APPENDIXES.

APPENDIX A. REVOLUTION OF THE EARTH.

1. Apparent Movements of the Sun. — In addition to the daily rising and setting of the sun there is a slower change in its position which can be detected by noting the point of sunrise or sunset for a week or two. In the north temperate zone, the sun rises exactly in the east and sets due west on March 21 and September 23. From March to September sunrise and sunset are north of true east and west, and the days are longer than the nights. But from September to March the sun rises and sets south of due east and west, and the nights are then longer than the days. The midday sun also changes in position. It is higher in summer than in winter, but is always in the southern half of the heavens. In the southern hemisphere the same changes occur in the opposite season; but there the midday sun is always in the northern half of the heavens.

2. Experiment to Illustrate Revolution. — One or two simple experiments will aid in a better understanding of the way in which revolution (p. 5) causes these apparent movements of the sun. Place two balls in a tub of water (Fig. 548), one in the center to represent the sun, the other off to one side to represent the earth. The water surface represents the *plane of the ecliptic*, or the plane in which the earth moves in its revolution around the sun. If the earth ball is moved around the central ball, its path will represent the orbit of the earth in its revolution.

A needle inserted in the earth ball represents the position of the earth's axis. When the ball is so placed that the needle projects straight up into the air, the axis of the ball is perpendicular to the water surface; if the axis of the earth were in a similar position, it would be perpendicular to the plane of the ecliptic. Now turn the earth ball until the needle is inclined as in Figure

548, which is the same angle as that at which the earth's axis is inclined. The earth is inclined 66½° to the plane of the ecliptic, or 23½° to a perpendicular from that plane.

Float the earth ball around the central ball, always keeping the needle axis inclined at the same angle, and you will see quite clearly in what position the earth moves around the sun.

Position 1 (Fig. 548), with the needle pointing *toward* the central ball, may represent the earth's position in summer when the North Pole points toward the sun. In the ball on the opposite side of the tub (3), the needle is inclined *away from* the sun ball, as the North Pole is in winter; but the other end of the needle, or, as we may call it, the South Pole, is then inclined toward the sun ball. Halfway between these summer and winter positions (2 and 4) the axis is inclined neither toward nor away from the sun. These points represent spring and autumn.

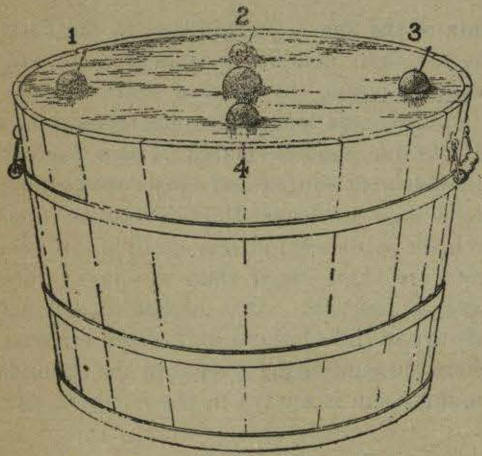

FIG. 548. — To illustrate revolution of the earth.

3. Rotation and Revolution. — The manner in which revolution causes the sun's position in the heavens to change may be understood by another simple experiment. Let a globe or ball represent the earth, and a lamp or candle the sun. Carry the globe in a circular path around the light, being careful to always keep the axis inclined at the same angle.

When the position is that of summer, the full rays of the lamp illuminate the northern half of the globe and reach beyond the pole. So in the case of the earth, when it has reached the summer position in its orbit, the sun's rays reach beyond the North Pole, and illuminate all the space within the Arctic Circle (Fig. 549).

This circle is located 23½° from the pole because the sun's rays of midsummer (June 21) reach that distance beyond the North Pole. They reach that far because this is the amount that the earth's axis is inclined.

Now rotate the globe, and you will see that all points within 23½° of the pole are lighted throughout the entire rotation. The same is also true of the earth. This makes it clear why, on the longest day, June 21, every point within the Arctic Circle has sunlight for the full 24 hours (Fig. 550).

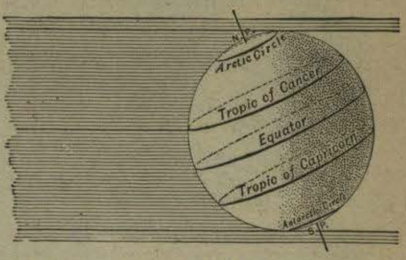

FIG. 549. — Position of the earth June 21.

Still holding the globe in this position, observe the conditions at the opposite end of the axis, or the South Pole. Even when the globe is rotated, no light reaches that portion. This is also true of the earth in summer, for then the midday sun just barely appears on the Antarctic Circle, 23½° from the South Pole. All within that circle is dark, even at midday.

Moving the globe to the opposite, or winter, position (3, Fig. 548), with the North Pole inclined away from the lamp, conditions are reversed. All is darkness within the Arctic Circle, while all within the Antarctic Circle is bathed in light (Fig. 551). This is the earth's condition in winter. Thus, each year as the earth revolves, there is a season of darkness and one of light around each pole.

FIG. 550. — The sun at midnight in the Arctic in summer when the region within the Arctic circle is lighted during the entire rotation.

If the globe is now placed in the position of spring or autumn (2 and 4, Fig. 548), the light will exactly reach each pole. The half of the polar region that faces the lamp is lighted, the half away from it is in darkness; but by rotating the globe the dark side is turned toward the light. When the earth reaches a corresponding position in its orbit, it is divided into a dark and a light half by a plane passing from pole to pole (Fig. 552). At these times, the *equinoxes* (equal nights), all over the earth day and night are each 12 hours long. One period is called *vernal* (spring) *equinox*, the other *autumnal* (autumn) *equinox*.

