GEOLOGIC ATLAS
OF THE
UNITED STATES
FRANKLIN FURNACE FOLIO
NEW JERSEY

INDEX MAP

CONTENTS

WASHINGTON D.C.

1908
The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio is included in the topographic 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 work of man, called culture, as roads, railroads, buildings, villages, and towns.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, reach into all the indentations and folds of the landscape, and are closely spaced along the steeper parts. These relations of contour curves to the forms of the landscape can be used in the interpretation of the map.

3. Contours show the approximate grade of any point. The altitudinal space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope. Therefore contours are far apart on gentle slopes and near together on steep ones.

4. For a flat or gently sloping country a small contour interval is needed; for a steep or mountainous country a large interval is necessary. The smallest interval used on the sheets of the Geological Survey is 5 feet. This is sufficient for regions like the Mississippi delta and the Gaspé Peninsula. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, and 50 feet are used.

5. Proteins.—Watercourses are indicated by blue lines. If a stream flows from the centre of the line is drawn mistaken, but if the channel is dry part of the year, the line is broken or dotted. Where a stream sinks and reappears at the surface, the spot is indicated by a small blue dot. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

6. Cultures.—The works of men, such as roads, railroads, and towns, with boundaries of towns, cities, and States, are printed in black.

7. The area of the United States (excluding Alaska and Indiana possessions) is about 9,303,000 square miles. A map representing the area of the United States to the scale of 1 mile to 1 inch would cover 9,303,000 square inches of paper, and to accommodate the map the paper would need to measure about 24 by 360 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one square mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the scale of the map. In this case it is 1 mile to 1 inch. The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 12 inches in a foot and 5,280 feet in a mile, the scale "1 mile to an inch" is expressed as 12 inches to 5,280 feet.

Three scales are used on the atlas sheets of the Geological Survey: the moderate scale, the large scale, and the largest scale. These correspond approximately to 4, miles, 2, miles, and 1 mile to the inch. The moderate scale is used for scale, a square inch of map surface represents about 1 square mile of earth surface; on the scale, about 4 square miles; and on the scale, about 16 square miles. At the bottom of each map, the scale is expressed in three ways: by a graduated line representing miles and parts of miles in English inches, by a similar line indicating distance in the metric system, and by a fraction.

8. Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are used in geologic surveys to illustrate the geological features of the area. These are called quadrangles. Each sheet on the scale of contains one degree of latitude and longitude, each sheet on the scale contains one-fourth of a degree, each sheet on the scale contains one-twelfth of a degree, and each sheet on the scale contains one-ninth of a degree. The area of the quadrangles are about 4,000, 1,000, and 250 square miles.

9. The other sheets, being parts of one map of the United States, divided political boundaries, such as those of counties, states, and towns, are used. When a map is published, it is represented in this manner, the names of all well-known towns or natural features within its limits, and its boundaries and contours and names of bodies of adjacent sheets, if published, are printed.

Use of the topographic map.—On the topographic map, the reader can see the division of the land into miles or counties, the location of features, the relief of the land, and the drainage and water courses of adjacent sheets, if published, are printed.

The surface of the earth is not fixed; it is in constant motion. The above example shows that the shore lines of the ocean are changed. As a result of the rising of the land, marine sediments may be formed or uplifted, and the original rock layers are cut by erosion and are removed. The processes of crustal movement and erosion are the same as those that have been going on throughout the earth's history. The sedimentary rocks that are formed by the processes of sedimentation and erosion are the same as those that have been going on throughout the earth's history. The sedimentary rocks that are formed by the processes of sedimentation and erosion are the same as those that have been going on throughout the earth's history.

The following gives the principal divisions of the earth's crust, which are: the crust, the mantle, the core, and the atmosphere. The crust is the outermost part of the earth's crust, and it is composed of rocks and minerals. The mantle is the middle part of the earth's crust, and it is composed of rocks and minerals. The core is the innermost part of the earth's crust, and it is composed of rocks and minerals. The atmosphere is the outermost part of the earth's crust, and it is composed of gases and water vapor.
DESCRIPTION OF FRANKLIN FURNACE QUADRANGLE


GEOGRAPHY.

By A. C. Spencer.

GENERAL RELATIONS.

The Franklin Furnace quadrangle is bounded by the 78th meridian of longitude and parallel lines running north and south at latitudes 44° 30' and 44° 45' west longitude, comprising an area of 240 square miles. The principal town is Franklin Furnace, which is located on the 78th meridian and 44° 30' west longitude. The quadrangle extends from the mouth of the Hoosick River to the Hudson River, and from the 78th meridian to the west boundary of the town of Hoosick. The quadrangle is divided into sections by the 44th parallel of latitude, which runs from the mouth of the Hoosick River to the Hudson River.

The soils of the Franklin Furnace quadrangle are varied, consisting of a mixture of sandy loams, clayey soils, and loamy soils. The soils are well-drained and support a wide variety of vegetation. The climate is moderate, with temperatures ranging from an average of 30°F in January to 70°F in July.

The topography of the Franklin Furnace quadrangle is characterized by rolling hills and low mountains. The highest point in the quadrangle is the summit of Mount Hope, which is located in the southeastern part of the quadrangle. The summit of Mount Hope is located at an elevation of 1,200 feet above sea level.

The principal water bodies in the Franklin Furnace quadrangle are the Hoosick River and its tributaries, which flow from west to east. The Hoosick River is a tributary of the Hudson River, and is located in the eastern part of the quadrangle. The river is about 60 miles long and has a drainage area of 1,200 square miles.

The soils of the Franklin Furnace quadrangle are well-drained and support a wide variety of vegetation. The climate is moderate, with temperatures ranging from an average of 30°F in January to 70°F in July.
The general structure of the Highlands pro-
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In all the gneissic foliation is conditioned both by the interlayering of different varieties of rock and by the more or less elongated or flattened form of the gneiss, the divergence of the arrangement of these gneisses in such a manner that their longer dimensions lie in sets of nearly parallel planes, and by the development of a structure of foliation, and of the second sort textural foliation. Textural foliation may be developed during the early stages of crystallization of a rock mass, when consolidation takes place under influence of the surrounding pressure, as, for instance, while the rock was being emplaced in the molten state. It may be induced by processes of rheosynthesis accompanying complete deformation of the rock after it had ceased to flow. The gneisses in the precambrian rocks, notably in northern New York and Canada, foliation exists in different stages of development, leaving in certain localities no doubt of the secondary manner in which it has been produced. Throughout New Jersey, however, evidence of crumbling in the minerals of the gneisses is almost entirely wanting and appearances strongly favor the belief that the gneissic foliation is original in the invading rocks of the pre-cambrian complex.

Less abundant than the granitic rocks, but still of considerable importance in the field at large, is the gneiss of a later period. The rocks embrace those that under this term have the composition of igneous dikes or gabbros, but whether they have been introduced into the sedimentary formations, or as is more commonly the case, in part, both the pre-existing formations have been invaded by the gneiss, and the crystallization and the enclosure itself appears to have been created by a fluid not derived from the earlier period.

All the gneisses which owe their origin to the hornblende, pyroxene, or biotite which they contain, are grouped together under the name of gneiss. A second group, the members of which show brown-green, brownish, pink, and aconitic colors, is called the biotite gneiss. These are included a great variety of granitic or gneissic
to the branch of the geologic facies that so strikingly resembles the parent gneiss. Rocks of intermediate composition do not in general consist of readily definable geologic masses, and as a rule, the various gneissic rocks, many of them nearly white, which contain lines-exed feldspar as an essential and characteristic mineral, separate them from the other gneisses. However, several masses of coarse granite occurring in the northern part of gneiss and defined as such by geologists and land surveyors, have inclined pleistocene age.

All the rocks that have been mentioned are cut by irregular dike-like masses of pegmatite, but these rocks have not been mapped except within the general area of the Precambrian rocks. The varieties of gneisses are distinct in size, there being many different and many large mounds of deformed gneiss. A general rule is that the geologic maps of the Precambrian region in general and the Precambrian gneisses in particular, have been produced the existing distributions of Paleozoic formations. Near these breaks the minerals of the gneisses are considerably desegregated, banded gneisses are ordinarily not finer-grained than the basic gneiss; the more common forms of the gneissic facies are present in the largest amount of light-brown gneiss; rocks which have the appearance of gray and darkcolored gneiss, and to the base of the mountain gneiss and Bynum gneiss. There can be little doubt that these rocks have subdivided in part out of Alpine and Middle Proterozoic gneissic formations, and are probably in the Precambrian gneissic facies of the region.

Cross breaks have been found in some of the rocks, but unusually they are not important and few of them are discoverable on the surface.

THE GEOLoGICAL RELATIONS OF THE ROCKS

The gneisses of the New Jersey Highlands, with a few exceptions, correspond accurately in their mineralogical and chemical composition with common types of metamorphic and igneous rocks like the granites and diorites. They differ from the usual igneous rocks in that they possess foliated or linear structures instead of a granular structure. The members of the gneissic facies which are present in the largest amount of light-brown gneiss, rocks which have the appearance of gray and darkcolored gneiss, and to the base of the mountain gneiss and Bynum gneiss. There can be little doubt that these rocks have subdivided in part out of Alpine and Middle Proterozoic gneissic formations, and are probably in the Precambrian gneissic facies of the region.

The Precambrian limestone locally retains traces of organic growth, but the lamination observed within masses of this rock is regarded merely as a sort of flow structure resulting from the say of the molten material. The injection of the gneissoidal material, the parting out and kneading of the masses of the matrix, and the detaching gneissoidal rocks from the foliation plane so formed is connected in origin with a single cause.

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blocks of Kittitian limestone, one 30 miles long and from about 222 miles wide, and the other 7 miles long and somewhat more than 1 mile in greatest width. A third strip of the limestone, occupying the Vermont Basin, extends for a distance of 30 miles north of eastern Vermont and for a distance of 8 miles southwest into New Hampshire. The western boundary of the Belt rocks is defined by a line of escarpment, the other end, which is about 1 mile in width, is bounded by the southern boundary of the region of the Belt rocks.

**Description.**—The limestone of the Belt rocks is a white, highly crystalline rock, generally massive, but showing a tendency to subangular blocky structure. The surface of the rock is smooth and shiny, and the matrix is composed of calcite crystals, some of which are of a peculiar, thread-like form. The limestone is very pure, containing a small admixture of quartz, and is very free from organic matter. The structure and texture of the limestone are typical of the region, and are indicative of the conditions under which it was deposited. The limestone is very hard and durable, and is used extensively for building purposes. It is also a valuable source of limestone for agricultural and industrial uses.

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**Summary.**—The limestone of the Belt rocks is a white, highly crystalline rock, generally massive, but showing a tendency to subangular blocky structure. The surface of the rock is smooth and shiny, and the matrix is composed of calcite crystals, some of which are of a peculiar, thread-like form. The limestone is very pure, containing a small admixture of quartz, and is very free from organic matter. The structure and texture of the limestone are typical of the region, and are indicative of the conditions under which it was deposited. The limestone is very hard and durable, and is used extensively for building purposes. It is also a valuable source of limestone for agricultural and industrial uses.
At Mount Asah and Erc, in Orange County, N.Y., near the north end of the Franklin lime-
stone belt, masses of coarse granite invade the limestone, producing considerable metamorphism and extending throughout the belt and in some of the outlying areas. This metamorphism seems to have had little effect on the includ-
ing limestone. Taken as a whole, the limestones are not more crystalline at the pegmatite contacts than at a distance, and although the granites are found syngenetically distributed without any constant relation to the proximity of these invading rocks. It is possible, however, that the limestones were slightly altered at the time the pegmatites were injected into them.

The earlier metamorphism, which affects both the Franklin limestone and the Pocheduck gneiss, is regarded as one of the results of the general metasomatism of the field by the granite Louse and Byram gneisses. In many places where the dark Pocheduck rocks are seen to be cut by the Louse gneisses, as along the crest of Pocheduck Mountain, layers of the fragmental matrix that have been displaced by the intrusive mass seem to have a little effect on the enclosing limestone. Taken as a whole, the limestones are not more crystalline at the pegmatite contacts than at a distance, and although the granites are found syngenetically distributed without any constant relation to the proximity of these invading rocks. It is possible, however, that the limestones were slightly altered at the time the pegmatites were injected into them.

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the average about 75° SE, so that the rock evidently passes beneath the adjacent limestone.

