Name: Richard A. Tubb Date of Degree: May 26, 1960

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: LEARNING EXPERIENCES IN THE EARTH SCIENCES

Pages in Study: 28 Candidate for Degree of Master of Science

Major Field: Natural Science

Scope and Method of Study: Many secondary schools lack money for equipment to study the earth sciences. Inexpensive demonstrations and experiments can be constructed, and the facilities nature provides can be used to overcome this handicap. The possibility of using simple inexpensive, improvised equipment in the areas of geology, meterology, and astronomy, was explored. The study was aimed at providing resources in these areas for the seventh to tenth grade levels, and to provide a guide for further learning experiences.

Findings and Conclusions: The use of simple improvised equipment appears to have several advantages. Complex equipment often obscures the purpose of the demonstration or experiment. The student gains a valuable learning experience from constructing simple equipment. The student may also be encouraged to perform scientific experimentation outside of the classroom. The principal disadvantages are the time used in the construction of apparatus, and the lack of accuracy obtained from improvised equipment. The lack of accuracy is not great in most cases and the illustrations of basic concepts do not appear to be diminished by these errors.

ADVISER'S APPROVAL James H. Zant

LEARNING EXPERIENCES IN THE EARTH SCIENCES

By

RICHARD ARNOLD TUBB

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1958

Submitted to the faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1960

LEARNING EXPERIENCES IN THE EARTH SCIENCES

Thesis Approved:

Thesis Adviser

Dean of the Graduate School

ACKNOWLEDGMENT

The author would like to express his appreciation to Dr. James H. Zant for his counsel and constructive criticism of this report. The writer is indebted to Dr. V. B. Monnett and the Geology Department of Oklahoma State University for their cooperation in the writing of this manuscript.

Finally a word of appreciation to my wife, Farl, for typing this report.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

Introduction

The alert and effective science teacher is constantly confronted by problems. One of the most common problems facing him is how to present or enrich the scientific topics under consideration. If the teacher limits himself to the use of the blackboard, textbook, and charts, the science course becomes dull or uninteresting.

For the student to appreciate verbal descriptions of scientific phenomena and statements of scientific principles, he must have realistic experiences involving these concepts. Students vary in their abilities to learn from words. The teacher can aid the learner by providing demonstrations and experiments so that the student can observe the reality behind the words. In some cases the visual approach is almost a necessity if the students are to gain much from science instruction.

The demonstrations and experiments necessary for teaching elementary and secondary students in the earth sciences and biology need not contain expensive and complex equipment. Complex equipment oftens obscures the purposes of the experiment, and money is not always available. Nature has provided a marvelous laboratory which is available to all. It is the problem of the teacher of how best to take advantage of these facilities.

Many experiments and demonstrations may be suggested by the students. Devising and constructing the apparatus necessary to carry out these experiments can be a worthwhile activity in problem solving and the application of the scientific method of approaching a problem. The teacher should have another source of demonstrations and experiments which are available to him. Although the literature abounds in such material, much of it is unreliable, not suited to the teacher's need, or materials required to perform the experiments are not available. The purpose of this report is to collect a series of learning experiences which will aid the science instructor in presenting some of the fundamental concepts found in the earth sciences with a minimum of equipment.

No attempt has been made by the author to classify these demonstrations into grade levels of instruction. Since elements of the earth sciences are taught in the elementary school, some of the demonstrations can be used at this level. For the most part these demonstrations are intended for use from the seventh through the tenth grade levels.

Many technical terms have been omitted from this report so that the student can make use of this report. After the student finds that scientific experimentation can be carried out without expensive equipment, it is hoped that he will be encouraged to carry out experimentation outside the classroom.

No claim of completeness is made for this report. Since different aspects of the earth sciences are stressed in different secondary schools, it was difficult to decide what to include. It is hoped that this source of learning experiences and materials will serve as a guide to the teacher and the student in devising their equipment and experiments.

CHAPTER II

Demonstrations and Experiments for the Study of the Earth

The impact of a raindrop can be shown by using a medicine dropper, a saucer partially filled with dirt and a piece of paper. Place the saucer containing the dirt on the paper. Fill the medicine dropper with water and hold it about one yard above the saucer. See how much soil is splashed out on the paper. Then see how much soil is removed after placing an obstacle in the path of the drop. How does vegetation aid in preventing erosion?[1]

To illustrate the formation of buttes and mesas, punch a series of small holes in the bottom of a coffee can. Fill the can with loose dirt and place a few coins on top of the dirt. Sprinkle the dirt with water. As the dirt is washed away the area protected by the coins will appear as small flat-top mounds. What might be one reason these flat-top mounds do not usually occur in a wet climate?