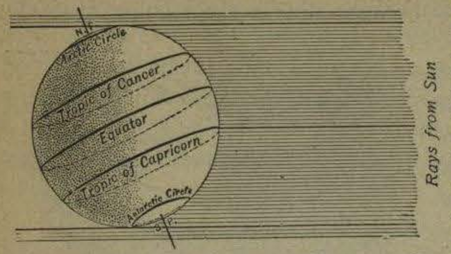

FIG. 551. — Position of the earth December 21.

During the equinoxes, when the sunlight just reaches each pole, the midday sun is directly above the equator. After December 21, in all parts of the earth, the sun appears to be slowly moving northward, and the sunlight slowly creeps over the curvature of the earth into the Arctic. After the earth has passed its summer position, the sun seems, from all points on the globe, to be slowly moving southward, and the sunlight is gradually withdrawn from the Arctic.

If the earth's axis were perpendicular to the plane of the ecliptic, there would be no such changes; but, since it is inclined, revolution turns one hemisphere toward the sun for a time, then away from it. These annual changes recur so regularly that, in all the time of human history, there has been no noticeable change.

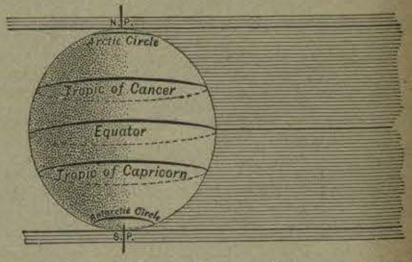

FIG. 552.—Position of the earth September 23.

SUGGESTIONS. — (1) Study Sections 2 and 3 at the same time that you are yourself performing the experiments described. (2) Make careful observations of the change in the sun from day to day. On a platform, or table, placed where the sun reaches it from morning till night, draw intersecting north-south (p. 419) and east-west lines. Where they cross drive a long knitting needle into the table. Once a week at noon mark on the north-south line the point to which the needle shadow reaches. Also mark the point reached by the shadow just after sunrise or just before sunset. What movements of the sun cause these changes? Observe also the exact place where the sun sets each week. (3) In what direction does your shadow point at noon? In what direction would it point in South Africa? At each tropic, in the middle of March, June, September, and January? At the equator? What is the direction of a shadow at noon in summer in the Arctic? At midnight? Are such shadows longer or shorter than in the temperate zone?

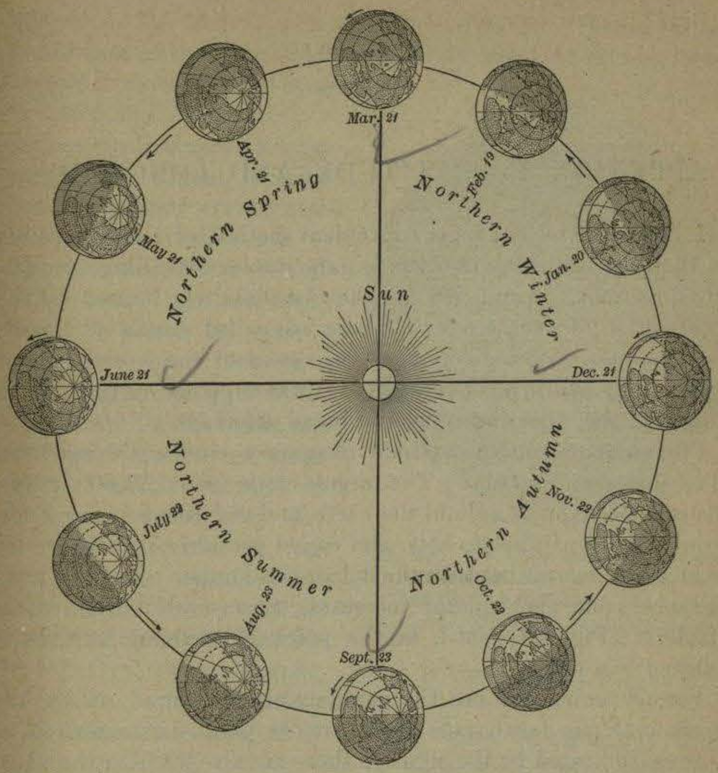

FIG. 553. — To illustrate the revolution of the earth around the sun.

APPENDIX B. LATITUDE AND LONGITUDE.

1. Latitude. — The most convenient method of locating points on the spherical earth is by imaginary circles extending in opposite directions. Any point can then be definitely located by the intersection of such circles. These are called circles of *latitude* and *longitude*, names given when the extent of the world was not known, and one direction (longitude) was supposed to be the long direction, the other (latitude) the broad direction.

For measurement of latitude imaginary circles are extended in an east-west direction. The largest circle (about 25,000 miles), the *equator*, extends around the earth midway between the poles. Other circles parallel to this, and called *parallels of latitude*, are located at intervals between the equator and either pole. As their distance from the equator increases, these circles diminish in diameter (Fig. 554) until, at the poles, a circle of latitude is reduced to a point.

For convenience in use the parallels are numbered. From the equator to the north pole there are 90 parallels, numbered as *degrees* (indicated by the sign °); there are also 90 from the equator to the south pole. The equator is called 0° latitude; the north pole, 90° north latitude (abbreviated N. Lat.); the south pole, 90° south latitude (S. Lat.). The Tropic of Cancer is 23½° N. Lat.; the Arctic Circle, 66½° N. Lat.; the Tropic of Capricorn, 23½° S. Lat.; the Antarctic Circle, 66½° S. Lat. Which parallel of latitude is nearest your home?

