, or 86 per cent of all courses offered as being especially designed for the institute participants. In all of these course offerings, regular participants—those receiving stipends—were usually the only students enrolled. In three institutes, a total of 14 teachers, other than regular participants were permitted to take the institute courses. Only one institute had non-teachers enrolled as students in institute courses; four such students were in the institute astronomy course along with 33 teachers.
These four students are not included in the total of 760 teachers enrolled in institute courses.

**Physical Geology.** Nine institutes offered courses in physical geology which, from the brief descriptions given, were essentially introductory courses requiring little or no background in geology. The number taking a course dealing with physical geology concepts was 336, or 44.2 per cent of the total teachers in the institute programs.

**Meteorology.** Four institutes included meteorology in their summer offerings, all at the introductory level. Teachers taking meteorology as a part of their institute program totaled 161, representing 21.2 per cent of the teachers in the programs.

**Field Geology.** Three institutes offered a major portion of the summer's work in the field. One of these institutes required a previous background in geology or a previous summer institute. The other two institutes offered introductory geology courses with a major portion of the course taught in the field. Seventy-eight teachers participated in these three institutes. Thus, slightly over 10 per cent of the total number of teachers in the institute programs had a major portion of their work in the field. In the other institutes, field trips were included in most of the geology and meteorology courses that were offered, but the number of such trips was limited.

**Physical Geography.** One institute offered physical geography as a separate course in the program. This course was taken by 22 teachers.
Development of Modern Science. Teachers in one institute took a course in the development of modern science. This course is described as dealing with the nature of science and its place in human culture and is developed from a study of sequences from the history of science. Twenty-four teachers studied this course.

Historical Geology. Courses involving the understandings of historical geology concepts were included in the offerings of ten institutes. As in the case of the physical geology courses, little or no background in geology was required of the students prior to this course. In the ten institutes, 372 teachers, 49 per cent of all participants, obtained information and background in historical geology.

Earth Science. Six of the 20 institutes offered what may be considered as integrated courses in earth science or concurrent courses related to the earth-science theme. From the descriptions of these offerings, the 201 teachers enrolled, 26.4 per cent of the total, were concerned with basic concepts from physical and historical geology, paleontology, astronomy, meteorology, and physical geography. Four of the six institutes had no prerequisite for the courses, while the other two required previous course work in the earth sciences or in biology, chemistry, and physics.

Oceanography. Four institutes offered course work in oceanography. One of these required a substantial academic background in science as prerequisite to the study of oceanography. Three institutes included oceanography content as a part of a survey course or combined with meteorology. A total of 146, 19.2 per cent of the teachers obtained oceanography concepts in the institute programs.
Astronomy. Astronomy was offered as a separate course in five institutes. In each case, the course was offered at the introductory level with no prior courses in astronomy required. Of all teachers participating in the program, 197, or 25.9 per cent, took introductory astronomy.

Mineralogy. One institute offered a course in mineralogy to its participants. A prerequisite for this course was at least one geology course. The course was thus considered an advanced one for the 40 teachers who participated in this institute.

Course and Enrollment Summary
Related to Needs of the
In-Service Teacher

In the preceding descriptions of the ten kinds of courses offered, the predominance of basic or introductory courses is apparent. Physical and historical geology were taken by 44.2 per cent and 49 percent, respectively, of the total of 760 institute participants. An additional 26.4 per cent of the participants were concerned with basic concepts in an earth-science course organized to present the areas commonly included in the secondary school earth-science course - geology, astronomy, and meteorology. The participants taking other basic but separate courses include the following: oceanography, 19.2 per cent; astronomy, 25.9 per cent; meteorology, 21.2 per cent; field geology, 10 per cent; physical geography, 3 per cent; development of modern science, 3.2 per cent; and mineralogy, 5.3 per cent.

From the viewpoint of the academic specialties involved in the courses offered, each course may be considered basic to the broad field
of earth science. A varying amount of science background was required by individual institutes, but only 3 courses - mineralogy, one field course, and one advance geology course - required any prerequisite course in geology, and no earth-science prerequisites were required in the other courses offered. All of the institutes thus offered basic or introductory courses. It must be assumed that those responsible for conducting these institutes considered basic courses as the greatest need of the in-service earth-science teacher.

The assumption obtains a degree of validity when related to the number of teachers applying for possible selection to a given institute's program. Several reports mentioned the problem of selecting a relatively small number of invitees from the large numbers of worthy applicants. Other reports were quite specific, such as: selecting 50 invitees out of 754 applications, 25 out of 547, and 30 out of 300. A conservative estimate would seem to be that 10 per cent or less of all teachers applying were able to attend earth-science institutes designed primarily for teachers who lacked introductory academic preparation in the earth sciences. The numbers of teachers applying indicated the need for the earth-science offerings by the applicants and justified the assumptions made by the scientists who plan the programs.

**Selection Processes**

Selection of participants for the institutes was generally done by the director and one or more persons who would be directly concerned with the persons invited. In some cases, the applications were
screened initially by the director or clerical help to eliminate those who obviously could not meet the selection criteria. All applications were evaluated according to criteria established by each institute director. Selection of participants was then made on the basis of how well the applicant met the established criteria.

**Generalized selection criteria.** The criteria used for selection of participants varied in some details among the 20 institutes participating in this study. Variations were noted in criteria for age requirements, years of teaching experience, and grades attained in previous science courses. A combination of the criteria used in each institute resulted in six generalized selection criteria which were representative of those reported by each director. The typical applicant was selected within the following criteria:

1. Preference is given to those applicants who have participated in the fewest number of previous institutes. A previous institute should prepare the student for this one.

2. The applicant should have a fair to good background in the sciences, preferably in two or more areas such as chemistry and physics, or biology and chemistry.

3. The applicant should have at least two years of successful teaching experience and be currently teaching one or more earth-science or general science courses. If not teaching such a course currently, he must anticipate this field as a teaching or supervisory responsibility in the coming year.
4. The applicant must need academic work in the institute offerings, either through not having had such work, or having had the work so long ago that it is no longer usable.

5. Through his scholastic record, the applicant must have demonstrated ability to perform at a satisfactory level in this institution. His grades in previous science courses will be carefully considered.

6. The applicant's motivation and reasons for wanting to attend the institute, as indicated in his essay, must be sound and reasonably well stated.

These generalized criteria indicate that the applicants who were selected needed the basic or introductory course work being offered in the institutes. Earth-science course work was not the only need; the applicant must have had a background in other science areas to benefit from the institute. Such a background should have come from previous undergraduate work, or study in a prior institute. A third need was the motivation and desire to participate successfully in the institute and to utilize the information gained from the institute in his own teaching.

Effectiveness of the selection process. The use of the selection criteria was subjectively evaluated by each director in his report. In 15 of the 20 reports, the directors indicated that the criteria proved highly satisfactory although six qualified their responses with respect to one or more of their criteria. The qualifications included these comments:

1. Only 70 to 80 per cent of the participants had similar usable backgrounds.
2. Letters of recommendation tended to be over-flattering and lack objectivity,

3. Education courses being listed in the application was not helpful in selecting participants,

4. There was a lack of correlation between college grades and performance in the institute,

5. There was a direct correlation between the quality of the participant's essay (required on each application) and his performance in the institute.

Four additional directors indicated their satisfaction that the selection process was effective in selecting most of the participants. Some dissatisfaction was expressed concerning the performance of a few participants who met the criteria and did not perform as well as their applications indicated they should. The difficulty of equating grades earned in various colleges and universities was the source of another dissatisfaction. One director was disappointed that "few of the participants demonstrated any more than a mediocre ability to express ideas and very few took the opportunity to use original thinking or ideas in answering subjective questions."

Problems Concerning the Content or Level of the Program

The majority of the institute directors, 16 of the 20, reported that their program needed very little adjustment. The common reason given was that the institute program was tailor-made with the needs of the teachers in mind. Exploratory examinations were given in one institute in determining the level of presentation. A director of one of the three field programs indicated that adjustment was relatively easy in a course taught in the field. Any given topic could be treated
from a very elementary to an advanced level whenever the need arose.

In the four reports which indicated that the programs needed to be adjusted, a number of problems were mentioned. Two directors reported that the weak backgrounds of the participants necessitated a downward adjustment in scientific terminology and content; that they were overscheduled and moving too fast for the participants. Their schedules were adjusted accordingly. It should be noted that in both of these institutes, participants with a weak background in science were intentionally selected. Among other problems mentioned were the following: the teachers were overly concerned about grades; the teachers were concerned about the methods of teaching earth science, which should not be the concern of this institute; adjusting to widely divergent abilities and backgrounds is difficult; the work in some areas of study is more demanding on the individual than in others, depending upon the student's background; and two problems concerning choice of material - that of selecting appropriate material from the wealth of material available; and that of selecting material which will be useful directly or indirectly in the teacher's earth-science course.

Program problems related to the science teacher's needs. The need of secondary school science teachers for introductory course work was emphasized by the comments in the directors' reports concerning the content or level of the program. Since 16 directors reported their planned course work, which was essentially introductory, needed little or no adjustment in content and level, it was apparent that these courses were appropriate for the participants. The adjustments that
were made were such as to lower the level of sophistication - a further indication of need for a basic understanding of the areas comprising earth science.

One difference in viewpoint concerning methods of teaching earth science was apparent in the directors' reports. Three directors listed the problem of helping teachers become familiar with the selection of materials and/or content appropriate for use in a secondary school. One director indicated problems of teaching methods should be the concern of education-type courses rather than the institute's science courses.

**Effectiveness of Extra-Curricular Activities in Meeting Participants' Needs**

A variety of extra-curricular activities was reported by the directors. One-half of the institutes had regularly scheduled, but voluntary, conferences, seminars, or special lectures which were well attended and considered effective in meeting the participants' needs. In three of these ten institutes, regular sessions were devoted to the presentation and discussion of demonstrations, projects, and subject matter suitable for use in secondary schools. Seven institutes provided facilities and personnel at times other than class hours for study sessions, extra laboratory work, and informal discussions. Field trips, in addition to those scheduled, as a part of the course work, were arranged in five institutes. These extra field trips were requested by the teachers and were considered to be a helpful addition to the teachers' experience. Other activities mentioned included: instructors entertaining at private receptions and picnics, informal
discussion groups or dormitory "bull sessions," and luncheons with the staff members. All were considered effective in encouraging group interaction and in meeting the individual needs of the participants.

Positive and Negative Reactions of Participants to Their Institute Experience

The directors' reports contained the positive (favorable) and negative (unfavorable) reactions of participants to the institute programs in several forms. Some reactions were generalized to reflect the thinking or statements of a majority of participants at a given institute. Other reactions were quoted or paraphrased as obtained in questionnaires, letters, or conversations. These reactions have been grouped into similar categories common to several institutes.

Positive reactions. One reaction was common to 19 of the directors' reports. This was a general good reaction to the institute experience showing up in such phrases as: very informative, great value, information will be used, my students will profit, related to my work in high school, most rewarding experience of my college career, learned a lot in a short time, and obtained a whole new frame of reference.

Other reactions were given that are somewhat more specific. The comment that the institute dealt with concepts and principles rather than fact memorization was common to reports of three institutes. Five reports gave the reaction that the participant was challenged to do a better job and now felt better prepared to do so. Seven directors reported reactions to the field trips in such terms as: exceptional,
outstanding, and of great help. The comments made by participants in eight institutes were favorable reactions to the administration and teaching in the institute. Typical comments were that the staff was capable, sincere, and enthusiastic, that the planning and teaching showed that the staff was sensitive to the needs of the participants, and that the instructor-student relationships were excellent.

A few of the favorable reactions appear in only one or two of the directors' reports. These reactions tended to be towards a specific feature of the institute such as credit being applicable for advanced degrees, laboratories being well planned and extremely worthwhile, the helpfulness of meeting other teachers and exchanging ideas, the content being suitable for adaptation in the high school, and the wisdom of selecting participants who lack formal preparation in the fields they taught.

Negative reactions. The negative reactions of the participants to the institute programs did not combine easily into related groups. In a given report, a negative reaction of one or a few participants contradicted a favorable reaction of several or most of the other participants. Only two negative reactions were common to four or more institutes. Five reports mentioned that the institute was conducted at too high a level, or too much material was presented too fast. Four directors reported that participants said that the institute was not practical enough or that more supplementary information and help with teaching techniques were needed.

Other negative reactions appeared in from one to three reports. These are listed below with the number of reports including the reaction given in parentheses following the reaction.
1. Not enough study time (3)
2. Not enough time in the field and too much time in class (3)
3. Staff not familiar with high school problems (2)
4. Not intensified enough in subject matter (2)
5. Not enough social events (2)
6. Reading assignments too long (2)
7. Some field trips were a waste of time (2)
8. Laboratories too long (2)
9. Concentrate on fewer topics (2)
10. Undue emphasis on examinations and grades (2)
11. Not enough individual attention (1)
12. Could make better use of experts in different fields of geology (1)
13. Object to use of mathematics in meteorology and earth physics (1)
14. Not enough credit for the work involved (1)
15. Object to the use of graduate students as laboratory instructors (1)
16. Visiting lecturers are a waste of time (1)
17. Should be all male participants, too diversified a group (1)

Implications of participant reactions for meeting science teacher needs. The positive reaction common to 19 of the directors' reports was one of receiving information, understandings, and ideas that would be helpful in the participants' teaching. Specific indications of needs being met were the positive reactions to laboratory work,
field trips, receiving credit toward advanced degrees, and a variety of comments relating to the appropriateness of the subject matter learned in the institute. Thus, from the participant's viewpoint, the introductory earth-science subject matter and the experiences they had in these courses, fulfilled some of their needs as secondary school science teachers.

The lack of common negative reactions and the variety of individual reactions of this type suggested at least three possibilities. One possibility was that the participants may have been reluctant to criticize the programs negatively. Secondly, a lack of success in the institute by a participant may be reflected in a negative reaction to specific parts of the program. A third possibility was that individuals participated in the institutes who had various backgrounds, interests, and experiences, and accordingly found most of the institute program helpful, but reacted negatively to one or more facets of their institute experience.

Participants' Plans for Continued Development

The directors cited examples of the plans of their institute participants for continued development upon the completion of the Earth Science Institute. Fifteen directors reported that institute participants were applying the course work towards a degree program, or, as a result of the institute, were initiating a degree program. The number of participants seeking an advanced degree was not included in the reports - just the fact that this was a plan for continued development. In 11 of the reports, the directors commented that participants
planned to continue graduate study without degree plans. This con-
tinuation would be in other Summer Institutes, in Academic Year
Institutes, In-Service Institutes, or at the individual's own expense.

Participants in seven institutes were reported as planning to
continue their development through independent study. Specific plans
were to begin geological research in the teacher's home area, contact
state geological surveys for information, exchange specimens and
slides with other teachers from various geographic locations, engage
in planned reading programs, prepare field trip guides, develop an
earth-science curriculum guide, and conduct an in-service program in
earth science for elementary school teachers.

Although not a definite plan for continued development, six
directors reported participant interest in an advanced institute in
earth science. Topics or courses mentioned as suitable for advanced
work were paleontology, more practical field work, and a planned
sequence of courses leading to a master's degree. Five of the six
reports included that a sequential program leading to a degree was of
interest to the participants.

Plans for continued development related to teacher needs. The
earth-science teacher apparently has a need for an advanced degree
since such a plan for continued development was reported by 15, or
75 per cent, of the directors participating in this study. A smaller
number, mentioned in seven reports, see a need for learning the geology
of the teacher's home area and will work towards this end through
independent study. Neither of these needs was being met in the 1962
earth-science institutes since none of the institutes in this study were of a sequential nature and few of the participants were from the community in which the institute was held.

