GEOLOGICAL SURVEY OF GEORGIA.

THE PALEOZOIC GROUP.

The Geology of Ten Counties of Northwestern Georgia

BY

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His Excellency,

W. J. Northen,

Governor of Georgia :

Dear Sir—I have the honor of transmitting to you herewith my report upon the Paleozoic Group, which constitutes one of the natural great belts of geological formations in Georgia. In this report I have treated Northwestern Georgia from the scientific, economic and agricultural standpoints.

Yours respectfully,

J. W. Spencer,

State Geologist.

Atlanta, March 22d, 1893.

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OF THE

REPORT UPON THE PALEOZOIC GROUP OF GEORGIA

PART I.

Geological and Physical Characteristics

OF THE

PALEOZOIC GROUP

OF

GEORGIA,

IN

POLK, FLOYD, BARTOW, GORDON, MURRAY, WHITFIELD,

CATOOSA, CHATTOOGA, WALKER AND

DADE COUNTIES.

BY

J. W. SPENCER.

Geology of the Paleozoic Group.

CHAPTER I.

SKETCH OF THE GENERAL GEOLOGICAL STRUCTURE OF NORTHWEST GEORGIA.

CONTENTS.

NOTE.

Note.—The topographic features, the soils, and the resources of the State are all the outgrowth of the geological structure. The facilities for geological investigations are dependent upon the physical features of the country. Owing to this reciprocal relationship of topography and structure, an intelligent view of the geology of a limited region requires a general survey of the whole. The foundation rocks, which are exposed in any locality, are only some of the many series which go to make up the state or even continent; so that some knowledge of the general geological laws and classification becomes necessary for understanding the problems presented in these investigations.

The object of the geological survey is principally for the benefit of the citizens of Georgia; and particularly those who are not familiar with geological science, rather than for the specialist. As the present report covers a territory which comes in contact with rocks not yet scientifically studied, but with striking boundaries, owing, in part, to great dislocations and repetitions of strata, it is advisable to give some general explanations of geological structures as related to the country in question. Without constant attention to the general characteristics described, it would be impossible to get any order out of the complex structure of the State. Whilst over the vastly greater area of the continent, only rocks of sedimentary or organic origin are found, here in Georgia igneous and metamorphic rocks occupy a large area of the State.

LITHOLOGY.

Igneous Rocks.—The igneous rocks have resulted from fusion processes, and belong, on some portion of the globe or another, to all geological periods. But as the globe has passed through various stages of consolidation from the gaseous condition, it appears that the oldest rocks of the earth's crust are igneous, and from them all the forms have ultimately been derived. Of younger igneous rocks none are found in Georgia; and of the older, granite may be taken as a type; but igneous rocks do not occur in the belt surveyed.

Sedimentary Rocks.—Whilst the sedimentary formations have been primarily derived from older igneous rocks, the newer have often resulted from the destruction of older stratified rocks; the most common forms of these materials are gravel, sandstones, shales or hardened clays, and limestones.

Limestones.—Limestones are of sedimentary origin, but mostly accumulated through the agencies of marine animal life, from calcareous matters dissolved in the waters.

Metamorphic Rocks are commonly sedimentary deposits (or occasionally igneous rocks), rendered crystalline and compact through agency of heat, in presence of moisture, acting upon unaltered rocks. There are various degrees of rock metamorphism. The metamorphic formations of Georgia are of very wide extent. They are also represented in different geological epochs, but the altered rocks, in the State, have not yet been scientifically investigated. To these groups belong such rocks as gneiss, mica schist, hydromica schist, etc. The eastern or southeastern edge of the country, now reported upon, is bordered by crystalline strata, which will be referred to in this report by their structure, and not by their scientific relationships, as such characteristics are easily distinguishable, even to the most casual observer, especially as the topographic features are also marked.

FORMATION AND DESTRUCTION OF ROCKS OCCUR IN CYCLES.

As has been stated, the sedimentary rocks are derived from the older crystalline formations; and these newer strata may again be altered into crystalline rocks.

Cause of Rock Destruction.—The great destructive agents in wearing down the older rocks are the rains, rills, rivers and, along coast lines, wave action. The chemical action of rain water washes out alkalies, lime, etc., from the crystalline and calcareous rocks, thus leaving them porous and easily washed away by the rains, rills and rivers.

Every observer in middle Georgia is familiar with the decayed rocks. It was not always thus—once the rocks were as compact as the hardest granite. On the northern part of the continent, the compact rocks are seen. Their upper layers are not decayed, but are undecomposed and hard, because, in recent times, a geological broom swept from those regions such decayed rocks and soils as now cover middle Georgia, leaving, great, barren, desolate regions. But from our southern uplands, the rills and rivers are carrying off the remains of decaying rock, almost as fast as they form. The degree and amount of the rock decay varies, ranging from the incipient decay of some superficial granites, to depths of 95 feet near Atlanta. In northwestern Georgia, the decayed remains of limestones reach a thickness of 200 feet, whilst the maximum depth of residual earth is not known. In this case, the calcareous matter is dissolved away, leaving a great accumulation of residual siliceous impurities, covering the irregularly weathered surfaces of the limestones (as in figure 1, see also plate III.)

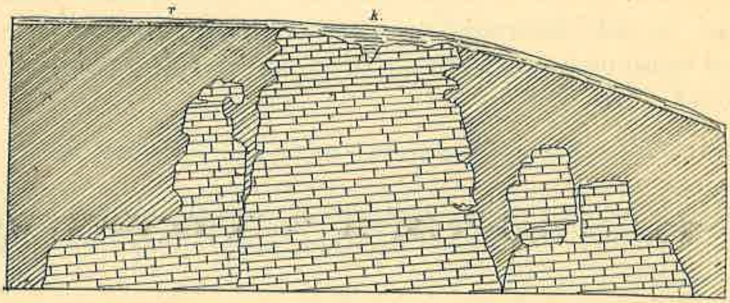

FIGURE 1.—At lime quarry two miles east of Kingston—Residual clays covering the unequally weathered surfaces of limestone.

The Formations of New Beds of Rocks.—The washings of the land are carried down to the sea; some portions, such as soluble alkalies, lime, etc., are borne off in solution. The muds are carried off to be assorted and laid down beneath the sea as the foundation of new lands; the sand and pebbles form shore deposits and the fine clays and muds cover the more distant sea bottoms, in nearly horizontal sheets.

For the conditions of the deposition of iron, manganese, alumina, see the Economic Report.

Thus the destruction of the land by atmospheric agents only supplies materials for the construction of new lands by the sea.

Upon the mud and clay plains, formed on the neighboring sea bottom, marine organisms, as shells, corals, etc., grow and extract from the sea water dissolved calcareous matter; and from their remains the accumulating muds or sands become calcareous, or are succeeded by beds of limestones of varying degrees of purity and thickness.

EFFECT OF TERRESTRIAL MOVEMENTS ON GROWTH OF STRATA.

Oscillations.—The greater portion of the land wastes are accumulated near the shore, with the beds becoming thinner, on extending seawards—the sea bottoms remaining nearly stationary. The margins may be characterized by swamps or lagoons, which are being gradually filled by the detritus brought down by the rivers or carried along by the coastal currents. These deposits grow outward and have only the thickness of the depth of the sea. But the sandstones, shales and limestones have often a development of thousands of feet, and also alternate with each other. This great thickness results from accumulations of the various muds upon a sinking sea bottom. In some portions of mountainous regions, this subsiding of the land has permitted of accumulations of rock to a thickness of many miles upon the original sea floor, although in no place is the sea nearly so deep, but the floor has yielded to the great weight of the forming beds. This great thickness diminishes to a mile or less in the interior of the continent. The subsiding is not continuous, and in many regions, it is replaced by movements of elevation. The amount of uplift has again become sufficient to bring the newly formed beds above the sea level, whereupon, the atmospheric agents begin to grind them down or carve them out into prominent features.

Unconformity.—Upon subsequent subsidence, these recent lands again become covered with sheets of new sediments, but they do not lie flat upon the underlying disturbed surfaces, and here then is produced a most important structure which geologists call *unconformity.* Sometimes unconformity represents only short intervals of time elapsing between the production of the succeeding strata, or it may indicate long eras—that is to say, long breaks in the geological succession. But the structure is always most important in making geological surveys. Thus, if formations, belonging to horizons above, let us say the Coal Measures, are discovered, resting directly above others which belong beneath them, it would indicate the absence of coal and would be useless to search for coal in localities showing such gaps. This enormous unconformity may be represented by weathered surfaces and water channels as shown between d and c in figure 2, or by disturbances in position of beds as between b and c, or by both disturbances of beds and surface erosions as between aa and the other strata.

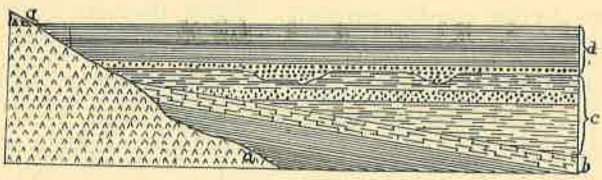

FIGURE 2. – Showing unconformities.

Succession of Unlike Materials.—When the crust movements do not bring the sea bottom above its surface, but only produce varying conditions of depth or changes of currents, as from muddy to clear water, or *vica versa,* alternating beds of sandstones, shales or limestones, in varying degrees of purity, may be formed. Under such circumstances different materials may all belong to the same or to different geological horizons, extending over wide areas, as the conditions obtaining throughout the geological periods, or their formations, may have varied. When the same conditions extended over wide regions, the lithological characters of the strata, as now seen, are of primary value in the surveys. But the uniformity of deposits does not generally continue for great periods of time over extensive areas—thus the sandstones are shore accumulations of the same formations, which are composed of muds farther seaward, or still beyond or above, of limestones ; and the relationship of one class of deposits may sometimes be traceable, upon lithological ground alone, into the others. But it is often necessary to resort to the use of fossils.

Fossils.—The animal and vegetable organisms living upon the coast, or in the deeper sea, leave their more lasting remains embedded in the accumulating muds, which are building future rock formation. In the lapse of time, the families of animals and plants often change so that the inhabitants of one period are replaced by other types in succeeding periods. Their remains preserved in the rocks, then, become characteristic records, and upon them we must ultimately depend for the recognition of the different geological horizons. And each of the formations of geological classification has its own value, whether positive or negative, to agriculture, mining and manufacture.

Position of Strata.—Except the primitive rocks of the globe, of which we have perhaps no knowledge, and also such igneous rocks as have been forced through or into stratified masses, the accumulations of all the geological formations have been more or less in horizontal beds, beneath the surface of water. Had they also remained in this horizontal position, the earth's surface would have been less marked by the wrinkles and scars of mountain ranges, and our knowledge would have been more superficial and less varied. There are very few strata that do not dip gently, even a few feet per mile, in some directions. In such cases, as in southern Georgia, the same formations occupy broad belts. In middle and northern Georgia, the rocks seldom lie flat, and they are often thrown at high angles, or even turned upon their edges. But upon receding towards the interior of the continent, the strata are flattened out again, and also become thinner.

THE GREAT GEOLOGICAL BELTS OF GEORGIA.

From such disturbances and reconstructions, the belts of rock formations in Georgia have arisen. Middle Georgia (as in figure 3) is composed of our most ancient and very old crystalline rocks.

FIGURE 3.—A, Archæan backbone of the State; B, Paleozoic group; M, Mesozoic; C, Cenozoic.

The Archæan (and most other) strata are resting at all angles, but generally dip to the east-southeast. If we take a line across the State from northwest to southeast, that portion between Cartersville and Macon is composed of metamorphic strata. To the northwest of this first point the rocks are all indurated, and belong to the Paleozoic (means ancient life) formations, which may lie almost horizontal, or again may be almost vertical, and at all angles between; but the prevailing dip is usually moderate, and of less than 30° in direction east-southeastward. Still, in many places, especially, in going continentward, the dip is in the opposite direction. The lower beds are often abnormally brought into higher positions by faulting.

Southeast of Macon the strata have an entirely different aspect, dipping only a few feet per mile to the southeast. Exclusive of some of the limestones, most of the strata are poorly consolidated rocks, everywhere having a youthful appearance, and belong to a limited degree to the upper Mesozoic (middle life), but mostly to the Cenozoic (new life) group.

Thus it appears that in most ancient times Georgia was a portion of a great island, commencing in Alabama, broadening in Georgia, even far coastward of present surface exposures, of crystalline formations, and extending towards the northeast. On the one side there are very old and disturbed strata; on the other side the formations are comparatively young.

INCOMPLETENESS OF THE GEOLOGICAL FORMATIONS AND MODE OF REGIONAL GROWTH.

The physical revolutions of the early geological times left the formations west of Georgia above the sea line, for there is a general absence of the succeeding formations toward the southeast. Yet these may have once been locally deposited, and since washed away by the enormous denudation which occurred. But except the western portion of the metamorphic zone, Georgia formed part of an island in the earlier geological periods. The eastern side of the ancient land extended far eastward of the present surface limit of metamorphic belt, even perhaps far seaward, as the continental margin, now submerged, extends 200 miles oceanward of the coast of Georgia. Central and northwestern Georgia long remained above the tide, during the time that the Paleozoic formations were accumulating upon its western side. Indeed, the southeastern lands date back only to a period subsequent to the uplift and formation of the mountain ridges of northwestern Georgia. But it is with northwestern Georgia we are here mostly concerned.

From the early Paleozoic era, the Georgia lands were bordered upon their northwestern side by a sea, into which the washings of the land were being carried. These washings now form various hardened sedimentary rocks, intercalated with beds of limestone, originally of great thickness. These accumulations were laid down more or less horizontally along the old seashore. Throughout the Paleozoic era, there was not simply a continuous submergence beneath the sea, but there were periods when much of that part of the State became dry land, only to be again submerged. Thus the Paleozoic series are incomplete. But eventually the sea was filled up, leaving swamps in the northwest corner of the State, in which coal-making vegetable accumulations were forming. Throughout this succession of events the general horizontality of the beds was not greatly disturbed. No mountains existed, and no other valleys than those which the drainage of the generally level lands of the different periods had produced. All the mountain features were only completed at or since the close of the Paleozoic era. Even the deformations of the then more or less rugged features of central Georgia have had their strata still further disturbed at the time of the uplift of the mountains of the northwestern parts of the State.

DISTURBANCES AND DISLOCATIONS OF THE ORIGINAL BEDS.

Elevation and Folding of the Beds.—By the elevation of the mountains at the close of the Paleozoic era, the general trend of the ridges from northeastward to southwestward, and the outcrops of the various formations in that direction, have brought to view belts of variable widths. This uplift was a complex movement of a portion of the earth's crust, acting from the southeastward, and diminishing in the extreme northwestern corner of the State, as the strata flattens out toward the interior of the continent. The strata in the moutainous region of northwest Georgia have not been merely thrown into all degrees of inclination, but have also been folded into ridges (the term *anticlinal* being applied to strata dipping from the axis of the folds) and troughs (*synclinals* where the strata dipped towards the hollow) or forced one set of beds upon the others (*faults*). These movements occur upon the gigantic scale as well as in miniature, from which the study of the greater movements can be made. Also by laboratory experiments, many of the terrestrial movements may be immitated.

An example, of the more simple folding, is shown in figure 4, from a photograph taken along the Ocoee river, wherein the squeezing passes, in places, into fracture, producing a convex structure

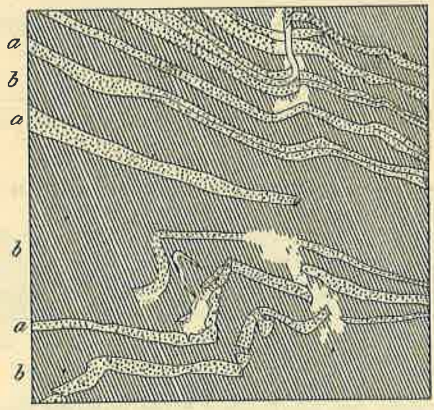

FIGURE 4.—Bending and fracture of strata along the Ocoee river; a a a represent quartzose beds; b b b, are slates.

which eventually overturns some of the strata. In the movement, the slaty beds (shaded portions of figure) have more or less adjusted themselves by being squeezed into position, but the quartzose layers are those which have been bent and broken.

The folded structure is carried farther and is well shown along a section near the iron bridge over the Etowah river, southeast of Cartersville (figure 5). The section has a length of about 400 feet. Here two synclinals and three anticlinals occur, in which the beds upon the northwestern side dip the more steeply and are somewhat overthrown. Erosion has denuded the crests, and if the surface of the section were level, only a number of strata dipping in different directions would be visible; but these would be sufficient for recognizing the position of the beds. However, washes in the road have given more perfect exposures, and thus a fine study may be seen.

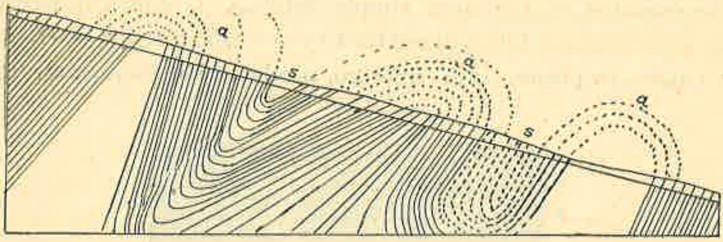

FIGURE 5.—Section at Iron bridge, south of Cartersville; a a a represent anticlinal folds; s s, synclinal folds.

The undulation on a grand scale may be seen in figure 6.

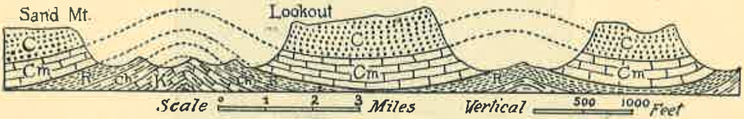

FIGURE 6.—Sections across Sand, Lookout and Pigeon mountains, showing undulations of strata.

When the thrusts are continued after passing the limit of folding, the strata must be faulted (as at F, figure 7). A beautiful example on a small scale, in a section about 200 feet long, is seen at the cut of the Western and Atlantic Railway, on the northwestern bank of the Etowah river.

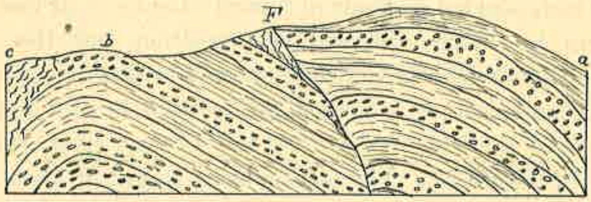

FIGURE 7.—F represents fault line, c, decayed rock.

Here, then, is an anticlinal with axis trending northeastward, the thrust coming from the southeast. The upper beds, along the fault line are completely cut in two and slidden over those upon one side of the fault. Lower down in the section, the fracture and slip has been less perfect, with the beds forced into an anticlinal and carried to the point of fracture, with only a slight slipping and a tendency to invert the strata. By the position of the layers other complex movements are indicated, but not exposed in the cut.

On the large scale, we find all the above conditions repeated, and great beds are often inverted. These complex features add to the difficulty of determining the thickness of formations, and location of special layers, when the lithological characteristics and the fossil contents do not readily explain the conditions.

Faults.—The further thrusts not only produce breaks, but often carry the beds over upon other strata. In some cases, these slips, technically called faults, will simply lift the rocks upon one side of the break or produce a downthrow, so that the same beds are no longer continuous (F, figure 7).

Very often, when the strata are pushed over the others, the movement becomes a *thrust fault*, in which case the beds upon the side of the fracture, from which the movement comes, are forced over those upon the opposite side, or, in northwestern Georgia, those on the southeastern side slide over towards the northwest. This is a *normal thrust fault.* An illustration of thrust faults is seen west of

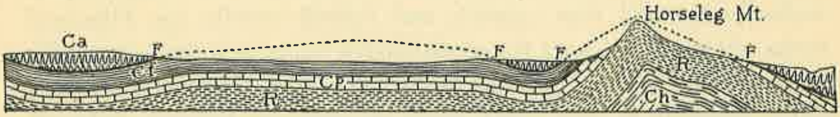

FIGURE 8.—Illustrating a thrust fault (adapted from Hayes). F F F F, line of fault; Ca, Cambrian shales forced over Silurian (R) and Sub-Carboniferous (Cf) strata.

Rome, where a narrow trough of Cambrian strata has been carried at least four miles to the westward, over Sub-Carboniferous strata, as shown in figure 8. This thrust fault represents a vertical dislocation of from 7,000 to 10,000 feet. Erosion has caused the removal of the shales between the trough and the Cambrian belt to the eastward over what is now known as Horseleg mountain, which was forced up during or after the faulting movement. This will be again described in the local geology.

Thus, although the whole series of beds may dip to the southeast, yet the newer are those towards the northwest, and appear to underlie the others, which would be the case if the faults did not exist.

Such faults are common on large scales in northwestern Georgia, bringing into contact widely separated geological horizons. Still more frequently the same series of beds are repeated in parallel ridges; also small faults are very common, repeating the same adjacent strata; and others which do not amount to more than a few feet. Often the structure is very complex, arising from a combination of folds and faults, as shown in faults at Cave Spring and at Erwin.

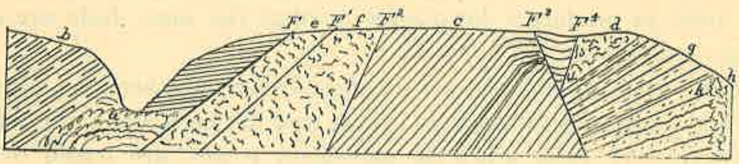

FIGURE 9.—Faults F F F F, one mile west of Cave Spring. Strata crushed at a, and decayed at e f d and h.

It is by one of these great thrust faults that the metamorphic rocks are brought into contact, and indeed overlie the Paleozoic rocks all the way along the southeastern margin of the belt under exploration. This overthrust of the crystalline rocks above Cambrian limestone is well shown along the creek at Erwin's Mills on the southern border of Gordon county.

Sometimes the troughs of the folds are thrust under their arches, when the effect is the converse of the above, as if the movement came from the opposite direction; such are called *reversed thrust faults.*

In normal faulting, the overlying strata are much nearer the horizontal than the more steeply inclined and overridden beds, these last occurring on the northwestern side of the folds. The opposite is true in reversed faults.

In normal faulting, the lower beds are sometimes dragged over, producing subordinate and local reversed folds.

The effects of the faulting and repetition of the same beds have not been merely to make simple ridges and valleys. These folds and faults are coincident with both the great and small valleys crossing not only the State, but extending from Alabama across Georgia to Tennessee and northward. In the northwestern part of the belt reported on, the same strata are brought to view in narrow belts rising from beneath upper Paleozoic strata, which are wanting to the east. Accordingly, the same sheets of lower Paleozoic beds, once nearly horizontal, still occur everywhere beneath all the various series of the overlying series.

Effects of Folding upon the Materials of the Strata are primarily to harden them, and often to produce metamorphism of various degrees. Thus, the original textures become more or less obliterated, as also the organic remains; and then the fossils are rare or very obscure. Such rocks are apt to be more or less traversed by veins. Very often the internal slipping in the rocks results in polished joints or surfaces (which structure is called *slickenside*). The joints are not always visible, but form lines of easy fracture or decay.

Effects of Atmospheric Action upon the Folds.—The crests of the folds, especially where the thrusts have produced faults, are more or less fractured and weak; whilst the troughs have the material of the beds hardened. Accordingly, the ridges are not only more exposed to the action of rains, washes and rills, but more susceptible to destruction on account of the accessibility of these weathering agents to the materials and their weakened powers of resistance. Consequently the rock structures of the valleys are commonly anticlinal, or the remaining ledge of the rocks dip from the axis of the valleys into the sides of the ridges. But the destruction of these ridges, going on more rapidly in the steep beds, as on the side removed from the directon of thrust, than in the more gently inclining strata of the other side, may remove all surface traces of the anticlinal structure, so that the country is composed of series of ridges and valleys, with the strata all dipping, but at varying angles, in the same direction as if they were monoclinal, whilst in reality the valleys are often anticlinal. This condition adds to the number of ridges and repetitions of strata in northwestern Georgia, being often the result of folding rather than faulting, and accounts very often for the small number of places where the rocks seem to dip northwestward.

Many of the narrow ridges, separated by valleys, are characterized by disturbed strata, in which the more durable beds, such as cherty layers, have been elevated and occur in parallel belts, with the more calcareous layers. In this case, unequal decay has been the immediate cause of the ridges, protected often by only thin chert coverings, whilst the rains and washes affected the valleys. Such valleys, although occupied by streams, do not usually indicate their excavation by great rivers.

DECAY OF THE SUPERFICIAL ROCKS OF NORTHWESTERN GEORGIA.

Everywhere the surface rocks are deeply decayed, and the surface soils have been formed without extensive transportation, except adjacent to the streams. Some of the limestones have been impure from admixtures of clay, and of cherty masses. From these, the calcareous matter has been extensively removed, and in many places, the surfaces are covered with a mantle of clay and cherty gravel. So great has been the destruction of the limestones, that in their place may be found from 100 to 210 feet, and perhaps even more, of residual clay, as in the valley at Oredell (in Polk county), or near Tunnel Hill. Owing to this great accumulation of surface *débris* the complicated structure is obscured, so that the only surface indication of the faults is the sudden transition from one kind of soil to another. However, there is method in the distribution of this mantle of loose earth, so that from the survey of the soils, etc., the distribution of the different geological formations can be recognized, and upon the distribution of the formations the value of the land depends.

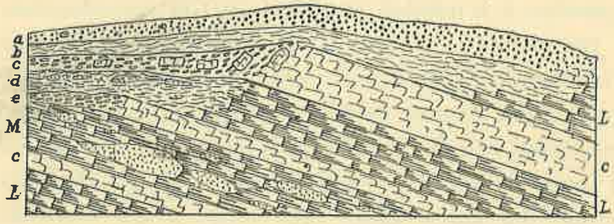

FIGURE 10.—Decay of dolomitic limestones (a b c d) upon the surface and side of ridge near Cave Springs. c, represents the more siliceous beds; L, the more calcareous; M, manganese boulders.

Residual earths, derived from decayed limestones may be seen from analyses in the agricultural report to contain from 64 to 84 per cent. of silica; from 6 to 15 per cent. of alumina, and from 3 to 10 per cent. of ferric oxide. Such rocks as those from which the decayed remains were derived, contained, only from 3.5 to 6 per cent. of silica; from 1 to 3 per cent. of alumina, and from half of 1 to 2 per cent. of ferric oxide. Occasionally, in very impure limestone the proportion of alumina and ferruginous matter is vastly increased. In the decay, more or less iron is dissolved out, and the clay washed out. But most of the silica remains in the residual earth. From a careful study of analyses of soils, derived from Knox dolomite rocks, there is found to remain about 67 per cent. of silica. If the standard of 6 per cent. of silica be that taken in the original limestone, it appears that ten times as much calcareous matter has been removed as there are residual earths remaining. Reducing this somewhat, and allowing for local variations, it is safe to assume that every foot of such *débris* was once represented by ten feet of more or less impure lime rocks. Thus, in places, as much as 2,000 feet of limestone appear to have been removed by the solution of the original calcareous rocks of northwestern Georgia, leaving a mixture of elements of nearly the same composition as those derived from calcareous shales.

ORIGIN OF THE VALLEYS.

This question is a natural sequence to the consideration of the last two paragraphs. Although the Paleozoic belt of northwest Georgia is characterized by both broad and narrow valleys, sometimes separated by narrow ridges, or again by sharp crested, or by broad mountains, yet this configuration is immediately due to the effects of meteoric and river erosion; that is to say, that the present valleys would not exist where they occur if the materials which once filled them had not been carried off by washes and streams. This is true even though the location of the streams may have been primarily determined by movements of the earth's crust, which has produced warping and ridges of upturned beds of rock. However, such movements have been slower than the carving of the valleys out of the more easily degraded rock beds.

In the old Coosa basin, the origin of the valleys may not appear so simple as those of the newer formations of the Chickamauga and Lookout valleys, from the structure of which the key to the explanation of the older valleys to the east is obtained.

Let the Lookout valley be taken as an example. That valley is bounded on either side by plateaus from a few hundred to as much as fifteen hundred feet above the floor. The plateaus, which were formerly one plain, is capped by hard durable sandstones, lying at low angles, dipping from the valley on both sides. This plateau has been incised by Lookout creek and its branches, until the stream reached the base level of erosion, deeper than which the valleys could not be cut. The streams then began to broaden the valley, which is now two to four miles in width. This widening could not have been done by Lookout creek alone, but by the tributary streams, rills and rains undermining the mountain sides. Upon Lookout mountain, there are still many streams cutting down to the base level of erosion, and the various stages of valley making are in progress. Where the streams are flowing in opposite directions, there the heads of the valleys gradually unite and often appear as one continuous valley, with walls hundreds of feet high and miles in width, as may be seen at the union of Lookout and Big Wills' creek valleys.

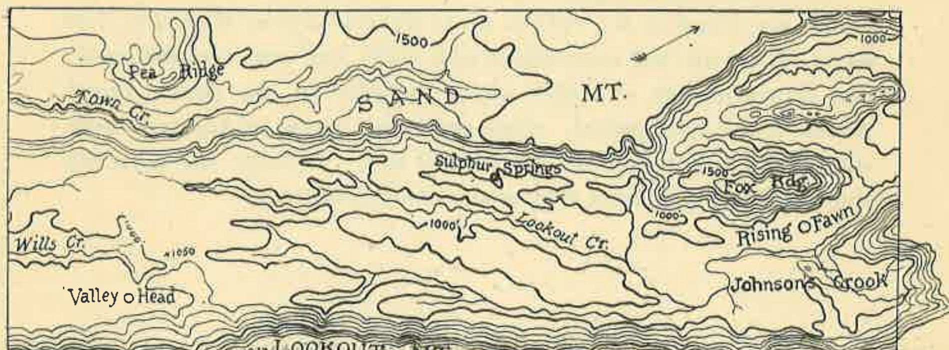

FIGURE 11.—Map showing form of the broad, deep valley, cut into the formerly one plateau of Lookout—Sand mountain table-land, at the heads of Lookout and Wills' creeks.

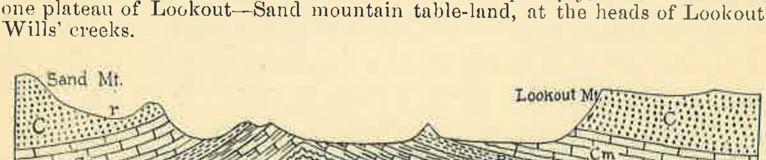

FIGURE 12.—Section across Lookout valley, near Sulphur Springs, showing combined erosive effects of small streams in making a broad valley.

The valleys just described were once filled with the Carboniferous rocks containing valuable beds of coal, which have been swept away and carried into the sea. From narrow ravines this process of degradation of the rocks may be traced through various developments to twenty miles or more in width. Here and there remnants of degraded formations are left, showing that even the Carboniferous rocks extended much further into Georgia than the valuable beds of to-day; thus it becomes apparent that 1,500 feet of

Carboniferous rocks alone, and elsewhere 2,000 feet or more of limestones, belonging to the earlier Paleozoic periods, have been removed from what are now the valleys of northwest Georgia.

RECENT GRAVELS AND LOAMS.

Often coarse quartz gravel and other stones, as well as associated loams, are found in the valleys up to elevations from 80 feet to 150 feet. These are not everywhere met with, but are very common; and represent bar or other shore deposits in the great, broad streams, at a late period, when the lower parts of Georgia were submerged to a depth of 700 or 800 feet. Locally the soils are thus made to vary from that of the residual clays.

CHAPTER II.

GEOLOGICAL GROUPS OF NORTHWEST GEORGIA.

CONTENTS.

TABLE OF GEOLOGICAL GROUPS.

In order to give a clear idea of the order of superposition of the different formations which geologists recognize, and the relations of the strata occurring in Georgia, the following table is given:

GROUPS.	SYSTEMS.		LOCATION IN GEORGIA.
CENOZOIC	Modern		River deposits.
	Pleistocene		(South Georgia.)
	Pliocene	Neocene	South Georgia.
	Miocene		South Georgia.
	Eocene		South Georgia
MESOZOIC	Cretaceous		South Georgia.
	Jurassic		Not known.
	Triassic		Not known.
PALEOZOIC	Permian		Not known.
	Carboniferous		Northwest Georgia.
	Devonian		Nor'w'st Ga., but almost w'nting.
	Silurian		Northwest Georgia (only one small but important fragment).
	Ordovician		Northwest Georgia.
	Cambrian		Northwest Georgia.
ARCHÆAN.	Metamorphic Rocks		(Laurentian and other systems(?). These have not been differentiated in Middle Ga.

GEOLOGICAL SYSTEMS IN NORTHWESTERN GEORGIA.

Eastern border of unaltered rocks are all more or less metamorphic or igneous. The upper beds belong to systems distinct from the lower, just as the Paleozoic group is comprised of several systems. In several scattered regions in America, there are well marked series of crystalline accumulations devoid of determinable fossils, which overlie the lower Archæan, and underlie some member or other of the Paleozoic group, but they cannot be correlated as yet or positively assigned to a system in the general table. In such cases, we must simply investigate the local characteristics and wait until their true relationships have been discovered. Such rocks form important members of the metamorphic country east of the belt under survey, against which it is brought by a gigantic fault, which has been suitably named the "Cartersville Fault," by Dr. C. W. Hayes. *

It is quite probable that some of these upper crystalline rocks belong to the Cambrian system; but as they occur east of the physical break, they will not be considered here.

Range of Geological Formations.—Throughout the belt reported upon, the rocks range from the Cambrian to the Carboniferous system, inclusive. But the lower beds of the Cambrian system, and possibly portions of the upper Ordovician formations, are wanting. In the northwestern portion of the area surveyed, there are most striking repetitions of the formations. The northwestern side of the Lower Paleozoic strata of the Coosa valley are brought in contact with the various upper members of the Paleozoic group; but particularly with the rocks of the Carboniferous system. This fault has been explored from Virginia to Alabama, and was first named by Prof. J. J. Stevenson,† the "Saltville Fault," since locally called the "Rome Fault," by Dr. Hayes.‡ In Georgia this fault amounts to a vertical displacement of from 7,000–10,000 feet.

* Bull. Geological Society, Am. Volume II. 1890. Page 147.

† J. J. Stevenson, Pro. Am. Phil. Soc. XXII. Phila. 1884.

‡ Bull. Geological Society, Am. Volume II. Page 144.

PALEOZOIC FORMATIONS OF GEORGIA.

SYSTEM.	Series.	Names of Formations in Georgia.	Safford's Equivalents in Tenn.	Smith's Equivalents in Ala.	Hayes' Equivalents.
CARBONIFEROUS	Coal Measures.	Coal Measures.	Coal Measures.	Coal Measures.	Walden Sandstone. Lookout Sandstone.
	Lower or Sub-Carboniferous.	Mountain Limestone.	Mountain Limestone.	Bangor Limestone.	Bangor Limestone.
		Floyd Shales.		Oxmore Sandstone and Shales.	Floyd Shales.
		Fort Payne Chert.	Siliceous Group.	Fort Payne Chert.	Fort Payne Chert.
DEVONIAN.		Chattanooga Black Shales.	Black Shale.	Black Shale.	Chattanooga Black Shales.
SILURIAN.	Clinton. (?)	Red Mountain.	Dyestone, gr. White Oak Mt. and Clinch Mt. Sandstone.	Red Mountain.	Rockwood.
ORDOVICIAN.	Hudson. Trenton. Chazy.	Chickamauga (including Rockmart Slate).	Nashville. Trenton. Maclurea.	Trenton or Pelham Limestone.	Chickamauga Limestone.
	Calciferous.	Knox Dolomite.	Knox Dolomite.	Knox Dolomite.	Knox Dolomite.
CAMBRIAN.	Potsdam. (Up. Cam.)	Oostanaula Shales.	Knox Shales. Knox Sandstone.	Montevallo Shales including Weisner quartzite Coosa Shales.	Connesauga Shales. Rome Sandstone.
	Acadian. (Mid. Cam.)				
	Georgia. (Lower Cam.)		Chilhowie Sandstone. Ocoee Conglomerate.		

Value of Fossils.—The groupings of geological phenomena scarcely reached the dignity of a science until William Smith, an English mineral surveyor, discovered that certain fossils were characteristic of special beds, and were not found out of their proper horizons. He made use of his discovery a century ago, in order to ascertain whether the rocks were above or below the coal horizon. Lithological characters of themselves are only, at best, local indications of age, or of horizon; for rocks of the same position over widely separated areas may be of entirely different characters, or rocks of the same characters may belong to different horizons; consequently geologists must ultimately depend upon the fossil contents of different beds. Again, many physical breaks occur in the succession of strata, and characterize certain epochs in one locality, without leaving traces in others. They are not always coincident with the great changes in the types of fossil remains. Thus, there is a closer relationship between the sedimentation of the Knox shales and the Knox dolomites than between the Knox dolomites and the overlying Chickamauga formation, although both of these latter are highly calcareous deposits; yet the relationship of the animal remains is such as to cause the Knox shales and Knox dolomites to be placed in different systems. Indeed, it is only on account of the inability to perfectly correlate the minor grouping over widely separated areas that local nomenclature lasts longer than a temporary provision. This inability arises from various breaks in the continuity of formations, thinning out or thickening of strata, and in the replacement of one kind of deposits by another, with the consequent changes, unequal development and preservations of fossils. As an illustration: sandy shore deposits are apt to be replaced by clays found in deeper water; or limestones, when the waters were clear enough to favor accumulations of animal life and their consequent remains. Thus, on the flanks of mountainous countries, sandstones or shore deposits occur, whilst, as the formations recede towards the plains of the continent, these fragmental members diminish in magnitude, and are often replaced by limestones which are more favorable for the preservation of fossils than the clays and sandstones. Accordingly, by tracing continuity in the stratigraphy, portions of the beds may be found which are fossiliferous, and thus the horizons can be determined; still, the general types of the whole remain with local variations.

Throughout the southwestern end of the Appalachians, the fossils of the Lower Paleozoic formations are not generally preserved; and on the lithological characters one must often depend in surveying the development of many formations, with only occasional references to fossiliferous strata.

THICKNESS OF THE LOWER PALEOZOIC FORMATIONS.

The difficulty of making accurate determinations of the thickness of the various formations is considerable, as the extensive sections of the different rock formations are commonly in decayed conditions, or the strata are buried or obscured. As a consequence, the apperently great thickness may have to be reduced, owing to unperceived undulations or faultings. However, estimates based upon incomplete observations are made. Long ago, Prof. Safford* estimated the thickness of the rocks, in East Tennessee, which pass into Georgia, as follows:

ORDOVICIAN.	Nashville and Trenton	2,500	feet.
	Knox Dolmite	4,000	"
CAMBRIAN.	Knox Shales,	1,500–2,000	"
	Knox Sandstone.	800–1,000	"
	Chilhowie,	2,000	"
	? Ocoee,	10,000	"

Thus the extended thickness of the Cambrian in East Tennessee, without the Ocoee conglomerate, which is not included in the report, is from 4,300–5,000 feet thick; and the Ordovician or Lower Silu-

*Geol. of Tennessee, 1869, pp. 158-60.

rian, is 6,500 feet. To the rocks belonging to the Cambrian system, Mr. A. R. McCutchen assigned a thickness of 10,400 feet.* In Alabama, Prof. Eugene A. Smith gives the maximum thickness of the Cambrian deposits exclusive of the Ocoee conglomerate, as 10,000 feet; and that of the Ordovician system as 4,900 feet.†

Dr. C. Willard Hayes estimates the thickness of these same formations in the southern Appalachians at from 6,600 to 8,500 feet‡ for the Cambrian beds, above the Chilhowie; and from 4,700 to 6,300 for the Ordovician system.§ The maximum thickness of the Cambrian rocks of Georgia above the Chilhowie and Ocoee formations must reach 5,000 to 6,000 feet; and the beds of the Ordovician must aggregate 6,000 feet in its maximum developments.

THICKNESS OF THE UPPER PALEOZOIC FORMATIONS.

Most of the Upper Paleozoic formations are more easily measured than those of the lower portions of the group, the maximum thickness of which is shown in the following table:

Carboniferous System.	Coal Measures,	1,400–1,600	feet.
	Sub-Carboniferous, (Including Floyd shales).	1,500–2,600	"
Devonian	Black shales,	10–25	"
Silurian	Red Mountain,	800–1,100	"

In northwestern Georgia, the Red Mountain series is developed to a considerable thickness, whilst in Alabama it diminishes to 100 feet. In Tennessee, Safford estimates the whole series at from 1,200 to 1,500 feet, and Mr. Hayes places it at 600 to 1,500 feet.

The Devonian shales dwindle down to 10 feet in Alabama, but

* See Cotton Report, Tenth Census, Vol. VI., part 2, page 21.

† Geological survey of Alabama, "Cahaba Coal Field," 1890, 148–154.

‡ At the time of Hayes' estimate, he classified the Coosa shales as a number below the Connesauga shales, so also did Smith. But as these local developments appear to belong to the same horizon (Walcott) the larger estimate has been reduced.

§ "Overthrust Faults of the Southern Appalachians," Bull. Geol. Soc. Am. 1890, page 143.

thicken to 100 feet in Tennessee. The Sub-Carboniferous of Georgia is greatly increased by the Floyd shales, which are locally developed to a thickness that can be only roughly estimated at 2,500 feet (Hayes). Exclusive of these shales, Prof. Safford gives a thickness of the Sub-Carboniferous rock at from 600 to 1,250 feet, and the Coal Measures from 200 to 2,500 feet. In Alabama, Mr. Joseph Squires measures a development of 1,200 feet on the Sub-Carboniferous, and 5,525 feet for the Coal Measures, which, however, are much more largely developed in Alabama than in Georgia.

FAULTS.

Many faults occurs in northwest Georgia where the different formations are duplicated. The most remarkable is the *Saltville or Rome fault,* which transposes the Cambrain shales over all formations, even to and including the Carboniferous system. This dislocation is an overthrust fault whereby the Cambrain shales where pushed westward at low angles for distances of at least four or five miles, bringing into contact formations which are geologically from 7,000 to 10,000 feet apart, in vertical range. This fault is further noticed under the local geology of Floyd and Gordon counties. The great number of repetitions of strata in Whitfield county may be seen in figure 13.

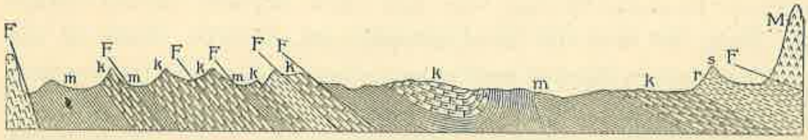

FIGURE 14.—Section from Rocky Face to Cohutta Mountains, showing repetition of Knox strata (k) by faulting (F) and folding.

CHAPTER III.

GENERAL CHARACTERS OF THE CAMBRIAN SYSTEM.

CONTENTS.

TABLE.

SERIES.	FORMATION.	
Upper Cambrian (Potsdam)	Oostanaula	Knox or Connsauga Shales.
Middle Cambrian (Acadian)	Oostanaula	Knox or Rome Sandstone.
Lower Cambrian (Georgian)	Chilhowie. Ocoee (?)	

THE OCOEE SERIES.

The type of this formation is along the Ocoee river, only a short distance from the Georgia line, and these deposits extend within the State, but their full development is not known. Some of the rocks in eastern Bartow county have been assigned to this horizon by Prof. Little.* With equal propriety, at many points along the western margin of the metamorphic rocks various beds could be assigned to the same series, but the survey has not progressed sufficiently in this direction to allow expression of opinion. The rocks along the Ocoee river cover a zone about twelve miles wide, and present a long succession of beds mostly dipping at rather steep

* Handbook of Georgia, 1876.

angles to the southeast, and forming precipitous cliffs over the river, which cut across the formation. In many places foldings are seen, and elsewhere the strata is much broken. Whilst the faulting and folding is often obscured, it must be very great, or else the thickness of the series would amount to five or six miles. Prof. Safford provisionally placed the series at 10,000 feet. But it is impossible to make a correct estimate of the thickness. The great proportion of this mass is composed of semi-metamorphic hydromica schist, chloritic and clay slates, with occasionally beds of fine conglomerate and quartzite, which, in some placee, are very thick, especially in the higher beds, and to a less extent near the base. The pebbles are usually small, but sometimes an inch or two long. They are composed mostly of quartz, with some feldspar, or in places fragments of slate; greenish and bluish slates prevail. They are commonly weathered, but in the road making there are many places where the blue compact slates are exposed.

At several points all the way to Cartersville, I have crossed the edge of the metamorphic zone and found hydromica schists, slates, coarse and fine conglomerates, quartzite and sandstone, but as yet have not reported upon them. Yet it is reasonable to expect that some of these deposits may be referred here; at any rate, such rocks form the border of the country reported upon.

These rocks have been placed by Prof. Safford in a horizon at the base of the Cambrian, where we will leave them until future research shall require them to be differently classified. They are not fossiliferous, so far as known, and their structural relations are not easily made out, but their occurrence is in contact with the known lower Paleozoic rocks, on account of there is extensive faulting.

CHILHOWIE SERIES.