Since there are 180° from pole to pole there are twice that number, or 360°, in a complete circle extending around the earth across the poles. It is customary to divide circles into 360°. This is a convenient number because it is exactly divisible by so many numbers.

The length of a degree of latitude, that is the distance between two circles, varies slightly because the earth is not a perfect

sphere (p. 3). It is $\frac{1}{360}$ of the circumference. Divide the circumference of the earth (25,000 miles) by 360. At the equator a degrees is about 68.7 miles, at the poles about 69.4 miles.

FIG. 554. — To show how the meridians converge at the pole. Trace the 0° meridian to the opposite side of the globe. What is it numbered there?

On a small map of a large area, as a continent, it is impossible to draw every parallel, for the lines would be too close together. Accordingly, every fifth or tenth circle is placed on such a map. But for a map of a small section (Fig. 78) the degrees are too far apart, and additional circles are necessary. For this purpose degrees are subdivided into minutes (indicated ′), and minutes into seconds (indicated ″). There are 60 seconds in a minute of latitude, and 60 minutes in a degree. What is the latitude of your town in degrees, minutes, and seconds?

2. Longitude. — Circles of latitude serve to accurately locate places in a north-south direction; but there is need of location in an east-west direction also. Circles of longitude serve this purpose. These circles all start from the poles, broadening out toward the equator, and are therefore not parallel (Fig. 554). To them the name *meridian* is often applied.

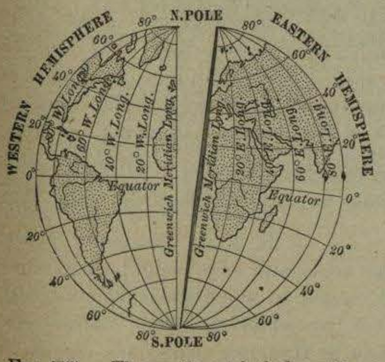

FIG. 555. — The earth cut in halves along the Greenwich meridian.

At the equator a degree of longitude is about equal to a degree of latitude (69 miles), being $\frac{1}{360}$ of the earth's circumference. In latitude 40°, which is a much smaller circle than the equator (Fig. 554), a degree of longitude, $\frac{1}{360}$ of that circle of latitude, is only about 53 miles. In latitude 60° a degree of longitude is about 34.7 miles; and at the poles, where all the meridians come together, a degree of longitude has no length.

The circles of longitude are numbered as degrees, there being 360 degrees. Since there is no such natural starting point as the equator, there is no general agreement as to where the numbering of meridians shall begin. Most nations, however, have adopted as the 0°, or *prime meridian*, the circle that passes through the Greenwich Observatory, just outside of London. From this meridian the circles are numbered up to 180° both east and west. New York is 74° W. Long. Jerusalem is 35° E. Long. What is the nearest meridian to your town?

Degrees of longitude are divided into minutes and seconds, as degrees of latitude are. What is the longitude of your home in degrees, minutes, and seconds?

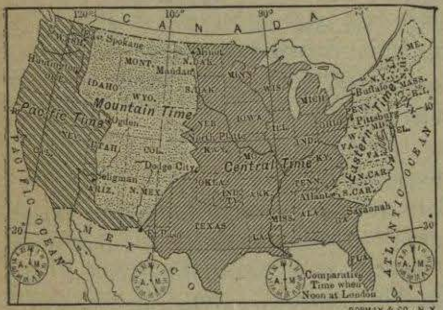

FIG. 556. — Map to illustrate standard time in United States. The meridians 75°, 90°, 105°, and 120°, extend through the middle of the four time belts. The irregular boundaries are due to the fact that railways have chosen convenient points on their lines to make the change.

3. Longitude and Time. — Rotation causes the sun to appear to pass completely around the earth in 24 hours. That is, it passes over 360° in 24 hours; and, dividing 360 by 24, we find that it passes over 15° in an hour. From this it is evident that places 15° apart will have just one hour's difference in time. Formerly, places in United States kept local or solar time, and even neighboring cities might have a different time. This caused so much inconvenience that it was agreed to adopt a *standard time*, by which the time changes one hour for every 15° of longitude. Now in traveling across the continent one need change his watch only three times (Fig. 556).

If longitude may be used to determine time, it is evident that time may be used to determine longitude. Ships crossing the ocean are able in this way to determine their position. They start with an accurate clock, or *chronometer*, set to Greenwich time. By means of an instrument, the *sextant*, an officer observes the sun to determine the local noon, that is, the time when the sun has reached its highest position. Comparing this local time with that of the chronometer, it is easy to tell just how many minutes' difference there is between Greenwich time and that where the ship is. Knowing that one hour's difference means 15° of longitude, the longitude of the ship is readily determined.

SUGGESTIONS. — (1) To understand the need of circles of latitude and longitude, try to locate New York City without these. Do the same by use of latitude and longitude. (2) By tying the ends of strings together make three circles so that one will fit over the equator of a globe, one over parallel 45°, and one over parallel 60°. Make three other circles for meridians and place them on the globe, one over 0° longitude, one over 60° west longitude, one over 120° west longitude. With ink, mark on each of the latitude strings the place where two of the meridians cross. Take the strings off, and measure the diameters of each. How do the diameters of the meridian strings compare with the equator string? How do the three latitude strings compare in diameter? Measure the distance between the ink marks made on the latitude strings. How do these distances compare? This shows how the length of degrees of longitude varies. (3) Get a local surveyor to explain and illustrate the method of determining latitude and longitude. (4) Recall your previous study of standard time (see Second Book of Tarr & McMurry's Geographies, p. 116). If the earth were flat, what would be the effect on time? To answer this, imagine a table top to represent the earth. Raise a lighted candle up to the edge to represent the rising sun. How much of the table do the rays reach at once? Is any more of the table reached as the candle is raised higher? Now, to represent part of the globular earth, place a curved object on the table top; for example, a large sheet of cardboard or blotting paper, resting on books or dishes. How much of this curved surface is lighted when the candle is raised? Is more lighted as the candle is raised higher?

