

THE EFFECT OF BEHAVIORAL AND NON-BEHAVIORAL OBJECTIVES  
ON ACHIEVEMENT IN INTRODUCTORY COLLEGE GEOLOGY

by

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## Chapter 1

### Introduction

Hambleton (1963) charged that the curricula of geology are outmoded, obsolete, and static; that gifted students are no longer attracted to the study; and that the discipline lacks purpose and direction. It was to answer such charges that the American Geological Institute (AGI) established a Geological Orientation Study (GEO-Study) to identify problem areas and to predict trends in undergraduate geological education. The first GEO-Study conference was held in Boulder, Colorado in 1963. The following objectives were listed:

1. To make an objective analysis of the present status of education in the geological sciences;
2. To identify significant trends and to develop new ideas and concepts for improving education in the sciences;
3. To provide guidance by predicting changing requirements in the geological sciences for the next several decades;
4. To consider means for identifying students who can contribute to the advancement of the geological sciences and to determine ways to encourage them to pursue careers in the geological sciences;
5. To consider ways and means of aiding faculties to meet changing requirements of education in geological sciences;
6. To effect the broadest possible involvement of the geological profession in the study so that a large sample of ideas can be obtained, and to invite the advice and ideas of people in other disciplines (Hambleton, 1963:1-2).

From this conference came a plan by which forty-five college geology departments were personally visited by conference representatives. (To insure that no one was overlooked, questionnaires were later mailed to all departments.) The survey was intended to determine what geology

departments were doing and what they thought they should be doing, as well as to consider ways of helping faculties meet the changing requirements of geological education (GEO-Study questionnaire, 1965).

To Nutter (1971:14) the results of this reconnaissance suggested "that there was in 1963, on the part of some educators in the geological field, an increasing awareness of the inadequacies of the content, methodologies, and teacher preparation in the field of geology." He summarized this awareness in three statements:

1. Introductory courses are not meeting student needs;
2. Innovations in the teaching of geology courses are not being seriously considered (probably because the average teacher of geology was unaware of the contributions such innovations could make, and were generally distrustful of those they knew about);
3. Teachers do not have the proper training, though there was no consensus as to what should be included in the proper training [14-15].

In 1964 the Council on Education in the Geological Sciences (CEGS) was established to continue inquiries and develop means of assisting geological education. As an educational project of AGI supported by the National Science Foundation, CEGS was specifically mandated to:

1. Maintain continuous inquiry into the state of geological education at the undergraduate level and to provide detailed recommendations and guidelines in specific areas;
2. Encourage and assist the development of new materials and activities;
3. Review and evaluate projected programs in geological education;
4. Provide for communication and consultation on education improvement in the geological sciences; and
5. Involve the widest spectrum of the teaching profession in various projects (Fooks, 1968:11).

To implement these objectives, panels of recognized authorities administered the Curriculum Program--designed to stimulate curriculum improvement; the Instructional Materials Program--to develop materials

that permit effective use of techniques of allied sciences and problem-oriented approaches; the Introductory Course Program--to explore experimental course designs; and other projects (Fooks, 1968). Four pertinent examples of CEGS Programs Publications Series published by AGI, Washington, D. C. are:

Audio Tutorial Instruction: A Strategy for Teaching Introductory College Geology, edited by Peter Fenner and Ted F. Andrews. 1970, 22p.

Teaching Introductory College Geology by Television, John E. Bowen et al. 1971, 38p.

Undergraduate Geology: A Strategy for Design of Curricula, F. H. T. Rhodes et al. 1971, 79p.

Introductory Geology: Aspects and Options, John E. Bowen et al. 1972, 48p.

The quest for improvement in geological education has thus included a number of approaches and innovations little used in geology. Examples are: audio-tutorial and programmed instruction, closed circuit television, variations in course structures and content, and unusual methods, e.g., student-centered introductory geology.

Since the early sixties then, considerable effort has been directed toward curriculum development and betterment of teaching in geology. It is surprising therefore to find that recommendations for the use of instructional objectives as aids to instruction are conspicuously absent from most of these inquiries. Even when mentioned, they seem to be limited to audio-tutorial applications. Novak (1970:18-19), for example, commented on the necessity of objectives for successful audio-tutorial instruction:

The clear specification of instructional objectives, as suggested by Mager is the element most often absent in unsuccessful A-T instruction. When instructional objectives are clearly specified, it is possible to identify optimal sequences of auditory, visual, olfactory, tactile, and other experiences. Preceding an instructional sequence with a general statement that has meaning for the student can serve as an organizer and facilitate subsequent learning. To design effective organizers for instructional sequences requires clear instructional objectives.

Referring to television presentation of an elementary geology course, McCullough (1971:11-12) wrote that "One major obstacle at the present time is the limited availability of . . . course behaviors stated in performance terms and hierarchical schemes . . . ." In discussing Science--A Process Approach, Commentary for Teachers,<sup>1</sup> he further states:

This publication describes the processes of science as defined by the AAAS Commission on Science Education, and also deals with the development of objectives and their evaluation. This program is the only one of which I am aware that has defined objectives in performance terms, developed evaluation instruments to determine if the goals had been met, then published the results.

Even though the desirability of behavioral objectives for certain techniques has been stressed, their use in more traditional geology classes has been neglected and their application severely limited thus far. The continuing concern for improvement makes it imperative that the usefulness of instructional objectives be investigated in this context. Baker (1969:5) commented that "Educators disagree on the relative merit of stating classroom objectives behaviorally or non-behaviorally and have

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<sup>1</sup>American Association for the Advancement of Science, Commission on Science Education, Science--A Process Approach, Commentary for Teachers, (New York: Xerox Educational Division, 1970).

done little to add data to their argument." Consequently this investigation was designed to develop two sets of objectives, behaviorally stated and non-behaviorally stated, and to compare the effects of both types upon achievement and attitude of students in traditional geology classes.

#### STATEMENT OF PROBLEM

The primary goal of this investigation was to compare the achievement of students who were furnished behaviorally stated instructional objectives to the achievement of students given non-behavioral objectives in outline form. All students were enrolled in an introductory geology course at Virginia Western Community College in Roanoke, Virginia.

Secondary purposes were to determine the attitudes and preferences of students for each type of instructional objective.

And finally, a set of instructional objectives was to be constructed for an introductory physical geology course. Other than that given by Capper (1969), there is little of this material in the literature. These objectives would not be universally applicable by all instructors but could be adapted to the individual need. The reduction of initial effort afforded by the availability of a "bank" of objectives might encourage their wider use.

The principal goals of this study can be stated in the form of two hypotheses:

**HYPOTHESIS 1:** In an introductory college geology course, there will be no difference between the mean scores of students who receive behavioral objectives and the mean scores of students who receive outline objectives, as measured by a series of achievement tests.

HYPOTHESIS 2: In an introductory college geology course in which both behavioral and outline (non-behavioral) objectives have been used by all students, there will be no difference in student attitudes toward the usefulness of either type of objective, as measured by an attitude scale.

### LIMITATIONS

The study was limited to the students enrolled in Geology 101 during fall quarter, 1974, and Geology 102 during winter quarter, 1975. Geology 101 and 102 are sequential courses constituting introductory physical geology at Virginia Western Community College. All students involved were enrolled in the courses for the first time. The experimental group consisted of 32 students and the comparison group included 30 students. All classes were taught by the researcher and the research dealt solely with the lecture portion of the course.

An unavoidable limitation of this research was the impossibility of randomly selecting subjects for each group. Instead, high school rank, age, pretests, and reading and intelligence tests were used to demonstrate the equivalence of both groups. Possible limitations also arose from the reliability and validity of these instruments and measurements as well as the reliability and validity of the test instruments and attitude questionnaire. A further limitation was related to the chance that the teaching and/or presentation unintentionally varied to a significant degree.

### DEFINITION OF TERMS

Behavioral objective as used in this study refers to statements of specific learning goals. A behavioral objective:

1. States the behavior that the student is asked to exhibit, i. e., after accomplishment of the objective, what he will be able to do;
2. States the conditions under which the task is to be performed;
3. States a standard by which the student's performance will be evaluated.

In this study the last two criteria were brought to the attention of the students at the beginning of the course rather than as a part of each objective. Each student was given a Proclamation (Appendix F) which included a description of the type of tests to be given, testing conditions, and scheduling of tests, as well as the following grading scale:

90 - 100	A
80 - 89	B
70 - 79	C
60 - 69	D
Below 60	F

Non-behavioral objectives are statements of behaviors couched in vague or general terms without exact specification of performances. Typically the student is told to "know" or "understand."

Outline objectives are non-behavioral objectives in which terms and concepts are listed in outline form. The result tends to develop a hierarchical grouping much as would be shown by an outline of a lecture (see Appendix C).

Instructional objective, as used in this study, is a general term referring to any immediate learning objective and includes all of the above types of objectives.

## ORGANIZATION OF STUDY

The remainder of this report was organized as follows:

In Chapter 2 pertinent literature was reviewed in four principal areas: 1) Popular concepts of instructional objectives; 2) The rationale fundamental to the use of instructional objectives; 3) Some typical arguments from both sides of the debate over the usefulness of behavioral objectives; and 4) Empirical research focused on instructional objectives, especially behaviorally stated objectives.

In Chapter 3 the design of the experiment, the subjects involved, and the procedures and instruments employed to collect the data were described.

In Chapter 4 the analyses applied to the data were explained and, in Chapter 5, the investigation was summarized and the findings were given along with conclusions and recommendations.

## Chapter 2

### REVIEW OF RELATED LITERATURE

Before attempting to test the relative merits of behavioral and outline (non-behavioral) objectives as they affect student learning, it was necessary to review popular concepts and empirical evidence in the literature. Therefore this chapter has been organized to examine four major aspects of instructional objectives:

1. Various concepts of instructional objectives;
2. The purpose and rationale of instructional objectives;
3. Logical and philosophical arguments for and against the use of behavioral objectives; and
4. Results of empirical investigations of instructional objectives.

See Kliebard (1968), Ammons (1969), and Popham (1969a) for abbreviated historical reviews of objectives.

### CONCEPTS OF INSTRUCTIONAL OBJECTIVES

In all likelihood instructional objectives have concerned teachers since the earliest beginnings of the art of instruction. Popham (1969a) speculated that even primitive men while tutoring their young in the crafting of hand axes surely considered what kinds of axe-makers they wished the initiates to become. Socrates seems to have had very definite objectives in mind when, by questioning passersby, shopkeepers, students, and senators, he sought to have men perceive their ignorance or discover a truth (Compayre, 1886). Ammons (1969:908) in summarizing the historical development of objectives wrote:

Educational objectives have for centuries occupied the attention of educational specialists, of representatives of other areas of study, and of laymen. That they are matters of basic concern is attested to by the amount written about them; both educational and non-educational literature is replete with formal and informal statements of objectives of education and with descriptions of methods for determining what objectives should be.

One ambiguity which arises in a discussion of instructional objectives stems from the lack of fixed meanings for many of the terms. Although numerous volumes have been published classifying objectives within different "domains" (see, for example, Bloom, 1956, and Krathwohl et al., 1964), there is no standard taxonomy of such terms as educational, instructional, performance, behavioral, or non-behavioral when applied to objectives. Popham (1972:432) observed that "Some educators use the terms objectives, goals, aims, intents, etc. interchangeably. Others use the terms differently, depending on the level of generality involved." The specification of the performance to be acquired by a learner is referred to by Mager (1962) as behavioral objectives; by R. W. Tyler (1964) as educational objectives; by Esbensen (1967) as performance objectives.

Kibler, Cegala, Barker, and Miles (1974) divide educational objectives into two groups: general, non-specific objectives written to indicate broad goals of education (general educational objectives); and highly specific objectives formulated to communicate instructional intentions to learners (instructional objectives). They admit, however, that there are some educational objectives that do not neatly fit into either category and include as examples (1) outlines of objectives, (2) some objectives that have been developed for language arts, and (3) the types of objectives exemplified in the first two volumes of the Taxonomy of Educational Objectives (Bloom, 1956, and Krathwohl et al., 1964).

Examining the research regarding educational objectives and outcomes, Ammons (1969:908) recognized several important factors:

. . . First, the terms themselves have no universally accepted definition, so discourse about objectives occurs upon several levels of generality. Second, a statement of objectives or a recommended methodology for determining objectives is almost couched in value terms, which renders empirical research in the classical sense difficult. Third, the question of what objectives ought to be sought has a history which dates at least from Plato. Fourth, pronouncements about objectives are more or less explicitly analyzed and justified opinions. Fifth, studies of a largely empirical nature in relation to objectives are few compared to the number of statements of objectives based upon individual or group opinion [emphasis not in the original].

After reviewing some of the important twentieth century contributions to the development of objectives, she concluded:

The authors cited . . . tend to make a distinction between objectives and other statements of goals, restricting the use of the term "objectives" to those statements which describe desired student behavior and appropriate content. Other kinds of statements of purpose may be called goals, aims, or purposes [911-912].

According to Kibler et al. (1974:2), "Instructional objectives are statements that describe what students will be able to do after completing a prescribed unit of instruction." The Curriculum Committee of the American Chemical Society (1972:484) defined a performance objective as:

. . . a statement which clearly and explicitly specifies what a student should do in response to a request to act which suggests (to the teacher, by that action) that the student has mastered a portion (usually) or the whole of a topic (concept, principle, fact, set of facts, etc.) or has mastered interrelationships between and among different topics.

Payne (1968:11) stated more simply that "An educational objective may be broadly defined as a statement of desired change in pupil behavior." Montague and Butts (1968:33), on the other hand, emphasized that in

behavioral objectives the learning, or outcome, must be ". . . expressed in terms of observable behavior." Mager (1962) in his classical programmed text was even more explicit in requiring that objectives describe behaviors that are not only observable but also terminal. Ammons (1969) appended the provision that, in addition to describing desired student behavior, behavioral objectives should indicate the content through which the behavior is to be developed. She also (1967) presented a case for behavioral objectives in which the behaviors might not be observable but could be inferred according to definitions mutually acceptable to parties concerned. She further identified objectives as descriptions of direction rather than as descriptions of terminal behaviors, pointing out that Herrick (Anderson et al., 1965) also sees objectives as direction setters.

#### PURPOSE AND RATIONALE OF INSTRUCTIONAL OBJECTIVES

Most writers seem to be in general agreement as to the purpose of objectives, or at least there is considerable overlap in their statements. Esbensen (1967:246) for example, gave his opinion that "the purpose of an instructional objective is to make clear to teachers, students, and other interested persons what it is that needs to be taught--or what it is that has been taught [emphasis his]." After focusing on the characteristics of well-written objectives and illustrating how the student and teacher can benefit therefrom, he concluded, "If teachers at all levels of schooling would be this explicit in writing instructional objectives, they might reasonably hope to eliminate almost immediately one

major cause of learning failure among students: the traditional fuzziness of classroom assignments [247]."

In Plowman's (1971:ii) introduction to his small but practical volume on behavioral objectives, he defined an objective ". . . as an aim or desirable outcome of action." And stated that objectives are to be used ". . . first to direct our effort and then as a yardstick to assess our degree of achievement . . . . In this context the objective is useful in proportion, first, to how specific it is and, second, to how well we can see or measure its attainment."

Similarly, Baker and Popham (1973), in their programmed text relating humanism and behaviorism, indicated that objectives should be prepared for the double purpose of helping instructional designers delineate their activities so that learning is effective and enjoyable, and providing a sound basis for determining whether desired learning has taken place.

In a paper presented to the Curriculum and Objectives Committee during the 1968 annual meeting of the American Educational Research Association, Eisner (1969:1-2) summarized the characteristics of educational (behavioral) objectives thusly:

For one, it is argued that educational objectives should describe pupil behavior, not teacher behavior: that is, they should describe how pupils are to perform after having had educational experiences. Second, objectives should describe both the behavior to be displayed and the content in which the behavior is to occur . . . . Third, objectives should be stated at a level of specificity that makes it possible to recognize the behavior should it be displayed. . . .

Eisner then concluded that once the aspiring curriculum maker has formulated objectives according to these criteria, the following

functions are facilitated:

First, a clear statement of educational objectives gives direction to curriculum planning. Second, they provide criteria for selecting content and organizing curriculum activities. Third, they provide cues for formulating evaluation procedures inasmuch as evaluation should proceed from specifications set forth by objectives [2].

Duchastel and Merrill (1973) echoed a similar viewpoint in their review of empirical studies of the effects of behavioral objectives on learning. They recognized that numerous rationales for the specification of behavioral objectives can be and have been expressed by various authors (e. g., Lindvall, 1964; Popham, 1969a; and L. L. Tyler, 1969). "However, for the purpose of clarity," Duchastel and Merrill deemed it appropriate ". . . to view behavioral objectives as serving three main instructional functions: (a) direction for teaching and curriculum development; (b) guidance in evaluation; and (c) facilitation of learning [53]."

Gagne (1971), on the other hand, distinguished four major reasons for specifying objectives. There is widespread agreement that the first two, "Revealing the nature of the terminal behavior" and "Specifying postlearning behavior for measurement," are important bases for specifying objectives. The last two, "Distinguishing the varieties of behavior which can be modified by instruction" and "Defining the reinforcement situation for the learner," are not widely cited but neither are they antithetical to the rationales previously cited.

Substantiating the effect of evaluation and objectives on facilitation of student learning, Ausubel (1968:568) stated, "It has been shown that students distribute their study time and apportion their learning effort in direct proportion to the predicted likelihood of various topics

and kinds of information being represented on the examination."

The last few years have seen the emergence of accountability as a cogent issue in the establishment of confidence in our educational system (Elam, 1970; Lessinger, 1970). Cohen and Brawer (1969) also examined in considerable depth the question of the assessment of teachers based on student learning. Wight (1972:9) recognized the significance of accountability when, in discussing some problems with and alternatives to behavioral objectives, he declared:

The problem of accountability is thus central in the controversy over behavioral objectives and provides the behavioral objectivists with their strongest argument. The major purpose of behavioral objectives is to provide clarity of intent in education and precision in the measurement of outcomes . . . it would be difficult to argue that this would not be of benefit to education.

Kibler et al. (1974) wrote a compact supplementary text which quickly and efficiently deals with the key aspects of objectives in the realm of instruction and evaluation. The book is especially valuable not only because of the inclusion of a chapter designed as a programmed text on writing objectives, but also for a programmed unit developed to teach students how to use instructional objectives. In their analysis of the rational basis for using instructional objectives, they showed agreement with Wight (1972) and other writers, contending that "among the more compelling reasons [for the use of objectives] is that the use of instructional objectives is consistent with the concept of accountability . . . (Kibler et al., 1974:3)." While emphasizing the prominence of the issue of accountability in this context, Kibler also cited additional reasons for using instructional objectives in the educational process. These reasons are summarized below:

1. Clear specification of objectives would appear to make learning easier and to eliminate the necessity of students' guessing teachers' expectations.
2. Given clearly specified objectives, curriculum planners are better able to arrange sequences of courses or units of instruction.
3. Students and advisers are better able to plan course programs when course descriptions include instructional objectives.
4. Clear instructional objectives enable teachers to tell other teachers what they teach.
5. Classification in terms of taxonomic levels helps avoid undue emphasis on a certain level of objectives.
6. Clearly defined goals enable teachers to design, achieve, and evaluate the effectiveness of instructional experiences.
7. Specification of objectives makes possible the determination of a student's present level of mastery for any prescribed objective at any time.
8. Because of inclusion of a minimal level of performance (performance standard), most students can be expected to master each objective.
9. Performance standards help teachers determine the adequacy of their instructional program [4-5].

Cohen (1970:73) epitomized the pursuit of a rational basis for instructional objectives when he said:

All possible concomitants cannot be stated because the study of social structures or individual human endeavors simply does not offer concepts or methodologies sufficiently comprehensive to encompass every contingency. Nevertheless, some attempt to understand the issues must be made, for specifying objectives is more than a casual exercise. It is a way of conceptualizing institutional purpose--hence, it affects nearly all preexisting practices and tendencies.

#### BEHAVIORAL OBJECTIVES: CONCURRENCE

#### AND CAVEAT

Elliot Eisner (1969:1) summed up the status of behavioral objectives in the following manner:

The concept of educational objectives holds a central position in the literature of curriculum, yet the way in which educational objectives should be formulated--if at all--continues to be the subject of professional debate.

Most of the writings for and against behavioral objectives have been based on logical arguments, and the controversy has at times been heated. "Some authors exhort instructors to specify objectives lest ultimate evil befall them, while others, condemning all 'behaviorists' to the nether world, reject the whole idea (Cohen, 1970:2)." After developing a rationale for behavioral objectives, Cohen admonished:

If college instructors are to stay abreast of the times, then they must give serious thought to specifying the goals of their own instruction. They must work through the process in their courses--build their objectives, specify their outcomes, collect the evidence of student learning--or be guilty of abandoning to others the responsibility they tacitly accepted when they entered the teaching profession [3-4].

Emphasizing his strong convictions about using behavioral objectives, Mager (1962:3) asserted ". . . an instructor will function in a fog of his own making until he knows just what he wants his students to do at the end of the instruction."

Popham (1969a:33), in discussing the lack of adequate instructional objectives and their disuse even when available, commented:

But this wretched and inexcusable situation is changing. We are at the brink of a new era regarding the explication of instructional goals, an era which promises to yield fantastic improvements in the quality of instruction. One can only sympathize with the thousands of learners who had to obtain an education from an instructional system built on a muddle-minded conception of educational goals.

Geisert (1969:233), who energetically favors the use of behavioral objectives in biology, expressed agreement with the need for specification of objectives when he stated, "Without objectives a course has no direction, no goal, and no way of measuring the students' performance."

Consalvo (1969) viewed education as a process that brings about changes in the learner. In directing attention to the evaluation of these changes, he wrote:

The purposes of evaluation can be realized when objectives are stated as observable behaviors. Knowledge of student achievement becomes clearer, and assignment of grades becomes easier and more accurate [231].

Walbesser (1972:418) stated, "The idea that instructional purposes be described in terms of reliably observable learner behavior has the appeal of precision." But, at the same time, he viewed ". . . with great alarm the growing number of negative effects on mathematics education that are being generated by the application of behavioral objectives." He proposed that the problem be alleviated, not by turning away from specification of objectives, but by eliminating those of poor quality and improving the quality of others.

Although opinions favoring specification of objectives seem to greatly predominate in the literature, opposing viewpoints are defended with no less vigor. For example, there is debate as to whether, in curriculum planning, determination of behavioral objectives should be the first step. In supporting early specification of objectives, Mager (1962:3) declared:

When clearly defined goals are lacking . . . there is no sound basis for selecting appropriate materials, content, or instructional methods. After all, a machinist does not select a tool until he knows what operation he intends to perform.

Atkin (1968) and Eisner (1967) disagreed, holding to the view that curriculum developers begin with broad ideas about activities and concepts to be included, rather than specific behavior changes to be induced. Atkin additionally believed that ". . . early articulation of

behavioral objectives by the curriculum developer inevitably tends to limit the range of his exploration. He becomes committed to designing programs that achieve these goals [29].

While confirming his belief that worthwhile goals should be developed before seeking methods for assessing progress toward those goals, Atkin further charged that "it borders on the irresponsible for those who exhort us to state objectives in behavioral terms to avoid the issue of determining worth [30]." As an attempt to vitiate such criticisms, Walbesser (1972) introduced *puissance*, an intriguing concept for expressing a dimension of quality of objectives. The *puissance* of a behavioral objective was conceived as ". . . a linear continuum--the most powerful behaviors being those that enable the learner to independently generate knowledge, and the least powerful behaviors, those that are associated with rote responses from the learner [437]."

Atkin (1968:29) believed that numerous important educational concepts arise in unplanned classroom situations and that many such ". . . ideas are taught with the richest meaning only when they are emphasized repeatedly in appropriate and varied contexts."

Kuhn (1970:126), who promoted the use of behavioral objectives as instruments of curriculum development in the life sciences, countered that "the essence of good curriculum development is the sequencing of instructional paradigms to maximize learning and minimize the duplication of previously learned material."

Eisner (1967:250) recognized the dangers of denigrating behavioral objectives but argued that:

. . . educational objectives clearly and specifically stated can hamper as well as help the ends of instruction and that an unexamined belief in curriculum as in other domains of human activity can easily become dogma which in fact may hinder the very functions the concept was originally designed to serve.

Eisner then detailed four aspects of the specification of objectives which appear to support his contention. The key point of each is listed below:

1. Instruction is a dynamic and complex process which yields outcomes far too numerous to be specified in behavioral and content terms in advance.
2. The theory behind behavioral objectives fails to recognize that, while objectives can be specified with great precision in some subject areas, such specification is frequently neither possible nor desirable in other areas.
3. Not all--perhaps not even most--outcomes of curriculum and instruction are amenable to measurement.
4. The procedure of first identifying objectives before proceeding to identify activities is not necessarily the most psychologically efficient way to proceed [253-259].

Eisner seems to have based his opinions, at least in part, on his conviction that curriculum development and measurement of outcomes are largely "artful tasks" which cannot entirely be reduced to precision and specificity.

Tiemann (1971:16) agreed that many criticisms of behavioral objectives are responsible and rational but believed that:

. . . a more general acceptance of instructional technology by our critics is limited by our lack of skill in developing specific criteria serving to define meaningful goals and not by something inherent in the specific statement of the criteria themselves.

In a paper presented to the 1968 annual meeting of the American Educational Research Association, Popham (1969b:67-72) examined eleven reasons commonly given in opposition to stating objectives in terms of

measurable learner behaviors. Those reasons are quoted below together with a summary of Popham's comments on each:

1. "Trivial learner behaviors are the easiest to operationalize, hence the really important outcomes of education will be underemphasized."  
The fact that these behaviors can be made explicit permits the teacher and his colleagues to scrutinize them carefully and thus eliminate them as unworthy of our educational efforts.
2. "Pre-specification of explicit goals prevents the teacher from taking advantage of instructional opportunities unexpectedly occurring in the classroom."  
On the contrary, pre-specification of explicit goals only tends to make the teacher justify these spontaneous learning activities in terms of worthwhile instructional ends.
3. "Besides pupil behavior changes, there are other types of educational outcomes which are important, such as changes in parental attitudes, the professional staff, community values, etc."  
It seems that the school's primary responsibility is to its pupils. Hence, all modifications in personnel or external agencies should be justified in terms of their contribution toward the promotion of desired pupil behavior changes.
4. "Measurability implies behavior which can be objectively, mechanistically measured, hence there must be something dehumanizing about the approach."  
Experience shows that our measurement procedures do not have to be based on a theory of reductionism. It is currently possible to assess many complicated human behaviors in a refined fashion.
5. "It is somehow undemocratic to plan in advance precisely how the learner should behave after instruction."  
Instruction is by its very nature undemocratic and to imply that freewheeling democracy is always present in the classroom would be untruthful.
6. "That isn't really the way teaching is; teachers rarely specify their goals in terms of measurable learner behaviors: so let's set realistic expectations of teacher."  
There is obviously a difference between identifying the status quo and applauding it. Most of us would readily concede that few teachers specify their instructional aim in terms of measurable learner behaviors, but they ought to.