This formation was described by Prof. Safford: "It is a great group of heavy bedded sandstones, often dark, but generally weathering to a grayish white, and containing great beds of whitish quartzose sandstone or quartzite. Interstratified with the many bedded rocks are, at some points, sandy shales and thin flags, often containing mica scales. Some of the sandstones are coarse and approach fine conglomerate. It may be mentioned that not unfrequently the strata have green grains (glauconitic) disseminated through them."† Worn holes (*Scolithus linearis*) and impressions of fucoids are commonly found. The maximum thickness is given at not less than 2,000 feet. The great topographic features of the Chilhowie formation is their occurrence in bold, isolated knobs, issuing abruptly out of the valleys to heights of from 1,000 to 2,000 feet. Such knobs are characteristic features from Alabama to Virginia, but all are probably not of the same age. Overlying the sandstones of the typical Chilhowie mountain, Mr. C. D. Walcott found shales containing the *Olenelus* fauna, thus proving the correct determination of the geological position long ago by Prof. Safford, whereby the formation is shown to belong to the Lower Cambrian series.

In Alabama, Prof. Eugene A. Smith says that the lower part of the Cambrian system is not characterized by quartzites and sandstones, as by Chilhowie of Tennessee. But that similar masses forming the same bold Chilhowie-like knobs occur at many horizons in the shales.‡ So also Messrs. Willis, Keith and Hayes have observed similar extensive range in the geological distribution of these sandstones or quartzite knobs at various points in Tennessee. These great accumulations of sand were evidently local, in positions close upon the mainland, where streams or currents were piling the washings of the land. With the oscillations in the level of the land and sea the localities of such deposits naturally changed, being buried by newer sand bars, or having these formed upon the late muddy sea floors.

† Geology of Tennessee, 1869, p. 199.

‡ Geological Survey of Alabama. "Cahabâ Coal Field," 1890, p. 150.

In the country at present reported on, Indian mountain (mostly in Alabama) is the only knob that is considered. Its position is beneath the Oostanaula shales, the basal sandy members of which may be of identical horizon with that of Indian mountain. Some of the sandstones on Cohutta, Pine Log and other mountains may belong here, as suggested by Prof. Little; however, these are on the metamorphic side of the "Cartersville Fault," which is the limit of the present survey and of this paper, but are approached in examination of its boundary.

OOSTANAULA SERIES.

COOSA VALLEY PHASE.

This is the lowest formation in which fossils have been found in Georgia. The mass of the formation is composed of reddish, yellowish, brownish and greenish shales with thin bedded limestones, having shaly partings, or the limestenes are in concretionary layers within the shale. These beds are often at high angles, and the great variation of the dip shows much folding and faulting. The shales weather into stiff soil. Higher in the series there are dark massive limestones, highly seamed by white calcite veins. These rocks cover part of the country known as "flat woods," along the Coosa valley, and also with some interruptions extend northwestward to near Dalton. In part, is a comparatively level country, and in part it is composed of moderate sized ridges. The deposits form the most western Cambrian deposits, and are in contact with Carboniferous formations upon their western side, owing to the extensive faulting. On the eastern side of the flat woods, there is an extensive fault—the OOSTANAULA—which line is characterized by the chain of low serrated ridges which cuts the "flatwoods" off from the Cambrian valleys to the east, and produces the repetition of the same formations.

The thickness of these deposits is only conjectural, owing to the great repetition of the apparent mass on account of foldings and faultings, as the strata are found from almost horizontal positions to almost vertical, and the development may be taken at anything from 3,000 to 6,000 feet, increasing towards Alabama. This phase is charactered in part by thin, often grayish soils and poor ill drained lands, and in southern Floyd, the county is sparsely settled, but farther north the land becomes better and is more thickly settled.

These shales of the Coosa valley contain fossils, which from a point three miles southwest of Rome, Mr. C. D. Walcott has determined as belonging to the genus *Olenoides*, and consequently belong to the Middle Cambrian series. The rocks of this basin were classified upon lithological grounds as the Coosa series of Prof. E. A. Smith and adopted by Mr. C. W. Hayes, before the determination of the fossils, by Mr. Walcott. The shale ridges (which contain some sandstone) to the east of the basin below Rome apparently belong to a position beneath the shales to the west as well as to the east of them, owing to the Oostanaula fault upon their western side.

CONNASAUGA VALLEY PHASE.

The Oostanaula shales constitute a great accumulation of red, green and variegated calcareous shales containing thin seams of sandstone sometimes quartzitic in the lower members, and dark-bedded limestones in higher strata. The sandstones and some interbedded shales show ripple marks and impressions of fucoids, indicating their shallow water origin. The limestones are often impure; sometimes they are oolitic. The maximum thickness does not seem to be less than from 4,000 to 6,000 feet. Such an accumulation of sediments represents changing conditions of deposition, of long duration. As is seen to-day, upon the surface of the country the calcareous matter of the shales has been mostly washed out, leaving the more siliceous matter to form varied soil, from sandy in the region of the sandstone members, clay loams in more calcareous regions, and again disintegrated chips of shale covered with thin soil. The limestones often appear through the shales and clays along the streams. These are commonly dark colored, and are often traversed by a network of shaly films, which become apparent on weathering.

In Alabama, great isolated lenticular masses of quartzite, or these beds with intercalated shales, form knobs and rugged mountains rising from 1,000 to 2,000 feet above the valleys (Smith). These are the Weisner quartzite, and cannot yet be definitely connected with any set of beds in the great series. There is some possibility that these knobs and their shales as well as Indian mountain should be placed along with the Chilhowie series beneath the Middle Cambrian strata.

Such a mass of sediments might be expected to be divisible into several distinct horizons. In Alabama, Prof. Smith says that the separation of the sandstone series of the Middle Cambrian series from the higher shales, is not practicable, as the sandstones occur at many horizons. In Tennessee, Prof. Safford long ago separated the lower and upper beds into Knox sandstones and Knox shales, and more recently Mr. Hayes has renamed them the Rome sandstones and Connasauga shale. A justification of this change of nomenclature might arise from the correlation of these deposits in the Cambrian system, whilst the overlying Knox (dolomite) series belongs to the Ordovician. In Tennessee, this division is more practicable than in Alabama, for massive beds of sandstone are there interbedded with many colored shales. In Georgia, the thick sandstones are of rarer occurrence; and the boundary lines are often obscure, although the resulting soils are sometimes more sandy. Topographically, the lower sandstone members of the Oostanaula series occur in part in more or less low crested ridges, whilst the neighboring shales form valleys. But in many localities the shales form the ridges, as there is considerable variation in the beds, and in some places they are more or less metamorphic. This difference may arise from including several divisions in the same systen. Indeed, at least three distinct paleontological horizons are included in the Knox shales (Walcott); whilst as yet there is no known paleontological ground for separating the Knox sandstones from the upper members of this great series, part of which is Middle Cambrian. As fuller researches may lead to a new nomenclature for these divisions, and as simplicity and brevity are needed in this report, we cannot do better than to include all of the shaly series belonging to the middle and upper Cambrian under one class—the Oostanaula shales, and treat the whole as a unit on one map. This name has the advantage of avoiding confusion with the Knox limestones of the Ordovician system.

The position of the Oostanaula series in the great geological scale, as determined from the fullest information in the possession of Mr. C. D. Walcott, is from the following evidence:

In the northern suburb of Rome, from arenaceous shales and clays above the sandstones, fossils of the genus *Bathyuriscus* were found, and from the sand stones *Annelid* remains. Professor Safford has also found fucoids in the sandstone. Bathyuriscus beds belong to the Middle Cambrian series. Below the Bathyuriscus beds, and between their exposures and the abrupt terminations of the shales, against the Carboniferous fault in Tennessee, and at apparently the same horizon as the sandstones, Mr. Walcott found numerous specimens of *Linguella, Obelella* and *Bathyuriscus*. On the eastern side of and above the sandstone ridges, seven miles south of Rome, a bed of limestone, intercalated with shales, contains *Bathyuriscus* and *Ptychoparia* and species of *Orthis*—all being Middle Cambrian fauna. As already stated, the shales west of the Oostanaula fault contain *Olenoides*, and represent a lower division of the Middle Cambrian fauna. Accordingly, the sandstone members must belong to or below the Middle Cambrian series. Mr. Walcott, our best paleontological authority upon the Cambrian fauna, to whom all our intricate questions in this department are referred, has further determined three subdivisions in the upper portion of the Middle Cambrian fauna, in the Knox shales of Tennessee, but says that these shales may be Upper Cambrian in part.

A short distance beyond Georgia, a mile south of Cleveland, Tennessee, in a railroad cut, there are six hundred or seven hundred feet of limestone beneath the cherty beds in the base of the Knox dolomite (Ordovician) system.

These limestones contain *Ptychoparia* and other Cambrian fossils (Walcott).* It appears that the physical or lithological breaks in or adjacent to Georgia do not correspond to the change of fauna, as it often does, but with the changing life from the Middle Cambrian to the Upper, and from the Upper Cambrian to the Ordovician periods, the transition of physical conditions and growth of the continent was gradual; consequently, for accurate determinations, we must obtain the fossils, which are unfortunately not abundantly preserved, and the lithological characters alone are not sufficient guide. But in this economic survey, the study is simplified by considering as a unit the Oostanaula series, without a further introduction of new names or subdivisions. The Oostonaula series then embraces upper portions of the Middle, and all of the Upper Cambrian sediments as found in Georgia.

The Oostanaula shales are internally greatly faulted as well as folded.

The Oostanaula series occupies broad and narrow belts in the Coosa basin, and narrow belts occur in the Chickamauga and Chattooga drainage, the common feature often being the valley making elements. Where the rocks are calcareous they weather to rich red lands; where less calcareous the shaly soils are often thin and of inferior quality.

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* The citations from Mr. Walcott are derived from references; in Correlation Papers of Cambrian System in Bulletin No. 81, United States Geological Survey; and particularly from interviews and correspondence, he having visited the region and collected all the evidence available on this special subject.

CHAPTER IV.

GENERAL CHARACTERISTICS OF THE ORDOVICIAN SYSTEM.

(LOWER SILURIAN OR CAMBRO-SILURIAN.)

CONTENTS.

TABLE.

SERIES.		FORMATION.
Trenton (and Chazy)	Chickamauga	Rockmart Slate.
		Deaton Ore Beds.
Hudson		Maclurea Limestone.
Calciferous		Knox Dolomite.

KNOX DOLOMITE.

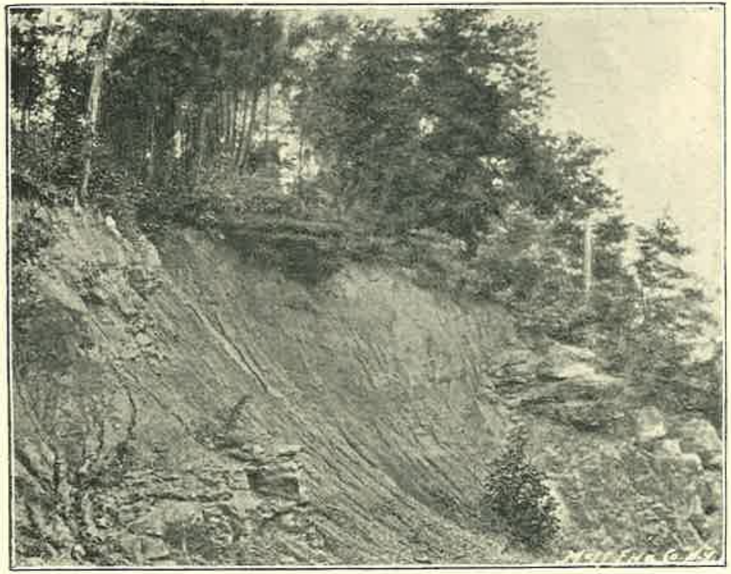
This wide-spread series of rocks is distinctive, well named and not confusing. Economically it is one of our most valuable formations, being rich in ores and building materials. It was first described by Prof. Safford, in Tennessee. It is characterized by magnesian limestones or dolomites. These are sometimes very massive, with indistinct stratification, (as in plate II.) and again they comprise thinner layers. Some of the beds are composed of simple limestones. These solid rocks are sometimes dark colored, but are oftener of light shades. The texture is compact or granular. The rocks present many degrees of purity: those containing sand weather to a coarse porous sandstone with rough surfaces; others, rich in clay, soon break down, and superficial deposits of clays and loams are found; also great pockets of white clays occur in the deeply decayed rock. The result of weathering upon the disturbed rocks is to produce gentle, rounded undulations, and loamy soils most commonly of a red color. (See plate VII. illustrating ore banks at Grady.)

PLATE II.

KNOX DOLOMITE.

At cut on Rome Railway, showing character of strata.

PLATE III.



KNOX DOLOMITE.

Railway cut, one mile south of Dalton. Ledges of rock rising irregularly into the residual clay.

In the lower Knox dolomite, the accumulations of limonite, or brown ore, manganese, kaolin and bauxite occur in large quantities.

Higher up in the Knox dolomite, the beds are more apt to be siliceous and contain concretionary masses of chert or flint. Sometimes the siliceous matter forms nodules of flint arranged in layers, or else in thick irregular pockets. Upon disintegration these cherty masses weather out into angular gravel or boulders, which cover and protect the surface of the numerous steep ridges. The covering mantle of chert is usually superficial, and beneath it light colored siliceous clays are most common. Thus the cherty ridges and gray dolomite lands usually go together. Prof. Safford first discovered a characteristic of the chert in that it commonly contains rhomboidal cavities, which are molds arising from the removal, by solution, of crystals of dolomite from the chert; also that fresh quarried cherty rocks still contain the crystallized mineral. The fossils are scarce, but still occasionally found.

Different portions of the beds of the dolomite formation weather differently. Many exposures of the solid rock are well shown in the cuts along the Rome railway. In some cases, the thin bedded and earthy strata weather the most readily, but in other places thick compact layers of dolomite rise up through other beds which are decayed to depths of scores of feet, showing very unequal weathering in apparently the same beds (see fig. 1 and plate III.).

The compact beds show jointing or cracks, which favor weathering and the formation of rounded hummocks rising in relief. This propensity for weathering has left the solid rock deeply covered by earth, and accessible only on the sides of occasional ridges or sometimes in valleys. Still it forms extensive exposures, as upon Ladd's mountain, west of Cartersville, which is a characteristic but isolated dolomite ridge rising about 500 feet out of the plains (Plate IV.).

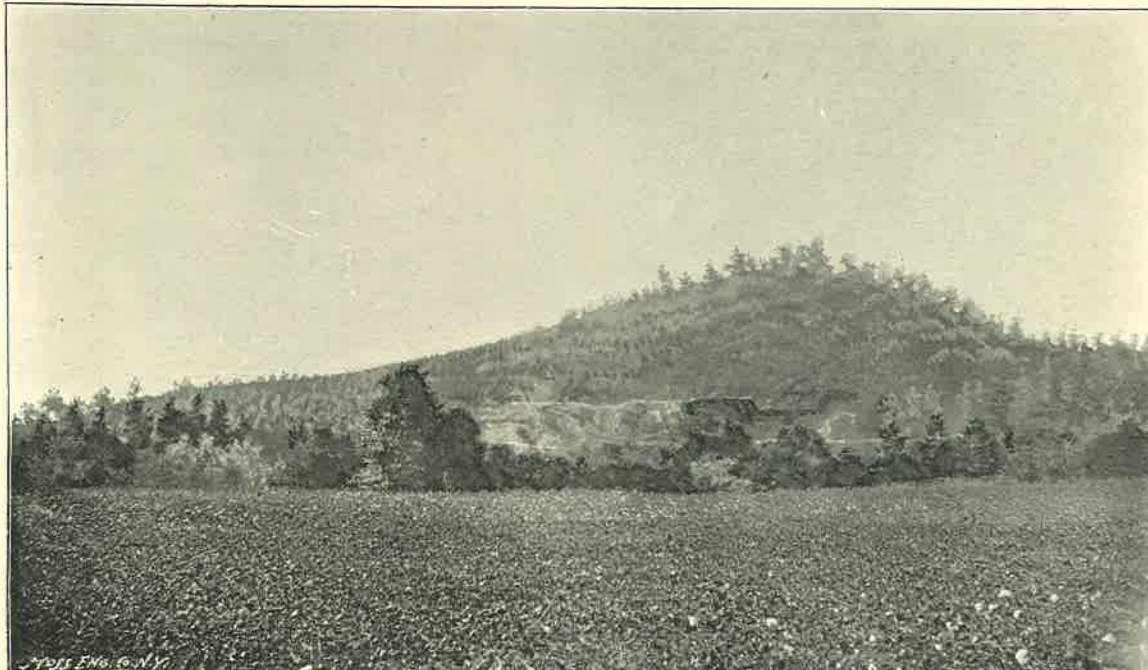
The depth of decayed covering is variable. Occasionally the solid rock comes to near the surface. Again, in the residual earthy coverings, wells are often from 60 to 90 feet without reaching solid rock, and the decayed rock débris at Oredell is 200 feet deep. This represents the removal of an enormous mass of calcareous matter from limestones, of which only the clay and earthy matter remains. The topography of ridges, undulations and valleys arises from atmospheric decay and removal of material from the disintegrated strata, which often dip at low angles of 5° or 10°, and rarely exceeding 20° or 30°.

It is difficult, as it is with all the rocks in this section, to determine the thickness of the formation. Mr. McCutchen placed it at 5,000 feet. Mr. C. W. Hayes estimates it at 3,500 to 4,000 feet. In Alabama Prof. Smith assigns about 4,000 feet to it. Owing to the limestones being deeply covered with their disintegrated remains, the country composed of these rocks is mostly known in the form of cherty ridges and loamy valleys, and the exposure of the stratified rocks is insufficient to make definite measurements of their thickness, for the disintegrated residual clays and cherts only form heterogeneous masses. However, east of Vann's valleys, southwest of Rome, it is not unreasonable to make an estimate of 4,000 feet as the thickness of the series.

Just east of the last named locality, a ridge is found composed of a consólidated rock made up of angular fragments of dolomitic limestone. This structure implies an upper horizon in which the older rocks had become exposed to degradation, and out of their ruin the new beds were constructed. Fossils have not yet been found there, but the general topographic position indicates the lower part of the Knox dolomite series.

Many caverns occur in the Knox dolomite formations.

In Polk, Bartow and Floyd counties, the Knox series form broad undulations and cover a wide belt; but further north the formation occupies numerous belts, owing to faults, or produce subordinate ridges in anticlinal valleys.



LADD'S MOUNTAIN (BARTON COUNTY),

500 feet high, showing form of ridges produced by weathering of Knox dolomite. Cotton field in foreground.

Fuller details of this formation may be found in the local distribution given in succeeding pages. Other information as to minerals and thelr compositions is given in the Economic part of the report.

CHICKAMAUGA SERIES.

This series of rocks comprises such of the Hudson, Trenton and Chazy formations as occur in Georgia. Their separation in the southern Appalachian region has always been a source of difficulty, as the physical and lithological structure in some places permit of separation, whilst in other cases they become a unit. Nor can exact parallelism be established. Hence, the adoption of Dr. Hayes' nomenclature.* The rocks, as a unit, are best developed in the Chickamauga valley, as also in Whitfield county, although in Polk county the separation into Safford's Maclurea limestone and Hayes' Rockmart slates is very distinct.

The Chickamauga series west of Taylor's ridge is notably an impure bluish limestone, often in thin beds and more or less flaggy. These limestones are frequently fossiliferous. In places, the rocks are intercalated with beds of shale. When the calcareous matter is dissolved away from the limestone, owing to weathering processes, prominent ledges of flaggy material of shaly character remain in relief. These limestones are usually at low angles from 10° to 20°, although steep in places, and often protrude through the soil and form the rocky pavements of the country. The Chickamauga series characterizes narrow valleys and low rocky ridges; this formation also extends upward often to a considerable elevation in the neighboring mountain ridges, which are capped by more durable rocks. Sometimes the rocks do not appear through the soil, especially when the outcrop is narrow and in valleys at the foot of mountains. The soil which results from the decay of these rocks is usually a stiff, reddish or brownish clay, forming some of the most fertile

*Bull. Geol. Soc. Am. Vol. II., p. 143.

lands of Georgia. In this part of Georgia, the thickness is from 1,200 to 1,800 feet.

In Polk county, the lower subdivision or the Maclurea limestone forms massive beds, some of which are remarkably pure limestone, often fine granular in texture, and from light to dark gray in color. In that district, it is slightly metamorphic, forming gray and colored marbles. In weathering, they do not usually disintegrate but have their surface worn away by solution, thus producing rounded hummocks (see plate I, where these hummocks have been covered by higher materials now removed), rising up in the valleys and sometimes forming considerable billocks, even to an elevation of one to two hundred feet. The formation is often characterized by caverns. This portion of the Chickamauga series has probably a thickness of 600 or 800 feet.

The Deaton ore beds, occurring northeast of Rockmart, overlie the Maclurea limestone at low angles. These beds are ferruginous limestones, varying in thickness from a few inches to a few feet. They are dark gray, fine grained and compact, and sometime contain 30 per cent of iron. More commonly the beds are earthy and weather into ferruginous clay, or angular slabs of iron ore. The thickness is from 100 to 200 feet. Similar beds occur in Whitfield county. These ore beds represent some portion of Safford's iron-limestone series in Tennessee. (See plate I.)

The Rockmart Slates of Polk and adjacent counties form the upper member of the Chickamauga series. The rocks dip at angles varying from 20° to 40° near Rockmart, and approach the vertical, near the Cartersville fault, a few miles to the south. Farther west, they cover the Maclurea limestones on a rather flat rolling country, although about Rockmart they form ridges. The slates weather to a grayish, reddish or variegated color, and are broken into small chips covered by thin soil. They are semi-metamorphic and in places have a cleavable fissile structure. Some of the upper beds, which are not fissile, weather into a bed of beautiful clay, capable of being carved into ornaments, or the so-called Caenstone. The estimated thickness is 1,200 feet.

Another feature of the Chickmauga series, in the ridges south of Rockmart, is a heavy bed of breccia composed of angular and sub-angular chert with some slate. This is cemented into a hard rock which has been used for millstone. This breccia points to an epoch of disturbance at the close of the Knox dolomite, just as the breccia at the base of the Knox dolomite (noted on page 44) pointed to a disturbance about the close of the Cambrian period, for these deposits, although exposed to only a limited extent, belong to the base of the Chickamauga series.

The local features of the Chickamauga series will be noted in later chapters on the various counties.

CHAPTER V.

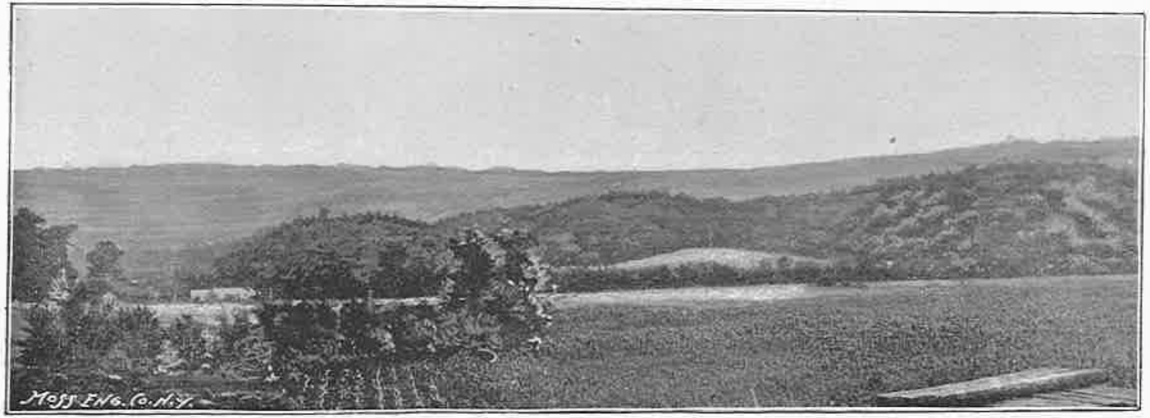
GENERAL CHARCATERISTICS OF THE SILURIAN SYSTEM.

RED MOUNTAIN SERIES.

The Silurian system overlying the Chickamauga limestone is only imperfectly represented in the southern Appalachian region by a series of rocks which Safford, in Tennessee, described under the names of Clinch mountain sandstone, White Oak mountain sandstone, and the Dyestone group; and Smith, of Alabama, named the Red mountain, or Clinton series, which Mr. Hayes has renamed Rockwood. All of these rocks appear to belong to horizons, including the Medina, Clinton and probably lower Niagara series, with the upper portion of the Silurian system wanting. There is no ground for local subdivisions, although great variation in rock masses occur. Thus, in Murray county, on Rocky Face, and other ridges, massive sandstones, capping the lower shales, give rise to bold, high but narrow ridges. Taylor's ridge, to the westward, is of a similar character, but with a diminution of sandstones. Westward of this last ridge the sandstones become less abundant and are replaced by thick deposits of shale, which are seen in "Shinbone ridge" (or the foot-hills of the Lookout plateau). Here the ridges are narrow and low, but with interrupted points rising two or three hundred feet above the valleys, owing to their protection by Sub-Carboniferous cherts. On account of the strata inclining at considerable angles, usually not exceeding 30°, but sometimes nearly vertical, the characteristic feature of the formation is that of narrow ridges. (See plate V opposite.)

The mountains and ridges are portions of synclinal folds, which, for instance, pass under the Carboniferous rocks of Lookout mountain. Thus, the formation usually bounds anticlinal valleys, the centers of which are occupied by older formations.

PLATE V.



SHINBONE RIDGE,

(Red Mountain Series, etc.), along the foot of Lookout Mountain, at Rising Fawn.

The sandstones are often massive, and vary in color from light gray to brown and red. The shales are commonly fissile, in thin beds, amongst which there are intercalated, at various horizons, thick layers of sandy shale which pass into flaggy sandstone; sometimes there are thin beds of fossiliferous sandstone, as well as beds of hematite or red fossil ore, which renders this formation extremely valuable. These iron ores occur somewhat above the medial horizon. The iron ore beds are commonly made up of masses of shells converted into oxide of iron, leaving the structure of the shells, amongst which there are flattened concretionary nodules. Above the drainage level, this "fossil ore" does not usually contain much calcareous matter, but below the water levels, where it has not been leached out, there is sufficient calcareous matter for self-fluxing, and the calcareous layers are better preserved than near the surface. The total thickness of the formation in Georgia reaches from 800 to 1,100 feet, and is best shown at the end of Pigeon mountain, where it is exposed by railway cuts across the whole formation, dipping regularly at about 8° to the east of southeast. In Alabama, the formation dwindles to about 100 feet in thickness.

As a surface feature the Red Mountain series forms only narrow belts. The rocks appear to lie comformably upon the Chickamauga limestones. which often rise high in the sides of the mountain. Overlying the Red Mountain series, a thin deposit of black shales, belonging to (probably the upper part of) the Devonian system, occurs. Whilst unconformity is not recognizable, yet it is probable on account of the great gap apparent in the geological succession.

CHAPTER VI.

GENERAL CHARACTERISTICS OF THE DEVONIAN SYSTEM.

CHATTANOOGA BLACK SHALE.

The Devonian system in Georgia is represented by only from ten to twenty-five feet of black shales, which are valley making. At the surface they are rarely exposed, owing to the usual covering of *débris* from the adjacent ridges. Still, where the streams cut across the formations, the black shales are usually found between the Red Mountain beds and overlying cherty limestones. In Alabama, they dwindle to a thickness of ten feet, whilst in Tennessee the same beds increase to a thickness of 100 feet. The top layers of the shale become lighter colored and contain rounded concretions. At some points, the black shales are wanting, thus permitting the contact of the Silurian and Carboniferous systems.

This shale is commonly mistaken for coal. It is often characterized by sulphur and mineral springs.

CHAPTER VII.

GENERAL CHARACTERISTICS OF THE CARBONIFEROUS SYSTEM.

CONTENTS.

The Lower or Sub-Carboniferous series is extensively developed in northwestern Georgia in three different phases. In the valleys adjacent to the Coal Measure ridges, the Mountain Limestones are bounded by cherty ridges of the Fort Payne series with the intermediate Floyd shales wanting. But east of Taylor's ridge the Sub-Carboniferous valleys are carved out of the Floyd shales, whilst the ridges are covered with the Fort Payne chert.

FORT PAYNE CHERT.

The Fort Payne chert consists of a siliceous limestone more or less filled with cherty concretions. Sometimes the chert occurs in layers, but again it is in the form of nodules. The calcareous matter is dissolved out upon the weathering of the rocks, leaving the country covered with a cherty gravel mantle, which favors the production of ridges. This chert is more or less porous from the remains of fossil impressions. It lies upon the black shales of the Devonian system, except where it is wanting. East of Taylor's ridge, the rocks at the surface form crested ridges. West of the Chickamauga valley they form ridges covered with chert adjacent to the valleys of the Mountain Limestone. These cherty hills often protect the iron bearing shales of the Red Mountain series. (See plate V.) The thickness of the formation varies from 240 feet to 510 feet. In this formation fossils are found in many places, and in some horizons crinoidal rocks abound. Upon the map, it is not practicable to represent the belt of this series, which everywhere bounds the Mountain Limestone on the one hand, and forms the ridges adjacent to the Floyd shales on the other. A few outlying patches of this series cap some outlying ridges of Lower Paleozoic rock in the Coosa drainage.

FLOYD SHALES.

These shales have the greatest development in Floyd county. They are composed of black or yellowish shales, or a dark blue calcareous shale, and beds of limestone. The beds of limestone are very fossiliferous west of Rome. This formation constitutes a considerable portion of the "flatwoods" of the Coosa basin, and forms comparatively level land. The rocks are more or less disturbed, but have an estimated thickness of 1,500 feet. The soils over the "flatwoods" are usually thin and away from the calcareous layers often poor. Amongst these shales there are some sandstones which may be the equivalent of the Oxmoor sandstone of Alabama.

THE MOUNTAIN LIMESTONE.

This upper member of the Sub-Carboniferous series is a pure, blue limestone, with a development of about 900 feet in thickness. It forms the sides of the mountains, which are capped with Coal Measures, and extends down into the valleys. It is a highly fossiliferous rock, rich in crinoid stems. Within the limestone, on Lookout mountain, a bed of sandstone is found. The upper portion of the limestone becomes somewhat earthy as it approaches the shales of the Coal Measures. As a surface rock, it is most conspicuously developed at the end of Pigeon mountain. The Mountain Limestone usually lies at low angles beneath the Coal Measure basins of the mountain plateaus.

THE COAL MEASURES.

The Coal Measures lie in synclinal basins capping Sand, Lookout

PLATE VI.

LOOKOUT MOUNTAIN,

Seen from Rising Fawn (1,000 feet high), showing the escapement of conglomerate capping and protecting the plateau.

and Pigeon mountains. The same rocks of these formations also cap one or two ridges to the eastward of Taylor's ridge. These outlying fragments are necessary, in showing the former wide extension of the Coal Measures which have been removed by denudation (see pages 18 and 25). In contrast with the rugged character of the Red Mountain series, the topographic features of the Coal Measures are mountain plateaus, which have been preserved, owing to the nearly horizontal hard sandstones so largely prominent in the series. The total thickness of the Coal Measures in Georgia reaches from 1,400 to 1,600 feet upon Lookout mountain, and to half that thickness on Sand mountain. The Coal Measures may be divided into the Lower Coal Measures and the Upper Coal Measures. The Lower Coal Measures on Lookout mountain have a thickness of 600 feet. This is characterized by shales, succeeded by 40 feet or less of sandstone or fine grained conglomerate and another deposit of shale, followed by heavy sandstones and conglomerate which reach a thickness of from 175 to perhaps even 250 feet. Included in this succession of rocks, there are two beds of coal, one of which may be workable in places. This conglomerate forms the striking feature of Lookout mountain, as it surrounds that plateau as a battlement wall, broken into by occasional streams (plate VI.). The rocks commonly dip at low angles from both sides into the mountains, and form a basin. At some few points, however, the disturbances have been great, and have thrown the rocks into steeply inclined positions.

The Upper Coal Measures consist of a succession of shales with bedded sandstones, and reach a thickness of 840 feet, including seven seams of coal of variable thickness from four feet to a few inches. As the upper part of the series is made up of shales, these deposits have suffered extensive erosion, but remnants of the higher beds still constitute the productive Coal Measures of Lookout mountain.

The Coal Measures on Sand mountain have a somewhat different physical appearance, and are represented by about 500 feet of shales and sandy shales; with both the lower and upper conglomerates, here mostly sandstone, which are less developed than on Lookout mountain. The Lower Coal Measures contain seven seams of coal, some of which, however, are thin. Above these Lower Coal Measures about 300 feet of the Upper Coal Measures are composed of shales with some thin sandstones and sandy shales; these deposits are followed by a capping of sandstone. In this upper series there is at least one seam of coal.

It is noticeable that the conglomerate, or its equivalent in the form of sandstone on Sand mountain, occurs above the most productive part of the Coal Measures in place of below, as on Lookout mountain and most other regions. It will be seen in comparison with the coal fields of Alabama that the volume of the Coal Measures is greatly reduced in Georgia, for the thickness in Alabama is 5,525 feet, whilst in Tennessee the series has a thickness of from 200 to 2,500 feet.

The conglomerate consists of a coarse sandstone, occasionlly charged with pebbles, usually not greater than from half to three-fourths of an inch in diameter. The beds are sometimes thin, but occasionally form masses from 10 to 75 feet in thickness. The shales may be argillaceous and constitute a fire clay, or in places they are sandy and pass into pure sandstones. In some places, the shales are ferruginous and weather to a red color; in other places they are of a bluish tint.

In order to better understand the structure of the Coal Measures in Georgia, reference to figure 14 will show a section across the formation and the relationship of the Carboniferous system to the other formations.

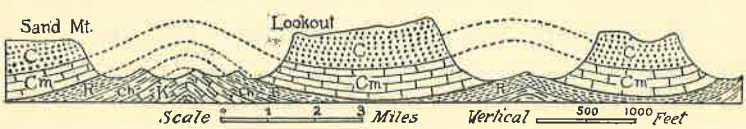


FIGURE 14.—Section from Sand to Pigeon Mountains; C, Coal Measures; Cm, Mountain Limestone; Heavy line is Devonian; R, Red Mountain; Ch, Chickamauga; K, Knox series.

CHAPTER VIII.

RECENT FORMATIONS, AND EVOLUTION OF NORTHWESTERN GEORGIA.

LAFAYETTE (?) AND MODERN.

In the decayed rock accumulations over the whole Paleozoic belt have been in process of formation throughout most of the periods from the Carboniferous to the present day, but we have one remnant of a later formation than the Coal Measures. This remnant consists of the deposits of gravel and loam found at altitudes from 50 to 150 feet above the waters of the Coosa basin. These gravels are the equivalent of the Lafayette (?) series of southern Georgia, but there accumulations have been largely removed by subsequent denudation, so they are mostly seen to-day upon the hills within two miles of the rivers. In the Coosa basin, the gravels do not occur at elevations higher than 800 feet above the sea; however, in the higher country, amongst the crystalline rocks to the east, along the tributaries of the Coosa and the Tennessee rivers, apparently, the same gravels occur to 100 feet above the modern streams, at elevations from 1,500 to 2,000 feet above the sea. These deposits modify the agricultural features of the country. Along the Chickamauga and other valleys west of the Coosa basin, in Georgia, the gravels and loams have not been recognized—a rather remarkable absence. The gravels are usually composed of quartz, derived from the crystalline rocks, with occasional pebbles of local material. Their position above the rivers is indicative that they could not have been so deposited from the swollen volumes of the streams, but their deposition was favored by the slack water of the estuaries occasioned by the submergence of the southeastern part of the continent, in this region, to a depth of nearly 800 feet. The occurrence of the same accumulations at high elevations in the mountains to the east is probably an indication of considerable warping movement of the earth's crust since the depositions of the Pleistocene epoch. It must be emphasized, however, that the deposits have been largely removed by denudations subsequent to their accumulations during the late subsidence of the land.

The only modern formations represented is the river alluvium of the present streams, which sometimes has a width of a mile or more, adjacent to the principal rivers; but is not greatly developed along the smaller streams. There are remnants of terraces, but these belong to the Lafayette series. The continuing decay of the older rocks, constituting the common soil of northwestern Georgia cannot, of course, be regarded as a distinct formation.

EVOLUTION OF NORTHWESTERN GEORGIA.

From the generalized descriptions of the geological formations of the Paleozoic belt of Georgia, some interesting knowledge as to the growth of the continent may be inferred. At the close of the Archæan era, or rather at the close of those periods which produced the more recent crystalline rocks, the crystalline belt to the southeast constituted elevated land from which the waters were washing the decaying products into a sea covering the now Paleozoic belt. Fragments of the old shore lines and remnants of river deposits are occasionally seen in those masses of sandstone, such as Indian mountain; however, the subsequent physical changes have obliterated these early conditions of the growth of northwestern Georgia, leaving only unmistakable remnants of the Middle Cambrian period in the thick shales of the Oostanaula series. These shales were in part an off-shore deposit, but probably a not distant accumulation, as shown by their sandy character; still, at times, the waters were sufficiently clear to allow of the accumulation of impure limestones. In the later Cambrian days, there appears to have been some interruption, so that at the beginning of the Lower Silurian, or Ordovician period, some traces of unconformity are recognizable in the breccias which are found associated with the Knox dolomite at a few localities. The shales of the Cambrian period, however, extended from the old coast line, on the eastern side of the Coosa valley, all the way to the farthest limit of Georgia. With the advent of the early Ordovician period, the sea was freer from the muddy deposits coming down from the highlands to the east, and upon its floor was accumulated an enormous thickness of limestones, with which, however, some clays and sands were commingled. The limestones were mostly turned into dolomite. It was in this period that the iron, manganese and beauxite ores were deposited among the forming limestones. At the close of the Knox dolomite epoch there appeared to be local interruptions, as shown by the presence of breccias near the base of the Chickamauga series in Polk county. But the Chickamauga sea was characterized by an influx of more or less muddy waters, which interfered with the calcareous growths. This influx, however, was more or less interrupted, as some beds of pure limestone were formed in basins protected from the muddy streams. After the close of the Chickamauga epoch, the Paleozoic sea was flooded with muddy waters, carrying down the sands and clays which now form the Red Mountain series. The shore lines of this epoch had moved many miles westward of those of the earlier Cambrian days, and are preserved in the heavy sandstone deposits of the eastern ridges of the Red Mountain series, whilst the Red Mountain series further westward is composed mostly of clays which were carried into deeper water. However, along with these deposits some beds of limestone were formed. The upper part of the Silurian system is not represented, so that it is probable that for a considerable length of time the whole of northwestern Georgia became dry land, and this condition continued far into the Devonian period, which is represented by only a few feet of shales, although the Devonian system, elsewhere on the continent, reaches a thickness of 13,000 feet.

With the advent of the Carboniferous period, the waters of northwestern Georgia, driven farther seaward by the growth of the land, became the home of a rich marine fauna, which has built up the great deposits of limestones. However, into a portion of that sea, enormous quantities of mud were carried and locally deposited, as in Floyd county. Perhaps, elsewhere in the State, there was a temporary elevation of the lowest Carboniferous rocks, which, however, were not subjected to great erosion, as the unconformity between the limestones is not apparent, even where the shales are wanting. Later on, the Sub-Carboniferous sea appears to have gradually become muddy, and the basins became filled with the shales and sandstones of the Coal Measures, which occasionally gave rise to swamps, producing in Georgia at least nine beds of coal, separated, however, with mechanical deposits washed down from the outward growing shore line of the State. It is probable that the Sub-Carboniferous sea during its early days extended over most of northwest Georgia, as outlying fragments are met with. The Coal Measure series extended ten or twelve miles eastward of Pigeon mountain, as shown by outlines on Little Sand and Rocky mountains east of Taylor's ridge. These indicate an enormous erosion since the Carboniferous period.

Throughout the Paleozoic era, the succession of strata appears to have suffered no other disturbance than occasional interruptions, owing to temporary rising and sinking of the lands, without any great disturbances in the position of the strata. The faulting, overthrowing and folding of the formations, which are represented by the mountains and valleys of to-day, did not take place until after the close of the Coal epoch; still sufficient time has elapsed to permit atmospheric and river erosion to remove thousands of feet of the various Paleozoic strata, and leave the present valleys, ridges and mountains, formed in a large measure, owing to the durability and position of the strata favoring or retarding the grinding away of the country, by subsequent rains storming the rocks through several geological ages, as shown in figure 15.

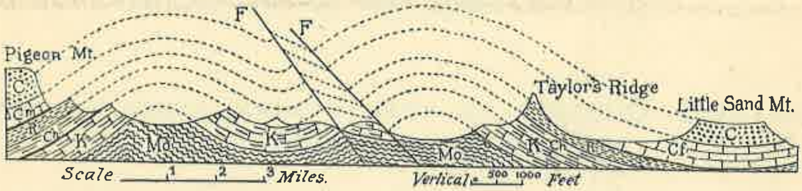


FIGURE 15.—This shows a section of fifteen miles, from which the Coal Measures and other formations have been removed by denudation, with the formation of valleys. The denuded beds from Coal Measures (C) to Middle Cambrian (Mo), are represented by dotted lines. F, great faults.

From the Coal epoch to the Lafayette (which is probably Pliocene) northwestern Georgia appears to have been continuously dry land, followed by the submergence and re-elevation of the Lafayette epoch, since the beginning of which, however, the mountains to the eastward of the Coosa basin have been probably elevated to a greater extent, compared with the country to the west, than before that time. But this study of physical geography of the past and the growth of this section of the State cannot be properly separated from the growth of the adjacent States.

CHAPTER IX.

PHYSICAL FEATURES OF THE COUNTRY UNDERLAID BY PALEOZOIC ROCKS.

IN POLK, FLOYD, BARTOW, GORDON, MURRAY, WHITFIELD, CATOOSA, CHATTOOGA, WALKER AND DADE COUNTIES.

CONTENTS.

GENERAL FEATURES OF THE COOSA VALLEY AND ITS EASTERN BOUNDARY.

This definition is not strictly accurate, as in places metamorphism has somewhat affected both the Cambrian and Ordovician rocks, in contact with the more highly altered rock to the east, adjacent to the great Cartersville fault.

Northwest of this fault line, in the Coosa basin, the general altitude of the broad rolling valleys is from 850 to 900, occasionally rising to 1,000 feet above the sea, as shown by the 250 feet contours on the geological map. Across Bartow, Gordon and Murray counties, the country is somewhat lower, with a general altitude from 750 to 850 feet, occasionally rising to 900 feet. This general valley country is sharply defined by mountains, which enter Polk county, between one and two miles south of Esom Hill, with an altitude between 1,200 and 1,300 feet above the sea, and constitute a defined range along the southern edge of the country, passing near Felton, Hightower (Mills), to Simpson's Mills about four miles south of Rockmart. This range of hills is a conspicuous feature across the country, which for long distances forms the prominent landscape of "Dug Down Mountain." The outline is somewhat regular and broken to only an unimportant degree, as the water-shed dividing the streams flowing north from those flowing south is close to the brow of the range.

In the broken country, southeast of Rockmart, the regular features of this range of crystalline rocks is lost, as some of the Paleozoic rocks rise (as in Carnes' Mountain 1,291 feet above tide) higher than the more metamorphic rocks to the south and east. From this point the Paleozoic valleys are bounded by lower metamorphic hills, or rather the ends of numerous spurs, left between the streams flowing northward to the Etowah river. These hills swing around and leave an embayment of the valley southeast of Cartersville, with some isolated points upon its northern side, rising to about 1,500 feet above the sea.

From the vicinity of Cartersville, the Paleozoic valley is again bounded by more regular ranges of hills, with occasional knobs rising from 1,300 to 1,500 feet above the sea, as spurs of Pine Log mountain, which, farther north, rises to 1,800 feet. Three or four miles east of the valley, upon the eastern boundary of Bartow county, these mountains rise to over 2,300 feet.

East of Pine Log Postoffice, Pine Log creek forms an embayment in the chain of hills, changing the direction of the range, which, however, soon trends again to the north, and enters Gordon county near Fairmount. For many miles south and north of this point the valley is sharply defined by an apparently regular range of mountains, which rises from 1,400 to over 1,500 feet above tide, with the next embayment made by Talking Rock creek, two or three miles above its discharge into Coosa river. A contrast is noted between relationship of this creek and the river, as they pass through the mountains; the creek has produced a large valley in the mountains, whilst the river cuts through the range without greatly modifying its outline, thus giving the valley a newer appearance.

The range of mountains, still of the same general height, enters Murray county, passes by Dennis and eastward of Fort Mountain Postoffice. Here is a chain crossing the country obliquely, with its highest point rising to 2,827 feet. The name Fort Mountain is given on account of the remains of a prehistoric (supposed to be Spanish) zigzag wall built across the end of one of its spurs like a stone breastwork. Fort mountain, with its northeastward trend, is separated from Cohutta mountain by the valley of Holly creek, forming a deep embayment in the general mountain wall which bounds the eastern side of the great Coosa valley. The highest point of Cohutta mountains (Bald mountain) is 4,450 feet above the sea. Northward, the mountains continue to form a prominent boundary to the valley, although declining in elevation to 1,500 feet or less, and at a point about four miles west of the Murray-Fannin line, they cross into Tennessee.

From Fort mountain northward, the trend of the ridges is usually at broad angles (up to 90°) to the trend of the hills forming the boundary of the Coosa valley, thus showing a notable and abrupt truncation of the mountain spurs; which features mark the great fault line that bounds the unmetamorphic Paleozoic region of Georgia.