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APPENDIX C. COMMON MINERALS AND ROCKS.

MINERALS

This appendix should be studied with an accompanying use of mineral specimens. Each mineral should be carefully examined to note its color, hardness, cleavage, luster, aud crystal form. The text may be referred to, but each student should have a set of specimens and be expected to find the features visible.

A MINERAL may be defined as a single element, or two or more elements chemically combined, forming a part of the earth's crust. Some, like sulphur, consist of one element; but most minerals are formed by a combination of several. For example, quartz is made of silicon and oxygen; one of the feldspars contains silicon, oxygen, aluminum, and potassium.

There are about 2000 known minerals, of which only one or two hundred are abundant, while less than a dozen are common in most rocks. The more important of the rock-forming minerals are described below.

1. Common Rock-forming Minerals. — *Quartz.* — This, the most common of minerals, is present in many rocks and soils. It is made of silicon and oxygen, forming silica (SiO_2). These elements are so firmly united that quartz does not decay; but it is slightly soluble in underground water. It has a glassy appearance, or *luster*, and varies in color from clear glassy to milky white, blue, rose-colored, red, and variegated. Agate, opal, jasper, and chalcedony are varieties of silica. It is so hard that it will scratch glass, but is brittle and easily broken, having a shelly or *conchoidal fracture*, like glass. When it crystallizes it takes the form of a six-sided (hexagonal) prism terminated by a six-sided pyramid.

The Feldspars. — There are a number of kinds of feldspar, each formed by the union of several elements, and all nearly as hard as quartz. Crystals are not common. *Cleavage planes*, extending through feldspar, cause it to break along smooth faces. Unlike quartz, feldspar is not soluble. When exposed to air and water, however, it decays, becoming dull and whitish; and, if exposed long enough, the hard mineral crumbles to a whitish clay, or *kaolin*. Many soils contain decayed feldspar, and some of the best pottery clays are kaolin. Thus, though insoluble and nearly as hard as quartz, its decay makes feldspar less durable.

Calcite (calcium carbonate), like quartz, varies greatly in color. It often has a perfect crystal outline; and since it has cleavage in three directions, when broken it is apt to take the form of a rhomb. It has a pearly luster. Unlike quartz and feldspar, calcite is so soft that a knife readily scratches it. Moreover, it is one of the most soluble of common minerals; and the cleavage planes afford opportunity for water to enter and dissolve the mineral. For these reasons a calcite rock is far less durable than one made of feldspar and quartz.

The mineral *dolomite* resembles calcite; but it is less soluble, and has a different chemical composition. Calcite contains calcium, carbon, and oxygen, and is, therefore, carbonate of lime ($CaCO_3$); dolomite has magnesium in addition, and is, therefore, magnesian carbonate of lime ($((CaMg)\ CO_3)$).

The Micas. — There are a number of different minerals belonging to this group, all having a complex chemical composition. Some are black, some colored, and some so colorless that they are used in stove doors as "isinglass." Two of the most common forms are *biotite* and *muscovite*, the former dark colored, the latter light. All are easily scratched with a knife, and all have so remarkable a cleavage that they readily split into thin sheets. Some micas decay readily; but others so resist decay that they occur as shiny flakes in soils and some rocks, such as sandstones and shales.

Hornblende is a black mineral of complex chemical composition, common in some granites and lavas. It is hard, has a bright luster, is often crystalline, and has well-defined cleavage. When exposed to air and water it decays, one of the products being an iron compound which stains the rock. Iron is one of the elements in this mineral.

Augite, found in many lavas, resembles hornblende in several respects, and in small grains is difficult to distinguish from it. Its chemical composition, crystal form, and the angle at which the cleavage faces meet are different, and the color is dark green instead of black. Like hornblende it decays readily.

Iron Ores. — Small quantities of iron are present in many minerals and rocks, and the yellow and red color of soils is due to iron stain. Among the iron minerals are several which are of value as ores.

Magnetite, a compound of iron and oxygen (Fe_3O_4), is black, hard, heavy, usually crystalline, and has a metallic luster. A magnet will attract the grains. *Hematite* (Fe_2O_3), another oxide of iron, is red and either earthy, crystalline, or in smooth, rounded masses. Like other iron ores it is heavy. The red coloring of soils is due to a hematite stain. *Limonite* is yellow, and common iron rust and the yellow color of soils are due to this mineral. It is an iron oxide with water, or a hydrous oxide ($2Fe_2O_3\ 3H_2O$). It is easy to determine an ore of iron by scratching it on a piece of white quartz, or of broken china. Magnetite gives a black streak, hematite red, and limonite yellow.

Siderite, the carbonate of iron ($FeCO_3$), is a heavy brownish mineral, resembling calcite in general appearance. *Iron pyrite*, or pyrites, the sulphide of iron (FeS_2), is not useful as an ore. It is a hard, heavy, golden yellow mineral, sometimes mistaken for gold, and hence called "fool's gold." It often occurs in perfect cubical crystals.