**General Reaction of Staff to Institute and Participants**

The general reaction of the staff to the institute and participants may be summarized in two categories, one favorable, the other negative. Seventeen reports contained examples of favorable reactions to the institute itself. These were expressed as: complete cooperation in organization and administration, worthwhile, congenial, excellent, enthusiastic, and a valuable method for increasing the efficiency and up-grading of secondary school teachers. In 13 reports, favorable staff reactions to the participants included such comments as: participants were better prepared and more capable than expected, favorably impressed with interest, willingness and desire to learn, progress was good, participants are highly motivated, enjoyed the participants' company, and the staff was willing to spend extra time with participants.

Negative reactions of staff members to the institute and participants were expressed with much less frequency than the positive reactions. None of the directors reported a negative staff reaction to the institute itself. Seven reports included negative reactions towards the participants. In these cases, one or more staff members were dissatisfied with some participants with respect to ability, weak science backgrounds, no formal background in earth science, performance in examinations, over-concern about grades, concern about credit for
advanced degrees, and the amount of pressure needed to get good performance.

The implications of both the positive and negative reactions for the needs of earth-science teachers and the purposes of the institute programs is that the need for the basic courses offered was being met in the opinion of staff members. A few participants may not have profited from their institute experience because of a lack of ability or generally weak backgrounds in science. The concern for grades and credit toward advance degrees was considered as detrimental to good performance, but may reflect the need of the teacher to obtain graduate credit in maintaining his teaching position.

Use of the Analyses

In this chapter analyses have been made of: (1) the status of earth science in secondary schools in 1962-1963; (2) textbooks used in earth-science courses; (3) state and local courses of study in earth science; and (4) Earth Science Summer Institutes. The implications of the analyses for meeting the needs of prospective teachers have been pointed out at numerous points. Data in each of the four analyses have provided information on the nature of the earth-science course as it has been developing in the secondary schools. These data, after analysis and when synthesized, form a basis for identifying the abilities needed by an earth-science teacher. Because of the comprehensiveness of the analyses, the following chapter has been devoted to a synthesis of the information obtained from them and from the review of the literature.
CHAPTER IV

UNIQUE COMPETENCIES NEEDED BY
TEACHERS OF EARTH SCIENCE

Information contained in Chapter II, the review of the literature, and Chapter III, the determination of the nature of the developing earth-science course, has a direct meaning in proposing a curriculum for the preparation of earth-science teachers. Through such information, competencies unique to teachers in the field of earth science may be identified. The development of these competencies in prospective teachers is a major function of the curriculum.

Identification of the unique competencies has been carried out through a synthesis of the information according to criteria established and applied to it. The criteria have also been applied to information obtained through personal interviews which form a source of data in support of the needed competencies. The implications for curriculum design are then considered.

Identification of Needed Competencies

Many of the competencies needed by an earth-science teacher are those common to all teachers in the secondary school. It has been assumed in this study that these general competencies will be developed within the total curriculum in the general education and professional education areas taken by all prospective teachers. Those abilities
unique to the field of earth-science teaching have been identified through establishing and applying the following criteria.

Criteria for Identification of Competencies

Appropriate experience for either learning or teaching the earth sciences are those that contribute to an understanding of:

1. The major topics included in present earth-science courses in secondary schools.
2. The topics likely to be taught in future courses.
3. Effective presentation of earth-science concepts to secondary school students.
4. Both classical and modern earth-science concepts.

These criteria have been developed on both philosophical and practical bases for determining competencies unique to the prospective earth-science teacher. The meeting of any one of the established criteria is considered to be sufficient to identify a needed competency.

Determination of Needed Competencies

Application of the criteria to the review of the literature and to the data presented in determining the nature of the developing earth-science course revealed a variety of competencies needed by the earth-science teacher. These competencies have been grouped under four major headings:

1. Knowledge of earth science.
2. Knowledge of other sciences.
3. Interrelationship of the sciences.

4. Teaching procedures in earth science.

1. Knowledge of earth science. A knowledge of his teaching field is a competency required of every science teacher. Only a thorough understanding of his science field will enable the teacher to keep abreast of new developments and maintain his confidence in himself and his teaching. The unique competency required of an earth-science teacher lies in his knowledge of the interdisciplinary field of earth science. Such competencies as the following are required:

1.1 Geology. The earth-science teacher needs a functional understanding of the concepts included in introductory geology courses and enhanced through study of such specialized areas of geology as mineralogy, petrology, geomorphology, structural geology, stratigraphy, and paleontology. Depth of understanding should be extended through field work involving each of these areas and combinations of them.

1.2 Oceanography. The physical oceanography topics of composition, extent and distribution of the oceans, and the processes and results of the actions of waves, tides, and currents need to be understood by earth-science teachers. The increased rate of recent discoveries in oceanography suggests that the prospective teacher be proficient in the concepts relating to the ocean floor and the forms of life found in present and past oceans.

1.3 Astronomy. The concepts in astronomy most needed by earth-science teachers are those related to the solar system with special
emphasis on the earth as a planet. Basic concepts of stellar astronomy would provide additional depth of understanding. The astronomy-related topic of space travel should be well understood in both its scientific and technological aspects.

1.4 Meteorology. The teacher of earth science needs a comprehensive understanding of the nature of the atmosphere, cause and effect factors in weather phenomena, and the contributing factors and distributions of world climates.

1.5 Physical geography. Concepts of physical geography needed by the earth-science teacher are those associated with the recognition of land forms, world climates, distribution of land masses and bodies of water on the earth, and the effects of these features on the distribution of life.

1.6 Conservation. An understanding of the renewable and non-renewable natural resources, physical factors affecting man's use of the natural resources, and scientific and social means of assuring wise use of the earth's resources is needed by the earth-science teacher.

2. Knowledge of other sciences. The earth-science teacher needs a breadth of preparation in science not only to help achieve the general education goal of scientific literacy, but also to make effective use of scientific principles from the separate sciences in earth science. Needed competencies in other sciences include four major areas:

2.1 Biology. The earth-science teacher needs to be familiar with the basic concepts and principles of botany and zoology to the point of being able to apply them in ecological studies and in understanding evolution.
2.2 Chemistry. Competency in applying the basic concepts of chemistry, including analytical techniques, to problems in earth science is needed by the teacher.

2.3 Mathematics. The earth-science teacher should be competent in the use of mathematics through college algebra and trigonometry. Recent developments in the earth sciences indicate that to keep abreast of these developments an earth-science teacher will profit from an understanding of calculus and statistics.

2.4 Physics. The concepts acquired through the study of energy relationships in the fields of mechanics, heat, light, sound, magnetism, and electricity are essential in interpreting earth-science phenomena. In addition, a basic understanding of radioactivity acquired through study in physics or chemistry would aid the teacher considerably in interpreting changes that take place in mineral substances and in the determination of the age of radioactive minerals.

3. Interrelationship of the sciences. The earth-science teacher needs to develop a clear understanding of the interrelationship of the sciences:

3.1 Interrelationship of other sciences with earth science. Study in earth science involves utilizing the principles of the biological and physical sciences in the study of materials and processes that occur in, on, and around the earth. This interrelationship needs to be understood as being more than just the application of principles from the separate fields. The understanding needed is one involving
the principles that cut across all fields such as the universal nature of change, order in nature, equilibrium, and the conservation of mass and energy.

3.2 **Interdisciplinary nature of earth science.** The earth-science teacher needs an understanding of the interdisciplinary nature within the field of earth science itself. In addition to the utilization of biological and physical science principles, the earth sciences (geology, astronomy, meteorology, and physical geography) are closely interrelated among themselves. As taught in the past, earth science has frequently been presented as separate science areas. Indications for the future are that the interdisciplinary nature of earth science will receive greater emphasis.

4. **Teaching procedures in earth science.** The earth-science teacher needs to develop competencies in teaching his subject that would be common to all science teachers. There are, however, needed competencies that apply specifically to the teacher of earth science:

4.1 **Specimens.** The teacher will need to be able to obtain, identify, store, display, and utilize specimens of minerals, rocks, and fossils in his teaching. Locally obtained specimens are desirable. The teacher should have information enabling him to obtain specimens not available locally.

4.2 **Earth-science literature.** The teacher needs to become familiar with the periodical, textbook, and reference literature in the field of earth science. He should be able to discriminate which literature is appropriate to his own needs and those of his students.
4.3 Audio-visual materials. The earth-science teacher needs competency in locating and selecting appropriate audio-visual materials for use in his classes. Special proficiency in the use of maps is needed.

4.4 Teaching procedures. The earth-science teacher needs experience and competency in presenting demonstrations, utilizing the laboratory, supervising projects and displays, planning lessons and units, and working with students in these activities. The unique feature of these for the earth-science teacher lies in presenting the subject matter of earth science through such procedures.

4.5 Field trips. The planning and conducting of field trips is an important competency of the earth-science teacher. Many of the examples of earth-science topics can best be studied in the field where the lithosphere, hydrosphere, biosphere, atmosphere, and celestial sphere can be observed directly.

4.6 Problem solving. The teacher of earth science needs to be competent in solving problems through the methods used by earth scientists and in developing this ability in his students.

Support of Needed Competencies

The competencies identified as being unique needs of the earth-science teacher were presented to ten persons in individual interviews. The interview form was designed so that it could be completed by either the investigator or the person interviewed. In three instances, the form used in recording the information obtained in each interview is found in Appendix D.
the investigator recorded the responses of the person interviewed. Seven of the persons interviewed elected to complete the interview form after giving further consideration to the questions asked; the form was then mailed to the investigator.

Each of the ten persons had responsibility for the preparation or supervision of earth-science teachers, and in two instances the persons interviewed had both responsibilities. The area of responsibility and the number of persons having each responsibility were: supervisor of student teachers - three; teacher of college courses for earth-science teachers - four; head of a department preparing earth-science teachers - two; state supervisor of earth science - one; and consultant for earth-science courses, institute programs, and certification proposals - two. Based on their experience in these responsibilities, a majority of this group indicated support of the following competencies. The number of interviewees who indicated that the competency was essential is given in parentheses following each descriptive phrase.

Knowledge of science. The earth-science teacher should be familiar with the concepts, principles, and understandings of the following science areas.

Science other than earth science:

- general chemistry (10)
- college algebra (10)
- trigonometry (9)
- basic biology (6)
general zoology (8)
ecology (7)
general botany (7)
evolution (6)
mechanics (6)
sound, heat, light (6)

Earth science:
physical geology (10)
general meteorology (10)
historical geology (9)
solar system (8)
common rocks (8)
common mineral deposits (8)
field work in geology (8)
descriptive astronomy (7)
geomorphology (6)

Other competencies of the earth-science teacher. The following competencies were indicated as being essential by the number of interviewees given in parentheses following each competency:

Familiarity with the geology of his teaching locality. (10)
Ability to communicate ideas. (9)
Familiarity with earth-science content. (9)
Familiarity with the purposes of science teaching in public schools. (9)
Ability to evaluate student learning. (9)
Demonstrated enthusiasm for science. (9)
Ability to plan and conduct field trips. (8)
Ability to demonstrate scientific principles. (8)
Familiarity with appropriate reference materials. (7)
Familiarity with related sciences. (7)
Ability to direct learning activities in the classroom. (7)
Ability to recognize and state hypotheses and suggest ways of testing them. (6)
Familiarity with sources of films and laboratory materials. (6)

On the basis of these responses, support of the unique competencies which had been identified was indicated by the persons having a responsibility for earth-science teachers. The opinion of these persons is considered to be significant because of their varied experience with the preparation and supervision of earth-science teachers. The interview responses may be interpreted as indicating that the identified competencies are those of importance. The subjective nature of such opinions and the small number of persons interviewed limit the use of these data to such an indication.

**Implication of Needed Competencies for Curriculum Design**

The competencies needed by the earth-science teacher have direct implications for the design of the curriculum for preparing such teachers. It is through the curriculum and the attitudes and abilities
resulting from the students' experiences in the curriculum that the
needed competencies can be developed. Basically, two kinds of unique
competencies must be provided for in the curriculum: competency in
science, and competency in teaching earth science.

Ways of Meeting Needs

The curriculum for the preparation of an earth-science teacher
will undoubtedly determine the extent to which the needed competencies
can be developed. The number of needed competencies and the limitations
of time in the typical four-year period of preparation imply that both
regularly offered science courses and specially designed courses be
utilized. Knowledge of earth science, biological science, and physical
science may be acquired through study of introductory courses in each
area with depth of study in the earth sciences. Recognition of the
interrelationships of these sciences, however, would not be guaranteed
by exposure to sciences taught as separate disciplines. Thus, special
attention to the interrelationships of the sciences will be required
at appropriate points in the curriculum in the form of specially de-
signed courses or through conscientious treatment of interrelationships
in the various science courses.

The prospective teacher needs to become aware of what is being
taught at the junior high school level in the earth-science course.
He will also need to develop his skill in determining and using appro-
priate teaching procedures, develop his ability to evaluate the teaching
and learning process, and develop his understanding of behavior patterns
of students in the secondary schools. Such skills and understanding may
be accomplished through science courses where special attention would be given to these considerations and in special courses in the teaching of earth science.

Proficiency in using effective techniques of learning and teaching earth science will require conscious consideration in the curriculum. The prospective teacher should develop competency in planning and performing field work, preparing specimens, classifying and using identification keys, using and preparing maps, interpreting aerial photographs, making models, and using special instruments such as telescopes, planetariums, spectrosopes, and microscopes. These competencies may be developed in several of the science courses if special attention is given to them within the course or in a special laboratory section for prospective teachers.

**Relationship of Needs to Special Content Courses**

In the curriculum for preparing earth-science teachers, many of the unique competencies of such teachers will be developed through the academic courses in the sciences. Through the proper selection of individual courses, it should be possible to provide for the desirable elements of breadth and depth of preparation in science. The likelihood that these courses will meet the needs of understanding (1) the inter-relationships among the sciences, and (2) of teaching procedures is not great. For this reason, the means of developing the needed understanding, in at least a few of the courses, must be considered.
Interrelationship of science concepts. Study in the field of earth science provides unusual opportunities for students to interrelate concepts of earth science and those from other areas of science. The realization of such interrelationships is more likely to occur after the student has had a broad background in science and while studying the more advanced courses in earth science. It cannot be assumed, however, that students will make the associations independently. Through his teaching, the college or university professor can help the student become aware of the artificial boundaries between the various fields of science. More effort in teaching interrelated science concepts should be encouraged.

An additional opportunity to develop an understanding of science concepts that cut across the separate disciplines would involve study of the history and philosophy of science. Such study may be initiated through one or more courses by including historical and philosophical background in science or science education courses and through independent study. One or more courses devoted to the history and philosophy of science would be desirable.

Teaching procedures in earth science. There is general acceptance of the observation that "teachers tend to teach as they have been taught." Even if there is only a modicum of validity in this statement, the implication is clear that prospective earth-science teachers should experience good teaching methods in their preparatory courses. Perhaps of equal importance, the prospective teacher should be made to realize there are several methods appropriate for presenting many concepts.
The choice of methods depends upon factors such as class size, the ability and interests of students in the class, available facilities, and the ability and imagination of the instructor. These method-content relationships should be pointed out to prospective teachers in as many of the special content courses as possible.

There appear to be two possible ways of helping the pre-service teacher through academic courses to recognize and evaluate teaching methods that will be useful to him. First, the instructors of the science courses could hold separate special meetings of those students in their classes who are prospective teachers. In such meetings the unique implications of the courses for science teachers and teaching could be developed. Second, the course instructor, or other interested person, may work with the pre-service teachers in separate laboratory sections of regularly offered science courses or in one or more additional laboratory courses especially designed for prospective teachers. A third possibility for developing competency in teaching procedures lies in designing an earth-science methods course. This course should give special attention to the procedures, materials, and development of skills needed for effective teaching. In the planning and teaching of such a course, cooperation of science education and earth-science faculty members would be considered essential for success.