Beyond the narrow strip of Palaeozoic rocks which hinders the growth of the vast gorge southwest of Hamilton, the road leading from the Gravelly shore toward North Church, several outcrops may be observed in the road cuts which reveal parts of the rock, but there is but one exposure. Beyond the railroad the dark grusseis appear, and along the crest of the ridge opposite Mannie-Stratt’s Farm the rock is a hornblende gneiss, a strip of which lies between them and the western edge of the pre-Cambrian area. From knolls of bed rock rising out of the sand plains east of Lake Grinnell, it is known that this westly band of white gneiss continues beneath the glacial drift in the direction of Woodford Gap. In the knoll northeast of Woodruff Gap (elevation 620 feet), and in the next knoll to the southwest (elevation 715 feet), a considerable amount of light gneiss occurs with layers of hornblende. The 715-foot knoll contains large amounts of pegmatite.

Associated with the Franklin limestone outcrop of the 715-foot knoll are layers of gneises containing pyroxene and amphibole, which have probably been formed by the metamorphism of the sedimentary material. Layers of similar amphibolite-bearing gneises are present at several places in the continuation of the Pockwhit band toward the northeast. At Andover quarry, one-half mile south of the Franklin Furnace quadrangle, this rock is intimately associated with the granulite and in the vicinity of the Andover and Tar Hill iron-ore mines it occurs in company with narrow patches of pegmatite to prove it is the same rock by gneisosity along the strike. Both limestone and quartzite are present in the mine workings, and the forms of gneisosity-bearing gneiss occur around Tar Hill.

The southwestern part of the western band of Pockwhit, which is very poorly defined against the rocks which lie to the east, the location of the boundary being very arbitrary. On the west, except for the presence of white gneisses extending from Pinneyville to Sportsman Junction, the rock is limited by the overlap of Hardyston quartzite.

In the mine workings north of Nassau Mills the limestone of the Pinneyville area can be seen to come against the dark gneiss along a clean parting where it dips about 45° SE, so that the limestone passes beneath the gneiss. At this place there is no apperance of gradation between the two rocks. This is in part because of the present nature of the strike of both white and dark gneisses, extensive extending from Pinneyville to Sportsman Junction, the rock is limited by the overlap of Hardyston quartzite.

In the old mine workings north of Nassau Mills the limestone of the Pinneyville area can be seen to come against the dark gneiss along a clean parting where it dips about 45° SE, so that the limestone passes beneath the gneiss. At this place there is no appearance of gradation between the two rocks. This is in part because of the present nature of the strike of both white and dark gneisses, extensive extending from Pinneyville to Sportsman Junction, the rock is limited by the overlap of Hardyston quartzite.

The peculiar shape of this area reflects the structure of the gneises, the layers of which are thrown into a northwardly dipping fold. The rock above and below the area is Byram gneiss, including wisps of the dark rock. This structure may have existed before the granite rock in which the dark gneiss, or it may have developed during the deformation caused by that invasion; the point is not clear. It is evident, however, that the dip of the Pockwhit and white-limestone masses with reference to the granite rocks must be interpreted as produced by the same causes, and that the dark gneiss are the white gneiss may be regarded as together constituting a greatly disrupted mass.

The dark gneiss which enter the Franklin Furnace quadrangle from the southwest at the head of the Valley rock outcrop, then passing through the oak forest occupying a narrow triangular area northwest of the fault which limits the strip of Kittitzy limestone.

**Dikes in the Franklin limestone.**—Thin plates of dark gneisoid rock of common occurrence in the white limestone of the Franklin Furnace belt. These are of the Pockwhit gneiss and are derived from the northwest corner of the quadrangle. Toward the north this area widens, and in the northern part of the Pockwhit Mountain includes two strips of granite. The Pockwhit gneiss is recognized by the field of its lack of strong coloration. It is generally white in natural outcrops, and slightly grayish in artificial exposures. In fresh rock it is brought to the rock. The gneiss is composed mainly of oligoclase (a sodic-rich variety of plagioclase feldspar) and biotite, and a small amount of hornblende, quartz and pyrite are common accessory minerals. In the old Franklin Furnace, northwest of Franklin Furnace, some diorite masses occur, and these contain microcline in place of the ordinary oligoclase.

The texture of the rock is invariably foliated by a more or less tabular gneissic nature in the parallel planes forming the walls of the dikes.

In Northrop gneisoid dikes essentially similar to those have been shown to be the result of a chemical alteration of rocks that were originally gabbros. A like alteration may have produced the sapphirine-bearing rocks here, but the steps of such a change have not been recognized and it seems quite possible that the initial rock was a biotite hornblende, which by recrystallization to produce the mineral unaltered.

**LOOSE GNEISES.**

**General statement.**—The group of foliated gneisoid rocks here called the Loose gneises includes the gneisses on the west side of the model table in the page and in many slightly weathered exposures nearly white. They are distinguished lithologically from the variety of Byram gneises by containing very little or no orthoclase (with feldspar) instead of microcline or microperthite (potash feldspars). They differ from the Pockwhit gneiss in that they contain much quartz and only minor amounts of dark minerals.

The Loose gneises are regarded as an intrusive igneous rock younger than the Pockwhit gneiss and the Franklin limestone. Its relation to the Byram gneises is not known, but it is cut by granite and by veins of pegmatite.

**Distribution.**—In this quadrangle there are four fairly well defined areas of the White gneisses and two others less clearly set apart. In the belt of gneisses from 1 to 11 miles wide next to the limit which the southeastern area of sedimentary rocks, the Loose gneises are found and in many areas of coarse granites and a large amount of coarse pegmatite. This band is not sharply defined against the Byram gneises to the north and the southern boundary given on the map is arbitrary. A second belt, which begins a short distance north of the Hamburg-Stockholm wagon road and runs southeastward through Loose and Martin peaks to the edge of the quadrangle, has a width of one-half mile to 11 miles, and is known to be 20 miles in length. Though actual contact between the Loose and the surrounding Byram rocks have not been observed, the limits of this band are closely determinable. In many places, but particularly along the edges of the zone, the white gneises include innumerable layers of Pockwhit rock, which it has been brought into contact with.

West of the Wallkill Valley an ill-defined belt of white gneisses about 1 mile wide lies between the quartz diorite and the granodiorite of Pockwhit gneises. Within this belt are many shreds of Pockwhit gneises and several large patches of Loose gneises. The Loose gneises are intruded by the northern termination of this belt has been represented in an arbitrary way. The narrow strip of white gneiss in the intrusive mass of orthoclase is limited on the west by the Palaeozoic overclay. It is supposed that this belt belongs beneath the granodiorite of the Pockwhit Mountain. A triangular area of the Loose gneisses is included within the band of gneises in the

**Microscopical and chemical composition of Loose gneises.**

<table>
<thead>
<tr>
<th>Loose gneiss</th>
<th>Oligoclase</th>
<th>Quartz</th>
<th>Hornblende</th>
<th>Biotite</th>
<th>Magnetite</th>
<th>Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40</td>
<td>36.9</td>
<td>25.7</td>
<td>12.5</td>
<td>10.5</td>
<td>9.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Distribution.**—West of the Wallkill Valley the Byram gneises is the most abundant rock in a belt including the Bear Ridge and the central part of the Pine Hills. On the east it occupies a general belt including the Wallkill, Harscap, and Wawaka-Gravelly Mountain, which are approximately 15 miles wide and 25 miles long. This area is divided by a large fault which is, in reality, a narrow zone containing numerous minor faults which are parallel. The belt is divided by a large fault which is, in reality, a narrow zone containing numerous minor faults which are parallel. The belt is divided by a large fault which is, in reality, a narrow zone containing numerous minor faults which are parallel. The belt is divided by a large fault which is, in reality, a narrow zone containing numerous minor faults which are parallel.

Though these estimates of the microscopic composition apply to the bulk of the rock, there are many variations in the microscopic make-up from place to place. Locally in the western areas the oligoclase decreases in amount and is replaced by orthoclase and microline. In other places consider-ably more pyroxene and hornblende are present.

**Microscopical composition of Byram gneises.**

<table>
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1. Pockwhit hornblende feldspar from band gneiss containing 15% hornblende, south of Hamburg-Stockholm road, near Claryville. 2. Gabbroic granite from the Passaic Valley near the Hackensack River. 3. Gabbroic granite from the Passaic Valley near the Hackensack River. 4. Gabbroic granite from the Passaic Valley near the Hackensack River.
of the fine-grained rock in the region, the term "ore pods" in descriptions of the shoots of ore. As a rule, to which a few exceptions are on record, it is found that the largest dimensions of the shoots or pods, as they lie in the plane of the ore layer, decline from the horizontal toward the vertical. In other words, the shoots have a northeast pitch independent of the dip of the ore layer. Along the pitch the ore pods are ordinarily persistent for very considerable distances, and yet there has been little deep mining whose limits have added more than a few hundred feet to the total length of the shoot. In several places it may be shown, or fairly inferred, that individual shoots extend for 1000 to 2000 feet, and at the Harde mine, the traces of which extend for a distance of over 1000 feet, the shoots are of variable width, but in many of them the distance from pitch to pitch is not far from 200 feet or more. In the Harde mine, the interval between the shoots is perhaps usually not greater than their width. On comparing the lengths and widths of the shoots, it appears that the minimum length may be expected to average perhaps from 30 to 60 times the width, though these, cannot be taken as limiting measures.

There are for deep mines in the New Jersey Highlands, and the most extensive workings are on the more regular veins, as at the Hibernia mine, in Morris County, where swelling and pinching of the ore belt are not prominent features. For this reason the occurrence of several well-marked swells on a single vein has seldom been shown by continuous working underground. In the main the ore shoots occurred in bands, however, by studies of surface workings which leave no room for doubt that in several places three, four, five, and even a greater number of ore shoots lie one above another upon the same level, being connected by thinner masses of ore occupying a considerable portion of the vein. The bands of ore shoots in the Ford and Schofield mines in the Franklin Furnace quadrangle, and the relation is clearly exhibited in the surface pits on the Mount Hope tract, north of Dover, N. J., where the occurrence of several parallel veins have been opened continuously for a distance of more than 100 feet. In the mines it is usually found that the shoots narrow down rather abruptly in the roof and bottom margins, and it is impossible to determine the full extent of the ore, as mining coes when the vein runs down to a thickness of 2 to 4 feet. Some of the ore shoots are cleanly capped or bottomed by rock, or even entirely surrounded by the gross. Completely isolated ore bodies of this sort are rather unusual, so far as observation goes, and we have been the ore body may be referred to the same layer in the country rock. Nevertheless, its seems likely that they have originated in a similar manner to the swellings of the continuous layers, the difference being that the pitch is more complete.

As a rule, the ore layers are materially thicker, whose principal irregularities of form being the swellings and pinchouts already described. Gentle curving outcrops and variation in the angle of dip show, however, that certain layers are slightly warped, and in a few places the veins turn back upon themselves and present the appearance of having been folded or as do a number of ore shoots at Franklin Furnace and Sterling Hill. Similar features are to be observed both in the folds of both the country rock and the ore shoots.

Assuming the veins merely occur, but spurs have been noted, in some places diverging upward, and in others downward from the main body of ore. In the Hard mine at Wharton, which is not to be confused with the abandoned mine of the same name mentioned above, a downward spur was found to terminate about 80 feet below its junction with the main vein, and the mine workings show that several hundred feet of the form falls away toward the northeast, in consequence with the pitch of the finely worked marked ore shoots of the vein. This pitch inclining that the inclining of the ore bodies, the workable width of which is whereby decreased. In general the vein shows the same pendulous shape and northeasterly pitch as the ore shoots, and though many veins are nearly free from these, there is a considerable number of them. In place solid veins split up into a series of wedges which dovetail with narrow angles into the country rock. Masses of rock, with beds are complex agglomerations of thin plates of magnetite alternating with plates of silicate minerals. Deposits of this sort have much the aspect of darker varieties of the vein.
The country groves, the only essential difference being that their dark mineral is magnetite instead of hornblende or pyroxene. The groves are always made up of the ordinary minerals of the country rock. Hornblende and feldspar, the commonest minerals of the country rocks, make up the micaeous and silted material of the gneiss, but replacing or in addition to quartz, mica, and pyroxene occur locally. Where minerals such as hornblende, calcite, and quartz are most abundant, it is almost invariably the only nomenclature mineral present. Between magnetite-bearing hornblende and biotite, the latter is much less common. In the field, the hornblende is very abundant, and the minerals of the gneiss are, in fact, in the form of iron oxide. Biotite, pyrrhotite, and pyrite, the latter being more common than the former. The hornblende is more abundant in the central part of the field. The other rocks are less abundant, and the micaeous and silted material of the gneiss is almost entirely composed of hornblende.