Owing to the features just described, no doubt is left as to the boundary of the unaltered Paleozoic systems, in the country under report, as shown at M and M in figures 16 and 17 on page 63.

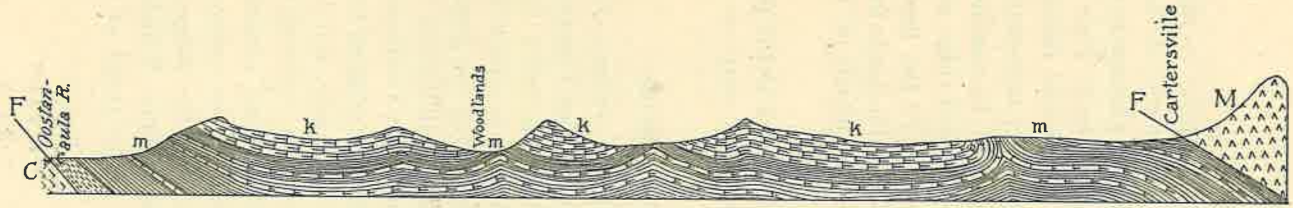


FIGURE 16.—Section showing undulations of profile in the middle portion of the Coosa basin in Georgia.

FIGURE 17.—Section across the northern portion of the Coosa basin between Rocky Face and Cohutta Mountains (M).

The subordinate ridges in the valley are mostly composed of Knox dolomite, and rise from 100 to 400 feet high. The eastern limit of the valley is commonly bounded by high mountains of metamorphic rocks, and the western by bold ridges of the Paleozoic group.

NORTHWEST OF THE COOSA BASIN.

Whilst the valleys west of the Coosa basin are similar to those to the east, in respect to undulating plains and low ridges, yet there is a marked contrast in the high mountain ranges and plateaus to the west. The most eastern of these high ranges is Rocky Face or Chattoogata and its zigzag continuations and repetitions through Horn's and John's mountains, skipping to Lavender mountain, a spur of Taylor's Ridge. Taylor's Ridge, which, with its continuation, White Oak mountain, forms a second sharp-backed ridge with elevations from 600 to 800 feet above the valleys. To the northwest, Lookout and Sand mountains form elevated table-lands from 700 to 1,400 feet above the valleys, which have an altitude of 750 to 900 feet above the sea.

A general view of this part of the State may be seen in the profiles of the geological sections upon the geological map or in figure 15, page 59.

THE CHARACTERISTICS OF THE RIVERS AND STREAMS.

The general Coosa valley, with its subordinate valleys, is a portion of a great mountain basin or trough crossing East Tennessee, Georgia, and extending into Alabama. Entering the valley from Tennessee, the Connasauga flows by a very circuitous course to a point about four miles northeast of Calhoun, following the general course of the mountain valley. At the point just indicated, this river is joined by the Coosawattee—the two forming the Oostanaula. Near Resaca, the appearance of the valley is that the original Connasauga river was once continuous with the Oostanaula, and that the Coosawattee should be considered as the tributary, crossing the trend of all the ridges. The Oostanaula, with the same meandering course, keeps close upon the western side of the valley to Rome, where, being joined by the Etowah crossing the ridges, it becomes the Coosa. The smaller streams throughout Whitfield and Murray counties are mostly subordinate to the trend of the valleys, and are consequently longitudinal, only crossing the trend of the ridges to a small extent, and flowing with a southward direction. South of the Coosawattee, several creeks flow northwestward across the primary direction of the ridges, thus producing a broken country.

The creeks which join the Etowah flow from one side or the other in the general trend of valleys, northeast and southwestward.

Below Rome the Coosa valley is broad and constitutes the "flat woods" with unimportant streams. The embayment of the great mountain valleys, in Polk county, is marked by only one large stream—Big Cedar creek and its tributaries.

A characteristic of all these streams is their ancient appearance. In a general way, the channels of the larger rivers are no greater than can be filled during floods,* and the smaller streams almost flow on top of the ground; that is, without deep river beds. Still the adjacent hills are often high, but manifestly they have been fashioned more by atmospheric erosions than by the rivers, for they are very deeply sculptured. Whilst this ancient appearance is everywhere conspicuous, with the absence of abrupt topographic features, yet the shallowness of the channels might bespeak their newness. The conclusions which are drawn from the topographic features point to the great antiquity of the streams, and that long ago they had reached the base level of erosion; that is to say, the erosion had continued until the streams could no longer deepen their channels, and consequently their work consisted in broadening the valleys and softening the outlines of the higher lands. But only to a limited extent were the processes of erosion succeeded by deposition of the highland muds washed down by the smaller streams. In recent geological changes of level, the streams became more sluggish, and, to a limited extent, river deposits were formed high up upon their banks (from 80 to 150 feet above the modern

* At Rome, floods overflow the plains to various depths. A flood of 1886 caused the water to rise 41 feet above low stages.

rivers), according to their locality. But the subsequent elevation of the continent lowered the waters; and now we find the streams digging out their channels to a small extent, for land is again higher than during the long ages required in moulding out the general topography of the valleys of northwest Georgia. Be this as it may, the fact remains that, although the rivers flow through broad, rolling valleys, there is a common absence of deep channels and gorges throughout the Paleozoic belt.

The streams amongst the mountains and ridges beyond the Coosa valley also indicate the extreme antiquity of the base level of erosion, and flow through the valleys which have been extensively broadened by lateral action of atmospheric erosion. At the end of John's mountain, on the east side of Taylor's ridge, the Armuchee creek breaks through mountains of the Red Mountain series, and is joined by Texas creek, flowing between Lavender mountain and the main ridge of Taylor's mountain. East of Taylor's ridge, in Whitfield county, the East Chickamauga river rises between it and the Rocky Face, but has cut through the ridge at Ringgold. The valleys between Taylor's ridge and Lookout mountain are drained by the branches of the Chickamauga creek, flowing to the northward, and the Chattooga river flowing to the southward. These rivers, whilst reducing the base level of erosion somewhat, are still flowing near the surface of the valley like those of the Coosa basin. Some considerable creeks rise upon the Lookout plateau, and cut, longitudinally, into the mountain, thus making the summit of the plateau rugged. Lookout creek and Nickajack creek are similar creeks to those upon the plateau, but they have already cut deep, broad valleys to near the base level of erosion. As the accumulation of river deposits throughout this section are, usually, of no great thickness or extent (the soils of the valleys being mostly residual from the decay of the rocks), it would appear, from the present character of the streams, that the modern, slight elevation, above the base level of erosion, dates back but a very short time ;

or, in other words, that the land of northwestern Georgia has been lately elevated to a moderate extent above the ancient level as, compared with the sea, during which time the streams, being no longer able to deepen their channels, have favored the widening out of the valleys down to their base level of erosion; accordingly, the rolling plains were produced. The streams at many points now flow over rocky shoals on account of the recent elevation of the region just referred to, and give rise to a number of water powers. The principal waterfall is Lula on Lookout mountain. (See Local Features of Walker county, page 73.)

THE MINOR PHYSICAL FEATURES.

IN POLK COUNTY.

The older geological formations cover most of Polk county, and occupy an embayment in the metamorphic girdle, which swings around in that region to the westward and changes the direction of the ancient Paleozoic valley. The features are closely related to the geological structure, being dependent upon the characters of the rocks, the dip and folding of the strata and the subsequent degradation of the land.

The boldest feature in the county is the Indian mountain, partly in Alabama, rising to 1,982 feet above tide, or 1,100 above the valley at Etna. It is a mass about seven miles long, but that portion with an altitude of 1,500 feet, is not over three miles in length.

From this mass, the valleys trend east of north, the principal being that of Etna, and its continuation into the Little Cedar creek, with narrow ridges to the east rising to 200 or 300 feet above the drainage. The northwestern portion of the county is somewhat rugged, from the prevalence of gray cherty hills or ridges. The northern central portion of the county is more or less level, with rounded outlines and ridges. The same is true of the southern portion of the county, with notable exceptions in some cherty ridges west and north of Lime Branch (P. O.). The elevations of the central part of the county vary from 50 to 150 feet, with only limited areas rising higher. Often high and slightly undulating lands extend for many miles. The eastern part of the county, east of Rockmart, becomes rough and bold, amongst prominent hills of the Ordovician slates and limestones. The highest of these is Carnes' mountain, 1,291 feet. In this corner of the county, the capping of hard siliceous rocks on the disturbed slates has caused the bold character of the ridges. The same is true on other hills near Lime Branch. The more abrupt hills and ridges are otherwise generally characteristic of the cherty portions of the Knox dolomite; whilst the more gentle undulations are principally due to the decay of the more calcareous Knox limestones; and the valleys are mostly derived from these limestones, some calcareous shales of the Oöstanaula, and the calcareous rocks of the Maclurea series.

The streams of the county are all small, except Big Cedar creek (a tributary of the Coosa river). Fish and Camp creeks, in the eastern part of the county, are small and flow towards the Etowah river. The streams in the valleys amongst the rugged hills are insignificant, and many flow only in damp seasons.

IN FLOYD COUNTY.

The northwestern side of the Lower Paleozoic belt in Floyd county is approximately defined by a line drawn directly between the bend of the Coosa and the Oostanaula rivers, upon their right or northwestern side. But the margin is irregular.

From Rome southwestward, the Coosa valley forms the extensive "flatwoods," comparatively level land across which the Coosa river flows in an irregular, broad valley. This tract on the east is bounded by a low range of hills, which skirt the western side of Van's valley (from Cave Spring to near Rome).

Eastward of this belt (made of the Knox or Rome sandstone, a lower Oostanaula series) is Van's valley, from one to two miles wide, excavated out of Oostanaula shales. This is the valley in which the East Tennessee, Virginia and Georgia Railway is built.

East of this last zone, there is a succession of valleys in Floyd county—south of the Etowah river—which are largely characterized by narrow ridges mostly trending somewhat east of north with intersecting connections. These ridges rise from 150 to 300 feet above the stream. This character continues to the valley of Spring creek, where the features are broader in outline. Due east of Chulio, on the border of Bartow county, there are several high isolated ridges.

North of the Etowah river, or of Rome, the Oostanaula river flows through a broad valley of shales. Upon its western side, it is sometimes continuous with the valley composed of Carboniferous series which is brought in contact with the Oostanaula shales by the "Saltville" fault. East of the valley, there are the crested ridges of the siliceous members of the Lower Oostanaula series. Upon their eastern or southeastern side, there is a great valley which is a continuation of Van's valley (not so called), through which runs the East Tennessee, Virginia and Georgia Railway. This valley widens to about four miles in the northeastern corner of the county. The southeastern side of the valley is bounded by somewhat rugged hills, which in the northwestern corner of the county, at Hermitage or "Ridge Valley," rises into a ridge of 500 to 600 feet in Armstrong's Mountain.

Along the Etowah river the country is rolling without crested ridges, as also the higher country drained by Dyke's creek.

Spring creek flowing northward and Dyke's creek flowing southward are the only important streams in the eastern part of Floyd county.

IN BARTOW COUNTY.

Between the metamorphic hills and the Etowah river, the country is undulating without sharp crested ridges. On the border of Floyd county there are some high ridges.

Northward of Cartersville a broad, undulating valley extends along the base of the metamorphic mountainous border to beyond the county line—with its character somewhat broken, near Pine Log Postoffice, amongst low ridges and hills, at the divide of waters flowing southward and northward.

Between this valley and the meridian, a mile or two east of Kingston, the country is variable and rolling, with broad surfaces and numerous streams, but generally with high crested ridges. But from Kingston to a point on the Gordon county line, three miles east of Adairsville, there is a chain of ridges, and the country is somewhat broken. Westward of Kingston and Adairsville the country is rugged, and in the northwestern corner of the county, near Armstrong mountain, it is quite broken. Southwest of Kingston, and southwest of Cassville the country is rugged, but with softened contours between. West of Cartersville, and back from the river, several isolated domes rise to heights of 500 feet above the Etowah valley. Between these and Cass station the valley is gently rolling.

Numerous small streams flow from the metamorphic girdle northward to the Etowah. Northward of the river about two-thirds of the country is drained by the streams flowing into the Etowah, the northern portion draining through Gordon county.

IN GORDON COUNTY.

The Oostanaula river flows through a continuation of the "flatwoods," a belt composed in part of comparatively flat land, and in part of minor ridges.

The valley of that river, as well as the Coosawattee, above Resaca, is a broad, irregular plain. The Oothcalooga, Sallacoa and Pine Log creeks are the principal secondary streams, and all flow northward, through rolling valley lands. West of Lilly there are some ridges, the highest rising 150–250 feet above the drainage plains. The central portion of the county forms a gently undulating meridional belt. Farther east, the streams have moulded the features into greater undulations of hills and valleys. On the whole, the topography of the country is simple as far as the metamorphic belt at its eastern edge.

IN MURRAY COUNTY.

Between the Connasauga river and the Cohutta and other mountains, the country has a simple structure with gentle undulations. The elevations range from 750 to 850 feet above the sea. South of Dunn postoffice there are some short ridges rising to 1,200 feet. So also north, from near Loughridge postoffice for about six miles there is a chain of crested ridges rising to from 1,000 to over 1,200 feet above the sea.

The valleys of the Connasauga river and of the principal creeks (the Holly, Mill, and Sumach) have considerable breadths. These streams have numerous tributary branches.

IN WHITFIELD COUNTY.

From the Connasauga river to the Cooahulla creek, the features of the county are similar to those of Murray county, but somewhat more rugged. In the vicinity of the East Tennessee, Virginia and Georgia Railway, the county is characterized by several parallel chains of interrupted ridges, from 100 to 300 feet above the valleys, which are sometimes narrow and again broad and undulating. These cherty ridges form the northwestern water-shed of the Coosa drainage which flows towards the Gulf of Mexico. Separated by valleys more or less underlaid with shales, the ridges extend throughout the western part of Whitfield county; however, the bold Rocky Face ridge rises to an elevation of from 1,500 to 1,700 feet, crosses the western part of the county and forms the eastern water-shed of the East Chickamauga creek which flows through the valley about 900 feet above the sea. The western part of the county is occupied by "Taylor's ridge" and its parallel spur, Dick's ridge, including some valleys within the mountains.

The East Chickamauga and the Cooahulla creeks are the only streams of importance flowing through the county, apart from the Connasauga river upon its eastern margin.

IN CATOOSA COUNTY.

The eastern part of Catoosa county is similar to Whitfield, with a continuation of the same ridges and valleys, including Taylor's ridge and its extension, beyond Ringgold, the White Oak mountains. These mountains rise into a bold, narrow ridge from 1,300 to 1,500 feet above the sea. Westward of the mountains two forks of the Chickamauga, and the Peavine creek flow through broad valleys, separated by cherty ridges rising from 100 to 300 feet.

IN CHATTOOGA COUNTY.

East of Taylor's ridge, and between it and John's mountain are Dirt Town and Armuchee valleys, separated by a plateau, known as Little Sand mountain. This plateau rises 300 to 500 feet above the valley, whilst John's mountain, to the east, has an elevation of from 1,300 to 1,468 feet above the sea, or 600 to 800 above the Armuchee creek. Dirt Town valley is broad and rolling. The Armuchee creek drains to the southeastward into the Coosa river. John's mountain forms the eastern boundary of the county. In crossing the county, Taylor's ridge has an elevation of 1,300 to 1,400 feet above the sea. Between it and Pigeon mountain the valley is traversed by some cherty ridges rising 200 or 300 feet above the Chattooga river and tributaries. The northwestern corner of the county is represented by the plateau of Pigeon mountain rising to an elevation of 1,700 feet above the sea.

IN WALKER COUNTY.

This large county presents two features—the broad valley, east of Taylor's ridge, and that of Lookout creek. These have an elevation of 800 to 900 feet above the sea, with a number of cherty ridges extending in a northeastward direction, rising from 100 to

250 feet above the general elevation of the valley. One of the most prominent of these subordinate elevations is Missionary ridge. Into the county, a northeastern spur of the Lookout mountain extends, which is known as Pigeon mountain, with an elevation of from 1,800 to 2,000 feet above the sea, but with one point rising to 2,331 feet. Along the top of this mountain, the boundary of the county is located, and thus the features pass into Dade county. Lookout mountain presents an elevated plateau from 1,800 to 2,000 feet above the sea, but with a few points rising higher. High Point has an elevation of 2,408 feet, and Round Top, to the south, 2,378 feet above the sea. Round mountain has an elevation of over 2,200 feet. From this point, Rock creek rises and flows longitudinally along the surface of the mountain, forming one of the most picturesque features of Georgia, adjacent to Lula falls and Lula lake. McLamore's cove, between Pigeon and Lookout mountains, is nothing more than an enlargement of a similar stream to that of Rock creek, running longitudinally along the mountain. This cove is drained by the west branch of the Chickamauga creek. East of Pigeon mountain, the valleys are drained southward by the Chattooga river.

IN DADE COUNTY.

Lookout mountain is deeply incised by lateral valleys known as Trenton's gulf and Johnson's crook. Fox mountain is an isolated remnant of the Lookout plateau. Lookout valley is traversed by a number of ridges parallel to its sides—a similar repetition, but on a smaller scale, to the topography east of Lookout mountain. Separated by the deep valley of Lookout creek (which has an altitude in Georgia of from 800 to 900 feet, is Sand mountain forming a pläteau somewhat lower than Lookout, from which the principal stream flowing in Georgia is Nickajack creek. In Lookout valley, however, there are some isolated remnants of the former extended plateau.

LAKELETS, SINKS AND CAVES.

In the Knox dolomite country, especially connected with the gray lands, there are many lakelets or ponds, sinks and caves. These lakelets are simply lime sinks containing water. Such are of commonest occurrence east of Adairsville, and west of Cartersville. To a lesser extent lime sinks are seen in the belt of Oostanaula shales, but these are of small size owing to the inferior development of the underlying limestones. Lula lake, in Walker county, is simply a pothole in the cañon of the stream.

The sinks are always situated over limestone formations, and are closely connected with the system of caves which traverse them, as they are simply surface depressions occasioned by the falling of the roofs of the caverns.

Hardin's cave (lot 104, 17th district), about three miles southeast of Kingston, is one of the largest caves seen, and of great extent with far reaching galleries. Some of the chambers are 20 to 25 feet high. Owing to the sloping roof the cave appears higher. The floor is covered with four to eight feet of cave dirt, overlaid by fallen blocks. It was once a source for saltpetre.

These caves are of geological interest. That in Ladd's mountain gives (see plate) some records of the date of its excavation. The mountain is now an isolated peak rising 500 to 600 feet above the broad Etowah valley. The rocks dip at gentle angles, and some portions of the caves show that its excavation was subsequent to the mountain uplifts, which disturbed the strata. But the caves, in this isolated knob, are above an elevation where any sufficient stream capable of forming such cavities could now gather. This shows that the excavation took place before the great rock decay and atmospheric erosion had lowered the valley of the Etowah below the level of the dome and caves, else there had been no gathering ground for them to give rise to the subterranean stream. In short, the excavations of the cave commenced immediately after the completion of the mountain uplifts, at the close of the Paleozoic era, but their formation has long ceased, owing to the lowering of the general level of the country by denudation.

At Cave Spring, near Nannie, Woodlands, and numerous other places, extensive caverns also occur in the limestone formations.

In northwestern Georgia, beyond the Coosa basin, caverns are occasionally met with in both the Knox and Chickamauga limestones. Crawfish Springs, at Chickamauga, is amongst the most interesting, as a large stream, sufficient for utilization as a water power, issues from an underground cavern and is now converted into a beautiful lake and waterfall.

Many caverns, some of which are extensive, occur in the Mountain Limestone at the bases of Lookout, Pigeon and Sand mountains.

ALTITUDES OF RAILWAY STATIONS IN NORTHWESTERN GEORGIA.*

	FEET ABOVE SEA LEVEL.	
Esom Hill	927	East and West Railway of Alabama.
Berry	853	“ “ “ “
Cedartown	767	“ “ “ “
Rockmart	741	“ “ “ “
Taylorsville	721	“ “ “ “
Cartersville	750	“ “ “ “
Alabama State Line	930	East Tenn., Va. and Ga. Railway.
Pryor's	844	“ “ “ “
Cave Spring	697	“ “ “ “
Van's Valley	662	“ “ “ “
Cunningham	707	“ “ “ “
Rome	652	“ “ “ “
Reeves	658	“ “ “ “
Dalton	782	“ “ “ “
Seney	830	“ “ “ “
Rockmart	762	“ “ “ “
Cass	765	Western and Atlantic Railway.
Kingston	710	“ “ “ “
Adairsville	710	“ “ “ “
Calhoun	657	“ “ “ “
Oostanaula river is 32 feet below		“ “ “ “
plains.		“ “ “ “
Resaca	654	“ “ “ “
Tilton	665	“ “ “ “
Dalton	775	“ “ “ “
Tunnel Hill	853	“ “ “ “
Ringgold	785	“ “ “ “
Gordon Spring	965	“ “ “ “
Villanow	914	“ “ “ “
Holland	783	Along Central Railroad.
Summerville	780	“ “ “
Lafayette	871	“ “ “
Chickamauga	750	“ “ “
Cassandra	982	In McLamore's Cove.
Rising Fawn	797	Along Alabama Great Southern R'y.
Trenton	739	“ “ “ “ “
Wildwood	742	“ “ “ “ “
Cole City	1354	On Sand Mountain.
Round Mountain Station	1810	On Lookout Mountain.

* Corrected from Gannett's Dictionary of Altitudes, and Mr. McCutchins' Report to Hon. J. T. Henderson.

CHAPTER X.

LOCAL GEOLOGY OF POLK COUNTY.

CONTENTS.

CHILHOWIE AND OOSTANAULA SERIES.

Only a very small area in the northwestern corner of Polk county is occupied by Cambrian rocks; and this is very much broken by great faults.

The valley in which the East Tennessee, Virginia and Georgia Railway is constructed, between Tecumseh and Cave Spring, is mostly excavated out of Oostanaula shales. Parallel with the railway, and close upon its eastern side, the shales are sharply bounded with the decayed rocks in the ridges of Knox dolomite. The characteristic rocks are blue shales dipping about 20° in direction S. 40° E. But at the surface they are drab or variegated, and broken up into fine shingle owing to their decay and disintegration. The calcareous matter is removed from the shales, and out of them, the valley is mostly formed. Below the depth of disintegration the shales show semi-metamorphic texture and form slates. Upon the western side of the valley the shales rise in subordinate ridges, often covered with thin soil.

Beyond these subordinate ridges, Indian mountain rises to 1,100 feet above the valley. In the lower portion, thick beds of quartzitic sandstone occur intercalated with shales, similar to those described. Higher up, the crest of the mountain is covered by great massive quartzites, or crystalline sandstones. These beds dip at from 40° to 50° towards S. 30° E. Between the mountain mass and the valley shales, a great fault is situated, with the probable remains of a fold, in which the Oostanaula series appears on one side; and the Chilhowie, or Lower Cambrian, on the other, in the form of the local lenticular mountain mass, like rocks referred to the Weisner quartzites of Alabama.

From the Alabama line, for some three miles, the fault brings into contact only different beds of the Oostanaula series, but farther north, the Indian mountain fault brings the Knox dolomite against a wedge of the Cambrian deposits just described. The importance of the faults is most strongly marked in connection with the next formation—the Knox dolomite. The thickness of the shales, exclusive of the mountain mass, may be placed at 2,000 feet; and of the mountain quartzite series, probably at 2,000 feet more.

Economically, the quartzites are of value. Some of the iron ores in the eastern side of the valley appear to rest upon the shales, but probably belong to the overlying series. Below the depth of surface-rock decay, some of the slates on the western side of the Etna valley may prove of value.

The agricultural features of these Cambrian deposits are varied. Indian mountain is rough and broken. The valley of Etna and northward present choice farms. On the ridges, calcareous matter is leached out, and the soil is thin. But this area of Cambrian shales is small, and does not form a type of the series as seen elsewhere.

THE KNOX DOLOMITE SERIES.

This is the most important series in the belt of country surveyed. As will be seen by the map, it covers a large area.

Its features are however variable. It is the formation in which the great deposits of brown iron ores, beauxite, manganese, white clay, some building stones and lime, occur, and on which many of the best farms are located. Accessible at the surface, there are but few deposits of limestone in the county. The lower beds are the more calcareous, and give rise to the most valuable brown ore deposits, and best valley lands,—most commonly red. The upper beds contain the greater quantity of siliceous matter and originate the gray ridges covered with cherty gravel. The dip of the rock is often difficult of determination, as their decayed remains do not generally show stratification. Still, in some artificial cuts, laminations are exposed. (See plate II.)

The less disturbed portions of the Knox dolomite begin with the fault, just east of the Tennessee, Virginia and Georgia Railway, where ridges rise 200 or 300 feet above the valley. The western side of this chain of ridges is marked by subordinate rounded ridges, covered with red residual soil, and often rich brown ore deposits, which are described in the Economic Report. At this fault line the Knox dolomite beds have been dislocated by compound faulting, which has caused the beds to move upon others of the same formation, near "Hematite" siding, but upon both sides wedges of the Oostanaula series have been left. The general effect has been to leave a basin of Knox dolomite, in part ore bearing, to the westward and northwestward of the shales, and to bring up the quartzites of Indian mountain in topographically a high position. The fault-producing movements have come from different directions, and made a remarkable deformation of structure.

On the State line some artificial cuts in iron mines reach a depth of 60 or 70 feet, with the original rock decayed, and leaving only residual clay, etc., with iron ore. Some of these ferruginated masses occur in beds four or five feet thick, dipping as much as 40° both to the northeast and northwest, showing great disturbances and breaking up of the strata, not merely as if by dislocation, but if as in part by the strata falling into caverns on the removal of the calcareous matter from the original limestone.

In a railway cut at Oredell, the decayed strata, showing great disturbance, consists of white clay or other rock débris at each end of the section, with intermediate deposits of confused strata, some holding iron ore. The chert is now scattered through the mass in a manner almost as heterogeneous as northern drift. These beds dip at variable angles and in direction about north 15° west. Near by the ore accumulations rest beneath a white clay 10 to 15 feet thick. On adjacent ridges there are cherty beds more or less ferruginous. On some of the subordinate ridges all structure is lost, and only accumulations of residual clays and ore deposits are found. Whilst the more cherty rock comes to the surface in many of the ridges, yet the valley is deeply underlaid by decayed rock, which is ore-bearing, in an artesian well, to a depth of 180 feet.

The Knox basin west of Hematite siding is marked by ridges and valleys. Some of these ridges are characterized by heavy beds of ferruginous cherty rock, and, in some cuts, show remains of stratification. The valleys, which are fertile between the cherty ridges, form the subordinate part of this belt of country.

Northwest of Cedartown, the basin of Cedar creek and its tributaries form a rolling country with red fertile soil, but away from it, in the northwestern corner of the county, the ridges are of cherty gray soil. The cherty limestones on the border of Floyd county, south of Cave Spring, dip at only 10° to the east. Some of the ridges contain iron ore and manganese. Near Cave Spring, the subordinate ridges in the valleys are ore-bearing.

On the road from Cedartown to the crossing of Cedar creek, the red clays predominate. But beyond this point, in crossing the ridges, gray lands occur.

West of Cedartown, for three miles, on the road to Pryor, the red rolling lands predominate. Near this point, a ledge (three feet) of cherty rock occurs. Beyond no bed rock is seen. The red ridges and ore lands in Etna valley are noted elsewhere.

The same road crosses ore bearing ridges before reaching the grayer land. In the large ore workings in this vicinity, occasional glimpses of the structure have been exposed. In one place, a ledge of the ferruginous rock was seen passing under white clay (Peek's Bank) on the hillside; near by is a bluff of ferruginous siliceous rock, much jointed with seams resembling stratification; apparently the dip is 45° E. S. E.

The country between the limestones (Ordovician) extending southwestward from Cedartown and the State line, near Esom Hill, is underlaid mostly by the Knox series, similar to the country to the west of Cedartown, but with few of the more crested and cherty ridges, and with many red lands and ore beds.

Between Cedartown and the Fish creek region, near Grady, the Knox dolomite mostly forms a high rolling gray or cherty country. But its western side, adjoining the valley of Cedar creek is characteristically red soil, with subordinate ridges of iron ores, containing more or less white clays (see cut illustrating clay "horses"). The position of the strata may be seen west of Young's Mills, where some masses of ferruginous rock occur with bedded structure, dipping eastward at high angles.

In the northern central part of the country, along the waters of the north branch of Cedar creek, and mostly between Grady and Seney, there is a broad area of red lands with some ore deposits.

From west of Grady to half a mile east of Fish creek (P. O.) the red land prevails in the valley of Fish creek, and along the junction of the Knox dolomite beds and the succeeding limestones. Between Fish creek and Rockmart, the country is composed of rolling, low cherty ridges. All of these belts trend northeastward.

Across the northern part of the county the Knox dolomite has an unbroken width of over sixteen miles with expansions reaching more than twenty miles. The rocks, where indicating the dip, are always at considerable angles, which would represent an inconceivable development, were the apparent thickness not reduced by undulations, folds or faults. As the rocks are so seldom exposed, showing the position of the beds, the occurrence of the undulation might be doubted. But as some indications are found in the decayed rocks and in the overlying Maclurea limestones and Rockmart slates, the evidence is conclusive that these are not merely undulations, but folds with occasional overthrows more or less affecting the underlying strata. Again, the occurrence of the lower beds of the Knox series is seen in the decayed red soils and ore beds, in some half dozen principal parallel belts which are more or less characterized as valleys separated by subordinate ridges.

The relation of the valleys to the rocks, has, in a large measure, been decided by the greater solubility of the calcareous beds of the inferior portion of the formation, and the protection rendered to the higher beds by thin mantles of residual chert. Thus it is that—during the long erosion, which has left from 100 to 200 feet of residual clay derived from the decay of 1,000 or 2,000 feet of the impure limestones—the valleys, subordinate ridges (often also resulting from protection of iron ores) and red lands are characteristic of the lower portion of the Knox dolomite series, which is repeatedly brought to the surface by undulation of the strata. Some of the crested ridges are probably in part, at least, due to folds and overthrows and in some cases to minor faults.

The residual Knox clays do not retain water, and wells are only obtained at the considerable depths of commonly from 60 to 100 feet.

Some characteristics of the Knox dolomite are better developed in other countries, and the occurrence of the ores are given in the Economic Report.

CHICKAMAUGA SERIES.

MACLUREA LIMESTONES.

About Cedartown and resting in a basin of the Knox series, there occurs the Maclurea limestone, which is often somewhat impure, especially in lower beds. The limestones are found in beds with somewhat indistinct stratification, and again, in thin but compact beds. The rocks in this county are somewhat metamorphic limestone. These weather into rounded surfaces and are valley making. Consequently they are usually closely related to the valleys of the Knox dolomite series. But the exposed belts are mostly narrow. The soil is usually more or less heavy red clay. This formation occurs about Cedartown and is well exposed along the streams. It is also cavernous and often gives rise to large springs (as at Cedartown).

Bordering the slates of Fish creek region, the limestones come to the surface and are best shown along the various creeks.

In the Rockmart district the series, underlying beautiful valley lands, forms an extensive wing to the northwest of the slates.

The rocks frequently lie at low angles; at Blue Springs, Cedartown, the dip is 5° to 10° in direction N. 20° W. About a mile to the south, at Tanyard Branch, there is an anticlinal where the rocks dip upon their eastern side 10° or less, in direction S. 70° to 80° E., whilst upon the western side they dip 45° decreasing, to 15° in direction N. 80° W. At a mill about two miles south of the town the rocks dip 70° S. 80° E. These dips correlated with others in the succeeding shales indicating folding, which will be noted in the paragraph on Rockmart slates.

About Rockmart, the limestones are commonly at comparatively low angles. In the railway cut east of Devitte lime quarry the limestones dip at about 20° S. 40° to 50° E., and lie unconformably beneath slate hills.

The Maclurea limestones and their analyses are noted in connection with their Economic phase.

DEATON ORE BEDS.

These rocks seem to be identical with Safford's Iron-limestone series. They are only known at interrupted points for several miles northeast of Rockmart. They are thin bedded, ferruginous limestones. In some places the rock is so decayed as to leave only laminations of ocherous earth, or this again is charged with more or less shingle of iron ore. Other beds are compact, dark gray limestone. At the Deaton mine, the beds formed the roof of a cavern excavated in Maclurea limestones. (See plate I., frontispiece.) At the pit of Central Mining Company, four miles northeast of Rockmart, the represented ore series is on a small anticlinal, resting over Maclurea limestone which trends northeastward.

ROCKMART SLATE.

These rocks are semi-metamorphic slates and overlie the Maclurea limestone, occupying three basins, upper part of Cedar creek, Fish creek and Rockmart district. In the Cedar creek basin, the surface rocks are everywhere decayed; when not discolored in decaying the slates are blue; but usually the weathered shingle is drab or sometimes red.

The shales commonly lie at comparatively low angles in the Cedar creek basin.

However, at the C. R. & C. Railway station, in Cedartown, they dip 85° in direction S. 80° E., whilst 30 feet beyond (eastward) the dip is only 45° to 50°. Combining this structure with the dip noted in the Maclurea limestones, we find that there is a fold and local overthrow passing along a line just east of Cedartown, with the axis about S. 10° W.

Owing to this folding, the underlying Knox dolomite is brought up to the surface in two or three subordinate ridges south of Cedartown.

Whilst the strata are seen to dip nearly eastward, yet the eastern border of the basin is defined by the Knox dolomite, owing to the undulations and foldings of the rocks; to which are evidently due the metamorphism that has hardened the shales and somewhat crystallized the limestones.

The southern border of the Rockmart slates is defined by the

Cartersville fault, beyond which Dug Down mountain is composed of hydromica schists.

In this basin, the slates are more or less valley making, but underlie some chert (Lower Carboniferous) deposits. The characters of the Fish creek basin are similar to those of the Cedar creek slaty basin. They extend around to that of Rockmart. At Hightower Mills, the hydromica schists of Dug Down mountain abut against the slates, and dip 45° S. 80° E., the trend of the fault not being that of the strike of the rock beds.

Five or six miles to the eastward, at Simpson's Mills, the Rockmart slates are at very high angles, whilst the overlying hydromica schists of Dug Down mountain overlie the former (owing to the Cartersville fault) at only from 20° to 25°, in direction S. 30° to 50° E.

The Rockmart series, in the Rockmart district, form bold ridges, some of which are covered with cherty deposits (Lower Carboniferous).

In the slate quarries, at Rockmart, the beds are more or less jointed, but dip at 45°, and more southeastward. In the railway cut, east of Devitte's lime kiln, the slates dip 25°-30° in direction S. 50° E.

In some places, the decay does not reach more than a few feet into the slates. In weathering, the surface sometimes becomes bluish, but generally yellowish gray, or more rarely yellowish brown, being covered at several points; the lower slates weather into a thin soil, and into the banded and indurated clay known locally as "Caen stone," susceptible of being turned and polished (see Economic Report).

In the Rockmart district, the slate ridges form a rough country, but to some extent the rolling valleys are a slate formation.

Conglomerates occur at about two miles south of Rockmart, in a ridge on the road to Simpson's Mills. They consist of irregular masses of slate and quartz, cemented into hard rocks, reaching nearly 200 feet in thickness, and dipping 60° or 70° S. 40° E. The rocks are underlaid and succeeded by the slates. At this point the disturbances have been great. These constitute a lower member of the Chickamauga series.

The slates are elsewhere considered in their economic bearing.

RED MOUNTAIN SERIES.

Overlying the Rockmart slates, at a point four miles southeast of Esom Hill, near the foot of Dug Down mountain, there occur thick beds of massive quartzitic sandstones, covering only a small area. These may be referred provisionally to the Red Mountain series. Similar sandstones in some of the ridges beneath the Sub-Carboniferous chert belong to this horizon.

LOWER OR SUB-CARBONIFEROUS SERIES.

Overlying the slates of the Rockmart series, there are several ridges covered with blocks and fragments of chert south of Cedartown, between Young's and Esom Hill. Again, the cherts on the ridges in the Rockmart district belong to the same horizon, and may be referred to the Fort Payne chert. In places, the chert forms a bed of sandstone, which is ferruginous in part (as on Mr. West's farm); and also near Rockmart. The preservation of the ridges, as also those of the Rockmart district, are due to the protection given by the flinty beds and cherty gravels.

MODERN DEPOSITS.

"Except the continued action of the weathering of the older rocks, the creeping down the hillsides of decomposed material, and the occasional deposits in swampy ground (which are rare), no modern formations can be considered as occurring in the country, for the streams are not flowing through such lands as would permit of bottom formations; still there are a few places where streams overflow the basins through which they pass."

CHAPTER XI.

LOCAL GEOLOGY OF FLOYD COUNTY.

CONTENTS.

OOSTANAULA SERIES IN COOSA VALLEY WEST OF THE OOSTANAULA FAULT.

The rocks of this formation are mostly reddish, greenish or variegated, calcareous shales, forming gray or brownish soil or reddish farther north. However, there are thin beds of earthy and siliceous limestones, and in the upper portion, the limestones are more massive, and veined with white calcites.

On the Georgia and Alabama line, this series covers a country about ten miles wide. It dwindles down to a narrow belt at Rome. But northeastward it broadens out into a belt one or two miles wide. On the southeastward side, the outline is somewhat regular as is marked by the topographic features in the more sandy ridges (Knox or Rome sandstone), or lowest portion of the Cambrian system exposed. Owing to the remarkable faulting on the northwestern side, there are two marked troughs nearly surrounded by the Lower Carboniferous series.

This belt occupies a comparatively level region, from 120 to 150 feet above the river, and forms the "flatwoods" country. Some points rise higher and the hills are capped in some places by cherty gravel (remains of overlying patches of Knox cherts). North of Rome, ridges are more characteristic of this belt than south of that point. But, as a whole, the country presents no very prominent features. The soil has lost most of its calcareous matter and is often poor, but again, it appears of fair value.

The most notable limestones form a surface of about 200 feet in width, and is situated at a short distance from hills along the Oostanaula fault. These limestones are dark colored and earthy, but mottled with numerous veins of white calcite. This limestone forms a characteristic bed. About half a mile northeast of Thomas' Mills, it dips 45° S. 40° to 50° E. At a roadside quarry, about half a mile southwest of Thomas' (on Kirk's Groove road) the bed dips 25° N., 20° E., and just beyond the dip is again S. E.

Again, one mile west of Cunningham station, it is a notable feature. About three mile southwest of Rome, a bluff of the mottled earthy limestone rises 30 or 40 feet above the river. The limestones also occur in the northeastern corner of the county.

The shales dip at variable angles. Near the Alabama line (one mile north of Lumpkin's store) the shales dip 50° S. 20° E., whilst at a point near the line, but two miles from the border of the series, there is a narrow belt of shaly limestone dipping 75° S. 10° E. These variations, as well as many foldings, seen in overlying horizons from Rome to Cave Spring, show very great disturbances and numerous foldings. Southeast of Livingston there is a belt of shaly limestones which are somewhat fossiliferous.

Upon approaching Livingston, the soil changes from a residual deposit to a recent series—probably the Lafayette series—which will be noted later.

North of the Coosa river the faulted character of the northern border of the series is striking. One long, narrow tongue, forming an anticlinal belt of shale, has been carried westward of the great overthrust fault and there preserved, whilst similar strata, once lodged upon Horseleg mountains, have been removed by denudation.

OOSTANAULA SERIES EASTWARD OF THE FAULT.

The ridges of hills which bound the southeastern side of the "flatwood" belong to the lower division of the Oostanaula series, and have been called Knox or Rome sandstone. Still the shales, often calcareous, predominate in this lower member. The sandstones form thin beds amongst the shales and are very rarely in thick layers. The sandstones are more or less earthy, and when the thin beds are broken up angular or subcubical fragments result and then lie scattered over the often yellowish soil. One of the best sections seen is where Big Cedar creek cuts across the formation, some three or four miles northeast of Cave Spring, near Connor's Mills. On the stream just named the earthy sandstones are shown, and dip 30° S. 60° E., resting on dark shale. In a ravine, near by is "Slide Rock" at the same dip. It is a quartzitic bedded sandstone with a drab colored surface, but bluish in the interior. This is the most massive bed of sandstone seen, being two feet thick. It is succeeded by other but more earthy and thinner sandstones. This slide rock has its surface highly polished, as if glaciated; but the smoothed surface passes beneath other rock and is a case of slickensides, due to internal movements of the rocks. Just beyond, near the ford of the creek, on road to Thomas' Mills, the sandstone members are exposed.

In the vicinity of Rome, the different members of the Oostanaula series are very much disturbed and broken by faults, many of which are seen in sections where road cuttings, etc., have been made. In the northern suburb, there is much dark shale amongst the sandstone. The shales dip 45° S. 60° E. northeastward, the crested ridges are interrupted, and are usually of no great height. The soil is often of yellowish color, or, again, reddish. These sandstone members of the series do not cover more than from half of one to two miles in width (except locally), and are known where best developed by their ridges being covered with angular blocks of sandstone, and are confined to the zone west of the shale-formed valleys, through which the East Tennessee, Virginia and Georgia Railway extends. The ridges often dwindle to insignificant features.

The variegated calcareous shales of the higher members of the Oostanaula series are characterized by zones of impure bedded limestones, often in thin layers with earthy partings. Its topographic feature is valley making, covering a belt from one to two and a half miles (in the northeastern part of the county) wide, and giving rise to fine farming lands. But the shales themselves may form subordinate ridges. Owing to faulting, a spur extends into Polk county; but the valley passing northward to Cave Spring continues northward under the name "Van's" valley and extends to Rome.

At Cave Spring the series is folded and dislocated, as seen in a section on the hills west of the town as shown in figure 9, p. 20.

Some of the shales are siliceous, of dark color and indurated. Disturbances almost equal to those of the "flatwoods" are shown in the shales on the ridge between Cave Spring and Thomas' Mills.

In many places the limestones appear in the valleys. Thus, at Connor's Mills, and Little Cedar creek, about three miles northeast of Cave Spring, thin bedded limestones (some two feet thick) are developed in the shales to a thickness of about 50 feet. Here the dip is 30° S. 30° E. At various places in Van's valley, limestones are exposed along the branches. Just west of Cunningham station, in the valley, borings have been made, and these limestones with a dark brown color were found to be more than 90 feet thick. They dip at low angles of less than 10° towards the southeast. About a mile and a half northeast of Cunningham, about 25 feet of these same limestones are again exposed in a railway cut, dipping at low angles.

Just south of Rome the shale series present more hilly characteristics and are particularly disturbed and dip at various angles up from 40° to 60°, and in variable directions approaching S. 60° E. In several road cuts the beds are much faulted by small throws in different directions. At this place, in some brown shales, there is a fault hading 20° to southward, whilst the beds dip at about 40°. A quarter of a mile farther south (at end of a hill) there is another fault hading 60° to northwest. These differences show complex movements and distortion. At a quarry just south of Rome, along roadside the disturbed shales dip 50° to 60° S. 60° E.

Along the Etowah river, just above Rome the disturbances of the strata are well shown. At the waterworks heavy limestone beds were struck at thirty feet. This is in part a flinty limestone and in part a compact dolomite rock, resembling some beds of the Knox dolomite, but in position near the junction of the calcareous and the siliceous beds of the shale series. The rock is much fissured by subterranean drainage. Fossils are not preserved, but the lithological character suggests a fault or overthrow, bringing Knox dolomite into the horizon of the well without its appearance at the surface. The thickness of the rock is more than 60 feet. Just above the waterworks, sections of the shales and limestones are shown. Impure limestones, in beds from one-half to two feet thick, occur in the mottled shales, some of which have the appearance of hydromica. These dip 30° S. 65° E. Some of these limestones are dark blue, fine grained, of crystalline texture, having a thickness of 100 feet or more. A few hundred feet higher up the river, where E. T., V. & G. Railway crosses the Rome Railway, there is a fold and overthrow, the axis of which trends N. 30° E. The rocks are very much crushed but where not too much distorted show vertical jointing in direction S. 65° E. and N. 45° E. There is not only folding but also faulting.

Owing to the great disturbances and dislocations the true structure about Rome is somewhat difficult to recognize. A spur of the upper part of the series runs from Rome up the valley of Silver creek, and at several points the limestone beds are seen. Amongst the Knox ridges between Silver creek and Cunningham, there are several spurs of the shale series. Northeastward from Rome the shale bearing valley widens out somewhat and forms an excellent agricultural district. Wherever the streams cut across the shales the included limestones appear in their valleys.

References to the economic phases and the soils are made elsewhere in this report.

KNOX DOLOMITE SERIES.

West of Cave Spring there is a narrow basin of this series, brought into position by faults already referred to in Polk county. Otherwise the series covers only the county southeast of the valley already described, or most of the country southeast of the East Tennessee, Virginia and Georgia Railway (Alabama branch).

South of the Etowah river, the western part of the Knox dolomite country is characterized by ridges of the gray cherty lands, with red, loamy intervening valleys. The broadest of the Knox valleys are those of Silver creek and Spring creek, and outside of them the country is rather broken. Between these streams there is a belt of the red Knox lands, as also east of the latter creek. However, all the ridges are not of gray cherty land but most of those of the more abrupt configuration. In many of the valleys there are subordinate ridges of brown ore. In some of the less abrupt ridges and gray land country there are beauxite beds.