7. "In certain subject areas, e. g., fine arts and the humanities, it is more difficult to identify measurable pupil behaviors."  
Because it is difficult in certain subject fields to identify measurable pupil behaviors, those subject specialists should not be allowed to escape this responsibility.
8. "While loose general statements of objectives may appear worthwhile to an outsider, if most educational goals were stated precisely, they would be revealed as generally innocuous."  
The ploy of "obfuscation by generality" must be abandoned and exactly what we are doing made clear. Then we are obliged to defend our choices.
9. "Measurability implies accountability; teachers might be judged on their ability to produce results in learners rather than on the many bases now used as indices of competence."  
The possibility of assessing instructional competence in terms of the teacher's ability to bring about specified behavior changes in learners bring with it far more assets than liabilities to the teacher.
10. "It is far more difficult to generate such precise objectives than to talk about objectives in our customarily vague terms."  
A very significant objection . . . but the difficulty of the task should not preclude its accomplishment.
11. "In evaluating the worth of instructional schemes it is often the unanticipated results which are really important, but pre-specified goals may make the evaluator inattentive to the unforeseen."  
Really dramatic unanticipated outcomes cannot be overlooked by curriculum evaluators. It is indefensible to let an awareness of the importance of unanticipated outcomes lead one to the rejection of rigorous preplanning of instructional objectives.

Conceding the probability of the existence of elements of truth in these and other criticisms of behavioral objectives, Popham contended that "any risks we run by moving to behavioral goals are miniscule in contrast with our current state of confusion regarding instructional intentions [72]."

## BEHAVIORAL OBJECTIVES AND EMPIRICAL RESEARCH

A review of the literature shows that much has been written during the last fifteen years about instructional objectives. Most of this material has, however, been polemic in nature and only a small proportion has been based on empirical data (Duchastel and Merrill, 1973; Baker, 1969). In consideration of the research into the effectiveness of behavioral objectives, Cohen (1970:2) commented, "The concept has not yet received anything approximating a thorough examination. In common with most other education practices, specific instructional objectives are receiving their trials in the field rather than in the laboratory."

### Earlier Reviews

The majority of research inquiring into the effects on students when teachers specify behavioral outcomes has, in fact, been limited to doctoral dissertations, and most of these have been accomplished within the last five or six years. Payne (1972) conducted a review of 35 doctoral dissertations completed in 1970 and 1971 which investigated the effectiveness of the use of behavioral objectives. He found that the literature cited could be grouped into the following five areas:

1. The effect of the use of behavioral objectives on the achievement of students;
2. The teacher effect on the achievement of students and the use of behavioral objectives;
3. The use of behavioral objectives in evaluation and measurement of courses and curriculums;
4. The effect of the use of behavioral objectives on retention and acquisition of materials studied;
5. The effect of achieving certain hierarchical learning tasks by the use of behavioral objectives [25-26].

Payne recognized that these investigations attempted to correlate several factors including: the effects on students of the use of behavioral objectives in the cognitive, affective, and psychomotor domains; the effects of behavioral objectives written at different levels of Bloom's taxonomy; and interrelationships among use of behavioral objectives, achievement, and learner and teacher characteristics. He noted that, although research has been done over a wide range of areas, a significant portion has involved attempts to identify appropriate instructional processes so that increased student achievement would derive from the use of behavioral objectives. Despite the fact that earlier studies seemed to be based on the conviction that behavioral objectives should increase student achievement, Payne observed that this approach has not been especially fruitful. He further concluded that, even though it was probably too early to make a positive judgment of the effectiveness of specifically stated objectives, "most research has shown some evidence that behavioral objectives have a place in education [50]."

While cognizant that behavioral objectives serve other functions, Duchastel and Merrill (1973:54) focused a review of empirical studies on the issue: "Does communicating behavioral objectives to students have a facilitative effect on their learning?" Twenty-eight investigations completed or published during 1967-1971 were grouped into the following four categories:

1. Investigations of the general issue of the effect of objectives on learning;
2. Investigations of the effect on learning according to the type of learning involved;
3. Investigations of possible interactions between availability of objectives and certain learner characteristics;

4. Investigations utilizing time to criterion as the major dependent variable.

In summary Duchastel and Merrill concluded that:

Results obtained from the research which simply addressed the general issue are, to say the least, inconsistent. Studies which have found no significant differences between experimental and control groups are as numerous as those which have found such a difference. Furthermore, when we consider the total number of studies which have investigated effects on student achievement, an even smaller proportion of studies have found a significant main effect for this variable. However, those studies which have found such an effect have usually favored the presentation of objectives (the one exception is the Yelon and Schmidt (1971) study). A further difficulty in interpretation arises in those studies which have found different results between immediate learning and retention [63].

### Recent Studies

Although more recent (i. e., post 1971) research has continued to investigate varied aspects of the use of instructional objectives, effect on student achievement has remained the principal dependent variable. Of the studies involving student learning, many of those reviewed simply distinguished between furnishing specific objectives and furnishing no objectives. A few have provided more than one type of objective and several have supplied training, practice, or special instruction in the use of objectives. Other investigators have attempted to find interactions between achievement and the manner in which the objectives are presented, whether to the student, to the teacher, at the beginning of instruction, repeatedly, or in some other manner.

Another group of variables included student characteristics. Most frequently used were ability, sex, study methods, and ranking or perception of objectives. A final independent measure focused upon by several investigators was the type of learning involved. Some researchers formulated

objectives within the framework of a learning hierarchy, while others varied the instructional material, e. g., structured versus unstructured.

The dependent variables most often employed were learning (achievement), and retention. Learner attitude toward the use of behavioral objectives was sometimes surveyed but rarely quantified and tested statistically.

The research reviewed in this section is grouped into five categories, a classification adapted from Duchastel and Merrill (1973). The first category includes those studies directed toward the general issue of the effect of objectives on learning. The second category is comprised of those studies which vary the manner in which the objectives are presented. The third category consists of investigations involved with learner characteristics. In the fourth category types of learning are considered. And finally, research comparing the effects of specified and non-specified objectives constitutes the fifth category.

General. The six studies included in this section merely sought to answer the question: Do students provided with behavioral objectives achieve more than students not provided with objectives?

Phillips (1972) investigated the effects of instructional objectives on the achievement of 300 students enrolled in an economics course at three California community colleges. Objectives were presumably distributed to some students but not to others although the procedure is not stated. No significant differences were found between experimental and control groups on either group mean scores or mean gain scores. The results may have been confounded, however, by a number of factors such as a significant initial difference between pretest scores of experimental

and control groups, and large differences in grading procedures used by participating instructors.

The effect of student knowledge of behavioral objectives on achievement and attitudes of 105 students enrolled in an educational psychology course was investigated by Patton (1972). Two sections of the class were provided behavioral objectives and two sections were not. Apparently no attempt was made to randomize subjects or establish equivalence of groups. No significant differences in achievement were found on teacher-made criterion tests administered after each of two units. Students attitudes were, however, more positive toward the use of specified objectives than toward the conventional method of instruction.

Motillo (1973) compared the achievement and attitudes of senior high school physics students who received behavioral objectives to those of students who did not receive objectives. After ten weeks without objectives, lists of objectives were distributed alternately to two of four classes for each chapter during the succeeding ten-week period. Achievement was measured by short criterion quizzes at the end of each chapter and by the classroom teacher's test at the end of the unit. Application of the F test to the results of the short quizzes caused the null hypothesis (no difference between groups) to be rejected seven times and accepted 35 times. With the t test, rejection was accomplished 22 times to 20 failures to reject. Applied to the teacher's unit test, the null hypothesis was rejected six times to ten failures when the F statistic was used, ten times to four failures with the t distribution. The students overwhelmingly endorsed the presentation of behavioral objectives prior to instruction.

A study by Mattox (1973) sought to determine the effect on performance when behavioral objectives are used in a beginning typewriting class. Two control and two experimental groups were established based on random sampling of students who had been classed according to previous experience, I. Q., and manual skill. Measures of typing skill and cognate knowledge taken over a fourteen-week period indicated no significant differences at the .05 level. It was noted that the differences were significant at the .25 level and, moreover, were consistently in favor of the experimental group.

True (1973) explored the effect of advance knowledge of performance objectives on the achievement of two classes of vocational students in a ten-week industrial communications course. Students in the experimental group were randomly selected and equivalency was determined by a *t* test of scores on Differential Aptitude Tests. Achievement was measured by the difference between pretest and posttest scores. Control group achievement was significantly greater on four units, whereas that of the experimental group was greater on two units. It was concluded that overtly revealing performance objectives had little or no effect on achievement.

Kruse (1973) compared the achievement of students in a differentiated reading program. Three groups were provided performance objectives cooperatively established by students and teachers while three other groups were not provided with objectives. Statistical analysis indicated differences that were significant in three of eight areas. Two of these three favored the experimental group. Trend analysis showed higher percentages of increased scores for each experimental group. It was concluded that cooperatively established individual performance objectives

have a tendency to improve interest and motivation of remedial and developmental readers.

Type of presentation. The six studies included in this category sought to determine the effect on achievement of special modes of presentation of objectives. Two principal methods were noted: one in which objectives were provided only to the teachers; the other in which specific training was given in the use of objectives or the timing of the presentation was varied.

Bassett (1974) hypothesized that student achievement would be increased by training in the use of behavioral objectives and by informing learners of the results of tests. One hundred forty-six college students enrolled in human communication theory were each randomly assigned to one of six treatment groups (two levels of training and three levels of knowledge of results). Achievement was measured by scores on unit tests and final examination. Training learners in the use of behavioral objectives was found to have positive effects on test performance, but the predicted positive effects of knowledge of results were not determined. Possible methodological flaws were suggested to account for the latter finding.

Jenkins and Neisworth (1973) compared student performance on test items for which objectives had been provided to performance on test items for which objectives had not been provided. Subjects had previously completed a course wherein instructional objectives had been presented on each unit. Overall, students performed significantly better on items which corresponded to the objectives they had been provided. Almost half the students were dropped from the experiment, however, because they had

discovered that there was another set of objectives besides their own.

The effects of possession of behavioral objectives and training in their use were also investigated by Morse (1973). Thirty-four undergraduates enrolled in a course in Human Development and the Educative Process were randomly assigned to six treatment groups. A 3 x 2 factorial design was used. The three treatment levels were training plus practice in the use of objectives, training in knowledge about well-stated objectives, and no training. It was concluded that: 1) The training procedures applied did not enable students to make better use of objectives; 2) Both types of training led to more favorable attitudes toward objectives; 3) Achievement was facilitated by the possession of objectives; and 4) Students given objectives learned unrelated material equally as well as students without objectives. This study appears to have been seriously weakened by the small number of subjects in each treatment group.

Ferre (1972) assessed the effectiveness of repeating performance objectives. Twenty subjects were not provided performance objectives, 39 subjects received objectives at the beginning of each unit, and 44 subjects were presented objectives daily. Daily presentation of objectives proved most effective and produced the most significant achievement gains. Not providing objectives produced the least significant result.

The effects on learning when students are informed of behavioral objectives before or after a unit of study were investigated by Zimmerman (1972). One hundred fifty students enrolled in Math for Elementary Education Majors were assigned to three treatments involving programmed exercises. The first group received material with behavioral objectives inserted before each section, the second group received material with

objectives inserted after each section, and the third received no objectives. Achievement was measured by a 50 item test. Analysis of covariance failed to show any difference between treatments.

Holmes (1973), on the other hand, studied the achievement gain of secondary school pupils whose student teachers used behavioral objectives. Sixteen student teachers (and their classes) were utilized, two in each of eight academic areas. One of each pair of teachers was trained in the writing and use of behavioral objectives. Student achievement was measured by STEP tests administered at the beginning and at the conclusion of the student teaching period. It was concluded that the writing and use of behavioral objectives by a student teacher did not materially affect his pupils' performance on a standardized achievement test. Nor was there any apparent relation between the use of objectives and change in teacher attitude. No interaction was found between student achievement and ability level.

Student characteristics. The studies included in this category have explored the possibility of interactions between availability of behavioral objectives and certain characteristics of students. Most often used as independent variables were ability and sex; however, others have included the students' academic major and their opinions or ratings of individual objectives.

Olsen (1972) attempted to assess the effects of behavioral objectives on class achievement and retention as well as possible interactions between these and ability levels. Eight experimental classes in physical science were given stated behavioral objectives and six control classes were not. Intact classes were used. The experimental classes obtained

significantly higher mean scores on both achievement and retention. The experimental group mean scores for all three ability groups (high, medium, low) were also significantly higher on achievement and retention with one exception, the lower ability level on achievement.

Whether achievement, as measured by a classroom test, is a function of behavioral objectives, sex, and ability levels was investigated by Rabalais (1973). One hundred twenty-eight junior college students enrolled in General Psychology were randomly assigned to treatment and control groups. The treatment group received a printed list of objectives. Achievement was found to be a function of ability level but not of behavioral objectives or sex. Neither were any interactions discovered among these variables.

Shields (1973) sought to determine the effects of behavioral objectives on achievement in a college biology class using the audio-tutorial approach. One hundred seventy-four students enrolled in three pre-assembled class sections were utilized. Group I received a list of behavioral objectives prior to each of 13 units. Group II received objectives prior to each of units 8 through 13. Group III received no objectives. Other independent variables were sex of students and intellectual ability. Achievement was not found to be a function of any of the independent variables.

In a similar study Coleman (1973) investigated the effects of performance objectives on learning outcomes in a college physical science course. Also included as independent variables were sex of student and academic major. Ninety-four freshmen non-science majors were randomly assigned to a treatment or control group (behavioral objectives or

placebo). Dependent variables were achievement test scores, Welch Science Process Inventory, and the Watson-Glaser Critical Thinking Appraisal. No significant differences were found according to sex, major, or availability of objectives.

Gibson (1974), in an unusual approach, attempted to relate achievement to the students' acceptance of objectives. Fifty-nine participants in a graduate level course, Principles of Vocational Technical Education, ranked the class objectives (from most to least acceptable) at the beginning and at the conclusion of the course. No significant relationship was found between student ranking of objectives and consequent scores on either the final examination or a later test of recall.

Type of learning. The four studies reviewed in this category have attempted to discover relationships among achievement, behavioral objectives, and variations of learning levels, processes, and experiences. Some investigators have used objectives organized according to a standard taxonomy or an experimenter developed hierarchy. Effects of using structured versus unstructured materials were also considered along with prior experience of subjects.

Moody (1973) assessed the effectiveness of behavioral objectives classified according to Bloom's taxonomy. Ninety-three members of four, intact, high school, social studies classes were utilized to constitute a treatment and a control group. Independent study materials were used but objectives (classified according to the major levels of cognition) were given only to the treatment group. A test to measure learning was administered at the completion of the unit and, again, three weeks later to measure retention. At the synthesis level the control group's mean

true-retention adjusted for learning and the mean retention adjusted for grade point average and learning were significantly higher than the experimental group. Otherwise no significant differences were found.

The effect of behavioral objectives on measures of learning and forgetting of high school algebra was investigated by Loh (1972). Fifty-two students were randomly partitioned into two treatment groups for the learning phase and into three retention groups for the forgetting phase. Instructional materials were programmed within the framework of a learning hierarchy. Six criterion variables were observed: index and rate of learning, index and rate of forgetting, index of retention, and index of efficiency. No significant differences were found between groups on any of the criterion variables.

Prothero (1972) explored the effects of behaviorally stated objectives upon the learning and retention of structured (programmed) and unstructured (textbook) material. The third variable was the ability levels of the students. Second and third year college students of three ability levels were used in the pre-assembled classes. Objectives were found to have little benefit for the students studying structured material but were beneficial to students studying unstructured material. No differences were found across ability levels.

Duchastel (1974) tested the hypothesis that instructional objectives serve as organizational support of learning, much the same as advance organizers. An artificial passage 30 sentences long was given to 241 participating high school students. The three independent variables were objectives (presented or not presented), text organization (structured or random), and prior experience (valid, non-valid, none). The

results of recognition and free recall tests did support the orienting function of objectives. Objectives also increased relevant recall and depressed incidental recall but only for the valid experience group and then only in the random structure condition.

Behavioral versus non-behavioral objectives. The final category deals with the effects of stating objectives in specific behavioral terms compared to stating objectives in non-specific terms. Previous researchers have apparently felt the need to first establish the intrinsic value of behavioral objectives. The four investigations reviewed here appear to represent the principal studies in the area of comparison of specific and non-specific objectives.

Payne (1972) compared the achievement of high school chemistry classes whose teachers and students used behaviorally stated objectives with classes whose teachers and students used non-behaviorally stated objectives. Seven high school chemistry classes totaling 259 students were divided by class into an experimental and a control group. The experimental group received investigator-written behavioral objectives and the control group received the general objectives stated in the CHEM Study teachers' guide. Achievement on the two chapters was measured by tests furnished with the CHEM Study Materials. No significant differences were found between groups as a whole or according to ability levels. In the analysis of gain scores the F-ratio did, however, approach significance in favor of the experimental group. The results of a survey of students and teachers indicated a favorable attitude toward the use of behavioral objectives but it was recommended that a questionnaire be quantified to better investigate student opinions.

Some possible weaknesses of the study lay in not establishing equivalence of groups, use of the same instrument for both pre and post-test, and lack of student familiarity with behavioral objectives. It was further recommended by the researcher that a similar study should be accomplished covering more material and using teacher developed objectives.

The effects of specificity and placement of objectives on attitude and learning were investigated by Lawson (1973). Materials consisted of five written passages on engineering graphics presented to 84 engineering students. A 2 x 2 scheme resulted from the factorial combination of the specificity of the objectives (general or specific) and the placement of objectives within the written passages (at the beginning or interspersed throughout). Dependent measures consisted of intentional and incidental test items. On immediate achievement, all objective treatments were found to be superior to the conventional method but no significant differences were discovered between levels of specificity or between respective placements of objectives. It appeared that general objectives enhanced both intentional and incidental learning, whereas specific objectives promoted intentional learning.

Booth (1973) studied the effects of behavioral and non-behavioral objectives on student achievement and attitudes. Twenty instructors and their 417 students in Fundamentals of Speech Communication were assigned to two treatment groups. Achievement was measured by a researcher-designed content test of 50 items. Results indicated that students provided with behavioral objectives scored significantly higher at all three levels of learning. No significant difference was found in student attitudes toward instructors as measured by the Purdue Rating Scale for

Instruction.

Jenkins and Deno (1971) investigated the effects of type and knowledge of objectives on learning. General and specific objectives were utilized in a 2 x 3 factorial design in which only the teachers, only the students, and both teachers and students were provided with objectives. A control group consisted of students who were neither taught by teachers nor given copies of either type of objective. Compared to the control group significant learning occurred in all six treatment groups. However, among the treatment groups, neither type of objective nor knowledge of objectives differentially influenced performance.

Of the four studies reviewed which investigated the relative effectiveness of behaviorally stated versus non-behaviorally stated objectives, only one found behavioral statements to be significantly more effective. One other, however, discovered a persistent trend in that direction although it remained below the level of significance. These results together with recommendations for improved designs suggest the need for continued research in this area.

#### SUMMARY

The specification of learning behaviors has been shown to be an issue which is not only complex, but controversial, causing feelings to run high. Among the many uses suggested for behavioral objectives are: + to give direction for teaching and curriculum development, to provide guidance for evaluation, and to aid the process of learning. Although some may consider the first two functions to be the most important (Duchastel and Merrill, 1973), this investigation was concerned with the

usefulness of objectives when used as an aid to learning. The review of research has therefore dealt with studies which addressed the effect on achievement when students were provided with objectives.

Unfortunately it is difficult to generalize the results of these investigations because of inconsistencies and contradictions. Objectives have not been shown to work better in any particular area although they have seemed more effective when students were given training or practice in their use and when convinced of a correlation between objectives and test questions. Overall assessment was also handicapped by the lack of detailed descriptions or operational definitions of the behavioral objectives used in the studies. Examples of objectives used were even more rare. Neither were the few studies focusing on two types of objectives explicit as to what was intended by "general" or "non-behavioral" objectives. The general statements of course intent furnished in the teachers' guide appeared to have been used in one such case. No evidence of the use of an integrated outline form of objective was noted in any study.

A number of investigations reviewed have also employed attitude questionnaires to elicit student feelings. With few exceptions the results have tended to show strong preferences for the provision of objectives. The only other safe generalization appears to be that the issue has not yet been resolved and that further effort is needed. This investigation was therefore primarily directed at a comparison of the merits of behavioral and outline objectives when used as an aid to learning.

## Chapter 3

### PROCEDURES

This study was primarily designed to test the respective merits of behavioral and outline objectives as used in an introductory college geology course. An attempt was also made to evaluate the preferences of the students both for the use or non-use of objectives and, comparatively, for each of the two types of objectives applied. The first section of this chapter deals with a description of the subjects involved; the second with the experimental treatments applied; the third with the materials used; and the fourth with a consideration of experimental validity.

### THE SAMPLE

Participants in this investigation were students enrolled in the introductory geology course at Virginia Western Community College, Roanoke, Virginia, during the fall quarter 1974 and winter quarter 1975. Introductory geology at Virginia Western, at that time, was comprised of three one-quarter sequential courses: Geology 101, 102, and 103. Geology 101 and 102 consisted of Physical Geology and Geology 103 dealt with Historical Geology. Most of the students were freshmen and only two were science majors.

Four intact classes initially totaling 72 students were divided into two treatment groups of two classes each. Each group consisted of a morning class randomly paired with an afternoon class. During the

first quarter eight students either withdrew or failed to take one or more tests. At the end of the quarter a poll turned up two students (one from each group) who had been studying together and had thus been exposed to both treatments. These students were eliminated from the study and the analysis of data was restricted to the remaining 62, 32 in the experimental group and 30 in the comparison group.

Because scheduling complications did not allow random assignment to classes it was necessary to establish the equivalence of the two groups. To this end the following demographic data were collected on each student: age, high school rank, and I. Q. score. (See Appendix A for a complete tabulation of data.) Tables 1 through 7 show the frequency distributions of these descriptive statistics. In most of the tables the scores have been grouped into intervals to make them less cumbersome and more readily comprehensible, however, statistical treatment utilized ungrouped data. All test data were collected at the beginning of fall quarter, 1974.

Age.--The age of each subject (to the nearest year) was collected from college records. The distribution of ages in both groups is shown in Table 1. Mean age for students in the experimental group was 21.5 with a standard deviation of 3.8 and a range of 17 to 31. Ages of students in the comparison group had a mean of 21.8, a standard deviation of 6.2, and ranges from 17 to 42.

Table 1  
 Frequency Distribution of Ages by Group  
 As of September 1974

Age	Experimental Group	Comparison Group	Total
17	1	1	2
18	4	11	15
19	8	5	13
20	5	3	8
21	2	2	4
22	3	0	3
23	2	0	2
24	1	3	4
25	2	0	2
26	0	0	0
over 26	4	5	9
Total	32	30	62

High School Rank.--Information on student rank in high school graduating class was obtained from high school transcripts, from telephone contacts with schools, and, in a few cases, from personal interviews with students. In order to compensate for different class sizes, each student's rank was divided by the number in the class and the result then multiplied by 100 to eliminate decimals. High school rank was utilized because of its value as a predictor of college achievement. The successful use of high school rank and SAT scores to predict first semester grade point averages of college freshmen was reported by Chase and Thompson (1973). Astin (1971:5) also noted that "Of all the information available about the high school student, his record of academic performance is the best single indicator of how well he will do in

college. This fact has been documented in thousands of studies."

Table 2 shows the distribution of high school rank according to the above calculations. Rank of students in the experimental group averaged 48.4 with a standard deviation of 23.8. The comparison group averaged 43.2 with a standard deviation of 21.5.

Table 2  
Frequency Distribution of High School Rank by Group

Interval	Experimental Group	Comparison Group	Total
1-10	1	2	3
11-20	3	4	7
21-30	5	5	10
31-40	3	2	5
41-50	5	4	9
51-60	7	6	13
61-70	2	4	6
71-80	3	2	5
81-90	1	1	2
91-100	2	0	2
Total	32	30	62

Geology Pretest.--Although no subjects had previously been enrolled in geology, a number had been exposed to earth science either in public school courses or as personal hobbies. It was therefore deemed necessary to include, as a part of the student descriptions, a pretest of the material to be covered. The test instrument (Appendix B) was devised by the investigator and consisted of 40 multiple choice questions. Four questions on each of ten weekly units were randomly

selected from a pool of questions derived from the objectives.

Table 3 gives the distribution of scores on the geology pretest. For the experimental group the mean score was 11.25 and the standard deviation was 3.37. Scores ranged from 4 to 17. Mean scores of the comparison group was 10.87; standard deviation was 3.36; and the range was 4 to 19.

Table 3  
Frequency Distribution of Scores on Geology Pretest

Interval	Experimental Group	Comparison Group	Total
18-19	0	2	2
16-17	3	0	3
14-15	7	4	11
12-13	4	6	10
10-11	9	7	16
8-9	4	7	11
6-7	3	3	6
4-5	2	1	3
Total	32	30	62

Vocabulary, Reading Comprehension, and Reading Rate.--Reading skills, considered to be an important dimension of learning ability, were measured by Form A of the Nelson-Denny Reading Test. "Research with the earlier forms of this test indicated a close relationship between test scores and scholastic achievement (Houghton Mifflin, 1960: 22)." Raw scores were used to avoid the loss of data that would have resulted from conversion to grade equivalents.

Table 4 shows the distribution of vocabulary scores by group. The experimental group had a mean of 40.5 and a standard deviation of 15.2. The mean for the comparison group was 38.0 and the standard deviation was 15.6. This compares with a mean of 36.3 and a standard deviation of 15.5 for the grade 13 norm group. A reliability coefficient of 0.93 for the vocabulary section of the test has been established by use of the equivalent forms method (Houghton Mifflin, 1960).

Table 4  
Frequency Distribution of Vocabulary Scores

Interval	Experimental Group	Comparison Group	Total
11-20	2	2	4
21-30	5	9	14
31-40	13	7	20
41-50	5	5	10
51-60	4	4	8
61-70	2	2	4
71-80	0	1	1
81-90	1	0	1
Total	32	30	62

Scores on the comprehension section of the Nelson-Denny test were distributed as shown in Table 5. The experimental group had a mean of 44.1 and standard deviation of 10.8, whereas the comparison group's mean was 43.2 and standard deviation was 13.3. A mean of 41.5 and standard deviation of 13.2 was reported for the grade 13 norm group. The reliability coefficient of this section was calculated to be 0.81

(Houghton Mifflin, 1960).