The country rock is a more or less limonitic rock. The micaeous and silted material of the gneiss is almost entirely composed of hornblende.

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of 1 per cent up to several per cent, and small amounts have been found in several analyses of where special tests have been made to determine its presence or absence. Not only are the zinc and iron deposits of the group being exploited, but they resemble each other in the form and structure of the ore bodies and in the manner of occurrence and are therefore said to be genetically related. The ores are regarded as a variety of ore deposit differing from the ordinary type mainly in the unusual amount of zinc that they contain.

ORDER OF THE ORE DEPOSITS.

Two theories have been held hitherto concerning the manner in which the iron ores of the Highlands district were formed. The first, which was stated by H. E. Rogers in 1897, admits a sedimentary basis for the genesis in which most of the ores occur, but regards the ore bodies themselves as igneous in origin. The similar magnetic deposits of the Adirondacks region in New York were regarded by Ebenreuter, according to his report of 1892 as "the geology of the northern district of New York," in igneous dikes injected into orogenic belts of sedimentary material and partially by igneous origin. The second theory held by Kittell in the report of the Geological Survey of New Jersey for the year 1895, places the ores as well as the magnetic deposits in the igneous belt, into their present condition by complete and widespread metamorphism. This second theory has not had advocates since the conclusions of Kittell were published and is nearly the only work of the New Jersey Geological Survey that has been of great importance. It has been stated that the magnetic and included iron ore have been derived from stratiﬁed or sedimentary rocks through processes of metamorphism of the type prevailing in the igneous belt. The use of the term "sedimentary" during the alteration. The question of genesis was raised in 1898 by Franklin Nison, who considered that the ores of knowledge did not afford an adequate basis for deciding between the sedimentary and igneous hypotheses. This view was likewise held by C. E. van Hise in his summary of literature of the pre-Cambrian rocks of the Highlands region, published in 1897. The ore deposits of the Highlands region offer themselves no adequate class for determining their origin, and the best that can be done in this direction is to assign the deposits to the most probable phase in the geologic history of the pre-Cambrian rocks. As the history of those old rocks is obscure, the assignment of these ores can be considered only very general terms.

The two deposits of zinc, iron, and manganese mixed ore of the region, and the deposits of manganese are inclined by highly metamorphosed sedimentary limestone, whereas most of the manganese deposits are regarded as of igneous origin. Both in the limestones and in the gneisses the ore deposits are layers of tufular masses which conform with the general structure of the country rocks. The fact that there are usually no sharp physical breaks between the ore bodies and the wall rocks indicates that the present characters of the ore masses originated contemporaneously with the final crystallization of the associated rocks, so that the deposits must have been introduced either before or during deformation and metamorphism. The crystallization of the limestones was undoubtedly produced during the deep-seated deformation and metamorphism. It is considered that the general alteration of these rocks proceeded from the interior to the edges of the deposit, and that the edges of the ore masses have been derived from the same source as the invading magmatic fluid. Collectively, it must be regarded as of magmatic origin.

The magnetic ores of the Highlands are believed to be sills of igneous rocks, bounded by the igneous rocks and that the deposits of iron which they contain were derived from the same source as the invading magnetic fluid. These conclusions must be regarded also as of magmatic origin.

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Cinnabarite: Mg,[Mg,SiO₃]·SO₄·H₂O. — Monoclinic. Crystals usually yellow to brown in color, are seen in the limonite of the southeastern iron-quartz at Franklin Furnace and very rarely in the black shale. Supposed cinnabarite in crude rhyolite ore in the vicinity of Franklin Furnace, Franklin Furnace, and cinnabarite in the limonite of the southeastern iron-quartz at Franklin Furnace. 

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Minerals. — The pegmatite deposits at Franklin Furnace and the adjacent areas are characterized by a wide variety of minerals. Some of the more common minerals include quartz, feldspar, mica, amphiboles, tourmaline, and epidote. These minerals are intergrown and often exhibit complex mineralogical relationships. The pegmatite deposits are typically composed of two distinct zones: the outer, quartz-rich zone and the inner, feldspar-rich zone. The composition of the minerals in these zones varies depending on the specific location within the deposit.

It is important to note that the pegmatite deposits in the Franklin Furnace area are not typical of most pegmatite deposits found elsewhere. The Franklin Furnace pegmatites are characterized by a unique mineral assemblage and exhibit a complex history of fluid flow and mineral precipitation. This unique combination of factors has resulted in the formation of economically important mineral deposits.

In summary, the pegmatite deposits at Franklin Furnace and the adjacent areas are a valuable resource for the study of mineralogy and the evolution of igneous rocks. The mineralogy of these deposits provides valuable insights into the processes that govern the formation of pegmatite deposits and the development of economic mineral deposits.
KITTITASY LIMESTONE.

Overlying the Barronforma is a thin magnesian limestone which takes its name from the Kittitas Valley, of which it forms in part the floor. It grades downward into the transition beds of the Bearpaw group and the pro-Cambrian, which are interbedded with shale and limestone. Above, it is limited by an unconfined area of the subformation, the overlying transition layers being interbedded with shale and limestone. South, it is limited by the unconfined stretch of the pre-Cambrian area across and cut off as the west by faulted in the cliffs of Walla Walla River below the near the summit. Overwidths are numerous within all the limestone areas, so that various planes may be readily studied. In outcrops are uniformly rough and irregular, giving a warty aspect to the surface.

It is generally blue or bluish-gray, in place dark, black, or rarely red, and has commonly been called the blue limestone, in contrast to the white (Barron) limestone. At various places in the limestone layers or nodules of black chert are abundant, and some beds in the basal portion are red, black, or gray. Most of the chert occurs as white, botryoidal, 3 or 4 ft. thick, but thin layers of limestone alternating with shale or thin-bedded sandstone are present near the top in 4 ft. at right angles to the bedding is developed. The formation is estimated to have a thickness of 2500 to 3000 feet. The vertebrate fossils of the formation, a series of thirty or more analyses of widely separated samples showing from 14 to 21 per cent of normal limestone, however, carry less than 3 per cent of magnesium.

The fossil fauna of the Kittitas limestone, for instance, is not extensive and is found at few localities, but it sufficiently to establish the Cambrian age of the greater part of the formation. The principal fossil faunas for this formation in the quadrangle at is O'Donnell & McKinniman's quarry in Newton, where the following species have been identified by Peter Weller:

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The lenticular species is the most abundant member of the fauna, which also generally is not significantly to some of the Saratoga ("Upper Cambrian") fauna of the upper Mississippi Valley. Orthoceras leavitti is found also in an old quarry about one mile west of Long Pond.

These fossils as a whole are of Saratoga type and the beds containing them probably in the upper portion of the formation, although their exact position cannot be determined. As Arctoceras ("Middle Cambrian") is north of west from Fontana, and in the Ossontus formations of the Hamiltonian quadrangle is considered to be of Georgian ("Lower Cambrian") age, and as no evidence of a break in sediments has been observed, an Arctoceras fauna would naturally be expected to occur somewhere in the formation. In one locality (southwest of this quadrangle) a fauna of Orthoceras (Beckman's) age has been found in beds near the top of the Kittitas limestone, and probably in the upper portion of the formation, although their exact position cannot be determined.

The rocks of the Orthoceras formation are here clearly defined and can be correlated with the Orthoceras beds. They are a part of the great area of Orthoceras sediments—principally shale—which extend from northern New York to Alabama and southward through the Cumberland山上 rock under the Appalachian Valley.

JACKSONVILLE LIMESTONE.

Above the Kittitas limestone and separated from it by a break in sedimentation indicated by a stratum of gray conglomerate which is a dark-blue or black felsiculous limestone, correlated with the Lowville, Black River, and lower Trenton lime-
stone of the New York section and highly channeled as "Trenton." The conglomerate is made up of poorly sorted fragments of the underlying magnesian limestone and is a fine-grained, angular matrix and ranging in thickness from a few inches to 20 or 30 feet. Abundant this area is over 200 feet thick, of dark-blue, highly felsiculous limestones, some layers of which contain as much as 90 per cent of calcium carbonate. They are usually separated by about 30 feet of more sandy beds, and clastic strata occur also at the top of the formation. This sequence, though common, is not of universal occurrence. At Jacksonville, Warren County, N. Y., the type locality, shales and thin-bedded shelly limestones 20 or 20 feet thick occur at the base of the beds, which is over 100 feet thick, of the top of the for-
mation not being seen. The shelly limestones are suitable for use in Pennsylvania, in a long, narrow area, and are not utilized within this area.

In this quadrangle the thickness of the Jacksonville formation is appreciable and the clastic strata occur in the upper part of the formation, which is now known to belong to the sandstone. The conglomeratic phase is best in the small area east of Ravineville, the higher layers in the Ravineville area, and the lowest layers in the vicinity of May Ave and Beaver Run, westward of Southfield, toward the Railroad and 2 to 3 miles north of Lafayette.

The limestones contain an abundant fauna, for instance, eighty-four species having been described by Weller from outcrops within and adjoining this quadrangle. The most characteristic forms are the following:

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The type locality the lower strata for a thick-
ness of 350 feet, carry a Lowville and Black River limestone and the fossils found in them. The principal fossil localities within this section are seven-eighths of a mile below the point of Dravusville, and at the north end of Dravo Village, and one-half mile northwest of Hill Pond.

MARTINSBURG SHALE.

There is a somewhat abrupt transition through 500 to 600 feet from the comparatively pure lime-
stone of the Jacksville to the overlying beds. The logs of the Martinsburg and sandstone which here fore been known as the "Hudson River slate" and which are now correlated with the Martinsburg shale of West Virginia and hence take that name.

The formation ranges from the finest grained beds and shale at the base of the Kittitas Mountain, of which it forms part of the floor of the Hudson River Valley. It is chiefly a coarse quartzite and conglomerate composed of small white quartz pebbles, generally 1 to 2 inches in diameter, and sandstone. The dark shale which generally steel-blue, but some beds have a yellowish brown color, and bedding layers occur near the base of the formation. These beds are locally interbedded with thick beds of conglomerate and sandstone and occur in small pockets. The conglomerate is generally 1 to 2 inches in diameter and consists almost entirely of small pebbles of quartz, white, yellow, and red, red shales, and red and purple quartzite, and a very few of red shales and red sandstone are present in this formation. The pebbles and pebbles are generally flat and bedded. Some of the white quartz peb-
bles have a pitted texture on their outer portion. The quartz pebbles were probably derived from the pre-Cambrian formations of the Catskill Mountain area, which are exposed in the valley. What of the white quartz pebbles may have come from the Kittitas limestone; and the Huronians may have yielded some of the
quantitative; but the sources of the pebbles of red and purple quartzite, red slate, pink Jasper, white, yellow, and red chert are unknown.

The matrix is composed of a quartz sandstone, vitreous in texture and generally of a dull-red color, but while, gray, and greenish strata are abundant, particularly in the basal portion, that the formation is not so exclusively red as it sometimes implied.

The beds are almost uniformly quartzitic in texture, and on account of their hardness form the long, narrow, steep-sided ridges that characterize the Green Pond Mountain. Locally, however, in regions adjoining this quadrangle, the basal portion of the conglomerate is friable and disintegrating readily, owing probably to the presence of a greater or lesser amount of calcareous material derived from the Kinnittayn limestone upon which it locally rests. The quartzite, which is interbedded in the upper portion of the conglomerate and rests upon it, is in general of a purplish brown color, but some layers are of pink, yellow, brown, and gray. Some of these masses are massive and show no laminae, but in others the thin stratification planes can be readily made out. The conglomerate beds are in many places very thick with but a slight trace of any bedding. South of the isolated hills south-west of Blockhouse Rock, the rock is much softer, and is a friable sandstone rather than a quartzite, and some of the beds are so completely decomposed that they have been dug for sand and gravel for many years.

In Bedrock Green and Green Pond mountains the conglomerate unexplainably rests directly upon the precambrian gneiss, although the actual contact is not seen. The gneiss, however, is exposed in the valley along the outlet of Green Pond, close under the conglomerate at the north end of Green Pond Mountain, and close to the conglomerate in Bowling Green Mountain. It is apparently over- lain conformably by the red Longwood slate, but nowhere in New Jersey have the two been seen in actual contact.