In various regions, especially in the vicinity of Cave Spring, manganese ores occur. In many localities, on the ridge and along some of the streams, the dolomite or magnesian rock is exposed in an undecayed condition showing the character of the formation. From the economic standpoint these characters are noted elewhere. The dolomite, as shown in the ridge east of Cave Spring, is a dark colored, more or less earthy, siliceous rock weathering to a lighter shade. It is massive, often with indistinct bedding. The dip is 30° S. 70° E. In this ridge there is one of the largest caves in Floyd county and through it a large stream flows, whence the name of the town, Cave Spring.

Overlying the Cambrian shales already described, the lower beds of limestones are well exposed about a mile east of Cunningham station, in a ridge rising over 400 feet in height. For nearly 300 feet of this elevation, the rock is seen, but the upper part of the ridge is covered with a mantle of stony soil and cherty gravel, but fertile soil. The limestones are dolomitic, somewhat earthy, and of dark color, but mottled with white calcite. The bedding is massive, and dips 10° southeastward.

A mile and a half east of the last, and at the northern end of the next ridge, on the land of Mr. Gibbons, there is a rock similar to the last mentioned, but of darker color forming a bold outcrop. It is peculiar in containing more or less angular fragments of breccia of impure dolomite, derived from older masses. But the whole is consolidated. These rocks have been quarried to some extent for a dark marble, noticed elsewhere (Egyptian quarry).

On the spur of Armstrong mountain, near Hermitage (Ridge Valley), the mountain rests upon Cambrian shales, and above them, 200 feet or more of the limestones are seen. The beds vary from one to eight feet thick, dipping less than 10° S. 60° E. Locally, some beds dip southwest (probably the results of a lime sink). Some of the lower beds are dark limestones, with crystalline facets; others are mottled with clayey matter. The upper rocks are of compact dolomite of light color. This chain of ridges continues through the northeastern corner of the county, and east of Nannie dips at 20° S. 60° E.

All of these deposits are from beds belonging to near the base of the Knox series, or perhaps some of the beds may be of Cambrian age, as in Tennessee, although lithologically connected with the Ordovician system. But so far, fossils have not settled the horizon.

On various ridges, the undecayed rocks occur near the surface, and also in the side of the valleys, as for instance, the thin bedded magnesian limestones along the streams on the Rome road, from Rounsaville, about four miles from the former place. The siliceous beds of the Knox dolomites are also often seen, and sometimes these are ferruginous, as for example, just east of New Prospect church, about six miles northward from Cave Spring. Other siliceous limestones decaying into gray soil, occur near the manganese deposits of Major J. M. Couper on border of Polk county, and of Mr. Stokes, also on border of county, near C. R. & C. Ry. In Bartow county, however, some characteristics are better exposed than in Floyd county, and will be noticed hereafter, and in that county will be found the description of the section shown at Dike's creek in Floyd county.

The Knox dolomite is usually decayed to a great depth, except on the higher ridges, the product being various forms of calcareous clayey land, and on the ridges often a cherty arenaceous soil. As the result of decomposition, great deposits of white kaolin of various degrees of purity are often seen. These beds contain much undecomposed feldspar, are commonly more or less associated with the iron ore, and were probably deposited in lenticular masses. Sometimes they arise from the cherty dolomites, in which case the white clays are charged with cherty fragments, as at Cave Spring.

West of the E. T., V. & G. Ry. (Atlanta division), the country consists of narrow ridges and valleys, and many beds of brown ore, manganese and also beauxite occur. In the southeastern corner of the county, the valleys are broader, with frequently the red soils and iron ore beds. The same remarks are true for the Knox formation of the county north of the Etowah river.

The greater dislocation and repetition of the ridges of the Knox series occur adjacent on the northwestern border of the formation, and consequently the greatest change of features and resources—given in detail elsewhere.

RED MOUNTAIN SERIES.

Southwest of Rome, the Red Mountain series occurs on part of Horseleg mountain, forming a sharp ridge, capped with heavy sandstones. This ridge is a remnant of an anticlinal elevation, with the sandstones preserved in places, so as to make the surface appear like a monoclinal ridge. Another small outlying ridge occurs farther west—Judy mountain. When disintegrated, the sandstones produce cubical or rectangular blocks, which become scattered over the surface of the ground.

Lavender mountain (with the highest point 1,683 feet above tide) is a spur composed of the Red Mountain series. The southern end of the ridge is badly dislocated and folded. In the cut of the Central Railway, the average dip of the shales is 25° S. 60° E. for the eastern portion; proceeding northwestward, the dip increases to 45°, beyond which the shales dip 60° to the northwest; but at a short distance, west of a ravine, the beds again dip southeastward at 30°. In part, the beds are much jointed with fracture seams trending S. 80° E., and dip 60° to 70°. In part, the rocks are heavy bedded shales, often calcareous, but weather to red, sandy shales. There are some flags of red sandstone from six to twelve inches thick, intercalated with shales. Some heavy bedded quartzitic sandstones also occur in the series. The whole formation is from 800 to 1,200 feet thick.

Near the northern end of the ridge, the strata, upon the eastern side, dips 20° S. 60° E. But in the mountain, the dip increases to 60° in the same direction. Upon the western flank of the ridge, the Fort Payne chert occurs. This indicates the anticlinal character of the mountain, but with the axis west of the summit, thus producing the superficial appearance of a monoclinal ridge. The rocks are shales, shaly sandstones, and some sandstones in beds two feet thick.

John's mountain and a spur of Taylor's ridge form the boundary of the county, but they will be considered in the geology of Chattooga county.

SUB-CARBONIFEROUS.

FORT PAYNE CHERT.

At the surface, the Fort Payne chert is characterized by cherty soil. This is shown upon the flanks of the ridges bounding Texas valley; also upon the west side of, and at the northern end of Horseleg mountain, and upon the southern end of Horn's mountain. In a few sections only are the cherty limestones exposed, as in Horn's mountain and on flanks of Lavender mountain, in belts too narrow to be shown upon the map.

FLOYD SHALE.

The series (named by Hayes) is best developed in this county, and in position lies above the Fort Payne cherts, and below the Mountain Limestones, which only occur beneath Rocky mountain. The rocks are composed of yellow, brown and black shales, often in heavy beds, calcareous shales and shaly limestones, and occasional beds of pure limestone. Some of the limestones and calcareous beds are very fossiliferous, as west of Rome, near the lime kiln, and at other places.

Near Rome, the rock is a dark blue shaly limestone, in thick beds, and dips at 10° S. 60° E.; whilst elsewhere, the dip is 20° to 30°. But in crossing the formation, the variation of the dip, sometimes S. E., and again N. W., shows great foldings and probably faultings, so that the true thickness of the formation cannot be estimated with any degree of accuracy.

This formation gives rise to a portion of the "flatwoods," with yellowish and dark grayish soils. Some sandstones occur as local features in the series, and give rise to low ridges in Texas and Dirt Town valleys.

COAL MEASURES.

A remnant of the lower portion of the Coal Measures occurs on an outlying ridge in Floyd county, called Rocky mountain. Its greatest geological interest is its position of fifteen miles east of the most eastern plateau of the Coal Measures. It is an index to the great amount of erosion, which has removed the Coal Measures from Georgia. (See question of erosion under Chattooga county.)

Rocky mountain is represented by eighty feet of massive sandstones and conglomerate rising in vertical walls, especially upon the western side of the ridge. Below the sandstones, the underlying strata are concealed for 250 or 300 feet, but they are probably composed of shales. The sandstones dip 20° S. 60° E.

LAFAYETTE (?) SERIES, AND MODERN DEPOSITS.

The loams and gravels above the greater streams in this belt of Georgia are provisionally correlated with the Lafayette formation of southern Georgia. Objections to the introduction of endless local names led to the use of this nomenclature, as their valley deposits probably belong in that series.

These deposits are extensive, and occur even as far as a mile or two back (rarely three miles) from the greater streams, and reach elevations no higher than in keeping with a depression, when the oceanic level of the waters allowed the accumulations of the Lafayette terrain as far north as Columbus, with probable embayments northward. From the typical Lafayette series in that latitude, there is no farther difference in the character of these deposits in Floyd county, than between shore accumulations and those formed in extensive bays or channels from two to four miles in width, such as existed along the lower part of the valley, when southern Georgia was 700 or 800 feet below the present altitude, which brought the sea far inland.

These Lafayette accumulations are usually red clayey loams, and coarse, well water worn gravel, up to four or even six inches long. It is mostly quartz, but occasionally with some local Paleozoic calcareous and fossiliferous stones. The deposits seldom reach a thickness of twenty feet, but commonly eight or ten, of which the gravel may be from two to five feet thick, or again wanting. The gravel underlies and to some extent graduates into the loam. A few places may be taken as typical representatives.

Livingston is on a plain about a mile from the river, with the sandy soil derived from the Lafayette deposits. Underneath, the gravel rises to 100 feet above the river terrace, which is about 20 feet above the ordinary water-line.

On the north side of the Coosa river, near Coosaville, these gravels rise 140 feet above the river, or about 780 feet above tide.

On the hills about Rome, the same deposits occur up to from 140 to 150 feet above the river, or about 790 feet above tide.

West of Nannie, and opposite the foot of Turkey mountain, the gravels rise again to 140 feet above the river (the Oostanaula), or something less than 800 feet above the sea.

There are frequent remains of terraces at 100 feet above the rivers, but these are imperfectly preserved. The principal terrace, often half a mile or more wide, is commonly between twenty and thirty feet above ordinary water, and is liable to floods.

Whilst the measurements are only aneroid, yet from the large number of observations, it may be said that the Lafayette deposits rose to the height of 140 feet above the rivers in Floyd county, and are now principally found, not in the valleys but on the hills; for since their accumulation enormous erosion has broken their continuity, and there remain only fragments of the former great sheet, as it has been mostly swept away, by denudation, just the same as has the Lafayette series in parts of southern Georgia.

Agriculturally, these deposits give rise to variety in the distribution of the soils. The Lafayette soils are often liable to be mistaken for red Knox dolomite soils.

CHAPTER XII.

LOCAL GEOLOGY OF BARTOW COUNTY.

CONTENTS.

OOSTANAULA SERIES.

Exposed along Tom creek, about Woodlands, the valley through this broken country shows a narrow belt of these shales, forming an anticlinal basin, in which the limestone members are seen. Upon its western side the limestones dip 40° N. 60° W.; upon its eastern side the shales dip at variable angles, S. 70° W.

At Kingston there is a small area of the shales. Northward a narrow belt of the series a few hundred yards wide extends to Cement. This is an anticlinal where the western strata dip 10° N. 70° W. In passing from the Connesenna valley, the belt broadens in the valley of Oothcalooga creek to a width of about three miles in region of Adairsville.

At the southern end of the basin, the limestones (forming hydraulic rock at Cement) form a prominent low ridge. (See plate XI. in Economic part of report.)

The rocks are more or less impure limestones, with earth seamings, so that they may weather into thin banded laminations, which are commonly characteristic of some of the beds of the limestones of this series. The series at Cement is exposed in the workings, so that measurements can be made. The section in descending shows:

Blue limestone	8	feet
Slaty limestone (cement rock)	4	"
Blue limestone	6	"
Argillaceous earthy limestone	2	"
Siliceous limestone (hydraulic rock)	4	"
Siliceous limestone (cement rock)	7	"
Fine black limestone	12	"
Earthy limestone	3	"
Shale	——	

The analysis of the cement rock is given in the Economic Report.

It is highly siliceous limestone, with alumina and iron. Some of the beds are composed of limestone with interlacing seams of earthy matter, giving a peculiar netted appearance, which is often characteristic of the limestones of the series.

At many points in this belt of Cambrian deposits, the limestones reappear and form a ridge or little escarpment like that at Cement and east of Adairsville. This valley in the Oostanaula series forms a very fertile belt.

The rocks dip at low angles, and form an anticlinal valley belt, in which there are caverns and lime sinks.

Southwest of Cartersville a tongue of the shale series has been brought to the surface by undulations of the strata. In places it contains limestone beds. Along the branch a mile westward of the town, the shale is indurated to a hard semi-metamorphic slate of dark color. Along the road to Ladd's mountain the decayed shales are sometimes blue: but the weathered shales are generally reddish, although of lighter color than the soils resulting from the Knox dolomite. Along the road just mentioned, about a mile from Cartersville, the beds dip to south of west; half a mile beyond, undulations of the strata are seen in the beds, which immediately underlie the residual Knox dolomite clays. Here they contain thin calcareous beds.

FIGURE 18.—Junction of Oostanaula shale and overlying residual Knox dolomite earths.

In the section (figure 18) decayed Knox dolomite succeeds an anticlinal of Oostanaula shale.

To the east of this exposure the clays are mottled red and bluish, and in composition are like the non-calcareous metamorphic schists of the neighboring mountains. (See Economic Report upon the clays.)

Along the Tennessee road, shales frequently occur, and about three miles north of Cartersville (at Dr. Felton's) an impure limestone (forming a light colored impure marble) is seen along a branch (on east side of road) dipping southeastward. Although the rock is metamorphosed and crystalline it belongs to the shale series.

Along Petty's creek, about four miles from Cartersville, the limestones of the shale series are exposed, and dip 70° S. 80° E. The valley along this creek is undulating and fertile. At the low divide between it and Sallacoa creek, the country is somewhat more broken. Here a dome resembling a northern drumlin in outline (about 60 feet high and 400 feet in diameter) is seen. Beyond, the softened features are renewed, and at Boliver (crossing of Pine Log creek) the limestones appear at the surface, and are penetrated with caverns, out of which large springs flow. The rocks of the overlying metamorphic series are decayed, and the hydromica schists often weather to a bluish color, and sometimes occur in the edge of the valley.

Just beyond the county line, at Erwin, the limestones lie beneath metamorphic schists, which have been forced over them.

At Roger's (old) furnace the limestone occurs in the valley, and near by is brown ore apparently resting upon it.

At Cassville the shales have more or less calcareous seams; in some cases they are indurated and resemble hydromica slates and Knox dolomite.

Most of Cedar creek and its branches flow through the shale country; and the limestones of the series are commonly exposed by the streams, showing the dip at from 10° to 15° S. 60° W. on Cedar creek and its branches.

Along little Pine Log creek and other branches the limestones rise through the shales. In this Cambrian series, in northeast Bartow, the shales rise into flattened ridges covered with indifferent land. But adjacent to the streams, and on the lower grounds, the agricultural features greatly improve. The calcareous shale formation, especially along its borders, is characterized by extensive fertile valleys.

One or two small outlying patches of the shales rise through the overlying dolomite, as for example, three miles southwest of Cass station.

KNOX DOLOMITE SERIES.

The characters of the middle and upper beds of the Knox dolomite are somewhat better shown in Bartow county than in Polk and Floyd counties.

Along the Rome railway, the ends of several spurs have been cut into. The characteristics seen here extend into Floyd county, but the sections along the railway are here noticed as a unit.

From Dyke's creek, to east of Wooley's ferry (three miles west of Kingston), there are several sections from which the following observations were obtained: Just east of Dyke's creek, the bluffs exposed in the railway cut rise 25 or 35 feet; the surface of the limestone is imperfectly rounded, and much more rugged than the limestone of the Maclurea series, or of the underlying Cambrian beds. The bedding is well defined, in layers from three to five feet, although these often become broken up or else end abruptly, owing to small faults. These fault lines, or joints, in many cases, are favorable to rock decay, and hence, seams of clay are often seen filling crevices formed by weathering. The texture of the rocks is sometimes semi-crystalline, as in the case of the lighter colored purer dolomites; but commonly, it is earthy or siliceous. The surface often weathers to dark colors, but the decay does not usually penetrate deeply into purer rock. All degrees of impurities are seen in the various strata. At places, great beds are made up of impure, laminated, calcareous beds, one or two inches thick, which are so earthy that they weather into siliceous, shale-like beds.

In the purer rocks, which are more durable, occasional layers of dark flint (like in chalk beds) one or two inches thick occur. In other cases, the flint predominates in beds one, two or more feet in thickness. Such beds have given rise to the sheets of vesicular chert often occurring on the ridges. Again, the chert is disseminated in irregular concretions through the dolomite, and as the calcareous matter is dissolved away from such exposed beds, the clay, sandy matter and flints are left. The finer matter, being washed off by rains and rills, finally leaves the ridges covered with mantles of cherty gravel, with some larger blocks. Many of the flints are more or less translucent in the beds, but those left upon the surface, after the rock decays, are white or stained with iron.

At the mouth of a small stream, on the border of Bartow and Floyd counties, at a railway cut, a bluff of residual earth, left from rock decay, rises 60 feet high.

On both sides of Wooley's ferry, there are fine exposures of the undecayed rock, rising in the bluffs, out of the yellowish residual clay. The structure of the rock is shown in plate II., opposite page 42. Repetition of strata as shown in figure 16.

As shown in plate, the bedding is often indistinct, but with lines of flinty concretions. The hard dolomite rocks rise up out of the residual clay in a remarkable manner, especially well shown as in plate III., page 43 (south of Dalton).

These masses of decayed rock are too great to have originated only along joint lines, and there seems no reason why portions of the beds should have remained solid, whilst other portions of the same horizon should show decay for the whole height of the exposed bluffs (30 or 40 feet). It is probably due to minor faults bringing some of the more durable rocks into contact with some of the less permanent. The solid rocks appear more frequently upon the eastern side of the deeply decayed masses. Occasionally, the residual clay shows bedding, but this is generally quite obliterated.

The dip of the rocks at Dike's creek is less than 10° S. 60° E. Locally the dip was seen to be also S. W. and N. E. West of Wooley's ferry the dip varies from nearly level to 15° N. 60° W. A short distance beyond this exposure the strata dip to S. E., showing a low anticlinal. In short the whole breadth of the formation is one of repeated undulations. Some sandy layers are included in the formation; and Algæ were found near the county line.

Ladd's mountain, three miles southwest of Cartersville, is an isolated mass, but may be taken as a type of the dolomite ridges. (Plate IV., opposite.) It rises about 500 feet high, with a northern and southern trend. Its face has been uncovered for quarry purposes. The rock is a siliceous, hard and somewhat brittle dolomite, from light to dark in color, but all fine grained, compact and crystalline. The layers are thick. The bedding is disturbed, and in places appears as if the rocks had fallen into cavities, which may have been the case. The dip is 10° S. 80° W., and owing to form of exposure and undulations, the direction cannot be accurately determined; but probably a little south of west. There are joints of 50 feet or more in depth, which have been opened by decay and filled with clay. These commonly trend east and west, and are 20 to 30 feet or more apart. There are other joints with directions northeast and southwest, and again others at right angles.

This mountain is pierced with caves, some of which are vertical channels. These have been formed by streams dissolving out the limestone after uplift of strata, but before denudation of the valley, as already pointed out. The caves contain large and beautiful stalactites.

About two miles west of Ladd's mountain, there is another similar isolated ridge about 500 feet high, the top of which is covered with chert; but ravines on western side show hard, crystalline dolomite. These beds dip 20° S. 60° E. Accordingly, the intervening valley is synclinal. Other similar ridges occur farther west.

At Hardin's (Saltpetre) Cave (lot 104, district 17) about three miles southward of Kingston, the dolomite is exposed in a ridge. The beds dip 20° N. 70° W. The rock is dark colored and of fine grained texture. The cave descends to a depth of about 80 feet, and the chambers are of large size, with numerous ramifications and many chambers. There are very few stalactites. (See article on caves.)

At Kington (or Aikins') lime quarry, two miles east of Kingston, the solid rock is again seen. The decomposed covering varies in depth to a remarkable degree, as before described (figure 1, page 10). The rock is dark gray dolomite with bands of black flint or chert.

Along Two Rock Run creek, south of Kingston, dolomite is exposed in a ridge. Hence to the Etowah (at Hardin's Ferry) the country is composed of low gray hills, which also appear above the river for a short distance upon the south side, beyond which to west of Ligon Postoffice, the red and iron-bearing ridges prevail (trending east and west), or rather a succession of hills and valleys, like a billowy sea.

On a farm of T. F. Nichols, a well in process of excavation showed the red earth to a depth of 30 feet, below which the residual clay becomes light colored but not cherty. (Depth of well is more than 60 feet.)

South of the Etowah, and along Euharlee creek, much of the country is rolling, without abrupt ridges, and with red and grayish red soil, and some ore deposits derived from the less cherty series of the Knox dolomite. Along the river, and for a mile or two back, upon the hills, the Lafayette accumulations cover the residual clays, in many places to an altitude of 90 feet (observed).

North of the Etowah river and west of Cartersville, the Knox series has produced a rolling country, with some isolated rocky ridges. Southwest of Cass station, the cherty ridges are more prominent. Northeast of Cass station there are two spurs with iron ore deposits, forming basins over the Cambrian shales. North of the Etowah river the formation is undulating, and even the gray lands are less rugged.

Between Tom's creek and the Connesenna creek, the country is occupied by both ridges and rolling red lands, in some places iron bearing. Between Adairsville and Armstrong mountain, the country is often rugged and cherty, but with some iron bearing hills.

The belt of country between the Cambrain shales east of the Western & Atlantic railway, and the south fork of Two Run creek and Cedar creek is formed out of Knox dolomite. Upon the western side of this elevated region there are prominent ridges, but elsewhere there is a somewhat more softened topography with rolling plains, which are often cherty. At Mr. Combs's, east of Adairsville, the Knox series dip 20° northwest. Adjacent to the streams, there are broader depressions, and in several localities iron bearing and red lands, derived from the lower portion of the formation, are seen.

CHICKAMAUGA SERIES.

Near Taylorsville, the Chickamauga limestone just enters the county; and two miles north of this village a small basin is seen.

LAFAYETTE (?) SERIES.

Along the Etowah river, the loams and rounded gravels occur upon the hills to a height of 90 feet. However, the greater portion has been removed by subsequent denudation. The gravel is often coarse, and composed of well rounded quartz.

Along some of the smaller streams, as the upper waters of Pine Log creek (vicinity of Pine Log Postoffice), coarse water-worn pebbles of sandstone and conglomerate occur. These are of local origin, derived from the metamorphic rock in the mountains to the east.

MODERN DEPOSITS.

To a limited extent only do river deposits occur. Along the Etowah river they are hardly more than twenty or twenty-five feet above ordinary water. Generally the other streams do not give rise to extensive bottom lands. For these bottom clays, see Economic Report on Clays.

Deposits containing fragments of small bones are found in Hardin (Saltpetre) Cave, near Kingston. These accumulations are from four to six feet deep, and are more or less covered with fallen blocks. The earth has been used in manufacture of saltpetre.

MOUNDS.

Three miles north of Cartersville, there are three prehistoric mounds (known as the Tumlin mounds). The largest of these covers about three acres, and is built up to a height of 40 feet, with steep sides but a flat top. The two smaller mounds seem to have been protective, and are situated just above and below the great mound, and between it and the river. They do not cover more than half an acre each, and rise about twelve feet above the plain. Some archæological remains are said to have been obtained from these mounds.

CHAPTER XIII.

LOCAL GEOLOGY OF GORDON COUNTY.

CONTENTS.

OOSTANAULA SERIES.

Across the western portion of Gordon county, there is a belt of shale defined upon the western side by the Sackville fault, which brings the Cambrian system into contact, often without topographical breaks, with the Carboniferous rocks which, in part, are composed of dark heavy shales, and in part of the remains of cherty limestones. The rocks are more or less variegated shales, but red shingle and light red and yellowish soil are prevalent. There is also a moderate development of the mottled earthy limestones so characteristic of the formation in a similar position farther south. In this section of country the shale series constitutes gently undulating plains with low ridges. The western belt in this vicinity is more cultivated than it is in the "flatwoods" southwest of Rome, and has generally a more fertile appearance than farther south, with growth of timber like that on the neighboring rich lands to the east.

In a field in the trough, north of Turkey mountain, the contact of red Cambrian shales and the brown Carboniferous shales is strongly marked—the actual contact being represented by crushed shales of a few feet thickness.

The shales of the river region are flanked on the eastern side by the lower beds of the river, brought up by a fault. These have occasional thin seams of decayed yellowish sandstone which form interrupted ridges. In the region of Resaca, the anticlinal structure of the basin in the southern part of the county still continues. At that point the limestones dip 15° N. 60° W.

In some cases, as west of Resaca, the shales are of darker color, but commonly the belt of those deposits closely resemble those of a higher horizon in the series. The timber on these ridges is the same as elsewhere on the Oostanaula series—short-leaf pine, red and spanish oak, a few sycamore and hickory, some chestnut, and black jack on some of the poorer ridges; but the lands do not generally indicate sterility.

Most of the country, as shown upon the map, is underlaid by the shale formation.

The valley of the Oothcalooga is the most fertile, with deep red soil and the limestone beds exposed in the valley. In the formation, there are occasional limestone sinks. Eastward of the Knox lands, the Cambrian formations are more or less broken with the red shingly beds predominating. These, where not weathered, are often of dark color. Along the streams the limestones are exposed. The surface soils are thin upon the upper ridges; but in the valleys, especially of the Sallacoa, and along the foot of the metamorphic mountains, to the east, they are of good quality. An anticlinal basin, projecting westward upon the Bartow-Gordon line, is composed of dark red shale lands, bounded by the ridges of the Knox dolomite series, dipping at low angles.

KNOX SERIES.

Northwest of Adairsville there are small areas of the Knox series, in which the more rugged features of Bartow county become softened to a gently undulating country.

To the east of the Oothcalooga basin the ridges continue from Bartow northward along the western part of the Knox basin, but diminish in height. Elsewhere in this basin there is a gently undulating country, composed of gray land. A small basin east of Calhoun has the same softened character.

RED MOUNTAIN SERIES.

In the northwestern corner of the county, Horn's mountain rises into a prominent ridge 800 or 900 feet high. West of Sugar Valley the ridge is capped by shales and sandstones of the Red Mountain series, the strata dipping southeastward. Upon the eastern flank, there is a characteristic red soil, but the "fossil ore" beds are wanting, as the formation scarcely reaches that horizon.

CHATTANOOGA BLACK SHALES.

Upon the eastern side of Horn's mountain, the deposits of the last series are succeeded by the black shales of the Devonian system, which are well shown at the old iron ore pits northwest of Sugar Valley. The accumulations do not exceed 20 feet in thickness.

SUB-CARBONIFEROUS SERIES.

The Fort Payne chert occurs on the southern end of Horn's mountain, and also above the Devonian shales upon the eastern side of the mountain, farther northward, and contains brown iron ore. In the valley east of the mountain the Floyd shales, with their flaggy brown or red weathered shales, are seen. These form a strong contrast with the weathered red shales of the Oostanaula series to the east, which are thrust over the eastern edge of the Floyd shales.

THE LAFAYETTE AND MODERN SERIES.

On the hills and for a distance of two miles, the red surface deposits of loam and of quartz gravels are seen up to an elevation of 80 feet. Distant from the rivers they are not seen and this elevation is as great as the country near the greater streams attains. The characters are the same as in Floyd county.

The valleys of the Coosawattee and Connassauga rivers, and of some of the larger creeks are wide, but defined by irregular hills. These plains are from fifteen to twenty-five feet above the ordinary stages of water and are liable to be flooded.

FAULT.

As the Oostanaula shales belong to the Middle Cambrian horizon, an enormous fault becomes apparent. This fault is equivalent to a vertical throw amounting to from 7,000 to 10,000 feet. However, upon examination, this dislocation is found to be an overthrust fault, whereby the older formations to the east have been pushed over the Carboniferous formations for a distance of four miles and a half, this measurement being obtained from the occurrence of an area of Sub-Carboniferous strata, which rises through the capping of the overthrust Oostanaula shales. The outcrops just referred to are situated west of Resaca, and have been exposed, owing to denudation, removing the overthrust strata from this area.

CHAPTER XIV.

LOCAL GEOLOGY OF MURRAY COUNTY.

CONTENTS.

OOSTANAULA SERIES.

Between the Connasauga river and the foot of the Cohutta mountains, the Oostanaula shales cover the whole southern part of the county, as also along the river and along Holly creek valley. The greater part of this region is made up of the red and variegated shales, which are often dark where not decayed. These deposits weather into shingle, covered by thin soil, where they form ridges. The limestone of the series frequently appears along the streams. Along the Connasauga river, Holly creek and other valleys, at the foot of the metamorphic mountains, shale containing more calcareous rocks form fertile valleys. The characteristics are simply an extension of those of Gordon county. The beds frequently show a great amount of internal folding and minor faulting.

KNOX SERIES.

Overlying the last series, there is an elongated basin of the Knox dolomite. It is usually an undulating country composed of fertile red lands—both hills and valleys—in its southern and central portions (as about Spring Place).

Further north there are some rolling gray lands. At several places magnesian limestones of the Knox dolomite series are extensively exposed in ridges, as on the property of Captain Tilton, and others west of Spring Place. (See Economic Report.)

As the Oostanaula shales and limestones often underlie the metamorphic rocks at the foot of the Cohutta mountain range, so along Sumack creek, the Knox dolomite passes under the metamorphic zone to the east.

CHICKAMAUGA SERIES.

Succeeding the Knox dolomite series there is a narrow belt occupied by higher slates, etc. But between them and the Knox series there are various beds of the gray limestone, exposed in the valleys as near Loughridge on the eastern side, and as east of Cohutta Springs P. O.

Overlying the limestones, there is a bed of variegated and brown shales, with occasional calcareous seams. The rocks are not metamorphic. These shales dip at moderate angles to the east-southeast. North of Loughridge they rise in ridges of considerable height, which, however, owe their preservation to a capping of Red Mountain sandstone. Between the ridges and the mountains, there is a broad, fertile valley modified by the disintegration of the sandstones overlying the shales. The metamorphic strata of Cohutta mountains are seen overthrust upon a portion of the Chickamauga series.

RED MOUNTAIN SERIES.

Capping the crested ridges of the Chickamauga series, there is a consolidated fine grained sandstone, occurring in thick beds which aggregate about 200 feet. It is these rocks which give rise to the crested ridges. The rock is fine grained and consolidated into a light colored quartzitic structure. These rocks are probably identical with Safford's Clinch mountain series or one of the variations of the Red Mountain series, as on Rocky Face.

LAFAYETTE (?) AND MODERN SERIES.

At various points above the Connasauga, the red loam and quartz gravel of the Lafayette (?) rises to about 80 feet above the rivers.

The flood plains of the Connasauga are not so high above this river as further south, and only rise 15 to 20 feet above the ordinary stages of the waters.

CHAPTER XV.

LOCAL GEOLOGY OF WHITFIELD COUNTY.

CONTENTS.

OOSTANAULA SERIES.

The Oostanaula shales present the same features as in other counties, being divisible into shingly beds (upon its eastern ridges), fertile anticlinical valleys and the low ridges with thin sandstone layers at the western area. (In this location, the grounds for lithological distinction into the Knox sandstone and Knox shales, obtain more forcibly than at any points to the south.)

In the valley of the Connasauga river and Cooahulla creek, the characters are identical with those of Murray county. In the western part of the county the Oostanaula shales are repeated by faulting, making four belts (see figure 19 and map). Such is the narrow fertile valley in which the E. T., V. & G. Ry. is built from Dalton to the Tennessee line. From Cove City, northward, there is another such valley between great faults. This shale valley is pinched out west of Varnell, but again continues to the northward

Another fertile shale valley, is that in which Tunnel Hill (P. O.) is situated, but its western side is succeeded by a ridge of the lower beds with sandstone (or Knox sandstone). This belt widens out eastward of Gordon Spring.

KNOX SERIES.

An elongated basin of the Knox dolomite occurs between the Connasauga and Coahulla creeks. It is an undulating country composed mostly of gray lands. At Cedar Ridge another small basin occurs. Here the dolomite limestones are preserved and to some extent quarried. Some of the beds are earthy, and others contain dark flint nodules.

East of the valley of Varnell (station) there is another trough with a character similar to the last—rolling gray lands with some cherty ridges. It is, in part, succeeded by higher rocks. West of Varnell there are two belts, in part, brought together by a fault. These belts are somewhat characterized by interrupted ridges, but they are largely gray lands forming a rolling valley.

West of Tunnel Hill another chain of interrupted ridges extends northward. Some of these ridges appear to be ore-bearing.

CHICKAMAUGA SERIES.

A belt of these Silurian rocks succeeds the Knox series in the northeastern part of the county. The limestones are seen in some of the valleys. The upper beds are brown and variegated calcareous shales which, in part, give rise to deep red soils. Some of these beds are highly ferruginous (see Economic report); others are siliceous. The limestones sometimes occur in thick beds. It is probable that the iron ore beds represented in this county belong to the Deaton sub-series.

The Dalton basin is made up of Chickamauga shales. Owing to the limitation of limestones, and some sandstones, a chain of crested hills extends northward from Dalton. These latter sandstones may be remnants of the Red Mountain series.

Between Dalton and Tunnel Hill there is a trough of the Chickamauga formation, with brown shales predominating, but intercalated with limestones and sandy shales. These deposits extend through the gap of Rocky Face mountain, west of which there is a long narrow trough of valley lands. The Chickamauga rocks extend upward into the mountain side.

RED MOUNTAIN SERIES.

Rocky Face or Chattoogata mountain forms a chain extending from near Tunnel Hill southward. This chain is dislocated into parallel but discontinuous zigzag ridges to Horn's mountain and is composed of the Red Mountain series with the different ridgelets connected by rocks of the same formation. The ridge rises up into a bold mountain from 1,500 to 1,791 feet above tide. It is capped with a quartzitic sandstone lying in heavy beds, dipping 25° N. 80° E. at the gap in the ridge north of the road. At Dug Gap, a few miles to the south, the strata dip 45° S. 80° E. Whilst there are some shales upon the eastern flank, from the summit of the mountain downward upon the western side, the section shows heavy bedded gray quartzitic sandstone, 20 feet; laminated sandstone in thick beds, 40 feet; red sandstones in thick layers with shaly partings, 40 feet; brown and red compact shale, with seams of sandstone, 200 feet; laminated shales weathering red, 200 feet. Below this elevation such shales as are exposed appear to belong to the Chickamauga series. The deposits represented in the mountain appear to rise to but do not include the "fossil ore" beds. Higher shaly beds occur on the east side of the ridge. Part of Dick's and Taylor's ridges are on the western border of this county; but they will be described in the other counties.

CHATTANOOGA BLACK SHALE.

The black shales overlying the last formation and described in Gordon county, extend northward upon the eastern flank of Horn's mountain into Whitfield county.

SUB-CARBONIFEROUS SERIES.

Upon the eastern side of the mountain just described, the Sub-

Carboniferous cherts and shales from Gordon county extend into Whitfield county.

FAULTS.

No county in northwestern Georgia has the strata so much repeated into striking features, owing to dislocations and subsequent erosions, as Whitfield county.

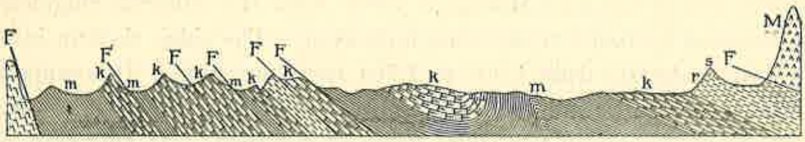


FIGURE 19.—Repetition of formations owing to faults and folds between Rocky Face and Cohutta mountains. F, Faults; K, Knox dolomite; m, Oostanaula shales.

RECENT FORMATIONS.

The most notable deposits are the gravels and loams upon the western side of the Connasauga river, similar in position to those upon the eastern side of the river in Murray county.

CHAPTER XVI.

LOCAL GEOLOGY OF CATOOSA COUNTY.

CONTENTS.

OOSTANAULA SERIES.

The Oostanaula shales cross this county in two belts, one of which, however, is divided by a spur of Knox dolomite brought to the surface by a fault. These belts form rolling valley lands, the more eastern of which, however, is traversed by ridges, owing to the presence of some sandstones which appear in the lower part of the series, and known as the Knox sandstones in Tennessee. This belt is brought into contact with various formations all the way from the Chickamauga to the Sub-Carboniferous series, owing to an extensive fault. The western belt of this series occurs along Peavine creek, which is an anticlinal valley, with the strata often dipping at high angles, bringing to the surface flaggy limestones and shales, which are probably the remains of impure calcareous rocks. Some beds of limestones are also seen.

KNOX DOLOMITE SERIES.

From Tunnel Hill northward there is a chain of ridges of this formation, forming light-colored cherty ridges and gray rolling lands. Some of these ridges show the occurrence of brown ore, manganese, etc. Across the center of the county there are two other belts of Knox dolomite, sometimes rising as much as 300 feet above the undulating valley lands. These are situated on either side of Peavine valley. In the northwestern corner of the county, the rolling gray lands in front of Missionary ridge are also composed of Knox dolomite. Generally speaking the soils along these three belts are gray lands, or sometimes thinly coated with cherty gravel, which material often thickly covers the ridges. Occasionally red lands are seen. The three western belts extend southward into Walker county.

The South Chickamauga creek cuts through the central ridge and exposes the undecayed Knox dolomite. At Grayville the extensive lime quarries have brought to view the character of the rock for a depth of nearly one hundred feet. The strata dip 40° S. 60° E. The beds are very massive and weakly marked by occasional lines of bedding. The stratification, however, is indicated by bands of coloring produced by impurities. The common thickness of the strata is from six to eight feet. Some layers have flinty seams through them. This steep inclination, however, does not recur everywhere throughout the belt. The limestones are rather dark gray in color. The residual earth upon the surface does not usually extend to a depth of more than from two to fifteen feet, and is composed of the material after the removal of the calcareous matter from the dolomite.

CHICKAMAUGA SERIES.

Two belts of this formation cross the county. The eastern zone is the valley of South Chickamauga creek; it occurs along the western side of Taylor's ridge and White Oak mountain. Whilst this valley is composed of fertile red land, yet the limestone beds, or those interbedded with sandy shale—a residuum of decayed calcareous rocks—come to the surface at low angles, dipping into the mountains at 10° or less to the S. 70° E.

Along the West Chickamauga creek this formation constitutes a broad belt of fertile lands, through which the rocks rise to the surface in the anticlinal valley. These rocks, dipping at low angles, produce extensive outcrops, and the roads over them are characterized by great roughness; but the material is at hand for making the best roads in the State.

RED MOUNTAIN SERIES.

Taylor's ridge terminates at Ringgold, to the north of which White Oak mountain commences and extends into Tennessee, thus forming one continuous chain, interrupted, however, by the passage of South Chickamauga creek. This ridge is narrow, and rises to an elevation of somewhat over 1,300 feet above the sea, or from 400 to 600 feet above the valley. The lower portion of the ridge is composed of the Chickamauga series, but the upper portion consists of shales with heavy sandstones, which cap the ridge; these are often quartzitic in texture. The formation of the mountain top reaches to the fossil ore beds, some remnants of which are found in Taylor's ridge, which are best developed south of this county. In the northern part of White Oak mountain, the beds dip at 10° S. 70° E. Taylor's ridge, in the southern part of the county, becomes synclinal, and encloses a basin of Sub-Carboniferous rocks. The eastern rim of this basin rises into a continuation of Dick's ridge, which is abruptly cut off by a fault upon the eastern side, bringing Cambrian rocks into contact with the Red Mountain series.

CHATTANOOGA BLACK SHALES.

Overlying this last formation there are a few feet of black Devonian shales, which underlie the Sub-Carboniferous series in the basins to the east of Taylor's ridge, noticed in next paragraph.

SUB-CARBONIFEROUS SERIES.

This series occurs in a synclinal trough upon the eastern side of Taylor's ridge proper. It is composed of some shaly rocks and characteristic cherty limestones of the Sub-Carboniferous series. North of Ringgold gap this belt is rugged and broken into hills and valleys.

CHAPTER XVII.

LOCAL GEOLOGY OF CHATTOOGA COUNTY.

CONTENTS.

OOSTANAULA SERIES.

Chattooga river, throughout nearly its length, flows through a valley composed of Oostanaula shales with occasional beds of limestone. Upon the western side, the formation abuts against higher formations owing to a fault. To the westward of this belt, another fault has brought to view a narrow basin of these shales. At Holland, there is a small anticlinal valley of the same formation. Farther northwest, in front of Pigeon mountain, another anticlinal valley begins and extends into Walker county. This is the most western belt of the Cambrian shales, and forms an elongated valley with the streams flowing longitudinally through it. These valleys contain fertile, red, calcareous, shaly land.

KNOX DOLOMITE SERIES.

This formation is repeated in three or four belts, according to its position in the county. Along the western side of Taylor's ridge, but separated from it by a valley, this formation is characterized by a chain of hills and rolling valley lands, the former being covered with cherty gravel, and rising 200 or 300 feet above the valleys, and the latter covered with gray dolomitic lands. West of the Chattooga river, similar ridges and rolling lands constitute another belt. In places, iron ore occurs, as also beauxite and white clays, as west of Summerville. West of Dirt Seller mountain, there is a similar repetition of rolling lands and ridges belonging to this series.

CHICKAMAUGA SERIES.

Along the western side of Taylor's ridge, there is a narrow belt, composed of calcareous shales and limestones, belonging to the Chickamauga series. These rocks, in part, form the valley, and in part, constitute the base of the western side of Taylor's ridge. Owing to a synclinal basin, the same formation occurs on both sides of Dirt Seller mountain, and extends northeastward, to near the county line. Another belt overlies the Knox dolomite, entering the State near Menlo, and forms a valley at the foot of Shinbone ridge. All these valleys are comparatively narrow, but contain fertile lands.

RED MOUNTAIN SERIES.

Taylor's ridge crosses the county, interrupted, however, by a dislocation to the eastward of Holland. High Point reaches an altitude of 1,606 feet above the sea, but the range is serrated with depressions recurring at 200 feet, or more, below this higher elevation. However, the mountain forms a characteristic feature, rising 600 to 800 feet above the valleys to the west. It is generally a portion of a synclinal elevation. This synclinal structure may be seen at High Point, where the rocks dip at 60° N. 30° W. At this point, the lower portion of the mountain is composed of shales and thick layers of gray sandstone, above which there are other sandstones which are of red or brown color. Farther north, the strata dip to the southeast, but come up again after forming an anticlinal basin at the southeastern end of the West Armuchee valley. Again, these strata dip at low angles to the southeast, and then rising reappear in Dick's ridge. Thus Dirt Town valley, and its continuation, West Armuchee valley, forms a synclinal basin, but with the central portion of it broken by the anticlinal ridge west of Subligna.

East of Summerville, a good section of the rocks is seen along 10° S. 60° E. Near the top of the pass, the dip increases to 20°. the newly excavated road. Upon the eastern side the dip is Upon the western side of the mountain there is an abnormal dip of 20° S. 60 W.; but farther west, the rocks dip normally towards the southeast. The thickness is 1,100 feet. In this locality, the higher rocks are composed of shales, underlaid by earthy sandstone, rarely thicker than one foot, separated by shaly partings. Some of the ledges are composed of a fine brown sandstone ; others are mottled ; but nowhere are the strata more than two feet thick. The lower beds of the series are mostly shales. The fossil ore bed lies above the heavier sandstone layers, and is seen at several localities, with a thickness of about twenty inches, forming a bed, dipping rather more steeply than the eastern face to the mountain, along which it is occasionally exposed in ravines.

John's mountain is a bold ridge about twenty miles long, and is, geologically, part of a chain of dislocated ridges of the Red Mountain series, connecting Rocky Face, Horn's, and Taylor's ridges, and has an elevation of 800 or 900 feet above the valley. It is capped with heavy ledges of sandstone, having a thickness of about 200 feet, interbedded with some shales. The lower part of the formation is shaly. In the central part of the mountain the rocks dip from 20° to 25° S. 60° E., and pass under the Sub-Carboniferous basin to the east.

Dirt Seller mountain forms a synclinal basin of the Red Mountain series, embracing the beds of the series as high up as the fossil ore, which occupies the trough a few feet below the surface shales. The ore has a thickness of between one and two feet.

This mountain is the only plateau-like elevation composed of the Red Mountain series.

Upon the eastern side of Pigeon mountain, Shinbone ridge consists of a serrated chain of hills, rising from 200 to 250 feet above the valley. This ridge is the outcrop of the Red Mountain series, which passes under Pigeon mountain in a synclinal trough. The higher points of this chain of hills have been preserved by the capping of cherty gravel or fragments of rock derived from the Fort Payne series. The strata dip at 20° N. 50° W., which may be taken as an average dip, but in places the beds are much disturbed, and even dip at 75°. Whilst the rocks are mostly shales, with occasional flags of limestone, yet the shales form compact, thick laminations, and pass into sandy flagstones of red color. This red color arises from the surface weathering, as the rocks exposed at depths in the mines are of the more bluish cast; so also below the drainage level the sandy shales become more calcareous, and pass into impure limestones.

Throughout Shinbone ridge the 'fossil ore' beds are more or less constantly represented, and have a thickness of from two to three and a half feet. They are sometimes broken up into two or more layers.

CHATTANOOGA BLACK SHALES.

Upon the western side of Taylor's ridge, and upon the western side of Shinbone ridge, from ten to fifteen feet of black shales occur. Where not weathered, these shales are hard and compact, and are often mistaken for coal; however, they are usually covered with overlying deposits, and are only exposed along occasional streams.

SUB-CARBONIFEROUS SERIES.

This formation occupies the greater portion of Dirt Town and West Armuchee valleys. The rocks adjacent to the black shales at the foot of Taylor's ridge are cherty limestones of the Fort Payne series, which give rise to gray, gravelly ridges. The gravels also occur upon the eastern side of the valley, as they rise over the Red Mountain series. Yellow and black shales, with some low ridge-making sandstones, and occasional limestones of the Floyd series, give rise to the rolling valley lands, with indifferent soils in the less calcareous portions of the formation; still, there is much good land throughout these valleys.