**Availability of special courses.** Academic and education courses especially designed for the preparation of earth-science teachers are not commonly available. The rapid increase in the number of schools...
offering earth science and the consequent demand for qualified teachers requires the attention of persons having a responsibility for teacher preparation. Obviously, the manner in which special courses could be provided will vary from one institution to another; the essential element is the realization of the need for these courses. Changes can then be made in existing courses which are taken by students preparing to teach earth science. New courses can be developed in either the academic or professional education areas, or in both.

Appropriateness of courses. A difference of opinion exists as to the appropriateness for science teachers of courses which are oriented towards preparing specialists in a science area. In one viewpoint, it is argued that depth of understanding results from research-oriented study in a science discipline. The necessity for teachers to have a broad background in carrying out their usual responsibility for teaching two or more science courses results in a second viewpoint.

While there is merit in developing depth of understanding in a given field through research-oriented study, the teachers' need for breadth of study and understanding of interrelationships among the sciences requires first consideration. In a preparation period of four or five years the prospective teacher's study may well include sufficient background in the earth sciences to enable him to pursue graduate study at a later date. Breadth of study in science will not only help meet the teacher's initial responsibilities, but will add a perspective to his view of science that is unlikely to be met through concentrated study in one discipline. On these bases, many of the science courses
in a given institution would not be appropriate for prospective teachers without being reorganized.

Problems involved in providing courses. The development of new courses and reorganization or modification of existing courses involve problems that must be considered in the implementation of a curriculum. Cooperation between education and science departments will help reduce the magnitude of the problems. Problems involved would include availability of teaching personnel, time required in providing separate sections and new courses for pre-service teachers, special and additional facilities that may be required, the ability and interests of the science department staff in the preparation of teachers, and the identification of content and procedures to be included in specific courses.

These problems indicate the need for professional education faculty who have an adequate academic background and orientation to the earth-science concept and for earth scientists who understand the purposes of teaching science in secondary schools, the process of teaching, and the nature of secondary school students. Neither educators nor earth scientists with such interest and background are commonly available. The preparation of college instructors with such competency is a concomitant problem, the solution of which will improve the quality of curriculums for earth-science teachers.

Summary of Needed Competencies and Implications for Curriculum Design

The unique competencies needed by an earth-science teacher are those concerned with his knowledge of earth science, knowledge of other
sciences, the relationship among the sciences, and appropriate teaching procedures in earth science. The subject-matter competencies can be developed through depth of preparation in an earth-science area such as geology or meteorology, and breadth of preparation in biological science, physical science, and additional areas of earth science such as astronomy, physical geography, and oceanography. An understanding of the interrelationships of the sciences and of the interdisciplinary nature of earth science itself is a needed competency. The teacher needs to develop special competency in teaching earth science through use of specimens, literature, audio-visual materials, special teaching procedures, field trips, and problem solving experiences.

The curriculum for preparing earth-science teachers provides for developing attitudes and abilities needed by these teachers through study in appropriate courses in science and in the teaching of science. The courses should include regularly offered science courses, special or additional laboratory sections of science courses, and new courses in science and science education where necessary to provide experiences not available in the existing courses of an institution. Changes in courses and the design of new ones involve cooperation among faculty members in education and science departments. Within the pattern of the proposed curriculum presented in the next chapter, the bases for planning the modification of existing courses and the development of new ones become available for cooperative study.
CHAPTER V

PROPOSED CURRICULUM FOR THE PREPARATION
OF EARTH-SCIENCE TEACHERS

The competencies which have been identified as being unique to teachers of earth science are interpreted and projected into a curriculum for the preparation of such teachers in this chapter. All prospective science teachers need to develop their understanding in both academic and professional areas. The following curriculum includes these two areas with respect to the desirable content and effective teaching procedures of special importance in preparing earth-science teachers.

Developing Academic Proficiency in Earth Science

The knowledge of science required by an earth-science teacher is not limited to the artificial confines of a single science field, or even to two or three sciences. As currently taught, earth science requires an understanding of concepts from geology, oceanography, astronomy, meteorology, and physical geography. Concepts in each of these depend upon knowledge of biology, chemistry, physics, and mathematics. This results in an interdisciplinary and unifying approach that, in itself, is a unique aspect of earth science when compared with the other sciences taught in the secondary school. Biological science has a corresponding quality in that concepts are interrelated from
botany, zoology, bacteriology, physiology, and to a limited extent, from chemistry and geology.

Two possible approaches to academic proficiency in earth science are suggested through a consideration of the interdisciplinary nature of earth science. One approach is to include basic courses from each of the sciences, with depth of study in one of the primary areas such as geology or astronomy. The rationale for providing depth of study lies in developing an understanding of the structure of one of the earth sciences - the characteristic ways in which the scientist adds to knowledge in the field, the nature and use of data, and the depth of understanding that enhances perception of subtle interrelationships. The disadvantage is that the time demanded may make it impossible to obtain adequate background in the other sciences. Even with breadth of study through courses in several science areas, the student needs help in interrelating ideas and concepts.

A second approach to the development of academic proficiency involves a major concentration in earth science as an interdisciplinary field. Breadth and depth of study are pursued concurrently throughout the undergraduate program. In such a program, major topics in earth science are investigated thoroughly, and information and techniques are utilized from any area that will aid in understanding the major topic. Courses in biology, chemistry, physics, and mathematics need to be a part of the curriculum so that maximum use can be made of them in the earth-science courses. When necessary, concepts from any of the science fields are studied in an earth-science course.
One of the problems involved in this second approach is in finding college instructors willing and qualified to teach earth science in the manner suggested. A second problem is the scheduling of courses at those times when they are of most value. Both the suggested approaches and the many possible variations or alternatives involve organizational and administrative problems of the institution providing the curriculum.

The surmounting of such problems is essential to the realization of the curriculum, in contrast to an organization of topics which would make up a course of study. The curriculum for developing academic proficiency in earth science consists of the learning experiences obtained by the student regardless of the particular organizational pattern of an institution.

**Curriculum for Developing Academic Proficiency**

The academic needs of the earth-science teacher have been identified in Chapter IV, as a knowledge of earth science, of other sciences, and of interrelationships of the sciences. The curriculum provides experiences to fulfill these needs through study of the major topics the earth-science teacher can expect to teach in the secondary school. The curriculum, however, is not limited to specific and predetermined topics developed only to the extent that they will be taught in the prospective teacher's classroom. The curriculum is instead the vehicle through which basic proficiency in earth science may be developed to enable the teacher to continue his development through scholarly interest and study throughout his career. Thus conceived, the curriculum
provides for general education in science as well as specialization in earth science.

Academic proficiency is developed through study of the topics basic to an understanding of earth science: the lithosphere, hydrosphere, atmosphere, biosphere, and the earth's environment in space.

The Lithosphere

The solid portion of the earth is a major source of information that man may use in interpreting his environment. Therefore, the structure, composition, processes, and history of the lithosphere become topics of interest to earth scientists and informed citizens. The earth-science teacher should be prepared to work intelligently with concepts and principles in the following topics.

Structure of the earth. Man's knowledge of earth structure has been derived from evidence obtained from the lithosphere itself and by making measurements using the crust of the lithosphere as a platform. Topics that should be studied in the curriculum for earth-science teachers include:

1. Division of the interior of the earth into zones on the basis of seismic evidence.
2. Determination of the interior composition from seismic evidence.
3. Determination of the size and shape of the earth from gravity measurements, geodetic measurements, and recently developed methods using data from satellite orbits and photographs from satellites.
4. Theories of the formation of the earth.
5. Theories of earth's magnetic field as related to internal structure.

These topics will develop an understanding of what is known about the structure of the earth and the manner in which this knowledge has been obtained. The above topics are interdisciplinary. Physics, mathematics, geology, and astronomy are utilized to solve problems of earth structure.

The earth's crust. The earth's crust is the outer shell of the lithosphere which includes the land masses and ocean basins. Much of earth science is concerned with the crust because of its importance to man. The continental surface of the crust is man's natural habitat and the source of most of the materials utilized by him. The crust is the source of information for most of man's knowledge of the materials and processes that make up the environment, as well as what man has learned of the history of the earth.

The earth-science teacher should be familiar with the following broad topics:

1. Determination of thickness of the crust from seismic and gravity data.

2. Discovery of the Mohorovičić discontinuity.

3. Theory of isostatic equilibrium.

4. Determination of the nature of crustal materials from direct evidence of surface specimens, well cores, and indirect evidence from electric well logs, gravity, and seismic data.
5. Attempts to obtain direct evidence of the nature of the crust under the ocean and the mantle materials by drilling through the Mohorovičić discontinuity - the Mohole Project.

Methods and principles from physics, mathematics, chemistry, and geology are interrelated in these broad topics of the earth's crust.

**Materials of the crust.** Prospective teachers need to become familiar with the materials that make up the crust of the earth. These are the sources of information on which many of the theories and concepts of earth science are based. The curriculum should give major attention to these subjects:

1. **Minerals** - composition, chemical and physical properties, occurrence and distribution, identification, and importance from both a scientific and an economic viewpoint.

2. **Rocks** - classification and characteristics as a result of their igneous, metamorphic, or sedimentary origin; occurrence and distribution; identification, mineral composition, and scientific and economic importance.

3. **Fossils** - identification, means of preservation, use in the correlation of rocks, and significance as evidence of evolution.

4. **Energy from the sun, from the interior of the earth, and from gravity** is directly related to the materials of the crust and their state of equilibrium.

Physics, chemistry, biology, geology, and astronomy are represented in these topics and are drawn upon in seeking explanations and information.
Processes of the crust. The processes that take place in and on the earth's crust are responsible for most of the observable features in the environment. The teacher should develop a comprehensive understanding of these processes:

1. Weathering - mechanical and chemical processes; rates, agents, and products, including soil.
3. Erosion - effect of ground and surface water, floods and their control, and soil conservation.
4. Deposition - causes, rates, locations, and products.
5. Lithification - conditions, types, and resulting materials.
6. Glaciation - conditions of occurrence, formation, movement; effects of valley and continental glaciers; and development of the theory of glaciation.
7. Igneous activity - intrusive and extrusive processes, conditions, and products.
8. Diastrophism - folding, faulting, and earthquakes; forces involved and significance in changing the crust.

Through study of these processes, the teacher should become thoroughly familiar with the concepts of uniformitarianism which is defined as follows: the law or doctrine that states that the processes that take place in the earth's crust at the present time also took place in the geologic past in the same way and for the same reasons, although not necessarily at the same rate.
Study of the processes that take place in and on the earth's crust involve concepts from all the sciences. The physical and chemical relationships are apparent; organisms are agents of weathering and are factors in erosion and deposition; elements and compounds from the atmosphere enter into the processes occurring in the crust; and energy from the sun and from gravity furnish the power for the hydrologic cycle which is involved in several of the processes.

Landforms. The earth's landforms are made up of the materials of the crust and have been produced by the processes that take place at the earth's surface. They are a major source of information for the earth scientist, who seeks to explain how they are being altered, of what they are composed, and the sequence of events that produced them. The earth-science teacher should study and interpret these interrelationships in the following topics:

1. Valleys as products of erosion by streams and glaciers.
2. Plains as products of erosion or deposition.
3. Plateaus as products of erosion, deposition, or diastrophism.
4. Mountains as products of erosion or diastrophism.
5. Distribution of landforms.
6. Geosynclinal theory.

Life on and in the lithosphere. Along with the atmosphere and hydrosphere, the lithosphere supports life and in turn is affected by the organisms living in the environment. The earth-science teacher will need to develop his understanding of biological principles to the point of being able to apply these to ecological studies of the lithosphere.
History of the earth. One of the major purposes of studying the earth is to develop a complete earth history. The earth-science teacher should understand the following topics related to the methods of deciphering such a history:

1. The rock record - identification of rock formations and the conditions under which they were formed.
2. The fossil record - correlation of rocks on a regional or world-wide basis.
3. The geologic time scale - based on characteristic forms of life that changed progressively through geologic time.
4. Measurement of absolute time - various means of determining absolute time with emphasis on radioactive methods.
5. Evolution as supported by the fossil record.

The Hydrosphere

The discontinuous shell of water on, in, and above the lithosphere has always been an important object of study to earth scientists, but it has added significance at the present time as a source of minerals, food, and water supply for a rapidly increasing world population. Teachers of earth science will profit from an understanding of major topics in their study of the hydrosphere.

The oceans. The oceans make up the bulk of the hydrosphere. Covering approximately three-fourths of the earth's surface, they provide a vast resource that will be the object of scientific study for many years. The earth-science teacher should understand the following
oceanography topics and their implications for man's social and economic life:

1. Extent and distribution of the oceans.
2. Chemical composition.
3. Physical and chemical properties.
4. Nature and geography of the ocean floor.
5. Changes that have taken place in the oceans in the past.
6. Shallow ocean basins (epeiric seas) as the loci of deposition for the major portion of the materials eroded from land masses.

Water resources of the land. The part of the hydrosphere that occurs in and on the land masses is extremely significant to man. Water is basic to all life processes; it is an essential source of energy and is an ingredient of industrial operations. Consequently, the earth-science teacher should study this part of his environment through these topics:

1. Surface water - lakes, streams, springs, and swamps.
2. Underground water - the water table, aquifers, and wells.
3. Temporary nature of bodies of surface water from the viewpoint of geologic time.

Processes of the hydrosphere. The processes that take place in the hydrosphere are interpreted through application of principles from physics, chemistry, astronomy, geology, and meteorology. The following topics should be included in the curriculum of the earth-science teacher:

1. Waves - origin, motion, and effect on the materials of the shore and bottom.
2. Tides - origin, cycle, and characteristics in relation to the shores and continental slope.

3. Currents - causes, patterns, and effects in the water body, on the shores and bottom, and on the adjacent land masses.

**Water in the atmosphere.** The water in the atmosphere is a small but important part of the total volume of the hydrosphere. The teacher should study this part of the hydrosphere as a part of the hydrologic cycle. Translocation of water in this cycle is the source of most of the water responsible for weathering and erosion as well as the fresh water supply of the earth.

**Life in the hydrosphere.** The hydrosphere, especially the oceans, is the habitat of large numbers and many species of living organisms. The earth scientist is interested in the organisms living in the hydrosphere as a basis for understanding past life forms and the process of evolution as well as the interaction of the organisms and their environment. The teacher should be able to utilize the concepts and principles of biology and chemistry that aid in interpreting life in the hydrosphere. The generally accepted fact that life on earth began in the oceans is basic to the theory of organic evolution. The teacher should become familiar with this theory through study of the hydrosphere and the life it supports.

**The Atmosphere**

The gaseous layers that surround the earth and travel with it through space make up the atmosphere. This is one of the unique features that makes life on earth possible. The atmosphere comes into
contact with both the lithosphere and hydrosphere. The relationships and interactions among these "spheres" are the objects of study in earth science. The teacher should understand the following topics that would be included in his curriculum.

**Materials of the atmosphere.** The atmosphere is composed of gaseous elements, compounds, and small amounts of suspended solid particles. The composition and its distribution within the atmosphere should be studied by the earth-science teacher as the source of materials that have an effect on life and the processes of the lithosphere and hydrosphere.

**Processes of the atmosphere.** A variety of processes takes place in the atmosphere that in turn influence the processes of the lithosphere and hydrosphere. Earth-science teachers should have experiences in the curriculum that would lead to an understanding of the following topics:

1. Temperature changes - causes, rates, and effects.
2. Pressure changes - causes and effects.
3. Electrical activity - causes, effects, and interpretation of lightning, auroras, and absorption of charged particles.
5. Local winds - causes and effects.
6. Weather - causes, results, and associated features such as air masses, fronts, cyclones, anticyclones, and storms.
7. Climate - factors, extent, and distribution of world climates.
Solar energy. The topic of solar energy should be included in a study of the atmosphere as a source of energy in the hydrologic cycle and the processes of the atmosphere. The absorption and transmission of solar energy in the atmosphere are topics that should be included in the curriculum to develop an understanding of the earth's heat budget.