The thickness of this formation has been measured on numerous sections from across Green Pond, Copper, and Kinnittayn mountains, where the approximate position of the inclining formations could be determined and where frequent measurements of the dip of the strata were made. West of Green Pond the conglomerate beds dip from 45° to 75° NW, indicating a probable thickness of 1200 feet. The average of measurements elsewhere is about 1200 feet.

As organic remnants are unknown in this conglomerate, inferences as to its age are based on stratigraphic position and lithologic character. On these grounds it is correlated with the Swangavargon conglomerate. Although in this quadrangle the conglomerate rests directly upon the gneiss, in closely adjoining regions it is found upon the cretaceous Kinnittayn limestone and beds certainly upon the Marble Mountain slate. The first rock exposed above the Longwood slate of the Green Pond Mountain region is a fossiliferous limestone containing a fauna of Silurian age. The fact that in the first fossiliferous limestone overlying the High Falls sandstone west of Kinnittayn Mountain, but whereas the beds in the Delaware Valley referable to the Silurian have a thickness of 2000 feet or more, those of the Green Pond Mountain region do not average more than 1400 to 1500 feet. It is still an open question whether the Paleozoic strata of the Green Pond region were once continuous with those of Kinnittayn Mountain across the intervening valley and highlands, a distance of 15 miles, or whether the Green Pond region represents a separate basin shelf off on the northwest from the larger Paleozoic sea, although corresponding with it in the northeast. The fact that its sediments are now cut off on the northwest by a profound fault is indicative that they once extended much farther in that direction. More refined work for better limits of this quadrangle is necessary to determine this question.

LUMINOUS STONES.

Immediately above the Green Pond conglomerate and on the shelf of slate, in which there is an irregular lamination is usually highly developed that the bedding planes can be determined only with difficulty. The rock, however, does not have a strata structure. This formation, which derives its name from Longwood Valley, in the Lake Hopatcong quadrangle, forms a narrow belt at the northern boundary of the Green Pond Mountain and along the northern margin of Delaware Valley. It is but owing to the covering of glacial deposits outcrops are rare except just south of Milton, where the beach deposits of the Green Pond conglomerate and is over lain by the Triassic limestone, and underlie the large drift-covered area north of Petersburg. The thickness is unknown but it is estimated as high as 1000 feet. The rocks that are found elsewhere determine the Hamilton age of these rocks. The formation takes its name from its extensive development along the Delaware river and is the "Monroe shale" of the reports of the New Jersey Geological Survey.

DECKER LIMESTONE.

A dark-grey impure siliceous and slaty limestone overlies the Longwood shale in the Green Pond Mountain region but is nowhere seen in contact with it, and in this quadrangle its outcrops are concealed by drift. It is not more than 50 feet thick, but no single exposure shows the entire thickness. The beds exposed contain fossils which permit their correlation with the lower part of the Delaware ("Decker Ferry") limestone of Delaware River and the upper Silurian beds of New York. The principal fossil localities are not within this quadrangle.

DETERMINATION.

Of the Devonian strata occurring in the isolated belt of Paleozoic strata that extend across the greatly dipping back from the Delaware River into the Martinsburg shale, and separated from the outcrops of the Swangavargon conglomerate which form the northern boundary of the quadrangle, a wood ridge rising steeply from a bench produced by the gently dipping back from the Martinsburg shale, and separated from the outcrops of the Swangavargon conglomerate which form the northern boundary of the quadrangle, and the Delaware River northwest of Kinnittayn Mountain. So different is this Coniacian formation from the present classification of the Devonian strata that the remaining Devonian strata occurring in the quadrangle, are 40° to 50°. The upper level of the ridge produced by the igneous rock is slightly below the plane of the base of the conglomerate, if the latter were projected outward from its present outline; but at both south and north ends the ridge of syenite dies out at the base of conglomerate cliffs which cut off its further extension and join the Martinsburg shale. On the lower side of the ridge of igneous rock the slope is in places almost in contact with it and is penetrated by breaches from the main mass. Satisfactory contacts with the Coniacian strata are not similarly possible as would show breaches and other connections, whether the igneous rock passes into the mountain under the conglomerate have not been seen. The rock is described as a large dike emerging at the present contact between the two sedimentary formations; it might, however, be a part of the same rock of similar texture along the contact. The last suggestion would accord best with the bulging form of the outcrop in the middle and the thinning at the ends where the two inclining formations come together. On the other hand, the two smaller bodies of this rock (described under the heading "Nephelitic dike rocks") are, like the large mass, parallel to the cleavage of the slate, and as they are intrusions, by analogy the same form might be supposed for the large body. Perhaps the rock cuts the lower part of the slate as a dike but spreads out laterally along the bedding into the conglomerate. If the rock forms a sill or breccia the thickness between the walls is about 600 feet at a maximum, if a vertical dike it is about 900 feet wide.

Lithologic character.—The rock forming the body of the igneous mass varies within wide limits both in the proportion of the constituent minerals and in the coarseness of grain. The color of the syenite ranges from a very dark gray, and in some gray and sandy varieties are exceedingly rich in biotite, augite, hornblende, biotite so potassic that they are called trineite, melange (a black grant), apatite, zircons, sodalite, amphibole, and pyrite as necessary. The variation in the relative amounts by weight of the minerals will be seen by the two analyses given below. The rock of No. 1 obtained toward the north end of the large mass; that of No. 2 toward the south end.

Nephelitic composition of nephelite syenite.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nephelite</td>
<td>72.6</td>
</tr>
<tr>
<td>Augite</td>
<td>19.8</td>
</tr>
<tr>
<td>Apatite</td>
<td>2.1</td>
</tr>
<tr>
<td>Hornblende</td>
<td>3.1</td>
</tr>
<tr>
<td>Quartz</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Under the microscope the biotite is seen in hexagonal plates, and the augite, feldspar, apatite, and other accessories are grouped together in crystals that are inclosed in the large crystals of orthoclase. Many of these are more than in inch in length. They have irregular boundaries and form numerous Carlsbad twins. Where the feldspar predominates over the nephelite it incloses the latter in hexagonal crystals, but where the nephelite predominates the two form a coarse granular aggregate. The centers of some of the larger biotite crystals are reddish, the outer zones green (augitite); the periphery deep green (augite). Secondary euhedral, euhedral, and pleochroite are common.

Contact metamorphism.—The Martinsburg shale region has been intruded and mineralogically altered for a considerable distance southeastward from the line of the syenite and north and south of its termination. The principal changes observed microscopically are especially notable in the contact in a zone of some 5 miles across the middle of the New Jersey, containing the chloritized microgranular to granular quartz and feldspar biotite crystals of nephelite, augite, and hornblende, and the syenite rock. In places the chloritic material has disappeared and a fine-grained granitic band rock is found, composed of polygonal granular orthoclase and some biotite and augite—some orthoclase-augite schist.

Nephelite dike rocks.

The nephelite syenite proper is cut by dikes, some of which are exposed in place, but there are also abundant loose blocks found on the surface of the ridge unconnected with actual outcrops. Most of these blocks are probably derived from dikes, but others may be due to local variations in the main syenite mass.

Another group of dikes occurs in the Martinsburg shale region, from 15 to 50 miles from the main syenite mass. They strike parallel to that area and nearly all of them were intruded parallel to the main syenite mass.

Lavolite tuffaceous.—The most of this rock is found in dikes associated directly with the main mass of nephelite syenite. It has been found, however, as far as 3 miles from the syenite. The material of the dikes and loose blocks is usually of a brownish-gray-green color and a general dense texture. It contains some phenocrysts of nephelite, orthoclase, or rounded 24-sided crystals that were originally crystals of orthoclase or nephelite. Under the microscope the groundmass, which contains the larger crystals just mentioned, shows smaller crystals of augite, biotite, and apatite, and a network of acicular green crystals of augite or augite, lying in a colorless background composed of irregular areas of orthoclase, nephelite, and in places some anatase. The analysis of the leucite tinge is given below; the mineral proportions are given.

Mineral composition of leucite tuffaceous.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyroxene</td>
<td>22</td>
</tr>
<tr>
<td>K-feldspar</td>
<td>56</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>56</td>
</tr>
<tr>
<td>Plagioclase, apatite</td>
<td>16</td>
</tr>
</tbody>
</table>

These dikes correspond to rocks often called nephelite or leucite nephelite, nephelite porphyry, and nephelite porphyrite. Some of the porphyritic varieties are exceedingly rich in biotite, augite, hornblende, and feldspar and nephelite becoming subordinate, and correspond to the terms of the leucite syenite of Bonnell called "jaspernite."
One mile east of Plumbago and the other a mile west of Wymark's. The first is about 150 feet wide and 900 feet long, the second 130 feet wide and 700 feet long. The dikes near Plumbago contain phenocrysts of olivine, nepheline, and augite in a groundmass of interstitial olivine and augite, with occasional small crystals of biotite. The Wykmerton dikes are finer grained and contain a microscopically sparse abundance of olivine, nepheline, and pyroxene crystals of augite, and the augite is more abundant in the center and gradually diminishes in size towards the periphery, and crystals of augite and melanite, with some of the augite and nepheline.

The mineral composition of this rock is as follows:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Weight Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepheline</td>
<td>28</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>16</td>
</tr>
<tr>
<td>Olivine</td>
<td>10</td>
</tr>
<tr>
<td>Biotite</td>
<td>5</td>
</tr>
<tr>
<td>Amphibole</td>
<td>5</td>
</tr>
<tr>
<td>Augite</td>
<td>4</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
</tr>
<tr>
<td>Magnetite</td>
<td>1</td>
</tr>
</tbody>
</table>

This appears to contain more feldspar than the analysis in the text. The analysis in the text would appear to contain more that of feldspar than in the analysis in the text.

To the Quaternary period of geologic time is referred most of the unconsolidated material lying on the bedrock described in the preceding pages. This material is commonly known as drift. It is primarily of glacial and partly of fluvial origin, and is made up of clay, sand, gravel, and boulders, locally separated from one another, but more generally cemented into varying proportions and without apparent order or arrangement. It is in places thick enough to entirely conceal the bed of the meander, and in other places so thin as to enable one to see that the great fluvial channels, which at all great perennial meander channels of the present time, were in reality great ice sheets, but thinly covered with silt, and as the ice surface had been given sufficient thickness to deform or flow under its own weight, movement was begun. This movement was glacial movement and the ice in motion was glacier ice.

From the separated centers the ice and snow sheets extended themselves in all directions, partly as the result of drift, and partly as the result of the marginal accumulation of snow. The ice sheets advancing from these centers ultimately became confluent, and invaded the territory of the United States as a single sheet which, at the time of its greatest development, had the area shown in fig. 3.

The map also shows that the edge of the drift-covered area was somewhat lobate. The lobation is, indeed, more pronounced than this small map shows.

Drainage Glaciations

In the preceding paragraphs the ice sheet has been referred to as it developed once, and then melted from the face of the land. But a great deal has happened since then. The ice has in hand showing that the evidence of history of glaciation was not so simple. One ice sheet developed and then melted partly or wholly, only to be succeeded by another, which in turn melted partly or wholly disrupted before a new period of glacial conditions caused a third advance of the ice. Within the United States the number of pronounced advances of the ice was not over five, though the ice did not reach the same limit in successive advances, and it probably did not reach to the same position during the epochs of deglaciation.

It is believed that the edge of the drift-covered area is now rather accurately defined, but the problem in the future is to determine the actual position of the ice as it moved inland and carried forward in its path.

The work affected by an ice sheet is twofold. In the first place, it covers the surface over which it advances, widening and deepening valleys which are usually affected to its direction of movement, cutting off hillsides, and smoothing down roughnesses of all sorts. In the second place, it sooner or later departs, and in its retreat it leaves in its wake a deposit of soil that changes and carries forward in its path.

Drainage glaciations tend, first to cut the surface down by erosion, and then to build it up by deposition, but the two processes rarely affect the same spot in an equal degree. The result is that the configuration of much of the surface is considerably altered by the passage of glacier ice over it. If the drift is thick it may level an uneven surface of rock, or it may be so disposed as to increase the relief instead of diminishing it. If the drift in thin its effect on the topography is less pronounced. Where the relief of the rock surface beneath the drift is great, the drift has relatively little influence on the topography.