A model to show the erosional effects of running water can be easily constructed. Two wooden trays, as shown in Figure I, are made watertight by sealing the corners with a caulking compound or putty. A small screen should be tacked over the open of the tray and the tray filled with soil. A bucket or a glass jar will serve to catch the run-off water. Sprinkle the soil with water and

---

[1]UNESCO Source Book for Science Teaching, (Paris, 1956), p. 62.

observe the rate of erosion. A comparison of the erosional rates of a tight clay soil and a loose sandy soil may be made. The trays may also be tilted at different angles and the rates of erosion observed. The effect of vegetation upon erosion may also be observed by covering one tray with sod, and leaving soil of the other tray bare.[2]

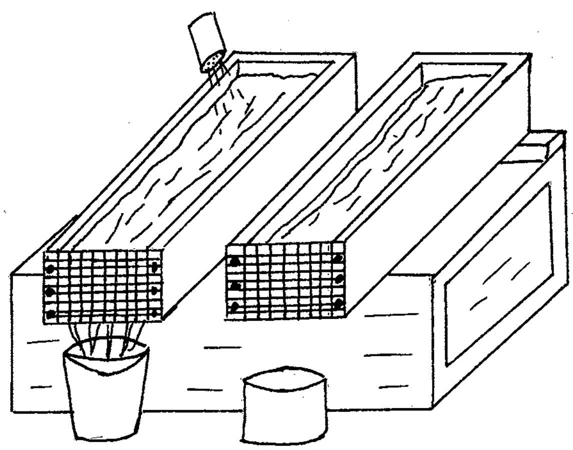

FIGURE I

A model to show geological faulting can be made from scrap pieces of plywood. Glue several pieces of plywood together to form a block. The pieces of plywood need not be of the same thickness, since they serve to illustrate geological formations. Saw the block at a 60 degree angle to the horizontal. Various types of faulting can be shown with this model, and simple problems involving the use of the 30 degree right triangle may be solved.

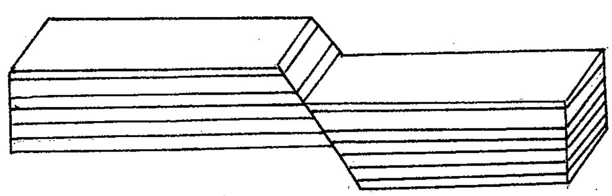

FIGURE II

---

[2]Ibid., p. 63.

The folding of geologic formations may frequently be caused by horizontal compression. An easily constructed primary couple can clearly illustrate these forces. A square frame made from scrap lumber and hinged at the corners is covered with rubber from an innertube. A thin veneer of modeling clay or wax is then spread across the rubber sheet. The frame is then subjected to a couple (Figure III). The axis of these folds will make an angle of 45 degrees to the direction in which the couple is acting.[3]

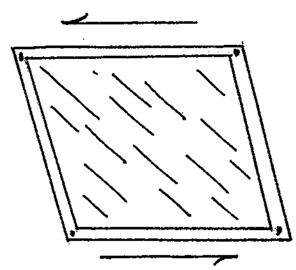

FIGURE III

A miniature geyser that erupts intermittenly can make a very striking demonstration. To make it, cut a piece of tin or galvanized iron 26 to 30 inches long and form in the shape of a trapizoid 1.6 inches wide at one end and 9 inches wide at the other end. Roll the trapizoid in the shape of a cone and solder the joints. A small disk is soldered at the base of the cone. Close the upper end of the cone with a short brass rod through which a 1/4 inch hole has been drilled. The cone should be watertight except for the 1/4 inch opening. The lid of a garbage can minus the handle can serve as a catch basin,

---

[3]Marland P. Billings, Structural Geology, (New York, 1947), pp. 94-95.

and reservoir. Solder the upper end of the cone into a hole cut in the basin making sure there is a good tight fit. The braces of heavy wire or iron are attached to the sides of the cone and the basin. Support the miniature geyser by means of a ring stand and clamps. Add the water to the cone. It is necessary to make several trials to find the amount of water necessary. The outside of the cone should be insulated with asbestos paper or some suitable insulating material. Heat is then added at the base of the cone by means of a bunsen burner.