Earth's Environment in Space

Man has been curious about his position in the universe since the beginning of recorded history. The teacher needs to understand the contributions made by astronomers in developing our present concepts of the earth's environment in space. With the recent emphasis on space exploration, the teacher will need to be prepared to help his students understand the scientific and technological aspects of space travel. The following topics of the earth's environment in space would be included in the curriculum.

The solar system. The solar system is of special interest to man because of the earth's position in it and the obvious but complex relationship of the origin of the earth to the origin of the solar system. Earth-science teachers should have knowledge of the following topics through study of the solar system:

1. Theories of origin - dust cloud, collision of stars, explosion of a companion star to the sun, and modified dust-cloud hypothesis of Weizäcker.

2. The sun - structure, composition, phenomena, and source of energy.
3. The earth as a planet - position in the solar system, motions, seasons, and time as related to the earth's motions.

4. Other members of the solar system - the moon, planets, satellites of the planets, asteroids, meteors, and comets.

The universe. The earth-science teacher should be cognizant of the space environment beyond the solar system. His curriculum should include the following topics to develop his understanding of the universe:

1. Stars - characteristics, size, distribution, cycles of age, and classification.

2. Galaxies - size, composition of stars and clouds of gas and dust, kinds of galaxies, and their distribution in space.

3. Time and distance - vastness of space and theories of an expanding universe.

4. Instruments used in studying the space environment - optical and radio telescopes, photographs, and spectroscopes.

Space exploration. The exploration of space promises to add to man's knowledge of the forces affecting the earth. The scientific and technological problems involved in space exploration should be recognized by the teacher as very interesting to high school students. The curriculum should include study of these topics:

1. Rockets - types, characteristics, and means of propulsion.

2. Orbits - orbital velocities, and paths.

4. Man in space - problems of weightlessness, bodily functions, food supply, protection, navigation and flight control, time limitations, and safe return to earth.

Interrelationships of Science in the Curriculum

At several points in the proposed curriculum for developing academic proficiency, the interrelationships of the various branches of science have been indicated. Even in such a topic as "the earth as a planet," laws and principles of physics and chemistry are utilized, although this topic is commonly assigned to the field of astronomy. The students in the curriculum should discover the close relationship of the sciences throughout the undergraduate program. Study in the supporting sciences thereby becomes a meaningful part of the curriculum. The student would no longer be simply satisfying course requirements.

Additional Considerations in Developing Academic Proficiency

History and philosophy of science. The historical and philosophical development of a given topic in the curriculum would seem to be a natural approach to teaching it. For example, the doctrine of uniformitarianism, the theory of evolution, and glacial theory, take on added significance when developed in a historical context. Through historical treatment and an understanding of the philosophy of scientific study, the student will become familiar with modes of scientific investigation. He will also begin to appreciate the cooperation among
scientists of various countries and the scientific attitudes they have displayed.

A separate study of the history and philosophy of science is a highly recommended part of the curriculum for the preparation of earth-science teachers. Through such a study, preferably late in the undergraduate program, interrelationships among the sciences should become apparent and meaningful to the student. Knowledge of the concepts and principles that cross subject-matter lines, and of the men who contributed them, can be extensively developed. The perspective added to the student's thinking through study of the history and philosophy of science is well worth the time the course would require.

**A fifth-year program.** The prospects of a teacher's taking a fifth-year program before or soon after beginning to teach are becoming more and more likely. In fact, in some state and local systems, such preparation is already mandatory. In such a program the teacher should have an opportunity to develop greater depth of preparation in the science area of his choice, achieve greater breadth of preparation if needed, and improve his teaching competence through courses or special study in the teaching of science.

**Effective Teaching Procedures in Earth Science**

The major objective of a curriculum for the preparation of science teachers is the development of abilities and competencies that will enable each student to become as effective a teacher as possible. Assuming the student to be academically competent, his effectiveness as a teacher is determined by his knowledge of, and skill in using,
teaching procedures that will result in the desired learning. Hopefully, many good teaching procedures would be used in the academic courses taken by the student. As the prospective teacher grows in his professional outlook, he will begin to perceive the merits of the procedures being used. He is likely to imitate the methods by which he was taught. If he is perceptive enough, he will adapt the methods he has observed to his own personality and the situation in his own classroom.

The student’s knowledge of effective teaching procedures cannot be left to the chance that he will have experienced them in his academic courses. Neither can it be assumed that the student will become perceptive enough to recognize the effective procedures and adapt them for his own use. In the curriculum for preparing earth-science teachers, the student’s knowledge and skill in using various procedures will be developed in four stages. Early in his career the student will gain an understanding of the psychology of human behavior, including the learning process, and of the related field of the methodology of teaching. Such competence could be developed late in the second year of his college program and before he has completed a substantial part of his academic course work.

At a second point is found a course in the teaching of science. In this course the student will have an opportunity to examine teaching procedures and their effectiveness and to develop a moderate degree of skill in using a few of them. He will also gain an understanding of the purposes of science teaching in the secondary school, the science curriculum, the importance of planning appropriate learning experiences,
and methods of evaluating student learning. A worthwhile learning experience for the student in this course would be the development of a comprehensive teaching unit on a major earth-science topic. The unit plan would include the objectives of the unit, the content, the procedures to be used, the materials needed, the means of evaluating students, and references for locating additional information.

The third and fourth stages in developing the student's competencies in teaching earth science involve special courses. One of these should be a course especially designed for students preparing to teach earth science. This course would offer prospective teachers the opportunity of developing both their skill in teaching techniques and their familiarity with the materials and resources available for use in teaching earth science. An important feature of this course involves the students in working with the materials currently in use in secondary school earth-science courses. Textbooks, teachers' guides, laboratory manuals, films and filmstrips, models, and laboratory equipment would be studied and evaluated. Through such a process the student becomes familiar with what is taught in the earth-science course as well as the materials available for teaching the course.

The other special consideration of competencies needed in teaching earth science is in conjunction with one or more of the academic courses in earth science. Through a means acceptable to the institution and the academic department, special skills and techniques of teaching should be developed. This may be done as a special section of the course limited to earth-science teachers, a special laboratory section,
or a laboratory section in addition to one required for all students
in the course.

Within either of the last two means of developing the unique
competencies of an earth-science teacher, the following areas should
be included:

1. Experience in planning and conducting field trips to achieve
   specific purposes.

2. Experience in planning and performing field work such as
   interpreting an exposed section of the earth's crust and making
   ecological studies and micro-climate studies.

3. Determination of the geology in a given area, preferably
   the area in which the student expects to begin his teaching career.

4. Demonstrations appropriate for the illustration of earth-
   science principles.

5. Development of a bibliography of reference materials and
   resource materials appropriate for either or both the high school
   student and the teacher.

6. Use of the laboratory in solving both contrived and real
   problems. Materials and records from field trips or field work should
   be utilized in the laboratory.

7. Determination of means of evaluating student performance
   through the keeping of records including observations of significant
   changes in student behavior and construction of tests to measure
   achievement and progress toward the objectives of teaching earth science.
8. Experience in preparing and/or using the following special teaching materials:
   a. Specimens of minerals, rocks, and fossils.
   b. Keys for identifying and classifying minerals, rocks, fossils, and cloud formations.
   c. Maps, both student-constructed maps and preparing commercial maps for field use.
   d. Models and displays.
   e. Aerial photographs.
   f. Audio-visual materials such as slides, filmstrips, motion picture films, and tape recorders. The prospective teacher should be encouraged to begin building his personal collection of slides.
   g. Special instruments such as the Brunton compass, soil sampler, psychrometer, refracting and reflecting telescopes, barograph, planetariums, Geiger counter, Jolly balance, and spectroscope.

9. Familiarity with the various commercial sources of earth-science teaching materials.

**Summary**

The curriculum for the preparation of earth-science teachers proposed herewith provides for the development of both academic proficiency and ability to teach effectively. Study of topics contributing to an understanding of the lithosphere, hydrosphere, atmosphere, biosphere, and the earth's environment in space are included. The
interrelationships of concepts in these topics with other sciences require information and methods of study from physics, chemistry, mathematics, and biology. A study of the history and philosophy of science is a recommended part of the curriculum.

Development of the ability to teach effectively is accomplished through a course in the teaching of science, an especially designed course for earth-science teachers, and attention to teaching procedures in academic courses. In these courses, the prospective teacher should develop skills in teaching techniques and become familiar with materials and resources useful in teaching the earth-science course.
CHAPTER VI

ADAPTATION OF THE PROPOSED CURRICULUM FOR EARTH-SCIENCE

TEACHERS AT THE OHIO STATE UNIVERSITY

The preparation of teachers is accomplished in an institution of higher education by a sequence of courses through which the students achieve the experiences that make up the curriculum. The proposed curriculum for preparing teachers of earth science, as presented in Chapter V, needs to be interpreted in terms of courses that would be made available by the institution preparing such teachers. This interpretation would vary because of differences in organization and administration among institutions.

An interpretation of the proposed curriculum for possible adoption at The Ohio State University is made in this chapter for two purposes. First, an earth-science teaching area does not now exist in the curriculum at this university, and the need for earth-science teachers is such that consideration should be given to establishing one. Second, an example is provided of how the proposed curriculum can be adapted within an institutional organization for teacher preparation. Interested persons in other institutions may make corresponding adaptations in providing a curriculum for teachers of earth science.

Preparation of Science Teachers at

The Ohio State University

Students prepare to become science teachers at The Ohio State University in a four-year program leading to the degree Bachelor of
Science in Education. Because a teaching area in earth science would be developed within the established pattern of the existing four-year program, the total program for students preparing to teach in the secondary schools is briefly reviewed.

**College of Education Requirements**

The program in which science teachers are prepared at The Ohio State University is administered in the College of Education. General requirements for teachers in secondary education include the completion of a minimum of 196 quarter credit hours of course work in the General Secondary Education Curriculum. The student must achieve a cumulative point-hour ratio of 2.25 on all work taken at this institution and a point-hour ratio of 2.50 in the courses in his teaching areas.

The General Secondary Education Curriculum taken by all prospective science teachers consists of requirements in the following five categories:

1. General university requirements of health and physical education and, for male students, military or air science, or six to ten hours of second-level academic courses in lieu of military or air science.
   
   2. General college requirements of nine hours of English composition.

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1The Ohio State University operates on the quarter system, therefore, requirements are given in quarter credit hours.

2Summarized from *College of Education Bulletin*, 1963-1964. The Ohio State University, Columbus, Ohio, p. 79.
3. University basic education requirements of 15 hours each in science, social science, and the humanities.

4. Completion of one of three options: (a) two major teaching areas, (b) one major and one minor teaching area, or (c) one comprehensive 80-hour teaching area.

5. Required professional courses as follows:

   Education 408 - Introduction to the Study of Education 3 hours
   Education 535 - Theory and Practice in Secondary Education 5 hours
   Education 536 - Student Teaching in Secondary Schools 9-15 hours
   Education 607 - Philosophy of Education 3 hours
   Education 632 - The History of Western Education 3 hours
   or 636 - Historical Foundations of American Education 4 hours
   Health Education 610 - Health Education for Secondary Teachers 3 hours
   Psychology 407 - Educational Psychology 5 hours
   Methods Courses for both major and minor teaching areas 3-12 hours

Categories 4 and 5 above are those in which the curriculum for earth-science teachers would be realized. The teaching areas in science that fulfill the requirements in the three options and the science methods courses are the topics that need to be considered.

**Teaching areas in science.** The student who is preparing to teach in one or more science areas may do so by planning two majors in science, a major and a minor, or a comprehensive major. The major and minor areas consist of required and elective courses in science and required professional courses in the teaching of science. The possible areas and the credit hours in science required are summarized in Table 12.
### Table 12

#### Teaching Area in Science at The Ohio State University*

<table>
<thead>
<tr>
<th>Science Area</th>
<th>Credit hours in science required for:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Major</td>
</tr>
<tr>
<td>Biological Science</td>
<td>50</td>
</tr>
<tr>
<td>Chemistry</td>
<td>37-40</td>
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<tr>
<td>Chemistry - Physics</td>
<td>49</td>
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<tr>
<td>Comprehensive Science Major</td>
<td>80</td>
</tr>
<tr>
<td>General Science (minor only)</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>36-40</td>
</tr>
</tbody>
</table>


There are three professional courses in science education.

Education 604, 4 hours, *The Teaching of Secondary School Science*, is required in all major and minor teaching areas. Education 605, 3 hours, *Problems in the Teaching of Biological Science*, is required of Biological Science majors and Comprehensive Science majors. Education 681, 3 hours, *Laboratory Practicum for Teachers of Science*, is required of majors in Chemistry, Chemistry - Physics, Comprehensive Science, and Physics. Required credits in professional courses amount to four hours for all minors and seven hours for all majors except the Comprehensive Science major in which ten hours are required.

The curriculum for preparing earth-science teachers would fall within the pattern of science teaching areas already in existence.
Before an earth-science teaching area can be specified in this pattern, the curriculum from Chapter V must be interpreted in terms of required and elective courses that would make up the teaching area requirements.

**Courses in the Earth-Science Curriculum**

The development of academic and professional abilities through study of topics and the effective methods of teaching them can be interpreted in the form of specific courses. Within the courses, the prospective teacher will have the experiences necessary in developing his competency. The college and departmental organization of The Ohio State University requires the utilization of courses that are offered in the College of Education, in the Departments of Astronomy, Chemistry, Geology, Mathematics, and Physics in the College of Arts and Sciences, in the Departments of Botany and Zoology in the College of Agriculture, and in the Department of Geography in the College of Commerce and Administration. Courses already in existence will fulfill many of the requirements. Desirable modifications of some existing courses appear to be warranted; at least two new ones need to be developed for the special needs of the earth-science teacher.

**Interpretation of the Curriculum into Courses**

The topical areas basic to an understanding of earth science are the lithosphere, the hydrosphere, the atmosphere, the biosphere, and the earth's environment in space. Study of these areas was indicated as involving basic concepts and principles from more than one science. The necessity of study in several science fields is obvious.
The following courses are available at The Ohio State University.

Each course includes information, concepts, and principles that bear directly on one or more of the topics in the curriculum for the preparation of earth-science teachers.³

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credit Hours</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy 500</td>
<td>(5)¹</td>
<td>Descriptive Astronomy</td>
</tr>
<tr>
<td>Astronomy 503</td>
<td>(3)</td>
<td>Solar System</td>
</tr>
<tr>
<td>Botany 401</td>
<td>(5)</td>
<td>General Botany</td>
</tr>
<tr>
<td>Botany 402</td>
<td>(5)</td>
<td>General Botany</td>
</tr>
<tr>
<td>Botany 505</td>
<td>(5)</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td>Chemistry 411</td>
<td>(5)</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>Chemistry 412</td>
<td>(5)</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>Chemistry 413</td>
<td>(5)</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>Conservation 401</td>
<td>(3)</td>
<td>Introduction to Conservation of Natural Resources</td>
</tr>
<tr>
<td>Geography 615</td>
<td>(4)</td>
<td>Climatology</td>
</tr>
<tr>
<td>Geology 416</td>
<td>(5)</td>
<td>Introduction to Geology</td>
</tr>
<tr>
<td>Geology 417</td>
<td>(5)</td>
<td>Physical Geology</td>
</tr>
<tr>
<td>Geology 418</td>
<td>(5)</td>
<td>Historical Geology</td>
</tr>
<tr>
<td>Geology 505</td>
<td>(3)</td>
<td>Study of Geologic Maps</td>
</tr>
<tr>
<td>Geology 520</td>
<td>(5)</td>
<td>Invertebrate Paleontology</td>
</tr>
<tr>
<td>Geology 525</td>
<td>(3)</td>
<td>The Common Rocks</td>
</tr>
</tbody>
</table>

³The courses are listed as given in the Courses of Instruction Bulletin, 1963-1964, The Ohio State University, Columbus, Ohio.