The deposits occasioned by glaciers fall into distinctly classes, those made by the ice itself and those made by the water derived from the ice itself. The former are often unsorted and unstratified; the latter are stratified and sorted. The unstratified drift constitutes moraines.

Characteristics of Glacial drift in general

From the method by which it was gathered, it can be seen that any facility may contain fragments of rock of every variety occurring along the route followed by the ice which removed it. The finer and better sorted of the materials in the drift may therefore be great.

Another characteristic of the drift is its physical and chemical properties. The drift may be gathered by the ice, some of the materials of the drift were fine and some coarse. The ice tended everywhere to grind and crush the debris it carried, reducing it constantly...
to a finer and finer state. Much of the other mat-
erial, such as slate, was crushed or ground to powder, fer-
der, forming what is popularly known as clay; other sorts of rock, such as sandstone, were reduced to sand; and masses of more resistant rocks were removed by the waters, increased and removed by bowdlerization. From clay and sand on the one hand to bowdler on the other, all grades of coarseness are represented in the glacial drift.

Still another characteristic of glacial drift is the closely distinct features of a terminal moraine is its topography. This, more than any other one feature, distinguishes it from the ground moraine. Although the topography varies from point to point, its most distinctive plane is marked by deep breaks and hollows, and the terminal moraine, as it were the trough, following one another in rapid succession, as illustrated in fig. 4. The relief is in places 200 to 300 feet, and 250 feet in some places; the differences included by the elevations are the sides of marshes, ponds, and lakes, wherever the material is very coarse, and it is only necessary to bowdlerize the water to retain the water falling and discharging into them.

A terminus in which the topography of terminal moraines was developed is worthy of note. In the first place, the various parts of the ice margin carried the material it had accumulated far enough to have covered the moraine of any region to be of unequal height and width at different points. In the second place, the material being maintained at the same general position during the making of a moraine, was not subject to any material changes; this, along with the peculiar hilltops and hollows which characterize terminal moraines may have arisen. Some of the depressions probably resulted from the accumulation of ice blocks left behind when the ice retreated.

Stratified drift — A large part of the drift is stratified, showing that it was deposited in layers. This is not strange when it is remembered that the total amount of water which operated on the drift was very much less than the total amount of water the larger part of the ice was ultimately converted into water, and to this was added the rain which effectively fell on the moraine and ran across the surface of the ice.

Stratified drift may be formed in various ways. It may be deposited by water alone, or by water in cooperation with the ice. The latter is called bowdlering or standing. When the ice cooperated with the water, it was generally a passive partner. The most extensive deposits of water arising from glacier ice are laid down either as the water issues from beneath the ice, or as it flows away.

The immediate edge of the ice sheet, therefore, certain deposits were made. The margin of the ice was probably irregular, as the ends of glaciers now are, and as the waters issued from beneath it they left some of their debris against its irregular front and in its recesses and nooks. When the ice retreated, the glacial accretions of sand and gravel were left behind it. Such hilltops of gravel and sand may be seen in places. The accumulation of sand and gravel, both of which are the materials deposited by the ice, carried some gravel, sand, and silt beyond the edge of the ice, and deposited them in the valleys and on the plains.

The waters passing over the ice and left behind it, as those of lakes did, came to the sea, and are dismembered by the sea. The sea water issues from beneath the ice, and water issues from beneath the ice, or as it flows away.

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mountain three-fourths of a mile from Beemerville, 1 mile at 60° W., and 1 1/2 miles at 45° W. This, as well as the fact that the special writer also observed on the limestone, is outcrop. Northwest of the outcrop some strata show 60°, 60° W., or 45° W. These strata and others more northeasterly are probably the same syneclitic bowlder zone of the crest of the mountain, that is, the fact that the lower part of the eastern slope of the range passed over by the crest is itself the outcrop, and not, as previously noted, that the distribution of the syneclite in the drift is in harmony with the direction of the strata.

THE ICE OF THE CREEK

As the ice moved from the Kittatinny Valley toward the highlands on the southwest and toward Kittatinny Mountain on the northwest, it follows that the surface of the ice must have been higher in the valley than it was in the mountains. Over by far the larger part of the remainder, the drift (usually thin) is quite apparent. In a few localities the drift occurs in the lee of hills, which are blown out by the wind, and in such a way that the syneclite is observed in the lee of the hills. As the limestone hills in general are low, a considerable part of the area is covered with drifted gravel, and is subject to the drifts of another part of the valley. Over by far the larger part of the remainder, the drift (usually thin) is quite apparent. In a few localities the drift occurs in the lee of hills, which are blown out by the wind, and in such a way that the syneclite is observed in the lee of the hills. As the limestone hills in general are low, a considerable part of the area is covered with drifted gravel, and is subject to the drifts of another part of the valley.

Drift of Kittatinny Valley

As shown by the rear geology map, this valley is underlain by shale and limestone debris in both the north and south, and with the general trend of the valley. The topography of the limestone hills is different from that of the shale hills, and the differences of such importance in the disposition of the drift, that some account must be taken of it at the outset.

Shale and limestone.-As the valley is underlain by shale and limestone debris, it is an important matter to note the effect of the strata and the general trend of the valley. The topography of the limestone hills is different from that of the shale hills, and the differences of such importance in the disposition of the drift, that some account must be taken of it at the outset.

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The valley of the Potomac.—Some of the most picturesque scenery of the Potomac valley is found on the south side of the Swann’s Narrows. Here the cliffs are very high and the scenery is wild and romantic. The valley of the Potomac is narrow and the river winds and twists through it in a way that makes it seem almost a continuation of the Chesapeake Bay. The cliffs are of sandstone and shale and the water is often so clear that you can see the bottom. The valley is very deep and the river flows through it in a series of rapids and waterfalls. There are also numerous small streams that flow into the Potomac here.

The valley of the Shenandoah.—The valley of the Shenandoah is one of the most scenic in the United States. It is a long, narrow valley that runs from the Blue Ridge Mountains to the Potomac River. The valley is deep and steep and the mountains on either side are magnificent. The river flows through the valley in a series of rapids and waterfalls, and there are numerous small streams that flow into it. The valley is very beautiful and is a popular spot for hiking and other outdoor activities. The Shenandoah Valley is also home to a number of historic sites and landmarks, including Monticello and the Blue Ridge Mountains.

The valley of the Rappahannock.—The valley of the Rappahannock is also very beautiful and is a popular spot for hiking and other outdoor activities. The river flows through the valley in a series of rapids and waterfalls, and there are numerous small streams that flow into it. The valley is very beautiful and is a popular spot for hiking and other outdoor activities. The Rappahannock Valley is also home to a number of historic sites and landmarks, including Monticello and the Blue Ridge Mountains.

The valley of the James.—The valley of the James is one of the most beautiful in the United States. It is a long, narrow valley that runs from the Blue Ridge Mountains to the Potomac River. The valley is deep and steep and the mountains on either side are magnificent. The river flows through the valley in a series of rapids and waterfalls, and there are numerous small streams that flow into it. The valley is very beautiful and is a popular spot for hiking and other outdoor activities. The James Valley is also home to a number of historic sites and landmarks, including Monticello and the Blue Ridge Mountains.

The valley of the South Fork.—The valley of the South Fork is a narrow, winding valley that runs from the Blue Ridge Mountains to the Potomac River. The valley is deep and steep and the mountains on either side are magnificent. The river flows through the valley in a series of rapids and waterfalls, and there are numerous small streams that flow into it. The valley is very beautiful and is a popular spot for hiking and other outdoor activities. The South Fork Valley is also home to a number of historic sites and landmarks, including Monticello and the Blue Ridge Mountains.
West of Haslytownsville and extending beyond North Church is a glacial delta (Fig. 7). It is a flat, low, dissected area which is bounded on the east by the lake, on the north by the lake, and on the south by the lake. It is about 3 miles wide and 5 miles long, with an average elevation of 600 feet. It contains extensive areas of marsh and upland, which are separated by narrow strips of open land. The surface of the delta is generally flat and level, with only a few small dunes or mounds of sand. The delta is drained by a number of small streams, which flow into the lake.

The delta is particularly well developed along the eastern shore of the lake, where it forms a large, flat area of marshland. The marshland is characterized by extensive areas of sedge, with occasional patches of scrub and woodland. The surface of the marshland is generally flat, with a few small dunes and mounds of sand. The marshland is drained by a number of small streams, which flow into the lake.

The delta is also well developed along the western shore of the lake, where it forms a large, flat area of upland. The upland is characterized by extensive areas of forest, with occasional patches of scrub and woodland. The surface of the upland is generally flat, with a few small dunes and mounds of sand. The upland is drained by a number of small streams, which flow into the lake.

The delta is well developed along the southern shore of the lake, where it forms a large, flat area of upland. The upland is characterized by extensive areas of forest, with occasional patches of scrub and woodland. The surface of the upland is generally flat, with a few small dunes and mounds of sand. The upland is drained by a number of small streams, which flow into the lake.

The delta is also well developed along the northern shore of the lake, where it forms a large, flat area of upland. The upland is characterized by extensive areas of forest, with occasional patches of scrub and woodland. The surface of the upland is generally flat, with a few small dunes and mounds of sand. The upland is drained by a number of small streams, which flow into the lake.

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The delta is well developed along the southern shore of the lake, where it forms a large, flat area of upland. The upland is characterized by extensive areas of forest, with occasional patches of scrub and woodland. The surface of the upland is generally flat, with a few small dunes and mounds of sand. The upland is drained by a number of small streams, which flow into the lake.

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tically glacial, many of them on all sides. This is partly because of the roundness with which they receive strie, and partly because they weather less rapidly than some of the others. Few if any of the limestone boulders on the scarp face show signs of glaciation. Many of them, indeed, are exsiced in their entirety.

Owing to the forested character and the scanty population of much of this region, exposures of the till are not numerous. The shallow cut along the road leads to a view of many of these till sheets, and perhaps nearly all the available data, aside from those furnished by the surface, from which to judge of the constitution, physical character, color, amount of oxidation, and thickness of the till.

The color of the till at the surface is uniformly that of the moistened clay of gneiss, a yellowish brown. This color commonly changes beneath the surface to grayish brown, but in many places exposures are too few to make this change evident. One of these is Exsiced on the red bad. Drift of the upper slopes, many of which have barely enough soil to afford a bedrock for timber. On the gentle slopes, on the lower and middle slopes of the hills, which are not so dark, though sown with grass and shrubs, and the color is more prominent. Though outcrops of rock are more or less continuous over the whole region, there are, in the aggregate, considerable areas where it is well concealed.

Without the evidence of numerous exposures as an indication of the thickness of the drift, it may be far short. Where its thickness exceeds the depth of the shallow exposures, there is usually no way of determining whether it is in 10 or 20 feet deep, though as between these extremes the surrounding country may give some clue. The surface of the hills is roughly estimated to be between 10 and 20 feet, and probably nearer the former figure than the latter. Thickness of 40 ft, however, are known. Similar drifts are rarely seen on the bed rock.

Till of the West—In the region west of the Sparta Valley till is generally bedrock, and notably thicker on the southern slopes and in the east on the north slopes and in the west on the upper slopes of the two high hills just north of the village, though thin on the lower and middle slopes. Boulders and other materials from the Kittitas Valley are more abundant here than in the same area farther north on the upper slopes. The exposures of the bedrock are mainly along the roads and railway. A well broken bedrock of gneiss 8 by 10 ft wide, between 2 and 3 miles southwest of Sparta, and Long Pond, a northeasterly from the town, is especially notable for its delicately balanced position on a gneiss ledge.

Drift of the Pochuck Mountains—Drift of the Pochuck Mountains is on the whole, thin, as everywhere in the Highlands region, though IH tens of 20 to 20 feet are known at several points. The material of the till is chiefly bedrock, but boulders from the scree slopes to the north are of common occurrence. Limestone boulders, however, are rare. Where thick, the till is usually shallow and compact, though as in the case of the deep depositions of the high hills outside of Deseret, the lee, show numerous exposures of the gneiss, but other areas are generally well concealed. These exposures are on the exposed rock surfaces here as throughout the Highlands. This is the result of postglacial weathering rather than of original failure, as evident from the faces of the high hills.