Table 5  
Frequency Distribution of Comprehension Scores

Interval	Experimental Group	Comparison Group	Total
61-70	2	4	6
51-60	8	3	11
41-50	10	11	21
31-40	7	6	13
21-30	5	5	10
11-20	0	1	1
Total	32	30	62

Table 6 lists the distribution of reading rates (given in words per minute) for each group. The mean and standard deviation for the experimental group were 297 and 101 respectively, and 333 and 153 respectively for the comparison group. The mean and standard deviation of the grade 13 norm group were given as 267 and 95 with a reliability coefficient of 0.93 for this section (Houghton Mifflin, 1960).

Table 6  
 Frequency Distribution of Reading Rate  
 in Words per Minute

Interval	Experimental Group	Comparison Group	Total
Over 549	1	1	2
500-549	1	0	1
450-499	0	4	4
400-449	1	3	4
350-399	4	3	7
300-349	7	4	11
250-299	7	8	15
200-249	7	4	11
150-199	4	3	7
<b>Total</b>	<b>32</b>	<b>30</b>	<b>62</b>

I. Q. Score.--Standardized tests are not required of all students entering Virginia Western and no single test had previously been taken by all subjects. Therefore, the Otis Quick-Score Test of Mental Ability was given to all participants by the investigator. According to the Manual of Directions (Harcourt, Brace & World, 1954:6), one of the principle purposes of the test is ". . . for research purposes, to obtain two or more groups of equal mental ability or brightness which may be given different methods of instruction for the purpose of determining which method is superior." Raw scores were used to avoid losing information by conversion to actual I. Q. levels.

Table 7 reveals the distribution of I. Q. measures by group. Mean and standard deviation of the experimental group were 52.5 and 8.87 respectively and 52.3 and 10.5 for the comparison groups.

Table 7

Frequency Distribution of Raw Scores on Otis  
Quick-Score Test of Mental Ability

Interval	Experimental Group	Comparison Group	Total
71-75	0	1	1
66-70	2	3	5
61-65	4	4	8
56-60	6	2	8
51-55	8	5	13
46-50	3	7	10
41-45	7	4	11
36-40	1	2	3
31-35	1	2	3
Total	32	30	62

Analysis of Variance of each of the above descriptive characteristics produced the F values and alpha levels shown in Table 8.

Table 8

F Values and Alpha Levels for Demographic Data

Characteristic	F Value	Prob > F
Age	0.043	0.84
High School Rank	0.834	0.36
Geology Pretest	0.201	0.66
Vocabulary	0.417	0.52
Comprehension	0.091	0.76
Reading Rate	1.197	0.28
I. Q. Score	0.007	0.94

Inasmuch as the tabled F value at the 0.05 level of significance

for 1 and 60 degrees of freedom is 4.00, the two groups appeared to be equivalent. This conclusion was further substantiated by Multivariate Analysis employing Hotelling's  $T^2$  test of the hypothesis of no overall group effect. The REGR procedure of Statistical Analysis System was used. A calculated F value of 0.565 with 7 and 54 degrees of freedom indicated no significant difference between groups at the 0.05 level. Under the hypothesis of equal means the probability of exceeding such an F value was calculated to be approximately 0.78.

#### TREATMENT

The principal independent variables were the two types of objectives, behavioral, which were given to the experimental group, and non-behavioral (outline), which were given to the comparison group. Tests were given at regular intervals throughout the course and a comprehensive exam was administered at the end. During the second quarter (Geology 102), both groups received behavioral objectives for two weeks and then outline objectives for two weeks, alternating in this manner for ten weeks. At the end of the course the researcher sought to discover the feelings and preferences of the students for the use of objectives. For this purpose an investigator-developed questionnaire was employed.

For each weekly unit of study (one to two chapters), students in the experimental group received objectives stated in behavioral terms, i. e., specific statements of what was to be learned and how such learning was to be exhibited. Students in the comparison group were given non-behavioral objectives reduced to a list of words and phrases in outline form. In contrast to the behavioral form, the outline objectives

did not specify exactly what was to be learned or how such learning was to be demonstrated. Students were simply told that they were receiving a list of what they were supposed to know and understand. (See Appendix C for a compilation of both types of objectives used.) To ensure maximum benefit from the use of the behavioral form, the experimental group received copies of a brief self-instructional unit (taken from Kibler et al., 1974) on how to use behavioral objectives. At the beginning of the course every student was furnished a proclamation (Appendix F) which included a description of the type of tests to be given, as well as the scoring system to be used. This information was also reiterated orally prior to each test. Establishing the testing conditions and evaluative criteria in advance avoided tedious repetition of such information as a part of individual behavioral objectives.

All classes were taught by the investigator and every effort was made to present equivalent instruction throughout. In some cases questions were eliminated from the question pool when it was felt that instruction on related objectives had not been equal in all classes. Lectures were given from an expanded outline paralleling the objectives but much broader in scope.

Because of the amount of testing required at the initiation of the study, it was necessary to explain to the students that they were part of a research project; however, the details were purposely left vague. Exchanges of information between classes was undoubtedly minimized by the nature of Virginia Western and its student body. No students live on campus--most live at home--and thus few contacts are made between students in different classes. This conclusion was borne out by a survey

at the close of fall quarter which found only two students who had shared the different objectives.

### MATERIALS USED

The sources of information and the test instruments used as a means of gathering demographic data have been discussed previously. Materials used in the treatment and measurement stages may be grouped into four categories: instructional objectives, test instruments, attitude scale, and the textbook and associated study materials.

#### Instructional Objectives

Two types of instructional objectives were utilized in this study--behavioral and non-behavioral. Their origin lay in an earlier effort to improve instruction in geology by directing the student's attention to what he was expected to learn. The initial step in this direction consisted of the development of the non-behavioral objectives in outline form. In this process the key elements, e. g., vocabulary, concepts, or principles, in each chapter of the geology text were compiled. Integrated into the above material were additional concepts considered to be basic by the investigator. Desirability and fitness of these items were judged in four contexts: 1) Was it consistent with the stated educational goals of the course? 2) Was it pertinent to the theme of each chapter? 3) Was it necessary as a foundation for later learning? 4) Was it prerequisite to laboratory applications? The resulting non-behavioral objectives were placed in an outline form which grouped related elements together in a hierarchical arrangement.

Once the important terms and phrases were selected and tabulated, they were analyzed for the specific behaviors desired. A second set of objectives was then constructed in which each objective was stated in behavioral terms. During the 1973-74 school year a pilot study was made employing both forms. Students in one geology class were given behavioral objectives while another class received the outline form. After one week, both classes were tested and the treatments were then reversed during the second week. Alternation of classes and treatments was continued in this manner throughout the course.

The pilot study found neither type of objective to have a significantly greater effect on achievement but the results were not considered experimentally valid. Sources of invalidity included: use of intact classes not shown to be equivalent, small number of students, and possible residual effect from alternating treatments. The project did, however, aid in further refinement of techniques and objectives. For example, ambiguous and poorly constructed objectives were identified and modified or eliminated; objectives were reorganized to better conform to the lecture; and the frequency of testing was reduced. The resulting sets of objectives were then utilized in the final investigation carried out during the 1974-75 school year.

### Test Instruments

Performance of students in the experimental and comparison groups was measured by a series of five short achievement tests given at intervals during the quarter and by a comprehensive final examination at the end of the course. These tests were constructed by the investigator

because no appropriate standardized geology test was available. Test questions were drawn from a pool of questions related to the objectives. Many questions were selected randomly but others were chosen purposefully in order to achieve broader coverage and/or to ensure that certain objectives were tested. Test items were occasionally eliminated if it was felt that equal coverage or emphasis was not made available to every class.

Two important factors bearing on the usefulness of a test instrument are validity and reliability. A test must be valid in order to properly measure an attribute or a property. Although several types of validity have been recognized, the concern here was with content validity. Kerlinger (1964) described content validity as the sampling adequacy or representativeness of the content or substance of a measuring instrument. In other words, does the test actually measure what it is supposed to measure? The tests constructed for this investigation were intended to measure students' knowledge of the instructional objectives.

Two approaches to the establishment of content validity were employed in this study. During the formulation period, an appraisal of both the instructional objectives and test questions was sought from two experienced geology teachers. Some minor changes were suggested but, on the whole, they agreed that the objectives and test items were appropriate and valid. Although a subjective evaluation such as this was believed to be useful, a more objective assessment and therefore a better demonstration of validity was obtained by indicating how well the tests sampled the instructional objectives. The results are summarized in Table 9 by showing the distribution of test and exam questions among the

Table 9

Distribution of Test and Exam Questions Among  
Major Topics and Units

Topic	No. Items on Test	No. Items on Exam
Test I		
Unit 1 (Chapters 1 & 2)		
Geology-geologic record	3	0
Major rock classes	1	0
Historical development	1	1
Energy sources for the geologic cycle	4	2
Gross characteristics of the earth	4	2
Miscellaneous	2	0
Unit 2 (Chapter 3)		
General characteristics of matter	4	0
Elements	2	1
Atoms and ions	2	0
Compounds	6	4
Minerals	2	4
Test II		
Unit 3 (Chapter 4)		
Major classes of rocks	1	1
Magma	1	2
Igneous rocks	3	3
Sedimentary rocks	0	2
Metamorphic rocks	0	2
Unit 4 (Chapters 5 & 6)		
Hydrologic cycle	1	1
Rock cycle	2	4
Geochemical cycle	10	4
Absolute & relative ages & correlation	2	3
Geologic column and time scale	5	4
Test III		
Unit 5 (Chapter 7)		
Major types of weathering	2	0
Agents of mechanical weathering	1	0
Processes of chemical weathering	3	2
Products of chemical weathering	2	2
Differential weathering	3	3
Soils	4	1
Minerals formed in soils	3	1

Table 9 (continued)

Topic	No. Items on Test	No. Items on Exam
Test IV		
Unit 6 (Chapter 9)		
Ground cover	1	0
Mechanics of stream flow	3	5
Base levels	1	1
Features of deposition	4	4
Unit 7 (Chapter 10)		
Stream erosion	1	2
Cycle of erosion	7	4
Rejuvenation	1	1
Stream patterns	5	2
Stream types	2	2
Test V		
Unit 8 (Chapter 11)		
Characteristics of aquifers	4	3
Ground water features	2	3
Water wells	1	0
Effect of ground water on bedrock	2	3
Types of underground water	1	1
Geysers	1	1
Unit 9 (Chapter 12)		
Glacial ice	1	2
Types of glaciers	0	1
Features of glacial erosion	5	4
Features of glacial deposition	6	3
Unit 10 (Chapter 13, not included in test)		
Deserts	0	1
Principal agents of weathering & erosion	0	2
Wind developed features	0	2
Water developed features	0	4
<b>Total</b>	<b>122</b>	<b>100</b>

major topics of each unit.

The concept of reliability was summarized by Roscoe (1969) as an expression of how well a test measures whatever it measures. Kerlinger (1964:430), defining reliability as "The accuracy or precision of a measuring instrument," continued:

. . . Reliability, while not the most important facet of measurement, is still extremely important. In a way, this is like the money problem: the lack of it is the real problem. High reliability is no guarantee of good scientific results, but there can be no good scientific results without reliability. In brief, reliability is a necessary but not sufficient condition of the value of research results and their interpretation [443].

Because the few existing standardized geology tests were unsuitable for this study, concern was therefore given to the question of reliability of the investigator-constructed instruments. To this end item analysis was performed on the test scores and estimates of reliability were obtained using the Kuder-Richardson formula 20 (KR20). The analyses were made using the computer facilities of Virginia Polytechnic Institute and State University and a program developed by Frary.

Table 10 shows the reliability estimates calculated for each short test and for the exam. Reliabilities for the tests ranged from 0.64 to 0.83; within the range considered sufficient by Herron (1971) to detect differences between experimental and control groups. The exam showed a very high reliability of 0.93, consistent with results obtained during the development stage and pilot study. Item analysis procedures were also used during the pilot study, and earlier, as a means of improving reliability and validity by identifying poorly constructed questions.

Table 10  
Reliability Estimates for  
Test Instruments

Test	KR-20
I	0.83
II	0.64
III	0.64
IV	0.68
V	0.82
Exam	0.93

#### Attitude Scale

All students in Geology 102, winter quarter, 1975, received behavioral objectives for two weeks and then outline objectives for two weeks, alternating in this manner throughout the quarter. Course conduct and testing continued similar to Geology 101. As a result all students were exposed to both types of objectives in the second quarter. At the end of the quarter an attitude scale (Appendix D) was administered to discern the students' feelings toward the use of instructional objectives and their relative preferences for the behavioral or the outline type. To preserve anonymity students were asked not to sign the form. All but two papers were returned.

The attitude scale consisted of 15 pairs of statements plus one question. Each of the 15 pairs was made up of two items which were identical except that one referred to behavioral objectives and the other referred to outline objectives. Students were asked to indicate strong disagreement, tendency to disagree, tendency to agree, or strong

agreement with each item. Four of the pairs were phrased in the negative and all 30 items were randomly ordered. Item 31 was a direct question as to the type of objective preferred by the student if restricted to just one type.

The validity of the attitude scale could not be established empirically, but rather was based on the derivation of the individual items from results and typical comments in the literature. These items were based, in large part, directly upon arguments that have been used both for and against the employment of instructional objectives, especially the behavioral form. Several were adapted from comments made in response to an open-ended questionnaire given to subjects by Payne (1972). Modification was of course necessary to adjust some items to the context of this particular course.

The reliability of the responses to the attitude scale was verified by, first, separating the 15 statements that referred to outline objectives from those that dealt with behavioral objectives, then, applying the KR20 formula to each set of 15 items. A reliability estimate of 0.89 was obtained for the outline items and 0.90 for the behavioral items. These results indicate a high degree of consistency of response within each set of items.

#### Other Materials

Additional materials used in the course included the textbook, Physical Geology, by Longwell, Flint, and Sanders (1969); the laboratory manual, Physical Geology, by Hamblin and Howard (1971); and other outside reading assignments such as Geology Illustrated, Shelton (1966);

and volumes 1, 2, and 3 of Readings in Earth Science, Scientific American Offprints.

#### EXPERIMENTAL VALIDITY

The design of this experiment, a posttest-only control group design, was based upon both Design 6 and quasi-experimental Design 10 of Campbell & Stanley (1963). Design 6 is a posttest-only control group design in which the necessity of a pretest is avoided by random selection of subjects for each group. Design 10, a non-equivalent control group design, is applied to ". . . naturally assembled collectives such as classrooms, as similar as availability permits but yet not so similar that one can dispense with the pretest [217]."

The major internal validity problems for Design 10 are regression and interaction between selection and maturation (Campbell & Stanley, 1963). Regression was not considered to be a problem because neither the experimental nor the comparison group was selected on the basis of extreme scores on a pretest or any other measure. Interaction between selection and maturation was not deemed a serious weakness because of the established equivalence of the groups and because of the unlikelihood that one group had a higher rate of maturation during the experiment than the other.

An additional source of invalidity that had to be considered was experimenter bias. So many writers (e. g., Rosenthal, 1966; Morgan & King, 1966; Lyons, 1965) have warned of the dangers of unintentional experimenter influence that it seems to have gained general acceptance.

Such an effect was not thought to have been a serious threat to internal validity in this study because the researcher was not consciously aware of any bias and conscientiously attempted to treat all classes in the same manner. Support for this view is found in a recent investigation by Barber & Silver (1968:23) in which it was concluded that ". . . the experimenter bias effect appears to be more difficult to demonstrate and less pervasive than was implied in previous reviews . . . ."

Campbell & Stanley (1963) indicated that dangers to external validity for Design 10 can arise from interaction of testing and treatment, interaction of selection of subjects and treatment, and reactive arrangements. The last two can also affect the generalizability of Design 6.

Interaction of testing and treatment seems more likely to jeopardize studies in which a pretest tends to sensitize subjects to the treatment (such as research involving attitude changes):

But in research on teaching, one is interested in generalizing to a setting in which testing is a regular phenomenon. Especially if the experiment can use regular classroom examinations as Os, but probably also if the experimental Os are similar to those usually used, no undesirable interaction of testing and X would be present (Campbell & Stanley, 1963:188).

All achievement tests employed in this experiment were regular classroom examinations except the geology pretest. This test was an abbreviated form of the final exam, constructed of items drawn from the same question pool but not then used on other tests. It was therefore considered that interaction of testing and treatment was not significant.

Interaction of selection and treatment represents a potential source of invalidity in that there is a possibility that validly

demonstrated effects hold only for the unique population from which the groups were drawn, i. e., geology students at Virginia Western Community College. The sample used in this investigation would have been more representative and broader generalization of results more tenable if additional schools could have been included. Campbell & Stanley (1963) indicated, however, that there is greater likelihood of interaction when difficulty in getting subjects is encountered (e. g., when a researcher is turned down by several schools before being accepted by one, he probably insures that his sample will be non-representative) and when schools in the target population differ markedly in various characteristics.

The current study was limited to one school but not for the above reasons. Furthermore, the groups were not made up of subjects who volunteered for the research. Volunteers can create problems of interaction as mentioned by Neale & Liebert (1973). The subjects involved in this study were undergraduate college students, but this raised no questions of validity because the results were to be generalized to a population within such a universe.

Addressing another external validity problem, reactive arrangements, Campbell & Stanley (1963:190) gave the following description:

In the usual psychological experiment, if not in educational research, a most prominent source of unrepresentativeness is the patent artificiality of the experimental setting and the student's knowledge that he is participating in an experiment.

A common example of reactivity is the Hawthorne effect which is "the increase in performance due to the knowledge that one is being observed . . . . (Neale & Liebert, 1973).

In this investigation, however, there was little or no artificiality. The course was taught in the usual manner in the usual setting and no "strange" teachers were used. Most important, there was no untreated control group--both groups received a treatment and therefore should have been equally reactive.

This experiment resembled Design 10 (Campbell & Stanley, 1963) in that intact classes were involved and pretests were given. The pretests consisted of an IQ measure, reading test (vocabulary, comprehension, and reading rate), and a geology pretest based on the material to be covered that quarter. However, the method differed from Design 10 in that these pretests were not used to obtain gain scores, as is typical in Design 10, but instead were combined with other demographic data (age and high school rank) to establish the equivalence of the two groups. This procedure was employed in order to compensate for some of the weakness of Design 10 and to approximate the strengths of Design 6 in which random selection of subjects is utilized to produce equality. Although the pretests did not offer absolute proof, the contention that the groups were equivalent was strongly corroborated. As emphasized by Neale & Liebert (1973:59), "it must be recalled that randomization does not guarantee [emphasis theirs] equality of groups." In addition, Campbell & Stanley (1963:217) have pointed out that ". . . Design 10 should be recognized as well worth using in many instances in which Designs 4, 5, or 6 are impossible."

## SUMMARY

Students enrolled in the fall quarter, 1974 beginning geology classes at Virginia Western Community College were used as subjects in this study of the comparative merits of behavioral objectives versus non-behavioral objectives stated in outline form. Four intact classes were divided into two groups. The experimental group of 32 students received behavioral objectives and the comparison group of 30 students received outline objectives. Because random assignment was not possible, demographic data which included age, high school rank, geology pretest score, vocabulary, reading comprehension, reading rate, and an I. Q. measure were collected on each student. Multivariate Analysis indicated no significant difference between groups at the 0.05 level.

The dependent variables were five short achievement tests administered at approximately two-week intervals and a comprehensive final exam given at the end of the course. Content validity of the test instruments was examined, and KR20 reliability estimates were calculated to be 0.93 for the exam and to range from 0.64 to 0.83 for the short tests.

During winter quarter, 1975, all students received behavioral objectives for two weeks, then, outline objectives for two weeks, alternating in this fashion throughout the course. At the end of the quarter an attitude scale was administered in an effort to ascertain student reaction to the use of objectives and student preferences, if any, for either the behavioral or the outline form.

## Chapter 4

### PRESENTATION AND ANALYSIS OF DATA

The primary goal of this study was to test the relative effectiveness of behavioral and outline objectives. An outline objective was described as a non-behavioral type in which words and phrases are organized in hierarchical form, whereas behavioral objectives were defined as statements which informed the student what was to be learned and how such learning was to be demonstrated (see Appendix C for examples). Principal dependent variables consisted of scores on a series of short achievement tests given during fall quarter, 1974, and a comprehensive exam administered at the completion of the course. The two groups of subjects were comprised of students enrolled in introductory geology at Virginia Western Community College, Roanoke, Virginia.

A second goal of the investigation included an exploration of student attitudes toward the use of instructional objectives and the assessment of student preferences for the behavioral or the outline form of objective. An attitude scale developed by the investigator was utilized for this purpose.

### ACHIEVEMENT TESTS

Achievement test data collected during this investigation were analyzed statistically to ascertain if the use of behavioral objectives had a significantly greater influence than outline objectives on:

1. The achievement of geology students as measured by five short tests;
2. The achievement of geology students as measured by a comprehensive exam; and
3. The achievement of geology students as indicated by Multivariate Analysis of the six test instruments.

### Simple Analysis of Variance

Analysis of Variance was used to determine the relationship between the independent variable (type of objective) and the dependent variable (test scores). Only two sources of variance are considered in the sample Analysis of Variance: that which derives from the independent variable and that which derives from sampling error. The four basic assumptions underlying this statistical procedure are:

1. The samples are independent random samples;
2. The samples are from normally distributed populations;
3. The populations are equally variable; and
4. The populations have equal means.

With respect to the importance of these assumptions, Roscoe (1969:236) commented:

. . . When the hypothesis is rejected, we prefer to assume it is inequality of the means that has been violated. Fortunately, the analysis of variance is much more sensitive to violation of the assumption of equal means than to violation of the assumptions of normality or of homogeneous variances. Generally, when the investigator is working with samples of the same or nearly the same size, he may ignore these assumptions . . . .

In the following tables, test score distributions and summaries of results of Analysis of Variance are shown for the six achievement tests.

Table 11 shows a ranked distribution of percentage scores by group for Test I (Units 1 and 2). The means of the experimental and

Table 11

Frequency Distributions, Means, and Standard  
Deviations of Scores on Test I

Interval	Experimental Group	Comparison Group	Total
96-100	3	0	3
91-95	2	1	3
89-90	4	0	4
81-85	6	5	11
76-80	3	2	5
71-75	6	6	12
66-70	3	5	8
61-65	1	4	5
56-60	2	2	4
51-55	1	1	2
46-50	0	2	2
41-45	0	0	0
below 41	1	2	3
Total	32	30	62
Mean	77.16	67.63	72.55
Std. Dev.	14.43	13.66	14.06

comparison groups were 77.16 and 67.63 respectively, the experimental group averaging 9.53 higher. Standard deviations were almost identical at 14.43 for the experimental group and 13.66 for the comparison group.

Table 12 contains the results of Analysis of Variance on the Test I scores of both groups. This analysis and those following were accomplished by means of Statistical Analysis Systems' programs and the computer at Virginia Polytechnic Institute and State University.

The tabled F value was found to be 4.00 at the 0.05 level of significance with 1 and 60 degrees of freedom. Because this was exceeded by the calculated F (7.1), the null hypothesis was rejected and a significant difference between the means was determined to exist. In fact, the means appeared to differ significantly above the 99 percent confidence level.

Analysis of Variance therefore revealed that the experimental group achieved significantly higher than the comparison group on Test I.

Table 12  
Summary of Analysis of Variance of Test I  
(Units 1 & 2)

Source	df	Sums of Squares	Mean Squares
$V_b$	1	1,404.17	1,404.17
$V_w$	60	11,867.18	197.79
$V_t$	61	13,271.35	
$H_0: m_1 = m_2$			
$H_a: m_1 \neq m_2$		F = 7.1	Prob > F = 0.0099

Table 13 is a ranked distribution of scores by group for Test II (Units 3 and 4). The mean of the experimental group was 76.66 and that of the comparison group was 76.30, the experimental group averaging only 0.36 higher. Standard deviations, however, were 12.85 and 15.60 respectively for the experimental and comparison groups, a difference of 2.75 in favor of the comparison group.

Table 14 contains the results of the analysis of variance for Test II scores for both groups. From these data an F value of 0.01 was calculated. With 1 and 60 degrees of freedom at the 0.05 level of significance, the tabled F was 4.00. Because the tabled F was larger, the null hypothesis was retained and the alternate rejected.

Analysis of Variance of the scores indicated that there was no significant difference between the achievement of the experimental and the comparison groups on Test II.

Table 13

Frequency Distributions, Means, and Standard  
Deviations of Scores on Test II

Interval	Experimental Group	Comparison Group	Total
96-100	1	4	5
91-95	4	3	7
86-90	3	3	6
81-85	3	3	6
76-80	11	4	15
71-75	2	2	4
66-70	1	3	4
61-65	1	2	3
56-60	4	4	8
51-55	1	0	1
46-50	0	0	0
41-45	1	2	3
Total	32	30	62
Mean	76.66	76.30	76.48
Std. Dev.	12.85	15.60	14.24

Table 14

Summary of Analysis of Variance of Test II  
(Units 3 & 4)

Source	df	Sums of Squares	Mean Squares
$V_b$	1	1.97	1.97
$V_w$	60	12,169.52	202.83
$V_t$	61	12,171.49	
<hr/>			
$H_0: m_1 = m_2$			
$H_a: m_1 \neq m_2$		F = 0.01	Prob > F = 0.92

Table 15 is ranked distribution of scores by group for Test III (Unit 5). The experimental and comparison group means were 77.25 and 64.73 respectively, a difference of 12.52. The standard deviation of the experimental group scores was 13.50 whereas that of the comparison group was 15.25.

Table 15

Frequency Distributions, Means, and Standard  
Deviations of Scores on Test III

Interval	Experimental Group	Comparison Group	Total
96-100	2	0	2
91-95	5	2	7
86-90	3	1	4
81-85	4	2	6
76-80	6	3	9
71-75	1	2	3
66-70	5	4	9
61-65	1	4	5
56-60	2	4	6
51-55	3	2	5
46-50	0	2	2
41-45	0	1	1
36-40	0	3	3
Total	32	30	62
Mean	77.25	64.73	71.19
Std. Dev.	13.50	15.25	14.37

Table 16 shows the results of Analysis of Variance of scores of both groups on Test III. From an F table with 1 and 60 degrees of freedom, a 4.00 critical F was obtained at the 0.05 level of significance. Inasmuch as the calculated F (11.75) was greater than the tabled value, the null hypothesis was rejected and the hypothesis of a significant difference in the group means of Test III was accepted. As with the scores on Test I, the difference appears to be significant even above the 99 percent confidence level.