As the apparatus is heated the vapor pressure rises until the water boils. As the water boils the aperture becomes filled with water vapor, this stops the escape of steam causing a pressure to develop beneath the liquid and forcing it out in a stream. The water is cooled in the air and then runs back into the cone and another eruption occurs in a few moments.[4]

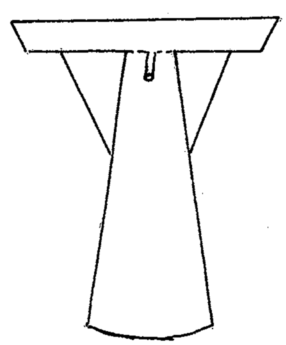

FIGURE IV

---

[4]J. O. Frank and G. J. Barlow, Mystery Experiments, (Oshkosh, Wisconsin, 1945), pp. 108-109.

A pie tin, three 12 inch dowels, a steel ball, and a piece of adhesive tape are all the materials necessary to construct a Foucault pendulum. The three dowels form a tripod which supports the pendulum. The legs are braced against the inside of the pie tin, and the steel ball hangs by a thread from the apex of the tripod. The adhesive tape serves to mark the plane in which the pendulum is released. After a few hours the plane of the pendulums swing will appear altered. This is caused by the spinning of the earth which is turning under the pendulum like the turntable of a phonograph.[5]

A dip needle may be constructed by using a metal knitting needle, a small wire, a piece of rubber tubing, and a small cardboard stand to which a plastic protractor is glued. The angle of dip is read directly. The rubber tubing is placed about the knitting needle and a short pin which has been softened over a flame is pushed through the tubing. After adjusting the rubber tubing so that the needle is suspended horizontally, the needle is magnetized by placing it in a magnetic field. The needle is then replaced on the stand. The pin must be bent to alter the relative positions of the center of gravity and the axis of suspension.[6]

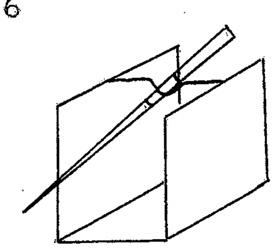

FIGURE V

[5]John S. Richardson, Science Teaching in Secondary Schools, (Englewood Cliffs, New Jersey, 1957), p. 267.

[6]J. A. Lanwerys, The Science Master's Book, Part IV, Series III, ed. L. J. Rowe and R. J. Bartle, (London, 1956), pp. 128-129.

To illustrate the magnetic field of the earth and its effect upon a compass, the following materials are required: a large round bottomed glass flask about 16 inches in diameter, a cobalt chrome bar magnet which is 7.5 centimeters in length, an inexpensive compass, two corks and a cementing compound. The round flask represents the earth. With a crayon, mark two great circles on it at right angles to one another. One of these circles represents the 0 and 180 meridians and the other represents the 90 E and 90 W meridians. A line representing the equator should also be marked.

The magnet is placed in a slot cut in the cork. The magnet should be tilted at an angle to the geographical poles. The poles of the magnet should be clearly marked. The cork is then attached to a small wooden pole and the magnet placed inside the flask. The rod should be turned until the magnet lies in the plane of the 0 and 180 meridians. As the compass is moved over the surface of the flask,

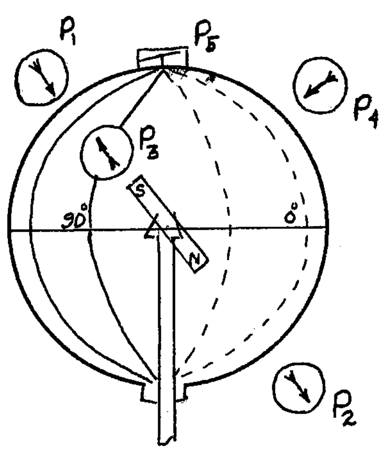

FIGURE VI

the variation should be zero along these meridians, except between the magnetic and geographic poles where it will be 180 degrees.[7]

In Figure VI, P_1 and P_2 show the magnetic poles. P_4 and P_5 show the angle of dip caused by the magnetic field. P_3 shows the variation on the 90 degree meridian.