Till of the Valleys—The till of the Highlands varies from the sparta and Vernon valleys is essentially the same as that of the Pochuck, Mountain and the Pochuck Hills. Except along the western faces of Worthington, Hamburgh, and Wallkill mountains, and in certain places along the show local sources of quartzite, sandstone, and shale, the Highlands till is made up almost wholly of gneiss. Where well developed, the drift of the west side of the valley in the Bear Branch of the river, near where it branches off the main stream at a point of gravelly knoll, coarse, and from there where it branches off. The drift of the west side of the valley is also very coarse, and from there where it branches off the main stream.
In this respect they follow the common Appalachian type of folds and faults, but there are some exceptions to this rule, where the reverse relationship holds true and the steeper limbs of the synclines are on the northwest. In addition to this close folding, the strata are affected by a series of cross folds of great length and low amplitude which make it difficult to distinguish the plane that the beds are folded about, on account of the minor folds which may be present. Some of these folds are simple, but more in the nature of the pinch of the axes of the northeast-southwest folds.

Folds.—Most of the larger folds are cut off by faults, and nowhere have the beds changed their original relations. The strata at or near the surface are concave near the center and convex outward. This is probably not true in all cases, for the history of pre-Cambrian time is very obscure. Where the strata have been affected by the horizontal compression and the minor differences in the sedimentary series, the strata near the surface would be concave upward, the strata near the base would be concave downward.

In the large scale area comprised of the northernmost portion of the quadrangle there is a large number of the synclines and anticlines which have produced the present state of the surface. The area appears to be largely an area of crystalline rocks, and the history of pre-Cambrian time is very obscure. Although the strata are not present in the area, the history of pre-Cambrian time is very obscure. Although the strata are not present in the area, the history of pre-Cambrian time is very obscure.
much longer. There is here no record of the Jack- 
sonburg, and the Kitteny limestone has only a 
fraction of its thickness elsewhere. Moreover, there 
is in this region only a single occurrence of the 
Martinsburg shale. These facts are interpreted to 
mean that the erosion interval was so prolonged as 
to remove most of the Martinsburg shale and 
prevent the deposition of the Jacksonburg lime- 
stone entirely and of the Martinsburg shale in 
great part at least. In the upper part of the hori-
zon, however, the unconformity is but slight.

The changes which terminated the deposition of the 
Jacksonburg limestone, and led to the deposition of 
the silicious shales and sand of the placostal series, 
were due primarily to the uplift of the Appalachian 
region. This is the major structural feature of this 
area at a much earlier period than in the typical 
Trenton area in New York; for here the lower 
Martinsburg shale contains evidences of long 
periods of deposition, which is characteristic of the 
middle Trenton of central New York.

With the close of the Ordovician there were 
very extensive crustal movements in Vermont and 
Canada which affected this region and raised it 
above sea level for a long period, for between 
these and the Jacksonburg shales is what has been 
referred to as a blanket of the western part of 
the region. The structure of the region is that 
of a folded belt dipping toward the northeast, 
which is parallel to the trend of the Atlantic 
Coast. The layers strike parallel to the fold, 
and the dip is toward the northwest. The geologists 
who have studied this region have divided it into 
six divisions, according to the nature of the rocks:

- **Silurian Series**
- **Devonian Series**
- **Carboniferous Series**
- **Permian Series**
- **Mesozoic Series**
- **Cenozoic Series**

Of course, the Silurian, Devonian, and Carboniferous 
series are the ones with which we are most 
concerned. The others are not as important in this 
region. The Mesozoic and Cenozoic series are 
not well developed here, and the Permian series 
is not present at all in this area.

**The Placostal Series**

This series includes the following rocks:

- **Silurian Series**
- **Ordovician Series**
- **Devonian Series**
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unusual character of the ore was recognized from the behavior in the blast furnace. The ore consists in the presence of a considerable amount of manganose, which gave the pig iron a composition favorable in making the whole the diameter 3 to 10 feet thick. Another mine just southwest of the Ogleon was also yielding excellent ore in large amounts.

The Ogleon mines comprised the Devon-Port, Ogel, Roberts, and Pardee, named in order of position from southwest to northeast. (See fig. 8.) At the Devonport mine the nearly alluvial deposits had been worked to a depth of 165 feet. The vein was 6 to 8 feet thick at the Pardee mine. In the years of 1870 to 1880 the mine had been idle since 1873. The Old Ogleon mine was reopened during the same year, and the Roberts mine had been put in opera-

In 1885 only the so-called Pardee-Ogelmine was in operation. Stepping had progressed 200 feet and for this distance the ore averaged 14 to 15 feet in width. It was mined at a height of 82 feet. *The* ore thins out to about 6 feet below the top of the rock. The actual limit in that direction is unknown, but in the bottom the ore is removed and one aspect of the ore seems to become more and more iron ore as the level descends. The walls of the stopes are nearly vertical, and the bottom of the ore descends slightly toward the southeast.

In 1884 the workings were 375 feet deep and the stopes were carried 110 feet high, so up and having been opened. The ore zone seems to indicate a possibility of work along a belt averaging 100 to 200 feet in width and nearly a mile in length. Tracks were laid to several points of access, and the rock was blasted down and loaded by steam shovels onto cars. Experimental work for perfecting the particle run-

The ore zone was stripped of alluvial soil, along a belt averaging 100 to 200 feet in width and nearly a mile in length. Tracks were laid to several points of access, and the rock was blasted down and loaded by steam shovels onto cars. Experimental work for perfecting the particle cut-

The Schodell, Ford, and Dodge mines are located nearly due east of the High Bridge of the Central Railroad of New Jersey. The Schodell shaft on the northeast and the Dodge shaft on the southwest are about one-half mile apart; the Ford workings are adjacent to those of the Schodell field. Two nearly parallel ore-shoots have been worked in each of these mines, and in the Ford and Schodell the ore bodies were in all probability identical, though connection was never made between the workings. The Dodge is on the strike of the other mines, but it is too far away to permit accurate correlation of the veins, though a strong magnetic attraction is common through the whole interval.

Along the same line southeast as far as Lake Hopatcong several prospects have been opened, and the Knothope, at the head of the lake, about 3 miles from the Schodell shaft, a small mine was formerly worked. The ore zone upon which these mines are located lies midway between the southeastward projection of the Ogleon range and the northeastern extension of the Little Mahantango range, the relative positions of which are shown in fig. 8.

The country rock is not well exposed near the mines, but for about two miles in the surrounding area is the ordinary Byram gneiss, containing micaceous and mica-litic as the principal feldspar, with micas and a few quartz porphyries. Masses of pegmatitic biotite, but in the crystallization of the same general
belt of rocks northeastward in the direction of Stockholm. The gneiss are not so strongly banded as those occurring in the vicinity of the Olgan mines, though their fabric can be recognized. The general run of the rock from the mines has a gray, hornpy color and contains more quartz and somewhat more feldspar than the black gneiss in the region, but in other respects is essentially like it. With the gray rock there are darker phases which in some places alternates with the lighter gray, notably in the vicinity of the Olgan mines.

The formation of this dark gneiss seems to be more abundant in association with the ore than with other constituents. All varieties of the rock have a distinct grain parallel with the bedding, and the grain is more or less distinctly marked by biotite or amphibole. The biotite and amphibole are associated mainly with the ore, and in the vicinity of the Olgan mines, they are often associated with the ore in such a way as to suggest that the ore was formed in the biotite and amphibole gneiss. This theory is strongly supported by the occurrence of the ore along the contact of the biotite and amphibole gneiss with the quartzite, and by the occurrence of the ore in the biotite and amphibole gneiss along the contact of the quartzite with the biotite and amphibole gneiss. The ore is also associated with the biotite and amphibole gneiss in the vicinity of the Olgan mines, where it is associated with the biotite and amphibole gneiss along the contact of the quartzite with the biotite and amphibole gneiss.

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The same report contains the partial analyses given below.

<table>
<thead>
<tr>
<th>Analyses of ore from Franklin Porphyry group.</th>
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<tbody>
<tr>
<td>Fe 12.40</td>
<td></td>
</tr>
<tr>
<td>Al2O3 5.20</td>
<td></td>
</tr>
<tr>
<td>CaO 8.90</td>
<td></td>
</tr>
<tr>
<td>MgO 1.50</td>
<td></td>
</tr>
<tr>
<td>SiO2 47.30</td>
<td></td>
</tr>
<tr>
<td>P2O5 2.40</td>
<td></td>
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<tr>
<td>S 0.10</td>
<td></td>
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<tr>
<td>H2O below 10%</td>
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<tr>
<td>H2O above 10%</td>
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Franklin Porphyry

The Pucklock limonite mine, though at one time a large producer, has not been operated for more than thirty years. The old workings are situated about 1 mile east of the town of McArthur, on the western slope of a prominent ridge of Franklin limonite lying between the valley occupied by the Lehigh River and Franklin Porphyry and Pucklock Mountain. The mine is about 200 feet above the midland, with which it was formerly connected by a series of adits, of which, however, little more than the beginning of one remains. The mine was begun in 1823 and was not finally abandoned until 1875. The locality is mentioned in the first report of the first New Jersey Survey as at that time (1835) giving promise of becoming a rich mine. The following description is condensed from the final report of the first Survey:

This large accumulation of ore occurs at the summit and slope of a narrow ridge of limonite 300 feet in length and 200 feet in breadth, with Pucklock Mountain, 1200 feet very rich in iron in the immediate vicinity, the ore, which exists in the concretionary state embedded in a highly ferruginous clayey bloom, which displays the utmost variety of color, texture, and composition, being metamorphosed and streaked with darks of white, yellow, red, and brown. The purest limonite was the most abundant variety of the ores, and the mineralogical description of these ores, which is occupied several months of time by the writers of this report, is now given for the first time, as it is the most abundant kind of ore. The ore is compact and dense and compact or as to require breaking. The workings are generally dry. The earth in mine portion of the ore is nearly dry and well baked, and the earthy concretionary state is distinguished from the most ironiferous varieties of the ores by its compactness, and the position of the fault is therefore clearly shown by several prospecting pits extending in a nearly straight line for about 1200 feet southwest of the principal mine opening. Still further south the fault can be accurately located and the blue limonite no more than 5 feet apart. At the place where the position of the fault is so clearly determined no iron outcrop appears.

The mine openings show that the main body of ore occurred beyond the north end of the blue limonite included in the older pyritic quartzite rocks. These rocks comprise white limonite as the principal rock: dike of pyrites, evidently formed by the dikes of light-colored gneiss, with which they are also intrusive into the limonites. The western edge of the white limonite belt is not exposed, but is located somewhere in the extreme southeast of the county.

In 1883 the mine was equipped with a hoisting plant, and a gravity tramway was built, giving an outcrop to the rail road. Operations continued from that time until 1876. The ore was bounded on the east by the mineralogical descriptions of the ores, which is occupied several months of time by the writers of this report, is now given for the first time, as it is the most abundant kind of ore. The ore is compact and dense and compact or as to require breaking. The workings are generally dry. The earth in mine portion of the ore is nearly dry and well baked, and the earthy concretionary state is distinguished from the most ironiferous varieties of the ores by its compactness, and the position of the fault is therefore clearly shown by several prospecting pits extending in a nearly straight line for about 1200 feet southwest of the principal mine opening. Still further south the fault can be accurately located and the blue limonite no more than 5 feet apart. At the place where the position of the fault is so clearly determined no iron outcrop appears.

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The Ehall lime-mortar or micaceous pit is located about 1½ miles east of Hamburg. In 1840 the excavation was reported to be 140 feet long, 40 feet wide, and 40 feet deep, and there occurred in ferruginous lenses. The locality is near the eastern edge of the white-limestone belt where this rock comes against the granite, and it may in fact be situated along this contact, the position of which can not be accurately determined because of the glacial drift which covers bed rock in the vicinity. For this reason any suggestion can be made concerning the nature of the deposit. It may be an accumulation of material derived from the decay of the adjacent rocks, in which case it would be rather shallow; or, as has been inferred for the deposit at the Pooleke mine, it may be the decomposed cupping of a pyritic deposit.

**ZINC MINES.**

**By A. C. MAURER.**

**HISTORY OF DEVELOPMENT.**

Two large bodies of zinc-bearing ore, different in character from any other known ore deposit, occur at Mine Hill, near Franklin Furnace, and at Sterling Hill, near Ogdensburg. Some evidence exists that these deposits were discovered and prospected prior to 1850, but the earliest authentic record concerning them shows that about 1774 several tons of "red ore" were sent to England by a landed proprietor of that period, Lord Sterling.

About 1821 the lands on which the present mines are situated came into the possession of Dr. Samuel Fowler, and in 1822 the first descriptions of the deposit were published by Nattali and by Vauxmont and Kneutig. Previously the minerals zincite and franklinite had been analyzed and described by Bacon in 1819 and by Holmes in 1812.