The Analysis of Variance indicated that the achievement of the experimental group was significantly higher than that of the comparison group on Test III.

Table 16  
Summary of Analysis of Variance of Test III  
(Unit 5)

Source	df	Sums of Squares	Mean Squares
$V_b$	1	2,425.81	2,425.81
$V_w$	60	12,387.87	206.46
$V_t$	61	14,813.68	
$H_0: m_1 = m_2$			
$H_a: m_1 \neq m_2$		F = 11.75	Prob > F = 0.0011

Table 17 consists of a ranked distribution of scores by group for Test IV (Units 6 and 7). The mean score for the experimental group was 74.69 compared to a similar mean of 74.33 for the comparison group.

Table 17

Frequency Distributions, Means, and Standard  
Deviations of Scores on Test IV

Interval	Experimental Group	Comparison Group	Total
96-100	0	1	1
91-95	3	0	3
86-90	2	7	9
81-85	4	4	8
76-80	7	5	12
71-75	5	3	8
66-70	7	3	10
61-65	2	3	5
56-50	0	2	2
51-55	0	0	0
46-50	2	0	2
41-45	0	1	1
below 41	0	1	1
Total	32	30	62
Mean	74.69	74.33	74.52
Std. Dev.	11.03	15.72	13.50

Standard deviations, on the other hand, showed a greater difference than on any other test; 11.03 and 15.72 respectively for the experimental and comparison groups.

Table 18 represents the results of Analysis of Variance of scores of both groups on Text IV. An F value of 0.01 was calculated. The tabled F with 1 and 60 degrees of freedom was 4.00 at the 0.05 level of significance. Because the calculated F was less than the tabled value, the null hypothesis was retained. The test score means were not significantly different.

Analysis of Variance of scores on Test IV revealed no significant difference in the achievement of the experimental and comparison groups.

Table 18  
Summary of Analysis of Variance of Test IV  
(Units 6 & 7)

Source	df	Sums of Squares	Mean Squares
$V_b$	1	1.94	1.94
$V_w$	60	10,937.54	182.29
$V_t$	61	10,939.48	
$H_o: m_1 = m_2$ $H_a: m_1 \neq m_2$			
		F = 0.01	Prob > F = 0.92

Table 19 is composed of a ranked distribution of scores by group for Test V (Units 8 and 9). The mean of the experimental group was 73.09, only slightly above the 72.53 mean of the comparison group.

Table 19

Frequency Distributions, Means, and Standard  
Deviations of Scores on Test V

Interval	Experimental Group	Comparison Group	Total
96-100	2	2	4
91-95	2	2	4
86-90	3	4	7
81-85	4	2	6
76-80	5	3	8
71-75	2	4	6
66-70	5	4	9
61-65	3	2	5
56-60	2	1	3
51-55	2	1	3
46-50	0	1	1
41-45	0	1	1
36-40	0	3	3
31-35	2	0	2
Total	32	30	62
Mean	73.09	72.53	72.82
Std. Dev.	15.66	17.06	16.35

Standard deviations of the experimental and comparison groups were 15.66 and 17.06 respectively.

The results of Analysis of Variance of Test V scores for both groups are shown in Table 20. The tabled F value was found to be 4.00 at the 0.05 level of significance with 1 and 60 degrees of freedom. Inasmuch as the calculated F (0.018) was exceeded by the tabled value, the null hypothesis was retained. There was no significant difference between the mean scores of the two groups.

Analysis of Variance of the scores on Test V indicated no significant difference in the achievement of the experimental and comparison groups.

Table 20  
Summary of Analysis of Variance of Test V  
(Units 8 & 9)

Source	df	Sums of Squares	Mean Squares
$V_b$	1	4.86	4.86
$V_w$	60	16,040.19	267.34
$V_t$	61	16,045.05	
<hr/>			
$H_0: m_1 = m_2$			
$H_a: m_1 \neq m_2$		F = 0.018	Prob > F = 0.89

Table 21 is a ranked distribution of scores by group for the final exam. The mean of the experimental group was 74.25 and that of the comparison group was 69.07, a difference of 5.18. The standard

Table 21

Frequency Distributions, Means, and Standard  
Deviations of Scores on Exam

Interval	Experimental Group	Comparison Group	Total
96-100	1	0	1
91-95	2	1	3
86-90	1	3	4
81-85	7	3	10
76-80	10	5	15
71-75	1	4	5
66-70	2	3	5
61-65	3	3	6
56-60	3	2	5
51-55	0	2	2
46-50	0	1	1
41-45	0	2	2
36-40	2	0	2
31-35	0	1	1
Total	32	30	62
Mean	74.25	69.07	71.74
Std. Dev.	14.25	15.10	14.67

deviations were similar, 14.25 for the experimental group and 15.10 for the comparison group.

Table 22 contains the results of Analysis of Variance of the exam scores for both groups. From an F table with 1 and 60 degrees of freedom, a 4.00 critical F was obtained at the 0.05 level of significance. Because the calculated F value (1.93) was less than the tabled value, no significant difference was found to exist and the null hypothesis was retained.

Analysis of Variance of the scores on the final exam indicated that the experimental group did not exhibit significantly higher achievement than the comparison group.

In summary, Analysis of Variance of scores on the six achievement tests revealed that the experimental group scored significantly higher on tests I and III. Differences on the other four tests were in favor of the experimental group but were below the level of significance.

Table 22  
Summary of Analysis of Variance of Exam

Source	df	Sums of Squares	Mean Squares
$V_b$	1	416.00	416.00
$V_w$	60	12,909.87	215.16
$V_t$	61	13,325.87	
<hr/>			
$H_0: m_1 = m_2$			
$H_a: m_1 \neq m_2$		F = 1.93	Prob > F = 0.17

### Multivariate Analysis

In addition to the simple Analysis of Variance applied to each of the six achievement tests, Multivariate Analysis was used for further testing of the major hypothesis. The multivariate program utilized was Hotelling's  $T^2$  test included in the REGR procedure of Statistical Analysis System.

According to Finn (1974), the  $T^2$  statistic is a matrix generalization of Student's  $t$  to multiple criterion measures. A distinct advantage in the interpretation of results is that a transformation of  $T^2$  can be compared directly to tables of  $F$  distribution.

The two-sample  $T^2$  statistic was transformed to an  $F$  value of 3.074 with 6 and 55 degrees of freedom. The appropriate tabled  $F$  at the 0.05 level of significance was 2.34. Because the calculated  $F$  exceeds the tabled value the null hypothesis must be rejected.

Table 23  
Summary of Multivariate Analysis of Achievement  
Test Scores

Test	Mean of Experimental Group N = 32	Mean of Comparison Group N = 30	Mean of Combined Groups
Test I	77.16	67.63	72.55
Test II	76.66	76.30	76.48
Test III	77.25	64.73	71.19
Test IV	74.69	74.33	74.52
Test V	73.09	72.53	72.82
Exam	74.25	69.07	71.74

$H_0: \underline{m}_1 = \underline{m}_2$	df = 6 and 55	
$H_a: \underline{m}_1 \neq \underline{m}_2$	F = 3.074	Prob > F = 0.0115

Under the hypothesis of equal mean vectors the probability of exceeding the calculated F value (3.074) would be less than 0.0115. The overall achievement of the experimental group was therefore considered to be greater than that of the comparison group at the 95 percent confidence level.

#### ATTITUDE SCALE

A second purpose of this study was the assessment of student attitudes toward behavioral and outline objectives. The attitude scale (Appendix D) was administered at the end of winter quarter, 1975 (Geology 102), after all subjects had been repeatedly exposed to both types of objectives. The instrument included 15 pairs of items. Both items of a pair were identical except that one referred to behavioral

objectives and the other referred to outline objectives.

Data collected by means of the attitude scale were analyzed to determine:

1. If significant differences existed in student attitudes toward the usefulness on each type of objective;
2. If students tended to prefer one type of objective to the other; and
3. If students considered the availability of objectives to be preferable to having no objectives.

Table 24 contains the response frequencies, mean response levels, and correlation coefficients for each of the 30 paired items on the attitude scale. For clarity and convenience, paired items are listed adjacent to each other, outline (O) first and behavioral (B) second. Numbers of items refer to original numbers on the attitude instrument. The eight items stated in negative form are indicated in the table. Although the response frequencies for these items are shown without change, values were reversed for all other calculations. Response choices 1 through 4 respectively were: disagree, tend to disagree, tend to agree, agree.

All correlations of individual outline items with total score on outline items were positive and tended to be relatively high. Correlations of outline items with total score on behavioral items were negative except for two which were essentially zero. Similarly, each behavioral item correlated positively with total behavioral score and negatively with total outline score.

These results seemed to indicate that there was a dichotomy of attitudes; that students who tended to favor one type of objective did not find the other to be as useful.

Table 24

Response Frequencies, Mean Response Levels, and  
Item Correlations for the Attitude Scale

Type	Item No.	Response Frequencies For Each Choice				Mean Response Level	Corr. with Outline	Corr. with Behav.
		1 D	2 TD	3 TA	4 A			
O	1	6	9	11	34	3.22	0.68	-0.55
B	10	11	17	16	16	2.62	-0.52	0.82
O	4	3	8	22	27	3.22	0.34	0.01
B	8	10	11	19	20	2.82	-0.26	0.61
O	5*	28	15	12	5	3.10	0.60	-0.32
B	22*	20	25	12	3	3.03	-0.28	0.40
O	6*	7	12	29	12	2.23	0.16	-0.16
B	13*	7	17	25	11	2.33	-0.07	0.32
O	7*	13	22	14	11	2.62	0.39	-0.29
B	21*	10	30	14	6	2.73	-0.34	0.40
O	11*	15	22	15	8	2.73	0.28	0.02
B	3*	12	22	21	5	2.68	-0.05	0.22
O	12	7	11	11	31	3.10	0.84	-0.67
B	15	15	13	13	19	2.60	-0.56	0.88
O	14	10	22	17	11	2.48	0.65	-0.48
B	23	12	25	15	8	2.32	-0.33	0.47
O	18	6	15	17	22	2.92	0.81	-0.52
B	2	11	12	16	21	2.78	-0.41	0.74
O	19	9	11	20	20	2.85	0.76	-0.36
B	30	6	21	16	17	2.73	-0.51	0.73
O	20	8	16	20	16	2.73	0.79	-0.45
B	16	14	16	16	14	2.50	-0.43	0.80
O	24	3	12	21	24	3.10	0.71	-0.40
B	26	9	19	18	14	2.62	-0.60	0.85

\*Items stated in negative form.

Table 24 (continued)

Type	Item No.	Response Frequencies For Each Choice				Mean Response Level	Corr. with Outline	Corr. with Behav.
		1	2	3	4			
		D	TD	TA	A			
O	27	9	14	21	16	2.73	0.58	-0.27
B	17	7	18	22	13	2.68	-0.24	0.57
O	28	9	10	15	26	2.97	0.88	-0.56
B	25	17	13	14	16	2.48	-0.57	0.82
O	29	19	15	16	10	2.28	0.74	-0.55
B	9	36	7	10	7	1.80	-0.54	0.72

Table 25 contains the total scores by individual on both the set of 15 outline items and the set of 15 behavioral items. Using these data, a Pearson correlation coefficient ( $r$ ) was calculated to be  $r = -0.59$ . The null hypothesis,  $H_0: \rho = 0$ , was tested by means of the  $t$  distribution. Using a two-tailed test at the 0.01 level of significance with 58 degrees of freedom, the tabled value of  $t$  was 2.704. Because the calculated  $t$  equaled -5.634, the hypothesis was rejected and the correlation coefficient was determined to be significantly different from zero. The negative correlation between scores on outline and behavioral items substantiated the idea that students who favor one type of objective tend to perceive the other type as less useful.

Table 25

Total Scores by Individual Student on Outline  
Items and Behavioral Items

Subj.	Out.	Beh.	Subj.	Out.	Beh.	Subj.	Out.	Beh.
1	32	47	21	49	27	41	53	30
2	27	57	22	28	52	42	53	31
3	45	44	23	52	30	43	50	26
4	39	45	24	32	47	44	43	14
5	31	44	25	47	36	45	49	49
6	54	60	26	56	28	46	31	43
7	38	39	27	37	46	47	48	30
8	47	41	28	34	52	48	48	24
9	50	31	29	57	28	49	51	39
10	42	34	30	33	44	50	15	57
11	46	27	31	53	52	51	29	49
12	43	41	32	29	52	52	53	37
13	43	32	33	51	31	53	47	26
14	44	30	34	44	31	54	40	38
15	36	46	35	34	46	55	37	49
16	55	38	36	45	40	56	53	32
17	50	23	37	25	53	57	43	35
18	46	42	38	50	22	58	29	49
19	33	47	39	53	47	59	50	25
20	27	39	40	43	32	60	33	38
r = -0.5948			H <sub>0</sub> : $\rho = 0$					
			H <sub>a</sub> : $\rho \neq 0$			t = -5.634		

Table 26 is a compilation of total score statistics for each set of 15 items. The mean of all students on the outline and behavioral items was 42.28 and 38.73 respectively. In order to test the hypothesis of equal means, a  $t$  statistic for two related samples was calculated.

Table 26  
Total Score Statistics for all Students

Statistic	Outline Items	Behavioral Items
Mean	42.28	38.73
Std. Dev.	9.34	9.73
Reliability (KR20)	0.89	0.90
Std. Error of Meas.	3.14	3.12
$H_0: m_1 = m_2$	N = 60	
$H_a: m_1 \neq m_2$	$t_d = 3.20$	

Using a two-tailed test at the 0.05 level with 59 degrees of freedom, the tabled  $t$  was found to be 2.00. Because the calculated  $t$  (3.20) exceeded the tabled value, the null hypothesis must be rejected. It appeared therefore that, overall, the students considered the outline objectives to be significantly more useful than the behavioral form.

Item 31 on the attitude scale was a direct request for an expression of preference for one of five choices. Listed below are the five options and the percent of students choosing each:

1. Behavioral objectives	38.3%
2. Outline objectives	56.7%
3. Some other kind	1.7%
4. No objectives	0.0%
5. Have no opinion	3.3%

As is obvious from the above, the students overwhelmingly favored the availability of objectives in some form. More than half, however, indicated that they would choose the outline form if restricted to one type.

#### SUMMARY

In order to test the major hypothesis of this study, student achievement was measured by five short tests and a comprehensive final exam. Simple Analysis of Variance of each test instrument showed that the experimental group scored significantly higher on tests I and III. Other test differences were not significant at the 0.05 level, although all were in favor of the experimental group.

A multivariate approach, Hotelling's  $T^2$  statistic, was used to analyze simultaneously the data from all six tests. This procedure indicated that, overall, the achievement of the experimental group was higher than that of the comparison group at the 0.05 level of significance.

To investigate the attitudes and preferences of students toward the use of instructional objectives, an attitude scale was administered after each subject had experienced both the behavioral and outline forms. Analysis of the results indicated that:

1. Students were almost unanimous in desiring to have some type of instructional objectives available; ✓
2. A majority of students indicated that outline objectives would be their first choice; and ✓
3. With respect to the mean attitudes of students toward the usefulness of behavioral and outline objectives, there was a significant difference in favor of the outline form.

## Chapter 5

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This investigation was primarily designed to test the relative effectiveness of behavioral and outline (non-behavioral) objectives as used in an introductory college geology course. Behavioral objectives were made up of statements in which students were informed of what was to be learned and how such learning was to be demonstrated. The non-behavioral type, called outline objectives, consisted of lists of words and phrases arranged in hierarchical groupings. Students receiving the behavioral form were furnished a short self-instructional unit on the use of behavioral objectives. Students receiving the outline form were simply told that they were being given a list of terms and concepts to know and understand.

The instructor-researcher made every effort to reduce experimental bias by organizing, presenting, and teaching the classes in the usual manner. The research was adapted to the course rather than the course to the research. Instructional objectives employed were those developed and used during previous years, subject only to continuing refinement.

A second purpose of the study was to examine the attitudes of students toward the usefulness of objectives and to assess student preferences for behavioral or outline types.

The importance of the answers sought by this research is attested by the extensive literature composed of aggressive pleadings of

the advantages of behavioral objectives and equally polemic arguments against their use. Preconceived ideas about behavioral objectives, the difficulties of writing them well, and their relative inflexibility have seemed to discourage their use, especially at the college level. Appropriate research has therefore been needed to establish the effectiveness of behavioral objectives or to find viable alternatives.

#### SUMMARY OF PROCEDURES

The specific objectives of this study were: 1) To determine if students in an introductory college geology class achieved higher when furnished behaviorally stated objectives or when furnished non-behavioral objectives in outline form; 2) To determine whether students identified behavioral or outline objectives as being more useful; and 3) To determine if students had strong preferences for either type of objective.

Students enrolled in four intact geology classes taught by the investigator participated in the investigation. Two classes were assigned to the experimental group and two to the comparison group. Because scheduling difficulties precluded random assignment to groups, the following demographic data were collected on each student: age, high school rank, geology pretest score, vocabulary, reading comprehension, reading rate, and an I.Q. measure. Multivariate analysis of these demographic variables disclosed no significant difference between groups at the 0.05 level.

Throughout fall quarter, 1974, the experimental group (32 students) received behavioral objectives and the comparison group (30 students) received outline objectives. The dependent variable,

achievement, was measured by five short tests during the course and a comprehensive final exam at the end. The hypothesis of equal means was tested individually on each set of achievement scores by applying simple Analysis of Variance, and simultaneously on all six sets of scores by using a form of Multivariate Analysis, Hotelling's  $T^2$ .

Throughout winter quarter, 1975 (during the second part of Physical Geology), the students were alternately given behavioral and outline objectives. At the end of the quarter an attitude scale was used to explore student feelings about both types of objectives. The  $t$  statistic, item analysis, and Pearson's correlation coefficient were used to analyze the results.

The content of the courses involved in the experiment (Geology 101 and 102) was based primarily on the textbook, Physical Geology, Longwell, Flint, and Sanders (1969).

## FINDINGS

To enable the principal results of this investigation to be statistically tested for significance, the following major hypotheses were stated:

HYPOTHESIS 1: In an introductory college geology course, there will be no difference between the mean scores of students who receive behavioral objectives and the mean scores of students who receive outline objectives, as measured by a series of achievement tests.

HYPOTHESIS 2: In an introductory college geology course in which both behavioral and outline objectives have been used by all students, there will be no difference in student attitudes toward the usefulness of

either type of objective, as measured by an attitude scale.

Hypothesis 1 was tested both by simple Analysis of Variance of the scores of each achievement test and by Multivariate Analysis of all six tests. Results of simple Analysis of Variance indicated that the experimental group scored significantly higher than the comparison group on Test I and Test III, at the 0.05 level. Group means were 77.16 and 67.63 (experimental and comparison) for Test I and 77.25 and 64.73 respectively for Test III. The means of the two groups in both instances were significantly different at well above the 99 percent level.

Results for Tests II, IV, and V were not as striking. The difference between group means was less than one point on each of the three tests and was, therefore, non-significant at the 0.05 level.

On the final exam the experimental group mean was 74.25 and the comparison group mean was 69.07. Analysis of Variance determined that these means did not differ significantly at the 0.05 level. However, because a probability level of 0.17 was calculated, it was considered that the results were not inconsistent with those of Tests I and III.

Overall, the experimental group showed significantly higher achievement on Test I and Test III. Differences for the other four tests were not significant at the 0.05 level. Because of the wide variation in results, the tests were reexamined, but no obvious reasons for such disparity were noted. Other than the exam, Test I was the longest, but Test III was the shortest. Reliabilities gave no clue; that of Test I was a relatively high 0.83, that of Test III a relatively low 0.64. The other tests varied from 0.64 (Test II) to 0.93 (Exam). It did appear that the attainment of, or approach to, significant

differences was more closely related to variations in the achievement of the comparison group. Experimental group mean scores were very consistent, varying only from 73.09 to 77.25 over five tests and an exam. Comparison group means ranged from 64.73 to 76.30 (see Table 23, page 79). A point perhaps worth noting is that all differences in group means were in favor of the experimental group.

Hypothesis 1 was further tested by a multivariate procedure, Hotelling's  $T^2$ . This approach allowed scores on all six tests to be analyzed at the same time. Because a transformation of the  $T^2$  statistic is distributed as F, the results can be compared directly to tables of F distributions. An F value of 3.074 was obtained for the six sets of achievements tests and the probability of exceeding this value was calculated to be 0.0115. Because the calculated F was larger than the tabled value at the 0.05 level, hypothesis 1 was rejected and it was considered that, overall, the experimental group achieved significantly more than the comparison group.

Hypothesis 2 was tested by means of Student's t statistic for repeated measures. The mean attitude score of all subjects on the 15 outline items was 42.28; on the 15 behavioral items, 38.73. Because the calculated t exceeded the tabled value at the 0.05 level, hypothesis 2 was rejected. It appeared that there was a significant difference in the mean attitudes of the students toward the usefulness of outline and behavioral objectives.

In addition to the statistical test of responses to the 30 paired items of the attitude scale, the responses to a direct question of preference were examined. Students were all but unanimous (96.7%)

in favoring the use of some type of instructional objective. More than half (56.7%) gave outline objectives as their first choice and 38.3% chose the behavioral form.

Correlations were made between individual items of the attitude scale and total score on the behavioral items and on the set of outline items. A Pearson correlation coefficient between responses to outline items and responses to behavioral items was also calculated using the total score of each student on both behavioral and outline items. Both procedures suggested that students tend to have definite preferences either for behavioral or for outline objectives. Conversations with individual students brought out that these feelings were often quite strong.

The major question raised by this study was directed at the relative effectiveness of behavioral (specific) and outline (non-specific) objectives. Numerous efforts to establish the value of behavioral objectives have not resolved the controversy but instead have produced contradictory results. Of the 23 studies reviewed earlier which were conducted to examine the influence of behavioral objectives on achievement, eight found significant evidence in favor of behavioral objectives, four found partial support, and eleven found no advantage. Of the four studies reviewed earlier which tested the relative merits of behavioral and non-behavioral objectives, one found strong evidence in favor of behavioral objectives, one found a trend in that direction, and two found no difference. The results of the current investigation lend cautious support to those studies in which behavioral objectives were seen to be beneficial, in particular, the findings of Booth (1973) and the trend noted by Payne (1972).

Some care should be exercised, however, because of the possibility that none of the studies reviewed may have been similar enough for direct comparison. For example, Booth (1973) provided only nine objectives (confined to material in the text) covering a three-week study unit. Although he argued convincingly that too many objectives can cause a loss of effectiveness, these simple conditions are unlikely to obtain in many college classroom situations, especially in a comprehensive science course. The current study used at least twice as many objectives each week as used by Booth in three weeks and these objectives were not limited to the text. In addition, results of the present study indicated that, because of differences in material or other unrecognized variables, outcomes may vary from unit to unit and conclusions based on a one-unit, one-test design are hazardous. Another possible weakness of Booth's design was the use of intact classes without random assignment or establishment of equivalence of groups.

Payne (1972) researched the effects of behavioral and non-behavioral objectives in high school chemistry classes and discovered differences which appeared to approach, though not attain, significance. Because all differences were in favor of behavioral objectives, some advantage for their use might be inferred from his results. Such an inference would be consistent with the present study.

Payne apparently used as non-behavioral objectives the course objectives contained in the teachers' guide. These and many other examples of non-behavioral objectives are typically written as broad general statements about broad general topics. As an example, Lawson (1973) formulated each behavioral objective to be relevant to one

concept contained in a single sentence. In contrast, each general objective was written to be relevant to as many as five concepts. Outline objectives, on the other hand, while giving no overt expression of desired learning outcomes, do tend to direct the students attention to specific topics or concepts. Outline objectives may be viewed as being intermediate between the specificity of well-constructed behavioral objectives and the vagueness of typical examples of non-behavioral objectives.

Payne (1972) made several recommendations for the improvement of research into the comparative effectiveness of behavioral and non-behavioral objectives. Chief among these were the suggestions that the students should be familiarized with behavioral objectives in advance, that the time and material involved should be increased (his lasted three weeks), and that the objectives should be developed by the instructor. These suggestions were incorporated into the current study.

After reviewing the literature, Booth (1973) concluded that some of the critical factors which may have significantly influenced previous studies were the lack of operational definitions of objectives, the failure to distinguish clearly between behavioral and non-behavioral objectives, the lack of specificity of some behavioral objectives, and student unfamiliarity with behavioral objectives. The lack of uniformity of the non-behavioral objectives employed by the various researchers would also seem to have contributed to the inconsistency of results. Most research on instructional objectives has emphasized the question, "Are behavioral objectives better than no objectives?" When behavioral objectives have been compared to non-behavioral, little attention seems

to have been directed at the development of effective non-behavioral objectives.

Comparison of the current investigation with those which found behavioral objectives to hold no advantage over non-behavioral reveals factors which may have critically influenced the results of those studies. Lawson (1973) discovered both types of objectives to be superior to no objectives but detected no differential effects between types. His results may have been affected, however, by several elements such as use of intact classes, loss of over 20% of subjects during the study, small treatment and control groups (averaged less than 17 per group), no training of subjects in use of objectives, and use of same test questions three times (sub-unit tests, unit test, and retention test). Four treatment combinations were randomly assigned within each intact class but there appeared to be no check on exchange of information.

Jenkins and Deno (1971) employed a one-unit, one-test design to compare the effectiveness of behavioral and non-behavioral objectives. It was suggested that their results may have failed to show significance because of the subjects' lack of training or experience with objectives. Bassett (1973) demonstrated that training learners to use behavioral objectives had positive effects on test performance.

As recommended by Payne (1972), student attitudes toward instructional objectives were investigated by means of a questionnaire which could be analyzed quantitatively. The finding of positive attitudes toward objectives was consistent with the determinations of almost all of the pertinent studies reviewed (e. g., Patton, 1972; Payne, 1972; and Mottillo, 1973). The few studies utilizing course evaluation

instruments (e. g., Booth, 1973) have encountered more contradictory results than those using direct investigations of student preference. It seems obvious that a student's overall evaluation of a course would depend upon many more variables than would his preferences for objectives.

Analysis of the attitude scale revealed a significant student preference for outline objectives. This finding tends to conflict with Booth (1973) who detected no significant effect on attitude toward instruction (as measured by the Purdue Rating Scale for Instruction). It is doubtful, however, that the results of the two studies can be compared meaningfully in view of the different methods of attitude measurement as well as the differences in the types of non-behavioral objectives employed--conventional generalized sentence style versus outline form.

Comparisons among the present and previous investigations have proven difficult not only because of the great range of experimental designs but also because of the wide variations in the forms of both behavioral and non-behavioral objectives. Inconsistency may continue to be the principal fruit of similar research unless stricter definitions of terms and more rigorous, standardized, and valid procedures are adopted.