Gypsum, the sulphate of lime, occurs in small grains in many rocks, and sometimes in beds. It is so soft that it can be scratched with the finger nail; and, being soluble, is often present in "hard" water. The color varies, but is often white. Sometimes it is well crystallized, then having such perfect cleavage that it splits into thin flakes; but, unlike mica, the flakes are not elastic.

Minerals in Rocks. — The tables (pp. 410–413) show that the common rocks are made chiefly of the minerals described above. Other minerals, while abundant in some localities, are relatively rare in the rocks of the earth; but some of the rarer minerals, such as the ores of gold, silver, copper, etc., are of great value to man.

ROCKS.

2. Classification of the Common Rocks. — Rocks are mixtures of minerals, and are not usually of definite chemical composition. They may be classified in three great groups: —

(1) *Sedimentary rocks*, most of which were deposited in water; (2) *Igneous rocks*, which were once molten; and (3) *Metamorphic rocks*, which have been altered from some previous state by heat, pressure, and water. A few of the most common are described below.

3. Sedimentary Rocks. — *Fragmental or Clastic Rocks.* — By the disintegration of rocks, fragments of all sizes, from clay to bowlders, are detached. When assorted by water these are deposited in layers (p. 33), the pebbles forming *gravel beds*, the sand, *sand beds*, and clay, *clay beds*. Rock fragments may also be brought by glaciers, by wind, and by volcanic explosions, which supply ash and pumice. These fragmental, or clastic, materials may be cemented into solid rock by the deposit of mineral substances carried by underground water (p. 39).

Consolidated gravel beds, called *conglomerates*, are composed of whatever minerals were in the rocks from which the pebbles are derived. Consolidated sand beds, or *sandstones*, usually consist of small quartz grains, quartz being the most indestructible of common minerals. Some sandstones are well cemented and firm, others friable; and iron oxide cement often gives to them red, yellow, or brown colors.

A well-cemented sandstone or conglomerate, with much quartz in it, is one of the most durable of rocks, resisting denudation so well that it forms peaks and ridges, as in the Appalachians. Since quartz does not decay and produce plant food, as feldspar and many other minerals do, sandstones make poor soils.

Shale, the most common clay rock, varies in color from black to blue or light gray. Because of the presence of large numbers of flattened particles, often small mica flakes, it splits readily along the bedding planes. Shales split so easily, and are so soft, that they readily disintegrate, and among mountains are, therefore, usually found in the valleys. Soils produced by the decay of shale are much more fertile than sandstone soils.

Chemically formed Rocks. — The decay of minerals produces many substances which underground water dissolves. After being carried for a while, some may be deposited. For example, carbonate of lime is being deposited as *stalactites* in caverns (p. 60) and as *calcareous tufa* around the Hot Springs of Yellowstone Park (Fig. 243). On the coast of Florida and in Great Salt Lake it is also being precipitated in small, rounded, or *oolitic grains*

(p. 163). *Salt* is being deposited on marshes bordering Great Salt Lake and the Caspian Sea; and, by the drying up of salt lakes, as in western United States, *gypsum* has been precipitated. Deposits of silica around the geysers of Yellowstone Park form *silicious sinter* (Fig. 244); and *bog iron ore* is being accumulated where certain spring waters, on reaching the air, are forced to deposit iron. Underground water has deposited many veins of valuable metal in fissures in the crust (p. 132).

SEDIMENTARY ROCKS.

ORIGIN.	NAME.	COMPOSITION.
Fragmental or clastic rocks.	Gravel beds.	Made of pebbles derived from other rocks.
	Conglomerates.	Consolidated masses of pebbles.
	Sand beds.	Finer fragments, usually quartz grains.
	Sandstones.	Consolidated sand beds.
	Clay beds.	Disintegrated feldspar, hornblende, etc.
	Shale.	Consolidated clay beds, splitting readily.
Chemically formed rocks.	Stalactite, oolite, calcareous tufa.	Carbonate of lime, deposited in water.
	Iron deposits.	Some ores of iron, especially bog iron ore.
	Silicious sinter.	Silica deposited from water.
	Salt.	Sodium chloride.
	Gypsum.	Sulphate of lime.
Organic rocks.	Most limestones.	Carbonate of lime, made of shells, etc.
	Coal (bituminous, lignite, peat).	Made of plant remains.

Organic Rocks. — Carbonate of lime, dissolved in water, supplies many animals with materials for shells, or limy framework. Where such animals are abundant, as in coral reefs (p. 217), their limy remains often accumulate as thick beds of *limestone*. Many such beds have been raised to form part of the land. Limestone, being both soft and soluble, is worn away to form lowlands; and, since it is rich in plant food, it forms a fertile soil. This is illustrated in the broad, fertile limestone valleys which extend among the mountains of New England and New Jersey, and thence through the Shenandoah valley of Virginia to Tennessee. *Dolomite* is not so easily worn, and, when very massive, sometimes forms mountains. One very rugged section of the Alps is known as the Dolomite Alps.

Remains of plants accumulate in swamps, as in *peat* bogs (p. 168), where the water retards decay. When such swamp deposits have been covered with beds of other rocks, they gradually lose their water and gases, and change to *coal* (p. 170). The early stages of this change form *lignite*, later stages *bituminous* coal.

4. Igneous Rocks.—These rocks, which have risen in a melted condition from within the earth, have cooled either on the surface, as near volcanoes, or below the surface as *intruded* masses in the crust (p. 126). In the latter case, the overlying blanket of strata has allowed the lava to cool so slowly that the minerals have had opportunity to grow to fair size, giving these intruded rocks a coarse crystalline structure. In many places denudation has worn the surface down to these intruded igneous rocks.