About 1850, at the United States Arsenal in Washington, the first metallic zinc made in the United States was produced. The reduction of zinc oxide was carried out by Dr. Fowler, to Dr. Hauser, then Superintendent of the Coast and Geodetic Survey. This metal was used in preparing the standard weights and measures ordered by Congress. The ore from which this metal was made came from a pit on Mine Hill which was afterward known as the Weight and Measures open. The process of reduction employed was too expensive to permit its adoption on a commercial scale, and it was not until about 1850 that the production of spelter from New Jersey ore was placed on a practical basis.

Experiments made for Dr. Fowler had resulted in the production of a bluish oxide of zinc, which about 1830 he had used as a substitute for blue lead in painting his house. Between 1848 and 1850 there was considerable activity in the zinc mines, the ore being used mainly for the manufacture of white oxide of zinc for use as a paint. During the same period several serious attempts were made to manufacture a special grade of iron from the franklinite.

At Sterling Hill two superficial bed-like deposits of calcite and smithsonite were mined out about 1855, and underground mining of zincite and franklinite continued until 1906. At Mine Hill extensive operations have been in progress since about 1850.

The treatment of New Jersey zinc ore has presented many difficult problems, the practical solution of which has given the mines their present value. Metallurgical methods now in use were developed mainly before 1860, but in ore dressing the greatest advance came in 1896, with the perfection of the Wehrethell system of magnetic concentration.

**DESCRIPTION OF THE ORE.**

The complex ores of Mine Hill and Sterling Hill are composed of varying proportions of the valuable minerals franklinite, wulfenite, and zincite, usually mixed with calcite and in the former, especially at Mine Hill, by a variety of silicate minerals including garnet, tourmaline, and rhodochrosite (variety frederikite). In parts of the vein franklinite at Mine Hill is the only metallic mineral; elsewhere it is accompanied by both wulfenite and zincite, or by one of these alone; and in still other places there are layers composed

The flanks become narrower and narrower toward the north until below the 620-foot mine level it is a very thin wedge. The principal underground workings are those of the Mine Hill mine. The vertical shaft situated east of the deposit extends to the 550-foot mine level, the workings of which are reached by a tunnel about 300 feet long. In this mine the deposit has been almost completely outlined by foot-wall and hanging-wall drifts on levels 90 feet apart from 700 feet north to 1100 feet. The lowest point in the mine, at the bottom of the ore body, is 1126 feet below the top of the Parker shaft, which is taken for a datum for measures in depth.

The southern part of the 700-foot mine level was worked through the Taylor mine, which is reached from the open-pit workings on the south by a long slope nearly parallel with the pit of the east vein. On the 600-foot level of this mine the bottom of the ore body has been outlined and the west vein developed.

**MINE HILL DEPOSITS.**

The courtesy of the officers of the New Jersey Zinc Company in allowing the use of the surveyed plans of the extensive underground workings has made possible the preparation of the plan in clear manner the essential form of the great ore body which lies beneath Mine Hill. (See figs. 11, 12.)

The long line of the ore body is slightly varying in thickness from about 12 feet to 100 feet or more, bent upon itself to form a long rough and irregularly rounded height. The rough line with its knee pitching in a northerly direction at an average rate of 56 feet per 100 feet horizontal distance of about 2800 feet from the elbow of the hook-shaped outcrop at the south end of Mine Hill. Still further to the north, the ore body at the rate of 10 feet per 100 feet, to the north edge of the deposit. The west flank rises from the keel at an average rate of about 57' and comes to the surface along the northwest brow of the hill. Its outcrop is about 2600 feet in length, but toward the north its full extent is not seen because the top of the hill is capped by Palisades formations. The greatest dip length of the west vein, measured from the surface in the bottom of the shaft, about 1350 feet is on a section near the most northerly outcrop. On either side of this the height of the vein is less. Near the north edge of the deposit the flank is slightly broken, though not yet determined, is probably not over 1000 feet. Toward the south the height decreases through the gradual rising of the keel.

The east flank has not been fully developed in the underground workings, but enough is known to show that its attitude is somewhat variable. In the lower part of the mine it apparently stands nearly vertical. Further south it dips strongly to the east and largely lies nearly parallel with the west; and still further south, as its outcrop is approached, it either stands nearly vertical or dips steeply toward the east. This side of the outcrop appears at the surface for a distance of about 900 feet northward from the elbow where it is joined by the outcrop of the west leg. Its maximum height, about 300 feet, is in the north end of the outcrop. Between the elbow and the point in the upper part has been eroded away. To the north it is seen only by a carefully cut plane of the white limestone, and the crest line formed in the nearly the same azimuth as the keel of the rough, though somewhat more steeply, namely, about 60 feet per 100. As a result of this steeper pitch the flanks become narrower and narrower toward the north until below the 620-foot mine level it is a very thin wedge. The principal underground workings are those of the Mine Hill mine. The vertical shaft situated east of the deposit extends to the 550-foot mine level, the workings of which are reached by a tunnel about 300 feet long. In this mine the deposit has been almost completely outlined by foot-wall and hanging-wall drifts on levels 90 feet apart from 700 feet north to 1100 feet. The lowest point in the mine, at the bottom of the ore body, is 1126 feet below the top of the Parker shaft, which is taken for a datum for measures in depth.

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**MINERAL COMPOSITION OF ZINC ORE FROM MINE HILL.**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Weight Percent</th>
<th>Volume Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franklinite</td>
<td>51.58</td>
<td>19.86</td>
</tr>
<tr>
<td>Wulfenite</td>
<td>31.28</td>
<td>10.99</td>
</tr>
<tr>
<td>Calcite</td>
<td>52</td>
<td>1.79</td>
</tr>
<tr>
<td>Galena</td>
<td>15.62</td>
<td>5.81</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>0.98</td>
<td>0.36</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.96</td>
<td>0.35</td>
</tr>
<tr>
<td>100.00</td>
<td>100.00</td>
<td>38.58</td>
</tr>
</tbody>
</table>

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holes driven from the wall of the east vein into the hanging wall has this rock been found. In this direction there are no other rocks than limestones and injected dikes of pegmatite, from which it is apparent that the parting between the limestones which lie under the ore and the gneiss beneath does not rise parallel with the east leg of the vein, as was at one time supposed.

Intercrystalline of the ore are produced by some minor faults, by a few irregular injections of pegmatite, and by a diabase dike which crosses both sides of the trough about 600 feet north of the elbow in the outcrop. This dike stands nearly vertical, and is from 15 to 20 feet thick.

Cross sections A to D, accompanying the economic geology map, illustrate the present concept of the general structural relations of the Mine Hill ore body. In shape it is illustrated by a stereogram in fig. 11. The plan in fig. 12 represents the outcrop and horizontal plane of the ore bodies at 100, 300, and 500 feet below the top of the Fuller shaft and on the 700, 900, and 1100-foot mine levels. The boundaries of the ore have been fairly well determined on all the mine levels, but above the 700-foot level the outlines have been intersected everywhere in the neighborhood of the Trucker mine. A longitudinal projection on a vertical plane (also shown in fig. 12) exhibits the pitch of the klip and of the crest of the east vein and the vertical relations of these features to the outcrop of the west vein. The height of the east vein may vary more than has been indicated, as the data on this point are rather meager.

STERLING HILL DEPOSIT.

The Sterling Hill deposit, like that of Mine Hill, is a layer in the form of a trough. (See fig. 13.)

The layer ranges in thickness from 10 to 30 feet, and in places it is composed of two parts, one stained in riebeckite and the other composed largely of franklinite. The sides of the trough, which are of unequal height, both strike in a northeasterly direction, the western flanks outcropping for about 600 feet, and the higher east flank for about 1500 feet from the sharp elbow at the southeast where they meet. Both veins dip toward the southeast, and the keel of the trough plunges in an easterly direction. Near the surface the west vein dips about 45°. Underground, in different parts of the mine, the east vein, which is the one principally developed, shows dips ranging from 45° to 60°, and from the mine maps it is seen that on each level the inclination of the ore layer becomes gradually steeper as the keel is approached. In the open pit of the Noble mines, situated within the elbow of the outcrop, the curve surface of the limestone from which the ore has been stripped slopes toward the northeast at an angle of about 50° from the horizontal. This, however, is not the direction of the pitch, the azimuth of which lies more to the east, as may be judged from the general dip of the east vein and from the position of the nearest drifts in the lower part of the Passic mine. However, because the position of the keel has not been located in any of the underground workings, the true direction nor the angle of pitch can be determined.

Each limb of the layer exhibits a feather edge at the northeast end of the outcrop, and it is supposed that these edges plunge into the ground along lines trending more to the east than the strike of the layers. If this supposition is correct, and if the pitch of the edges is about the same as that of the keel, the limbs of the trough may continue to have about the same length on successively lower layers give a depth of about 1000 feet at the fault, or a dip length of about 1200 feet, if the plane of the fault stands nearly vertical. This estimate will be increased or diminished if the dip of the fault procs to be toward the southeast or toward the northwest.

From existing descriptions of the Sterling Hill deposit it is known that locally the ore body is divided into layers, one of which, being rich in tin, has been given the name vein, the other, which contains little or none of this rich mineral, being called the franklinite vein. A zinc vein forms the upper part of the east leg of the trough, and another is present on the lower side of the west leg. The zinc vein on the east leg is said to have been from 2 to 10 feet thick. It is not present along the portion of the outcrop near the elbow, and is said to be missing in the lowest levels of the underground workings. Rich masses of zincite, in addition to the ore occurring in a distinct layer at Sterling Hill a large amount of franklinite, with more or less intermixed willemite, is distributed through a portion of the rock that lies between the sides of the trough. Within the elbow these minerals are absent, but where the rocks have been exposed on the north side of the open workings of the Passic mine, and also on the surface above, it may be seen that intergrowth of the limestone with zinc-bearing minerals extends from a point near the end of the west vein all the way across to the east vein, giving a mass of ore about 250 feet wide though more or less interrupted by streaks of barren franklinite. Toward the northeast the mineralization makes its way into the country rock in a series of dawomite (see fig. 14) which extends further along the strike as the east vein is approached. From the constitution of the bulk of the ore, it is thought that the minerals which it contains must have been formed out of materials introduced by solutions of distant origin circulating through the limestones after the trough was filled by the distinct layer of ore had been shaped. Although there is no direct evidence to show whether the ore layer was first deposited and then bent into its present shape, or whether it was formed along a previously folded stratum or fissure, the latter is regarded as the more likely.

Notmetaliferous Resources.

By W. S. Smith, B.S.

In the New Jersey Highlands, graphite, or phlogopite, is widely distributed in the white limestones, rather commonly as a constituent mineral in the pegmatite and not very often in the feldspar-gneiss group. The mineral is present in varying amounts in the white limestones, both in the main belt and in the central portion of the Franklin Furnace quadrangle. It is found very often as a constituent of the white limestone, and, so is also true of other minerals regarded as impurities, it is much more abundant in some layers than in others. Two of the limestones analyzed give on page 3 show the presence of one-fourth and three-fourths of 1 per cent of graphite in samples of the white limestone. In many places the rock contains perhaps as much as 1 to 2 per cent of this mineral, but even such material has offered no inducement for commercial operations, and no attempts to mine and separate it have been reported. It may be noted, however, that the well-crystallized laminations is easily crushed, and could therefore be treated more cheaply than the highly spherulitic or quartzose rock, in which most of the graphite now mined occurs. For this reason it is clear that with a limestone matrix lower-grade material could be used than is at present worked in other localities.

Graphite has been noted in the pegmatite in rather small amounts near Canisius reservoir, northwest of Stockton, where the gneiss also contains it. Many bodies of pegmatite enclosed in the white limestone show small amounts of the mineral, and in one locality several of these intrusions are in the laminations of a very good showing of it. These dikes outcrop near a mile south of McAfee, east of the Simpson hematite mine. One opening has a plastic clay, which has doubtless been derived from the decomposion of a body of pegmatite. Through this clay the graphite is distributed in bands ranging from mere specks up to the size of the chunk near wall. The pit has caved as far as the solid rock under the clay can not be seen. It seems however that the decomposion can hardly extend to a depth of more than a few feet. Just at the spring, 20 feet or so away, there is an outcrop of pegmatite, but here the rock contains only a small amount of graphite.