Taken altogether the results of the current study presented an intriguing contradiction. Students who used behavioral objectives appeared to achieve significantly higher overall than students who used outline objectives, although not on every test. Students using behavioral objectives were certainly more consistent. However effective behavioral objectives were in the area of achievement, students tended

to view the outline objective as more useful, and the majority of students selected outline objectives as their first choice. These results might be accounted for if it could be construed that outline objectives were more effective in certain areas. By acting as advance organizers, they could better help the student to organize his work. By more closely paralleling the lecture and by grouping related items, they would undoubtedly assist note taking. By being in outline form, they might have been easier to refer to and thus seem easier to use. These and perhaps other unrecognized reasons may have accounted for their popularity while obscuring the difference in effectiveness.

#### CONCLUSIONS

1. The results of this study support the idea that the use of behavioral objectives has a greater positive effect on overall student achievement than does the use of outline objectives. At the same time, such differences in achievement were not shown to be consistent from test to test. Differences in group means were significant on two of six tests and approached significance on a third; however, even when not significant, these differences were always in favor of the experimental group. Perhaps because of the self-instruction unit assigned at the beginning of the course, there was no suggestion that the effectiveness of behavioral objectives increased with experience; significant differences occurred on the first and third tests. The experimental group did, however, maintain far greater consistency of achievement as measured by group means on each of the six tests. The inconsistency of

the comparison group highlights the danger of basing conclusions on one or two tests.

2. Students appear to perceive outline objectives as more useful and helpful than behavioral objectives. As a natural result, a majority of students apparently make the outline form their first choice. These favorable perceptions may be based on a deceptive appearance of simplicity, clarity, and ease of use. Students tend to have fairly strong preferences, however, for whichever type of objective they prefer. Students seem to react very favorably to the availability of objectives and overwhelmingly support the use of one type or the other rather than have none available.

#### RECOMMENDATIONS

It is recommended that studies of similar nature be undertaken to confirm or repudiate these findings as well as to test related hypotheses. Some recommendations for improvement, modification, and new directions are: 1) Results might be improved if tests were lengthened to increase reliability coefficients; 2) A larger number of subjects and instructors should be used to allow broader generalizations to be made; 3) The students should be randomly assigned to groups, if possible; 4) If random assignment is not possible, a larger number of demographic variables should be collected on each subject; 5) Data should be analyzed for interaction among student characteristics, instructor characteristics, student achievement, and type of objective; 6) Case studies should be undertaken to identify the characteristics of students which determine their cognitive and affective responses to the use of different types

of instructional objectives; 7) Studies should be conducted in other areas of science as well as other disciplines; and 8) Attitude scales should be signed so that factor analysis of responses and other data could be accomplished.

Because of the somewhat equivocal nature of the results of this experiment, broader recommendations are more difficult. It would not seem unreasonable, however, to suggest that community college administrators should encourage experimentation (both formal and informal) with the development and use of both behavioral and non-behavioral objectives. Participation should be voluntary to prevent prejudicing individual faculty and because the best results may be obtained from those who are interested and wish to take part. An atmosphere should be created which is conducive to innovation without being coercive.

Practical assistance to participants might take the form of release-time, clerical help, or additional pay--perhaps summer employment. In-service workshops could be provided utilizing recognized experts as well as involving experienced local faculty.

Interested faculty members should expand present studies not only to other disciplines but to the development of more effective objectives of both types. For example, the non-behavioral objectives used in this study could probably be made more efficient by adding indicators of importance or emphasis such as "know" or "know these relationships." Previous attempts to develop effective non-behavioral objectives appear to be completely lacking.

Studies of the usefulness of different types of objectives also need to be further extended to different student groups (e. g., high

risk versus fully prepared) and to different community college programs (e. g., developmental, one and two year, and college transfer). If greater effectiveness of different forms of objectives can be shown to be related to these variables, counseling departments can then help to channel students into appropriate treatments.

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## APPENDICES

Appendix	Content
A . . . . .	Master Data Sheet
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C . . . . .	Behavioral and Outline Objectives
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F . . . . .	Proclamation

## APPENDIX A

## MASTER DATA SHEET FOR EXPERIMENTAL GROUP

Demographic Data								Test Scores					
Stu ID	Age	Geol Pretest	Voc <sup>1</sup>	Comp <sup>1</sup>	WPM <sup>1</sup>	M.A. <sup>2</sup>	HS Rank	I	II	III	IV	V	Exam
401	19	09	37	32	275	61	35	85	92	76	71	76	82
403	23	06	48	40	238	42	30	78	80	84	88	87	85
405	25	05	17	28	250	44	44	69	55	64	67	70	59
406	18	07	37	46	349	43	57	72	84	96	71	76	79
407	31	17	53	52	216	43	62	53	76	92	88	89	82
408	21	09	51	54	327	55	49	70	92	68	79	92	76
409	19	14	20	42	287	52	34	92	87	88	92	84	71
410	23	12	64	66	384	70	78	85	80	88	79	98	96
411	19	14	26	28	250	41	30	91	68	80	83	84	85
412	20	16	36	34	318	56	73	88	88	92	92	80	83
413	19	07	39	34	226	54	52	58	45	52	46	54	37
415	20	09	23	36	226	45	11	58	92	52	83	80	78
417	19	13	32	42	226	47	50	84	76	68	75	74	77
418	22	10	40	38	161	37	81	66	80	72	63	84	80
419	19	12	70	62	436	64	42	97	72	96	75	68	95
420	18	04	24	40	396	60	27	73	80	56	50	34	69
421	22	10	39	52	314	52	75	86	85	84	67	34	56
422	18	14	50	50	174	64	54	87	80	68	67	54	77
423	18	11	45	50	524	58	38	83	74	92	67	76	87
424	22	11	41	44	216	64	99	64	58	60	63	64	56
201	19	17	26	29	205	35	69	29	64	52	68	65	36
202	20	11	21	25	186	49	57	84	59	80	68	68	63
203	19	11	37	54	359	59	30	89	80	76	76	67	80
205	24	08	35	48	275	42	60	97	76	92	72	58	79
206	21	15	38	52	309	53	60	74	59	68	80	70	65
208	17	15	54	60	384	66	04	97	95	84	92	96	94
209	30	12	88	58	618	55	58	73	87	92	84	84	81
211	20	14	57	42	309	59	20	83	56	68	80	64	68
212	30	11	42	54	338	56	45	78	96	88	68	71	78
213	25	11	33	30	185	53	16	73	81	84	76	86	76
214	29	15	40	48	298	53	95	75	76	80	76	60	64
215	20	10	34	42	250	48	15	78	80	80	84	92	82

## MASTER DATA SHEET FOR COMPARISON GROUP

Demographic Data								Test Scores					
Stu ID	Age	Geo <sup>1</sup> Pretest	Voc <sup>1</sup>	Comp <sup>1</sup>	WPM <sup>1</sup>	M.A. <sup>2</sup>	HS Rank	I	II	III	IV	V	Exam
301	19	11	23	22	216	49	24	58	56	60	83	75	72
302	19	10	23	24	250	34	42	75	84	68	83	66	74
303	18	06	36	44	309	39	55	67	72	40	63	74	61
304	37	08	72	58	491	57	74	34	88	76	88	94	91
305	18	14	33	48	298	56	52	81	79	83	87	76	79
306	18	10	39	50	456	69	54	49	63	38	71	56	53
308	19	10	42	50	298	48	16	75	92	80	75	86	70
309	18	13	34	62	371	64	20	81	96	64	63	77	80
310	19	12	23	26	259	47	53	82	92	64	79	80	72
311	20	19	28	30	417	49	79	76	90	64	88	68	83
312	18	11	30	48	238	47	41	64	83	72	58	69	54
315	18	07	26	36	298	43	35	85	98	72	83	75	78
316	18	12	37	44	226	48	48	75	76	64	88	94	81
317	21	09	30	14	245	34	62	69	60	40	67	64	67
318	17	11	30	44	318	66	44	61	56	68	80	46	45
319	18	09	49	50	461	70	54	79	84	68	88	84	85
320	18	08	35	40	150	40	13	91	86	76	83	82	87
321	18	04	42	50	326	64	29	59	43	48	58	36	42
322	20	14	52	58	436	52	58	50	68	56	79	63	61
323	24	13	61	62	318	61	24	82	80	92	96	98	90
101	30	09	68	56	287	54	17	61	75	52	88	90	74
102	31	12	60	48	287	53	30	36	44	53	75	44	49
103	24	11	45	40	463	53	10	73	80	48	63	74	56
104	42	14	51	24	250	49	29	75	68	88	79	68	68
105	24	14	54	62	284	74	09	72	96	84	88	99	90
106	20	12	20	34	174	55	68	52	60	60	21	52	58
107	21	07	27	32	976	43	39	66	64	44	42	40	35
109	18	09	20	42	185	44	64	67	92	68	67	90	78
110	30	08	40	36	250	44	64	64	68	60	67	70	62
111	19	19	43	62	452	63	88	70	96	92	80	86	77

<sup>1</sup>Nelson-Denny Reading Test Vocabulary, Comprehension, and words per minute

<sup>2</sup>Otis mental ability raw score

## APPENDIX B

## Geology Pre-Test

Choose the number that represents the best answer to each question and mark the corresponding space on the IBM answer sheet.

1. Loose material derived from rocks and overlying bedrock in most places:  
1) regolith 2) humus 3) strata 4) sediment 5) lithosphere
2. The "Principle of Uniformity:"  
1) steep slopes change uniformly to nearly horizontal 2) rocks gradually alter to soil or sediment 3) given time, mountains are reduced to plains 4) the present is the key to the past 5) radioactive elements decay at a uniform rate
3. The gravitational attraction between two bodies is:  
1) inversely proportional to the masses 2) directly proportional to the distance between 3) inversely proportional to the square of the distance 4) directly proportional to the square of the masses 5) inversely proportional to the square of the masses
4. The edges of continents covered by the sea:  
1) lithosphere 2) continental shelves 3) crust 4) continental slope 5) continental platform
5. The coriolis effect is responsible for:  
1) materials in motion being deflected to the right in the northern hemisphere 2) deviation of a compass needle from true north 3) increasing temperatures with greater depth in the earth 4) tides 5) typhoons
6. Two or more elements combined chemically and electrically balanced:  
1) atoms 2) ions 3) compounds 4) radicals 5) neutrons
7. The most abundant element in the rocks of the earth's crust:  
1) oxygen 2) iron 3) silicon 4) sodium 5) potassium
8. The internal structure of all silicates is based upon:  
1) rhombohedra 2) quartz 3) chains 4) tetrahedra 5) sheets
9. The tendency of a mineral to break along smooth plane surfaces:  
1) cleavage 2) fracture 3) tenacity 4) conchoidal fracture 5) forms crystal faces
10. A fracture along with no movement has taken place:  
1) strike-slip fault 2) thrust fault 3) normal fault 4) dip-slip fault 5) joint

11. The major controlling factor in metamorphism:  
1) heat 2) pressure 3) chemically active fluids 4) metasomatism 5) crushing and pulverization
12. Clastic sedimentary rocks such as sandstone, shale, and conglomerate are classified on the basis of:  
1) composition 2) composition and texture 3) lithification 4) stratification 5) particle size
13. The largest of the igneous intrusives:  
1) laccolith 2) lopolith 3) batholith 4) xenolith 5) coprolith
14. The continuous reaction series of Bowen is represented by:  
1) plagioclase feldspars 2) ferromagnesian 3) muscovite-quartz 4) olivine-augite 5) hornblende-biotite
15. A cooling reaction in which one mineral dissolves as another mineral starts to form is represented by:  
1) discontinuous series 2) continuous series 3) congruent melting 4) incongruent melting 5) tectonic cycle
16.  $C^{14}$  is created:  
1) from atmospheric nitrogen 2) in living plants 3) in living animals 4) in living plants and animals 5) during volcanic eruptions
17. For age dating, the maximum period of usefulness of  $C^{14}$  is about how many years?  
1) 10,000 2) 20,000 3) 40,000 4) 500,000 5) 500 million
18. Which of the following would be classified as an era?  
1) Devonian 2) Paleozoic 3) Cretaceous 4) Tertiary 5) Triassic
19. The mantle of weathered rock that generally covers the earth is called the:  
1) batholith 2) regolith 3) xenolith 4) lithosphere 5) hydrosphere
20. Pedalfers are typical of:  
1) Temperate forested areas 2) humid tropical 3) high cold deserts 4) hot climates 5) arid regions
21. One of the most important coloring agents in soils is:  
1) Mg 2) Ca 3) Fe 4) K 5) Si
22. Mechanical weathering is the dominant weathering process in:  
1) jungles 2) humid regions 3) northern forests 4) arid regions 5) hot climates

23. A body of sediment that has been deposited by any process of mass-wasting:  
1) debris flow 2) talus 3) sliderock 4) colluvium  
5) rock avalanche
24. Piles of rock fragments formed by repeated small rock falls and found lying at the foot of a steep slope are called:  
1) talus 2) rockslides 3) slumps 4) rock glaciers  
5) colluvium
25. A delta would most likely be found:  
1) along the banks of a stream 2) at the head of a stream  
3) on the outside of a meander bend 4) at the mouth of a stream  
5) where two streams join
26. The material transported by a stream by rolling, sliding, and skipping makes up the:  
1) stream capacity 2) suspension load 3) discharge 4) bed load  
5) point bar
27. A broad flat valley floor that is inundated during floods:  
1) natural levees 2) stream terraces 3) flood plain  
4) point bar 5) oxbow
28. A youthful valley feature would be a:  
1) meander 2) ox bow 3) back swamp 4) pothole 5) peneplain
29. A stream pattern characterized by right angle bends in the streams:  
1) dendritic 2) rectangular 3) trellis 4) radial  
5) consequent
30. Groundwater usually moves by what kind of flow?  
1) static 2) saturation 3) laminar 4) turbulent 5) confined
31. Which of the following best exemplifies the conditions existing within the capillary fringe?  
1) bottle of beer (capped) 2) bottle of beer (uncapped)  
3) pumice floating on water 4) wick in kerosene lamp  
5) bucket of dry sand
32. Water being added to the hydrologic cycle for the first time is called:  
1) connate 2) firm 3) meteoric 4) juvenile 5) artesian
33. Karst topography gets its name from a region in:  
1) France 2) Kentucky 3) Mexico 4) Pennsylvania  
5) Yugoslavia

34. A chain of small glacial lakes connected by a stream in a mountain valley would be called:  
1) roche moutonnee 2) bergschrund lakes 3) kettle lakes  
4) Pater Noster lakes 5) recessional lakes
35. The angular blocky ends of roches moutonnees or rock knobs are caused by:  
1) abrasion 2) ablation 3) cavitation 4) plucking  
5) any or all of above
36. An erosional feature of glaciers is the:  
1) roche moutonnee 2) kame 3) valley train 4) esker  
5) two of these are erosional features
37. A conspicuous characteristic of dune deposits:  
1) poor sorting 2) graded bedding 3) frosted grains  
4) mud cracks 5) cactus
38. Probably the most effective agent of erosion in deserts is:  
1) wind 2) sudden temperature changes 3) evaporation  
4) water 5) frost action
39. Tropical deserts form:  
1) because of the pattern of atmospheric circulation 2) because they are located in the hot tropics 3) more than 30° north or south of the equator 4) where warm rising air removes moisture 5) in the rainshadow of mountain ranges
40. The most useful aid to long distance correlation of rocks:  
1) sandstones 2) volcanic ash 3) fossils 4) radioactive elements 5) radioactive isotopes

APPENDIX C

Behavioral Objectives for  
Experimental Group

BEHAVIORAL OBJECTIVES  
Chapter 1  
Science of the Earth

List or select from a list:

- The three components of the geologic record.
- The three major classes of rocks.
- The five principal steps in the scientific method.

Given a description or definition of any of the following, furnish the proper term or select the term from a list of five:

- |            |               |                           |
|------------|---------------|---------------------------|
| Geology    | Catastrophism | Metamorphism              |
| Morphology | Static        | Strata                    |
| Regolith   | Dynamic       | Weathering                |
| Bedrock    | Igneous       | Erosion                   |
| Outcrop    | Metamorphic   | "One Cycle of Causation"  |
| Sediment   | Sedimentary   | "Great Geologic Cycle"    |
|            |               | "Principle of Uniformity" |

Given a list of some or all of the five principal steps in the scientific method, arrange them in the proper order.

.....

Chapter 2  
Gen. View of the Earth

List or choose from a list:

- The two principal sources of energy for the geologic cycle.
- Origin of solar energy.
- Approximate dimensions and shape of earth.

Given a description of any of the following, supply the correct term or select it from a list:

- |                   |              |                     |
|-------------------|--------------|---------------------|
| Centrifugal force | Lithosphere  | Continental shelves |
| Centripetal force | Crust        | Geothermal gradient |
| Atmosphere        | Ocean basins | Continental masses  |
| Hydrosphere       | Biosphere    | Continents          |

Given the temperature of the surface and the depth to a point within the earth, calculate the approximate temperature at that depth.

Given the gravitational constant, the mass of two bodies, and the distance separating them, calculate the force of attraction between them in dynes.

Given the amount of change in the distance separating two bodies (e.g., from 10 to 20 miles) or in the mass of either body, determine the proportion of change in the gravitational attraction between the two masses (e.g., doubled, tripled, halved).

List, or select from a list:

- The three fundamental particles of atoms and their major characteristics, i.e., relative size, charge, & location within the atom.
- The most abundant group of rock-forming minerals.
- The most abundant group of silicate minerals.
- The general chemical composition (in words or formulae) and the internal structure of the nine common silicate minerals.
- The four common ferromagnesian silicates.
- The five common non-ferromagnesian silicates.
- The basic structural unit of the silicates.
- The distinguishing characteristics of solids, liquids, and gases.
- The three states of matter.
- The number of known naturally occurring and man-made elements.
- The main factor which controls ionic substitution.

Given a description of any of the following, furnish the correct term or select it from a list:

atom	molecule	amorphous	electron
atomic No.	isotope	surface tension	proton
mass No.	ion (+ & -)	capillary action	neutron
nucleus	ionization	mineral	compound
radical	crystal	crystal face	
element	crystalline		

Given a chemical formula, identify it as:

oxide, sulfide, sulfate, carbonate, silicate

List, in order of abundance, the five most abundant elements (by weight) in the earth's crust and identify as metallic or nonmetallic:

Given any two of the following, determine the remaining:

- 1) Number of electrons, or number of protons, or atomic number;
- 2) Number of neutrons;
- 3) Mass number.

Given any of the following chemical symbols, match the symbol with the respective element, or furnish the name of the element:

H, C, O, S, Cl, Pb, Cu, Na, Mg, Al, Si, K, Ca, Fe

BEHAVIORAL OBJECTIVES  
 Chapter 4 + Appendix C  
Rocks and Regolith

List or select from a list of terms:

The basis of the classification of rocks into the three major classes.

The basis of classification of igneous rocks, of sedimentary rocks, and of metamorphic rocks.

Given a description of any of the following, furnish the correct term or select it from a list of five:

fabric	phenocryst	essential minerals
texture	matrix	accessory minerals
phanerite	porphyry	magma
aphanite	volcanic	detrital sediments
glass(y)	plutonic	chemical sediments

Given the texture and/or the composition (essential minerals) of a rock, identify it as one of the following rocks:

Granite, rhyolite, gabbro, basalt

Conglomerate, sandstone, shale, limestone, evaporites

Slate, schist, gneiss, marble, quartzite

List, or select from a list of terms, the parent rocks of marble and quartzite.

List the two principal factors which affect crystal size in igneous rocks.

Given the composition of a magma (i.e., silica-rich, silica-poor), determine the dominant minerals which would ordinarily form.

List the three most abundant constituents of sedimentary rocks.

BEHAVIORAL OBJECTIVES  
Chapter 5  
Major Geologic Cycles

List the four main cycles which make up the geologic cycle.

Describe briefly (1-5 words) what happens to the majority of water that falls on land--and what happens to the rest of the water that falls on the land.

Furnish an example of an evaporite, or select one from a list of five rocks and/or minerals.

Given a blank drawing of the rock cycle, label any or all processes and products.

List, or select from a list, the three groups of igneous rocks based on content of silica, and an example of a typical rock from each group.

List, or choose from a list, the average silica content of typical basalt (mafic) and granite (silicic).

Express silica as a chemical formula.

Given a blank drawing of Bowen's Reaction Series, label the eight principal minerals involved, the discontinuous series, the continuous series, the ferromagnesian silicates, high temperature, and low temperature.

Given a list of elements, select the three that are diagnostic positive ions of the feldspars and relate them to their respective feldspars.

List, or select from a list, the most abundant salt in the sea.

List the two most abundant gases in the atmosphere.

Select from a list of minerals the two that are likely to be abundant in rocks formed from magmas either rich in silica or poor in silica.

Given a description of any of the following terms, furnish the correct term or select it from a list:

evaporite                      geochemistry                      silica  
fractional melting

BEHAVIORAL OBJECTIVES  
Chapter 6  
Geologic Column and Time

Given a description or statement of each of the following principles, provide the correct name or choose it from a list:

Principle of Superposition  
Law of Faunal Assemblages

List, or select from a list:

The probable age of the earth  
The most important means of long distance correlation of sedimentary rocks

List in chronological order (oldest on bottom, youngest on top), or arrange in order from a list:

1. All post Precambrian eras
2. All periods (systems) of each era

Given a description of any of the following, supply the correct term or select it from a list:

Fauna  
Flora  
Assemblage

List, or choose from a list:

- The two main types of weathering
- The most effective agent of mechanical weathering
- Up to four agents of mechanical weathering

From a description of its similarity to the parent rock, identify a soil as having been derived from limestone or granite.

Match names of common elements or minerals with descriptions of what happens to them during chemical weathering (e.g., leaves in solution, recombines with oxygen, alters to clay and soluble salts).

Given an incomplete chemical reaction related to the weathering of limestone or a common silicate mineral, fill in the missing item(s). Words or chemical formulas are acceptable.

Given a description of any of the following, provide the correct term or select it from a list:

sinks, differential weathering, caliche, bauxite

Given a list of statements concerning the effect that particle size has on surface area and speed of chemical reactions, choose the one which is, or is not, correct.

Identify sandstones, shales, and limestones as resistant or non-resistant in humid or arid climates.

Specify the relative stability (resistance to weathering) of the common rock-forming silicates listed in Bowen's Reaction Series.

List, or select from a list, the most stable of the common rock-forming silicate minerals (igneous), and the most stable and abundant silicate developed during weathering.

Match the three types of soils, bauxite, caliche, and iron ore with the climate in which they form, or with the processes by which they are formed.

From a list, select the composition of bauxite and caliche.

List the most important factor in determining soil type.

Given a list of factors, distinguish between those that hasten chemical weathering and those that retard chemical weathering.

Distinguish the relative effectiveness of the following types of ground cover in preventing erosion: forest, alfalfa, grass, row crops, plowed field

Distinguish between laminar and turbulent flow or match each to its description.

Given a description of any of the following terms, supply the correct term or select it from a list:

stream capacity	discharge	meander
stream load	delta	point bar
bed load	alluvial fan	oxbow lake
suspended load	pothole	floodplain
saltation	runoff	natural levee
settling velocity	alluvium	gradient
ultimate base level	base level	braided stream

List, or choose from a list:

1. The three means by which particles of the bed load are transported.
2. The three factors which determine discharge.

From a sketch or description of different parts of a stream, identify the area with the highest velocity.

Furnish, or select from a list, the factors which influence the settling velocity of a particle.

Given sketches or descriptions, choose the one which best exemplifies the typical shape of a long profile.

Indicate whether each of the following typically increases or decreases in upstream or downstream directions:

gradient, width, depth, velocity, discharge

List, or select from a list, up to two examples of temporary (local) base levels.

Locate erosional and depositional features of a stream (e.g., levee, delta, pothole, etc.) with respect to a stream (e.g., at the mouth, along the banks, near the headwaters, in the channel, etc.).

BEHAVIORAL OBJECTIVES  
Chapter 10  
Sculpture of the Land

Given a description of any of the following, list the correct term or select it from a list:

drainage basin	trellis pattern
divide	cycle of erosion
penplain	rejuvenation
monadnock	well-adjusted system
water gap	stream terrace
headward erosion	dissected
dendritic pattern	
rectangular pattern	

Match type of stream or stream pattern with a description of the bedrock on which it would most likely develop.

Given a sketch or map identify the stream types or stream patterns shown.

Relate (match) landforms, such as meanders, penplains, potholes, etc., to the stages in the cycle of erosion that they represent.

Relate features associated with streams (such as entrenched meanders, stream terraces, thickened alluvial fill) to rise or fall of base level, or uplift or depression of earth's crust.

Given a description of any of the following stream types, identify each by supplying the appropriate name or selecting it from a list:

consequent stream  
subsequent stream  
antecedent stream  
superposed stream

Given a description of any of the following terms, furnish the correct term or select it from a list:

porosity	zone of aeration	Karst topography
permeability	zone of saturation	perched water table (body)
water table	artesian well	cone of depression
aquifer	drawdown	connate water
sink	dripstone	juvenile water
geyser		meteoric water

Given a list of descriptions, select the one which best illustrates the relationship (shape) of the water table with respect to the ground surface.

Given a list of water features, identify those that represent an extension of the water table above the surface.

List the two most important factors controlling permeability.

Given a list, or descriptions, of common sediments or sedimentary rocks, indicate which would probably have high or low porosity and permeability.

List, or choose from a list, the rock type most easily dissolved by ground water.

List, or select from a list, up to three typical features of Karst topography.

BEHAVIORAL OBJECTIVES  
Chapter 12  
Glaciers and Glaciation

List the three main kinds of glaciers or identify each from a description or example.

List, or choose from a list, the general geographic location of each kind of glacier (such as, mountains, polar regions, Greenland, etc.).

Distinguish between erosional and depositional features of glaciers.

Distinguish those features made up of stratified drift from those made up of till.

Identify, from a description, photo, or drawing, the major erosional and depositional features associated with glaciers (e.g., drumlin, terminal moraine, etc.).

Given the relative amounts of wastage and accumulation, determine whether a glacier would advance, retreat, remain in the same place, build a terminal moraine, or spread a ground moraine.

Given a description of any of the following features (or its location with respect to the glacier), supply the correct term or select it from a list:

firn	bergschrund
wastage	zone of fracture
tarn	zone of flow
kettle	zone of accumulation
crevasse	zone of wastage
drift	stratified drift
till	permafrost

From a list of five statements, select the one(s) which best describe the causes of the two major types of deserts.

List, or choose from a list, the approximate percent of world land surface occupied by deserts, and the general geographic location of each type.

List, or select from a list, the most effective agent of erosion and the most prominent type of weathering in deserts.