¹The number of quarter credit hours for each course is given in parentheses after the course number.
A total of 124 credit hours of course work is included in the above listing. Obviously, some choices have to be made in a program of four years duration with 196 credit hours required for the baccalaureate degree. Two other factors complicate the use of the courses listed as the part of the curriculum leading to academic proficiency: (1) the courses Geology 525 and 600 require a prerequisite in mineralogy that is not included in the courses listed, and (2) no provision is made for developing proficiency in earth-science field work in the courses listed.

A solution to the problem of providing the desirable depth of study represented by the courses Geology 525, The Common Rocks, and
Geology 600, *The Common Mineral Deposits*, would be to modify these two courses through providing separate sections or additional laboratory periods for prospective earth-science teachers. The necessary concepts from mineralogy could be developed as needed without decreasing the quality of the course.

The solution to the problem of developing proficiency in field work in earth science would require the development of a new course designed especially for the needs of teachers. The design of the course would be best done through interdepartmental cooperation among representatives of the biological sciences, geology, meteorology, and education. Concepts from each of these areas would be studied in a field camp or in areas near the campus. In the latter case, a series of related field trips would be required. The field course should include making an interpretation of a given area on the basis of evidence obtained by the student. The interpretation should include the geology and present ecology of the area. Evidence would be obtained by mapping the area, identification and correlation of rocks, determination of soil present, determination of the macro- and micro-climate, and determination of the present flora and fauna. Thorough study by the interdepartmental committee should precede the adoption of such a course. The function of this committee would be to determine suitable localities for the field work, identify typical problems that could be solved in the localities, suggest possible faculty members for the course, and specify the course requirements.
Courses for developing effective teaching procedures. The translation of the teaching procedures identified in Chapter V into courses reveals that one existing course can be utilized, modifications would be desirable in two or more courses, and one new course would be desirable.

Essential background that begins to develop an understanding of the purposes of science teaching in the secondary school, the science curriculum, and the methods of teaching appropriate in the secondary school is provided in Education 604, The Teaching of Secondary School Science. This course would be included in the earth-science teacher's curriculum.

The modifications that would be desirable in developing teaching competencies were indicated in Chapter V as special sections of academic courses and special or additional laboratory sections in which the prospective teacher would have an opportunity to develop the needed abilities. Experiences would include doing field work, using special instruments, using reference materials, using the laboratory, and preparing appropriate teaching materials such as specimens, simple equipment, maps, demonstration devices, charts, and displays. The experiences provided should be those that are most closely related to the concepts from the course that will be taught in the high school. The following academic courses are those in which a modification would be desirable:

Geology 417  Physical Geology
Geology 418  Historical Geology
Through these modifications, the prospective teacher's attention to developing professional competence would begin earlier and extend over a longer period in his preparation than would be possible otherwise. His motivation to learn both the content of earth science and ways of teaching it should be enhanced.

A desirable new course would be one devoted to development of professional competencies unique to the area of earth science. This course would be offered in the College of Education in the present organizational pattern of The Ohio State University. The course would be taken by students after most of the academic courses were completed and either just preceding or concurrent with student teaching. The new course in the teaching of earth science would include experience in planning and developing teaching materials, locating resource materials, working with the materials being used in high school earth-science courses, and developing skill in teaching procedures. These would build on and extend the experiences obtained in previous academic and education courses. Each student would assess his preparation for teaching earth science and be provided with the opportunity to reinforce his background.

Such a practicum, thus proposed for earth-science teachers, would parallel in purpose and design the current practicums in biological science (Education 605, Problems in the Teaching of Biological Science).
and in general and physical science (Education 681, Laboratory Practicum for Teachers of Science). Experience with the latter courses over a period of many years has established their value to both prospective and experienced teachers.

A Teaching Area in Earth Science for

The Ohio State University

The earth-science major provides for depth of study in geology, supporting study in astronomy and meteorology, and broad preparation in several fields. The courses to be studied are divided into four groups requiring a total of 94 credit hours; 87 hours of the total are science courses and 7 hours are science education courses. The student would be expected to meet the mathematics prerequisites for the physics courses in addition to the requirements given below.

Group A. Earth Science Courses - 42 hours

Required courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy 500 - Descriptive Astronomy</td>
<td>5</td>
</tr>
<tr>
<td>Geography 615 - Climatology</td>
<td>4</td>
</tr>
<tr>
<td>Geology 416 - Introductory Geology</td>
<td>5</td>
</tr>
<tr>
<td>Geology 417 - Physical Geology</td>
<td>5</td>
</tr>
<tr>
<td>Geology 418 - Historical Geology</td>
<td>5</td>
</tr>
<tr>
<td>Geology 525 - The Common Rocks</td>
<td>3</td>
</tr>
<tr>
<td>Geology 601 - Geomorphology</td>
<td>5</td>
</tr>
<tr>
<td>Geology 6xx - Field Course for Earth-Science Teachers</td>
<td>5</td>
</tr>
<tr>
<td>Physics 420 - Descriptive Meteorology</td>
<td>5</td>
</tr>
</tbody>
</table>
Group B. Related Science Courses - 30 hours

Select a minimum of 10 hours from each of the following groups:

Group I.

Botany 401 - General Botany  
5 hours

Botany 402 - General Botany  
5 hours

Botany 505 - Introduction to Ecology  
5 hours

Zoology 400 - Principles of Biology  
5 hours

Zoology 401 - General Zoology  
5 hours

Zoology 402 - General Zoology  
5 hours

Zoology 509 - Evolution  
5 hours

Group II.

Chemistry 411 - General Chemistry  
5 hours

Chemistry 412 - General Chemistry  
5 hours

Chemistry 413 - General Chemistry  
5 hours

Group III.

Physics 411 - General Physics: Mechanics and Sound  
5 hours

Physics 412 - General Physics: Heat, Electricity, Magnetism, Light  
5 hours

Physics 413 - General Physics: Modern Physics  
5 hours

Group C. Science electives - 15 hours

Select a minimum of 15 hours from the following courses:

Arts Survey 608 - Development of Modern Science  
5 hours

Conservation 401 - Introduction to Conservation  
3 hours

Geology 505 - Study of Geologic Maps  
3 hours
Geology 520 - Invertebrate Paleontology  5 hours
Geology 600 - The Common Mineral Deposits  3 hours
Geology 602 - Structural Geology  5 hours
Geology 606 - Economic Geology: Nonmetals and Coal  5 hours
Photography - Scientific Photography  3 hours
Additional courses in Groups I, II, or III of Group B, each  5 hours

Group D. Required Professional Courses - 7 hours
Education 604 - The Teaching of Secondary School Science  4 hours
Education 6xx - Problems in the Teaching of Earth Science  3 hours

The above teaching area in earth science would fulfill the demands of the proposed curriculum to the extent of providing basic competency for the beginning earth-science teacher. Additional course work in earth science and related science areas would be desirable in a fifth year of study.

Relationship of the Earth-Science Teaching Area to Certification Requirements in Ohio

The certification requirement for the teaching of earth science in the State of Ohio is 15 semester hours "including appropriate courses in Geology and Geography." The intent of the certification requirement

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is not clear with respect to the meaning of the term "appropriate" and whether or not courses in both geology and geography are required. Assuming that any course in geology and geography concerned with topics that are taught in the secondary school is considered to be appropriate, the question of requiring both geology and geography remains. If both are required, the planned teaching area in earth science would barely meet these requirements since only one course in geography is included.

The certification requirement of 15 semester hours (or $22\frac{1}{2}$ quarter hours) is greatly exceeded in the earth-science teaching area as proposed. The earth-science courses in the teaching area have a minimum total of 28 semester hours (42 quarter hours) or almost double the requirement of the State of Ohio.

**Summary**

An interpretation has been made in this chapter of the curriculum proposed in Chapter V for possible adoption at The Ohio State University. The curriculum has been adapted to the existing pattern for preparing science teachers by identifying courses that form a teaching area in earth science. Modifications in four science courses have been suggested so that prospective teachers would have the opportunity to relate teaching procedures to the content of earth science at several points in their preparation. Two new courses have been proposed; one is a field course and the other a practicum designed to develop the students' ability in the teaching of earth science.
The teaching area proposed is an earth-science major requiring 94 credit hours of course work. Earth-science courses account for 42 credit hours. Related science courses in the biological sciences, physics, and chemistry are required in the amount of ten credit hours in each. Fifteen credit hours of science electives are included, bringing the science course requirements to 87 credit hours. The other seven credits are required professional courses in the teaching of science.

The proposed teaching area exceeded the credit requirements of other science teaching majors. If it is considered that 15 of the 87 credit hours of required science courses fulfill the general education requirement in science, the remaining 72 credits compare favorably with the credit requirements for a major and minor in other sciences.
CHAPTER VII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to propose a curriculum for the academic preparation of earth-science teachers. The need for making the study arose from the increasing demand for teachers prepared in the earth sciences, and the lack of a program for preparing earth-science teachers at The Ohio State University. In order to develop the curriculum and verify the need for it, it was necessary to determine the nature and current status of earth science in the secondary school. Likewise, it was necessary to ascertain the needs of teachers in utilizing earth-science content for incorporation in the proposed curriculum.

The review of the literature revealed that many teachers currently teaching earth science in New York, Pennsylvania, New Jersey, and Ohio have an inadequate preparation for their teaching assignment. A similar lack of preparation was found among the applicants to Summer Institutes in Earth Science at Colorado College, and at Franklin and Marshall College. Few of these teachers met the certification requirements for earth science in the states in which they were teaching. This inadequate preparation has been attributed to the rapid growth of earth-science courses in recent years. Teachers have not been prepared in sufficient numbers to meet the demand.
Earth-science courses were common in the form of physical geography at the beginning of the Twentieth Century. By 1920, general science had replaced physical geography in most schools. The revival of interest in earth science began in 1948 when an experimental program was initiated on a limited basis in the schools of the State of New York. In 1958, after a gradual increase for several years, earth-science courses began to be adopted in many other school systems in New York and nearby states. By 1961, earth science was offered in 39 states. Data obtained in this study revealed that this number had increased to 46 states in 1962. In these states, 3,052 schools offered earth-science courses. There were 4,195 teachers instructing 190,418 students during the 1962-63 school year. Thus, the growth has been rapid during the past four years.

Interest in the earth-science course has been shown by local and national scientific groups. Local geological societies have cooperated with public libraries, Boy Scout troops, and schools in providing programs, materials, courses, and field trips. The American Geological Institute sponsored the Duluth Conference which produced the Geology and Earth Science Sourcebook. This association is now sponsoring the Earth Science Curriculum Project with support from the National Science Foundation. Such activities have aided earth-science teachers by providing them with information, experience, and materials directly related to their needs.

Information from science consultants and state certification officers was obtained and analyzed in determining the nature of the
developing earth-science course. The analysis revealed that 27 states had certification requirements for earth-science teachers. The requirements for an earth-science major ranged from 15 to 54 semester hours in earth-science courses. The mean requirement was 29.6 semester hours. Among the facts revealed in analyzing the information from state officials were the following:

1. Earth-science courses were taught in 46 states in 1962-1963.
2. The earth-science course was taught most frequently at the ninth grade level.
3. Less than one-third of the states, 14 of 46, included laboratory work in earth science.
4. The greatest need in establishing these sources was that of obtaining qualified teachers.

Earth-science textbooks and courses of study were analyzed to determine the content of earth science in the secondary schools. On the basis of this analysis, the teacher of earth science needs to be competent in teaching concepts from the science areas of geology, oceanography, meteorology, and astronomy. Geology topics make up about one-half of the total number of topics identified as being appropriate to the earth-science course. Topics from meteorology constitute about one-fourth; astronomy, oceanography, and conservation topics make up the remaining one-fourth of the course.

Directors' reports from summer institutes for earth-science teachers in 1962 were utilized in determining the kinds of experience and academic preparation needed by earth-science teachers. The
greatest need of teachers who applied for and attended these institutes was for basic course work in physical and historical geology, oceanography, astronomy, and meteorology. Specific kinds of experiences that proved helpful to participants were laboratory work, field trips, collecting and identifying rock, mineral, and fossil specimens, and the exchange of ideas and information on effective teaching procedures.

The unique competencies needed by teachers of earth science were identified from the analysis of data and literature as: (1) a knowledge of earth science; (2) knowledge of other sciences; (3) an understanding of the interrelationship of the sciences; and (4) knowledge and ability in the procedures effective in teaching earth science. The proposed curriculum was developed in light of the needed competencies in these areas.

The proposed curriculum resulting from the foregoing analyses consists of the experiences in the study of earth-science topics. The major topics are those essential to the development of an understanding of the lithosphere, hydrosphere, atmosphere, biosphere, and the earth's environment in space. Study in each of these involves information and concepts from all of the sciences which emphasizes the interdisciplinary aspect of earth science. The curriculum thus involves study in astronomy, chemistry, biological science, geology, meteorology, and physics.

The curriculum for the preparation of earth-science teachers provides for developing the abilities and competencies needed in teaching the earth-science courses. This facet of the teacher's preparation is
developed through attention to teaching procedures in the academic courses and in special courses in the teaching of earth science. Attention to teaching procedures can be effectively directed in special laboratory sections of certain of the academic courses for earth-science teachers.

An interpretation of the proposed curriculum was made for possible adoption at The Ohio State University. A teaching area in earth science was established within the pattern of the existing program for preparing science teachers. Courses were identified which would provide a background of information and understanding of the topics in the curriculum. The resulting teaching area consists of three groups of courses requiring 87 credit hours in science courses, and seven credit hours in required professional courses in science education. The student would take 42 credit hours of required courses in astronomy, geography, geology, and meteorology. He would select thirty credit hours of study in the biological sciences, chemistry, and physics, with a minimum of ten credit hours from each area. An additional 15 credit hours would be selected from related science courses. The seven credit hours of required professional courses would include a course in the teaching of secondary school science, and one concerned with problems in the teaching of earth science.

The teaching area, as proposed for The Ohio State University, exceeds the certification requirements for an earth-science teacher in the State of Ohio. The state requirements are 15 semester hours in appropriate courses in geology and geography. The proposed teaching
area requires 28 semester hours (42 quarter hours) in earth-science courses.

Conclusions

The following four conclusions have been reached as a result of this study:

1. The hypothesis that the number of schools offering, and those which are planning to offer, earth-science courses has created a demand for earth-science teachers was substantiated. The information obtained and analyzed in this study revealed that the problem of obtaining qualified teachers was acute in states where earth science is an established course as well as in states where the course is just becoming a part of the curriculum. Inadequately prepared teachers are teaching earth science in many schools. Preparation of greater numbers of earth-science teachers is needed if the course is to be successfully introduced in schools where it is not included in the present curriculum. Increased numbers of qualified earth-science teachers would permit reassignment of some teachers to teach in the science areas of their greatest competency.

2. The hypothesis that an academic curriculum can be planned that will adequately prepare an earth-science teacher for his initial teaching responsibility and make provisions for his continued growth was substantiated. The curriculum as proposed and interpreted for an earth-science teaching area at The Ohio State University has been based on the needs of teachers. Meeting these needs provides the basic background of information and experience for the beginning teacher. The
depth of preparation in earth science in the curriculum would enable the teacher to continue formal study in a fifth-year program or through independent study.