Granite (Fig. 33).— Granite is the most common intruded igneous rock. Of what minerals is it composed (see table p. 412)? The structure is so coarse that the different mineral grains are plainly seen and easily distinguished. The color of granite varies according to the color of the feldspar, being commonly light and either gray, grayish green, red, or pink. It is a valuable building stone, and is one of the hardest and most durable of rocks, resisting destruction so well that, in the wearing down of mountains, it is commonly left standing as peaks.

Syenite, a coarse-grained rock, resembles granite, but has no quartz. Gabbro, norite, and anorthosite, found in the Adirondacks and in Canada, are hard, intruded igneous rocks, less common than granite.

Diorite and *Diabase* are dark-colored igneous rocks without quartz, the color being due to dark-colored minerals, especially hornblende, augite, and mica. Diabase, also called *trap*, is often so fine grained that the minerals cannot be distinguished without a microscope. The Palisades of the Hudson and the trap hills of New Jersey and the Connecticut valley are diabase.

Rhyolite, *trachyte*, *andesite*, and *basalt* (see table) are among the most common lavas erupted from volcanoes. The first two are light, the last two, dark colored. In most cases, erupted lavas have cooled too rapidly for the mineral grains to grow large enough to be distinguished by the eye alone; but large *porphyritic crystals* are often scattered through them, having been formed while the rock was still molten, then inclosed in the fine-grained mass, which quickly cooled when the lava reached the air.

Sometimes lavas cool so rapidly that they resemble black glass, and they are then called natural glass or *obsidian*.

A porous structure is given lavas by the expansion of steam, which forms cavities; and rapid expansion of the steam blows the lava into bits, forming *pumice* (Fig. 33) and *volcanic ash* (p. 122).

The ash from the Martinique eruption (p. 113) was andesite lava blown to pieces by steam; the lava of the Hawaiian volcanoes is basalt. Much of the country west of the Rocky Mountains is covered with basalt, andesite, and other lava rocks erupted from ancient volcanoes and fissures. These lavas, having many cavities for water to enter, and being made of minerals that decay readily, are soon covered with a fertile soil, for the minerals of lava are rich in plant food.

IGNEOUS ROCKS.

TEXTURE.	NAME.	CHIEF MINERAL COMPONENTS.
Coarse grained.	Granite.	Quartz, feldspar (orthoclase), and hornblende, or mica, or both.
	Syenite.	Feldspar (orthoclase) and either mica, or hornblende, or both.
	Diorite.	Feldspar (plagioclase) and either hornblende, or mica, or both.
Both coarse and fine grained.	Diabase.	Feldspar (plagioclase) and augite.
Fine grained.	Rhyolite (quartz porphyry).	Quartz, feldspar (orthoclase), and hornblende, or mica, or both.
	Trachyte.	Feldspar (orthoclase), and either hornblende, or mica, or both.
	Andesite.	Feldspar (plagioclase), and either hornblende, mica, augite, or two of these.
	Basalt.	Feldspar (plagioclase), and augite (often olivine).

5. **Metamorphic Rocks.**—Any rock subjected to great pressure, as in mountain folding, and to the action of heated water, is certain to suffer change or *metamorphism*. In sandstone, for example, silica may be deposited around the grains until the rock becomes almost one solid mass of quartz, called *quartzite*. Shale, when altered by metamorphism, changes to *slate*. New minerals are then developed, which have cleavage so perfect that the slate is caused to split, or cleave readily. By metamorphism limestone is changed to crystalline calcite, as in the case of white *marble*.

In the Appalachian Mountains (p. 109), coal has been metamorphosed to *anthracite*. In Rhode Island, where mountain folding was even more intense, coal has, in some cases, been changed to *graphite*, which is pure carbon.

When subjected to metamorphism so intense that the minerals have recrystallized, some rocks are altered to *gneiss*. Gneiss resembles granite; but there is a slight banding of the minerals (Fig. 33), due to the fact that they have developed along lines of least resistance—that is, at right angles to the pressure. Where the banding is so distinct that the rock readily cleaves, it is a *schist*. Gneisses and schists are durable crystalline rocks, found in regions of intense mountain folding.

METAMORPHIC ROCKS.

NAME.	SOURCE.	MINERAL COMPOSITION.
Quartzite.	Altered sandstones.	Quartz.
Slate (argillite).	Altered clay rocks.	Partially crystallized micaceous minerals developed out of the clay particles.
Marble.	Altered carbonate of lime.	Calcite.
Anthracite (graphite).	Altered coal.	Mainly carbon and carbon compounds.
Schist.	Altered from various rocks, *e.g.* shale, conglomerate, diorite, etc.	Variable — usually two or more of the following: feldspar, quartz, hornblende, or mica.
Gneiss.	Altered from various rocks, *e.g.* shale, conglomerate, granite, diorite, etc.	Variable — usually two or more of the following: feldspar, quartz, hornblende, or mica.

SUGGESTIONS. — (1) Collect minerals from your neighborhood and study them. *Dana's Minerals and How to Study Them* is a good book of reference. (2) Collect rocks from the ledges, bowlders, quarries, and stone yards. If you live in a part of the country reached by the ice sheet (Fig. 270), you will find a varied store of rock specimens in the gravel banks. See how many kinds you can collect. Study their characteristics; place them in one of the three groups and, if possible, give them their proper names. The teacher can systematize this work and make it of great disciplinary value. (3) Place pieces of quartz, feldspar, and calcite in weak hydrochloric acid. Which is attacked by it? Water in the earth is often weakly acid, and in this state attacks minerals. (4) Grind up some mica, mix with sand, and stir in water. After the sediment has settled, notice the position of the mica flakes. It is for this reason that shales split readily along the bedding planes. (5) To which of the three groups do the rocks of your neighborhood belong? What kind or kinds do you find? Of what are they made? Are they hard or soft? Do they make rich or poor soil? If your home is in a valley, see if the rocks on the hills are different. What are the differences? Do they help account for the hills and valleys?