Given five statements of the relationship between deflation and desert pavement, select the one which is most correct.

Given five statements of the relationship between particle size and settling (terminal) velocity in air, select the most accurate.

Given a statement concerning the slowness of chemical weathering in deserts, supply the missing word(s).

Given descriptions of the following, furnish or select from a list, the correct terms; or, given an incomplete description of any of the terms, supply the missing word(s):

badlands	loess	interior drainage
playa	blowout	basin of interior drainage
playa lake	ventifact	deflation
pediment	inselberg	desert pavement
dune	bahada	perennial stream
desert	steppe	intermittent stream

Given the direction of movement of an object, determine the direction of deflection, in either hemisphere, caused by the coriolis effect.

Given a list of lithologic characteristics, select those which are, or are not, typical of dune deposits.

BEHAVIORAL OBJECTIVES  
Chapter 14  
Coasts and Continental Shelves

Given a description of any of the following terms, furnish the correct term or select it from a list:

tidal marsh	swash	longshore drift
tide	backwash	eustatic change in sea level
barrier island	beach	tectonic change in sea level
wave base	groin	wave of oscillation
wave refraction	breaker	wave of translation
progradation	cause of tides	deep water waves

Given a drawing, photo, or description of any of the following, identify the feature by furnishing the name or selecting it from a list:

wave-cut cliff	sea arch	continental shelf
wave-cut bench	stack	wave length
wave-built terrace	bay barrier	
tombolo	spit	

Given the wave length, determine the approximate water depth at which particle motion in a wave is negligible, i.e., when the wave begins to "feel bottom" or increase in height. Or, vice versa.

Given the height of a wave, determine the approximate depth at which the wave would break. Or, vice versa.

List, or recognize from a list, the two dominant geologic agents along most coasts.

Relate topographic features, such as wave-cut cliffs, drowned river valleys, etc., to emergence or submergence of a coast. In other words, distinguish between emergent features and submergent features.

List, or identify from a drawing, photo, or description, the three types of reefs.

Given a cross sectional drawing of a reef and lagoon, indicate the area where the most active reef growth will usually take place.

List, or select from a list, up to three primary conditions necessary for prolific reef growth.

Choose from a list, the main characteristics of constructive or destructive waves.

Distinguish between erosional and depositional features of coasts.

BEHAVIORAL OBJECTIVES  
 Chapter 15  
The Deep-Sea Floor

Given a drawing or description, identify the principal morphologic features of ocean basin margins and floors, including continental shelves, seamounts, and guyots.

Given a description of any of the following, identify each term by supplying the name or selecting it from a list:

echo sounding	evaporite basin
continuous seismic profile	stagnant basin
graded bedding	aerated basin

List, or select from a list, the three different classes of density currents.

Select from a list, the feature characteristics of turbidity current deposits.

List, or choose from a list:

- The four major groups of deep-sea sediments.
- The principal source of each group of deep-sea sediments.
- The two principal types of pelagic sediments.
- The two main constituents, or types, of oozes.
- The probable mode of origin and typical location of submarine canyons.

Match each of the three types of depositional basins (evaporite, stagnant, aerated) with the typical characteristics and constituents of sediments which form in each.

Given a description of any of the following, identify by supplying the correct term or by selecting it from a list:

density current	sand flow
contour current	foraminifera
turbidity current	radiolarian
salinity current	

Given a common marine organism, or its living habits, identify it as: Plankton(ic); Nekton(ic); Bethos (benthonic).

BEHAVIORAL OBJECTIVES  
Chapter 16  
Sedimentary Strata

List, or select from a list: the two major groups of sedimentary rocks; the common rocks of each group; the three most abundant sedimentary rock types; the three most abundant minerals in sedimentary rocks.

Given a diagram of Pettijohn's classification of sandstones, identify the rocks represented by the different areas.

Match the major types of sandstones with related types of source areas, conditions of crustal stability, and composition.

Correctly identify the Principle of Original Horizontality and the Law of Superposition from a statement or description of either.

Given a description or drawing of any of the following, identify by furnishing the correct name or by choosing it from a list:

stratification	mudcracks	imbrication	cross-strata
centimeter	ripple marks	conformable	geode

Given a description of any of the following, list the correct term or select it from a list:

beds	rounding	nodule	concretion	sedimentary rock
laminae	sorting	fossil	formation	detrital sediments
varve	detrital	facies	clastic	chemical sediments

List, or choose from a list, the major cause of stratification and up to two examples of other causes.

State, or select from a list of statements, the significance of wave ripple marks and mudcracks in the interpretation of depositional environments.

Distinguish between examples of well- and poorly-sorted sediment.

List, or choose from a list, the two most common sources of sediment color, or, match color and source.

Match the names of common sedimentary rocks with their standard symbols.

Match types of sediments with high or low energy conditions at depositional site.

From a photo or sketch of ripple marks or truncated current cross-bedding, determine whether beds are rightside up or upside down.

Given a sketch or description, distinguish between wave generated (i.e., symmetrical ripple marks or ripple marks of oscillation) and current generated (asymmetrical) ripple marks.

BEHAVIORAL OBJECTIVES  
Chapter 16  
Sedimentary Strata

Determine direction of current at time of deposition from a sketch of current ripple marks.

Furnish, or select from a list of examples:

- Up to three examples of evidence showing displacement.
- Maximum known fault displacement occurring at one time.
- Effect of temperature and confining pressure on strength.

Given a description, or diagram (cross section or map), identify the following structural features:

- The three types of folds.
- The three types of unconformities.
- Normal (gravity), reverse (thrust), and right and left lateral faults.
- Joints.

Given the attitudes of the limbs and axial plane of a fold, identify the structure as completely as possible as to type of fold and symmetry (e.g., an overturned anticline).

Given a description or drawing, identify the following by listing the correct name or selecting it from a list:

- Plunge, axis, axial plane, limb.
- Symmetrical, asymmetrical, overturned, recumbent, or isoclinal fold.
- Dip and strike, dip-strike symbol.
- Horst, graben, rift valley.
- Hanging wall, footwall, upthrown block, downthrown block.

Given a map view showing dip and strike symbols, determine the type of fold.

Given a description of the following, furnish the name of each or select the correct term from a list of terms:

- |              |                            |
|--------------|----------------------------|
| deformation  | compressive strength       |
| strength     | tensile strength           |
| dip          | strength of fluids         |
| strike       | elastic limit              |
| attitude     | slickensides               |
| unconformity | law of original continuity |

Match type of fault with the type of force that causes it--tension or compression.

BEHAVIORAL OBJECTIVES  
Chapter 18  
Earthquakes: Earth's Interior

State, or select from a list of examples, the cause of most earthquakes.

Given a list of numbers, choose the one that represents the estimated annual occurrence of earthquakes.

List, or select from a list of terms, the three major structural zones of the earth.

Given a list of synonymous names or characteristics of the three principal types of seismic waves, match with the appropriate wave or indicate if insufficient information to identify.

Given a list of statements concerning a seismic wave, choose the one which is (or is not) correct.

Given an incomplete statement concerning a seismograph station, complete the statement by furnishing the necessary term(s) or by selecting them from a list of words.

Given a description of the following, state the term described or select it from a list. Or, given a list of statements about any of the following, indicate the statement which is (or is not) appropriate:

focus	surface waves	sial
epicenter	body waves	sima
earthquake intensity	seismograph	shadow zone
earthquake magnitude	tidal wave	wave front
isoseismic lines	tsunami	wave path
Richter scale		wave refraction

Furnish, or choose from a list of statements, the two main grounds for concluding that the earth's core is liquid Ni-Fe.

Select from a list of statements the greatest danger associated with earthquakes in heavily populated areas.

Given a list of statements concerning Project Mohole, its purpose and rationale, pick the one which is correct.

Given a description or drawing of the following, furnish the correct term or select it from a list. Or, given an incomplete statement concerning the following supply the correct term(s):

crust	core
mantle	M-discontinuity (Moho)

Given a description of the following, furnish the correct term, or select it from a list of terms. Or, given a list of statements about any term, select the most appropriate or least appropriate as indicated:

crater	volcanic	shield volcano
caldera	plutonic	composite volcano
rhyolite	pahoehoe	tephra (cinder) cone
basalt	pillow lava	plateau (flood) basalt
fumarole	extrusive	nuee ardente
lava	intrusive	tephra (pyroclastic)
aa	pumice	welded tuff

List, or identify from a list, the three types of material erupted by volcanoes.

Match the principal characteristics of quiet (Hawaiian or shield) and explosive (e.g., Peleean) volcanoes with their respective volcanic type.

List, or identify from a list of terms or a description, the main types of tephra (pyroclastics).

List, or select from a list of terms, the most abundant gas produced by volcanoes and the source of explosive energy of volcanoes.

Distinguish between tephra (pyroclastic) and non-pyroclastic materials.

List up to three ways in which volcanoes are useful to man.

Distinguish between welded tuff and rhyolite.

Given a list of three terms or statements concerning volcanic materials, processes, or products, choose the item that does not belong.

Given an incomplete statement concerning the eruption of tuff or pillow lava, furnish the appropriate term(s) necessary to complete the statement.

Distinguish between the relative abundances of basalt and granite in the oceanic and continental crusts.

List, or select from a list of statements, the two major reasons for variations in viscosity of magmas.

List, or select from a list of statements, the probable source of most of the water produced by volcanoes.

List, or select from a list of examples: an example of a caldera, of an explosive type volcano, and of a quiet volcano.

BEHAVIORAL OBJECTIVES  
Chapter 20  
Plutonism & Metamorphism

Given a drawing or description of the following, furnish the correct name or select it from a list of words:

sill	laccolith	composite pluton	stock
dike	batholith	volcanic neck	columnar jointing

Given a drawing or description of the contact relationships between layers of igneous and sedimentary rocks, distinguish dikes, sills, and lava flows, and determine relative ages.

Given a list of statements describing a pluton, select the one which is (or is not) correct, as directed.

List, or select from a list of statements: a mechanism of magmatic differentiation, an example of field evidence in support of Bowen's Theory, and a major flaw in Bowen's Theory.

From a list of statements, select the one which best describes Bowen's Theory.

Furnish, or select from a list, the most abundant intrusive igneous rock and the most abundant extrusive igneous rock.

Given a description or statement concerning the following, furnish the correct term or choose it from a list:

pegmatite	recrystallization	recombination	granitization
migmatite	reorganization	replacement	magmatic differentiation
pluton			tiation

Given a list of statements concerning the distribution of basalt and granite within the earth's crust, choose the one which is (or is not) correct.

Given a list of statements about the origin of granite or the origin of basaltic magma, select the one which is (or is not) correct.

List or select from a list:

- Up to three types of metamorphism
- Up to three agents of metamorphism

Given a list of statements concerning the origin of slaty cleavage or its relation to axial planes, shear, or compression, select the one which is correct.

BEHAVIORAL OBJECTIVES  
Chapter 20  
Plutonism & Metamorphism

Furnish, or choose from a list of terms, the parent rocks of:  
slate, phyllite, quartzite, marble, hornblende schist

Match the typical features of mountain chains, and the rocks that occur within them, with the appropriate zone (i.e., marginal, interior, central, or continental interior).

Match the physiographic provinces of Virginia, and other major Appalachian physiographic features (such as Green Mts., Adirondacks), with the appropriate zone.

List, or select from a list of statements, the three geologic characteristics of linear mountain belts.

Given a description of the following, furnish the name of each or select it from a list of terms:

orogeny	basement	appalachian structure
epeirogeny	isostasy	alpine structure
diastrophism	plateau	

Given an incomplete statement concerning the earth's gravity acting upon a body, complete the statement by adding the correct term(s) or by choosing from a list of statements.

Given an incomplete statement about the theories of Pratt or Airy, furnish the word(s) necessary to complete the statement correctly.

Given an incomplete statement concerning the behavior of a plumb line: (1) normally; (2) near large masses of rock; and (3) during the survey of India, complete the statement by adding the necessary terms or by selecting them from a list of words.

List, or choose from a list of terms, the two items of information from which may be calculated the theoretical value of gravity at any point on the earth's surface.

Furnish, or select from a list of names, the following examples from the Appalachians:

1. An example of high-standing basement within the Marginal Zone.
2. An example of an elongate patch of basement within the Interior Zone.
3. An example of large fault blocks or block faulting.

Given a list of statements concerning the relationship of gravity to mass and distance, choose the one which is (or is not) correct.

List, or select from a list of statements, the factors which determine the weight of an object (gravitational force) at the surface of the earth.

OUTLINE OBJECTIVES FOR  
COMPARISON GROUP

OUTLINE OBJECTIVES  
Chapter 1  
Science of the Earth

Know these terms and concepts:

Geology	"One Cycle of Causation"
	"Great Geologic Cycle"
Geologic Record	"Principle of Uniformity"
Earth's morphology	
Regolith	Catastrophism
Bedrock	Scientific method
Outcrop	Form. of hyp.--data
	collection--prediction--
Rocks	test prediction--modify
Igneous	hyp.
Sedimentary--Sediments	
Metamorphic--Metamorphism	Static vs. Dynamic
Strata (beds)	
Weathering	
Erosion	

.....

Chapter 2  
Gen. View of the Earth

Energy for geologic cycle  
  Solar energy  
  Origin  
  Gravity  
    Universal law of gravitation

$$F = \frac{GM_1M_2}{d^2} \quad Foc \frac{M_1M_2}{d^2}$$

Earth's size and shape  
  Centrifugal force  
  Centripetal force

Atmosphere	
Hydrosphere	
Lithosphere	Ocean basins
Crust	
Continental masses	Biosphere
Continents	Geothermal gradient
Continental shelves	1°C/30m or approx. 100'

OUTLINE OBJECTIVES  
 Chapter 3  
Matter and Minerals

The three states of matter

- Solid-(rigid, incompressible)
  - Crystalline--regular geometric framework of atoms
  - Crystals--crystal faces
  - Amorphous--irregular framework of atoms
- Liquid-(non rigid, incompressible)
  - Random pattern of moving atoms
- Gas-(non rigid, compressible)
  - Expands to fill container

Elements

- 92-103
- H, C, O, S, Cl, Pb, Cu, Na, Mg, Al, Si, K, Ca, Fe
- Atoms

- Three fundamental particles
  - Electrons, protons, neutrons
- Atomic No., mass No., nucleus
- Ion--ionization--positive & negative
- Isotope

Compounds

- Molecules
- Radicals
- Oxides, sulfides, sulfates, carbonates, silicates
- Chemical formulas

Five most abundant elements in earth's crust (in order)

Minerals

- Silicates (most abundant)
  - Basic structural unit
  - Silica tetrahedron
- Ferromagnesians
  - Olivine, augite, hornblende, biotite
  - Internal structure, general chemical composition
- Feldspars (most abundant silicate)
  - Internal structure, general chemical composition
  - Plagioclase (Ca-Na)
  - Orthoclase (K)
- Clay and quartz
  - Internal structure, general chemical composition
- Ionic substitution--solid solution
  - Controlled by size of ion and charge on ion

- Surface tension
- Capillary action
- Viscosity

OUTLINE OBJECTIVES  
 Chapter 4 & Appendix C  
Rocks and Regolith

The three major classes of rocks  
 Basic of this classification

Classification of common igneous rocks

Texture

Phanerite, aphanite, glass  
 Phenocryst, matrix, porphyry

Fabric

Composition

Essential minerals  
 Accessory minerals

Granite, rhyolite, gabbro, basalt

Magma

Volcanic--plutonic

Factors affecting crystal size

Cooling history

Viscosity

Silica-rich versus silica-poor magma

Effect on mineral composition of rock

Classification of sedimentary rocks

Detrital sediments

Texture

Conglomerate, sandstone, shale

Chemical sediments

Composition

Limestone, evaporites

The three most abundant constituents of sedimentary rocks

Classification of metamorphic rocks

Foliated

Slate, schist, gneiss

Non-foliated

Marble, quartzite

Parent rocks?

The four main cycles of the Geologic Cycle

Hydrologic Cycle

Water that falls on land  
 Evaporites  
 Examples

Rock Cycle

Processes and products

Geochemical Cycle

Geochemistry  
 Most abundant salt in sea  
 Two most abundant gases in atmosphere  
 Fractional melting  
 Silica  
 Chemical formula or description  
 Three groups of igneous rocks based on silica content  
 Silicic (ave 73% silica)  
 Granite--orthoclase & quartz  
 Intermediate (ave 62% silica)  
 Andesite  
 Mafic (ave 52% silica)  
 Basalt

Bowen's Reaction Series

Eight minerals  
 Continuous and discontinuous series  
 Ferromagnesian silicates  
 High and low temperature minerals  
 Feldspars  
 Ca-plagioclase (anorthite)  
 Na-plagioclase (albite)  
 K-feldspar (orthoclase)

Tectonic Cycle

OUTLINE OBJECTIVES  
Chapter 6  
Geologic Column and Time

Relative time

Principle of Superposition

Fossils

Fauna

Flora

Assemblage

Law of faunal assemblages

Long distance correlation of sedimentary rocks

Absolute time

Radiometric age dating

Probable age of earth

Geologic column and time scale

Post Precambrian eras

Periods (systems) of each era

## Weathering

## Mechanical

Frost action, plants, animals, temperature change, chemical weathering

## Chemical

Importance of CO<sub>2</sub>

Limestone versus igneous rocks

What happens to common minerals and ions during chemical weathering?

Origin of caverns, sinks

## Differential Weathering

## Particle size

Effect on surface area and chemical reactions

## Factors that affect rates of weathering

Particle size, moisture, CO<sub>2</sub>, rock type, climate

## Rates of weathering

Relative resistance of common sedimentary rock types in arid and humid climates

Relative resistance (stability) of the common silicates

Stable minerals formed during weathering

## Three major classes of soils

## Characteristics

## Origin

Geographic and climatic distribution

Effects of:

Climate, time, maturity

Ore minerals, caliche

Relative effectiveness of different types of ground cover in preventing erosion.

Mechanics of stream flow

- Laminar flow
- Turbulent flow
- Stream load
  - Suspended load
  - Bed load
    - Saltation, rolling, sliding
- Stream capacity
- Discharge
  - Velocity, width, depth
  - Distribution of velocity
  - Flood
- Settling velocity
  - Size, shape, density

Runoff

Base level

- Local base levels
- Ultimate base level

Features of deposition:

- |              |           |               |
|--------------|-----------|---------------|
| alluvium     | delta     | floodplain    |
| alluvial fan | point bar | natural levee |

Features of erosion:

- |          |         |            |
|----------|---------|------------|
| pot hole | meander | oxbow lake |
|----------|---------|------------|

Long profile

Braided stream

OUTLINE OBJECTIVES  
 Chapter 10  
Sculpture of the Land

Drainage basin

Stream divide

Headward erosion

Cycle of Erosion

Stages

Youth--steep gradients, rapid erosion, V-shaped valleys,  
 broad stream divides.

Maturity--entire surface dissected, streams approach base  
 level, stream divides narrow, valleys are widened  
 rather than deepened, little or no original surface  
 remains, beginnings of meanders and flood plains.

Old age--peneplain, monadnocks, meander belts meander.

Rejuvenation--stream terraces, entrenched meanders.

Change in stream energy

Change in base level

Movement of crust

Change in climate

Stream patterns--depend on rock type, geologic history

Dendritic

Rectangular

Trellis

Stream types

Consequent

Subsequent

Antecedent

Superposed

Well-adjusted system

Water gap

Disected

## Porosity

- particle size, sorting, packing, cement, fractures

## Permeability

- Size and continuity of openings, porosity
- Relative porosity and permeability of typical sedimentary rocks

## Ground water

## Water table

- Zone of aeration
- Zone of saturation
- Shape of water table with respect to ground surface
- Relation to springs, streams, lakes, marshes
- Perched water table (body)

## Aquifer

## Wells

- Artesian
- Drawdown-cone of depression

## Effect on bedrock

- Soluble rock
  - Caves and caverns
  - Sinks
  - Dripstone
- Karst topography
- Characteristics

## Types of underground water

- Meteoric
- Juvenile
- Connate

## Geysers

Firn

Wastage versus accumulation

Glacial ice flow features

- Crevasse
- Bergschrund
- Zone of fracture
- Zone of flow
- Zone of accumulation
- Zone of wastage

Three main types of glaciers (characteristic and locations)

- Valley
- Piedmont
- Continental

Glacial erosion

- Cirque
- Tarn
- Horn
- Arete
- Hanging valley

Glacial deposition

- Drift
  - Stratified drift
  - Eskers
  - Ice tunnel
  - Kames
  - Outwash (plain)
  - Kettle

Till

- Moraines
  - Medial, terminal, recessional, lateral, ground.
- Drumlins
- Erratics

Permafrost

## Steppes

## Deserts

- Climate
- General geographic distribution
- Percent land surface
- Two main types
- How formed

 Principal agents of weathering and erosion  
 Mechanical versus chemical weathering

## Wind action

- Particle size versus settling (terminal) velocity
- Erosion
  - Deflation
    - Blowouts
    - Desert pavement
  - Ventifacts
- Deposition
  - Dunes
    - Characteristics of sand grains
    - Frosting, bedding, sorting, rounding, size, etc.
  - Loess

## Water action

- Erosion
  - Badlands, pediment, inselberg
- Deposition
  - Alluvial fans, bahadas
- Basins of interior drainage
  - Playa
  - Playa lake
- Intermittent stream
- Perennial stream

## Coriolis effect

- Northern & southern hemisphere

OUTLINE OBJECTIVES  
Chapter 14  
Coasts and Continental Shelves

## Tides

- Cause
  - Sun & Moon
- Tidal marsh

## Waves

- Particle motion as wave passes
- Wave length
- Wave height (vs. water depth in which wave breaks)
- Wave base
  - Relation to wave length
- Wave refraction
  - Concentration of energy
- Deep water waves
- Wave of oscillation
- Wave of translation
- Swash--backwash
- Breaker
- Longshore drift

## Erosional features

- Sea arch
- Stack
- Wave-cut cliff
- Wave-cut bench

## Depositional features

- Tombolo
- Spit
- Barrier island
- Beach
- Bay barrier
- Wave-built terrace

## Dominant geologic agents along coasts

## Groin

## Constructive waves

- Long period--spilling breakers--weak backwash

## Destructive waves

- Short period--plunging breakers--strong backwash

## Changes of sea level

- Eustatic
  - Volume of ocean water or of ocean basins
- Tectonic
  - Uplift or subsidence
- Features of emergence versus features of submergence

## Reefs

- Fringing, Barrier, Atoll
- Warm, clear, shallow water
- Zone of most active growth

## Progradation

## Continental shelf

Echo sounding  
 Continuous seismic profile

The principal morphologic features of ocean basin margins and floors.

Density currents  
 Temperature  
 Contour currents  
 Salinity  
 Turbidity  
 Origin  
 Characteristics  
 Graded bedding

Sand flow

Major groups of deep-sea sediments  
 Pelagic  
 Brown clay  
 Oozes  
 Calcareous (e.g., foraminiferal)  
 Siliceous (e.g., radiolarian)  
 Terrigenous  
 Tephra  
 Shallow-water carbonate sediments  
  
 Sources (origin) of each group

Submarine canyons  
 Origin & typical location

Restricted circulation & open circulation & their effect on sediments.  
 Evaporite basin  
 Oxydation, evaporation  
 Evaporites, red beds  
 Stagnant basin  
 Reduction-- $H_2S$ ,  $FeS_2$   
 Aerated basin  
 Oxydation

Marine life  
 Plankton(ic)  
 Nekton(ic)  
 Benthos (benthonic)

Classification of sedimentary rocks

Detrital

Cgl (& breccia), ss, sh

Sandstone

Arkose, graywacke, quartzose, etc.

Pettijohn's classification

Reflection of source and crustal stability

Chemical

Organic--ls, dol, coal

Inorganic--ls, dol, evaporites, chert

Relationship between type of sediment and energy conditions at site of deposition.

The three most abundant sedimentary rocks.

The three most abundant minerals in sedimentary rocks.

Principle of Original Horizontality

Law of Superposition

Stratification--causes

Beds

Laminae

Varves

Centimeter

Cross-strata

Implications

Other features of sedimentary rocks

Imbrication

Ripple marks

Symmetrical--oscillation--waves

Asymmetrical--currents

Significance

Mudcracks

Significance

Sediment color

Fe

Organic matter (carbon)

Facies

Fossil

Concretion

Nodule

Geode

Conformable

Symbols of common sedimentary rocks

Evidence of displacement

Attitude of strata

Dip and Strike

Symbol (and its meaning)

Structural features

Folds

Types--anticlines, synclines, monoclines

Features--plunge, axis, axial plane, limb

Symmetry--symmetrical, asymmetrical, overturned, recumbent,  
 isoclinal

Faults

Strike-slip (lateral fault)

Right lateral-left lateral

Dip-slip

Normal (gravity fault)

Tension

Reverse (thrust fault)

Compression

Oblique-slip

Hanging wall-footwall

Upthrown block--downthrown block

Structural features of normal faulting

Horsts and grabens

Rift valleys

Slickensides

Joints

Unconformities

Angular unconformity

Disconformity

Nonconformity

Maximum known fault displacement occurring at one time

Deformation

Strength

Compressive vs tensile

Of fluids

Effect of temperature

Effect of confining pressure

elastic limit

Law of original continuity

OUTLINE OBJECTIVES  
 Chapter 18  
Earthquakes: Earth's Interior

Earthquakes

- Main cause
- Principal danger to populated areas
- Estimated number per year
- Intensity
  - Isoseismic lines
- Magnitude
  - Richter scale
- Focus
- Epicenter
- Tsunami
  - Characteristics
  - Tidal wave ?

Seismograph station

Seismic waves

- Surface waves
  - L waves
- Body waves
  - P and S waves
- Characteristics
  - Relative velocities
  - Relative arrival times
  - Paths followed
  - Synonymous names
  - Particle motion in each type
- Wave refraction
  - Wave front--wave path
  - Shadow zone

Internal structure of earth

- Crust
  - Sial--Sima
- Mantle
- Core
  - Evidence that suggests core is liquid Ni-Fe
- M-discontinuity (Moho)
  - Project Mohole
    - Purpose and rationale

## Volcano

Extrusive (volcanic) versus intrusive (plutonic)

## Volcanic products

## Gases

Most abundant gas

Source

Source of explosive energy

## Lava

Composition

Basalt--andesite--rhyolite

Fluidity (viscosity)

Variation with composition

Silica

Water

Pahoehoe--aa--obsidian

Pillow lava

## Tephra (pyroclastics)

Dust-1/16-ash-4-lapilli-32-blocks & bombs

Welded tuff (confusion with rhyolite)

Pumice

## Volcanic edifices and their characteristics

Shield volcano

Composite volcano

Tephra (cinder) cone

Plateau (flood) basalts

Crater

Caldera

"Crater" Lake

## Typical eruptive activities and characteristics

Hawaiian (shield or quiet) type

Peleeian (explosive) type

Nuee ardente

Fissure eruptions

Fumaroles

Ways in which volcanic activity is useful to man.

