The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called relief; as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called drainage, as streams, lakes, and swamps; (3) the works of man, called culture, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea-level; the heights of most points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the horizontal outline, or contour, of all, and to indicate their grade or steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called contours, and the uniform vertical space between each two contours is called the contour interval. Contours and elevations are printed in brown.

The manner in which contours express elevation, for intermediate relief contour intervals of 10, 20, 30, 50, 100, and 200 feet, and so on, may be explained as follows:

1. A contour indicates approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200, and so on, above sea-level. Along the contour at 200 feet lie all points of the surface 200 feet above sea; and similarly with any other contour. In the space between any two contours are found elevations above the lower and below the higher.

2. Contours define the forms of slopes. Since contours are horizontal lines conforming to the surface of the ground, they wind around and about smoothly as the ground contours and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of the surface. The vertical gradient of the slope, or the slope of the ground, is given by a broken blue line. Where this is not possible, certain intermediate relief contour intervals of 10, 20, 30, 50, 100, and 200 feet are used.

Fig. 1.—300 feet and corresponding contour map.

The sketch represents a river valley between two mountain ranges. The fresh water is the sea with which it is partly closed by a hooked sand-bar. On each side of the valley is a terrace, from the terrace to the hill sides gradually, while from that on the left the ground ascends steeply in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. In the terrace on the right a hill rises gradually, while on the left a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones. For all parts of the map the contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Dismal Swamp. In mapping other places, such as those in Colorado, the interval may be 200 feet.

For intermediate relief contour intervals of 10, 20, 30, 50, 100, and 200 feet, and so on, the representation is shown by a broken blue line. If a stream flows the year round the contour interval is doubled, but it is less broken. Where a stream sinks and reappears at the surface, or changes direction, or is shown by a broken blue line. Marshes, swamps, and bodies of water are also shown in blue, by appropriate symbols.

Cultures.—The works of man, as such, as roads, railroads, and towns, are shown by the boundaries of towns and cities, and artificial objects, are printed in black.

Roads.—The area of the United States (excluding Alaska) is about 3,535,500 square miles, and the area covered by roads and railroads is about 1,500,000 square miles; on the map the roads are shown by a black line, and the railroads by a black broken line. The roads of the United States are published in atlas sheets of convenient size, and on the scale, to about 16 square miles.

For intermediate relief contour intervals of 10, 20, 30, 50, 100, and 200 feet, and so on, these roads are shown by a black broken line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate symbols.

Culture.—The works of man, such as roads, railroads, and towns, with boundaries of townships, are shown, and artificial objects, are printed in black.

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forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in lakes and chasms, and the confluences of the streams that flowed to the ocean, to the lateral ridges and mounds of sand and gravel, known as coes, or coers, and kames. The material deposited on the bottom of the glacial bed is called the drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to classify as drift rock the deposits of the sea and of lake and river that were made at the same time as the ice deposit.

**Ages of Rocks**

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a formation, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a system. The time taken for the deposition of a formation is so prolonged that the unit is usually taken for that of a system, or some larger fraction of a system, a period. The rocks are mapped by formations: the periods, the systems, and the formations are classified into systems. The rocks composing a system and the time for their deposition are given the same name; the system and formation are classified into periods, the periods are classified into systems, Cambrian period.

As sedimentary deposits or strata accumulate the youngest rest on those that are older, and the relative ages of the deposits may be discovered by observing their relative positions. This relationship holds except in regions of intense dis­turbance; sometimes in such regions the distur­bances of the beds have so great an effect that their position is reversed, and it is often difficult to determine the relative ages of the beds from their positions; then fossils, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

Strata often contain the remains of plants and animals which lived in the sea or were washed into the land from lakes or seas or were buried in surficial deposits on the land. Rocks that con­tain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those of other periods. Only the sim­pler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex forms developed, and as the simpler ones lived on in modified forms, the more varied. But during each period there lived peculiar forms, which did not exist in earlier times and which have not continued into later times. These are characteristic forms, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote one from the other and it is impossible to observe their relative positions, the characteristic fossil type found in them may determine which was deposited first.