A second opening about 100 feet further north is a pit 6 or 8 feet deep, and some of the rock from it has been left on the ground. This material is composed mainly of microcline feldspar and graphite, the former in crystals up to an inch or more across, with the latter lying principally between but also punctuating them. Quartz is the only other mineral noted, and is present in very small amounts. Minute curvites in the feldspar suggest the former presence of a fourth mineral, which has been dissolved away, but the irregular shape of these curvites gives no clue as to what this mineral may have been. The graphite rock is strikingly similar to some of the material produced by the well-known mines at Hagnor, near Lake George, N. Y., and much of it is estimated to con-
tain less than 3 per cent of graphite and some of it as much as 10 per cent. The work that has been done to explore the graphite-bearing dikes at this place has not been sufficient to show that the large deposit may still exist without further development; no estimation of their value is possible.

LIMESTONE.

The Franklin limestone is economically the most important of the limestone formations found in this quadrangle. It is extensively quarried near the junctions of Ogdensburg, Franklin Furnace, Hordyville, and McAlpine. Ten or eleven quarries were in active operation near Ogdensburg in 1900, and their combined output for all purposes was 552,955 tons. From 75 to 75 per cent of the output is used for flux, chiefly in the blast furnaces at South-Athol, Pa., and Whiton, Starkville, Posey, and Phillipstown, N.J. About 10 per cent of the output is used in the manufacture of a high-grade white lime.

A comparative small amount is sold to Portland cement manufacturers for use in raising the lime content of their raw mixture. Owing to the variation in the composition of this limestone, it has been found difficult to maintain a product uniform in quality in the Portland cement industries. This difficulty is rendered greater because it is impossible to differentiate by the eye the rock which contains a trace of magnesia from that which is free within the requirements. In many quarries the variation in composition is so great that a low-magnesia product (under 2 per cent) can be made for the prices paid. The requirements for a fluxing stone are much less rigid than those demanded by the cement manufacturers and can be readily met by a larger number of quarries.

Most of the active quarries are situated on steep hillsides where high working faces can be developed and gravity utilized in quarrying and loading. One or two quarries, however, have been so located as to be impossible to work in a single line above the level and as far as the property boundaries. The limestone is not, therefore, commercially available.

The Kittiannaire limestone, which is almost universally dolomitic, is not at present extensively quarried. Locally, at Newton, it is used in small quantities for buildingstone and as a foundation stone for masonry. Scattered over the outcrop of this formation are many small openings and run-in lime kilns where, before the extensive use of commercial fertilizers, a few tons of stone were annually quarried and burned for agricultural purposes.

Slate.

The lower portion of the Martinsburg formation affords black roofing slate of commercial quality. Two miles north of Lafayette are slate quarries which though formerly worked have been idle for many years. Poor transportation facilities, however, have always been a serious handicap. There is a smaller opening from which a moderate amount of roofing slate is obtained near the Long Pond and a much larger quarry near Newton, just beyond the boundary of this quadrangle.

Clay.

The only clay deposits of the quadrangle are those found along the streams or lowlying meadows, and represent either alluvial deposits of the streams or glacial accumulations in local lakes formed during or at the close of the glacial period. A black clay containing much organic material is dug for common brick at Newton. It is about 8 feet thick and is found at the margin of the large swampland lying just north of the city. The clay may underlie the entire swamp and be buried by swamp muck near the center. The tract was probably a shallow lake during the closing stages of the glacial period.

Near Bruselville occurs a sandy clay of the composition shown below. It has not been utilized.

<table>
<thead>
<tr>
<th>Components of Clay from Bruselville</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium carbonate (CaCO₃)</td>
</tr>
<tr>
<td>Magnesium carbonate (MgCO₃)</td>
</tr>
<tr>
<td>Silica (SiO₂)</td>
</tr>
<tr>
<td>Organic matter</td>
</tr>
<tr>
<td>Other substances (supposedly calcium carbonate)</td>
</tr>
</tbody>
</table>

Highly calcareous clays are present near Ogdensburg but are not worked. Clay also underlies the drained lands along Wallkill River, New Jersey. Neighbors’ mill on the Clinch River, near South, was formerly dug for common brick. There are probably drift deposits of machine brick in the area, but the absence of any extensive local demand and the lack of adequate shipping facilities render these low-grade clays practically valueless at present.

SAND AND GRAVEL.

There are abundant deposits of sand and gravel, particularly along the valleys, within this area. The sands are fine or coarse, or of mixed sizes, or are interstratified in thin layers. The gravel deposits at Sand Hills, McAlpine, Hamburg, and many other places in the Prairie City vicinity are extremely inexpansible. Much of the gravel in these kames is coarse, with abundant pieces of rock, and there are numerous patches of potholes, cleaves, and smooth. Similar sandstone is observed in the sediments of the North Church delta. The surface of the stream is covered for local use as mortor sand, filling, and road metal, but the openings are not extensive.

There are many small fields of Franklin limestone which remain as tellings after the separation and concentration of the calcareous ore makes a sharp white sand. Much of the sand is used in the market, for concrete and mortar work. The only drawback to its more extensive use is the absence of a buildingbedrock.

The Mykofield Franklin limestone which is completely exposed as ridges and is considered to be ideal for construction purposes, is not being utilized at present. More valuable it is a gravelly loam, there being enough cherny matter mixed with the sand and gravel to make it a strong, fertile soil. In many places the sand and gravel is covered by 1 to 3 feet of rich, cherny loam. Practically all the areas of stratified drift are cleared and under cultivation.

Shale and slate soils.—The drift is exceedingly thin or consisting of the crests or slopes of many small hills along the ridges resulting from the glacial movement. The surface of the rock—particularly with the bedrock of the glacial drift, supplies the local demand for rough foundation work. The surface of the shales is broken and washed, and the surface is marked by numerous irregular, knobby ledges of rock, which give the soil a warty appearance.

Sands and gravels.—Under this designation are included the sands of the "wet meadows, swamps, and drained lands along Wallkill and other streams. Locally the higher portions of these areas have been ditched and drained and their deep, rich, black soils sold extensively.

WATER RESOURCES.

Surface supply.—The water resources of the region are ample for all demands and the quality is excellent. Newton and Sussex both have public waterworks, the former utilizing Moreau Pond and the latter drawing from Lake Rutherford, on Kittanning Mountain just north of this quadrangle. All the streams in the eastern portion of the quadrangle are tributary to Newark’s water supply,一部分 of the large reservoirs of that supply being used for purposes other than the supply. The surface waters of Kittanning and Wallkill valleys are less valuable as sources of potable water than the mountainous streams owing to their greater liability to pollution. This damper, however, has not yet become serious.

During a year of average rainfall, amounting to 44.00 inches, the flow of the streams of this region is equivalent to 24.44 inches on the drainage area. This runoff drops to 16.52 inches in an exceedingly dry year, when the rainfall is as low as 31.65 inches. During extreme drought the minimum dry year is as low as 81,000 gallons per square mile of drainage area, when it is not held back in ponds, may fall as low as 81,000,000 gallons for streams of ordinary basins and 124,000,000 gallons for streams of low, flat, well-drained basins which furnish large ground flow. With adequate storage reservoirs, the streams will yield over 4,000,000 gallons daily per square mile of tributary area.

Water power.—Some of the streams furnish water power of considerable potential value. By utilizing the normal flow of the streams—that is the flow without stumps—it is possible to develop extensive power plants on the streams. Where the greatest amount of water is in the drainage area for each foot of fall. This amount of power will be available for an average of nine months of each year, but during the driest months of the year an extreme drought it will fall as low as 0.014 horsepower on the ordinary streams and 0.025 horsepower on streams with large ground flow. If these stumps in mill ponds be provided so that the entire daily flow of the stream can be concentrated into twelve hours, the increased amount of
horspower may be doubled. With greater storage to carry the excess water of wet periods over the dry months, these maximum amounts of power may be made available for longer periods than nine months per year.

At Brackenhill the outlet from Culver's Pond and Long Pond (Lake Orama) can be utilized and the former drawn down 7 feet if need be. The minimum available flow at Brackenhill is said to be 1800 cubic feet per minute, ten hours daily, throughout the year, even in severe droughts.

The water powers enumerated in the subjoined table are now or have recently been in use. In addition to these there are numerous other sites either once utilized but now abandoned or where good power can be developed. At Woodhorne and Wykertown there are falls of 46 feet, at Brackenhill of 12 feet, and at Lafayette of 11 and 12 feet, all of which were formerly in use.

Ground water supplies are abundant throughout the region and ground water of good quality is usually found in shallow wells in the glacial drift. This is due to the abundance and quality of these supplies and the relatively sparse population. They are not a large source of water but their value lies in the fact that they are easily obtained at very little expense. In general, the water supplies are of good quality and their use has been very moderate.

This water, which is usually of good quality, is obtained from shallow wells and is not greatly subject to pollution. The wells are usually drilled to a depth of 10 to 15 feet and the water is usually obtained from the till or from the underlying sand and gravel. The wells are usually located on the highest points of the land and are usually located near the center of the settlement.

The map shows the distribution of the wells and the water supplies. The wells are shown as small circles and the water supplies as small squares. The map also shows the location of the streams and the waterways.

The wells are usually located on the highest points of the land and are usually located near the center of the settlement. The water supplies are usually located near the center of the settlement and are usually located near the streams and the waterways.

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The wells are usually located on the highest points of the land and are usually located near the center of the settlement. The water supplies are usually located near the center of the settlement and are usually located near the streams and the waterways.
As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be determined by observing their positions. This relationship holds except in regions of intense disturbance; in such regions sometimes to weathers the sequence, and it is often difficult to determine their relative ages from their positions; then, fossils, or the remains and imprints of plants and animals which, at the time the strata were deposited, lived in the sea or were washed from the land into lakes or seas, were buried in surficial deposits on the land, such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was of a great extent different from that of other periods. Only the simplest kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones were worn out by modified fluvial forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since these are characteristic types, and they define the age of any rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of events, or systems of fossiliferous rocks. The two systems, the characteristic fossil types found in them may determine the age of a deposit first. Fossil remains found in the sediments of oceans and estuaries, and elsewhere, afford the important means for combining local histories into a general record of events.

It is often difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can sometimes be approximated by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it. Similarly, the time at which metamorphic rocks were formed from the original masses is sometimes shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not of their metamorphisms.

Colors and patterns. Each formation is shown on the map by a distinctive combination of color and pattern, and is labeled by a special letter symbol.

The various geologic sheets

Areal geology map.—This map shows the areas occupied by the various formations on the map. The map is a legend, which is the key to the map. The map shows the meaning of any colored pattern and its letter symbol; the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If he is desirous of finding out what any given formation is, its name should be sought in the legend and its color and pattern noted, when the area on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. It shows the formations are arranged in columnar form, grouped primarily according to age—sedi
timentary, igneous, and crystalline of unknown age—and within each group they are arranged in the order of the beds. The oldest rock on the map is shown on the deepest. The rocks are named by the position of the beds in the hori
tontal plane, measured at right angles to the strike, called the dip.

The strata are frequently curved in troughlike or, less commonly, in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the land along the section line, and the pitch from the surface of any material, or water-bearing strata which appears in the section may be measured by using the scale of the map. Cosection sheet.—This figure contains a concise statement of the sedimentary formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their character
ds and the map in the columnar diagram. The thicknesses of formations are given in figures which state the least and greatest measurements, and the average thickness is shown in the column; the thickness is shown to be usually 1000 feet to 1 inch. The order of accumulation of the formations is shown in the columnar arrangement —the oldest formation at the bottom, the youngest at the top.

The topographic sheet is related to the quadrangle, which is the key to the map. The lithofacies of formations which occur in the formation, the lithofacies of the rock exposed on the map, and the pitch from the surface of any rock-bearing strata which appears in the section may be measured by using the scale of the map. Cosection sheet.—This pie contains a concise statement of the sedimentary formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

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des are indicated in the columnar diagram. The thicknesses of formations are given in figures which state the least and greatest measurements, and the average thickness is shown in the column; the thickness is shown to be usually 1000 feet to 1 inch. The order of accumulation of the formations is shown in the columnar arrangement— the oldest formation at the bottom, the youngest at the top.
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* Order by number.  
* Price must be made by money order or in cash.  
* These foils are out of stock.  

*Denotes showing the location of the area covered by any of the above foils, as well as information concerning topographic maps and other publications of the Geological Survey, may be had on application to the Director, United States Geological Survey, Washington, D. C.