Relationship of basalt and granite to oceanic and continental crusts.

OUTLINE OBJECTIVES  
 Chapter 20  
Plutonism & Metamorphism

## Plutons

## Classification

Size, shape, relationship to surrounding rock

	TABULAR	LENTICULAR	IRREGULAR	
			<40 mi <sup>2</sup>	>40 mi <sup>2</sup>
CONCORDANT	sill	laccolith		
DISCORDANT	dike		stock volcanic neck	batholith

Composite pluton

## Contact relationships

Distinguish dikes, sills, lava flows, sedimentary rocks.  
 Determination of relative age.

Most abundant intrusive and extrusive rock.

Relationship to the oceanic and continental crust

## Origin of granite

Bowen's Theory

Magmatic differentiation

Mechanisms

Examples of field evidence

Major flaws

Granitization

Migmatite

Origin of basaltic magmas

Origin of pegmatites

Characteristics and composition

## Metamorphism

Types

Contact

Dynamic

Slaty cleavage

Origin

Relation to axial planes &amp; direction of shear &amp; compression.

Regional

Associated with mountain building

Agents

Heat, pressure, chemically active fluids

Processes

Recrystallization

Reorganization

Recombination

Replacement

Parent rocks of slate, phyllite, quartzite, marble, hornblende schist

Three geologic characteristics of linear mountain belts.  
 Folded & faulted strata, regional metamorphism, granite batholiths.

Orogeny--epeirogeny--diastrophism

Physiographic provinces of Virginia

Plateau, Valley & Ridge, Blue Ridge, Piedmont, Coastal Plain.

Features of Marginal Zones of mountain belts.

Zones of high-standing basement rocks.

Example from Appalachians

Appalachian structure--Alpine structure

Carbonate sheets

Thin across continental interior

Thicker in marginal zone

Features of Interior Zones.

Carbonates grade into dark shales and siltstones

Great overthrusts

Elongate patches of basement

Example from southern Appalachians

Slaty cleavage

Features of Central Zones

Plutonic & metamorphic rock (great thermal activity)

Example from Appalachians

Volumes of ultramafics and volcanics

Plastic flow of rocks

Where strata can be "converted to basement"

Fault blocks (late stage)

Example from Appalachians

Relationship between gravity, mass, and distance.

Weight of any object (force of gravity)

Elevation, latitude, density of rocks in vicinity

Behavior of plumb line

Normally

Near large rock masses such as mountains

Why plumb line in India not deflected as much as calculated?

Isostasy

Theories of Pratt and Airy

Basement

Plateau

## APPENDIX D

## Attitude Scale

The following questionnaire asks for your feelings concerning the use of BEHAVIORAL OBJECTIVES (those given you in sentence form, telling what you were to learn and how you were to demonstrate that learning) as contrasted with OUTLINE OBJECTIVES (those furnished you as terms or brief statements in step outline form, with no specification as to how questions would be asked).

For each of the following, please circle the statement which most closely indicates your opinion: Disagree (D); Tend to Disagree (TD); Tend to Agree (TA); Agree (A).

- |   |   |    |    |   |
|---|---|----|----|---|
| 1. <u>Outline</u> objectives would be most useful in science courses.   | D | TD | TA | A |
| 2. The use or <u>behavioral</u> objectives helped me make better grades on the tests.                         | D | TD | TA | A |
| 3. <u>Behavioral</u> objectives caused some students not to study until just before test time.                | D | TD | TA | A |
| 4. <u>Outline</u> objectives were good for students who had missed the lecture.                               | D | TD | TA | A |
| 5. Student learning was restricted by using <u>outline</u> objectives.  | D | TD | TA | A |
| 6. <u>Outline</u> objectives were likely to cause some students to study only what the objectives had stated. | D | TD | TA | A |
| 7. <u>Outline</u> objectives tended to lead students toward memorization rather than understanding.           | D | TD | TA | A |
| 8. <u>Behavioral</u> objectives were good for students who had missed the lecture.                            | D | TD | TA | A |
| 9. Only the <u>behavioral</u> type objective should be used.  | D | TD | TA | A |
| 10. <u>Behavioral</u> objectives would be most useful in science courses.                                     | D | TD | TA | A |
| 11. <u>Outline</u> objectives caused some students not to study until just before test time.                  | D | TD | TA | A |

- |     |  |   |    |    |   |
|-----|--|---|----|----|---|
| 12. | I felt more secure in taking the tests after using <u>outline</u> objectives.  | D | TD | TA | A |
| 13. | <u>Behavioral</u> objectives were likely to cause some students to study only what the objectives had stated.  | D | TD | TA | A |
| 14. | The course could be successfully completed by using only the <u>outline objectives</u> and going to the teacher only when additional help was needed.    | D | TD | TA | A |
| 15. | I felt more secure in taking the tests after using <u>behavioral</u> objectives.   | D | TD | TA | A |
| 16. | <u>Behavioral</u> objectives made studying easier and decreased study time.  | D | TD | TA | A |
| 17. | The <u>behavioral</u> objectives were clear enough so that they could be understood and used effectively without the teacher's help.                     | D | TD | TA | A |
| 18. | The use of <u>outline</u> objectives helped me make better grades on the tests.  | D | TD | TA | A |
| 19. | <u>Outline</u> objectives gave a much better idea of what the teacher expected.  | D | TD | TA | A |
| 20. | <u>Outline</u> objectives made studying easier and decreased study time.   | D | TD | TA | A |
| 21. | <u>Behavioral</u> objectives tended to lead students toward memorization rather than understanding.  | D | TD | TA | A |
| 22. | Student learning was restricted by using <u>behavioral</u> objectives.   | D | TD | TA | A |
| 23. | The course could be successfully completed by using only the <u>behavioral objectives</u> and going to the teacher only when additional help was needed. | D | TD | TA | A |
| 24. | The use of <u>outline</u> objectives gave more meaning to the reading of the textbook.   | D | TD | TA | A |
| 25. | I would like to use <u>behavioral</u> objectives in all my courses.  | D | TD | TA | A |

- |  |   |    |    |   |
|--|---|----|----|---|
| 26. The use of <u>behavioral</u> objectives gave more meaning to the reading of the textbook   | D | TD | TA | A |
| 27. The <u>outline</u> form was clear enough so that the objectives could be understood and used effectively without the teacher's help.   | D | TD | TA | A |
| 28. I would like to use <u>outline</u> objectives in all my courses.   | D | TD | TA | A |
| 29. Only the <u>outline</u> type objective should be used.   | D | TD | TA | A |
| 30. <u>Behavioral</u> objectives gave a much better idea of what the teacher expected.   | D | TD | TA | A |
| 31. Complete the following statement by circling the words of your choice: If restricted to one type of objective, I would prefer: 1. behavioral 2. outline 3. some other kind 4. no objectives 5. have no opinion |   |    |    |   |

## APPENDIX E

## TEST INSTRUMENTS

## Test I

## GEOLOGY 101

## Quiz, Chapters 1, 2, 3

Place the number representing the best answer in the appropriate blank.  
(In all matching questions answers may be used more than once.)

Match each term with the appropriate description:

- |                      |   |
|----------------------|---|
| ___ 1. weathering    | (1) transport of rock materials                                   |
| ___ 2. catastrophism | (2) older rocks being transformed into new ones                   |
| ___ 3. erosion       | (3) development of the earth as a result of a series of disasters |
| ___ 4. metamorphism  | (4) breaking down of rock materials                               |
| ___ 5. regolith      | (5) loose material that locally covers bedrock                    |

Match each chemical formula with the correct chemical group:

- |  |                       |
|--|-----------------------|
| ___ 6. $\text{CaMg}(\text{CO}_3)_2$            | (1) carbonate         |
| ___ 7. $\text{KAlSi}_3\text{O}_8$              | (2) oxide             |
| ___ 8. $\text{CuFeS}_2$                        | (3) silicate          |
| ___ 9. $\text{Al}_2\text{O}_3$                 | (4) sulfate           |
| ___ 10. $\text{KMg}_3\text{Si}_3\text{O}_{10}$ | (5) sulfide           |
|  | (6) none of the above |

Match each statement of matter with its distinguishing physical properties:

- |                    |                               |                |
|--------------------|-------------------------------|----------------|
| ___ ___ 11. gas    | (1) rigid                     |                |
| ___ ___ 12. liquid | (2) non-rigid                 |                |
| ___ ___ 13. solid  | (3) compressible              | one point each |
|                    | (4) non-compressible          |                |
|                    | (5) expands to fill container |                |

Match each term with its appropriate description:

- |                           |  |
|---------------------------|--|
| ___ 14. centripetal force | (1) keeps earth traveling in a straight line |
| ___ 15. centrifugal force | (2) keeps earth from falling into sun        |
|                           | (3) keeps earth rotating on its axis         |
|                           | (4) keeps earth from flying away from sun    |
|                           | (5) none of the above                        |

## Multiple Choice:

- \_\_\_ 16. A solid having a random arrangement of atoms would be called:  
(1) crystalline (2) amorphous (3) a crystal (4) ferromagnesian  
(5) ionized
- \_\_\_ 17. The sun's energy is derived from: (1) oxydation of H (2) fis-  
sion of H (3) fusion of H (4) chemical reactions (5) latent  
heat of fusion
- \_\_\_ 18. The geometric arrangement of ions and their ability to substitute  
for one another in a crystal structure is largely determined by:  
(1) ionic diameters (2) number of electrons in outer shell  
(3) number of protons in nucleus (4) number of neutrons in  
nucleus (5) number of electron shells
- \_\_\_ 19. A substance which cannot be broken down into different components  
by ordinary chemical means: (1) NaCl (2) complex ion  
(3) compound (4) molecule (5) element
- \_\_\_ 20. Variations in the number of neutrons in the nucleus of atoms  
produce: (1) ions (2) isotopes (3) compounds (4) radicals  
(5) molecules
- \_\_\_ 21. The smallest unit of a compound that has all the properties of  
that compound: (1) atom (2) radical (3) ion (4) nucleus  
(5) molecule
- \_\_\_ 22. A sphere 40 cm. in diameter with a mass of 200 gm. is located  
1000 cm. (center to center) from another sphere 60 cm. in  
diameter with a mass of 10,000 gm. If the gravitational con-  
stant is .000 000 07, what is the strength of the gravitational  
attraction between them? (1) .000 000 07 (2) .000 000 035  
(3) .000 000 14 (4) .000 000 28 (5) none of the above
- \_\_\_ 23. A few meters beneath the surface the temperature is stable at  
14°C. A well being drilled to 6000 m would be expected to en-  
counter what maximum bottom hole temperature? (1) 614°  
(2) 314° (3) 214° (4) 600° (5) 200°
- \_\_\_ 24. A moon circles a planet at a distance of 200,000 km. If this  
distance is increased to 800,000 km, the gravitational attrac-  
tion between them decreases by a factor of: (1) 4 (2) 8  
(3) 16 (4) 32 (5) 64
- \_\_\_ 25. One of the stable isotopes of potassium (atomic No. 19) has a  
mass number of 39 and four electron shells. Its nucleus would  
contain how many neutrons? (1) 19 (2) 20 (3) 39 (4) 4  
(5) not enough information

Answer the following questions by writing the appropriate word(s) in each blank:

26. The diameter of the earth is approximately \_\_\_\_\_.  
(indicate mi or km)

27. Solid continuous rock is known as \_\_\_\_\_.

28. The basic structural unit of all the silicates is the \_\_\_\_\_.

29. The most abundant metallic element in the earth's crust is \_\_\_\_\_.

The two principal sources of energy for the geologic cycle are:

30. \_\_\_\_\_ and 31. \_\_\_\_\_.

What are the three components of the geologic record?

32. \_\_\_\_\_ 33. \_\_\_\_\_ 34. \_\_\_\_\_.

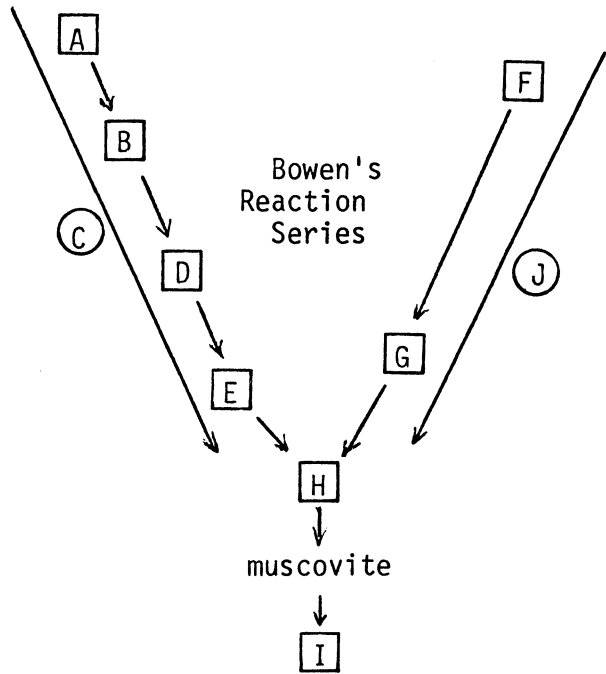
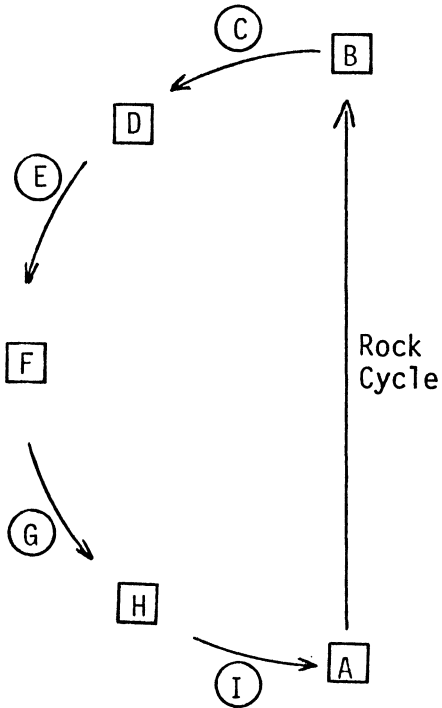
Test II

GEOLOGY 101  
Chapters 4, 5, & 6

Place the number representing the best answer in the appropriate blank.

Match rock composition with corresponding group:  
Answers may be used more than once.

- |                   |                      |
|-------------------|----------------------|
| ___ 1. 60% silica | 1) mafic             |
| ___ 2. granite    | 2) silicic           |
| ___ 3. 75% silica | 3) intermediate      |
|                   | 4) none of the above |



\_\_\_ 4. Melting is represented by:  
1) A 2) B 3) C 4) G  
5) I

\_\_\_ 5. Metamorphic rocks are represented by: 1) A  
2) B 3) G 4) H 5) I

\_\_\_ 6. The ferromagnesians are shown above by: 1) A 2) C  
3) J 4) H  
5) F

\_\_\_ 7. Orthoclase is shown as:  
1) I 2) H 3) F 4) G  
5) E

\_\_\_ 8. Na-plagioclase is represented by 1) H 2) E 3) G  
4) F 5) J

.....  
 Match each mineral with the ion that determines its name:

\_\_\_ 9. anorthite                    1)  $\text{Ca}^{++}$                     3)  $\text{Fe}^{++}$

\_\_\_ 10. orthoclase                    2)  $\text{Na}^+$                     4)  $\text{K}^+$

.....  
 \_\_\_ 11. The most abundant atmospheric gas is:

1) Nitrogen 2) Oxygen 3) Chlorine 4) Silicon

\_\_\_ 12. The middle period of the Paleozoic is:

1) Jurassic 2) Mississippian 3) Silurian 4) Permian  
 5) Devonian

\_\_\_ 13. The first period of the Mesozoic:

1) Cretaceous 2) Tertiary 3) Triassic 4) Cambrian 5) Permian

\_\_\_ 14. The period immediately following the Tertiary:

1) Cenozoic 2) Cretaceous 3) Quaternary 4) Mesozoic  
 5) Triassic

\_\_\_ 15. The youngest era (post-Precambrian):

1) Mesozoic 2) Quaternary 3) Cenozoic 4) Tertiary 5) Paleozoic

\_\_\_ 16. The period immediately preceding the Jurassic:

1) Triassic 2) Cretaceous 3) Paleozoic 4) Cenozoic 5) Permian

\_\_\_ 17. Igneous rocks are classified on the basis of:

1) texture 2) composition 3) texture and composition  
 4) texture or composition

\_\_\_ 18. A rock is classified as one of the three major types on the basis of: 1) texture 2) composition 3) origin 4) silica content

\_\_\_ 19. Texture of igneous rocks is primarily related to:

1) rate of cooling 2) temperature of formation 3) atomic structure 4) mineral content

\_\_\_ 20. The minor constituents of igneous rocks that do not affect the basic classification (i.e., name) are called:

1) phenocrysts 2) phenocrysts 3) accessory minerals  
 4) essential minerals 5) matrix

\_\_\_ 21. The age of the earth, based on radioactive determinations, is thought to be about (in years):

1) 4,500,000 2) 4,500,000,000 3) 45,000,000,000 4) 3,500,000

Answer the following questions by writing the appropriate word(s) in each blank.

22. That "younger rocks overlies older rocks" is recognized by most geologists as the principle of \_\_\_\_\_.
23. A rock composed mainly of augite and Ca-Na plagioclase with a trace of olivine would be a \_\_\_\_\_ (rock name).
24. Whether occurring in a pure state or as part of a more complex mineral, the composition of silica is \_\_\_\_\_.
25. Of the water that falls on land, what happens to the major part?  
\_\_\_\_\_

## Test III

GEOLOGY 101  
Chapter 7

Place in each blank the letter representing the best answer.

1. Match each soil type or product with the climate in which it forms. (In all matching questions, answers may be used more than once.) (4 points each)

_____ Pedocal	A. temperate humid
_____ Pedalfer	B. tropical humid
_____ Caliche	C. tropical desert
_____ Bauxite	D. temperate arid
_____ Laterite	E. arctic arid

2. Match the following to show what happens during chemical weathering: (4 each)

_____ Na	A. leaves in solution
_____ Fe	B. recombines with $O_2$
_____ Orthoclase	C. is unchanged
_____ Quartz	D. alters to plagioclase
	E. yields clay, soluble salts and silica

(8 points each)

- \_\_\_\_\_ 3. A rock which is resistant in arid climates but non-resistant in humid climates:  
a. sandstone b. shale c. quartzite d. limestone e. none of above
- \_\_\_\_\_ 4. The rate of chemical weathering tends to be increased by:  
a. increasing moisture b. decreasing particle size  
c. increasing air pollution d. all of above 3. two of above
- \_\_\_\_\_ 5. Chemical weathering of a limestone produces a residual soil that is:  
a. drastically different from the parent rock b. similar in composition to parent rock  
c. similar in composition to parent rock but with different mineral proportions d. high in silica  
e. rich in  $CaCO_3$
- \_\_\_\_\_ 6. The most effective agent of mechanical weathering is:  
a.  $CO_2$  b. plant roots c. running water d. burrowing animals  
e. frost wedging
- \_\_\_\_\_ 7. Laterization may result in the accumulation of bauxite with its major metallic constituent being:  
a. Ca b. Mg c. Na d. K e. Al

- \_\_\_ 8. Given sufficient time for maturity, the most important factor in determining the type of soil formed is:  
a. parent rock b. climate c. topography d. vegetation  
e. age of parent rock
9. Probably the most stable and abundant mineral formed during chemical weathering of igneous rocks is \_\_\_\_\_.
10. The two main types of weathering are \_\_\_\_\_ and \_\_\_\_\_.

## Test IV

GEOLOGY 101  
Chapters 9 & 10

Place the number representing the best answer in the appropriate blank.  
(In all matching questions may be used more than once.)

Match each feature with the appropriate description or location:

- |  |                 |
|--|-----------------|
| ___ 1. deposit at mouth of mtn. canyon | 1. lake         |
| ___ 2. inside of meander bend          | 2. alluvial fan |
| ___ 3. local base level                | 3. delta        |
| ___ 4. slope of stream                 | 4. gradient     |
|  | 5. point bar    |

Match each topographic feature with the appropriate portion of the cycle of erosion:

- |   |                       |
|---|-----------------------|
| ___ 5. broad flat-topped stream divides | 1. youth              |
| ___ 6. maximum difference in elevation  | 2. maturity           |
| ___ 7. falls and rapids                 | 3. old age            |
| ___ 8. V-shaped valleys                 | 4. rejuvenation       |
| ___ 9. peneplain                        | 5. rise of base level |
| ___ 10. monadnocks                      |                       |
| ___ 11. most of region "in slope"       |                       |
| ___ 12. stream terraces                 |                       |

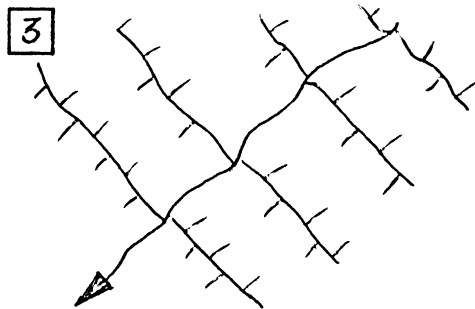
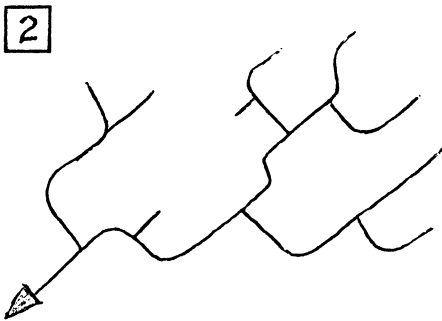
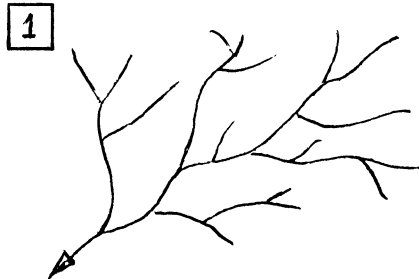
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- \_\_\_ 13. Which of the following is the most effective in preventing runoff and therefore erosion?  
1) grass 2) forest 3) corn 4) plowed field 5) turnips
- \_\_\_ 14. The term saltation is used to describe:  
1) the carrying capacity of a stream 2) the behavior of the bed load 3) the method by which a stream carries particles in suspension 4) the largest particle a stream can move 5) the formation of salt
- \_\_\_ 15. As a general rule, stream width, depth, velocity, discharge, and gradient: 1) increase downstream 2) decrease downstream 3) all but one increase downstream 4) all but one decrease downstream 5) two increase, two decrease, one unchanged.
- \_\_\_ 16. The triangular or irregular fan-shaped deposit that forms where a stream enters a standing body of water:  
1) terrace 2) delta 3) alluvial fan 4) point bar 5) levee
- \_\_\_ 17. A pass in a ridge or mountain through which a stream flows:  
1) divide 2) pot hole 3) consequent valley 4) water gap

- \_\_\_ 18. A stream that was let down from overlying strata onto buried bedrock having composition or structure unlike that of the covering strata:  
 1) consequent 2) subsequent 3) antecedent 4) superposed
- \_\_\_ 19. The stream pattern most likely to develop in regions of folded rocks such as the Appalachians:  
 1) rectangular 2) dendritic 3) radial 4) trellis
- \_\_\_ 20. A stream whose course has become adjusted so that it occupies belts of weak, non-resistant rock:  
 1) consequent 2) antecedent 3) superposed 4) subsequent

Match the correct stream pattern shown below with the name or bedrock description:

- \_\_\_ 21. alternating resistant non-resistant beds.  
 \_\_\_ 22. flat-lying sediments massive igneous rocks.  
 \_\_\_ 23. trellis  
 \_\_\_ 24. dendritic



25. Stream deposits formed on land are called \_\_\_\_\_.

## Test V

GEOLOGY 101  
Chapters 11 & 12

Match the landforms and features listed below with those illustrated on the extra pages. Place the letter of each feature alongside the appropriate name. Do not mark on the illustrations. There may be more than one answer to each name.

- |                |               |                             |
|----------------|---------------|-----------------------------|
| ___ 1. kettle  | ___ 5. tarn   | ___ 9. hanging valley       |
| ___ 2. kame    | ___ 6. cirque | ___ 10. terminal moraine    |
| ___ 3. esker   | ___ 7. arete  | ___ 11. recessional moraine |
| ___ 4. drumlin | ___ 8. horn   |                             |

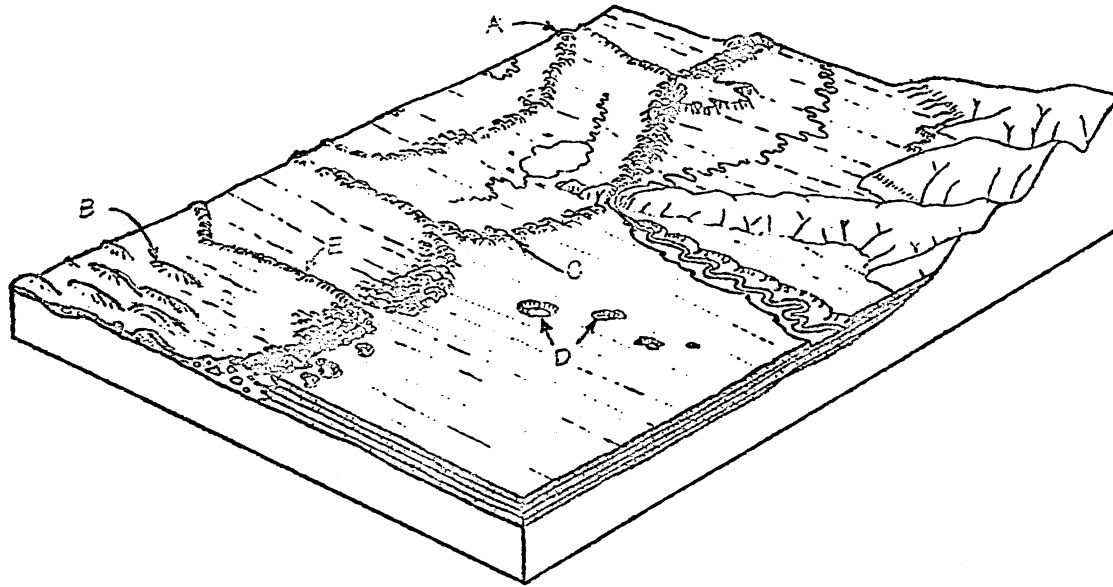
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Answer the following questions by supplying the appropriate word(s):

12. In marshes and swamps the \_\_\_\_\_ nearly coincides with the ground surface.
13. Original sea water trapped in a sediment is called \_\_\_\_\_ water.
14. A water-saturated aquifer may rest on an impermeable bed high above the main water table. In this case, water is prevented from filtering downward and forms a(n) \_\_\_\_\_ water table.
15. A hot spring that ejects water with considerable force is a \_\_\_\_\_.
16. Some humid regions have a characteristic topography marked by collapse valleys, sinks, caverns, and an underground drainage system. Because of its solubility, \_\_\_\_\_ (type of bedrock) is profoundly affected by ground water.
17. A region exhibiting the above characteristics is described as \_\_\_\_\_ topography.
18. A well in which the pressure is sufficient to raise the water above the top of the water bearing bed is called an \_\_\_\_\_ well.
19. The capacity of a rock to transmit a fluid is called \_\_\_\_\_.
20. A porous bed which contains and transmits water is called a(n) \_\_\_\_\_.