Students are always interested in fossils. In many localities fossils are abundant. Sedimentary rocks are the best source of fossils, particularly limestones. Shales frequently contain fossils, but sandstones are generally poor places to look for fossils. If the community does not contain any fossils, a letter to the state museums may prove helpful.

A collection of fossils is an interesting addition to the school museum. To be of any real value the fossils should be mounted and labeled. This label should include their identification, where they were collected, and who collected them. Many interesting facts about the geologic history of one's community can be learned from a study of these fossils.

The value of field trips should not be underestimated. A short field trip can be used to illustrate many processes of erosion, earth movements, and the changing face of the landscape. These field trips do not have to be long. The school playground, city park, or an open field will usually show some erosional features.

---

[7]W. Llowarch, The Science Master's Book, Part I, Series III, ed. G. H. J. Adlam, L. R. Humby, and G. N. Pingraff, (London, 1957), pp. 163-165.

CHAPTER III

Identification of Rocks and Minerals

The complete identification of rocks and minerals is beyond the scope of this report. There are some 2000 different minerals, of this number there are some 70 commonly occurring minerals. The author has considered only 15 of the most important of these minerals. These 15 minerals go together to make up the 23 rock groups considered. Most of these rocks and minerals can be found locally or they are inexpensive to purchase. A list of firms which supply them is included at the end of the chapter.

The methods used to identify these rocks have been simplified, but all of the methods set forth are common techniques used in making a megascopic identification. Although a 10X hand lenses is desirable it is not necessary. The key to the identification of any rock or mineral is careful observation of details.

A mineral is a natural occurring inorganic substance with a definite chemical composition, usually possessing a definite crystalline structure and having characteristic physical properties.[1] It will be noted that coal and petroleum do not fit into this classification, even though they are commonly referred to as minerals.

---

[1] Edward H. Kraus, Walter F. Hunt, and Lewis S. Ramsdell, Mineralogy, (4th ed., New York, 1951), p. 6.

In most cases minerals may be easily identified by their physical characteristics. In some cases a more careful observation than will be considered here may be necessary, and in a few rare cases a chemical analysis may be required. The basic properties of minerals considered in this report are (1) color, (2) streak, (3) cleavage and fracture, and (4) special features.

Some minerals have a distinctive color which sets them apart and makes identification simple. Galena has a distinct lead-gray color, and pyrite has a brassy-yellow color. Some minerals such as quartz, have a wide range of colors, but color is still an important characteristic in identifying minerals.

The streak is another important criteria in identifying a mineral. The streak is the color of the mark a mineral makes on unglazed porcelain.[2] The streak for any one mineral is always the same.

The relative hardness of a mineral is an important characteristic making an accurate identification. In most cases the hardness of a mineral is compared to a group of minerals of a definite hardness. The relative hardness values of these minerals range from one to ten. Since these minerals of a standard hardness may not be available, their approximate hardness may be approximated by using the following materials: the fingernail with a hardness of to 2.5, a copper penny up to 3, a knife blade up to 5.5, window glass 5.5, and a steel file from 6 to 7.[3]

---

[2]Ibid., p. 99.

[3]Ibid., p. 100.

Cleavage and fracture are frequently very conspicuous and highly characteristic. This is the ability of a mineral to split along definite planes.[4] Galena cleaves in three planes which are at right angles to each other. The micas (biotite and muscovite) cleave in only one direction. In some minerals cleavage is obscure and hard to determine, and in others it is completely absent.

In addition to the physical characteristics already mentioned some minerals have special features. All of the minerals have a specific gravity. This may help identify the mineral. Those minerals which feel heavier than the others contain heavy elements such as iron and lead making them easy to identify. Magnetite has the interesting property of being able to attract a magnet, and a drop of dilute hydrochloric acid placed on calcite causes an effervescence.

The use of a chart to aid in identification is a common practice. Figure VII shows how this identification can be carried out after the physical properties of a mineral have been determined.

"A rock is a composition of two or more minerals."[5] Unlike minerals, rocks do not have a definite chemical composition. For example, the common occurring granite is composed primarily of feldspar, quartz, and mica. Sandstone and quartzite are composed principally of quartz. Marble and limestone have calcite as their main constituent. Thus a knowledge of minerals is a great aid in identifying rocks.

---

[4]Ibid., 103.