Along the foot of Lookout mountain, there is a valley composed of Sub-Carboniferous limestone. On the eastern side, the rocks belong to the Fort Payne chert series, consisting of cherty limestones, which, upon decay, leave flinty fragments, such as are scattered over the western side of Shinbone ridge. The valley, however, is free from this gravel, as it is excavated out of the Mountain Limestone, which forms the base of the table-land. This limestone is a compact, more or less pure, blue rock. It is best developed in Walker county.

COAL MEASURES.

East of Dirt Town valley, occupying a synclinal basin, a remnant of the Coal Measures occurs on Little Sand mountain, which rises from 300 to 500 feet above the valley. The lower part of the mountain consists of shale succeeded by sandstones, which are massive, but in layers of moderate thickness. The surface of the southern end of the mountain forms a basin, drained by Mill creek, which cascades over a ledge of sandstone 15 or 20 feet thick. Descending the little chasm of the horse shoe falls, there is a layer of rock, more or less shaly, having a thickness of 15 inches, through which a dozen seams of coal are scattered, each with a thickness of a quarter or a half an inch. From this plateau a ridge extends some miles northward, composed of the same rock. No other coal is known upon it than that just described. The surface of the mountain is covered with light, sandy soil. This outlying basin of the

Coal Measures is of interest on account of indicating the eastward extension of the series. Little Sand mountain is cut off from the same formation of the Lookout plateau by a distance of about fifteen miles, with high Taylor's ridge intervening. Yet there is no doubt that the two plateaus were connected before the mountain movements, which have faulted and folded the intervening region, from which all of the lower formations have been more or less removed by erosion, with the preservation of their remnants, due to

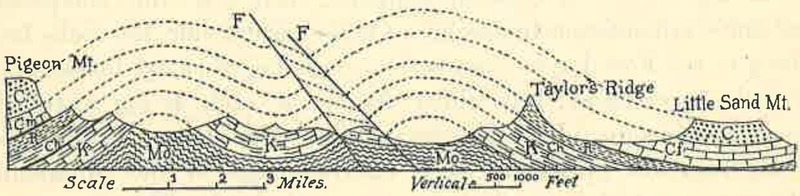


FIGURE 20.—This shows a section of fifteen miles, from which the Coal Measures and other formations have been removed by denudation, with the formation of valleys. The denuded beds from Coal Measures (C) to Middle Cambrian (Mo) are represented by dotted lines. F, great faults.

their hardy materials, resisting the diminishing power of degradation as the streams reached the base level of erosion. As the Coal Measures then capped Taylor's ridge, and all of the country thence to Pigeon mountain, the amount of material removed from the surface may be roughly estimated at not less than from 2,000 to 6,000 feet, as is represented in figure 20. The mountain movements have taken place since the commencement of this great erosion. A similar outlier occurs in Floyd county.

Lookout mountain forms a plateau crossing the extreme northwestern corner of the county, and rises up to 1,700 or 1,800 feet above the sea. The lower strata of the Coal Measures consist of shales which are mostly concealed, whilst the upper part of the mountain is bounded by a wall of sandstone or conglomerate (see plate VI., page 53) often in thick or heavy beds. Back from the brow of the mountain, higher beds of the formation occur. The dip of the rocks, as seen in Neal's gap, averages from 5° to 10° N. 60° W.

Beneath the conglomerate at least one bed of coal occurs, having a thickness of from 1 to $1\frac{1}{2}$ feet at the locality where seen—a mile north of Neal's gap. This is a portion of the wide-spread coal seam. At Gilreath's mill, the south fork of Little river cascades over the sandstones, below which the coal is again seen.

The top of the mountain consists of sandy soil derived from the disintegration of the sandstones and sandy shales.

CHAPTER XVIII.

LOCAL GEOLOGY OF WALKER COUNTY.

CONTENTS.

OOSTANAULA SERIES.

East of Taylor's ridge a belt of Cambrian shales enters the county from Catoosa, and terminates southwest of Villanow. It is brought into position owing to a fault upon its western side, and the subsequent removal of the Knox formation from the valley at the head of East Armuchee creek. In part, these are low ridges produced by the sandy members which are present in the series; otherwise, the belt forms a valley. Through the central part of the valley, the most western basin of the shales connects the similar basins in Catoosa and Chattooga counties. This is an anticlinal valley, occupied by the usual fertile soils. The rocks are shales or sandy shales, the remnants of decayed calcareous rocks. Included amongst these shales, beds of limestones occur, which are exposed along the streams as is the case everywhere over this formation.

KNOX DOLOMITE SERIES.

East of Dick's ridge, as also east of John's mountain, ridges with rolling valleys, carved out of this formation, form prominent features. These ridges are repeated, owing to an anticlinal and fault structure. The soil on the ridge is usually covered with chert, and on the rolling lowlands, it is gray, with only occasional basins of red material. Between Villanow and Furnace at end of John's mountain, the beds of dolomite rock are well shown and dip gently southeastward.

Between Taylor's ridge and Lafayette, there is a broad belt of the Knox series, which forms undulating valley land with occasional ridges. Here the soils are gray or cherty upon the ridges. This belt constitutes the eastern slope of the Lafayette anticlinal valley. The western side of the anticlinal forms a narrow chain of ridges of the same formation. These ridges are much interrupted by valley depressions.

Missionary ridge, with the rolling lands in front, is also composed of Knox dolomite, and occupies the position of an anticlinal from which the rocks have not been sufficiently eroded to expose the underlying Oostanaula series, as in the Lafayette (town) anticlinal valley. The ridges are often deeply covered with chert, and the rolling valley lands are composed of cherty or gray soil, with occasional developments of red land. At several points, the streams have exposed the rocks to a limited extent.

CHICKAMAUGA SERIES.

A narrow belt of these deposits skirts the western side of Horn's mountain, and unites with the synclinal basin surrounding the northern end of John's mountain. Two small exposures are seen passing under Dick's ridge. These limestones and shales are valley-making. Occasionally the limestone is exposed at the surface, as also sandy flags which are probably the remains of impure limestones. These rocks give rise to rough roads where highways cross them.

West of Taylor's ridge another belt of the same formation underlies a valley along the foot of the mountain, from which the rocks extend upward into the base of the ridge.

East of Missionary ridge, and occupying the valley of the West Chickamauga creek, there is a synclinal valley occupied by the limestones and shales of this formation; indeed, it is from this region that the local geological name has been adopted by Mr. Hayes. Whilst there are usually fertile red soils in this valley, yet the limestones, dipping at low angles, form outcrops of considerable extent, which give rise to thin soils and rough roads. Besides the more or less impure limestones there are beds of calcareous shales, some of which produce rough sandy flags upon weathering. The shaly members cannot be separated from the limestones in the series. The same rocks rise up on the western side of the Missionary ridge anticlinal. Another small basin surrounded with the Red Mountain ridges rises up through the northern end of the Missionary ridge anticlinal, forming the typical basin of the red or brown lands.

RED MOUNTAIN SERIES.

In the eastern part of the county, the northern end of John's mountain rises to form a bold feature. This, as well as Mill creek ridge (forming a part of the connection between Horn's mountain and Rocky Face), is composed of the rocks of the Red Mountain series. On these mountains the sandstone members predominate to such an extent as to give rise to the bold features.

Taylor's mountain and Dick's ridge together form a synclinal elevation. South of Greenbush they enclose the West Armuchee valley of Sub-Carboniferous rocks. Extending northward into the edge of Whitfield county, the same ridges enclose two basins of Sub-Carboniferous rocks, in part composed of the Fort Payne series and in part of Floyd shales. Very good sections can be obtained by crossing the mountain at Gordon Springs or Greenbush. The lower part of the formation consists of thin bedded shales, but the upper 150 feet of the mountain contain an excess of sandstone, often in beds even to eight feet in thickness. Some of these hard sandstones have brown or red colors. On the eastern side of the mountain, west of Greenbush, the shaly beds are concealed between the dark ferruginous soil. Overlying the sandstone horizon, the fossil ore bed is developed, and has a thickness of one foot or more, exposed in ravines. The rocks dip 20° S. 60° E. on the ridge west of Greenbush ; but upon the eastern edge of the synclinal at Wood's gap, where the strata rise to form Dick's ridge, the red sandstones of the series dip 80° N. 60° W. The iron ore is also exposed here, as also at Mr. J. Hamilton's to the north, where the rocks dip, upon the western side of the synclinal, at 25° S. 60° E., and on the east side of the synclinal at 25° N. 60° W. The iron ore occurs above the sandstones, and in the synclinal basin of the formation.

Shinbone ridge skirts Pigeon mountain and passes round the head of McLamore's cove, and thence skirts the foot of Lookout mountain. It forms a chain of narrow serrated ridges, rising 100 to 200 feet above the adjacent valleys. The higher points are frequently protected by a capping of cherty gravel belonging to the Fort Payne series. In these ridges the rocks are not generally well exposed at the surface, owing to the easy disintegration of the Red Mountain series,—being mostly composed of shale, often in thick layers with only occasional flaggy beds of sandstone or impure limestone. Some of these flaggy beds are the remnants of impure limestones from which the calcareous matter has been leached out; for in the mines at Bronco the calcareous beds are preserved below the drainage level; whilst at the surface only the red shale and flags appear. This extends and occupies a synclinal basin under Pigeon mountain, as also another basin beneath Lookout mountain, and a small basin surrounding Chickamauga limestones at the northern end of the Chickamauga anticlinal valley. Whilst these rocks are often in beds dipping from 15° to 20°, yet they are occasionally folded, and even overturned as may be seen at Bronco mines.

Another example of disturbance of the beds is seen at the Wessboro mines north of High Point. There the strata undulate very much; still the normal dip is 20° N. 70° W.; but the strata may be seen dipping even to 70°, and at the same time faulted. This disturbance involves the ore beds, which superficially appear to be duplicated. The structure is best seen in figure 21.

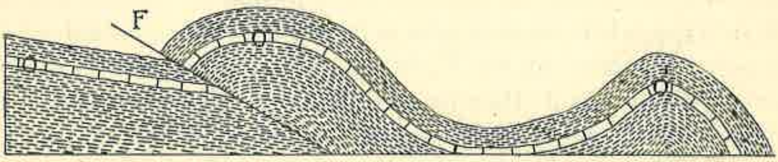


FIGURE 21.—At Wessboro mines. Folding and faulting (F) of beds. Ore bed (O).

The best exposed section of the Red Mountain series is along the railroad at the tunnel under the end of Pigeon mountain, where the shales are exposed for a distance of about 7,000 feet, across the formation, between the Chickamauga limestones and the black Devonian shales at the western end of the tunnel. The rocks dip moderately regularly at 8° S. 60° E. The whole formation may be said to be composed of shales, sometimes in thin layers, and sometimes more sandy in the form of flag-stones, with occasional beds of sandstone, which seldom reach a thickness of more than 14 inches. As all of these shales are above the drainage level, they are mostly weathered to a red or brown color, although occasionally blue. The whole thickness of the formation is 1,100 feet. The fossil ore bed, with a thickness of two feet, or more, is here divided, and in position, it is situated about 700 feet above the base of the series. At Blue Bird gap, near by, the formation is also well exposed.

Along the Chickamauga and Lookout Railway, approaching Eagle cliff, a section of the Red Mountain rocks is exposed. The average dip of the strata is 20° N. 70° W., although there are some undulations in the successions. The total thickness is about

800 feet. The rocks are mostly shales, sometimes thin bedded, but at other times in massive layers, which are more or less sandy. Some thin sandstones occur in the upper part of the series, near which is the ore bed. The ore bed is moderately constant throughout the Shinbone ridge. The characters of these rocks, in the anticlinal basin, at the northern end of the Missionary ridge are similar to those of Shinbone ridge. For the characters of the ore see Economic Report.

CHATTANOOGA BLACK SHALE.

Overlying the Red Mountain formation of Shinbone ridge, as well as Taylor's ridge and Horn's mountain, from 10 to 20 feet of black shales of the Devonian system occur. These probably belong to the upper part of that system, and whilst unconformity to the lower series was not detected, yet there is an apparent gap in the succession. This failure of detecting unconformity arises in part, from the small development of shales, which are rarely exposed at the surface by the infrequent streams. The best exposure of these shales, is at the western end of the Pigeon mountain tunnel; occasionally they are dug into, by mistake, for coal. As a surface feature these shales are unimportant.

SUB-CARBONIFEROUS SERIES.

In the extreme southeastern corner of the county, there is a small exposure of cherty surface deposits, upon Horn's mountain, belonging to this series. Along its margins, Armuchee valley consists of soils derived from the Fort Payne chert, and in the interior, from Floyd shales. Some of these shales are interbedded with limestones.

Round the end of Pigeon mountain, there is a great development of Sub-Carboniferous limestones. These are seen on the ridges bordering the Red Mountain formations. At the north end of Pigeon mountain, as shown at the tunnel, the lower member, or the Fort Payne chert, is composed of about 250 feet of limestones, charged with nodules or bands of chert. Adjacent hills are thickly covered with the disintegrated cherty gravel. The Fort Payne cherts are traceable upon the serrated hills of the Red Mountain series, round the head of McLamore's cove, and along the eastern foot of Lookout mountain.

The Mountain Limestone consists of compact, bluish limestone, mostly pure and in thick beds. It also contains some unimportant seams of shale, and one of sandstone. It is best developed at the northern end of Pigeon mountain, where it has a thickness of about 900 feet. This limestone is also traceable round McLamore's cove and Lookout mountain, and constitutes the lower slopes of the plateau. The narrow valleys, between the cherty ridges and the mountain are composed of soils, the result of weathering of this limestone. At the northern end of Lookout mountain, there is an excellent exposure, where the limestones appear to have a thickness of 700 feet, but those to the south are not so thick. The upper portion of the limestone becomes impure and somewhat flaggy, passing by transition into the shales of the overlying formation.

COAL MEASURES.

Pigeon mountain is a spur of Lookout, and is a synclinal plateau, surmounted by Coal Measures. At the head of McLamore's cove, these consist of laminated sandstones, with an average dip from 5° to 10° S. 20° E., but locally dipping to the southwest. Of these sandstones 125 feet are seen. Beneath the sandstones 65 feet of sandy shales occur, underlaid by 10 feet of heavy bedded sandy shales. The lower 250 feet of shales are laminated without hard layers. The undulations of the surface of the mountain, in this locality depend upon the dip of the strata, whereby the sandstones are carried to higher altitudes; but over these sandstones just named, at some higher points, shales occur. About a mile and a half to the northeast of the head of the cove, or Dougherty's gap, in a valley opening northward, about 150 feet of sandstones are seen, beneath which there is a bed of coal about a foot thick. In this gorge, the rocks, upon the right bank, dip southwestward, and on the opposite side to the northeast, making a steep synclinal, with the strata dipping from 15° to 20°. The highest point of Pigeon mountain rises to 2,321 feet, with the sandstones just described, forming the floor of the sloping plateau, with precipitous cliffs on the western side.

Pigeon mountain above Bronco shows the following section in descending order:

	Feet
Sandstones of variable character	10
Sandy and ordinary shales	90
Yellow sandstone	10
Sandy shales mostly concealed	10
Sandstones in thick, but with false, bedding	155
Shales and sandy shales	260
Sandstones with some conglomerate in thick beds, dipping 5° to 10° westward	40

The rocks above the thick sandstone, are located in the interior of the mountain, and belong to the Upper Coal Measures. The thick sandstone forms an escarpment around the mountain. (See plate V., page 53.) At the northern end of the mountain, High Point is composed of the same ledge of heavy sandstones, as have just been described. The formation is not more than from 300 to 350 feet thick, at the point where the Mountain Limestone rises to nearly 1,100 feet above the valley.

The Coal Measures, consisting mostly of shales below, with heavy beds of sandstone above, characterize Lookout mountain, which taken as a whole, is a synclinal, plateau, the same as Pigeon mountain. These synclinals, are, however, parallel.

At the north end of Lookout mountain, the Coal Measures are exposed in the following section, which does not, however, include the highest members of the series shown in the basin to the south:

	Feet
Upper conglomerate or sandstone, consisting of variable layers of sandstone in false bedding, with the lower 50 feet, mostly as a massive conglomerate, in which there is a coal film	225
Shales and sandy shales of variable thickness	35
Lower sandstone and conglomerate containing some shale	40
Shale and sandy shale containing coal film	50
Sandstone	15 to 20
Shale and sandy shale, with thin sandstone near the top	280
Sandstone (with shales below, passing into limestone)	10
	660

The rocks at the end of the mountain form a synclical basin with the rocks dipping at low angles; but on the eastern side of the mountain the dip increases to 70° N. 60° W.; this, however, is reduced in the exposures of the Fort Payne chert, near the foot of the mountain. Whilst the above section represents the series beneath the other beds, the section shown along the Chickamauga railroad, from Eagle cliff to Round mountain, gives the best section from the lower sandstones upward. At Eagle cliff the rocks dip 20° N. 70° to 80° W., flattening out into undulations to the southward; to the northward, the strata locally dip at about 45° to the northwest. The Eagle cliff is capped by the upper conglomerate of Lookout point; this same conglomerate reaches into High Point to the south, rising to an elevation of 2,408 feet above the sea, but does not include the highest beds of the Coal Measures, which occur in the interior of the mountain, and on Round mountain. The following section is obtained from the careful reduction of the measurements along the Chickamauga railroad. It extends from the top of Round mountain to the base of Eagle cliff.

	Feet
Laminated shales with a few layers of sandstone on Round mountain (partly concealed)	200

	Feet
Shales ? (concealed)	65
Shale	9
Coal and shale intimately interlaminated	14
Shale and sandy shale, partly concealed	25
Coal	0.7
Shale	18
Sandstone, gray laminated	35
Coal (3.5 to 4.5 feet) dips 1° E. S. E.; altitude at mouth of Durham seam mine, 1,849 feet above tide. There is a slaty parting in the middle of the seam. This bed is probably represented on the southwest side of the mountain at an altitude 30 feet lower	4
Sandstone, irregularly and often thinly bedded and undulating	80
Red shale	11
Black shale	4
Shale and sandy shale with a seam of limestone	10
Blue shale above and variegated shale below	7
Coal (altitude 1,668 feet)	1.8
Thin laminated blue shales	70
Red shales	35
Coal	0.2
Light blue clay	2
Shales and sandy shales, passing into sandstones and undulating so as to frequently appear and disappear for a distance of 3 miles, but characterized by some recognizable layers, estimated at	150
Coal	1.7
Sandy shales in steep undulation	1 to 3
Heavy bedded sandstones	25
Coal	0.2–0.8
Upper conglomerate and sandstone (at Eagle cliff)	150

	Feet
Shales laminated and also thick bedded	120
Lower conglomerate and sandstone	40
Shales, more or less concealed	(?) 250

On the southwestern side of Round mountain, there are probably two coal seams, different from and situated above the coal seams given in the above table. Beneath the upper conglomerate a bed of coal occurs with a thickness of from one to three feet, and said to be still thicker at some points. These coal seams are, probably, identical with those at the head of McLamore's cove and in Pigeon mountain.

The coal seams beneath the upper conglomerate are in the same position with others seen at various points near Rising Fawn. One of these coal beds occurs at Stephens' gap on the east side of Johnson's creek, beneath the sandstone, which dips 18° S. 60° E., resting upon fire clay. Above the furnace, on the northern side of the creek, there is a vein of coal formerly opened. This vein occurs in shales at a considerable depth below the conglomerate. The vein is said to vary from nothing to eight feet in thickness. Near the point of the mountain, to the west, another vein of coal occurs immediately below the conglomerate.

As the mountain has been unequally eroded, especially where the conglomerate is brought into high angles on the eastern side, the upper sandstones have been removed in places, as also some of the underlying shales and coals. The erosion must have been great, as the Coal Measures above the conglomerate have been generally denuded, except where protected by the form of the basin of Lookout plateau.

CHAPTER XIX.

LOCAL GEOLOGY OF DADE COUNTY.

CONTENTS.

KNOX SERIES.

Cherty ridges of the Knox dolomite formation enter the county from Alabama and extend only a few miles into Georgia, south of Rising Fawn. These are the lowest rock series of the anticlinal valley of Lookout creek.

CHICKAMAUGA SERIES.

On both sides of the anticlinal exposure of the Knox series there are developments of the Chickamauga formation. The limestones are conspicuous, and form strata dipping from the valleys often at low angles in both directions. Whilst they are in part valley making, yet some of the rocks rise up in ridges or make a stony floor to the valley. Some of the beds include light colored, fine grained limestones, breaking with a conchoidal fracture.

From a point north of Rising Fawn, down the Lookout valley, the Chickamauga series forms a fertile valley, where the soils are of red or brown color derived from impure limestones. In places these rocks are more or less massive beds of impure, often flaggy limestone, coming to the surface and forming low ridges. Elsewhere the decayed soil deeply covers the undecayed rocks. Whilst the beds mostly dip at angles from 10° to 20°, yet portions of the folds dip as much as 60°. The formation is about 1,200 feet thick.

RED MOUNTAIN SERIES.

Both basins of the Chickamauga limestones are surrounded by chains of undulating ridges rising from 100 to 300 feet above the valleys. The higher points are, however, commonly protected by cherty covering of the Fort Payne chert, or sometimes by remnants of the cherty limestone itself. The character of the ridges may be seen in plate V., page 53. The rocks are mostly laminated shales with some flaggy layers, and of a red color above the drainage level. There are occasional thin layers of limestones. Below the drainage level the rocks are more calcareous. The fossil ore is usually present in from one to three beds, and has a thickness varying from two to even seven feet, but usually it is not over two and a half feet thick, especially above the drainage level. Below that horizon the ore is always highly calcareous. On the eastern side of the valley the formation passes under Lookout mountain, and on the western side, it passes under Sand mountain.

CHATTANOOGA BLACK SHALE.

Overlying the Red Mountain series, the Devonian black shale everywhere succeeds it. As this shale is very easily disintegrated and removed, it is only preserved beneath cappings of the next formation. As a consequence, it is seldom seen except in occasional washouts or along streams, or along roadsides where cuts have been made. Its thickness does not exceed ten or twenty feet.

SUB-CARBONIFEROUS SERIES.

The Fort Payne chert is best known from the rough cherty fragments which commonly form a thick mantle succeeding the ridges of the Red-Mountain formation, on the lower portion of the mountain sides, where, however, streams often expose the natural rock.

Near the Rising Fawn furnace, the Fort Payne chert has a thickness of about 200 feet. It is also well shown east of New England City, owing to some extensive quarrying. Occasionally upon the serrated hills of the Red Mountain series, the cherty limestone is preserved, and weathers into castellated towers, as near the southern end of the hills where the two sheets of the ore beds come together. The flinty material is sometimes uniformly distributed through the somewhat thin beds of limestones, again it forms seams, or else it makes up most of the beds. In weathering, pockets of clay are often left and these may be of the nature of kaolin or other valuable clayey deposits.

Between the cherty ridges and the mountains there are narrow valleys formed out of the overlying rocks of the Mountain Limestone series. Whilst these rocks are not mountain making of themselves, yet along the foot of Lookout and Sand mountains they are protected by the overlying sandstones, and form more or less of the base and sides of the plateaus. They are usually compact blue limestones in thick beds. The upper beds have thinner laminations and are less pure, and somewhat sandy. The thickness of the formation is about 500 feet. Owing to coverings by superficial clays, derived from the weathering of the superior rocks, the limestones are more or less cemented. Below Cole City the limestones are exposed along Nickajack creek.

COAL MEASURES.

Lookout mountain Coal Measures have already been described in Walker county, as most of the plateau lies in that county. In Lookout valley there are two remnants of the Coal Measures left—on Fox mountain and on the plateau above Whiteside.

Sand mountain is capped with the Coal Measures. On its eastern side, however, the sandstone, which corresponds to the conglomerate of Lookout mountain, has been removed in many places owing to denudation.

The highest beds of the series lie about three miles north of Cole City, near Mr. Liedermann's. On the top of the ridge twenty feet of heavy sandstones remain. Amongst shales, 75 feet beneath the top of the sandstone, a bed of coal occurs. The lower beds are concealed, but they are probably mostly composed of shales. They represent a vertical elevation of 250 feet above Cole City. As the direction is along the strike of the formation, this measurement may be taken for the thickness of the upper beds on Sand mountain, in Georgia. From Cole City downward a good section can be obtained. Yet the strata are liable to local variation, and thicken or thin out so as to give considerable variation in different sections. The rocks generally dip at low angles, to almost horizontal, although locally there are steeper inclinations.

Along the railroad from the coal mines to the coke ovens a good section of the series, except the upper portion, can be obtained. The beds lie nearly level or undulate very slightly.

	Feet
Irregularly bedded sandstone or conglomerate	70
Castle rock coal	wanting
Shale	40
Dade coal seam	average 3
Sandstone and sandy shale, variable	12
Coal (Reese's red ash seam)	3
Shale	6
Sandstones, or conglomerate—upper half thin bedded, lower half thicker, with shaly seams	20
Coal variable	0.5–3
Sandstones and shales	10
Blue shales	10
Sandstones, thin bedded, and shales or sandy shales	15
Coal 3 to 15 inches	1.25
Shales, middle layers heavy bedded	54
Coal smut	—

	Feet
Shale	15
Coal smut	—
Shale	4
Concretionary beds	6
Shale	15
Sandstones, thick bedded	15
Shale	10
Shale with some thin layers of sandstones	95
Shales (?) concealed	90
Limestones	—

Other less perfect sections and borings have been obtained, some of which are given in the Economic report.

The Coal Measures give rise to light sandy lands. The shales exposed at the surface are usually weathered red, but those seen in the mines, below atmospheric action, are generally dark blue.

CHAPTER XX.

RECENT FORMATIONS WEST OF TAYLOR'S RIDGE.

West of Rocky Face and Taylor's ridge, none of the gravels which have been referred to the Lafayette formation were seen, nor were the red loams; but these last might have escaped observation where there was no gravel, as they are superficially difficult of distinction from red residual clays. The valleys are very little higher than the lands of the Coosa basin. The explanation may lie in the fact that the district referred to stood a little higher than the Coosa basin during the submergence which allowed the valleys of the Coosa basin to have been submerged. At any rate the quartz gravel coming from the metamorphic highlands to the east would have been obstructed by Taylor's ridge. Still west of this region, there were hard sandstones which could have supplied material for the production of gravel. At any rate, if loam were laid down, during the Lafayette epoch, it has been removed by subsequent denudation to such a degree as not to attract attention at the present time.

As the rivers have not made extensive flood plains the bottom lands are not conspicuous, although the streams overflow irregular lowlands to a limited extent. But it is not a country of true bottom lands.

The soil is everywhere the result of the rock decay, and varies according to the source. These residual earths commonly cover up the undecayed rock formations, where the natural strata are exposed in only exceptionally favorable places; but the residual earths assist in locating the underlying formations.

The rocks are often sufficiently fossiliferous for their identification; and in the coal mines some beautiful plant remains occur.

PART II.

Economic Resources

OF THE

PALEOZOIC GROUP

OF

GEORGIA,

IN

POLK, FLOYD, BARTOW, GORDON, MURRAY, WHITFIELD,

CATOOSA, CHATTOOGA, WALKER AND

DADE COUNTIES.

BY

J. W. SPENCER.

ECONOMIC FEATURES

REPRESENTED ON THE

GEOLOGICAL MAP.

COAL MEASURES.........	Coal, gray sandstone.
MOUNTAIN LIMESTONE .	Limestone and building material.
FLOYD SHALE............	Limestone and building material.
FORT PAYNE CHERT....	Road metal, brown ore.
CHAT. BLACK SHALES...	
RED MOUNTAIN..........	Fossil ore, brownstones and flagstones.
CHICKAMAUGA	Slate, limestone, iron ore, ochres.
KNOX DOLOMITE	Brown iron ore, manganese, beauxite, limestone, kaolin, road metal.
OOSTANAULA SHALE....	Cement, black marble, sandstone, road metal.
THE METAMORPHIC ROCKS..	Iron and manganese ores, ochre, soapstone, heavy spar, graphite.

NOTE.—The occurrence of the ores, building materials, soils, physical features, conditions of the roads, etc., are all dependent upon the geological structure, and before any information, of scientific value, relating to their distribution and modes of occurrence could be given, it was necessary to prepare a detailed account of the geological structure of the belt surveyed. For information concerning the local geological conditions reference must be made to the first part of this report and to the geological map.

CHAPTER XXI.

BROWN IRON ORES AND THEIR MODES OF OCCURRENCE.

CONTENTS.

KINDS OF ORE.

Except the "fossil ore," the most important iron deposits of the Paleozoic group belong to brown ores and limonite varieties.

Limonite, in its purer crystalline form, is more or less globular or botryoidal with the internal structure fibrous and more or less silky in luster, having a degree of hardness varying from 5 to 5.5. The color is dark, rich brown, and the luster is sometimes metallic. Other varieties have an earthy appearance, of dull yellow or yellowish brown color, and soft—varying from one to three or four degrees of hardness. According to the admixtures, the color of the powder varies from ochre to yellow brown.

In composition, limonite is a hydrous sesquioxide of iron, containing, when pure, iron, 59.92; oxygen, 15.68; water, 14.40 per cent. Commercially, the percentage of iron falls below these figures on account of impurities. When limonite has lost its water, the mineral becomes hematite, and then the metal rises to 70 per cent. As a matter of fact, very little of the iron ores, passing under the name of brown ores in northwestern Georgia, are pure limonite, but are usually admixtures of this mineral with hematite derived from the former by the loss of the water. Thus the percentage of iron is increased, as most of the available ores contain only two to four per cent. of moisture. This mixture of iron bearing minerals is commercially known as "Brown Ore." This always contains more or less admixture of clay and sand. Amongst the elements associated with the ores, in small quantities, which have a bearing on the value of the iron, phosphorus only need be mentioned, as it renders the iron brittle when present in excess of mere traces.

The brown ores vary much in physical appearance, with the modes of occurrence and geological sources. It is frequently red, earthy, in small concretionary particles and masses; occasionally in large boulders; and again in irregular sheets. In all of the residual ores of the Paleozoic series, the appearance is much more earthy and of a darker color than the beds of brown ores, such as are seen in the metamorphic rocks east of Cartersville, which have often an ocherous appearance.

SOURCE OF THE BROWN ORE.

The brown ores of the older Paleozoic belt have been entirely derived from ferruginous limestones. Whether the iron was in the condition of carbonate or of sulphide is of little consequence, for where available it is now always associated with the remains of decayed limestones, some of which were highly calcareous with but little flinty matter; whilst again to a lesser extent, the iron deposits are derived from the siliceous beds, with a marked difference in character. Some of the iron bearing limestones may have been ferruginated after their formation, and that irregularly, by iron bearing streams, often flowing transversely, across the formations, from the older metamorphic rocks to the east; for frequently the trend of the ore bearing ridges is across the general direction of the formations, which normally extend from eastward of north to the opposite direction. Possibly, the directions of some of these former iron bearing streams can be recognized; but probably a greater proportion of the ore has been deposited synchronous with the rock formations adjacent to mouths of streams, or in lagoons, or as pointed out, in connection with manganese and aluminum ores. As all the valuable deposits are of secondary origin, often derived from the concentration of the ore upon the decay of the limestone, commercially the questions are:

"What formations contain ore, and what are the modes of occurrence?"

The origin of the deposits is similar to that of manganese, a discussion of which appears under that head.

THE MODES OF OCCURRENCE OF BROWN ORE.

NOTE.

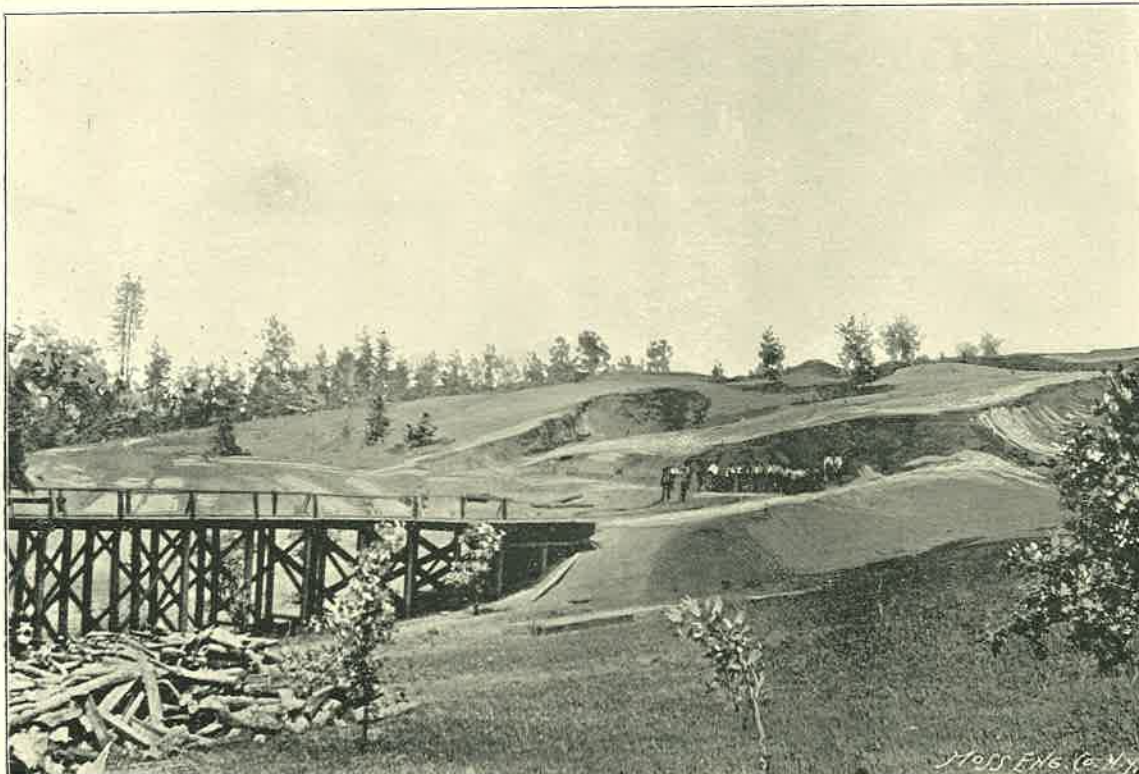
In the Geological Survey, the consideration of this subject is that of primary importance rather than a list of the known beds, as the object of the survey is to aid in the development of the resources, and in making known the belts of the same. Without the investigations recorded in the first part of this report, no key to the situation could have been obtained. Under such conditions the survey would have been only a catalogue of discovered iron bearing properties, without a scientific knowledge of the same. The applied deductions are here given as if the reader were familiar with the first part of the report.

The principal brown ores occur in distinct Lower Paleozoic formations—the Knox dolomite and the Deaton ore series, but it also occurs to a small extent in the Sub-Carboniferous series.

IRON ORE OF KNOX DOLOMITE SERIES.

From investigation, the first general deduction arrived at is the occurrence of the largest amount of workable ore upon subordinate elevations in red land derived from the lower Knox strata. The observation that such ore deposits are abundantly situated near the margin of the Knox formation can now be extended and explained

PLATE VII.



BROWN ORE RIDGE AND PITS,

In residual Knox clays, at Grady, near Fish Creek, Polk County.

from fuller surveys. This condition is dependent upon the accumulations of ore being largest in the lower and less siliceous numbers of the Knox series. These lower beds approach the surface, not merely along their northwestern margin, but where undulations of strata have brought the more calcareous beds to the surface. The presence of these beds has favored valley making, owing to their solubility and the absence of a protective covering of chert. Thus, by the deformation of the strata, the lower iron bearing beds are lifted up to view, adjacent to the underlying shale formations. But again, the ore deposits occur at no great geographical distance from overlying Ordovician limestones and shales, and, near the junctions of the formations, as in the Cedartown and Fish creek districts. This, however, is due, not to the presence of different formations, but to the undulations of strata and the elevation of lower beds, which have been reduced to valleys, owing to the removal of the calcareous matter, in localities where the cherty beds have not been sufficiently protective. This same condition obtains where undulations of the Knox series is not overlaid by higher rocks, as northwestward of Fish creek, west of Seney and onward. Consequently, wherever there are broad valleys, carved out of lower dolomite beds, with red lands, ore beds are more or less common, and accordingly, there are several parallel belts.

Naturally, the removal of the calcareous matter, would produce valleys, wherever it comes to the surface, but the ore deposits resist erosion and becomes more or less protective. Consequently, the brown ore is most commonly found on subordinate ridges in the valleys. (See plate VII. on opposite page.)

As already stated, the form of the ore is usually in small concretions, sometimes becoming large boulders, or occasionally beds of limited extent, very much disturbed. This refers to the ore in the red hills. The ore bank is an accumulation of ore deposit remaining from the decay of a great thickness of rock, and in many places, it is known to be more than from 40 to 50 feet deep, above the natural drainage level; and often passing far below it in other localities. In these regions, but little dependence, or indeed value need be placed upon the bedded portions. The accumulations of the "wash" ore are of greatest value on account of their better quality and more economic working.

A characteristic of these ore beds is the rising up of masses of clay—technically "horses" amongst the ore. Often the clay is white or pink with but little iron, and standing up in strong contrast with the ore. These clays often show a commingling of much undecomposed feldspar, and appear to have been deposited as irregularly as they are now found. (See analyses under clays.)

The proportion of concretionary ore in the banks varies, but has been worked where it yields upon washing even less than one-fifth of the mass; seldom is it more than one-half. The large ore masses, whilst being mostly made of limonite, are more expensive to work than the wash ore. The small ore has lost most of its water, and is usually of a brown or reddish color.

In portions of the cherty beds of Knox dolomite, brown ores occur similar to those just described, but their development is of less extent; perhaps due to the lower degree of concentration, owing to the protective mantles of siliceous matter. Again, vesicular beds of chert—the calcareous matter being removed and leaving the cavities—are often rich in iron, and occur in massive strata. The ore in such beds is usually too siliceous for present use, and the wash ore is generally less extensively developed in these gray than in the red hills.

Between these two characters of beds—red hills rising in the valleys, and gray ridges—there are intermediate conditions; so that the sharp lines between the relations of the ores cannot always be defined.

Stratification is not usually seen in the residual accumulations, as is already noticed; and consequently, the tracing of the beds is rendered difficult. This absence arises, in part, from the disturbed

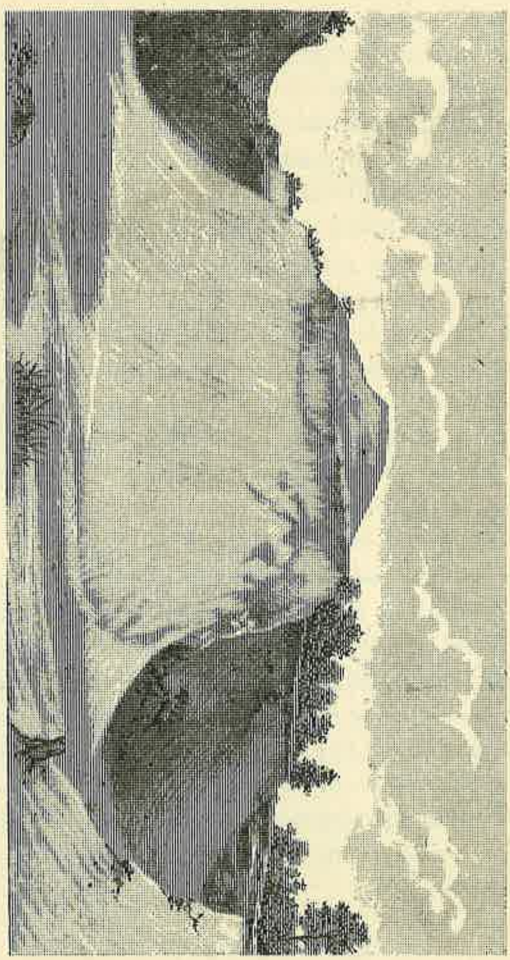


FIGURE 22.—White "clay horse" in brown ore banks at Grady.

condition of the strata, and, in part, from the irregular falling of the decayed beds into underground cavities, thus obliterating bedding. This is seen in some cases, as on the State line, in Etna pits, where some of the ferruginous rocks have been in heavy beds. (See plate VIII. beyond.)

The ferruginous beds can occasionally be traced short distances and are then found to graduate into ocherous beds of clay, and eventually become obliterated.

The ores of the Knox dolomite are often thickly strewn upon the surface of the low ridges, as pebbles, in size, from that of shot to large cobble stones, or boulders. In such cases, the ore may continue downward to the depth of undecayed rock. The hills are of deep red color, not only from the presence of ore, but from the coloring in the clay. Other portions of the hills are simply covered with deep red soil, and beneath them the ore is sometimes found. Such is especially the case when this covering is of the Lafayette series.

It may be stated here that when the Lafayette loam does not contain gravel, it is not always easily recognized from the residual superficial formations which have the same general appearance.

The covering of the valuable ore beds is often shallow. It is seldom more than eight feet thick. In it, the quantity of the ore often reaches twelve or fifteen per cent., and justifies the washing of this covering sheet, but the amount is seldom enough to warrant its use when the ore is only screened.

Sometimes, the ore occurs beneath clay horses. In these cases, it may soon become valueless, because of the masses of clay that must be first removed.

ORE OF THE DEATON SERIES.

These ores differ in appearance from those of the Knox dolomite. They never form concretionary or rounded gravel, but they make more or less angular shingle, scattered over the subordinate ridges. When these deposits are worked far enough, the ore is found more or less in beds of variable thickness. However, these beds often pass into ferruginous clays and soft ochres. (See plate I., frontispiece.)

The mineral is mostly limonite and is often yellowish, but that exposed on surface is brown or red. It may be slightly magnetic, on account of being associated with semi-metamorphic rocks. Thus, it appears, that the rocks were ferruginated before the metamorphism of the strata situated immediately to the south.

The ore is derived from ferruginous limestone, which may be seen in Deaton mine, near Taylorville. Here is found a dark, undecomposed compact crystalline limestone, containing 25 per cent. of iron. But usually the rock is disintegrated, leaving beds of shingly ore. At this named locality, the underlying Maclurea limestone was rendered cavernous, and the roof being composed of iron-limestones, has fallen in, making a confused mass of ore. This will be noted later and may also be seen in plate I. (Frontispiece.)

Ores of this horizon occur in low ridges in Whitfield county, lying in thick beds, associated with the limestone. The mineral, however, has a more specular appearance than seen at Deaton. These ores belong to a horizon which may be correlated with Safford's Iron-Limestone series.

ORES OF THE SUB-CARBONIFEROUS SERIES.

The lower member of the Sub-Carboniferous series consists of the Fort Payne chert, a siliceous or cherty limestone, in which some layers consist almost entirely of siliceous matter. In many localities some of these beds are highly ferruginous to such an extent as to give rise to beds of brown iron ore. Such may be seen on the ridges of southern Polk, where the ore is compact and approaches hematite in appearance.

In limited quantities the ore of the same horizon is sometimes seen in the extreme northwestern portion of the State. On Horn's mountain the ferruginous beds are near the base of the series immediately overlying the black shales of the Devonian system, on the eastern flank of the mountain. The original rock is decayed, and the calcareous matter is almost entirely removed from the limestones, leaving a concentration of residual clays (sometimes in "horses") in which boulders and irregular laminations of ore occur in workable quantities. If mining were carried below the drainage level, it is very doubtful if the ore would be sufficiently concentrated for an available supply of iron. This ore contains much more of the yellow limonite than the Knox ores.

CHAPTER XXII.

LOCAL DISTRIBUTION OF BROWN ORES.

CONTENTS.

KNOX ORES IN POLK COUNTY.

A portion of this county has already been reported on, but for the sake of fuller treatment of the subject, the general features given before will be included in this present and more extensive report. Only a few properties in the ore belt could be named, as every section bearing ore could not be visited, but those named will aid in the location of the richer belts in the ore bearing zone.

BROWN ORES IN THE BASIN WEST OF THE LITTLE CEDAR CREEK.

This is a basin about two miles wide and eight long, extending from Indian mountain, in Polk county, into Floyd. Owing to faults, this basin is isolated from the other portions of the Knox series. Here the country is made up of somewhat narrow valleys and rugged, gray, cherty ridges. In this basin, there are several deposits of brown ore of the usual type, but these often go below the drainage level. Thus, on the property of Mr. Linton Sparks, lots 139 and 140, 17th district, there are pockets of good and of indifferent ore, side by side, and these appear to have been derived from different beds. On the ridges near by there are several surface exposures of thick siliceous beds, some of which contain ore rich in iron. These sheets occur on the Stott-Folger and other properties. Again, there are other ferruginous beds of ore of inferior value to the ore banks, which can be more economically worked. Some of the ore is manganiferous. In a pit of Mr. Sparks' the ore is seen to pass down beneath a clay horse.

The outlet of this basin is "Hematite" siding on the E. T., V. & G. Railway.

BROWN ORE IN THE VALLEY ADJACENT TO THE E. T., V. & G. RAILWAY.

On the east side of the valley a chain of ore-bearing ridges from Alabama enters Georgia at Etna, on the extensive property of Col. Hamilton. On the western side of the valley, except near Oredell, the hills are slaty and barren. The bottom of the valley is generally underlaid by Cambrian shales or slates, but the ridges to the east are composed of overlying decayed Knox dolomite, partly brought into position by a fault. Along the western flank of the ridges there are subordinate ore banks.