3. It is evident that interdepartmental cooperation is essential in the preparation of earth-science teachers. Providing separate or additional laboratory sections in science courses, planning and teaching earth-science field courses, and developing a professional course in the teaching of earth science are examples of special instances requiring the efforts of personnel from various departments. Committees and consultants representing departments of astronomy, biology, education, geography, geology, and meteorology should participate in the development of courses for earth-science teachers.

4. A fourth conclusion drawn from this study is that more opportunities need to be provided for in-service teachers to improve their background in earth science. This conclusion is supported by the fact that many earth-science teachers do not meet the minimum certification requirements in their state. In addition, only 10 per cent of the teachers applying to Earth Science Summer Institutes in 1962 were able to participate in an institute because of limited enrollment in each institute. Both the need of teachers and their desire for additional course work in earth science indicate that opportunities to take courses during the summer and in evening classes during the academic year are desirable.

Recommendations

The faculty of the science education area of the Department of Education at The Ohio State University should initiate a proposal to
the Faculty Committee of the College of Education for the establishment of a teaching area in earth science. This proposal should be based on the teaching area developed in Chapter VI of this study. The development of the proposal should be assumed by the faculty of the science education area, since they would have responsibility for advising students in the program and in teaching the professional courses. Personnel from the earth sciences should be consulted or included on the committee in developing the proposal.

In conjunction with developing a teaching area in earth science, it is recommended that an interdepartmental committee of scientists and science educators begin to study and develop two new courses for inclusion in the earth-science teacher's curriculum. One of these would be an interdisciplinary field course in earth science, the other a special course in the teaching of earth science. Through cooperative study, the committee should identify the experiences the prospective teacher would have in the courses, where the courses should be taught, and who should teach them. The unique competencies needed by earth-science teachers identified in Chapter IV should be considered by the interdepartmental committee in designing the new courses.

Instructors in such academic courses as physical and historical geology, geomorphology, and meteorology should be encouraged to consider the possibility of special or additional sections of their courses for earth-science teachers. Responsibility for such encouragement should be assumed by the science education faculty. The interdepartmental committee responsible for developing new courses should include one or more of the instructors of these academic courses.
In this way, mutual understanding of the problems involved in preparing earth-science teachers could be developed.

The certification requirements for earth-science teachers in Ohio are in need of revision. As presently stated, these requirements are vague and inadequate. New requirements designed to raise the level of academic and professional qualifications of the teacher should be enacted. It is recommended that the State Department of Education re-study the certification requirements for earth-science teachers. The faculty of the science education area and representatives of the earth sciences should encourage the State Department of Education to re-study the requirements and offer their help in formulating new standards.

**Suggestions for Further Research**

In the course of this study a number of problem areas worthy of research became apparent. Studies in the following areas should prove to be helpful in continuing to provide a research basis for the preparation of earth-science teachers:

1. An evaluation of the curriculum as proposed in this study should be made if the curriculum is implemented at The Ohio State University. On the basis of the evaluation, the curriculum should be modified where necessary.

2. A comprehensive study is needed to determine the status of the preparation of persons currently teaching earth science. This should be on a nationwide basis. Such studies for the states of Pennsylvania, New Jersey, and Ohio have proved helpful in identifying
the needs of earth-science teachers. More complete information would provide a reliable basis for establishing programs to prepare teachers.

3. Information is needed concerning the amount of earth science that is included in the preparation of elementary school teachers and secondary school science teachers other than those teaching earth science.

4. The development of graduate level courses especially designed for earth-science teachers should be studied. The need for such courses is indicated by the relatively large number of earth-science teachers with a good background in other science areas, but little preparation in earth science.

5. Experimental studies to determine the effectiveness of field trips would be useful. Field trips involve scheduling problems in the secondary schools. Adequate evidence of their value is needed so that teachers and administrators can decide how field trips should be used in the school's earth-science course.

6. Summer institute courses in earth science should be analyzed for the possibility of offering such courses in the academic preparation of prospective teachers. Many special courses have been designed for the institute programs that have been helpful to inservice teachers; such courses may have value for the pre-service teacher as well.

7. The possibility of using a dual-degree program for the preparation of earth-science teachers should be investigated. The limitations of time in the traditional four-year period of preparation
leading to the baccalaureate degree may be partially overcome through extending the period of preparation to include a degree in a science area and one in education.

8. The products of the Earth Science Curriculum Project should be introduced and evaluated in teacher preparation programs. The materials currently being developed in this project will be available for use in the secondary school. Evaluation of the materials would serve the purposes of indicating changes or additions needed, enabling the prospective teacher to become familiar with materials he may use, and determining to what extent the curriculum has prepared the prospective teacher to use new materials as they become available.
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APPENDIX A

1. QUESTIONNAIRE SENT TO SCIENCE SUPERVISORS
2. COVER LETTER FOR QUESTIONNAIRE
3. FOLLOW-UP LETTER
INFORMATION ON EARTH-SCIENCE COURSES

Please check the appropriate answers and/or provide brief written answers where needed. All questions apply to your state only. The term "Earth Science" includes related titles such as "Earth and Space Science."

1. Name of State__________________________________________________________

2. In schools where earth science is taught, it is generally:
   □ taught as a separate course. Grade level(s)__________________________
   □ taught as a part of another science course. Grade level(s)_______________
       Course Name(s)____________________________________________________
   □ not offered in this state.

3. Earth-Science courses have been taught in this state for ________ years.

4. Certification for earth-science teachers:
   □ have definite certification requirements.
   □ no certification requirements for earth-science teachers.
   □ certification requirements planned and will become effective__________
      (date).

5. If your state has earth-science certification requirements, please list or enclose a copy of them.
6. If earth science is taught in your state, please give the following information for the current school year. If figures are for a prior year, please specify.
   a. Total number of schools offering earth science?
   b. Total number of sections of earth science in state?
   c. Total number of students enrolled in these courses?
   d. Total number of teachers teaching these courses?
   e. Total number of teachers in (d) who are certified to teach earth science?
   f. Information above based on [actual figures] [my estimate].

7. If earth science is taught in your state, please indicate:
   a. Textbook(s) used (Use 1 = most used, 2 = next in use, and 3 = least used)
      □ Finch, Trewartha and Shearer, The Earth and Its Resources.
      □ Fletcher and Wolfe, Earth Science.
      □ Namowitz and Stone, Earth Science, The World We Live In.
      □ Ramsey and Burklely, Modern Earth Science.
      □ Other, Author and Title: ____________________________
   b. Is it typically a laboratory course? □ Yes. □ No.
   c. If it is a laboratory course, what laboratory manuals are used (if any)?

8. Would you find it helpful to have a panel or committee of area geology teachers review your earth-science curriculum or related parts of other science courses and offer suggestions for your consideration? □ Yes. □ No.

9. What special problems have been encountered in the implementation and operation of earth-science courses?
Form completed by ________________ (name) ________________ (title)

☐ Please send an analysis of this information to me at the following address:

______________________________________________________________

PLEASE RETURN THE COMPLETED FORM IN THE ENCLOSED ENVELOPE TO:
Mr. John W. Shrum, 248 Arps Hall, The Ohio State University,
Columbus 10, Ohio.
COVER LETTER FOR QUESTIONNAIRE

March 2, 1963

246 Arps Hall

Dear [Name]:

The recent increase in the number of schools offering an Earth Science Course has raised problems of preparing teachers for these courses. The U. S. Office of Education is currently preparing its 1962 edition of "Offerings and Enrollment in Science and Mathematics in Public High Schools." For the first time that publication will list Earth Science as a separate course instead of being included with "Other Sciences." However, the data in that publication will not include certain items that would be quite helpful to those of us interested in preparing science teachers. The needed information is not available in compiled form from any source at this time.

Dr. E. S. Osbourn, Specialist for Science in the U. S. Office of Education, has suggested that you as a State Science Supervisor would be the best source for the needed information. I am therefore requesting that you complete the enclosed information form and return it at your earliest convenience. The information obtained will be tabulated and analysed. It will then form part of the background information in a proposed curriculum for the preparation of Earth-Science teachers, a research study being conducted under the supervision of Professor John S. Richardson.

The Committee on Education of the National Association of Geology Teachers had been planning to make a study very similar to this one. Instead, this NAGT Committee has authorized me to collect the data that they need. I will then share with them the data you submit. Through this cooperation, it is our sincere wish to obtain accurate information without imposing on your time on two occasions.

If an analysis of the information obtained from all states would be of interest to you, please check the appropriate statement on the enclosed information form.

Very truly yours,

John W. Shrum

Enclosures (2)
Follow-up Letter

April 9, 1963

248 Arps Hall

Dear [Name]

On March 2, 1963, I mailed a request to your office for information concerning earth-science courses in your state. Realizing that you may not have received this request or that it could easily have been misplaced, I am enclosing another form with this letter. If you will complete this form according to the information you have at hand, I will be able to compile data that are not presently available from any other source. Even if you have to use estimates for some of the requested numbers, the information will be helpful.

Please check the appropriate statement on the enclosed form if an analysis of the information obtained from all states would be of interest to you. I now have the information from three-fourths of the states and hope to have replies from all fifty states.

The information obtained from the State Science Directors will be tabulated and analyzed. It will then form part of the background information in a proposed curriculum for the preparation of earth-science teachers. This research is being conducted under the supervision of Professor John S. Richardson.

The Committee on Education of the National Association of Geology Teachers had been planning to make a study very similar to this one. Instead, this NAGT Committee has authorized me to collect the data they need. I will then share with them the data you submit. Through this cooperation, it is our sincere wish to obtain accurate information without imposing on your time on two occasions.

Very truly yours,

John W. Shrum

Enclosures (2)
<table>
<thead>
<tr>
<th>State</th>
<th>Years Offered</th>
<th>Offered as Separate Course at Indicated Grade Levels</th>
<th>Part of Other Courses: Course Name and Grade Levels</th>
<th>Have Cert. Reqmts. for Earth-Science Teachers</th>
<th>Cert. Reqmts. Planned to be effective (date)</th>
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<tbody>
<tr>
<td>Alabama</td>
<td>--</td>
<td>(in one school)</td>
<td>8, 11, 12</td>
<td>No</td>
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<tr>
<td>Alaska</td>
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<td>8 &amp; 9</td>
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<tr>
<td>Arizona</td>
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<tr>
<td>California</td>
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<td>9 to 12</td>
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<td>10</td>
<td>7,8,9 (1 yr. of 3)</td>
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<td>Some in elem.</td>
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<td></td>
<td></td>
<td></td>
<td>7 &amp; 8</td>
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<td>Georgia</td>
<td>--</td>
<td></td>
<td>All science 1 thru 8</td>
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<tr>
<td>Hawaii</td>
<td>1</td>
<td>8 &amp; 9</td>
<td>Gen. Sci. 7,8 &amp; 9</td>
<td>No</td>
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<td></td>
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<td>State</td>
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<td>Part of Other Courses: Course Name and Grade Levels</td>
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<td>Cert. Reqmts. Planned to be Effective (date)</td>
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<tr>
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<td>(will be in 1963-64, 8 &amp; 9)</td>
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<td>No</td>
<td>By Sept. 1963 or 63-64 school year</td>
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<td>(will be introduced in select schools - '63)</td>
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<td>information not compiled and therefore not available</td>
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<td>Part of Other Courses: Course Name and Grade Levels</td>
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<td>Cert. Reqmts. Planned to be effective (date)</td>
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<td>(in 2 schools)</td>
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<td>(in 10 schools)</td>
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<td>9 &amp; 10</td>
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<tr>
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<td>25</td>
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<td>9/1/63</td>
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<td>?</td>
<td>a few schools in 8 &amp; 9</td>
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<td>1967</td>
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<td>(15 schools-8th.)</td>
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<td>Oklahoma</td>
<td>10</td>
<td>9 &amp; 10</td>
<td></td>
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<td></td>
<td>Years Offered</td>
<td>Offered as Separate Course at Indicated Grade Levels</td>
<td>Part of Other Courses: Course Name and Grade Levels</td>
<td>Have Cert. Reqmts. for Earth-Science Teachers</td>
<td>Cert. Reqmts. Planned to be effective (date)</td>
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<td>---------------</td>
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<td></td>
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<td></td>
<td>11 &amp; 12 (10%)</td>
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<td>4</td>
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<td>8</td>
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<tr>
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<td>77</td>
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<td>Gen. Sci.</td>
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<td></td>
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<tr>
<td>Texas</td>
<td>2-3</td>
<td>8</td>
<td>1-6 Sp. courses 10,11,12</td>
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<td>Possibly 1965</td>
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<td>20</td>
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<td>Vermont</td>
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<td>Washington</td>
<td>30?</td>
<td>8 &amp; 9</td>
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<td>Gen. Sci. 9</td>
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<td>State</td>
<td>Years Offered</td>
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<td>Part of Other Courses: Course Name and Grade Levels</td>
<td>Have Cert. Reqmts. for Earth-Science Teachers</td>
<td>Cert. Reqmts. Planned to be Effective (date)</td>
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<td>---------------------------------------------</td>
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<td>Wisconsin</td>
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<td>Wyoming</td>
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<tr>
<td>District of Columbia</td>
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<td>7, 8, &amp; 9 as 8 wk. units in exp. progr.</td>
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### Table 14


<table>
<thead>
<tr>
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<th>No. of Schools Offering</th>
<th>No. of Classes in Schools</th>
<th>No. of Students Enrolled</th>
<th>No. of Teachers</th>
<th>No. of Teachers Certified in Earth Science</th>
<th>Actual (A) or Estimated (E)</th>
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<tbody>
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<td>Alabama</td>
<td>1</td>
<td>3</td>
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<td>Alaska</td>
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<td>10</td>
<td>157</td>
<td>7</td>
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<td>Arizona</td>
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<td>4,166</td>
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<td>150</td>
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<td>39*</td>
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<td>Indiana</td>
<td>14*</td>
<td>21*</td>
<td>425*</td>
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<td>40</td>
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<td>14*</td>
<td>350</td>
<td>14</td>
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<td>E</td>
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<td>not offered as separate course</td>
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Table 14 (Contd.)

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<th>No. of Schools Offering</th>
<th>No. of Classes in Schools</th>
<th>No. of Students Enrolled</th>
<th>No. of Teachers</th>
<th>No. of Teachers Certified in Earth Science</th>
<th>Actual (A) or Estimated (E)</th>
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<tbody>
<tr>
<td>Maine</td>
<td>40</td>
<td>70</td>
<td>1,500</td>
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<td>Mass.</td>
<td>(95)</td>
<td>(95)</td>
<td>(2,090)</td>
<td>(95)</td>
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<td>Minnesota</td>
<td>298</td>
<td>799</td>
<td>2,250*</td>
<td>35*</td>
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<td>E</td>
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<td>Mississippi</td>
<td>2</td>
<td>2*</td>
<td>(47)P</td>
<td>2*</td>
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<td>Missouri</td>
<td>10</td>
<td>20</td>
<td>200</td>
<td>12</td>
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<td>Montana</td>
<td>42</td>
<td>58</td>
<td>1,292</td>
<td>42</td>
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<td>32 A</td>
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<td>3</td>
<td>55</td>
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<td>New Hamp.</td>
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<td>140</td>
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<td>E</td>
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<td>8</td>
<td>11*</td>
<td>(259)P</td>
<td>11</td>
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<td>E</td>
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<tr>
<td>New York</td>
<td>570</td>
<td>1034</td>
<td>26,456</td>
<td>600</td>
<td></td>
<td>A</td>
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<td>North Car.</td>
<td>E.S. a separate course in a few schools, but, in general, it is presently taught as part of Gen.Sci.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. Dakota</td>
<td>15</td>
<td>27</td>
<td>810</td>
<td>15</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Ohio</td>
<td>50</td>
<td>100</td>
<td>2,500</td>
<td>60</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>50</td>
<td>75</td>
<td>5,000</td>
<td>50</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>(Experimental course)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oregon</td>
<td>4</td>
<td>4</td>
<td>104</td>
<td>4</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>400</td>
<td>700*</td>
<td>68,000</td>
<td>700</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>14</td>
<td>20</td>
<td>500</td>
<td>14</td>
<td></td>
<td>E</td>
</tr>
</tbody>
</table>
Table 14 (Contd.)