TABLE FOR GUIDE IN STUDY OF MINERALS.

NAME.	HARDNESS.	COLOR.	SPECIFIC GRAVITY.	CRYSTAL FORM.	CLEAVAGE.	FRACTURE.	LUSTER.	OTHER FEATURES.
Quartz.	7	Transparent.	2.6	Hexagonal.	None.	Conchoidal.	Vitreous.	
Calcite.								
Etc.								

Reference Books. — DANA, *Minerals and How to Study Them*, Wiley & Sons, New York, 1895, $1.50; KEMP, *Handbook of Rocks*, D. Van Nostrand Co., New York, 2d ed., 1900, $1.50.

APPENDIX D. GEOLOGICAL AGES.

WHILE it is impossible to tell the age of the earth in years (p. 45), geologists have divided the strata into stages, or periods, and have determined their *relative* age. This is made possible by the fossils the strata contain. For example, there was a time when no animals higher than fishes lived on the earth; and if strata contain remains of birds, it is certain that they were not deposited in those ancient times. Careful studies of fossils, in all parts of the earth, have so clearly revealed the history of the development of life that, on examining the fossils in a rock, geologists can now tell in what period it was formed. To the different periods names have been given, some of the most common of which are placed in the following table:

CENOZOIC TIME. (Age of Mammals.)	*Pleistocene, or Quaternary.*		Man assumes importance, particularly in upper part. Glacial period in first half.
	NEOCENE.	*Tertiary.*	Mammals develop in remarkable variety, and to great size, while reptiles diminish.
	EOCENE.		
MESOZOIC TIME. (Age of Reptiles.)	*Cretaceous.*		Birds begin to be important; reptiles continue; and higher mammals appear; land plants and insects of high type.
	Jurassic.		Reptiles and amphibia predominate.
	Triassic.		Amphibia and reptiles develop remarkably; low forms of mammals appear.
PALEOZOIC TIME. (Age of Invertebrates.)	*Carboniferous.*		Land plants assume great importance.
	Devonian.		Fishes are abundant.
	Silurian.		Invertebrates[1] prevail.
	Cambrian.		No forms higher than invertebrates.
In part **AZOIC TIME.** (No fossils known.)	*Archean.*[2]		Mostly metamorphic rocks; perhaps, in part, original crust of earth.

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[1] Invertebrates continue abundant to present time, but are of different kinds. Fishes, which began in the Silurian, continue, though with many changes, to the present time.

[2] Upper part sometimes called Algonkian.

APPENDIX E. TIDES.

THE full explanation of tides is considered too difficult and complex for statement in so elementary a book. It is known that they are caused by the attraction of gravitation which both sun and moon are exerting on the earth; but the moon is more effective in this than the sun.

This pull of gravitation draws the ocean water toward the moon (Fig. 557), producing a wave which follows the moon across the oceans. A second high tide is formed on the opposite side of the earth. In this way the ocean is distorted into a somewhat elliptical form. If the earth were all water, the attraction of the moon would change it to an ellipse; and, as the earth rotated, the form of the ellipse would constantly change to keep its axis pointing toward the moon.[1] That is to say, two waves would constantly be passing around the earth, following the moon. To understand this shape attach a rubber ball to the floor and, by a string on the upper side, pull until the ball loses its spherical shape.

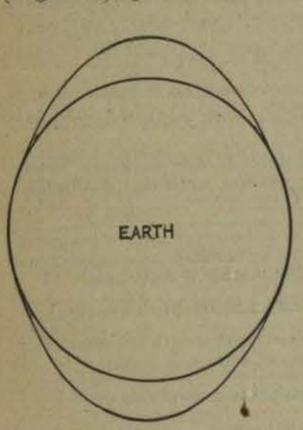

FIG. 557. — Distortion of ocean by attraction of moon, — distortion being greatly exaggerated.

Tidal waves are produced by the sun in the same way as by the moon; but, although the sun is so much larger than the moon, its greater distance makes its tide-producing effect less. The solar tides are, therefore, only about one third as great as the lunar tides. Thus, at all times, there are four tidal waves in the oceans, two formed by the moon, and two smaller ones by the sun. In each pair one is on the opposite side of the earth from the other.

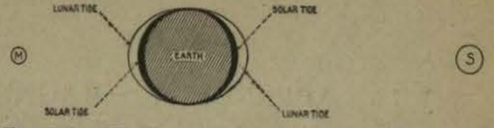

FIG. 558. — To illustrate cause of spring tides — distortion being greatly exaggerated.

At full moon (Fig. 558) the sun and moon are nearly in line. They are then pulling so nearly together that the solar and lunar tides combine, causing an uncommonly high tidal range, known as *spring tide*. At new moon, the sun and moon are again nearly in line, and spring tides are again formed. During the quarters (Fig. 559), on the other hand, the high tides formed by the moon occur where low tides are caused by the sun; consequently the tidal range is much less. These tides of low range are called *neap tides*. Each lunar month, that is every 29½ days, there are two spring and two neap tides.