On the State line there are extensive workings which have exposed the ore to a depth of 60 or 70 feet without reaching its bottom. As usual, it is a heterogeneous mass, but contains thick beds of solid ore, as if disturbed by the falling of the roofs over lime-sinks. In fact, the true stratification of the Knox ore beds is generally lost. The ore has a less concretionary and more massive form than is generally seen farther east in other Knox deposits, and contains more or less included flint.

Northwestward of the State line, there are many extensive ore banks belonging to the Etna Company. The analyses of some of these

PLATE VIII.

BROWN ORE WORKINGS

In the Knox formation at Etna (Col. Hamilton's).

ores will be given in the sequel. However, it may be noted here that considerable manganese is seen in various places, and that sometimes the fresh workings show efflorescence of vitriol. Beyond Etna, similar ore banks occur at Pryor's (Wood's, etc.) and Oredell, being subordinate ridges of red ore-bearing lands rising in the valley, or on its margin. In an artesian well sunk at Oredell the ore was found to continue to a depth of one hundred and eighty feet.

In a cut along the railway the decayed formation shows much confusion, but appears to dip at variable angles at N. 15° W., and the ore deposits seem to belong to one horizon. In a pit near by, the ore passes under a white clay horse 10 or 15 feet thick, below which it would hardly pay to work.

The ridges, on the eastern side of the valley, are to some extent characterized by accumulations of the usual type of ore, but there are also other deposits of ore associated with the flinty or siliceous beds of the gray lands. Usually these deposits are inferior to those on detached ridges farther from the cherty beds.

All of these ore beds are convenient to the E. T., V. & G. Railway.

Farther north, upon the eastern side of the railway, other workable beds of ore are found before reaching the Floyd line.

Thus, it is seen that the whole chain of ridges bounding the valley east of the East Tennessee, Virginia and Georgia Railway forms a belt of country rich in ore ridges.

BROWN ORES ALONG THE EAST AND WEST RAILROAD OF ALABAMA.

Upon the western border of the Ordovician or Lower Silurian slates, the Maclurea limestones are valley making. Beyond these, many beds of iron-bearing Knox ridges occur. These form the great deposits of the Cedartown district. This belt enters Georgia at Esom Hill, near which place are the Brewster and other banks. At various points the ore banks reoccur, such as at Mr. Rice's, near Berry station.

The largest assemblage of ore banks is two or three miles south and west of Cedartown, amongst the chief of which are the Reed, Ledbetter, Peek, Wood and other deposits, many of which are now included in the properties of the Augusta and the Central Mining Companies. Continuing onward, the ore appears at Mr. Waddell's and Mr. Frank Sheflets, two and a half miles north of Cedartown, and on some other lands. These ore banks rise from a few feet to fifty or one hundred feet above the valley. The ores are mostly small, concretionary lumps or masses, but with some greater blocks or boulders. In Peek's mine, ore has been seen approaching a bedding, and on an abandoned hill, ferruginous chert bluffs are seen. In all of these banks clay horses rise up and interrupt the pockets of ore (as represented in figure 22, page 155), but the ore has frequently a known depth of more than 40 feet. To one unfamiliar with the ore the first impressions are often disappointing, as the value of the fine ore is greatly obscured in the clay.

Southeast of Cedartown these ore banks are not continuous throughout the belt. Two of the ore-bearing ridges rise up through overlying Chickamauga shales two miles south of Cedartown. Another iron-bearing locality occurs east of the shale basin south of Cedartown, near Young's mills, and at the Cleveland, Pittman, Cox and Ray banks, between Young's and the metamorphic region to the south.

FISH CREEK DISTRICT.

A few miles to the eastward, ore beds of the Knox series are again brought to the surface, near Fish creek. At Grady station there is an assemblage of large ore banks belonging to the Cherokee Iron Company and to the Central Mining Company. There are large deposits of the usual type with great clay (often white) horses, rising into the ore accumulations. See plate 7.

Other ridges extend southward, as at Hickman's and Simpson's mines (lot 1015, 21st district), W. O. Morris' (lots 1088 and 1133); and Mrs. Morgan's and Mr. Winn's (lot 1060, 21st district).

This belt continues, with interruptions, northward, to between one and two miles west of Seney and thence into Floyd county. Northward of Grady, on this belt, ore occurs on lands of T. H. Peek and adjacent properties; on several lots belonging to Mr. T. Colbert (as on lot 306, 21st district), B. F. West and others, thus showing the continuity of this belt across the country.

LONG DISTRICT.

Another belt is adjacent to the East Tennessee, Virginia and Georgia Railroad, between Rockmart and Seney, especially in the region of Long station. These deposits are on subordinate ridges on the western side of the valley of the Chickamauga series. From these beds large quantities of ore have been shipped, the principal mines being those of the Central Mining Company, the Randall and the Cochrane.

RECAPITULATION.

There are now well established six different belts of brown ore deposits, dependent upon the geological structure as described elsewhere. These are: (1) in the fault basin north of Indian mountain; (2) that from Etna to Cave Spring; (3) the Cedartown; (4) that southeast of Cedartown; (5) the Fish creek zone; (6) the Long station district. There are outlying deposits of brown ore, especially among the chert ridges; but the deposits in the belts described are those of most value. In the survey of the belt, many properties were visited.

The belts having now been indicated with the modes of occurrence of the ore deposits, the primary object of the survey in the region is attained upon the publications of the report.

Knox Ores in Floyd County.

CAVE SPRING DISTRICT.

Entering Floyd county, the second belt of brown ore described in Polk county, continues northeastward, and with many breaks, extends across the country, amongst the Knox ridges eastward of Van's valley. These ores are, consequently, situated at no great distance from the border of the Knox dolomite formation. This belt of country is more broken than in Polk county, with ridges of the cherty beds of the Knox series, and consequently there are more repetitions of ore beds, although many are of inferior size. Then again, amongst the cherty ridges, the ore is frequently seen, with characters described elsewhere.

A few examples in the belt between Cave Spring and Rome may be given. Of the type of ore beds amongst the gray ridges and narrow rugged valleys, is the mine of Dr. Montgomery, north of Cave Spring (lot 620). This is on the eastern side of a steep ridge bounding the narrow valley. The ore is beneath residual beds of clay, dipping 10° S. E. The ore is very unequally developed.

The belt of Little Cedar creek enters Floyd county, and there are extensive deposits on the properties of Major J. M. Couper. This continues onward, and adjacent to Cedar creek the features of the country are rounded, and there is a considerable number of ore banks. Mr. J. W. Asbury's lot (950 ?), about two miles northeast of Cave Spring, has an extensive low ore bank situated in the valley. Near by, ore occurs on lands of Mr. Wiggins (lot 948), on Mr. Simmons' (lots 923 and 924), and other properties.

Near the creek, on the farms of Mr. Roberts and Mr. J. R. Scott, ore occurs, but associated with much cherty soil.

In the district northeast of Cave Spring, near Six Mile Station on the border of the valley composed of Cambrian shales, there is a subordinate ore-bearing ridge situated on farm of Mr. Gibson.

Passing near the western Knox ridges, ore is found in many places, and in some cases the deposits are large. At the foot of a ridge of gray land, there is a large development of brown ore, forming almost an irregular bed in Booboohollow, on lot 692, and adjacent properties.

Further south, on Cave Spring road, just back of New Prospect church, a large outcropping bed of siliceous brown ore occurs.

On the top of the red ridge, back of New Prospect church, brown ore (and also manganese) occurs. From a well, on this high ridge, it appears that only the surface is composed of red clay, and the cherty earth occurs beneath.

Again, the ore occurs on Mr. R. S. Brammon's land (lot 14, district 22). Large deposits of ore occur near Mr. J. A Howell's beauxite beds, lot 610, 22d district.

Indeed, ore in limited quantities, is likely to be found in many portions of the triangular area of the Knox formation, west of the East Tennessee, Virginia and Georgia Railway. The region is one characterized by gray ridges (sometimes red) and often narrow valleys, except along Cedar creek, and the northwestern border of the formation.

SPRING AND SILVER CREEK DISTRICT.

Between Seney and Silver Creek (P. O.) the valley is wider and less abrupt than west of this meridian. At less than two miles west of Seney, the road enters the Silver creek valley, which represents a belt of lower Knox ore-bearing lands, that extend southward to the banks of Grady. At about three miles from Seney (on Rome road), there is ore at several points, as on land of Mr. Vincent.

On nearing Silver Creek (P. O.) the valleys become broader, and on ridges up to 50 or 80 feet in height, brown ore occurs at several places, as on the lands of Mr. W. C. Howell, two miles south of Silver creek. On the ridges east of Silver Creek (P. O.) the ore again occurs on Coughly or Rich farm, and adjacent properties on road to Chulio.

From near this point a stream extends north, midway between Spring and Silver creeks. In this valley there are several large ore banks on the subordinate red ridges, as on the lands of Dr.

Boyd, Mr. C. Ivens, T. Cochrane, L. Mathews, S. Hoffman, and J. B. Alexander (lot 214, district 22). These latter are in gaps amongst the higher ridges, and show ore on extensive surface exposures. The deposits may be considered in the same belt as those of the upper part of Silver creek. The valley of Spring creek forms another belt of ores. This zone is a continuation of that at Long's, in Polk county.

About two miles southeast of Seney, there are large ore banks belonging to Mr. Henry Wood (lot 194, district 22), and on adjacent property of Mr. G. C. Drummond.

Several deposits occur about Chulio, and are reported on lands of Mr. N. Wimper (lot 222, district 22), Mr. A. Johnson (lot 205, district 22), Mr. Lyons (north of Chulio), etc.

Again, there are deposits of large size east of Rounsaville, passing into Bartow county, in the report of which they will be described.

North of the Etowah river, near the northwestern border of the Knox series, ores occur in quantities. On the Blackstock (about lot 186, 23d district) and other properties, the ore occurs in the red hills. In the northeastern corner of the county, adjacent to Armstrong mountain, there are many ore beds, some of which have been worked for the Ridge valley furnace, at Hermitage. Here the deposits are intermediate between the red and gray lands, or the purer and the more cherty ore beds.

RECAPITULATION.

In Floyd county, the ore belt of the Etna, Cave Spring and Cedartown district coalesce, but the country is broken up by the repeated ridges, into a vast number of deposits, many of which are small properties. Also, there is a close proximity of those deposits, derived from the cherty dolomites (gray lands), and from the more earthy red lands.

The Fish creek belt continues northward into the upper part of

Silver creek valley, and thence into another valley, midway between Rome and Spring creek.

The Spring creek zone commences in the Long district, in Polk county, passes east of Seney, and enters Bartow county, east of Rounsaville (or Bryant) P. O.

North of the Etowah, the principal ore belt lies near the northwestern margin of the Knox series, and extends to the Armstrong mountain.

Knox Ores in Bartow County.

SPRING AND SILVER CREEK DISTRICTS.

The Spring creek belt of ores enters Bartow county southwest of Rounsaville. Extensive beds are found near Ligon (on Mr. R. L. Griffin's land, lot 426, 17th district, and many neighboring lots); also on the farms of Mr. Z. T. Nichols, John Beck and Mr. C. Dodd. The quantity of the ore is large, and the conditions are similar to those at Cedartown.

At Mr. Nichols' house, in a well, the residual red clay extends to a depth of thirty feet, beneath which the earth was of lighter color but not cherty. These red hills form a chain of disconnected eminences trending east and west. Some small deposits of ore occur northeast of Taylorsville.

TOM'S CREEK AND CONNESENNA DISTRICT.

North of the Etowah river ore is again seen in the drainage valley of Tom's creek, as at Mr. Osborn Shaw's (about three miles from mouth of creek). Here the ore is more or less bedded in an excess of chert.

West of Linwood, on the Barnsley estate, the ores again occur. West of Adairsville, ore is seen in the broken country on lands of Mr. J. J. Johnson (lots 108 and 109, 15th section), Mr. Cass Walters and others.

In the valley of the Connesenna brown ore occurs, as on lot of

Mr. Connaway (lot 116, 17th district). Here the soil is yellow and the surface covered with some chert. Ore also occurs on land of Mr. C. W. Waldrop (lot 136, 16th district). Ore is seen again on lot (100, 16th district) of Mr. Robert Kerr. The ore is in quantities on lots 52, 99, 8, 9 and other properties east of the Connesenna valley.

In the upper part of Cedar creek, in northeast Bartow, small quantities of brown ore occur on lot 55, 6th district, on Mrs. Slaughter's land, and on adjacent ridges, etc.

Near Rogers' station (on the W. & A. Ry.) some ores are seen. In the valley of Petty's creek, about five miles north of Cartersville, brown ore covers some Knox ridges.

RECAPITULATION.

In the western part of the county, south of the Etowah river, brown ores occur, principally near the Floyd line. North of the river, the largest developments are adjacent to and mostly west of the Western & Atlantic Railway. The country is broken by ridges, but these are continuations of belts from Polk and Floyd counties. There are a few localities of ores in the central part of the county where outliers cannot be correlated with the other belts, except that they are in the Knox dolomite series.

ORES OF THE METAMORPHIC ROCKS.

The ores in the eastern part of Bartow are extensive, but belong to another group of rocks which have only been approached at a few points and not yet sufficiently surveyed to be reported on. The district is of great importance, as seen from the fact that one company alone shipped 30,000 tons of brown ore between October 1, 1890, and November, 1891.

THE ORES OF THE SUB-CARBONIFEROUS SERIES.

The brown ores of this series have been referred to. They occur in Polk county on cherty ridges, associated with cherty beds.

These are on Mr. West's and adjacent properties, about six miles south of Cedartown. Some of the deposits are rich in iron, but they are mostly massive. Similar, but poor deposits occur on ridges about Rockmart.

Deaton Ore Series.

These ores are found at only a few localities, northeast of Rockmart. The Deaton mine represents the principal working. This is situated near Taylorsville. A plate of the mine has already been given (frontispiece). The mine is on lots 81 and 64, 18th district. The Central Mining Company has similar deposits on and adjacent to lot 1076 of same district. The formation is found on lots 714 and 715 (Carlton's), 869, 870 and 932 (Haton's), and 868 (Jones'), all in the 18th district, most of which lots belong now to the Rockmart Development Company. These accumulations represent residual beds of the series resting upon the Chickamauga limestones, and at the edge of the hills of the Rockmart slates. Some of these banks rise to 100 feet above the valley. Their modes of occurrence are described elsewhere (pages 46 and 84). Other banks may yet be found. The workings at the Deaton bank are shown

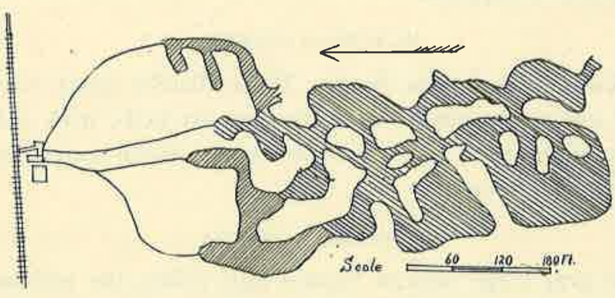


Figure 23.—Plan of Deaton Mine. Shaded portions show the galleries of the ancient cave, which became filled with ore by the falling of the roof of the iron-limestones. The enclosed white areas show natural pillars of limestone.

in the little map (figure 23). At the back part of the opening, the heterogeneous mass passes into bedded ore, not interrupted by the limestone pillars shown in figure and frontispiece. Almost the entire mass is ore, with only a moderate amount of ferruginous clay. The favorable conditions of occurrence, and the situation directly upon the line of railway, permits of the loading of the ore at less cost than any other ore in the State. The condition of the ore is already described. The depth reaches at least forty feet.

The beds at the Central Mining Company's property often show the ore passing into an ocherous clay. The other banks are not developed.

Knox Ores in Gordon, Murray, Whitfield, Catoosa, Chattooga, Walton and Dade Counties.

IN GORDON COUNTY.

The Knox ridges west of Adairsville extend as a wedge into Gordon county. These ridges diminish in size and die out. Amongst them there are iron ore deposits, but scarcely of importance. East of Adairsville the often ferruginous ridges extend into Gordon county, but die down into a gray rolling country, and most of the characteristics disappear.

IN MURRAY COUNTY.

The Knox series in the Spring Place district gives rise to the deep red soil so characteristic of the iron ore beds, with some surface accumulations of ore. In this region closer search may find larger deposits of ore.

IN WHITFIELD COUNTY.

On the gray ridge west of Tunnel Hill valley, the residual clays in part give rise to reddish earths, and in part to very cherty land. In these red earths, pockets of brown ore are occasionally found.

IN CATOOSA, CHATTOOGA, WALKER AND DADE COUNTIES.

In the cherty ridge of Knox series extending from near Tunnel

Hill northward, brown ore is frequently met with. It is more or less associated with cherty beds. In the belt of the same formation, west of Rocky Face, it also recurs northeast of Holland, and thence northward there are accumulations of ore in the Knox dolomite series. Also on the ridges west of Summerville. Indeed, wherever, the Knox formation occurs, there are apt to be some deposits of brown ore. In this section of Georgia, the cherty portions of the series prevail, with a consequent inferior development of ore as compared with the red lands of the same series east of the Coosa river.

The Deaton Ore Series.

The Deaton Ore series may be represented in the ferruginous rocks extending from eastward of Varnell to the Tennessee line. They are associated with deep red colored lands and ferruginous limestones. The ore is unlike any other in the belt surveyed, being a pseudo-specular ore with smooth surface and submetallic luster. The deposits are more or less bedded, except where such are broken. These deposits are seen not only at the Catoosa (?) Company's property, a mile and a half from Varnell, but also near Red Clay, on the land of Mr. W. K. Sheddon.

Sub-Carboniferous Ores.

Sub-Carboniferous brown ores occur in large quantities in the extreme southeastern part of Walker county upon the eastern flanks of Horn's mountain. These deposits extend into Gordon county, west of Sugar Valley. The beds have already been taken as a type (page 157) of Sub-Carboniferous brown ores. At that locality they have been extensively worked. The same ores also occur upon the western side of Big Texas valley. Similar ore is seen at many points where the Fort Payne chert comes to the surface, as on Fox ridge; still few diggings have exposed the occasional developments. As an ore-bearing formation, this series is less important than the Knox, the cherty members of which it often resembles.

CHAPTER XXIII.

THE COMPOSITION OF THE BROWN ORES.

MODES OF WORKING THE ORES; FURNACES, ETC.

ANALYSES.

The workable boulders of brown ore do not generally contain less than fifty per cent. of the metallic iron. The beds of cherty ore, so often associated with the gray ridges, are usually too high in silica for profitable working, on account of diminishing the percentage of iron and the additional cost of fluxing and reduction.

The quantity of the phosphorus is variable. In some cases the phosphorus is very low, but again it is sufficiently large to prevent its use, although this is not generally the case.

Manganese is present in some ore banks to an appreciable quantity. Zinc is occasionally found. A curious product was accumulated beneath the funnel of a charcoal furnace (Cherokee of Cedartown), and when the furnace was blown out in 1880, about ten tons of the following products were obtained:

	Per cent.
Zinc oxide	83.443
Alumina and iron	3.700
Coal dust	3.140
Alkalies (by difference)	9.857
Sulphur	0.203
Cadmium oxide	Trace
Insoluble matter	0.600

The variations in the composition of the ores of the Knox series is shown from analyses for the Cherokee Iron Company by Ernst. Sjösted, chemist:

CEDARTOWN AND FISH CREEK ORES.

	I.	II.	III.	IV.	V.	VI.
Silica	8.01	15.95	9.27	12.18	10.60	10.19
Alumina	13.21	17.01	41.48	5.52	3.71	6.85
Iron sesquioxide	70.57	57.00	78.85	71.28	80.14	75.14
Lime	1.27	1.13	1.61	2.99	1.49	2.41
Magnesia	0.42	0.22	0.48	0.50	0.11	0.41
Manganese	0.12	0.93	0.40	0.27	0.38	0.35
Phosphoric Acid	0.58	2.17	0.91	1.11	0.88	1.00
Water	5.01	4.88	4.20	6.08	3.08	3.51
Iron, metallic	49.40	39.90	55.00	49.9	56.1	52.6
Manganese	0.09	0.72	0.31	0.22	0.22	0.27
Phosphorus	0.253	0.949	0.399	0.491	0.386	0.438

No. 1. Roasted ore from the Grady Bank. II. Roasted ore from Peek's Bank. III., V., VI., ores used on three succeeding days in furnaces. IV. Washed ore.

The iron ores, being variable, yield metallic iron, containing from 0.20 to 0.75 per cent. of phosphorus.

ETNA ORES.

A number of analyses of the Etna ores was furnished by Colonel Hamilton. Of these, one complete analysis may be given:

	Per Cent.
Iron sesquioxide	81.26
Manganese sesquioxide	0.43
Alumina	1.12
Lime	6.12
Silica	5.79
Water	11.45
Phosphorus	0.05
Sulphur	0.01
	100.23
Metallic iron	56.88

The analyses of the ores obtained at eleven other ore banks gave the average yield:

	Per Cent.	
Metallic iron	from 58.45	to 51.10
Metallic manganese	from 0.20	to 5.60
Silica	from 2.40	to 7.87
Phosphorus	from 0.147	to 0.858

One analysis showed 16.39 per cent. of silica. Another analysis gave 1.396 per cent. of phosphorus. The above analyses were made in the laboratory of Messrs. Cooper & Hewitt, Reegelsville, Pennsylvania.

The analysis of the iron produced in May, 1890, showed the presence of:

Silica	0.253	0.337
Manganese	0.144	0.124
Phosphorus	0.412	0.393
Sulphur	0.000	0.000

The character of the ore, as ready for shipment, differs from that in the beds only in concentration.

THE ANALYSIS OF THE ORES FROM THE DEATON (COUPER) MINES.

	I.	II.	III.
Metallic iron	48.56	49.32	49.80
Silica	14.25	11.04	12.03
Phosphorus	0.363	0.335	0.287
Sulphur	Trace.	......	......
Titanium	0.011	......	......
Water	1.30	2.53	......
Lime	......	0.73	Trace.
Alumina	......	......	9.04

One individual analysis gave iron only 33.12 per cent., and others showed the phosphorus below 0.3 per cent.

MODE OF WORKING THE ORE BANKS.

Until comparatively recently, the ore was simply dug out of the banks and screened, thereby losing a large portion of the best ore. The product was thus concentrated to nearly 50 per cent. of metallic iron. In some cases, the ore was roasted before use, whereby further impurities, as adhering clay, were removed.

Washing of the ore is not adopted in the smaller workings, but this method is much more costly than where the pay dirt is washed, not only on account of greater cost of labor, but also because of the smaller product. Under such conditions the richer deposits can only be worked. Now a great change has been brought about by the use of screw washers, whereby ferruginous earth with only a small per cent. of iron concretions can be concentrated and sent cheaply into the market, with composition as given above. In a few cases, the cost is further reduced by the use of steam shovels. Under the former system it frequently costs a dollar a ton for raising the ore. At the Deaton mine, the ore can be put on the cars at less than fifty cents a ton.

The plant for washing costs $2,500 and upwards. But in the larger pits this has now become necessary. Still, even during the summer of 1891, many small pits were being worked, and the ore transported by wagons, three miles or more, to the railways.

THE ORE PRODUCT.

In 1890, the brown ores derived from the Knox series amounted to about 200,000 tons, shipped outside of the State. Besides this quantity, about 60,000 tons were consumed in furnaces in the districts.

Whilst railway facilities are close at hand for the shipment from many districts, yet there are many others too distant to be, as yet, in the market.

OCHRE WORKS.

Recently ochre works have been established at Rockmart for the manufacture of paint from the ferruginous clays in that district.

At Cartersville, an establishment has been in operation for some years. The ocherous clay is not then obtained from the Knox series, but from decayed, metamorphic rocks south of the town. Hence further notice will be postponed for a future report.

CHAPTER XXIV.

RED IRON OR "FOSSIL" ORE.

CONTENTS.

HEMATITE.

Hematite has a hardness of 5.5 to 6.5; specific gravity 4.5 to 5.3. When crystalline, the luster is metallic, but it also occurs in an earthy form. The color of the earthy form is red, with a cherry red or reddish brown streak. When crystalline, the color is steel grey or iron black. The fossil ore belongs to the red variety, although it often contains small concretionary particles, having a steel grey or iron black luster. Hematite is the sesquioxide of iron, and, when pure, contains 70 per cent. of metallic iron and 30 per cent. of oxygen. Hematite, especially the earthy varieties, arises from the dehydration of limonite, which itself may be formed from the decomposition of the carbonate or sulphide of iron.

THE FOSSIL ORE.

Fossil ore is essentially hematite—of the earthy variety, and is a mineral of secondary origin; in short, it is a limestone converted into iron ore, and contains the impurities of the original limestone. Above the drainage level, the calcareous matter has been completely removed, leaving the ore in a concentrated state, but containing more or less sand and clay as impurities. Below the drainage level the calcareous matter still remains, to a greater or less extent;

or, in other words, the ore bed is a ferruginous limestone, containing from 10 to 25 or 30 per cent. of iron. The structure of the ore is essentially that of a mass of broken shells intermingled with small flattened nodules. This form is best seen in the ore above the drainage levels, from which the calcareous matter has been removed. The ore at greater depths approaches a massive, granular structure. This more compact mineral is known as "hard ore," whilst that above the drainage level, which is richer in iron, is designated the "soft ore." Owing to the concentration of the iron by the removal of the calcareous matter, the soft ore may contain iron to the extent of 50 per cent. or more. The change from the soft ore to the hard ore is sometimes gradual, but at other times sudden, with the lower portion of the same outcrop much harder and more compact than the upper bed.

The source of the ore appears to be the ferruginous shales, in which the ferruginous limestones are interbedded, and which have been, in part, converted into ore beds, owing to the percolation of rain waters, and the deposition of the iron into the fossil beds, and the simultaneous removal of an equivalent amount of calcareous matter. The exact process, however, is not known; but from the structure and preservation of the forms of the shells it is manifest that the greater part of the ferrugination took place subsequent to the formation of the limestones.

MODES OF OCCURRENCE.

The fossil ore beds in Georgia are entirely confined to the Red Mountain series, which is part of the Silurian system. This ore bearing horizon is commonly correlated with the Clinton beds of New York, although the typical subdivisions are not sharply defined in the southern Appalachian region. The thickness of this formation in Georgia, as noted elsewhere, reaches 1,100 feet. Whilst a portion of the formation, especially the eastern outcrops, contains massive sandstones, yet in the richer portion of the series almost the entire succession of beds is made up of shales with occasional sandy flags; indeed, the fossil ore bed has often the form of ferruginous flagstones. The ore beds vary in thickness from 10 inches (or sometimes less) to as much as 7 feet, although thicker, in places in Alabama. The common thickness, however, is from 20 to 36 inches. It is sometimes in one solid bed, or divided into two or more layers, and, occasionally the layers are separated by laminations of shales; thus considerable variation is produced, although the continuity of the beds is remarkably constant. The ore appears to occur somewhat above the medial horizon of the Red Mountain series, and in a horizon higher and newer than the heavy sandstones, such as are found in Taylor's ridge and eastward.

Whilst the Red mountain beds commonly lie at angles of 20° or 30° or less, yet the formation is folded and distorted to a very great degree, so that the beds sometimes dip at as much as 80°. This folding, or undulation, sometimes gives rise to a superficial appearance of a duplicate set of beds, as shown in figure 24. At this point

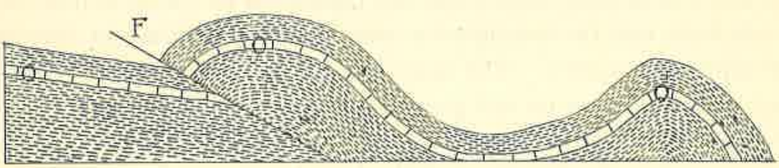


FIGURE 24.—At Wessboro mines. Folding and faulting (F) of beds. Ore bed (O).

not merely are the undulations seen, but also sharp faults.

Whilst the Red Mountain ridges rise up to form bold mountains in Taylor's ridge and eastward,—owing to the protective cappings of sandstone rock, yet the Red Mountain ridges which skirt Pigeon and Lookout mountains contain no heavy beds of sandstone, and thus the features are not so strongly marked across the country; but in many places, these foothills, composed of the ore formation, have been protected by interrupted cappings of Fort Payne chert, which have preserved the ridges and left a serrated chain of hills, rising two to three hundred feet above the valleys, as shown in plate IX. Upon these ridges, where not obscured by the chert, loose rectangular blocks of the fossil ore often mark the occurrence of neighboring beds of iron ores. However, the iron ore is commonly obscured by the covering of disintegrated red shales. Where the capping of chert is interrupted, the ridges are intersected by transverse depressions, which sometimes cut the ore beds in two, and expose their outcrops in the gullies, thus causing the continuity of the ore to be interrupted at the surface. At greater depths, however, these interruptions probably are of rare occurrence; and the ore extends downward forming sheets beneath the drainage level. Above the drainage level the shales are everywhere decayed, thus leaving the roofs of the mines in weak condition, although they become stronger the farther they recede from the surface, but below the drainage level, adjacent to the harder ores, the rocks become compact. In many localities the ore has a preservative effect upon the hills, and is found near the surface, and more or less parallel with the hill-slope. In such cases, the overlying shales are quarried off, without any attempt at mining, and the limit of such removal does not usually exceed 15 feet; but the ore is often taken out from beneath the shales by mining processes, as shown in plate IX.

Whilst the ore beds, in some places, are situated in the upper part of the Red Mountain series, yet the horizon is not fixed but somewhat variable. In many cases, there is only one bed; yet, in others this is broken up into two or more layers with shaly partings. When these shaly layers are thin, they do not prevent the mining of the ore; but in places, they become thick and then the amount of ore in the individual beds is insufficient to pay for the removal of the intervening rock. In some cases, the ore becomes shaly or sandy, and is too poor for working.

In the Red Mountain series, the shales above the drainage level are mostly red, although greenish or bluish where not weathered.

Also there are occasional layers of limestone, which have escaped ferrugination. Some of the shales become very sandy flagstones, and contain a large percentage of iron, but not sufficient for economic purposes. Indeed, the amount of iron in the workable beds is only a small percentage of the metal in the Red Mountain series. Below the drainage level, besides the ore beds, there are other layers of limestone, which have not been ferruginated. Sometimes the soft ore, near the surfaces, graduates into hard ore, below which again it becomes soft, owing to the admission of percolating waters, due to fracture and local faulting. The hard ore, below the drainage level has also a greater thickness than the soft ore at the surface.

CHAPTER XXV.

LOCAL DISTRIBUTION OF FOSSIL ORE.

CONTENTS.

DIRT SELLER MOUNTAIN.

This is a synclinal plateau entering the county from Alabama. Its surface is somewhat undulating, owing to unequal atmospheric erosion. This table-land rises 600 feet above the valley or 1,400 to 1,500 feet above the sea. This is the only table-land built out of the Red Mountain series, which usually gives rise to narrow steep ridges. The strata lie at low angles and the fossil ore layer commonly occurs near the top of the series, still remaining covered with only a few feet of shales. Where seen, it is composed of the rich "soft ore" variety. The ore bed is covered with disintegrated shale, which has been removed in workings, for the extraction of the ore. Mining operations have not been carried far underground. To the northern end of the mountain a branch railway has been constructed from Lyerly.

SHINBONE RIDGE.

Skirting Pigeon and Lookout table-lands, as well as the eastern side of Sand mountain, the serrated ridges of the Red Mountain series noted elsewhere form prominent features, as shown in plate V., page 48.

These narrow ridges rise from 100 to 300 feet above the valley.

In some localities, the preservation of the ridges is due to the ore beds, but the higher points usually owe their preservation to the remains of the Fort Payne chert series. Entering the State from Alabama, the first mines occur at Menlo, where the ore bed is divided into layers of nearly equal thickness, the whole varying from two to three feet. The upper layers are composed of soft ore. The strata dip at 20° N. 50° W. and the ore lies near the surface of the ridge upon its western side. Between this ridge and Pigeon mountain, there is a narrow valley. A short distance from the exposures noted, where the strata dip, at comparatively low angles, the ore beds are found dipping at 75°; and at one point the local synclinal was noted. The red ore continues northward throughout Shinbone ridge, and dips under the mountain to the west. These ore bearing ridges are, however, interrupted by occasional ravines.

At Bronco, the hard ore is being worked by a shaft over 200 feet deep. Adjacent to the foot of the shaft, the strata dip 80° N. 80° W. At this locality, the disturbances are great. On the eastern edge of the ridge, the dip is eastward; thence the strata pass into an overthrow at the mines, and afterwards flatten out beneath the plateau of Lookout mountain to the west. As this mine goes below the drainage level, the soft ore graduates into the hard variety. The former averages about 55 per cent. of metallic iron, whilst the hard ore contains from 40 per cent. downwards (see Composition of the Ores). The ore bed varies from three to three and a half feet, and lies in variable positions, owing to the physical disturbances. At a depth in the mine, several beds of unferruginated limestone occur. Although these are compact, yet they are more or less impure, and their weathered remains at the surface produce some of the red flaggy layers, which are of common occurrence at some horizons in the shale.

The best exposed section of the Red Mountain shales is seen along the railway cut at Dug Gap, which crosses the end of Pigeon mountain. It is shown along horizontal exposures, where the average dip is 8° eastward.

	Feet
Red laminated shales	510
Brown shales	180
Shales with numerous layers of flaggy sandstone, including some bands rich in iron, at a point 1,170 feet from the western end of section	600
Reddish laminated shales	1,140
Shales with hard flag-stones	180
Laminated shales	270
Shales with thin flag-stones	720
Hard red sandstones (14 inches thick) and shale beds with iron ore separated into thin seams	90
Hard sandstones, shales and flag-stones	450
Shales and flags with 2 feet of ore separated into layers by thin shales	90
Red and brown laminated shales	480
Ditto, with occasional flag-stones	1,280
Hard blue shales passing into red laminated shales, with some flag-stones	960
Devonian shales at western end of tunnel	

The longitudinal section reduced to vertical thickness gives 1,100 feet as the total depth of the Red Mountain series.

The ore formation gives rise to ridges about the northern end of Pigeon mountain. Again, it skirts both sides of the anticlinal valley of McLamore's Cove, and is seen on the property of Mr. Dougherty and Mr. Clarkson at the head of the cove, where the exposed ore beds have a thickness of from 6 to 18 inches. The ore beds are commonly more or less covered with shaly soil, and the full extent of the deposits is not known, owing to the few natural exposures. These ore belts continue northward, along the eastern side of Lookout mountain, almost to the Tennessee line.

Along the Chickamauga and Round mountain railway, there is a longitudinal section across the series, having a length of about half a mile. In this section, there are fewer flaggy beds than at Dug Gap, just described. At this locality the shales are more massive and less laminated than to the eastward. The strata dip at 20° N. 70° W. with some local disturbances.

A short distance south of the railway just mentioned, the Wessboro mines are in operation. The position of the ore beds is similar to that just mentioned, but with local disturbances produced from faults and changes of dip, varying from 20° to 70°, as shown in figure 24.

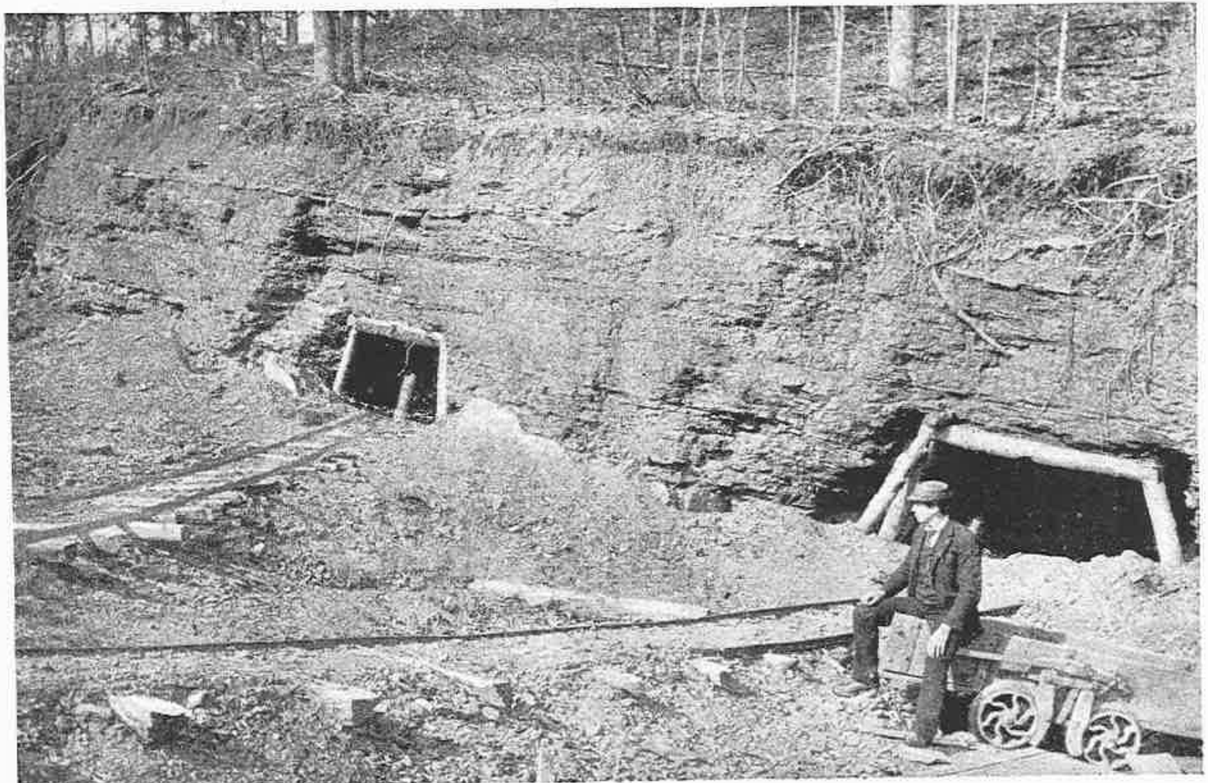
Here the soft ore, in the hillsides, has a thickness of 2 feet. The covering of the ore is removed until the limits of profitable working is reached, beyond which the shales are undercut for short distances, as shown in plate IX. But deep mining is not continued far into the hillsides.

East of High Cliff Postoffice, there is a separate basin of the fossil ore series, bounding an anticlinal valley. The ore where seen occurs in red shale, and has a thickness of only from 6 to 10 inches, but there may be other localities where it is thicker.

IN LOOKOUT VALLEY.

The Red Mountain series forms a chain of serrated hills (see plate V., page 48) skirting both sides of Lookout anticlinal valley, that is, both dip from the valley and pass under the two mountains on either side. Near the Alabama-Georgia line, as also near the Tennessee State line, the beds unite and cover the lower anticlinal formation.

Throughout the series in Lookout valley, the ore is generally met with, although interrupted by ravines crossing the ridges. In many places the soft surface ore has been extracted to as great a depth as would be permitted by the system of removing superincumbent earth. (See plate IX.)



MINING RED ORE AT NEW ENGLAND CITY.

Underground mining has not been resorted to except at Rising Fawn. On the ridges about the furnace, most of the superficial soft ore has been exhausted, but the hard ore passes down at low angles beneath Lookout mountain. The total thickness of the hard ore beds reaches 7 feet. Only in one locality, on Pudding ridge, north of Rising Fawn, is the surface ore as thick as 7 feet; even here the principal layer is only 3 feet, with the remaining 4 feet interbedded amongst shaly seams. Throughout the ridge the soft ore is generally from 20 inches to 3 feet in thickness. In a boring at Rising Fawn, Mr. Bleven found the hard ore 7 feet thick at a depth of 80 feet. Throughout the whole valley there are many workings in the foot ridges beneath the table-lands. The soft ore east of New England City has a thickness of about 2 feet, and is largely used for the manufacture of red ochre.

TAYLOR'S AND DICK'S RIDGES.

Near the Alabama line a limited amount of ore is seen in the eastern side of Kincade or Simms' mountain (a part of Taylor's ridge). Some ferruginous sandstones occur at Kitchen's gap, east of Holland. At High Point, the ridge has been preserved, owing to the presence of heavy bedded sandstones. On the land of Mr. Sculett, where the rocks dip 60° N. 30° W., on the eastern ridge of a synclinal fold, fragments of fossil ore are found over the sandstones. At various points to the northward, the ore is also seen. In one place it is said to be 34 inches thick. Nearly east of Summerville Mr. Cleghorn owns an ore bed from 16 to 20 inches thick; this is of a good quality. It dips 26° S. 40° E., and is somewhat steeper than the eastern face of the mountain, from the summit of which the ore descends in the form of a mantle, thinly covered with shales, which have been removed by washouts in several localities, thus exposing the ore in the ravines.

At various points throughout the ridge the ore is exposed. On the Greenbush-Lafayette road, the ore is seen upon the eastern side of the mountain and in ravines, where it has a thickness of 12 inches. Taylor's ridge and Dick's ridge together form a synclinal basin, with rocks of the latter ridge dipping 80° N. 60° W. at Wood's gap. In Dick's ridge, to the northward on Mr. Hamilton's land, the ore is from 10 to 12 inches thick. At no point north of this place is the ore known to be thicker. Ore blocks also occur on Dick's ridge at Gordon Spring, and also near Ringgold. On White Oak mountain, a continuation of Taylor's ridge, no important ore is seen. On the ridge above West Armuchee creek, near Subligna, the ore outcrops on Mr. Simms' land.

The ore horizon of Taylor's ridge is above the massive sandstones of the Red Mountain series, and consequently, has suffered from atmospheric degradation, which has been carried so far as to remove the valuable ore from Horn's, Rocky Face and John's mountains, the strata of which reach to the horizon of the fossil ore series.

CHAPTER XXVI.

COMPOSITION OF FOSSIL ORE.

ANALYSES.

The soft ore is rich in iron. Its commercial value depends also upon the quantity of silica and of phosphorus present. Examples of the analysis of the iron from Shinebone ridge have been furnished me by Mr. Beuk. One of these analyses show:

Metallic iron	60.72
Silica	8.28
Phosphorus	0.131

Besides these components, there were small quantities of alumina and lime. This analysis, however, is above the average in quality, both as to the percentage of iron and the low amount of phosphorus, which is usually higher in quantity; however, the soft ores commonly contain 50 per cent. and upwards of metallic iron. Such high quality of ore as that just given is often used for the manufacture of red ochres. Sometimes the hard ore contains 40 per cent. or more of metallic iron, whilst again, in the deeper workings, the metal commonly diminishes to 25 or 30 per cent. Of the better quality of the hard ore the following analyses were made for the Dayton Coal and Iron Company, and were furnished by Mr. Beuk. The ores were taken from the Bronco Mines on Shinbone Ridge, and the analyses were made by Dr. Gust. Bidtel.

Metallic iron	40.65	41.30	45.32
Silica	6.30	6.10	13.67
Alumina	7.00		
Lime	21.00	18.64	13.62
Phosphorus	0.42	03.51	09.58

The lime is given as oxide of calcium, not as the carbonate. Many of the hard ores are self-fluxing. In the poorer ores the silica increases to 20 per cent. or more.

The following are some of the analyses make by Dr. Gustave Bidtel, for the Dade Coal and Iron Company, and furnished by Mr. Julius Brown.

ANALYSES OF RISING FAWN HARD ORE.

Iron.	Insoluble Residue.	Caustic Lime.	Phosphorus.
30.38	8.21	26.79	.331
28.34	10.64	25.71	.289
24.13	8.91	30.48	.269
22.46	9.56	30.79	.337
27.81	11.36	25.56	.270
26.28	9.35	28.39	.268
30.39	9.76	23.56	.368
27.79	8.65	26.87	.285
32.19	9.22	23.04	.304
31.10	11.67	22.44	.308
28.91	8.46	28.62	.322
29.41	9.71	27.43	.338
31.08	15.16	24.64	.274
29.87	8.07	26.88	.304

ANALYSIS OF RISING FAWN SOFT ORE.

Silica	9.11
Metallic iron	59.00
Phosphorus	0.092

CHAPTER XXVII.

THE IRON FURNACES.

At Cedartown, the Cherokee Iron Company has, for more than twenty years, had a furnace with capacity of 20,000 tons a year. It was originally a charcoal furnace, but coke is now used. Its product is a high grade of iron.

At Etna, there is a charcoal furnace of 10,000 tons capacity per annum, and making a high grade of car-wheel iron.

At Rome, a large new Coke furnace went into blast in 1891, using red ore along with brown ores. Its capacity is about 20,000 tons a year. In April, 1892, they commenced making charcoal iron, using a large proportion of brown ores from Cedartown district, and a small proportion of red ore from Dirt Seller mountain. At Ridge valley, or Hermitage, another modern furnace is located, but it has not been in blast for some years.

At Rising Fawn, the Dade Coal and Iron Company have a furnace of 85 tons capacity per day. The ore is partly obtained at this point, but much is shipped to it from other points. The limestone is from the foot of the mountain near the furnace.

Dotted over the country there are the remains of several old, small furnaces, which have now no other than historic interest, marking the early efforts of local production of iron.

CHAPTER XXVIII.

MANGANESE.

CONTENTS.

USES OF MANGANESE.