<table>
<thead>
<tr>
<th>State</th>
<th>No. of Schools Offering</th>
<th>No. of Classes in Schools</th>
<th>No. of Students Enrolled</th>
<th>No. of Teachers</th>
<th>No. of Teachers Certified in Earth Science</th>
<th>Actual (A) or Estimated (E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Carolina</td>
<td>60</td>
<td>170</td>
<td>5,309</td>
<td>60*</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>S. Dakota</td>
<td>8</td>
<td>10</td>
<td>180</td>
<td>8</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Tennessee</td>
<td>not offered as a separate course</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas</td>
<td>500</td>
<td>500*</td>
<td>4,645$</td>
<td>500*</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Utah</td>
<td>23</td>
<td>139</td>
<td>4,048</td>
<td>28</td>
<td></td>
<td>A &amp; E</td>
</tr>
<tr>
<td>Vermont</td>
<td>32</td>
<td>34*</td>
<td>1,057</td>
<td>34</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Virginia</td>
<td>400</td>
<td>2000</td>
<td>12,000</td>
<td>1000</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Washington</td>
<td>65$</td>
<td>95$</td>
<td>2,100$</td>
<td>65$</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>W. Virginia</td>
<td>12</td>
<td>16</td>
<td>711</td>
<td>12*</td>
<td></td>
<td>E</td>
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<tr>
<td>Wisconsin</td>
<td>11</td>
<td>11*</td>
<td>315</td>
<td>11*</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Wyoming</td>
<td>13®</td>
<td>45$</td>
<td>1,000$</td>
<td>13®</td>
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<td>E</td>
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<tr>
<td>New York Sr.Hi.</td>
<td>38</td>
<td>330</td>
<td>11,217</td>
<td>75</td>
<td>50</td>
<td>A</td>
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<tr>
<td>City Jr.Hi.</td>
<td>75</td>
<td>125</td>
<td>4,300</td>
<td>75</td>
<td>75</td>
<td>E</td>
</tr>
<tr>
<td>Totals</td>
<td>3052</td>
<td>6839</td>
<td>190,418</td>
<td>4195</td>
<td>421</td>
<td></td>
</tr>
</tbody>
</table>

* = minimum figure derived from other figures, either # of schools or teachers.

$ = a range was reported, the range was averaged to obtain these figures.

( ) = Massachusetts reported E.S. taught in 20% of schools; used 20% of the 1958-59 enrollment figures.
<table>
<thead>
<tr>
<th>State</th>
<th>Textbooks used:</th>
<th>Laboratory work included:</th>
<th>Desire Curriculum Help</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>S</td>
<td>B</td>
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<td>Alabama</td>
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<td>Alaska</td>
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<td>Arizona</td>
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<td>Arkansas</td>
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<td>Colorado</td>
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<td>1</td>
<td>2</td>
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<td>Conn.</td>
<td>2</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Delaware</td>
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<td></td>
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<tr>
<td>Florida</td>
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<tr>
<td>Georgia</td>
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<td>Hawaii</td>
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<td>x</td>
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<tr>
<td>Idaho</td>
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</tr>
<tr>
<td>Illinois</td>
<td>no information available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indiana</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Iowa</td>
<td>1</td>
<td>3</td>
<td>2</td>
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<tr>
<td>Kansas</td>
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<tr>
<td>Kentucky</td>
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<td></td>
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<tr>
<td>Louisiana</td>
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<td></td>
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<tr>
<td>Maine</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>State</td>
<td>Textbooks used:</td>
<td>Laboratory work included:</td>
<td>Desire Curriculum Help</td>
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<td>FW</td>
<td>NS</td>
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<tr>
<td>Maryland</td>
<td>no figures available</td>
<td></td>
<td></td>
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<tr>
<td>Mass.</td>
<td>varies</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>Michigan</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Minnesota</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Miss.</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Missouri</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Montana</td>
<td>3 1 1</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Nebraska</td>
<td>no figures available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nevada</td>
<td>2 1</td>
<td>Yes ?</td>
<td>No</td>
</tr>
<tr>
<td>New Hamp.</td>
<td>No</td>
<td>Yes ?</td>
<td>Yes</td>
</tr>
<tr>
<td>New Jersey</td>
<td>3 1 2</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>New Mexico</td>
<td>x x x x</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>4 3 1 2</td>
<td>Yes With texts</td>
<td>Yes</td>
</tr>
<tr>
<td>N. Carolina</td>
<td>1 2 3</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>N. Dakota</td>
<td>3 2 1</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ohio</td>
<td>x x x</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Oklahoma</td>
<td>x Brownf et al</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Oregon</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>2 3 1 2</td>
<td>Yes ?</td>
<td>Yes</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>No</td>
<td></td>
<td></td>
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<tr>
<td>State</td>
<td>Textbooks used:</td>
<td>Laboratory work included:</td>
<td>Desire Curriculum Help</td>
</tr>
<tr>
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<td>---------------------------</td>
<td>------------------------</td>
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<tr>
<td></td>
<td>PA</td>
<td>TS</td>
<td>Fb</td>
</tr>
<tr>
<td>S. Carolina</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>S. Dakota</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tennessee</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Utah</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Vermont</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Virginia</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>W. Virginia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wisconsin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyoming</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>District of Columbia</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>New York City</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Textbook Use Code: 1 = most used, 2 = next in use, 3 = least used, x = used, but not ranked


Table 16

Status of Earth Science in the United States, 1962-1963:
Special Problems in Implementation and Operation

<table>
<thead>
<tr>
<th>State</th>
<th>Special Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>None listed</td>
</tr>
<tr>
<td>Alaska</td>
<td>None listed</td>
</tr>
<tr>
<td>Arizona</td>
<td>No information available</td>
</tr>
<tr>
<td>Arkansas</td>
<td>None listed - Earth science not taught as a special course.</td>
</tr>
<tr>
<td>California</td>
<td>None listed</td>
</tr>
<tr>
<td>Colorado</td>
<td>Good texts, qualified teachers, acceptance as a lab course.</td>
</tr>
<tr>
<td>Connecticut</td>
<td>Lack of well-qualified teachers, lack of adequate equipment and materials (in indiv. schools)</td>
</tr>
<tr>
<td>Delaware</td>
<td>None listed</td>
</tr>
<tr>
<td>Florida</td>
<td>Qualified teachers - those having background in geology, meteorology, and astronomy</td>
</tr>
<tr>
<td>Georgia</td>
<td>None listed</td>
</tr>
<tr>
<td>Hawaii</td>
<td>Trained teachers, scheduling problems with field trips</td>
</tr>
<tr>
<td>Idaho</td>
<td>Teacher preparation</td>
</tr>
<tr>
<td>Illinois</td>
<td>None listed</td>
</tr>
<tr>
<td>Indiana</td>
<td>Adequately cert. teachers - new ES curric. being written for Indiana schools - expect rapid expansion</td>
</tr>
<tr>
<td>Iowa</td>
<td>None listed</td>
</tr>
<tr>
<td>Kansas</td>
<td>None listed</td>
</tr>
<tr>
<td>Kentucky</td>
<td>State Department has recommended to State Board of Education that earth science be offered in grade 8 or 9 - hope for approval for 1963-64 school year</td>
</tr>
<tr>
<td>Louisiana</td>
<td>None - proposal to NASA for preparing ES syllabus to be introduced in selected schools in 1963-64</td>
</tr>
</tbody>
</table>
Table 16 (Continued)

<table>
<thead>
<tr>
<th>State</th>
<th>Special Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine</td>
<td>Convincing local school authorities that money should be spent for lab materials, and that extra periods should be allocated for lab work</td>
</tr>
<tr>
<td>Maryland</td>
<td>None</td>
</tr>
<tr>
<td>Mass.</td>
<td>None listed</td>
</tr>
<tr>
<td>Michigan</td>
<td>No information available</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Availability of teachers, teacher qualification, suitable curriculum materials</td>
</tr>
<tr>
<td>Mississippi</td>
<td>Teacher training; emphasis of other courses</td>
</tr>
<tr>
<td>Missouri</td>
<td>None listed</td>
</tr>
<tr>
<td>Montana</td>
<td>None listed</td>
</tr>
<tr>
<td>Nebraska</td>
<td>None listed</td>
</tr>
<tr>
<td>Nevada</td>
<td>Lack of teachers with proper background (Education)</td>
</tr>
<tr>
<td>New Hamp.</td>
<td>Introducing more laboratory, more field trips, utilization of available resource persons</td>
</tr>
<tr>
<td>New Jersey</td>
<td>Training of teachers in earth sciences, making into laboratory science</td>
</tr>
<tr>
<td>New Mexico</td>
<td>Availability of teachers</td>
</tr>
<tr>
<td>New York</td>
<td>Qualified teachers; time for laboratory work</td>
</tr>
<tr>
<td>N. Carolina</td>
<td>None listed</td>
</tr>
<tr>
<td>N. Dakota</td>
<td>Trained teachers and suitable text for 8th grade - writing teachers guide now for all 8th grade in Fall 1963</td>
</tr>
<tr>
<td>Ohio</td>
<td>Grade placement</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>None listed</td>
</tr>
<tr>
<td>Oregon</td>
<td>Lack of accurate information (establishing new research department)</td>
</tr>
</tbody>
</table>
Table 16 (Contd.)

<table>
<thead>
<tr>
<th>State</th>
<th>Special Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvania</td>
<td>1. Preparation of teachers. 2. Insuring a laboratory centered course.</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>None listed</td>
</tr>
<tr>
<td>S. Carolina</td>
<td>Teacher preparation, laboratory facilities and materials</td>
</tr>
<tr>
<td>S. Dakota</td>
<td>None listed</td>
</tr>
<tr>
<td>Tennessee</td>
<td>None listed</td>
</tr>
<tr>
<td>Texas</td>
<td>None listed</td>
</tr>
<tr>
<td>Utah</td>
<td>No guide or course of study prepared; converting teachers to a laboratory centered program</td>
</tr>
<tr>
<td>Vermont</td>
<td>Teachers lack training in earth science; schools lack equipment and laboratory room</td>
</tr>
<tr>
<td>Virginia</td>
<td>None given</td>
</tr>
<tr>
<td>Washington</td>
<td>Obtaining well-qualified teachers</td>
</tr>
<tr>
<td>W. Virginia</td>
<td>The inertia to change</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>None listed</td>
</tr>
<tr>
<td>Wyoming</td>
<td>Certification of teachers, acceptance of course in curriculum by community</td>
</tr>
<tr>
<td>District of</td>
<td>None listed</td>
</tr>
<tr>
<td>Columbia</td>
<td>Programming of laboratory periods</td>
</tr>
<tr>
<td>New York City</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

1. SUMMER INSTITUTES REPORT FORM
2. COVER LETTER
3. FIRST FOLLOW-UP LETTER
4. SECOND FOLLOW-UP LETTER
5. EARTH-SCIENCE INSTITUTE DIRECTORS
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DIRECTOR'S REPORT* PART

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SECTION D.

25,


### B. SELECTION PROCESS

1. List the major criteria applied in selecting participants and evaluate the effectiveness of the process,
C. INSTITUTE PROGRAM

1. Mention specific problems concerning the content or level of the program, such as overscheduling or adjusting to the participant level:

2. Discuss the effectiveness of scheduled extracurricular activities in encouraging group interaction and in meeting the individual needs of the participants, such as remedial sessions or counseling:
D. PARTICIPANTS

1. Give some examples of positive and negative reactions of the participants to their institute experience.
D. PARTICIPANTS (continued)

2. Give examples of the participants' plans to continue their development, such as independent study or degree work:

3. Mention any plans for follow-up studies on the post-institute activities of the participants:
E. STAFF AND VISITING LECTURERS

1. Comment on problems in obtaining staff and visiting lecturers:

2. Describe the general reaction of the staff to the institute and participants:

3. State your judgment of the value of the visiting lecturer program, particularly foreign lecturers:
# H. RECOMMENDATIONS FOR THE FUTURE

1. Please suggest ways to improve the Summer Institutes Program on the following levels:

   a. Local

   b. Regional
COVER LETTER

March 13, 1963

248 Arps Hall

Dear [Name]:

As an Earth Science Institute Director, and possibly from personal concern, you are already aware of the recent increase in the numbers of secondary schools offering courses in the earth sciences. Those of us especially interested in the preparation of science teachers are also concerned. Recent studies (Moss, Journal of Geological Education, June, 1962 and an article by Stone, Kosoloski, and Leux in Geotimes, October, 1962, for example) point out the need for more and better prepared earth science teachers. Research on the preparation of earth science teachers is conspicuous by its absence.

A study I am making will result in a proposed curriculum for the preparation of earth science teachers. Part of the information that will be of great value in this study is in your possession in the form of selected pages in your Summer Institute Director's Report. The National Science Foundation Office does not release these reports, but there is no objection to the individual director's making his report available. I am therefore seeking your help by requesting the information on the following pages of the Director's Report for your Institute in 1962:

Page 4, Part I : Descriptive Titles (Of courses offered)
Page 2, Part III B. : Selection Process
Page 3, Part III C. 1. : Specific Problems—content level
Page 4, Part III D. 1. : Positive and negative reactions of participants
Page 5, Part III D. 2. : Plans for continued individual development
Page 6, Part III E. 2. : Plans for follow-up studies
Page 8, Part III H. 1. : Ways to improve Summer Institute program on
   a. local level
   b. regional level
I have tried to select those report items that will yield significant information and, at the same time, not be prying into confidential information for your institute. The Education Director of the American Geological Institute has informed me that this information would also be useful to them in their Secondary School Earth-Science Project. Accordingly, I will make the compiled information available to AGI without identifying individual institutes. I would also be happy to share the analysis of these reports with you if you so request.

There are three suggested ways in which you can supply the needed information to me:

(1) Have the proper pages copied on the enclosed facsimiles.

(2) Reproduce the requested pages if copying equipment is available.

(3) Send me the requested pages, or the whole report if more convenient. I will copy the needed pages and return the material promptly.

Since there were only 24 Earth Science Summer Institutes in 1962, the success of this phase of the research depends upon your cooperation. If you feel that any of the requested information is too confidential for compilative treatment, please omit that part and send the remainder.

This study is being conducted under the supervision of Professors John S. Richardson and Robert L. Bates, my advisers in the areas of Science Education and Geology respectively.

Very truly yours,

John W. Shrum
Instructor
Ohio State University

Enclosures (7)
FIRST FOLLOW-UP LETTER

April 16, 1963

248 Arps Hall

________________________________________

Dear ________:

On March 13, 1963, I mailed a request to your office in which I asked for copies of selected pages of your 1962 Earth Science Summer Institute Director's Report. Realizing that you may not have received this request or that it may have been put aside because of pressing commitments at that time, I am sending another set of the facsimiles for the pages needed in this study. Replies have been received from two-thirds of the Directors and I am hopeful that information from all twenty-four Institutes can be compiled and analyzed. When this has been done, I will be happy to send you an analysis of the reports if it would be of interest to you. This analysis will not identify Institutes since this information is in the privileged, and sometimes confidential, category.

The following pages are those that have been selected to yield significant information without prying into confidential phases of your Institute program: Part I, Page 4, and Part III, Pages 2, 3, 4, 5, 6, and 8. On the enclosed facsimiles certain parts of these pages have been crossed out and are not needed. There are three ways in which the other Directors were able to supply the needed information to me:

1. Have the proper pages copied on the enclosed facsimiles.
2. Reproduce the requested pages if copying equipment is available.
3. Send me the requested pages, or the whole report if more convenient. I will copy the needed pages and return the material promptly.