[5]G. W. Tyrrell, The Principles of Petrology, (London, 1926), p. 7.

Mineral	Color	Streak	Hardness	Cleavage
Gypsum	White or Colorless	White	2	Fibrous
Massive Gypsum	White to Pink or Red-Brown	White	2	None
Quartz	Wide range of colors	White	7	None
Muscovite(Mica)	White or uncolored	White	2-3	1-perfect
Calcite	White to Yellow	White	3	3-perfect
Feldspar	Pink to Dark Green	White	6	2 at 90 degrees
Chert (Flint)	White	Yellow to Brown	7	None
Biotite (Mica)	Dark Brown to Black	White	2.5-3	1-perfect
Hematite	Dark Red to Brownish Red	Red-Brown	3-6	None
Sphalerite	Brownish Red to Yellowish Red	Yellowish-White	3.5-4	6-good
Garnet	Rose Red to Dark Red	White	6.5-7.5	None
Limonite	Yellow-Yellowish Brown	Yellow-Brown	Variable	None
Pyrite	Brass-Yellow	Black	6-6.5	None
Flint (Chert)	Black	White	7	None
Hornblende	Blackish Green to Dark Green	Grayish-Green	5-6	None
Galena	Lead Gray	Lead Gray	2.5	3 at 90 degrees
Magnetite	Iron Black	Black	5.5-6.5	None

FIGURE VII

Geology Laboratory Manual, Oklahoma State University, (Stillwater, Oklahoma), 1959, p. 3.

Rocks are placed into three classes: (1) igneous, (2) sedimentary, and (3) metamorphic. A knowledge of the origin of these rocks will aid in their identification and likewise their identification aids one in learning about the geologic history of a region.

As molten rocks cool and solidify, igneous rocks are formed. Granite, basalt, obsidian, pumice, and scoria are of this type. As soon as these rocks are formed they begin the process of erosion, or of being worn away. Many of these erosion products are carried away by the action of wind, water, and glaciers. Later they are deposited as sedimentary rocks. Such rocks as sandstone, shale, and limestone are of this type. The sedimentary and igneous rocks may be changed in appearance by the action of heat and pressure. These rocks are known as metamorphic rocks. Some of these are marble, slate, and quartzite.

Igneous rocks are classified by three characteristics: (1) texture, (2) color, and (3) mineral composition.[7] The texture refers to the relative size of the minerals which compose it. If the magma from which the igneous rock formed cooled slowly, the mineral particles can be seen without the aid of a magnifying glass, and the texture is course. If the magma cooled rapidly the texture will be fine and the individual mineral particles cannot be seen without a magnifying glass. At times the lavas may cool so rapidly that they take on a glassy appearance, and their texture is termed glassy. Lavas also contain many gases. These gases often fill the lavas with holes.

---

[7]Ibid., pp. 106-107.

These holes are called vesicles, and the texture is vesicular.[8] If the cooling rate of the magma changes from slow rate of cooling to a faster rate, some large crystals surrounded by a fine texture will be observed. Such a texture is called porphyritic, and the rock is called a porphyry.[9]

The color of a rock is determined by the minerals which form the rock. These may be roughly divided into two groups, light and dark colored. Only those rocks which are dark green or black are placed in the dark colored group.

The minerals which compose a rock are not always easy to determine, but they are the final criteria in naming a rock.[10] Since identification of the fine textured rocks is rather difficult, these may be placed in a general group of rocks known as felsites. Basalt, a black, fine textured rock is the only exception in the group of rocks under consideration.

In using the chart, Figure VIII, the texture should be determined first and then the color. After a careful observation of the minerals contained in the rock it may then be classified.

All rocks may be broken down by chemical or mechanical means. After these rocks have been broken down by processes of erosion, they form sediments. When these sediments become cemented together they form sedimentary rocks. Those sedimentary rocks that have been

---

[8]Geology Laboratory Manual, Oklahoma State University, (Stillwater, Oklahoma, 1959), p. 6.

[9]Ibid.

[10]Tyrrell, p. 104.

	Light Colored		Dark Colored	
	White or Pink Feldspar		Light Gray to Dark Feldspar	
TEXTURE	Quartz Present	Quartz Absent	Quartz Absent Gray Feldspar	Quartz Absent Dark Feldspar
Coarse	Granite	Syenite	Diorite	Gabbro
Fine	Felsite			(Black Color) Basalt
Porphyritic	Felsite Porphyry			Basalt Porphyry
Glassy	Obsidian (Black or Brown)			
Vesicular	Pumice			Scoria

FIGURE VIII

formed by a mechanical process are called clastics and those which have been formed by a chemical process are called non-clastics.