The uses of manganese in the arts are not so popularly known as those of iron, and, indeed, many people upon whose property it occurs have very little idea of the extensive applications of compounds of this metal.

The largest demand is for the manufacture of spiegeleisen and ferro-manganese, which are alloys of iron and manganese; of certain bronzes; of chlorine, for bleaching purposes; in decolorizing glass; in coloring glass, pottery and brick, and a variety of smaller applications. By far the largest quantity is used for the two first named products. These are used in the manufacture of Bessemer steel and other iron manufactures. It not only renders the metal hard but indirectly improves the product and gives valuable properties in a number of ways—such as reduction of oxides of iron formed in steel manufacture; the increasing of the power of carbon to combine with iron at high temperature, and the preventing of its separation as graphite at low temperatures, etc. For many purposes its value is recognized; and steel rails now commonly contain from 0.5 to 1.5 per cent. of metallic manganese.

The demand for manganese ores is constantly increasing. In the United States the product between 1837 and 1879 did not amount to more than 50,000 tons, of which 19,950 tons were obtained in Georgia between 1866 and 1879.* The total output of the ores in 1880 were 5,761 tons, of which the Georgia yield was 1,800 tons. The consumption has rapidly increased, as shown by the following table of the product for the whole country :

STATES.	1880. Tons	1881. Tons	1882. Tons	1883. Tons	1884. Tons	1885. Tons	1886. Tons	1887. Tons	1888. Tons
Virginia	3,661	3,295	2,982	5,355	8,980	18,745	20,567	19,835	17,646
Arkansas	.....	100	175	400	800	1,483	3,316	5,651	4,312
Georgia	1,800	1,200	1,000	.....	......	2,580	6,041	9,024	5,568
Other States	300	300	375	400	400	450	269	14	1,672
Totals	5,761	4,895	4,532	6,155	10,180	23,258	30,193	34,524	29,198

The greater part of the Georgia shipment was made from the Cartersville district, but in 1890–'91 over 3,000 tons were shipped from Cave Spring district, whence a few hundred tons were previously shipped. Besides these manganese ores, a large quantity of rich manganiferous iron ores are used by which the production of manganese compounds is largely increased.

KINDS OF ORES.

Economically, only the oxides of manganese are of any value to us in Georgia, and of these the characteristics may be given :

Pyrolusite or Peroxide of Manganese.—It is a soft mineral, having a hardness of 2-2.5, and specific gravity of 4.8. It has an iron black color with a black powder. It is commonly a crystalline mineral, and when crystallized is orthorhombic, and is often needle-shaped or fibrous. It has a metallic luster, and even when granular massive, it has often a glittering appearance. In composition it is dioxide of manganese, and theoretically contains 63.3 per cent. of manganese and 36.7 of oxygen. It often occurs in crystalline forms lining cavities or as incrustations.

* Mineral Resources of the United States, 1888, p. 125.

Psilomelane is a heavy mineral of 5-6 degrees of hardness. Specific gravity is 4-4.4. It is black or steel blue. The form is commonly botryoidal (like bunches of grapes); stalactitic or in irregular shaped masses. When freshly broken it has often a bluish, glossy, sub-metallic luster. In composition psilomelane varies, being largely peroxide of manganese, with more or less water. It also contains a variable amount of baryta from a trace to 17 per cent., and potash to the extent of 4 per cent. Thus the manganese in the ore varies, when freed from clayey matter, from 45 to 60 per cent. of the metal. With this mineral, pyrolusite and braunite are commonly associated.

Braunite is a mineral whose hardness is 6-6.5, and specific gravity 4.8. It occurs both massive and crystalline, of black or brownish black color, and dark brown powder. Luster is sub-metallic. It may be regarded as an anhydrous sesquioxide of manganese, containing silica. When pure it contains 69 per cent. of metallic manganese.

Manganite.—This is a mineral of medium hardness, hardness being 4-4.5; the specific gravity is 4.3—4.4. It crystallizes in orthorhombic prisms. It is also crystalline massive. Its color is black with a black or brown powder. Luster is metallic. It is a sesquioxide of manganese with water; and when pure, the composition is manganese 62.5, oxygen 27.3, water 10.2 per cent. Upon loss of its water the mineral changes to pyrolusite, braunite, etc.

Wad or Bog Manganese.—This is a light, earthy brown or black ore, and is essentially an impure peroxide of manganese, containing from 15 to 45 per cent. of the metal.

THE MANGANESE ORES OF THE KNOX DOLOMITE SERIES OF GEORGIA.

The principal ore is psilomelane, although commingled with it, more or less of all the above named oxides probably occur.

The psilomelane occurs in irregular or concretionary masses, and is more or less kidney-shaped or botryoidal. The masses are often porous. The surfaces are usually covered with the powder, but when freshly broken they are conchoidal and show the steel-blue color. In some portions of the deposits, especially at a depth, the mineral is blacker and more crystalline, probably from admixture of braunite. In other cases the interior of the masses contains, or is interlaminated with, pyrolusite, or the surface is coated with it. These manganese ores occur in detached masses from the smallest particles to a ton in weight, besides the larger pockets in the beds.

Scattered through the clay there are extensive accumulations of black powder, which may be mixtures of various oxides above described. All of them contain some water and often to the extent of several per cent. With all of the manganese ores more or less silica is included, even in the concretionary and stalactitic masses, and in the prepared ore more or less clay adheres to the grains or lumps.

Besides these ores there are in Georgia many admixtures of manganese and iron ores which are of value.

COMPOSITION OF THE ORES.

At the disposal of the survey, analyses from a few localities have been obtained, but they are types of the ores in the Knox series. At the mine of Major J. M. Couper, south of Cave Spring, the purer ore yielded the following analysis to Mr. J. Blodget Britton:

Metallic manganese	53.44
Ferric oxide	2.83
Baryta	8.62
Water	1.56
Silica	7.79
Alumina	1.52
Lime	0.08
Phosphoric acid (Phosphorus, .064.)	0.147
Oxygen with manganese, undetermined, etc	24.013
	100.00

In this case the potash was not determined. In other samples the amount of water is larger. For commercial purposes the analyses of car load lots is of more value than that of picked samples.

On December 1st, 1889, a car load of 30,200 pounds, from Major Couper's mine, yielded the following results:

Manganese	46.749
Iron	1.746
Silica	13.050
Phosphorus	0.059

In October, 1890, shipments from residuary surface ores yielded:

	I.	II.	III.	IV.
Manganese	42.685	42.938	42.578	42.307
Iron	1.729	5.240	1.50	2.40
Silica	10.000	8.009	11.95	10.39
Phosphorus			0.089	0.072

On Mr. Asbury's property, northeast of Cave Spring, surface ore sent to Carnegie & Co. gave the following result:

Manganese	45.189
Iron	7.840
Silica	7.620
Phosphorus	0.053

The ore from the Barnsley estate at Woodlands gave the following analysis to the Pittsburg Testing Company:

Manganese	43.730
Iron	1.010
Silica	3.530
Phosphorus	0.129

Many other analyses of car load shipments to Carnegie & Co. have been seen but the above are representative products of the washed ore.

In all of the ores moisture is included to the extent of from 1 to 8 per cent. The silica varies from 7 per cent. up to 16 per cent., which makes the ore less desirable, as it should not contain over 12 per cent.

The iron ranges from 2 to 14 per cent. or more. The shipper is paid for the iron, but its low price compared with the manganese reduces the value of the ore. In many deposits the amount of iron is so large that the mineral may be considered as a manganiferous iron ore.

The presence of phosphorus has an important bearing on the value of the ore, as its greatest use is in steel manufacture. Good ore should not contain over 0.2 per cent. of phosphorus. However, the ores of Georgia manganese are usually as low in this objectionable element as those of Virginia, which yield the largest supply. A large number of shipments of ore from Georgia show only from 0.05 to 0.167 per cent. of phosphorus, and the ores are consequently low in this element.

In the working of this ore it is very important to reduce the quantity of silica or chert by sorting and washings.

MODES OF OCCURRENCE OF MANGANESE ORES.

Manganese ores occur in the Archæan rocks of Georgia, as near Mount Airy, in certain semi-metamorphic rocks, whose age has not been settled, eastward of Cartersville, and in the Knox dolomite series of the Lower Paleozoic group. The Cartersville ores have been extensively worked for many years, their product in 1887 being 9,024 tons and in 1888 5,568 tons. Those mines border the zone of the present survey, but in this chapter they will not be discussed further than the statement that they are associated with certain metamorphic sandstones and shales, and are often of a more highly crystalline character than those belonging to the Knox zone.

Manganese occurs in mountain folds all the way from Nova Scotia and New Brunswick, along the Appalachian valley from Vermont to Alabama, and in a like district of Arkansas. This metal is not confined to one Paleozoic horizon but occurs in Cambrian rocks of Virginia, the Knox or Calciferous series of Georgia, beneath the Upper Silurian of Arkansas*, whilst on the Bay of Fundy the ore is found in Lower Carboniferous rocks. Throughout the Appalachian regions the manganese deposits occur in formations skirting the northwestern side of the crystalline rocks, which, in Georgia, are seldom more than 25 miles distant.

The manganese deposits of Polk, Floyd and Whitfield, and border of Catoosa, counties have not been correlated with those extending from Tennessee to Virginia, and occupy, in part, a different horizon. Whilst in those States, the ores occur near the contact of quartzites, of various ages, and succeeding shales and limestones, sometimes being in one or another of these beds*, the manganese of the belt from Polk to Whitfield counties occurs in beds of residual clays and cherts, belonging to the Knox dolomite series, and more particularly on the ridges of the western portion of the zone.

The occurrence of manganiferous clays is common in the mountain states. But in this western manganese belt of Georgia, the clays and cherts have been entirely derived from the earthy and impure Knox dolomites, described in the local geology of Bartow county, in the first part of this report. There, the limestones are shown to be in part earthy and in part highly cherty. These are easily disintegrated by leaching of the calcareous matter, leaving more or less confused sheets of clay in some places, whilst in others there are cherty accumulations, or these only partially depleted of the calcareous matter. The clay deposits have been the most easily eroded, and hence form valleys containing often low ore bearing hills. The more cherty beds afford protection against erosion, and hence are most commonly seen on the ridges, although

*See the excellent Report of Dr. R. A. F. Penrose, on the Manganese ores of Arkansas. Geological Survey of Arkansas, 1887.

sometimes the top of such ridges are covered with a mantle of red clay, with little or no chert.

The ore was originally bedded in the clayey or cherty dolomitic sand, perhaps as the carbonate, but more likely as a hydrous oxide, in position similar to its modern occurrence, in the clay. It probably now differs from the original form of deposits by such changes as are incident to the beds which have been disturbed upon the removal of the calcareous matter. Whilst the depth of decay of the rock is known to exceed 210 feet, in places. The exploration for manganese has not been carried to the solid rock, except where occasional protrusions of semi-undecayed rock approach the surface, in which the ore is sometimes seen; yet occasionally masses of rock have escaped decay and are embedded in the decomposed rock or clay, thus sometimes causing the structure to be deceptive.

The manganese is found in the form of grains, nodules, pockets or lenticular sheets, conforming more or less to the bedding. These lenticular beds and pockets are of various sizes and forms, and may be very much disconnected, or occasionally united with stringers.

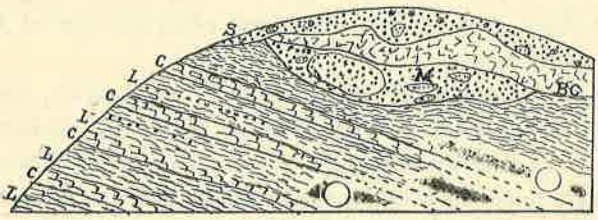


FIGURE 25.—Decay of Knox dolomites; L, the lower calcareous beds, weathering to siliceous loams; C, cherty dolomite, weathering to sandy soil with cherty gravel and loose blocks on the soil; M, pockets of manganese or iron in the decayed remains of limestone; S, surface red soil with fine concretious ore.

The relation of the lenticular beds to the undecayed rock is indicated on the late Bank's property of Major Couper.

On the side of a ridge, on the Couper property, the cherty beds (c) are seen at several horizons, dipping at about 20° southeastward.

Between the somewhat disturbed beds, there are the residual clays derived from the limestones (L), and in these, manganese pockets (M) are seen (as shown in figure 25).

On this same hill the upper beds have been most disturbed, and above the manganiferous residual clays the cherty layer is very much broken. Overlying this again is the surface mantle of manganiferous red clay. In this section iron ores occur in position above and below the manganiferous beds.

The ore in the individual pockets may amount to hundreds of tons. These pockets sometimes contain massive ores, or else are composed of an aggregation of nodules, the whole following the bedding of the original rock, which generally dips southeastward. There are also thin seams of ore or layers of nodules penetrating the clay or rock in various directions, and brown ore is often commingled in the beds. The chert and cherty clays are usually gray, or sometimes brown, or pockets of black clay are colored from presence of finely divided ore.

The color of the beds varies. It is often deep red or chocolate tinted from the presence of manganese. Again, it may be yellow, brown or black, and beneath the surface often like that of the typical gray cherty land.

The depth to which the ore descends is not known, but as the lenticular beds sometimes dip 20°, or more, the pockets of the ore may be eventually reached in solid rock, which, however, will be generally found only below the drainage level, as the rock decay is very deep.

Closely related to the manganese beds, brown ore is often found, even almost in contact with the manganese, as at Tunnel Hill. These iron ore beds, however, are of great extent and more constant than the manganese deposits, but the higher price of the manganese permits of the working of the less concentrated mineral.

The chocolate-colored surface clays result from disintegration of the rocks which may be free from any large cherty particles. Such conditions occur on the summit of many ridges, whilst the lower portions often show, in places, more or less partly undecomposed and often cherty rock.

Through the surface residual clays the ore is scattered in small particles, nodules, or even large masses of a ton in weight. It is possible that a portion of these grains and concretionary masses are not simply residual from the decomposed rock, but are of secondary chemical or molecular origin, owing to segregation in the porous residuary earths, and thus concentrated since the decay of the rock, especially in the red surface clays.

CHAPTER XXIX.

LOCAL DISTRIBUTION OF MANGANESE ORES IN THE KNOX SERIES.

CONTENTS.

There are three principal districts of manganese occurrence in the Knox dolomites of northwestern Georgia. These are on ridges extending from south of Cave Spring northward to near the Etowah river; a belt near the border of Bartow and Floyd counties, north of the Etowah river, in the region of Woodlands (Barnsley estate) and the Tunnel Hill district, on the border of Whitfield and Catoosa counties.

These districts are of broad extent, and include the distribution of the belts occupied by parallel ridges.

CAVE SPRING DISTRICT.

Manganese ores occur along with the iron at many localities, but the most important deposits are on a belt commencing in Polk county and extending eight or ten miles northeastward, with occasional scattered deposits to near the Etowah river.

The largest deposits which have been exploited are those of the Georgia Manganese and Mining Company, commencing in Polk county about two miles south of Cave Spring, and extending two and a half miles northeastward. The best deposits are on lots 1140, 1162, 1163 and 1141 (Bartow), 3d district (Polk county); 1009 (Ware) 1233, 1216, 1217, 1160, 1161 (Dougherty) and also on lots 947, 998 (Hancock), 1146 and 1142 (Floyd county).

The principal works are on a hill 195 feet above the valley of Cedar creek. The summit is covered with a red or chocolate or brown clay, varying from 2 to 15 feet in thickness, and containing manganese gravel. The ore of the surface clay is mostly in small grains and nodules, although masses of a ton in weight have been met with. Through the clay there is also much coarse manganese powder, which is not of value at the present time. It is probable that this clayey surface of the ridge was formerly more extensive, but has been washed from the sides of the hill.

Beneath the clay covering the deposit is brecciated cherty clay and the disturbed remains of the decayed manganiferous cherty limestone. (See figure 25, page 197.) Through this clay some layers appear to be entirely free from manganese. But other seams contain lenticular masses or pockets of manganese ores; and the general position is probably that of the original beds of dolomite, dipping at about 20° southeastward. A shaft has been sunk to a depth 50 feet and has penetrated large masses of ore.

Stringers of manganese extend irregularly through the ore-bearing lands. While much of chert is broken up and cemented into brecciated conglomerate, masses of partially undecomposed cherty rock occur in the clays. As far as the shaft has been sunk there is no appearance of the original solid rock.

Near by, on the sides of the hills, the partially solid strata appear with the beds, dipping, in some cases, as low as 10°, nearly eastward. Layers of manganese ore are seen, especially in the clays of the decomposed limestone, above and below some of these beds. Much of the ore is concentrated by the removal of calcareous matter, although part of the manganese has also been lost. Some of the manganese concretions in the clay may have been segregated from the mineral dissolved out of the original rock, and thus a portion of the "shot-ore" pellets and concretionary nodules may be accounted for, especially in the surface clays. (See figure 25, page 197.)

At other openings, the ore is seen in more cherty decayed rocks than that just described. Between the conditions of the surface, red clays and the ore in the cherty residual clays, there is every variety of conditions of occurrences.

The ore beds, just described, have associated with them two extensive deposits of brown ore. This commonly close association of iron and manganese ore has already been referred to.

Northeast of the Georgia Manganese and Mining Company (Major J. M. Couper, President) property, the surface ore is shown on the lands of Mr. Asbury (lot 922), Mr. Simmons, and others. On Mr. Asbury's, the lower part of the hill is cherty, and the manganese accumulations are scattered over the red or chocolate colored clay.

Again, to the northeastward, the manganese occurs on ridges of red land belonging to Mr. W. I. Taylor (lot 840, 3d district), and on other adjacent banks.

On a ridge to the eastward of the last deposit are the Rice or Hatchet manganese beds (lot 822, 3d district), near New Prospect church (lot 822). Mr. Harper, of Rome, and others own portions of this ridge. The summit of the ridge is of red clay, but the lower portion is of gray cherty formation, with masses of the rock of the same structure as the other deposits seen in the Cave Spring district. Brown iron ore also occurs on this ridge.

The localities given are only a few of the known deposits in the district, but they locate the belt, and are typical. There are many places, where explorations have been made, pits sunk, and more or less ore taken out.

The ores in this belt are not confined to one series of ridges but occur on several parallel hills, and extend on the Polk-Floyd county line, from Major Couper's mine to near the C. R. & C. Railway, as seen on the lands of Mr. Stokes—the belt of country having a breadth of several miles.

Longitudinally, the deposits are interrupted, not only on account of the topographic features, but on account of the nature of the deposits being large in some portions of the beds, and almost inexplicably disappearing in others.

The geological conditions for the occurrence of the manganese ores continue from northern Polk county to the Etowah river, although narrowing somewhat in breadth in passing northward; laterally, the belt extends from Van's valley, to near Spring creek.

Manganese and manganiferous iron ores also occur in the narrow Knox basin west of Cave Spring, already referred to in connection with iron ores. The manganese is on Mr. Simmons' and other properties. These deposits are about two miles west of "Hematite Siding" on the East Tennessee, Virginia and Georgia Railway. The basin is narrow and only a few miles in length, and totally disconnected from the Cave Spring district by Cambrian shales.

THE WOODLANDS OR BARNSLEY DISTRICT.

On the low ridges adjacent to the valley of Tom's creek, manganese is found in deep red or chocolate colored loam, like that on the top of Couper's hills, near Cave Spring. In places there is scattered chert upon the surface of the ground. The occurrence is similar to that near Cave Spring. One pit, 20 feet deep, was opened, and fifty tons taken out of it. In part, the deposit resembles a breccia, with manganese oxides for the cement. In this locality, there are a large number of deposits exposed on the surface, but not opened (see land lots 95, 63 and 84 and lot 36 of Mr. Morrow, and lot 97 of Mr. Conway). Brown iron ore occurs in proximity to all of these deposits, and so does beauxite.

The ores of the belt continue in ridges to near Nannie, where large surface accumulations of manganiferous nodules were seen on the land of Mr. Price.

TUNNEL HILL DISTRICT.

A narrow belt, mostly a chain of ridges, extends from a point west of Tunnel Hill, east of northward, into Tennessee. This chain of ridges is of variable elevations, sometimes rising over 100 feet. It is primarily a chain of gray cherty lands, although many points show but little chert upon the surface, where that is of red soil. The ore in the surface pits is mostly in the red residual clay, which has a variable depth.

Upon this belt, at about three miles from Tunnel Hill, the Catoosa Mining Company have made some extensive openings and different shafts—one said to be 210 feet in the residual decayed cherty clays. Manganese, often closely resembling that east of Cartersville (more or less crystalline), is seen on the surface about these mines, which were closed at the time of my visit. At several pits upon the surface brown iron ore is also exposed. The two minerals, in one place, come into close relationship. Part of the iron is a ferro-manganese ore. The deep ore in the grayer earths was not seen, owing to the shaft being closed.

Manganese ore was seen to limited extent upon the ridges of Knox dolomite southwest of Tunnel Hill and at other points, but the quantities were not large.

THE WORKINGS OF MANGANESE DEPOSITS.

Hitherto the manganese bearing surface clays have been screened, as in case of brown ores, and several pockets have yielded a few hundred tons.

Pits have not often been sunk more than twenty or thirty feet. The first serious attempt, at properly working the ores in this belt, was commenced by Maj. J. M. Couper, at the mines near Cave Spring. Here an improved plant was constructed, with two Cornish rolls, double log washer, screen, five giggers, etc. The water for washing is brought from Cedar creek, a mile away. It is only by means of the improved methods of washing that the separating of the siliceous matter from the ore can be satisfactorily accomplished.

At Tunnel Hill a still more extensive plant has been constructed, but it has not been in operation up to the present date.

CHAPTER XXX.

ORIGIN OF MANGANESE AND IRON DEPOSITS.

The position and general relationship of the various belts of manganese ore have been described. But if their origin were better understood, this greater knowledge of the necessary conditions of deposition would be of service in determining the variations in the modes of occurrence and distribution of the ores.

The rocks of the Paleozoic belt of northwest Georgia were formed from the degradations of those of the crystalline or metamorphic zone to the eastward. From the enormous decay of those rocks, the manganese, as well as the iron, was obtained. Many of the crystalline rocks contain much iron; and where iron occurs, smaller proportions of manganese usually are found. Along streams and springs one often sees deposits of yellow or red oxide of iron, and sometimes stains of black (from manganese). These encrusting deposits have been derived by chemical solution from older minerals and have subsequently been redeposited. Such transportation, accumulation and deposition can be seen going on to-day.

Among the commonest crystalline rocks in Georgia are hornblendic, or syenite gneiss, and granite, garnet rocks, etc. Manganese is associated with the iron of the hornblende, garnet, pyroxene or other rocks. Thus in the decay of these silicates, iron, manganese and aluminous compounds are liberated. Some other materials, such as rhodonite or silicate of manganese, hold the metal in a more concentrated state in pockets in crystalline rock. But the great supply comes from the concentration of the metals from the common rocks, containing only small a proportion of iron and manganese.

The decay of the crystalline rocks has been in progress for an enormous length of time, but a great portion of the disintegrated material is washed off into the streams and carried into the sea to build up new lands. The crystalline rocks at Atlanta are decayed so far that they may be considered completely rotten to a depth of 95 feet. However, incipient decay may reach as much as 300 feet In the disintegration much of the iron, manganese, and some alumina have been leached out of these rocks and deposited elsewhere.

The agents of rock decay are carbonic and various vegetable acids acting mainly on and near the surface of the rock; also sulphuric acid, arising from the decay of pyrites in the rock. These acids, in the presence of reducing agents, have the power of dissolving out the iron oxide and manganese, along with the magnesia, potash, soda, etc. of the rock. The removal of these compounds leaves the rocks porous and favors the erosion by rains and rills

The carbonates of iron and of manganese are carried off by the streams and are sooner or later deposited as the oxide or sometimes as the carbonate; the carbonate of manganese, appearing somewhat more stable than that of iron, is apt to be carried farther than the iron, or at least more or less separated from it; for the carbonic acid upon exposure escapes and the mineral becomes oxidized, as seen in the coatings of the red or the black films of these metals upon pebbles, rocks, etc.

The iron may be taken up and afterwards deposited as the sulphide, but this does not appear to be the case with the manganese.

Such being the primitive source of the brown iron and the manganese ores, their deposition would be expected along the streams and in basins lying not distant from the zone of rock, which gave origin to the metallic accumulations. Thus the manganese belt is situated upon the northwestern flank of the crystalline or metamorphic formations.

The Paleozoic rocks which contain the manganese and iron were derived from the same sources as the metals (the calcareous matter being indirectly secreted from sea water through the agency of marine organisms); and amongst these accumulations the ores as well as clays and beauxite were deposited. These ores are most abundantly found in the limestones, and to a less extent in the shales, but east of the belt of exploration they occur in the sandstones and slates.

As has already been seen the ores follow the trend of the ridges, being in zones whose general course is a little east of north. Also it has been shown that the deposits are not continuous throughout the zones. It has been further pointed out that the richer deposits are on chains of hummocks trending westward.

Any one familiar with the various coast lines is aware of the common occurrence of low islands, numerous channels and lagoons, such as are found along our own shores. The manganese, being converted into the soluble carbonate by superficial waters, at its original highland source, was borne by the streams which were eventually retarded upon entering the dismembered water basins along the coast. Adjacent to the streams, and in the quiet waters of the lagoons or the estuaries, the conditions are favorable for the conversion of the soluable carbonates of manganese into oxides. Under these conditions, the metals borne down by many streams, in both solution and to a small extent in a finely divided mechanical condition, would have been deposited in separated basins, all of which were, however, in a general trend, parallel with the direction of the coast line. Thus the interrupted character of the ore beds can be accounted for.

The metals are generally disseminated to a small extent amongst all the rocks, but they are concentrated only in limited areas.

The same streams brought down more or less clays and sands as mechanical sediment. These were deposited along with the metals and greatly in excess of them. (See Origin of Beauxite.)

As the ores under consideration occur in limestone deposits, it is probable that the lagoons may have been similar to those amongst coral reefs; even the intercolated siliceous beds are poorer in the metals than the more calcareous layers. The ores of the clay and sandstone regions may have originated in local basins similar to those on our own coast, interrupted by sand bars and islands.

Other sources may have given rise to a small quantity of the ores, but those of Georgia have originated entirely from the decay of crystalline rocks brought from the older Archæan lands into the basins in which the Knox dolomite was being accumulated.

In some cases the ores were originally segregated into large pockets. But the secondary decay of the Knox rocks in removing calcareous matter, has further concentrated the metals into a smaller volume of rock. Especially upon the surface, this is noticeable, for here the clays and sands have been to some extent washed away, which has scarcely been the case within the mass of the rock.

Furthermore, the ores upon the surface in the residual clays may not be entirely in place, but have been partly concentrated by washes from other portions of the higher hills, now reduced far below the level of the protecting gravel ore, on account of the erosion of the land surfaces.

In this connection it is again suggested that the concretionary and stalactitic nodules may have been originated in part by a secondary solution of the finer particles of ore and been redeposited in more concentrated forms in the surface clays. So, also, in the crevices of the lower clays, and in the spaces amongst the brecciated rock, the ore seams and cementing ore were concentrated by the filtering waters, from the manganese poorly scattered through the rock mass.

In all cases the ore is largely associated with siliceous materials, part of which came from the lands, but part from those secretions along with limestones which produced the chert, and this excess of silica is that which must be rejected in the use of manganese compounds.

If the workings of the manganese beds be carried down below the drainage levels and decay of the rock, the larger pockets of ore will probably be similar to those seen in the clay, and the partially decayed cherty rock, but in a more compact form. However, the ore in smaller pockets and nodules will likely be found less concentrated and more sparsely disseminated as the great volume of calcareous matter of the rock has not been removed by solution.

CHAPTER XXXI.

ALUMINIUM ORES.

CONTENTS.

NOTE ON ALUM AND ALUMINIUM.

Aluminium compounds are much sought for in the manufacture of alum, etc., which is used in great quantities as a mordant for setting the colors of dyes, and still more largely for sizing in the manufacture of paper, these two requirements consuming an enormous tonnage of the different ores.

To these demands others have been added in the production of aluminium. The uses of this metal are now growing very rapidly, owing to the reduction of its price. Its earlier uses were restricted on account of its high price. Until 1884 all of the metal used was imported. That year the importation amounted to 590 pounds, valued at $8,416. In 1883 Colonel Frishmuth, of Philadelphia, produced 63 pounds, and in 1884, 115 pounds. Since then the production has very rapidly increased, so that in 1889 it amounted to 47,468 pounds, valued at $97,335,* and in 1892 the product was increased to about 350,000 pounds with a further diminution in price to 50 cents a pound, although it has been again advanced in price as the supply is not equal to the demand. It is variously estimated that the cost of production can be reduced to from 18

*Bulletin of Eleventh Census, No. 79.

to 20 cents per pound (Hunt.) The demand for the metal is rapidly increasing on account of its lightness (one-third that of copper) durability, etc.

SOURCES OF ALUMINIUM.

The primitive sources of aluminium are the crystalline rocks which contain this element. Indeed, next to quartz, it is the largest component of crystalline rocks and shales. Amongst the older formations it is locked up in the form of the feldspars and micas, in granite, gneisses and schists. In other rocks it occurs in various shales, clays, kaolin, etc. Also several minerals are largely composed of it. Thus corundum (with its finer varieties, sapphire and ruby) is pure alumina; cyanite is a silicate; so are garnet and topaz, but these contain various other elements. The sulphate of aluminium occurs to a limited extent in a natural state.

The most important aluminous minerals are cryolite, kaolin (with allies including clay) and beauxite.

Cryolite is the double fluoride of aluminium and sodium. It is imported entirely from Greenland to the extent of nine or ten thousand tons a year, at a cost of from $9 to $10 a ton. It contains thirteen per cent. of aluminium or about twenty-four per cent. of alumina, but its value is enhanced by its contained soda.

Kaolin and Clays.—Kaolin occurs in clay-like masses, in texture from compact to mealy. Hardness 1–2.5, specific gravity 2.4–2.63. The luster is earthy to sometimes pearly. It is usually unctuous and plastic. Pure kaolin is white, soft and clay-like, and made up of microscopic pearly scales. The composition is typically: silica 46.3, alumina 39.8, water 13.9 per cent. It may contain iron, lime, magnesia or potash in small proportions as impurities, which affect its fusibility as the purer mineral is infusible. Kaolin is a decomposition product of the feldspars, and is liable to contain free quartz, or indeed, some undecomposed feldspar.

Clays are primarily of the same origin as kaolin, but differ in that they contain more or less fine quartz, and undecomposed feldspar, etc. The composition is extremely variable, from almost pure typical kaolin to even a predominance of free quartz.

The kaolin and clays are not considered here in connection with their importance in brick making, pottery, etc., but as associations of beauxite and iron ores. In the brown iron ore beds, clay "horses" of great size, and many other beds of white clay are of common occurrence. These are sometimes tinted reddish or purple. They also occur of various colors, often tinting streaks through the clay. As a type of their composition, the analysis from a clay "horse" in the brown ore deposit at Grady is given in the chapter on clays.

The economic value of these deposits will be considered as a separate subject. In their associations with beauxite care must be taken in the separation of clays as they reduce the value of the mineral shipped.

HALLOYSITE AND GIBBSITE.

Halloysite is clay-like, massive or earthy. Hardness 1–2, gravity 2.4. The massive varieties may be somewhat pearly with conchoidal fracture, color white or tinted. It absorbs as much as 20 per cent. of its weight of water. It is infusible, but it is decomposed by acids. The typical mineral contains alumina 37.7, silica 43.3, and water 19.0 per cent.

The mineral obtained from the Fort Payne chert, in Dade county, and analyzed by Mr. H. W. Shephard, of Philadelphia, showed a colloid form (favorable for porcelain manufacture) and gave:

Alumina	30.76
Ferric oxide	0.36
Silica	45.15
Water	23.55
	99.82

This mineral occurs in the Fort Payne chert (Sub-Carboniferous). The cherty limestone when weathered leaves kaolin-like clays intermingled with the residual chert. In places these white clays occur in large pockets or irregular beds. Some of the deposits form earthy or again porcelain-like, halloysite. Such deposits occur on the property of Mr. Blevin, south of Rising Fawn. Large pockets also occur on property of Mr. Alexander, about four miles from Subligna, on the eastern side of Taylor's ridge. When more exposures are made, there is no reason why many beds may not be found in the deposits of this formation, which is quite widely distributed.

In the manufacture of aluminium or its compounds, this mineral is inferior to beauxite only in containing a larger quantity of silica, and a smaller proportion of alumina than the former mineral.

Gibbsite, another mineral composed of hydrous alumina in stalactitic, mammillary and incrusting forms, has been found on the Barnsley estate in connection with beauxite. It has a smooth surface, with internally a faint fibrous structure. H=2.5--3.5, gr. 2.3. In color white, grayish, greenish, a reddish white. It has a clayey odor when breathed upon. In composition it is alumina 65.6, water 34.4 per cent.

CHAPTER XXXII.

BEAUXITE.

CONTENTS.

PROPERTIES.

It is a concretionary pisolitic granular mineral, also earthy and clay-like. The luster of the more compact varieties is often waxy. Hardness from one to about three; specific gravity 2.55. In color it varies from white to gray and deep red, according to amount of iron present. If the iron be regarded as an admixture, the mineral is a hydratė of alumina, with a composition of: alumina, 74.1; water, 25.9 per cent. In this case the composition is near another mineral—*diaspore*—which is not found in large quantities. But a portion of the alumina is replaced by variable quantities of ferric oxide, and silica is present, probably from admixture with kaolin. Titanic acid is always present in the Georgia mineral, and traces of lime, magnesia and rarer elements also occur. Accordingly, the mineral is of variable composition. Its appearances are deceptive, as often the most perfectly concretionary forms are of lower grade than those less promising. The clay-like varieties have been called Wocheinite.

Sometimes the pisolitic concretions are deeply colored with iron, whilst the matrix is of lighter color. Near the surface the mineral

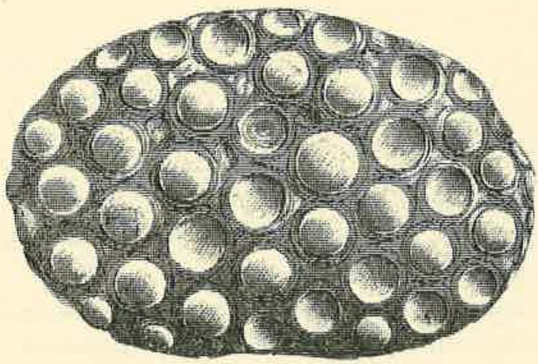


FIGURE 26.—Section of a concretionary pebble of beauxite, showing pisolitic structure. The pellets vary in size from small grains to an inch in diameter—but the smaller sizes are commonest.

is often vesicular, owing to the removal of the alumina from the interior of the cavities, in which siliceous or ferruginous dust alone is often left. This removal of aluminous matter reduces the value of the mineral. The quantity of iron often increases with the depth of the deposits below the surface; still the iron is no objection, as a valuable by-product is obtained in the manufacture of alumina. A number of analyses of beauxite were made by Prof. H. C. White, President of the State College. These were chosen as types of different varieties from various localities in Floyd and Bartow counties, and were not taken from the deposits, because they were known to be of good quality.

ANALYSES OF GEORGIA BEAUXITE

Sample 1.

At Flowery Branch (lot 21, 23d district) near Hermitage, Floyd county.

Variety: White porcelanous mass, with subordinate pisolitic grains; associated with white clay beds upon the side of a ridge:

Alumina	46.72
Ferric oxide	2.14
Silica	29.01
Water	20.15
Titanic acid	0.87

Sample 2.

From Mr. Doyle's (lot 906, 3d district) farm about seven miles northeast of Cave Spring, Floyd county.

Variety: Large concretionary pellets of whitish color stained with iron oxide. Interior of pellets partially dissolved away, leaving a semi-vesicular mass somewhat poorer in alumina than would be expected. It occurs in the valley:

Alumina	52.13
Ferric oxide	1.12
Silica	19.56
Water	24.21
Titanic acid	2.08

Sample 3.

From land of Mr. Culberson, one mile from Cave Spring.

Variety: Small pisolitic concretions in mass, grayish white, with some iron stains. It occurs on top of a ridge:

Alumina	39.75
Ferric oxide	1.62
Silica	41.47
Water	16.14

Sample 4.

On a farm of Mr John Henry (lot 910, 3d district) near New Prospect church, six miles northeast of Cave Spring.

Variety: Light reddish porous mass, as the interior of the grains is largely dissolved away; somewhat earthy. At a depth the mineral is not likely to be so porous as on top, and consequently richer in alumina. It occurs on side of a ridge:

Alumina	56.10
Ferric oxide	10.64
Silica	2.56
Water	30.10

Sample 5.

Near the last named locality.

Variety: Whitish mass, with occasional pisolites. Taken from side of a narrow gully:

Alumina	58.61
Ferric oxide	2.63
Silica	8.29
Water	27.42
Titanic acid	3.15

Sample 6.

On land of Montague & Company (late Mr. Connaway, lot 97, district 16), Bartow county, north of Kingston.

Variety: Earthy and white with reddish concretions. It is located on side of a ridge:

Alumina	43.18
Ferric oxide	8.74
Silica	28.11
Water	19.22

Sample 7.

On lot 61, 23d district.

Variety: Earthy looking mass of large concretions. Adjacent deposit is of higher grade. The sample was chosen to see whether much beauxite were lost in the rejection of the poorer and more clay-like earths. It is a clay mixed with much beauxite:

Alumina	36.86
Ferric oxide	1.28
Silica	40.02
Water	20.64

Sample 8.

On land of Mr. A. W. Bobo (lot 534, 3d district), about three miles north of New Prospect church, Floyd county.

Variety: Small concretionary boulder, with small pisolitic grains. Stained with iron oxide along fracture lines. It occurs on side of a ridge:

Alumina	59.82
Ferric oxide	2.16
Silica	6.62
Water	31.10

Sample 9.

On land of Mr. Shaw, two miles southwest of Adairsville, Bartow county.

Variety: Mixed white and reddish vesicular concretions:

Alumina	51.22
Ferric oxide	4.83
Silica	13.33
Water	29.82

Sample 10.

On lot 23, 16th district, Bartow county.

Variety: Hard red porcelanous mass of concretions. Occurs on surface of a ridge:

Alumina	53.31
Ferric oxide	12.92

Silica	1.16
Water	29.60
Titanic acid	3.22

Sample 11.

On Mr. Seay's land, lot 108, 16th district, east of Linwood.

Variety: White, small grained pisolitic in mass:

Alumina	45.21
Ferric oxide	0.52
Silica	35.88
Water	17.13

Sample 12.

On lot 115, 16th district, belonging to the Barnsley estate of Woodland.

Variety: White, small grained pisolitic in mass. Situated on a flat-topped ridge:

Alumina	61.25
Ferric oxide	1.82
Silica	1.98
Water	31.43
Titanic acid	2.38

Samples 13, 14, 15.

Other analyses of beauxite from the Julia mines (Barnsley estate) yielded the following results to the Pittsburg Testing Laboratory, and kindly furnished by Mr. B. F. Armington:

Alumina	67.53	60.61	60.63
Ferric oxide	trace	0.21	trace
Titanic acid	2.92	4.18	4.76
Silica	1.34	2.47	3.20
Water	28.00	32.00	31.00
	99.79	99.47	99.59

Sample 16.

From the Knowles property:

Alumina	61.88
Ferric oxide	0.21
Silica	2.13
Titanic acid	4.04
Water	31.50
	99.76

Titanic is always present, and where not determined separately, it is included with the alumina.

From these analyses, the variations in composition are seen to be very great. Some of the samples were from pits, others from the surface.

The vesicular varieties are mostly superficial, and in some cases contain a smaller amount of alumina. The iron seems to increase upon descending beneath exposed surfaces, and consequently the redder varieties are more abundant at a depth. Still the amount of ferric oxide is often small, considering the depth of color of the mineral. In some cases, the silica, as if free, renders the mineral gritty, but much of it is combined, so that the siliceous mineral may be regarded as containing a kaolin-like constituent. Indeed. the beauxite is commonly associated with a clay, often of white color. (See clays.)

The ore varies greatly in its affinity for the contained water. In some cases this is easily driven off by roasting, but other samples require to be heated to redness before losing all of its water. In the above analyses, where 28 to 32 per cent. of water occurs, a portion of the moisture is evidently hygroscopic.

DISTRIBUTION AND COMPOSITION OF FOREIGN ORES.

Beauxite is so named from its occurrence near the town of Beaux in France, where it occurs to a depth of 30 or 35 feet and said to extend for 90 miles. It also occurs in Austria, Germany, Ireland and Scotland.

In America, it was first worked by Mr. J. W. Hawkins, near Hermitage, in Floyd county, Georgia. The same belt extends into Alabama. It was also found by Dr. Branner, State Geologist in Arkansas.

The analyses of foreign ores upon the next page is taken from a treatise entitled, "Aluminium," by Mr. Joseph M. Richards:*

THE USES OF BEAUXITE.

Owing to the large percentage of alumina, and its solubility in acids, the demand for the mineral is rapidly increasing. Of minerals available in commercial quantities, none is so desirable for the manufacture of the compounds of aluminium, especially alumina (the direct source of the metal), the sulphate and compound alums.

The mineral, when powdered, is decomposed by "chamber acid," (dilute sulphuric acid), and the silica is left behind and separated. By this process the iron is also dissolved, and, being objectionable, it must be separated, or reduced to an ineffective condition; consequently, the mineral is not accepted for use by this process when it contains more than from 2 to 3.50 per cent. of iron. However, a large proportion of silica is admissible, up to 14 or 20 per cent., or even more, but if too much is present the quantity of the product is greatly reduced. Owing to competition with the foreign mineral, grades below 55 per cent. of alumina are not generally acceptable.

As has been seen, titanic acid is generally present in our beauxites. This is not an objectionable component, for it can be retained along with the alumina, as so much of its sulphate as is formed acts like that of the other metal in setting the size or the color in paper manufacture or in dyeing.

*Published by Henry C. Baird & Company, Philadelphia.

ANALYSES OF EUROPEAN ORES.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Alumina	60.0	75.0	48.12	43.44	61.89	45.76	55.61	76.3	50.85	49.02	73.0	63.16	72.87	44.4	54.1	64.6	29.80
Ferric Oxide ...	25.0	12.0	2.36	2.11	1.96	18.96	7.17	6.2	14.36	12.90	4.26	23.55	13.49	30.3	10.4	2.0	3.67
Silica	3.0	1.0	7.95	15.05	6.01	6.41	14.41	1.0	5.14	10.27	2.15	4.15	4.25	15.0	12.0	7.5	44.76
Potash and soda	....	....	.....	......	......	0.38	......	....	0.26	0.31	......	0.79	0.78	....	....	....	......
Water	12.0	12.0	40.33	35.70	27.82	27.61	32.33	16.4	28.38	25.91	18.66	8.34	8.50	9.7	23.9	24.7	13.86

1 and 2, Beauxite from Beaux; 3, from Irish Hill; 4, from County Antrim; 5, Glenravel; 6 and 7, Hadamar (Hesse); 8, Klein-Steinheim; 9 and 10, Landorff; 11, Commercial quantities from Dublin, imported and made into alum. Wocheinite varieties: 12, dark; 13, light; 14, Red Brown Beauxite; 15, yellow; 16, white; 17, white, Wocheinite from Austria.

By another process the mineral is fused with soda. In this case, the quantity of silica is restricted to from two to four per cent., as more would make its use too costly. It is by this process that the alumina for reduction to the metal is made. Iron in the beauxite is not an objection, for a valuable by-product is obtained.

Aluminium is now rapidly growing in use in the arts. The abundance of its compounds is coextensive with the clays. In commercial quantities, its oxide, or pure alumina, prepared from beauxite, or hydrated oxide, is the chief source from which the metal is extracted in the largest quantities. The aluminium has such strong affinity for oxygen, that the separation is difficult. In the more recent and cheaper processes, the metal is reduced by powerful electrical currents, from alumina dissolved in molten cryolite (which is not decomposed) in an electrical furnace. The affinity of oxygen for the metal is better appreciated by stating that the Pittsburg Reduction Company finds that a horse-power of electrical current, working from 18 to 22 hours, liberates only one pound of metal.

The value of beauxite is regulated by the price of the imported mineral, which can be delivered in Philadelphia or New York at about $6.50 per ton. But the Georgia beauxite commands a higher price, on account of its easier solubility compared with French ores. It has been sought for shipment to Germany. As much as $8.50 to $13.00 per ton have been paid for Georgia beauxite in Pittsburg and Syracuse. At interior markets, the transportation from the seaboard must be added, so that the Georgia beauxite can be shipped with better advantage to Cleveland, Lockport, Syracuse and Pittsburg, than to those coastal cities.

Another application, when desiccated, is its value as a refractory material in open hearths, especially in the basic processes of steel manufacture.

The quantities of Georgia beauxite are extensive, and with the increasing demand, a large supply can be obtained.

MODES OF OCCURRENCE OF BEAUXITE.

Beauxite occurs amongst the residual deposits of the decomposition of the Knox dolomite series, and extends from Polk county to Gordon. It is also found in continuation of this belt in Alabama. So far, it is not known outside of this formation, although Halloysite, a mineral of similar composition, occurs higher, in Sub-Carboniferous series. At Beaux, the mineral occurs in grains in compact limestone. In Arkansas, the beauxite lies between soft Tertiary beds (Branner), adjacent to igneous rocks.