Fossil remains found in the rocks of different areas, provinces, and continents are of great importance as means for combining local histories into a general earth history.

**Colors and patterns.**—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the color and symbols assigned to each, are given in the table in the next column. The names of certain subordinate divisions are also given. The colors as printed in geologic writings are bracketed against the appropriate period name.

To distinguish the sedimentary formations of any one period from those of another the patterns of the formations for each period are printed in the appropriate paragraph. The names of the first (PlIOCene) and the last (Archaeon) formations of any one period, excepting the Pleistocene and the Archeon, are distinguished from one another by different patterns, and the color and symbol of each period are used: a pale tint (the underprint) is printed evenly over the whole surface representing the formation of the period, and a dark tint (the overprint) is printed over the different parts representing different strata.

Each formation is further given a letter—brilliant color. The formation of is of known age, the color and pattern of the period is used to distinguish the sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period. The age of the formation is expressed in the pattern by the letter-symbol of the period being omitted.

The number and extent of surficial formations of the land an escarpment, or front, which is made up of strata. The vertical strata that cut a section so as to show the underground relations of the strata passed beneath the surface, draw sections that are inclined by their natural and artificial cuttings for its information concerning the earth's strata. Knowing the names of the formations of rocks, and having traced out the relations among the beds on the sur­face, he can infer their relative positions after they pass beneath the surface, surficial strata, which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

In cliffs, canyon walls, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a section, and the same name is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's structure, and a section exhibiting this arrangement is called a structure section. The geologist is often limited, however, in the natural and artificial cuttings for its information concerning the earth's structure. Knowing the names of the formations of rocks, and having traced out the relations among the beds on the sur­face, he can infer their relative positions after they pass beneath the surface, surficial strata, which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

In fig. 2 there are three sets of formations, dis­tinktulized by their underground relations. The strata were produced from the oldest deposit to the oldest, a formation, a set of sandstones and shales, which lie in a hor­i­zontal position. These sedimentary strata are isolated from one another by unconformities of their change of elevation shows that a portion of the earth's mass has upheaved upward from a lower to a higher level. The strata of this set are parallel, a relation which is called conformable.

The second set of formations consists of strata which cut through the first set. When two formations thus rest upon an eroded surface of older strata the relation between the two is an unconformable one, and their surface of contact is an unconformity.

The third set of formations consists of crystal­line schists and igneous rocks. At some period in the history of the earth, the rocks were shaping by pressure and traversed by eruptions of molten rock. But this pressure and intrusion of igneous rocks have been followed by the erosion of strata of the second set. Thus it is evident that an interval of consid­erable duration elapsed between the formation of the strata and the removal of some of the beds from their relative positions. This interval is often under­stood to indicate a period of time or, if the period of the strata is well understood, a period of time. The strata were removed by depression and were deeply eroded. The contact between the second and third sets, marking a time interval between two periods of rock formation, is another uncon­formity.

The situation and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections in the structure-section sheet are relations in the section in the figure is related to the landscape. The profile of the sur­face in the section correspond to the actual slope of the ground along the section line, and the depth of any mineral producing or water-bearing strata which appears in the section may be observed from the surface by using the scale of the map.

**Columnar-section sheet.**—This sheet contains a representation of the rock formations which occur in the quadrangle. The diagraphs and verbal statements form a summary of the facts obtained from a study of the geologic his­tories of the formations, and to the order of accumulation of successive deposits. The relative positions of the corresponding bounding, and their characters are indicated in the column diagram by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the column arrange­ment: the oldest formation is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments may be represented by the word " unconformity," printed in the columnar section.

Each formation shown in the columnar section is distinguished by a letter, a description of its character, and its letter-symbol as used in the maps and their legends.