The clastic rocks contain fragments of the older rocks from which they were formed. The size of the individual particles determines the classification of clastic rocks. A conglomerate contains rounded pebbles which are larger than 1/8 inch in diameter. Some conglomerates have rounded particles the size of boulders. A breccia is composed of particles which are also greater than 1/8 inch in diameter which have been cemented together. While these particles are small they can still be seen without the aid of a magnifying glass. A shale contains the finest grains of all the clastics. It is formed by the compaction of mud and clay. The individual particles cannot be determined with the unaided eye.

The non-clastics sedimentary rocks are formed by chemical precipitation of material or deposited because of the actions of organisms. The most important non-clastics are gypsum, chert, and different varieties of calcium carbonate. Gypsum and chert are both minerals and rocks and have been covered with the minerals. Calcium carbonate occurs principally in three forms: limestone, travertine, and dolomite. These can be easily identified by their reaction with hydrochloric acid. When a small amount of hydrochloric acid is placed on a carbonate rock, a bubbling or effervescence takes place.

Travertine is a type of limestone which is found deposited in streams and caves. It usually has a banded appearance and has a color which ranges from a buff to gray. Dolomite differs from limestone, because of the magnesium it contains. When testing this rock with hydrochloric acid it is usually necessary to scratch it before effervescence will occur.

Metamorphic rocks are those which have been formed as a result of heat and pressure upon pre-existing rocks. Although the appearance of the rocks has been changed and their properties altered, the origin of metamorphic rocks is usually apparent. Quartzite is a former sandstone which has been changed by metamorphism. The cement which holds the rock together has become so resistant that when the rock is fractured it will break across the sand grains. Slate had its origin in shale. The shale was altered by heat and pressure causing it to become much more dense. Marble is a limestone or dolomite in which the crystals have been reformed. It still remains soft and reacts with hydrochloric acid. A schist is an igneous rock that has been altered in appearance. It appears to be made up of a series of irregular layers, and contains a large amount of mica. Gneiss is a course metamorphic rock which has a well defined banded appearance. The bands consist of light minerals alternating with dark colored minerals.

Geological and Mineral Specimen Suppliers:

Schortmann's Minerals
10 McKinley Avenue
Easthampton, Mass.

Ward Natural Science Establishment, Inc.
Rochester 9
New York, New York

Minerals Unlimited
1924 University Avenue
Berkley 3, California

CHAPTER IV

Demonstrations and Instruments for Studying the Weather

The air pressure may be measured within limits of about 10 percent by using a spring balance and a suction dart. The suction cup of the dart is moistened and placed against a smooth rigid surface. The spring balance is attached to the dart. The force required to pull the dart away is read directly on the balance. The area over which this air acts may be somewhat difficult to find, but rough measurements will give an adequate result for the level for which this demonstration is designed.[1]

A mercury barometer is easily constructed if materials are available. A 32 inch length of glass tubing is closed at one end by heating it in a flame. Mercury is then added slowly. If air bubbles are trapped, shake the tube slightly. Place about 3/4 of an inch of mercury in a dish or bottle. After filling the tube with mercury, place the thumb over the end of the tube and invert it in a dish of mercury. Secure the glass tube in place. A meter stick or yardstick allows one to make a barometric reading in centimeters or inches of mercury.

---

[1] Brian Holmes, The Science Master's Book, Part IV, Series III, L. J. Rowse and R. J. Bartle, (London, 1956), p. 30.

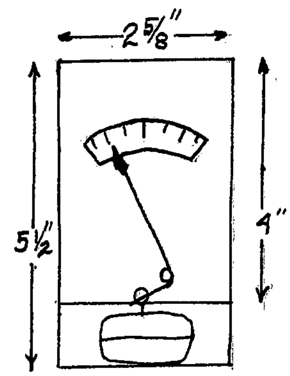

FIGURE IX

The framework of the barometer is made from light wood or cardboard. A can which contains a typewriter ribbon acts as the "reservoir". A small hole 1/16 inch in diameter is drilled in the lid. Place a small amount of water in the can and the lid is soldered on. After heating the can over a small flame quickly close the hole with a drop of solder. A short wire with a loop in the end of it is soldered to the can slightly off center.