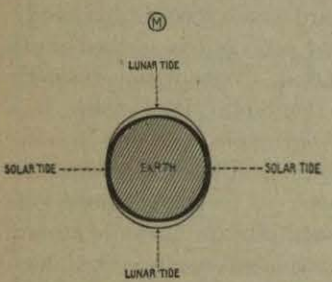

FIG. 559. — To illustrate cause of neap tides.

Another cause for variation in tidal range is the distance of the moon. The moon revolves around the earth in an ellipse, and when it is nearest to the earth, or in *perigee*, the lunar tide is higher than when it is farthest, or in *apogee*. Because of these variations in the relative position of sun and moon, and in the distance of the moon, the tidal range varies greatly. There is also an irregular variation due to wind (p. 271), which sometimes piles the water up in bays, causing it to overflow wharves and low land that the tide itself never reaches.

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[1] There is more to the tidal explanation than the mere pull of gravitation; there is also the effect of centrifugal force. However, unless the teacher, because of special interest, wishes to enter into a full study of tides, it does not seem well to introduce this complex question.

APPENDIX F. MAGNETISM.

In the United States, as in other regions, a bar or needle of magnetized steel, so suspended that it freely swings horizontally, will point north and south. An instrument having such a needle is a *compass*. Throughout most of the country the compass needle points a little to one side of a true north and south line. In central western Greenland the needle points westward, in northern Greenland, southwestward. The place toward which the compass needle points is known as the *north magnetic pole*, and is located north of Hudson Bay and west of Baffin Land. Within the Antarctic Circle, between New Zealand and the South Pole, there is a similar region known as the *south magnetic pole*.

It is because of these centers of magnetism that the compass is so valuable that sailors depend upon it for determining the course of their ships, and the steersman always has one in plain sight. In the Arctic the compass is much less useful, for, though nearer the magnetic pole, the needle is less sensitive and more easily deflected by outside influences, such as the presence of iron.

The reason for this fact is that the cause for the attraction of the needle lies beneath the earth's surface. This is proved by so suspending a needle that it will freely swing, or dip, vertically. At the magnetic pole, the needle of such a *dip compass* points directly downward; near the equator it swings horizontally; part way between the pole and equator it points toward the earth at an angle. From this it is evident that, the nearer one goes to the magnetic pole, the stronger becomes the downward attraction and the weaker the horizontal pull, and, therefore, the less useful the compass.

Along a line extending from South Carolina to Lake Superior, *magnetic north*, or north by the compass, is the same as true north; that is, the compass points toward the north pole. East of this line the compass points to the west of true north, northern Maine showing a difference between magnetic and true north, or a *declina-*

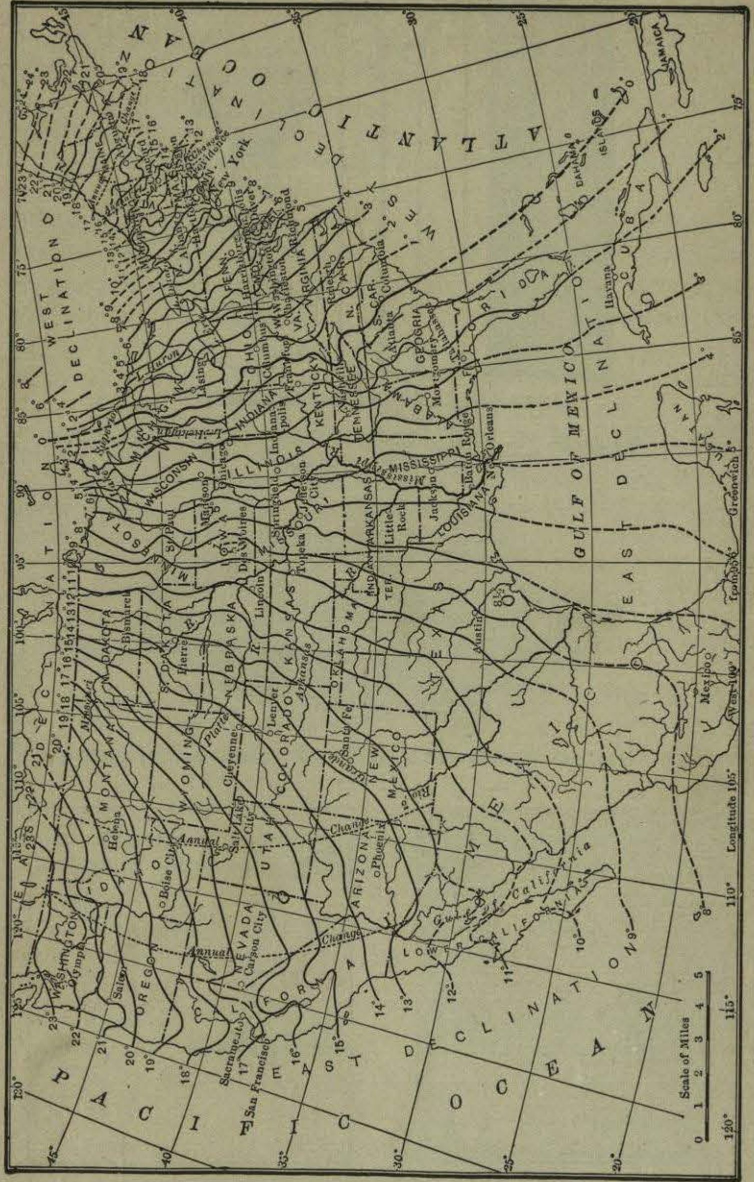

FIG. 560. — Isogonic map of United States, showing the amount of declination for 1901.