21. The two factors which have the greatest influence on the ability of a rock to transmit a fluid (other than porosity) are \_\_\_\_\_ and \_\_\_\_\_.
22. (6 points) Three of the characteristics of rocks which affect porosity. \_\_\_\_\_.
23. (2 points) When accumulation exceeds wastage, a glacier \_\_\_\_\_.

# MARGINAL DEPOSITS OF CONTINENTAL ICE SHEETS

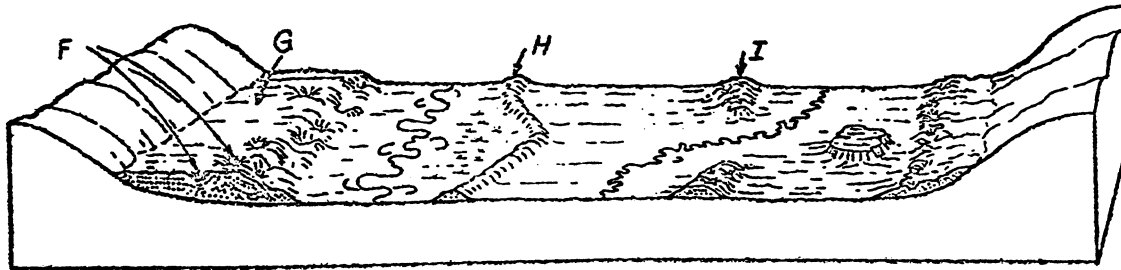
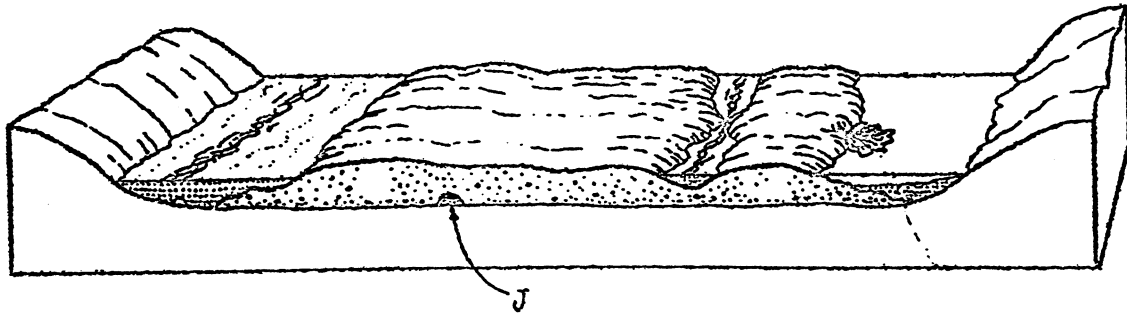


Edited by R. M. Scobler, Ph. D.

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163.09

# VALLEY DEPOSITS OF MELTING ICE

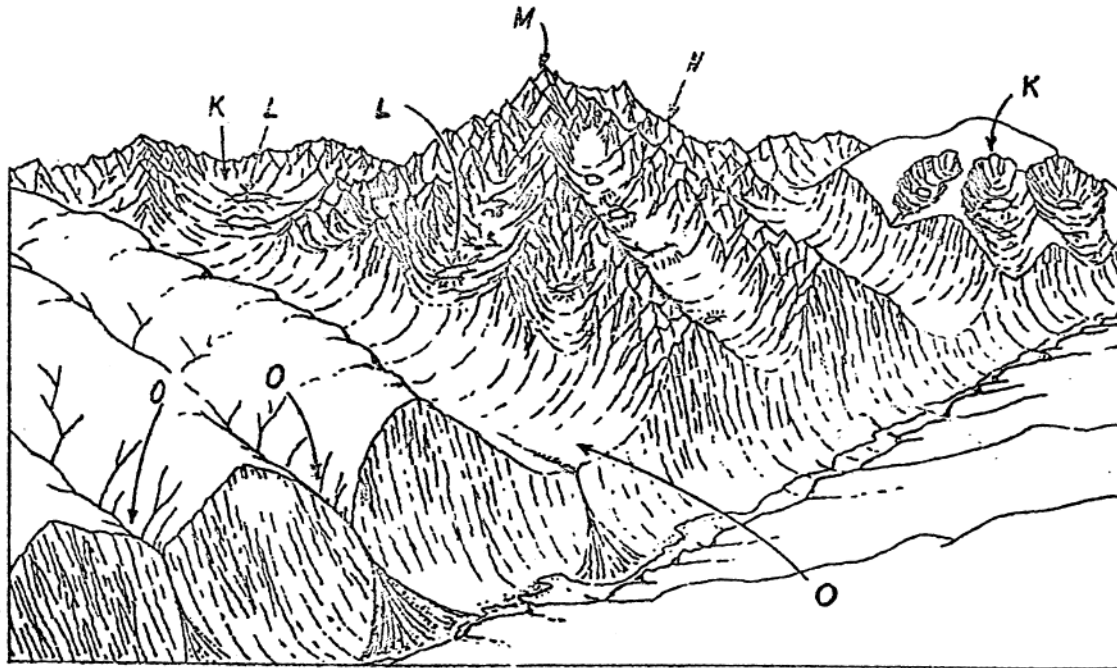


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PART NO. 663-0151

16311

# LANDFORMS CARVED BY ALPINE GLACIERS



Edited by A. N. Strahler, Ph.D.

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PART NO. 643-0143

103.03

FINAL EXAM  
GEOLOGY 101

Choose the answer which best completes the sentence and mark the appropriate space on the answer sheet. DO NOT MARK ON THIS SHEET.  
(In all matching questions, answers may be used more than once.)

1. The circumference of the earth is approximately:  
(1) 25,000 km (2) 25,000 mi (3) 8,000 km (4) 8,000 mi  
(5) None of the above
2. The belief that the earth developed as by a series of disasters:  
(1) uniformitarianism (2) metamorphism (3) catastrophism  
(4) superposition (5) causation
3. A few meters beneath the surface the temperature is stable at  $10^{\circ}$  C. A well being drilled to 6,000 m could be expected to encounter what maximum bottom hole temperature?  
(1)  $610^{\circ}$  (2)  $310^{\circ}$  (3)  $210^{\circ}$  (4)  $600^{\circ}$  (5)  $200^{\circ}$
4. A moon circles a planet at a distance of 100,000 km. If this distance is increased to 800,000 km, the gravitational attraction between them decreases by a factor of:  
(1) 4 (2) 8 (3) 16 (4) 32 (5) 64
5. The sun's energy is derived from:  
(1) oxydation of H (2) fission of H (3) fusion of H (4) chemical reactions (5) latent heat of fusion

MATCH each chemical formula with the correct group of compounds:

- |               |               |
|---------------|---------------|
| 6. CaO        | (1) sulfate   |
| 7. PbS        | (2) silicate  |
| 8. $KAlSiO_4$ | (3) carbonate |
| 9. $Na_2CO_3$ | (4) sulfide   |
|               | (5) oxide     |

10. The geometric arrangement of ions and their ability to substitute for one another in a crystal structure is largely determined by:  
(1) number of electrons in outer shell (2) number of protons in nucleus (3) number of neutrons in nucleus (4) number of electrons in nucleus (5) diameter of ion
11. The most abundant ion in the earth's crust is:  
(1) oxygen (2) silicon (3) sodium (4) calcium (5) sulfur
12. An example of a ferromagnesian is:  
(1) olivine (2) muscovite (3) quartz (4) feldspar (5) None of these
13. A mineral of almost pure silica is:  
(1) feldspar (2) olivine (3) orthoclase (4) muscovite (5) quartz
14. The most abundant rock forming silicate is:  
(1) olivine (2) muscovite (3) hornblende (4) quartz (5) feldspar
15. In igneous rocks, a large crystal surrounded by small crystals is called a:  
(1) groundmass (2) pegmatite (3) matrix (4) phenocryst (5) vesicle
16. The fine crystalline material in which coarse crystals of an igneous rock are embedded is known as:  
(1) porphyry (2) phenocryst (3) matrix (4) vesicle (5) amygdaloid
17. Texture of igneous rocks is related to:  
(1) time in cooling (2) temperature of formation (3) atomic structure (4) mineral content (5) pressure at formation
18. Magmas rich in silica tend to form rocks with abundant:  
(1) olivine and granite (2) feldspar and quartz (3) ferromagnesian and basalt (4) olivine and augite (5) biotite and hornblende
19. A rock composed primarily of orthoclase and quartz:  
(1) gabbro (2) granite (3) basalt (4) syenite (5) insufficient data

20. The three most abundant mineral constituents of sedimentary rocks:
- (1) clay, shale, sandstone
  - (2) quartz, clay, carbonates
  - (3) limestone, quartz, sandstone
  - (4) calcite, dolomite, clay
  - (5) quartz, feldspars, ferromagnesian
21. The parent rock of quartzite is:
- (1) marble
  - (2) limestone
  - (3) sandstone
  - (4) shale
  - (5) conglomerate
22. A detrital sedimentary rock made up of rounded quartz fragments more than 4 mm in diameter would be a:
- (1) conglomerate
  - (2) sandstone
  - (3) shale
  - (4) limestone
  - (5) breccia
23. Which of the following is an example of a non-foliated metamorphic rock?
- (1) slate
  - (2) marble
  - (3) gneiss
  - (4) schist
  - (5) granite
24. A rock is classified as one of the three major types on the basis of:
- (1) texture
  - (2) mode of origin
  - (3) fabric
  - (4) composition
  - (5) silica content
25. Of precipitation falling on the land, the largest amount:
- (1) runs off in streams and rivers
  - (2) returns to the atmosphere by evaporation
  - (3) infiltrates into the ground
  - (4) returns to the atmosphere by condensation
  - (5) none of the above
26. The age of the earth, based on radioactive determinations, is thought to be about:
- (1) 45,000,000,000
  - (2) 4,500,000,000
  - (3) 4,500,000
  - (4) 2,500,000,000
  - (5) 2,500,000
27. The most important means of long distance correlation of sedimentary rocks:
- (1) lithology
  - (2) walking the outcrop
  - (3) fossils
  - (4) isotopes
  - (5) potassium-argon
28. In undisturbed areas the oldest rock may be determined by following:
- (1) Hutton's Law
  - (2) Law of Superposition
  - (3) Uniformitarianism
  - (4) facies relationships
  - (5) Law of Original Horizontality

MATCH the following to show what happens during chemical weathering:

29. Na (1) leaves in solution
30. Fe (2) recombines (with  $O_2$ )
31. orthoclase (3) is unchanged
32. quartz (4) alters to plagioclase  
(5) yields clay, soluble salts and silica
33. A rock which is resistant in arid climates but non-resistant in humid climates:  
(1) sandstone (2) shale (3) quartzite (4) limestone  
(5) All of the above
34. Pedocals are typical of:  
(1) temperate forested areas (2) tropical jungles (3) high cold deserts (4) northern forests (5) temperate semi-arid regions
35. Weathering of different parts of rock at different rates is called  
(1) exfoliation (2) leaching (3) differential weathering  
(4) mechanical weathering (5) chemical decomposition
36. Evaporation is related to the formation of:  
(1) a horizon (2) caliche (3) bauxite (4) iron ore (5) humus
37. The rock-forming mineral most resistant to weathering is:  
(1) granite (2) orthoclase (3) plagioclase (4) calcite  
(5) quartz

MATCH each feature with it's probable location:

38. delta (1) at mouth of stream
39. levee (2) near headwaters
40. alluvial fan (3) along banks
41. floodplain (4) at mouth of canyon  
(5) in the channel

42. The total amount of material that a stream carries at any one time is its:  
 (1) capacity (2) load (3) competence (4) bed load (5) profile
43. Because erosion will eventually cause downcutting of the outlet and drain the lake, a lake is known as a temporary:  
 (1) delta (2) flood plain (3) peneplain (4) sea level  
 (5) base level
44. The velocity of a straight-flowing stream is probably greatest:  
 (1) in the center, near the surface (2) in the center, near the bottom  
 (3) at half the water depth (4) along the banks, near the surface  
 (5) little difference in velocity at any of the above.
45. The quantity of water that passes a given point in a unit time is called:  
 (1) volume (2) velocity (3) profile (4) turbulence  
 (5) discharge
46. Which of the following, as a general rule, tends to decrease downstream?  
 (1) gradient (2) width (3) depth (4) velocity (5) All but one
47. Particles of the bed load move:  
 (1) by saltation (2) in suspension (3) by sliding (4) two of above  
 (5) All of the above

MATCH each landform with the most appropriate stage of the cycle of erosion:

- |  |                       |
|--|-----------------------|
| 48. peneplain                                | (1) youth             |
| 49. V-shaped valleys                         | (2) maturity          |
| 50. falls and rapids                         | (3) old age           |
| 51. entrenched meanders                      | (4) rejuvenation      |
| 52. a landmass having steep stream gradients | (5) none of the above |
53. In lowering the steep profile of its upper course or head, the stream lengthens its course in an upstream direction. This is called: (1) flooding (2) headward erosion (3) meandering  
 (4) differential erosion (5) aggradation

54. The line that separates drainage basins:  
(1) divide (2) water gap (3) trellis (4) monadnock  
(5) alluvial terrace
55. A stream forced to alter its course after uplift is known as:  
(1) consequent (2) obsequent (3) antecedent (4) subsequent  
(5) superimposed
56. A stream pattern characterized by irregular "treelike" branching in many directions:  
(1) rectangular (2) trellis (3) dendritic (4) radial  
(5) subsequent
57. A stream pattern in which tributary streams are parallel and very long:  
(1) trellis (2) dendritic (3) rectangular (4) radial (5) none of these
58. A stream that has maintained its course across an area of the crust that was raised across its path by folding or faulting:  
(1) consequent (2) subsequent (3) antecedent (4) superposed  
(5) None of these
59. Large solution cavity open to sky:  
(1) sink (2) artesian well (3) cone of depression (4) karst hole  
(5) aquifer
60. The upper surface of the zone of saturation:  
(1) Zone of aeration (2) water line (3) drawdown (4) cone of depression  
(5) water table
61. The term used to describe the proportion of total volume of rock to its open spaces is  
(1) aquifer (2) permeability (3) capacity (4) percolation  
(5) porosity
62. A thermal spring that ejects water with considerable force:  
(1) artesian (2) hot spring (3) stalactite (4) geyser  
(5) volcano

63. The intersection of the water table with the ground surface may be indicated by a  
(1) lake (2) spring (3) stream (4) swamp (5) all of the above
64. Water escaping from a magma and entering the atmosphere for the first time would be called:  
(1) connate (2) fumarole (3) meteoric (4) juvenile (5) artesian
65. In hilly country the water table is  
(1) subparallel to the ground surface (2) perpendicular to the ground surface (3) parallel to the ground surface (4) a flat surface (5) not present
66. Which of the following does not affect porosity?  
(1) grain size (2) grain shape (3) sorting (4) cement (5) packing
67. Deposition of calcium carbonate in caverns forms icicle-like deposits of:  
(1) sandstone (2) dolostone (3) dripstone (4) claystone (5) whetstone
68. In a humid climate, which of the following would be most likely to develop caves or caverns?  
(1) sandstone (2) shale (3) granite (4) lava (5) limestone
69. The capacity of a rock to transmit a fluid is called its  
(1) transmissibility (2) capacity (3) porosity (4) miscibility (5) permeability
70. An erosional feature of glaciers is the  
(1) outwash plain (2) lateral moraine (3) erratic (4) kame (5) rock knob
71. The crack or opening between the glacier and the back wall of the cirque is the  
(1) crevice (2) sinkhole (3) crevasse (4) bergschrund (5) iceberg
72. The term used to distinguish unstratified glacial material from stratified:  
(1) drift (2) debris (3) till (4) outwash (5) gravel

73. The feature most likely to be found at the glacier origin is the  
(1) cirque (2) terminal moraine (3) lateral moraine  
(4) paternoster lake (5) kettle lake
74. In mountain glaciated regions one would expect to find:  
(1) kettles (2) outwash plains (3) drumlins (4) tarns  
(5) eskers
75. Granular ice crystals created from snow are called  
(1) aretes (2) ice sand (3) firn (4) till (5) sleet
76. The furthest feature from the glacier origin would be  
(1) outwash (2) terminal moraine (3) kames (4) kettles  
(5) ground moraine
77. The largest world area is occupied by  
(1) continental glaciers (2) piedmont glaciers (3) valley glaciers  
(4) mountain glaciers (5) Alpine glaciers
78. A depositional feature of glaciers is the  
(1) arete (2) hanging valley (3) truncated spur (4) erratic  
(5) horn
79. A tarn would most likely be associated with a:  
(1) col (2) cirque (3) bergschrund (4) rock knob (5) drumlin
80. A number of alluvial fans along a mountain front may coalesce to form a  
(1) ventifact (2) playa (3) pediment (4) bahada (5) bolson
81. Buff, unstratified deposits of small, angular, dust-sized fragments believed to have been deposited by the wind are called  
(1) siltstone (2) desert pavement (3) longitudinal dunes  
(4) varves (5) loess
82. Small, isolated desert peaks representing erosional remnants of an old age surface are called:  
(1) monadnocks (2) bahadas (3) ventifacts (4) pediments  
(5) inselbergs

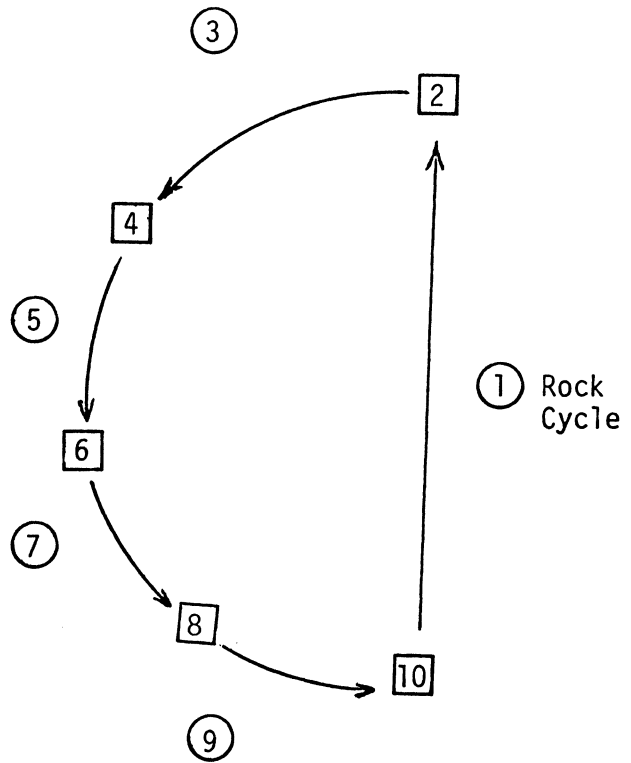
83. A stone faceted by wind abrasion is:  
 (1) desert pavement (2) inselberg (3) ventifact (4) pediment  
 (5) blowout
84. A temporary stream is referred to as (a):  
 (1) playa (2) perennial (3) pediment (4) intermittent  
 (5) ventifact
85. A dry lake bed in a desert basin:  
 (1) badlands (2) playa lake (3) playa (4) bahada (5) steppe
86. The most important erosive force in the desert is:  
 (1) orogenic factors (2) running water (3) wind (4) avalanche  
 (5) snow
87. Topographic deserts are caused by the presence of:  
 (1) circulating winds (2) landform barriers (3) nearby water  
 (4) counterclockwise air movements (5) the tropical low pressure  
 system
88. Chemical weathering is not very effective in deserts because of:  
 (1) frost action (2) low night time temperatures (3) lack of  
 vegetation (4) flash floods (5) lack of moisture

MATCH: Answers may be used more than once.

89. final period of the Paleozoic (1) Mississippian  
 (2) Tertiary
90. immediately follows the Devonian (3) Cambrian  
 (4) Triassic
91. middle period of the Mesozoic (5) Permian  
 (6) Silurian
92. earliest period of the Cenozoic (7) Cretaceous  
 (8) Quaternary  
 (9) Jurassic  
 (10) Pennsylvanian

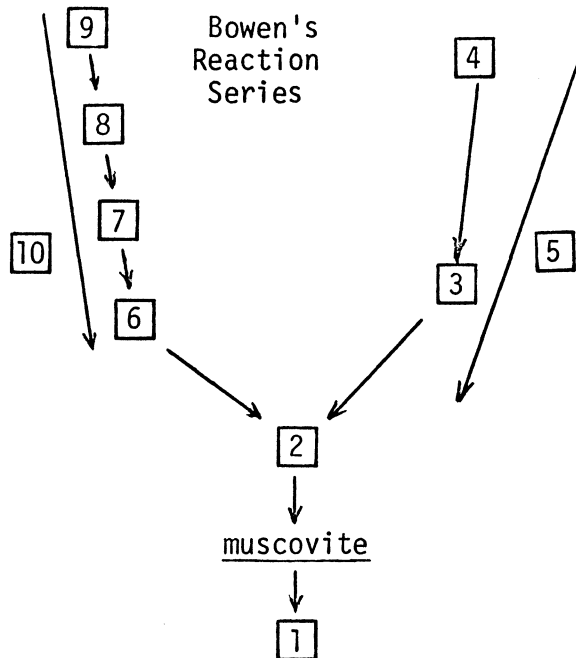
MATCH each term below with the correct number on the diagram of the rock cycle.

- 93. Igneous rocks
- 94. metamorphism
- 95. sediments
- 96. weathering and erosion



MATCH each mineral with its correct location on the diagram of Bowen's Reaction Series.

- 97. quartz
- 98. orthoclase
- 99. Ca plagioclase
- 100. olivine



## APPENDIX F

## P R O C L A M A T I O N

## Geology 101 and 102

## Physical Geology

R. G. Miles - 208 Anderson  
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Fall 1974 - Winter 1975

## TEXT: (101 &amp; 102)

Longwell, Chester, Richard Foster Flint, and John E. Sanders. Physical Geology, New York, John Wiley and Sons, Inc., 1969.

## LABORATORY MANUAL: (101 &amp; 102)

Hamblin, W. K. and J. D. Howard. Physical Geology, 3rd ed., Minneapolis, Minnesota, Burgess Publishing Company, 1971.

## OBJECTIVES:

A list of instructional objectives will be presented at the beginning of each chapter. These objectives, whether in outline or sentence form, will constitute those terms and concepts for which the student will be responsible. Test and exam questions will be drawn exclusively from these lists. You do not therefore have to "psych-out" the instructor but will be informed in advance of the material on which you will be tested.

The general education objectives of this course are:

1. Develop an appreciation of the role of geology in society.
2. Become better equipped to understand and evaluate environmental problems.
3. Acquire an understanding of the structure and composition of the earth and of the agents and processes that affect and have affected it, that mold and shape it, and that constantly destroy and renew it.

4. Sharpen individual powers of observation and interpretation.

#### CLASS PROCEDURES:

##### Lecture:

The class meets three times per week for lecture, during which the scheduled topics will be discussed by the instructor. Class participation is encouraged and it is strongly recommended that the appropriate material be read before coming to class. This includes the reading assignments on reserve in the library. These will be referenced on the weekly listing of objectives.

##### Laboratory:

The laboratory will meet once a week per section for three hours. Completed lab exercises must be turned in or exhibited to the instructor (as appropriate) before final departure. Be sure to check the schedule and bring any necessary accessories to lab.

#### TESTS:

As shown on the schedule, lecture tests will be given at approximately two-week intervals, usually at the beginning of the next class meeting following completion of the material. Tests will average 20-30 questions and will consist of multiple choice, matching, and short answer questions.

A final examination over all lecture and laboratory work covered during the quarter will be held at the last laboratory session of the quarter. The exam will consist of two parts, lecture and lab, and will be similar in format to the tests, except longer. Unexcused failure to take the final exam may result in an F for the course.

#### GRADES:

The final grade will be composed of the following:

Weekly test average	50%
Laboratory average	25%
Final examination	25%

Grades will be determined according to the following scale:

A	= 91 - 100%
B	= 81 - 90
C	= 71 - 80
D	= 61 - 70
F	= Below 61

#### NOTES:

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THE EFFECT OF BEHAVIORAL AND NON-BEHAVIORAL OBJECTIVES  
ON ACHIEVEMENT IN INTRODUCTORY COLLEGE GEOLOGY

by  
Roy G. Miles

(ABSTRACT)

The primary purpose of this study was to test the relative effectiveness of behavioral and non-behavioral objectives. The behavioral objectives attempted to specify to the student what was to be learned and how such learning was to be demonstrated. The non-behavioral form, called outline objectives, consisted of listings of terms and concepts in hierarchical groups.

A second purpose was to assess the attitudes and preferences of the subjects with respect to types of objectives.

Sixty-two students in four introductory geology classes were used as subjects. Two intact classes were randomly assigned to an experimental group (32 students) and two to a comparison group (30 students). Multivariate Analysis of seven demographic variables (age, high school rank, geology pretest, I.Q. score, vocabulary, comprehension, and reading rate) was used to establish the equivalence of both groups.

Throughout the first quarter the experimental group received weekly units of behavioral objectives whereas the comparison group received weekly units of outline objectives. Subjects were tested at approximately two-week intervals and were given a comprehensive

final exam.

Analysis of Variance showed that the experimental group achieved significantly higher on two tests. Differences on all other tests were in favor of the experimental group but were below the 0.05 level of significance. Multivariate Analysis indicated that the overall achievement of the experimental group was significantly higher than that of the comparison group.

During the second quarter, all students were exposed to both types of objectives. An attitude scale administered to assess student preferences revealed almost unanimous support for the use of objectives. Given a choice of behavioral or outline objectives, a majority of subjects indicated a preference for the outline form and appeared to view the outline form as significantly more useful.

It was concluded that the use of behavioral objectives was supported by this study but that students seemed to prefer the outline form. Further research should focus on the development of more effective variations of objectives and on case studies to determine which individuals make most efficient use of each type of objective.