The pointer is made of a stiff brass wire which is flattened at one end. The wire is bent twice around a pivot pin. The end of this brass wire is placed in the loop of the short vertical wire. A small piece of light wood or composition material placed in back of the pointer makes a firm hold for the pivot pin.[2]

An inexpensive anemometer for measuring the velocity of the wind may be easily constructed. Select two pieces of light wood

---

[2]Eric G. Brieze, The Science Master's Book, Part IV, Series III, ed. L. J. Rowse and R. J. Bartle, (London, 1956), p. 9.

about 20 inches long and 1/2 inch square. Cut a small notch 1/4 inch deep in each piece as shown in Figure X. Fit the two pieces together to form cross arms and drill a hole in the exact center of the cross arms. A small medicine tube is then mounted in the hole and held in place by cement.

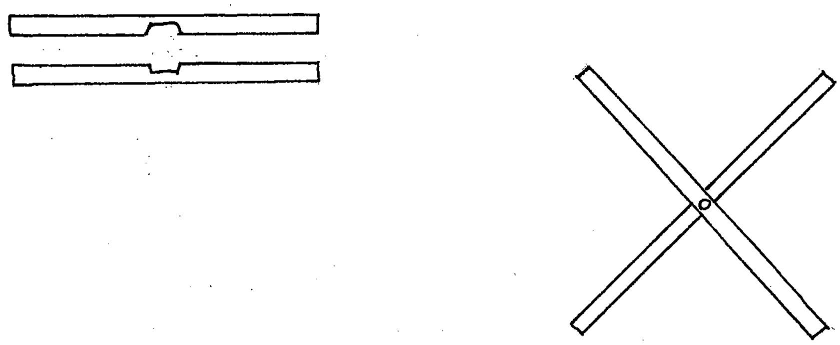

FIGURE X

Obtain two ball floats from a plumber and unsolder them to form four cups. These are then nailed to the end of the cross arms making certain the cups are all facing in the same direction.

A wooden rod with a sharp nail placed in the rod fits into the medicine tube so that the instrument is free to turn.

To calibrate the anemometer, choose a day when there is no wind or a very light wind. Slide the instrument out of the window of the car and record the number of turns it makes in 30 seconds at different speeds. These speeds should be about five miles per hour apart.[3]

---

[3]UNESCO Source Book for Science Teaching, (Paris, 1956), p. 87.

To find the relative amount of water in the air requires only the use of two inexpensive thermometers and a relative humidity table.

The two thermometers must be checked over a period of several days to see that they are in agreement. They are then mounted on a board so that they are about four inches apart. Wrap one of the thermometer bulbs in a piece of muslin cloth and place the other end of the cloth in a bottle of distilled water or rain water. Hang the board so that it will have free access to the air. Read both the thermometers and subtract the reading of the wet bulb from that of the dry bulb. Then use a relative humidity table to find the relative humidity. If you should read 30 in the table, this means that the atmosphere holds only 30 percent of the water vapor it is capable of holding at the dry bulb temperature.[4]

The dew point temperature is a frequent weather observation. It is the temperature at which the moisture in the air starts to condense. To measure this temperature, a shiny can, a thermometer, some water and ice are all that is necessary. The metal can must be dry and shiny enough to reflect the print of a newspaper or book. Place the water and thermometer in the can. Add the ice to the water a little at a time and stir with the thermometer. When dew begins to form on the outside of the can, read the thermometer and this will be the approximate dew point temperature.[5]

---

[4] Ibid., p. 88.

[5] Ibid., pp. 93-94.

The water cycle may be shown by heating some water until it nears the boiling point and placing it in a jar or drinking glass. A small florence flask or some other round bottom container filled with cool water is placed in the glass leaving some space between the hot water and the bottom of the container. As the water vapor evaporates from the jar it condenses on the round bottom flask and water droplets are formed which fall back into the jar as precipitation. The three important aspects of the water cycle - condensation, precipitation, and evaporation - are shown as they occur in nature.[6]

---

[6]Ibid., p. 93.