The analysis of the Institute Reports will be used in one phase of my research prior to proposing a curriculum for the preparation of earth-science teachers. The Study is being made under the supervision of Professors John S. Richardson and Robert L. Bates, my advisers in the areas of Science Education and Geology respectively.

Your cooperation will be sincerely appreciated.

Very truly yours,

John W. Shrum, Instructor
The Ohio State University

Enclosures (8)
SECOND FOLLOW-UP LETTER

April 29, 1963

240 Arps Hall

Dear [Name],

I am writing at this time with the hope that the pressures of busy teaching and research schedules may have eased off a bit and I could ask a special favor of you. You may recall from my letters of March 13 and April 16 that an analysis is being made of selected pages from the Director's Reports of the 1962 Summer Institutes dealing with the earth sciences. My research is now at the point where these reports will be of greatest value. Nineteen of the twenty-four institute reports have been received. The value of the study will increase considerably if all of the reports can be included. I am respectfully requesting your help in obtaining the data from your report.

The needed pages (page 4 of Part I and pages 2, 3, 4, 5, 6, and 8 of Part III) can be copied on the forms previously sent, reproduced on any available copying equipment, or sent to me for copying and prompt return. If the forms or return envelope have been misplaced, please send a card or call me collect (AX 9 4736, Columbus, Ohio) and I will send another set. As partial compensation for your time, effort and interest in supplying these data, I will be happy to send you an analysis of the phases of the Institute Program with which the reports deal. The identity of each institute will be safeguarded and no confidential information will be distributed.

Your cooperation will certainly increase the significance of the study and be sincerely appreciated.

Very truly yours,

John W. Shrum, Instructor
The Ohio State University
EARTH-SCIENCE INSTITUTE DIRECTORS
SUMMER 1962

Dr. Julian D. Mancill
Department of Mathematics
University of Alabama
Box 1503
University, Alabama

Dr. Gideon T. James
Engineering and Sciences Extension
University of California
Berkeley, California

Dr. Duncan Stewart
Department of Geology
Carleton College
Northfield, Minn.

Dr. Marvin E. Kauffman
Department of Geology
Franklin and Marshall College
Lancaster, Pa.

Dr. T. G. Perry
Department of Geology
Owen Hall
Indiana University
Bloomington, Ind.

Dr. John B. Droste
Department of Geology
Owen Hall
Indiana University
Bloomington, Ind.

Dr. Leo A. Thomas
8 New Science Bldg.,
Iowa State University
Ames, Iowa

Dr. J. R. Chalikowsky
Thompson Hall
Kansas State University
Manhattan, Kansas

Dr. Roy L. Ingram
Department of Geology and Geography
University of North Carolina
Chapel Hill, North Carolina

Professor E. M. Spieker
Department of Geology
The Ohio State University
Columbus 10, Ohio

Dr. Horace E. Hoffman
Oklahoma Science Service
1120 Faculty Exchange
University of Oklahoma
Norman, Okla.

Dr. J. J. Montean
College of Education
University of Rochester
River Campus Station
Rochester 20, New York

Dr. Richard K. Olsson
Department of Geology
Rutgers—The State University
New Brunswick, New Jersey

Dr. Allen M. Basset
Department of Geology
San Diego State College
San Diego 15, California

Dr. Albert Collier
Galveston Marine Laboratory
Department of Oceanography and Meteorology
Galveston, Texas

Dr. Melvin C. Schroeder
A. and M. College of Texas
College Station, Texas
Dr. J. H. Johnson  
Department of Geology and Geography  
Vassar College  
Poughkeepsie, New York

Dr. Richard H. Fleming  
Department of Oceanography  
University of Washington  
Seattle 5, Washington

Professor John T. Sanford  
Department of Geology  
Wayne State University  
Detroit 2, Michigan

Professor Everett H. Bush  
Department of Earth Science  
Wittenberg University  
Springfield, Ohio
APPENDIX D

1. INTERVIEW FORM

2. LIST OF PERSONS INTERVIEWED
A. Personal data:

NAME ____________________________ TITLE ____________________________

AREA OF SPECIALIZATION _______ INSTITUTION _______________

MAILING ADDRESS _____________________________________________

Do you have responsibility for the preparation or supervision of teachers who do or may teach earth science? _____ Yes _____ No

1. Extent of formal responsibility:

2. Extent of informal responsibility:

B. Earth science in the public schools:

1. Briefly state what broad areas of science should be included in public school earth-science courses.

2. Earth-science topics are best suited for:
   a. _____ separate course(s) at the _________ grade level(s).
   b. _____ part of other science courses in grades(s) ________.

3. Do you see any trend in the offering of earth-science courses? _____ YES _____ NO. If yes, please state the trend(s) briefly.

4. Are the earth-science teacher certification requirements in your state adequate? _____ YES _____ NO. What changes would you suggest, if any?

5. What unique qualities not ordinarily found in college courses would you consider as especially appropriate for earth-science teachers? These unique qualities may be found in academic and/or professional courses.
C. Objective of earth-science teaching in the public schools:

Please check the column you believe is the most appropriate for each objective. Add objectives as you see fit.

To what extent should the following be objectives of teaching earth science in the public schools:

<table>
<thead>
<tr>
<th>Major Objective</th>
<th>Minor Objective</th>
<th>Not an Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide a basic understanding of the earth and its position in the universe.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Develop an understanding of our physical resources.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Develop appreciation for the wise use of natural resources (conservation).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Identify and prepare youngsters for college work.</td>
<td></td>
<td></td>
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<tr>
<td>5. Develop thinking ability and use of scientific methods.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Develop understandings that will enhance the student's appreciation of his environment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Encourage students towards a scientific career.</td>
<td></td>
<td></td>
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<tr>
<td>8. Develop scientific attitudes.</td>
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<td></td>
</tr>
<tr>
<td>9. Increase the student's level of scientific literacy.</td>
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<td></td>
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<tr>
<td>10. Develop an understanding of the relationship of earth science to all of science</td>
<td></td>
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<td>11.</td>
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<tr>
<td>12.</td>
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</tbody>
</table>
D. Preparation of public school earth-science teachers, what percent of the total program should be devoted to each of the following broad areas:

a. General education (humanities, social sciences, sciences) ____ %
b. Professional education........................................____ %
c. Science courses in:
   (1) Earth science ........................................_____ %
   (2) Other sciences ........................................._____ %

TOTAL 100 %

2. Science background recommended for earth-science teaching majors:

Please think of the following topics as bodies of concepts, principles, and understandings to be derived from a study of the topic rather than to think of them as individual courses.

Which of the following topics should be included in the academic preparation of an earth-science teacher in a four year program? Please check one column for each topic.

<table>
<thead>
<tr>
<th>(1) Essential</th>
<th>(2) Desirable</th>
<th>Neither (1) Nor (2)</th>
</tr>
</thead>
</table>

a. Agronomy:

Soils
Origin and classification of soils
Soil erosion and control
Soil physics
Other

Other
### b. Anthropology:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory anthropology</td>
<td></td>
</tr>
<tr>
<td>Physical anthropology</td>
<td></td>
</tr>
<tr>
<td>Ethnology</td>
<td></td>
</tr>
<tr>
<td>Fossil man</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
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</tbody>
</table>

### c. Astronomy:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Descriptive astronomy</td>
<td></td>
</tr>
<tr>
<td>Solar system</td>
<td></td>
</tr>
<tr>
<td>Stellar astronomy</td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
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</tbody>
</table>

### d. Biology:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic biology</td>
<td></td>
</tr>
<tr>
<td>Biological techniques</td>
<td></td>
</tr>
<tr>
<td>Ecology</td>
<td></td>
</tr>
<tr>
<td>Microbiology (bacteriology)</td>
<td></td>
</tr>
<tr>
<td>Physiology</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

### e. Botany:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General botany</td>
<td></td>
</tr>
<tr>
<td>Local flora</td>
<td></td>
</tr>
<tr>
<td>Plant ecology</td>
<td></td>
</tr>
<tr>
<td>Plant physiology</td>
<td></td>
</tr>
<tr>
<td>Plant microtechnique</td>
<td></td>
</tr>
<tr>
<td>Plant genetics</td>
<td></td>
</tr>
<tr>
<td>Plant anatomy</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

### f. Chemistry:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General chemistry</td>
<td></td>
</tr>
<tr>
<td>Qualitative and quantitative analysis</td>
<td></td>
</tr>
<tr>
<td>Organic chemistry</td>
<td></td>
</tr>
<tr>
<td>Modern chemistry</td>
<td></td>
</tr>
<tr>
<td>Physical chemistry</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

### g. Geography:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory geography</td>
<td></td>
</tr>
<tr>
<td>Economic geography</td>
<td></td>
</tr>
<tr>
<td>Regional geography of the world</td>
<td></td>
</tr>
<tr>
<td>Geography of North America</td>
<td></td>
</tr>
<tr>
<td>Other</td>
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</table>
### h. Geology:

<table>
<thead>
<tr>
<th>Subject</th>
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</thead>
<tbody>
<tr>
<td>Physical geology</td>
<td></td>
</tr>
<tr>
<td>Historical geology</td>
<td></td>
</tr>
<tr>
<td>Cartography</td>
<td></td>
</tr>
<tr>
<td>Geologic maps</td>
<td></td>
</tr>
<tr>
<td>Common rocks</td>
<td></td>
</tr>
<tr>
<td>Common mineral deposits</td>
<td></td>
</tr>
<tr>
<td>Hydrology</td>
<td></td>
</tr>
<tr>
<td>Invertebrate paleontology</td>
<td></td>
</tr>
<tr>
<td>Vertebrate paleontology</td>
<td></td>
</tr>
<tr>
<td>Geomorphology</td>
<td></td>
</tr>
<tr>
<td>Structural geology</td>
<td></td>
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<tr>
<td>Stratigraphy</td>
<td></td>
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<tr>
<td>Sedimentation</td>
<td></td>
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<tr>
<td>Glacial geology</td>
<td></td>
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<tr>
<td>Oceanography</td>
<td></td>
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<tr>
<td>Economic geology</td>
<td></td>
</tr>
<tr>
<td>Geological surveying</td>
<td></td>
</tr>
<tr>
<td>Geophysics</td>
<td></td>
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<tr>
<td>Field geology (summer field camp)</td>
<td></td>
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<tr>
<td>Other</td>
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</tbody>
</table>

### i. Mathematics:

<table>
<thead>
<tr>
<th>Subject</th>
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</thead>
<tbody>
<tr>
<td>College algebra</td>
<td></td>
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<tr>
<td>Trigonometry</td>
<td></td>
</tr>
<tr>
<td>Analytic geometry</td>
<td></td>
</tr>
<tr>
<td>Calculus</td>
<td></td>
</tr>
<tr>
<td>Statistics</td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
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</tbody>
</table>

### j. Meteorology:

<table>
<thead>
<tr>
<th>Subject</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>General meteorology</td>
<td></td>
</tr>
<tr>
<td>Climatology</td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
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</tbody>
</table>

### k. Mineralogy:

<table>
<thead>
<tr>
<th>Subject</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystallography</td>
<td></td>
</tr>
<tr>
<td>Descriptive mineralogy</td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
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</tbody>
</table>

### l. Physics:

<table>
<thead>
<tr>
<th>Subject</th>
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</thead>
<tbody>
<tr>
<td>Mechanics</td>
<td></td>
</tr>
<tr>
<td>Sound, heat, light</td>
<td></td>
</tr>
<tr>
<td>Magnetism and electricity</td>
<td></td>
</tr>
<tr>
<td>Modern physics</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>
m. Zoology:

<table>
<thead>
<tr>
<th>General zoology</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invertebrate zoology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal ecology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
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</tbody>
</table>

3. Please suggest the major science theories that you think should be well understood by a prospective earth-science teacher.

4. Please suggest any specific books with which you think the earth-science teacher should be well acquainted.

E. Competencies of the earth-science teacher:

Please indicate by checking the appropriate column which of the following you think are essential, desirable, or unnecessary competencies of an earth-science teacher.

<table>
<thead>
<tr>
<th>Essential</th>
<th>Desirable</th>
<th>Unnecessary</th>
</tr>
</thead>
</table>

1. Familiarity with the geology of his teaching locality.

2. Plan and conduct field trips.

3. Able to communicate ideas.
<p>| | | |</p>
<table>
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<tr>
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<tbody>
<tr>
<td>4.</td>
<td>Familiarity with earth-science content.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Able to conduct his own scientific research.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Familiarity with the purposes of science teaching in public schools.</td>
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<tr>
<td>7.</td>
<td>Ability to demonstrate scientific principles.</td>
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<tr>
<td>8.</td>
<td>Familiarity with appropriate reference materials.</td>
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</tr>
<tr>
<td>10.</td>
<td>Able to evaluate student learning.</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Familiarity with related sciences.</td>
<td></td>
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<tr>
<td>12.</td>
<td>Make appropriate use of audiovisual aids.</td>
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</tr>
<tr>
<td>13.</td>
<td>Demonstrate a real enthusiasm for science.</td>
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<tr>
<td>14.</td>
<td>Ability to recognize and state hypotheses and suggest ways of testing them.</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Able to direct research by students.</td>
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</tr>
<tr>
<td>16.</td>
<td>Familiarity with sources of films and laboratory materials.</td>
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</tr>
<tr>
<td>17.</td>
<td>Able to conduct research on teaching.</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Proficiency in, or directing pupils in, building displays and models.</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>Able to direct learning activities in the classroom.</td>
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<tr>
<td>20.</td>
<td>Knowledge of the history and philosophy of science.</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Understanding of relationship of science and technology to society.</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LIST OF PERSONS INTERVIEWED

Mr. Harold N. Bliss
Department of Public Instruction
Bismarck, North Dakota

Professor Horace H. Bliss
University of Oklahoma
Norman, Oklahoma

Professor Loren T. Caldwell
Northern Illinois University
DeKalb, Illinois

Professor John Coash
Department of Geology
Bowling Green State University
Bowling Green, Ohio

Dr. John E. Kosoloski
Department of Public Instruction
Harrisburg, Pennsylvania

Mr. Edward Lyons
Ball State Teachers College
Muncie, Indiana

Dr. John W. Renner
University of Oklahoma
Norman, Oklahoma

Dr. William Ramey
Syracuse University
Syracuse, New York

Professor Herbert Speece
North Carolina State College
Raleigh, North Carolina

Mr. Gates Willard
Manhasset Junior High School
Manhasset, L. I., New York
I, John Wesley Shrum, was born in Jeannette, Pennsylvania, April 30, 1925. I completed my secondary school education at Jeannette High School in 1943 and enrolled at the Pennsylvania State University where I was awarded the Bachelor of Science degree in 1948. My undergraduate education was interrupted for thirty months while serving on active duty in the United States Naval Air Corps.

In June, 1956, I enrolled in the Graduate School of Bowling Green State University which granted me the Master of Education degree in June, 1959. The following September I was a member of the 1959-1960 National Science Foundation Academic Year Institute at The Ohio State University and initiated a doctoral program after this year of study. While completing graduate study, I have served for two years as Assistant to the Director of the Institute Programs and for one year as an Instructor in the Department of Education. During the Winter Quarter of 1963, I taught introductory geology at the Lima (Ohio) Branch Campus in addition to supervising student teachers in Columbus.

Prior to starting graduate study leading to the Doctor of Philosophy degree, I taught science and mathematics in the Williams County (Ohio) Public Schools for three years.

I have accepted an interdisciplinary position as Assistant Professor of Education and Geology at The Ohio State University.