CHAPTER V

Demonstrations for the Study of Astronomy

A film strip projector representing the sun, a volley ball representing the earth, and a tennis ball representing the moon can be used to demonstrate the phases of the moon and eclipses. The projector should be placed as far away from the earth as practical. By viewing the moon from different angles the phases of the moon are clearly illustrated.[1]

The cause of the different seasons may be illustrated by using a tennis ball, a knitting needle, and a light source. Push the knitting needle through the ball to represent the earth's axis. Mark off a circle about 16 inches in diameter on a piece of cardboard. Hang an electric light in the center of the circle. Tilt the axis about 23 1/2 degrees and rotate the ball about the light. At each quarter turn observe the amount of light that falls in each hemisphere, the part of the ball that is always illuminated, and the position of the direct rays of the sun.[2]

---

[1]B. Nicholl, The Science Master's Book, Part IV, Series III, ed. L. J. Rowse and R. J. Bartle, (London, 1956), pp. 3-4.

[2]Vera Shields and A. E. Clyde, "Something New to Show the Change of the Seasons", The Science Teacher, XXII, (1955), pp. 245-246.

The effects the angle of the sun's rays has upon the amount of heat received by the earth, can be shown with a flashlight and a piece of cardboard. Holding the flashlight vertical, shine the light on the cardboard and draw a line around the edge of the spot. Now hold the flashlight the same distance from the cardboard but at different angles to compare the size of the spots. Which area receives the most heat from the flashlight?

On a clear night, point a camera at the north star. Leave the lens open for several hours. How can the arcs made on the photograph be explained?

A model sundial for simple experiments can be made from light wood or cardboard. The latitude of the place where it is to be used must be known. Knowing the latitude, the gnomon which casts the shadow, can now be made. Make a right triangle with the base angle equal to the latitude. Then glue the gnomon into position with the hypotenuse of the triangle pointing at the north star. The hours can then be marked off on the baseboard.[3]

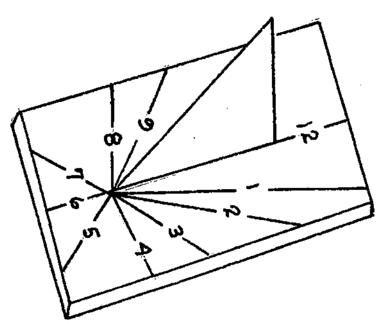

FIGURE XI

[3]UNESCO Source Book for Science Teaching, (Paris, 1956), p. 70.

An inexpensive astrolobe may be made from three inexpensive protractors, a drinking straw and some scrap lumber. The drinking straw is cemented to the base line of the protractor. The protractor is then fastened to a vertical wooden pole so that the protractor is movable. A plumb line should also be attached to insure that the pole is upright.

The base of the astrolobe consists of two protractors placed on a flat piece of wood, so that they form a circle. The vertical pole is then attached to the base by means of a screw. The pole should be able to rotate freely. A small washer placed between the vertical pole and the base will aid in its movement. A piece of wire or tin will indicate the angle on a horizontal scale.[4]

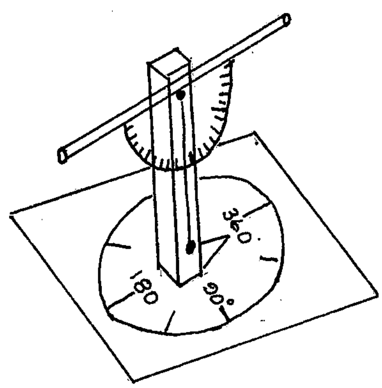

FIGURE XII

[4]Albert J. Read, "Teaching Aids in Astronomy", <u>The Science Teacher</u>, XXV, (1958), pp. 402-403.

VITA

Richard Arnold Tubb

Candidate for the Degree of

Master of Science

Thesis: LEARNING EXPERIENCES IN THE EARTH SCIENCES

Major Field: Natural Science

Biographical:

Personal Data: Born in Weatherford, Oklahoma, December 18, 1931, the son of James W. and Alberta Tubb.

Education: Attended grade school in Guthrie, Oklahoma; graduated from Classen High School, Oklahoma City, in 1949; received Bachelor of Science degree from the Oklahoma State University, with a major in Geology, in January, 1958.

Professional Experience: Received an honorable discharge from the United States Navy in September 8, 1955; instructed naval aviation cadets in simulated instrument flight; taught general science, biology and chemistry at Prague High School, Prague, Oklahoma, in 1958-1959.