In Georgia, beauxite deposits are associated with the higher members of the Knox dolomite series, and the belt is closely coincident with the manganese zone, but not with the more cherty members of the series. In elevation, the beauxite bearing ridges are usually 800 to 1,100 feet above the sea. The beauxite occurs upon the sides of the gently sloping ridges, especially in coves amongst them, and not usually upon the detached and subordinate valley ridges, as in the case of the best iron ore deposits. Brown iron ore deposits occur in the vicinity of all accumulations of the aluminous mineral seen, and manganese is found upon higher portions of the same or adjacent ridges. Beauxite appears in nodules, and in more or less earthy forms, in pockets, and in ill defined beds in the residual clays of the Knox dolomites. Its mode of occurrence is more or less similar to that of brown ore, except that the softer mineral has not withstood surface degradation as well as the iron or manganese ores. Sometimes the nodules are small, but again large boulders are seen. These deposits are known to reach a depth of 50 feet or more, but the full extent has nowhere been proved.

The surface of the ground is frequently yellowish, and with but little flinty covering. Upon it, boulders, nodules, or sometimes pebbles of the concretionary mineral, are strewn. The mineral is often only sparsely scattered through the surface clays, in which occasional boulders alone may occur, as if dumped into the mud of a sea bottom ; such, of course, is not the case, but this condition probably arises from the creep of earth down the hillside during long ages; thus, the beauxite beds are sometimes covered by from two to eight feet of clayey deposits. Consequently, the source of the beauxite is sometimes higher than the localities, where it appears upon the surface, although generally it is to be found near by.

THE ORIGIN OF BEAUXITE.

This is an open question. Its situation along with the iron and manganese ores in dolomites suggests a common genesis. The formation skirts the crystalline rocks of central Georgia, whence the materials were originally obtained. Prof. Branner says that the Arkansas beauxite, although in Tertiary rocks, is located near eruptive syenites, or hornblende granites. Such rocks in Georgia have given rise, in part, to the iron and manganese minerals. The feldspar, in others, contains the aluminium, and there remains only the necessary solvent to transport and deposit it as the mineral beauxite.

In the weathering of the rocks carbonic and vegetable acids remove the iron, manganese, lime, etc., from the hornblende, and potash and soda from the feldspar. So also carbonic acid in water can dissolve small quantities of alumina; thus the same waters can remove the iron, manganese and alumina.* The alkalies derived from the decay of feldspars can also dissolve the alumina. Thus transported, the alumina may be precipitated † in the lagoons in

* When alumina is precipitated by fixed alkaline carbonates, a small portion of alumina remains in solution at first, but this is deposited by degrees after the solution has stood a few days in the open air, at a temperature sufficient to expel the carbonic acid.—(*Bergman.*)

† The above explanation of the origin of the beauxite deposits is supported by Coquand in writing upon the French mineral, but differs in not being due to geyser action.

which the ferruginous and manganiferous clayey limestones were being formed. The white clays associated with the beauxite and iron ore deposits are usually of fine texture, indicative of deposition in quiet waters. The frequent replacement of part of the alumina by ferric oxide further shows the presence of both metals in the original solution, but in variable quantities at different times and places.

Upon the subsequent decomposition of the Knox limestone, the calcareous matter being removed, the ores were concentrated, leaving accumulations of beauxite more prominent than in the original beds.

The position of the beauxite appears to be more or less in pockets and lenticular masses in certain strata, and if workings are ever carried beneath the decayed rocks, the mineral will likely be found in pockets in compact limestone. Indeed, some of the apparent clays may be found to be the soluble aluminous mineral, which is so far as known in Georgia, generally more or less oölitic and concretionary, as are the iron and manganese deposits. The beauxite beds or pockets are less interrupted, and are much more extensive than the latter named mineral.

BEAUXITE IN GEORGIA.

The general distribution of the belt of ore is now known, and a large number of deposits have been visited. Often they have been found on different parts of the same ridges with apparently no reason for their intervening absence.

The beauxite also occurs on many properties adjacent to those given but not mentioned, as land boundaries were not known.

About a mile northeast of Cave Spring, a light colored variety occurs on the summit of a ridge belonging to Mr. Culbertson. The bed appears to be quite extensive; and some of the ore is reported as giving a higher analysis than that of the specimen reported on a previous page.

At other points, a mile and a half south of Cave Spring, the mineral is also reported.

Northeastward, about six miles from Cave Spring, both the red and the whitish mineral occurs on the land of Mr. John Henry, lot 910, 3d district. This is on the west side of the ridge and exposed by washouts descending the hill (see analysis). Much ore is shown upon the surface.

At a short distance to the north, is New Prospect church, and back of it, on lot 820 (Mr. Myles Mosley), is a light gray, earthy looking mass, with concretions of beauxite, beneath from two to four feet of gray soil. This is near the western foot of a ridge on which are iron and manganese ores. Indeed, near the beauxite, a siliceous iron ore is seen.

On lot 534, 3d district, is the deposit of Mr. A. W. Bobo; it lies in a cove on the eastern side of a ridge. It is a mixture of gray with some white and red beauxite, and much clay is associated with it. The grade is high (see analysis). It has been profitably worked. On properties near by, other deposits (Mrs. W. S. Johnson's, lots 692 and 677) are reported, and extensive deposits of iron ore have been worked on adjacent lots.

Upon the eastern side of a ridge, east of the last named, Mr. J. A. Howell's land (lot 610 or 615) contains beauxite in a cove, and also large deposits of brown ore.

On lot 906, 3d district, Mr. Doyle's farm contains beauxite (see analysis). This is in the valley, and may be only float. It lies on northwestern side of another ridge. To the east, Mr. Scott's farm, lots 897 and 960, 3d district, now owned by Mr. J. W. Hawkins, contains the white and red mineral, occurring on the lower part of the ridge and covered with more or less creep soil. On the side of valley eastward, beauxite occurs on property of Mr. R. S. Brammon (lot 14, 22d district). Upon the western side of a ridge, east of the C. R. & C. Railway, Dr. J. C. Reece has much light colored beauxite on lot 60, 22d district. This occurs on the western side of a ridge. This land here is gray, with very little chert.

In this district we thus see that the beauxite occurs on numerous parallel ridges, extending from Polk county northward to near Silver creek. Indeed, there seems no reason why the mineral may not be found nearly all the way to the Etowah river, along the more rugged western portions of the Knox dolomite series, west of Spring creek valley. Some beauxite has been reported east of this stream, but the existing conditions are different from those farther west.

Northeast of Rome the beauxite belt reappears, as on the lands of Mr. Wisnant and Mr. Walters and other properties. The belt continues northeastward, and is extensively developed near Hermitage. This is the localtiy where Mr. J. W. Hawkins first found it in 1887. More than 4,000 tons have been taken out of a pit on lot 61, 23d district (to October, 1891). This pit is more than 100 feet in diameter and 50 feet deep without reaching the bottom of the deposit. The beauxite is of red and white colors, the different varieties prevailing in different parts of the pit. It occurs in nodules and boulders made up of concretionary pisolites, bedded in an earthy mass. Or, again, it may be in the form of loose gravel-like masses, in which case it is apt to be siliceous. One of these boulders yielded sixty-four wagon loads. At this digging more or less earthy mineral and clay bands occur along with the beauxite or between the pockets. Also horses of clay prevail in the pit, so that more than half of the material has to be rejected. Much beauxite is lost with this refuse. The redder mineral seems to prevail in the lower parts of the accumulations.

The deposit is covered with from four to eight feet or more of light tinted red clay. Some of this surface covering is probably of creep origin, as it occurs on the side of a ridge. The surface is strewn with some cherty fragments. The beauxite here appears to be in great lenticular pockets peculiar to certain beds of the original rock. The bedding is mostly obliterated, but some bands of red clay, dipping southeastward, indicate the relation to the original bedding. The locations of the beauxite are near the head of the cove in the ridge. In another opening on the same property the white clay also prevails. Boulders of beauxite are occasionally scattered through the clay beds.

On Flowery branch, lot 21, 23d district, light colored beauxite and white clay occur on the gently rising ridge. (See analysis of clays.)

In this region beauxite occurs on many other properties; and is said to be found on lots 22, 19, 30, 39, 103, 104, 147, 134, 136, 23d district, by Mr. J. W. Hawkins.

The ore of this region is shipped from Cunningham station.

There are many iron ore deposits in this (Armstrong Mountain) district, which are more or less associated with the superficial cherty accumulations.

Northeast of these deposits the beauxite is found on Mr. Shaw's farm, lot 31 (?), 16th district, about two miles southwest of Adairsville. Here the mineral occurs as boulders in yellow clay. In descending into the mass the pisolitic grains become fewer. At the surface it is a light reddish mass, with the interior of the grains dissolved away, and the partial cavities containing a light reddish powder (see analysis).

The situation of the deposit is on the west side of a flattened ridge. This chain of deposits continues to the border of Gordon county. In a cove on lot 32, 15th district, on property of Mr. J. M. Pinson, there is a large deposit of the white mineral, but it has not been analyzed.

West of Linwood (late Hall's Station) beauxite occurs on the Barnsley estate (lot 115 and others in the 16th district, Bartow county) at Woodland. It is found in large boulders beneath a yellowish, sandy clay soil; on a flattened and also on more rugged ridges. It is a light colored, in part compact pisolitic mass of high grade (see analyses), and again in loose oölitic gravel. Iron and manganese ores occur near by. On the east side of the valley there are other deposits of high grade, which contain gibbsite. Large exposures may now be seen since the removal of three to five feet of soil.

Other ridges to the eastward contain large deposits of beauxite. On the ridge to the westward of the Connesenna creek, near Cement, beauxite occurs in yellowish red clay beneath yellowish soil, covered with only a small amount of chert, although the ridge is generally cherty. An example may be seen in the deposits of Montague & Co., lot 97, 16th district. Woodland is in a narrow valley excavated out of Upper Cambrian slates. Beyond, various ridges contain beauxite, as lots 107, 108, 109, 102, etc.

Eastward of Linwood some of the properties show large deposits, as that of Mr. Seay (lot 108, 16th district). This beauxite is whitish, oölitic and porcelaneous in places. Other deposits are red. On lot 108, the mineral is covered with from six to nine feet of yellowish soil. There are extensive iron ore deposits in this same region.

In the Knox series in the eastern part of Bartow county, beauxite also occurs, and at many other localities in the formation it may likely be found. The Bobo, Hermitage and Barnsley deposits are those where the principal workings are located. At other localities in northwestern Georgia, beauxite occurs upon the narrow belt of Knox dolomite associated with white clay and sparingly with brown iron ores. Thus beauxite is found on a lot of Mr. Taylor, west of Summerville. Elsewhere, in the narrow belts of the formation, beauxite may be looked for, as well as in the broader belts of the Coosa basin.

CHAPTER XXXIII.

ALUMINUM, ITS SOURCES AND USES.

BY R. L. PACHARD.

FROM AUTHOR'S SHEETS OF "MINERAL RESOURCES OF THE UNITED STATES FOR 1891."

NOTE.—Owing to the rising importance of aluminum and its sources of supply, the editor has deemed it advisable to append the paper to that of this report of the survey of the State as it was only received after the Georgia report was in type.

BAUXITE IN EUROPE.

"The mineral received its name from Baux, a village in the south of France, where it was first found, and the more highly ferriferous variety was regarded and worked as an iron ore, but proved too refractory. It sometimes ran as high as 42 per cent. metallic iron. The analysis by Berthier revealed its true character. The geological occurrence of the bauxite of Baux was studied by H. Coquand (*Bull. de la Société Geologique de France*, vol. 28, p. 98, 1871), who describes the mineral as of three varieties, pisolitic, compact and earthy. The pisolitic variety does not differ in structure from the iron ores of Franche Comté and Berry, although the color and composition are different. It occurs in highly tilted beds alternating with limestones, sandstones, and clays, belonging to the upper cretaceous periods, and in pockets or cavities in the limestone. The limestone containing the bauxite and that adjacent thereto is also pisolitic, some nodules being as large as the fist, and pisolitic bauxite has sometimes a calcareous cement, and at others is included in a paste of the compact mineral. M. Coquand supposed that the alumina and iron oxide composing the bauxite were brought to the ancient lake bed in which the lacustrine limestone was formed by mineral springs, which, discharging in the bottom of the lake, allowed the alumina and iron oxide to be distributed with the other sediment. In some cases the discharge occurred on land, and the deposit then formed isolated patches. He refers to other similar deposits of bauxite of the same period in France. Sometimes the highly ferriferous mineral predominates over the aluminous (white), at others diaspore is found enveloping the red mineral, while in others it is mixed with it, predominating largely, and sometimes manganese peroxide replaces ferric oxide. In some places the ground was strewed with fragments of tuberous menilite, very light and white.

M. Angé (*Bull. Soc. Geolog. de France*, 16, p. 345, 1888) describes the bauxite of Var and Hérault and gives analysis of it. Over 20,000 tons were being mined in this region annually at the time of writing his report (1888). In the red mineral of Var druses occur with white bauxite running as high as 85 per cent. Al_2O_3, and 15 per cent. H_2O, corresponding to the formula $Al_2O_3 + H_2O$. He refers to the prevailing theory of the formation of bauxite, according to which solutions of the chlorides of aluminum and iron in contact with carbonate of lime undergo double decomposition, forming alumina, iron oxide, and calcium chloride. Other deposits in the south of France, in Ireland, Austria and Italy, he says, confirm this view, because they also rest upon or are associated with limestone. The bauxite deposit in Puy de Dome which he studied could not, however, be explained by this theory because it was not associated with limestone, but rested directly upon gneiss and was partly covered by basalt. The geological sketch map of the deposit near Madriat, Puy de Dome, which he gives, shows gneiss, basalt, with uncovered bauxite largely predominating, and patches of miocene clays, while a geological section of the deposit near Villeveyrac, Hérault, shows the bed of bauxite conformably following the flexures of the limestone formation when covered by more recent beds, and when exposed and denuded occupying cavities and pockets in the limestone. This occurrence is substantially the same as that of the neighboring Baux. M. Angé agrees with M. Coquand in attributing the bauxite to geyserian origin. He uses as an illustration of the contemporaneous formation of bauxite the deposits from the geysers of Yellowstone park, which is evidently due to a misunderstanding. He made no petrographical examination of the bauxite of Puy de Dome, nor did he attempt to trace any genetic relation between the latter and the accompanying basalt. The occurrence is, however, noteworthy, and an examination might show that it is another instance of the direct derivation of bauxite from basalt, which is maintained in the two following instances, somewhat imperfectly in the first to be sure, but with greater detail in the second.

The first is a paper by Lang in the Berichte der Deutschen Chemischen Gesellschaft, Vol. 17, p. 2892, 1884. He describes the bauxite in Ober-Hessen, which is found in the fields in round masses up to the size of a man's head, embedded in a clay which is colored with iron oxide. The composition varies very widely. The petrographical examination showed silica, iron oxide, magnetite, and augite. The chemical composition and petrographical examination shows the bauxite to be a decomposition product of basalt. By the weathering of the plagioclase feldspars, augite, and olivine, nearly all the silica had been removed, together with the greater part of the lime and magnesia; the iron had been oxidized and hydrate of alumina formed as shown by its easy solubility in hydrochloric acid. The residue of the silica had crystallized as quartz in the pores of the mineral.

The more detailed account of the derivation of bauxite from basalt is given in an inaugural dissertation by A. Liebreich, abstracted in the *Chemisches Centralblatt*, 1892, No. 3, p. 94. This writer says that the well known localities of bauxite in Germany are the southern slope of the Westerwald near Mühlbach, Hadamar, in the neighborhood of Lesser Steinheim, near Hanau, and especially the Western slope of the Vogelsberg. Chemical analyses show certain differences in the composition of bauxite from different places, the smaller amount of water in the French bauxite referring it to diaspore, while the Vogelsberg mineral is probably Gibbsite (hydrargillite). The bauxites of Ireland, of Westerwald, and the Vogelsberg, show by certain external indications their derivation from basalt. The bauxite of the Vogelsberg occurs in scattered lumps or small masses, partly on the surface and partly imbedded in a grayish white to reddish brown clay, which contains also similar masses of basaltic iron ore and fragments of more or less weathered basalt itself. Although the latter was associated intimately with the bauxite, a direct and close connection of the two could not be found, but an examination of thin sections of the Vogelsberg bauxite showed that most specimens still possessed a basaltic (anamesite) structure, which enabled the author to determine the former constituents with more or less certainty. The clay from different points in the district carrying basalt, basaltic iron ore, and bauxite were examined, some of which showed clearly a sedimentery character. Some of the bauxite nodules were a foot and a half in diameter and possessed no characteristic form. They were of an uneven surface, light to dark brown, white, yellowish, and gray in color, speckled and pitted, sometimes finely porous and full of small colorless or yellowish crystals of hydrargillite. The thin sections showed distinct medium-granular anamesitic structure. Lath-shaped portions filled with a yellowish substance preponderated (the former plagioclases) and filling the spaces between these were cloudy, yellow, brown, and black transparent masses which had evidently taken the place of the former augite. Laths and plates of titanic iron, often fractured, were commonly present and the contours of altered olivine could be clearly made out. The anamesitic basalt of the neighborhood showed a structure fully corresponding with the bauxite. Olivine and titanic iron oxide were found in the clay by washing. The basaltic iron ore also showed the anamesite structure.

BAUXITE IN AMERICA.

The American occurrences of bauxite so far observed are in Alabama, Georgia and Arkansas. Prof. Eugene A. Smith, State Geologist of Alabama, has kindly furnished the following information in regard to the bauxite of that State. He writes:

IN ALABAMA.

"The mining of bauxite was begun in Alabama in November, 1891, by the Southern Bauxite Mining and Manufacturing Company, of Piedmont, Alabama, which has shipped up to date (November, 1892) about 3,600 tons. In July, 1892, the Republic Mining and Manufacturing Company, of Hermitage, Georgia (which is the pioneer in the business), secured a lease of the mines of the Bass Furnace Company, at Rock Run, Cherokee county, and has shipped up to date, about 1,300 tons. In addition to this both companies have several hundred tons under sheds drying out. The ore goes to Philadelphia and Natrona, Pennsylvania; Syracuse, Buffalo, Brooklyn, New York, and other places. * * * It comes into competition with ore from Baux in France, which can be purchased at a lower price than that at which this region can furnish it; but it is claimed by the manufacturers that our ore is more soluble, and therefore more valuable, though containing slightly less alumina. * * * [Our] alumina runs from 56 per cent. to 60 per cent. average carload analysis. Of the insoluble matter silica is the chief ingredient. The ore contains 1 to 3 per cent. of titanic acid, and will average from 25 per cent. to 30 per cent. of water. The ore occurs associated with limonites and kaolins in irregular beds, in the region underlaid by the Knox dolomite of the Lower Silurian formation. In Alabama these occurrences are always near to the foothills of the mountains formed of the Weisner quartzite or sandstone, which is a member of the Cambrian in this State. The bauxite therefore seems to be associated chiefly with the lower beds of the Knox dolomite. The best known occurrences are near Rock Run furnace in Cherokee county, where it has been followed for a few miles toward the Georgia line. This is the only place in Alabama where any systematic mining is done, and this by the two companies above named whose mines are closely contiguous. Near Jacksonville, Alabama, in Calhoun county, the ore has also been discovered, but not yet mined commercially.

"The mines are in S. 25, T. 11, R. 11, about three and a half miles northeast of Rock Run furnace and close to the Georgia line. In mining the limonite in one place great quantities of bauxite were moved and lie now in the dump pile. This was before it was recognized as bauxite."

The statistical information in the foregoing was furnished to Prof. Eugene A. Smith, State Geologist of Alabama, by Mr. J. M. Garvin, superintendent of the Rock Run Furnace Company.

He sends analyses, which are included with the others on a subsequent page.

IN GEORGIA.

The Georgia bauxite occurs in the same formation. The Bureau is indebted to Dr. J. W. Spencer, State Geologist of Georgia, for the following account of its occurrence:

"It occurs in the residual clay from decomposition of the Knox (calciferous) dolomite formation, which series is greatly developed in Georgia. The principal belt commences near Adairsville and widens out, extending in a southwestern direction to Alabama. It occurs in the vicinity of brown iron and manganese ores. Indeed, the bauxite-bearing portion of the Knox series is nearly coincident with the manganese deposits. It occurs in pockets, often of great extent, and is usually covered with a few feet of clayey surface. A kaolin is often associated with it. It is mostly in concretionary nodules forming large pockets of small kidney-shaped masses scattered through the clay. Much of the bauxite is light colored, but other portions contain much iron. At one locality Gibbsite occurs associated with it. It evidently has a similar origin with the brown iron or manganese ores, and was probably deposited in lagoons from solution of decomposed crystalline rocks, which occur 18 or 20 miles to the east. Alumina is slightly soluble in water containing CO_2, as are also the other metals." The analyses of the Georgia bauxite by Prof. H. C. White are given below.

An estimate of the quantity of bauxite mined in Georgia, furnished to this division by Mr. Wm. G. Neilson, of Philadelphia, gives 728 tons for 1889, 1,850 tons for 1890, and 3,300 for 1891. The total output for Alabama up to June, 1892, was 3,200 tons.

The Arkansas bauxites occur in Tertiary areas and in the neighborhood of eruptive syenites, to which they seem to be genetically related. The mineral is pisolitic in structure, and varies in color and chemical composition (analysis below). It has been mined for iron ore, some specimens yielding 20 per cent. metallic iron, and is of great abundance (Prof. J. C. Branner, *American Geologist*, VII., p. 181).

Having now traced the ore of aluminum to its origin, as far as present information will allow, the following analyses will show the wide variations in its composition.

(For analyses foreign and Georgia bauxite, see Chapter XXXII.)

* * * * * *

ANALYSES OF ALABAMA BAUXITE.

[Analyst, Dr. Wm. B. Phillips.]

	From Cherokee county.	Jacksonville, Calhoun county.	Jacksonville, Calhoun county, red.	Jacksonville, Calhoun county, white.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	37.87	18.67	7.73	23.72
Al_2O_3	39.44	45.94	47.52	41.38
Fe_2O_3	2.27	11.86	19.95	.85
H_2O hygroscopic	9.20	1.40	23.57	23.41
H_2O combined	12.80	21.20		
TiO_2	....	....	....	....

ANALYSES OF BAUXITE FROM JACKSONVILLE, CALHOUN COUNTY, ALABAMA.

[Analyst, W. F. Hillebrand]

	Red.	White.
	Per cent.	*Per cent.*
SiO_2	10.25	21.08
Al_2O_3	41.00	48.92
Fe_2O_3	25.25	2.14
TiO_2	2.53	2.52
P_2O_5	Trace.	Trace.
H_2O (100°)	.65	.45
H_2O (ign.)	20.43	23.41
Total	100.11	98.62

CaO, MgO, and alkalies, not looked for.

BAUXITE FROM PULASKI COUNTY, ARKANSAS.

	Black.			Red.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	10.13	11.48	5.11	4.89	3.34
Al_2O_3	55.59	57.62	55.89	46.40	58.60
Fe_2O_3	6.08	1.83	19.45	22.15	9.11
H_2O	28.99	28.63	17.39	26.68	28.63
Total	100.79	99.56	97.84	100.12	99.68

	Per cent.	Per cent.	Per cent.
SiO_2	2.00	10.38	16.76
Al_2O_3	62.05	55.64	51.90
Fe_2O_3	1.66	1.95	3.16
TiO_2	3.50	3.50	3.50
H_2O (ign.)	30.31	27.62	24.86
Total	99.52	99.09	100.28

METALLURGY.

The electrolytic process by which aluminum is extracted from its oxide, alumina, is now well understood by all persons interested in the subject. In this country it is carried on by the Pittsburg Reduction Company. The principle is that alumina is decomposed in the presence of a melted fluoride by the electric current, and metallic aluminum is liberated. Powerful dynamos furnish the current for this purpose. In practice the alumina is dissolved in the fused flux, consisting of fluorides of aluminum and sodium, which is regarded as serving as a vehicle for the alumina. The furnace for effecting the operation is made in the form of an open iron-cased box which is thickly lined with carbon and is provided with a spout at the bottom for tapping of the aluminum. A large block, or series of bars of carbon, carried on an adjustable support and arranged to dip into the center of the furnace, forms the anode, the furnace itself forming the cathode. After the flux and alumina have been introduced the carbon anode is brought well down into the furnace and the current turned on. At first considerable resistance is offered, but as the materials in the furnace become highly heated this decreases, and the anode can be raised somewhat. Decomposition soon begins, the alumina being resolved into oxygen and metallic aluminum, the former being liberated at the anode, and, combining with the carbon of which it is composed, passes off as carbonic oxide, while the metallic aluminum, being heavier than the melted bath, sinks to the bottom of the latter and is tapped off from time to time. As the alumina is used up the increase in resistance indicates the progress of the reduction, and fresh alumina is added. The operation therefore is continuous.

Several new processes were patented during the year 1891 in Europe and in this country, the published character of which describes variations (improvements) on those already well known. It would be without the scope of this report to describe these processes until there is evidence to show that they have been put in operation in this country. The Pittsburg Reduction Company and the Cowles Company were the only producers in 1891.

PRODUCTIONS.

The amount of aluminum produced in this country during 1891, including small experimental concerns and that contained in alloys, amounted to 150,000 pounds. The Pittsburg Reduction Company's plant was in operation only five months of the year, owing to its removal to Kensington. In the preceding year the production was 47,881 pounds; and in 1889, 19,200 pounds.

In 1889 it was estimated that the total amount of aluminum extracted up to that date was about 116 tons, but that the indications then were that the annual production would soon exceed that amount. This prediction has been more than verified. The Neuhausen Company was producing at the rate of 1,000 kilos a day at the close of 1891. (*Dingler*, 282, 2, p. 431.) A branch of this company at Fuges produces about 400 kilos daily, and altogether it is safe to say that over 500 tons of aluminum are being produced annually in this country and Europe. Although the American production has been far outstripped by the European, there are indications that the year 1892 will show an improvement in this industry in this country.

PRICE.

In the United States the price of aluminum ranged from 75 cents to 90 cents per pound, according to quantity. At the beginning of 1892 it was quoted at 50 cents wholesale in the market reports. The European price was 5 marks per kilo at the latter date.

USES.

Besides the metallurgical use of aluminum in casting iron and steel, to be referred to below, the metal is used for an infinity of small articles as has always been the case, and for which its lightness, strength, and freedom from tarnish eminently adapt it. Indeed, with a total production of between 500 and 600 tons, of which, perhaps, 300 only are available for manufactured articles, no extensive use on the large scale could be expected. The newspapers have frequently spoken of the Swiss steam launch of aluminum. A life-boat of aluminum was under construction at Stralsund, Prussia, in December, 1891. It was expected that the lightness of the metal would be of great advantage in dragging the boat over the sands and in hoisting and lowering it. The list of proposed uses continue to increase. Disregarding them, the actual use is sufficiently varied. Small articles, viz., drinking cups, rulers, and paper-cutters, perfumery stands, smokers' sets, ash-receivers, toothpick and match holders, watch cases, lemonade shakers, card-receivers, butter dishes, rings, spoons, picture frames, bracelets, napkin rings, sleeve and collar buttons, scarf and shawl pins, penracks, dog collars, key chains, hairpins, pencil cases, and pannikins are advertised.

In Germany aluminum tubing is used for penholders, umbrella handles, walking sticks, billiard cues, chair legs, photograph frames, and newspaper-holders.

Powdered aluminum mixed with chlorate of potassium has been used for flashlights instead of magnesium. It is said to make an excellent light and to give no smoke like magnesium.

Mr. Alfred E. Hunt, president of the Pittsburg Reduction Company, in a lecture delivered in March, 1891, gives some information in regard to the use of aluminum in railroad work. He says that the metal has been used, on account of its lightness, for slide valves (experimentally); for valves to control the passage of the air from the storage to the brake cylinders in the new and larger forms of the Westinghouse air brake, the inertia of the heavy iron or brass valves being a serious consideration; for the fan blades and frames of windmills; in semaphore signal disks and their moving frame work.

The use of aluminum for canteens and military equipments in the German army has suggested a similar use in this country, and aluminum curb bits, saber-belt plates, canteens, meat cans, cartridge-belt plates, and spoons and forks have been submitted to the War Department in Washington for consideration. The object is to save weight and avoid rust.

The substitution of aluminum for glass flasks for the army and its use in general for vessels which are designed for holding foods and drinking fluids have given rise to experiments in Germany to test the action of various fluids upon the metal. The results are on the whole favorable to its employment for such purposes. It must be remembered that the aluminum of commerce contains small quantities of other metals and metalloids, sometimes amounting to 2 per cent., so that it is virtually an alloy. The resistance of aluminum to acids has long been a popular belief, and, before giving the results of the experiments as to the action of drinking fluids upon aluminum, the following account of some experiments with nitric and sulphuric acids is given to show that the former belief in the resistance of the metal to all acid except hydrochloric must be modified. Undoubtedly the physical condition of the metal operated on, as well as its chemical composition, makes a great difference in its power to resist the action of acids, a finely divided metal being much more easily attacked than the same metal in large pieces. G. A. LeRoy (*Chemisches Centralblatt,* 1892, Bd. I., No. 2, p. 51) found that nitric and sulphuric acids of different strengths acted upon aluminum as shown below under the conditions specified. He used aluminum foil having the composition 98.29 per cent. to 99.6 per cent. aluminum, 1.60 per cent. to 0.30 per cent. iron, and 0.10 per cent. to 0.25 per cent. silicon. The foil was polished, freed from fat with caustic soda, washed with alcohol, dried in the bath, cut up, weighed, and introduced into the acids. In this fine condition the action of the acids was as shown in the following table, the weight being the amount of metal dissolved expressed in grams per square meter. The action lasted twelve hours.

ACTION OF VARIOUS ACIDS ON ALUMINUM FOIL.

ACIDS.	Specific gravity.	Temperature (centigrade.)	Samples. A.	B.	C.	D.
			Grams.	*Grams.*	*Grams.*	*Grams.*
Pure H_2SO_4	1.842	15°-20°	18.40	18.90	16.40	14.50
Common H_2SO_4	1.842	15°-20°	21.00	21.30	17.50	16.40
Pure H_2SO_4	1.711	15°-20°	24.50	25.00	22.00	20.00
Common H_2SO_4	1.711	15°-20°	25.80	25.70	24.60	22.40
Pure H_2SO_4	1.580	15°-20°	19.00	18.00	17.90	16.30
Pure H_2SO_4	1.263	15°-20°	4.60	....	2.60	3.40
Pure HNO_3	1.383	15°-20°	17.00	16.00	15.50	14.50
Common HNO_3	1.383	15°-20°	29.50	19.60	18.00	16.60
Common HNO_3	1.332	15°-20°	16.30	16.30	14.00	13.40
Pure H_2SO_4	1.842	150°	240.	225.	150.	200.
Common H_2SO_4	1.842	150°	267.	250.	210.	220.
Pure HNO_3	1.382	100°	....	....	Violent action.	Violent action.
Common HNO_3	1.382	100°	....	....		

According to these results almost pure aluminum, 99.5 per cent., is attacked even in the cold by nitric and sulphuric acids, so that the metal should not be used in apparatus for preparing these acids.

As to the action of drinking fluids, coffee, tea, beer, wines, brandy, etc., the following appears to be the state of the case: Messrs. Lübbert and Roscher, *Chem. Centralbl.*, 1891, Bd. II., No. 18, p. 780) tested the resistance of aluminum to the action of alcohol, ether, aldehyde, coffee, tea, wines and antiseptics, by allowing aluminum leaf to remain in concentrated solutions of the different liquids four days at the temperature of the room, and the fluids were examined either directly for alumina or were evaporated and the ignited residue so examined. The conclusion reached was that aluminum possesses only a slight degree of resistance to the agents named, except alcohol, ether and aldehyde, and that it is therefore unsuitable for wares which are to be used for acid drinks, coffee, tea, etc., or articles which are to be cleaned with soda or soap. Its application in daily life would therefore be very limited.

On the other hand, G. Rupp, (*Dingler*, 283, I, January 21, 1892,) criticizes the methods employed by Lübbert and Roscher for determining the action of the fluids by estimating the alumina contained in them, as well as the use of aluminum leaf for their experiments, which is attacked much more easily than the compact metal, the former being acted on even by boiling water, while the latter is unaffected. His own experiments were made upon aluminum vessels (canteens, drinking cups, etc.) and foil, the object being to determine the availability of the metal for use in the army. The carefully dried and weighed vessels were filled with the different fluids or the foil was immersed in them, and the action was allowed to continue four, eight and twenty-eight days, at the temperature of the room with frequent stirring. The fluids included wines of different kinds, beer, kirschwasser, cognac, coffee, tea, milk, drinking water, 1 per cent. solution of tartaric acid, acetic acid (1 per cent., 4 per cent., 10 per cent. solutions), vinegar (10 per cent.), soda solution (1 per cent.), besides butter, honey and preserved fruits. The articles were then cleaned, dried and weighed, to determine the loss of weight. The results, which fill a large table, showed that in most cases there was absolutely no action and in the few cases where there was a perceptible loss of weight it was so trifling as to be disregarded. To the objection that continued drinking of fluids containing a small quantity of alumina would eventually be dangerous, the author points out that the ash of all the fluids usually drank contains alumina, as well as most foods and drinking water itself. His conclusion is that there is no objection to the use of aluminum for canteens and similar vessels.

These conclusions of Rupp were confirmed by Dr. A. Arche (*Dingler*, Vol. 284, No. 11, p. 255), whose experiments show that the purity of aluminum (using the percentage of silicon as a means of classification) has much to do with its power of resisting the solvent action of fluids, and they also show that the mechanical preparation of the metal is an important factor. He found that hammered aluminum was least attacked, rolled metal came next, and then the drawn metal, while cast metal was much more easily attacked (by acetic acid).

METALLURGICAL USE.

The quantity of aluminum used in this country in the manufacture of iron and steel castings is probably from 25 to 30 per cent. of the total production. In Europe it is estimated by Professor Wedding to be 54 per cent. This use, as was explained in the last number of this series, consists in adding from 0.10 to 0.15 per cent. of aluminum to iron or steel just before casting, by which blow-holes are prevented and sounder casting are produced. This use is becoming general. The beneficial effect, as was shown by experiments referred to last year, is due in part at least to the deoxidizing action of aluminum upon carbon monoxide at a high temperature, a reaction which was demonstrated directly between the metal and the gas. This subject has not yet received an exhaustive examination. For this purpose it would be necessary to know the composition of the iron or steel operated on in each case and make comparative tests on the different specimens. It is also probable that the method of melting employed has an effect on the result.

A detail of manipulation in the method of applying aluminum, especially in castings for steam and pump cylinders and other castings intended to resist high pressures, is reported in *Dingler's Journal* (Vol. 284, No. 11, p. 255). The addition is made by first forming a mixture of aluminum and iron, which is effected by placing the proper quantity of heated aluminum in the bottom of a small ladle, running some iron into the ladle from the furnace, and waiting until the mixture begins to stiffen. Then the iron to be operated on is run into a large ladle and the iron-aluminum mixture is poured into it, whereby an intimate mixture of the whole is effected. For 100 kilograms of iron to be operated on 200 grams of aluminum are used (=0.20 per cent.) The iron is not poured at once from the large ladle, but is allowed to stand until it is orange yellow and a thin film begins to form on the surface. As soon as this occurs the film is removed and the iron is poured. The mold should be kept full. No reason is assigned for this procedure, but it appears that iron containing aluminum is inclined to shrink excessively and that this tendency must be obviated by pouring as cold as possible.

According to a paper read by Mr. J. W. Langley, at the Glen Summit meeting of the American Institute of Mining Engineers, the practice in the United States in pouring ingots is as follows: The aluminum, in small pieces of ¼ or ½ pound weight, is thrown into the ladle during the tapping, shortly after a small quantity of steel has already entered it. The aluminum melts almost instantaneously and diffuses with great rapidity throughout the contents of the ladle. The diffusion seems to be complete, for the writer has never seen the slightest action indicating want of homogeneity of mixture, all of the ingots poured from one ladle being precisely alike so far as the specific action of the aluminum is concerned. The quantity of aluminum to be employed will vary slightly according to the kind of steel and the results to be obtained. For opened-hearth steel, containing less than 0.50 per cent. carbon, the amount will range from 5 to 10 ounces per ton of steel. For Bessemer steel the quantities should be slightly increased, viz., 7 to 16 ounces. For steel containing over 0.50 per cent. carbon, aluminum should be used cautiously; in general between 4 and 8 ounces to the ton. If these statements are put in the form of percentages, it will at once be seen how extremely minute is the quantity of aluminum which causes such marvelous results, for the numbers are:

4 ounces	= 0.0125 per cent.	= 1-8000
5 ounces	= 0.0156 per cent.	= 1-6500
8 ounces	= 0.0250 per cent.	= 1-4000
16 ounces	= 0.0500 per cent.	= 1-2000

SOLDERING.

From the articles which occasionally appear in the trade journals, both in this country and Europe, and the patent list, it appears that the difficulties of soldering aluminum have not been overcome. Some of the new solders are introduced here without comment.

Chloride of silver has been recommended as a solder. It is to be finely powdered and spread along the junction to be soldered and melted with the blow pipe. Mr. Joseph W. Richards makes an alloy of aluminum 1 part, zinc 8 parts, tin 32 parts, and phosphor-tin, containing 5 per cent. phosphorus, 1 part. The aluminum is first melted, then the zinc is added, and finally the tin, which has been melted separately and mixed with the phosphor-tin. The alloy is poured into small bars for use. The object is to provide in the phosphorus a powerful reducing agent to prevent the formation of the film of oxide which usually prevents the intimate contact of the opposed surfaces. (United States patent 407789, October 5, 1891.) Another formula is, cadmium 50 parts, zinc 20, tin 30. The zinc is first melted, then the cadmium is added, and finally the tin. (*Dingler's Journal*, Vol. 284, No. 6, page 144.) Electroplating the surfaces with copper and then applying the solder was mentioned last year.

Other solders which have been used are composed of—

COMPOSITION OF CERTAIN SOLDERS FOR ALUMINUM.

	I.	II.	III.	IV.	V.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Aluminum	12	9	7	6	4
Copper	8	6	5	4	2
Zinc	80	85	88	90	94

In making these solders the copper should be melted first, the aluminum then added, and the zinc last. Stearin is used as a flux to prevent the rapid oxidation of the zinc. When the last metal is fused, which takes place very quickly, the operation should be finished as rapidly as possible by stirring the mass, and the alloy should then be poured into an ingot mold of iron, previously rubbed with fat. The pieces to be soldered should first be cleaned thoroughly and roughened with a file and the solder placed on the parts in small fragments, the pieces being supported on a piece of charcoal. The place of juncture should be heated with the blast lamp. The union is facilitated by the use of a soldering tool of aluminum. This last is said to be essential to the success of the operation. Alloy I. is recommended for small objects of jewelry; alloy IV. is said to be the best adapted for larger objects and for general work, and is that most generally used. The successful performance of the act of soldering appears to require skill and experience, but the results obtained are said to leave nothing to be desired. Soldering tools of copper or brass should be avoided, as they would form colored alloys with the aluminum and solder. The skillful use of the aluminum tool, however, requires some practice. At the instant of fusion the operator must apply some friction, and, as the solder melts very suddenly, the right moment for this manipulation may be lost unless the workman is experienced.

ALLOYS.

It is regretted that no statistics of the production of aluminum bronze and ferro-aluminum in this country can be given for 1891. Both of these valuable alloys have been produced by the Cowles Electric Smelting and Aluminum Company for a number of years, and have found their way into the market on a considerable scale. The ferro-aluminum made by this company was used as a vehicle for adding aluminum to iron and steel in making sound castings when that method was first introduced. Aluminum bronze is coming into use in Germany for torpedoes on account of its strength and non-corrodibility, and for telephone wires. It was estimated that 280,000 kilograms would be used during 1892. The 5 per cent. bronze has been used for some time for nozzles of gas motors on account of its non-oxidizable character, and the 12 per cent. bronze is used for the pins of needle guns, for which purpose it is said to be better than steel.

The number of patents which have been granted for aluminum alloys, either where that metal forms a minor ingredient or has small quantities of other metals added to it for special purposes, shows that experimenting in this direction is increasing. As yet much of this experimenting is done without definite knowledge or aim on the part of inventors. Doubtless, in time, valuable conclusions may be derived from this kind of work, after rigid experiments with a definite purpose or idea have been undertaken. Of alloys formed with a specific purpose in view, that containing a small quantity of titanium, and another containing silver, were described last year. Others are mentioned in a lecture by Mr. Hunt, president of the Pittsburg Reduction Company, whose statements are valuable because they are based on knowledge and experience. He says:

"The alloys of from 2½ to 12 per cent. aluminum with copper have so far achieved the greatest reputation. With the use of 8 per cent. to 12 per cent, aluminum in copper we obtain one of the most dense, finest grained, and strongest metals known, having remarkable ductility as compared with its tensile strength. A 10 per cent. aluminum bronze can be made in forged bars with 100,000 pounds tensile strength, 60,000 pounds elastic limit, and with at least 10 per cent. elongation in 8 inches. An aluminum bronze can be made to fill a specification of 130,000 pounds tensile strength and 5 per cent. elongation in 8 inches. Such bronzes have a specific gravity of about 7.50, and are of a light yellow color. For cylinders to withstand high pressures such bronze is probably the best metal yet known.

"The 5 to 7 per cent. aluminum bronzes have a specific gravity of 8.30 to 8, and are of a handsome yellow color, with a tensile strength of from 70,000 to 80,000 pounds per square inch; an elastic limit of 40,000 pounds per square inch. It will probably be bronzes of this latter character that will be most used, and the fact that such bronzes can be rolled and hammered at a red heat with proper precautions will add greatly to their use. Metal of this character can be worked in almost every way that steel can, and has for its advantages its great strength and ductility, and greater power to withstand corrosion, besides its fine color. With the price of aluminum reduced only a very little from the present rates, there is a strong probability of aluminum bronze replacing brass very largely.

"A small percentage of aluminum added to Babbitt metal gives very superior results over the ordinary Babbitt metal. It has been found that the influence of the aluminum upon the ordinary tin-antimony-copper Babbitt is to very considerably increase the durability and wearing properties of the alloy. Under compressive strain aluminum Babbitt proves a little softer than the ordinary Babbitt. A sample 1½ inches in diameter by 1½ high began to lose shape at a pressure of 12,000 pounds. A similar sample of the same Babbitt metal without the addition of the aluminum (having a composition of 7.3 per cent. antimony, 3.7 per cent. copper, and 89 per cent tin) did not begin to lose its shape until a compressive strain of 16,000 pounds had been applied. Both samples have stood an equal strain of 35,000 pounds. In comparative tests of the ordinary Babbitt metal and the aluminum Babbitt metal, the latter has given very satisfactory results.

"The following alloys have recently been found useful: Nickel-aluminum, composed of 20 parts nickel, and 8 parts aluminum, used for decorative purposes; rosine, composed of 40 parts nickel 10 parts silver, 30 parts aluminum, and 20 parts tin, for jewelers' work; sun bronze, composed of 60 parts cobalt (or 40 parts cobalt), 10 parts aluminum, 40 (or 30) parts copper; metalline, composed of 35 parts cobalt, 25 parts aluminum, 10 parts iron, and 30 parts copper.

"Prof. Robert Austin has discovered a beautiful alloy containing 22 per cent. aluminum and 78 per cent. gold, having a rich purple color, with ruby tints.

"The addition of from 5 per cent. to 15 per cent. aluminum to type metal composed of 25 per cent. antimony and 75 per cent. lead makes a metal giving sharper castings and much more durable type."

Mr. A. H. Cowles makes an alloy for electrical purposes consisting of manganese 18 parts, aluminum 1.2 parts, silicon 5 parts, zinc 13 parts, and copper 67.5 parts. This alloy has a tensile strength of 26,000 kilograms and 20 per cent. elongation. Its electric resistance is greater than that of "neusilber," and it is therefore especially applicable for rheostats. (*Chemiker-Zeitung*, March 12, 1892.)

Mr. C. C. Carroll makes an aluminum alloy for dentists' fillings, consisting of silver 42.3 per cent., tin 52 per cent., copper 4.7, and aluminum 1 per cent. It is reduced to powder and then forms an amalgam with mercury. (U. S. patent 475382, May 24, 1892).

Mr. Chas. B. Miller has patented an antifriction alloy of lead 320 parts, antimony 64, tin 24, aluminum 2. (U. S. patent 456898, July 28, 1891.)

Mr. Thomas MacKellar has patented an alloy for type metal of lead 65 parts, antimony 20, and 10 parts of an alloy consisting of equal parts of tin, copper and aluminum. The tin-copper-aluminum alloy is first melted, the antimony added to it, and the mixture is then added to the melted lead. (U. S. patent 463427, November 11, 1891.)

An aluminum bronze alloy contains aluminum 12 to 25 parts, manganese 2 to 5, copper 75 to 85. It is the product of John A. Jeancon. (U. S. patent 446351, February 10, 1891.)

The antifriction metal (Babbitt metal plus aluminum) contains antimony 7.3 parts, tin 89, copper 3.7, with from ¼ to 2.5 parts of aluminum. It is patented by Alexander W. Cadman. (U. S. patent 464147, December 1, 1891.)

ALUMINUM IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES FROM 1870 TO 1891.

Year ending—	Quantity.	Value.	Year ending—	Quantity.	Value.
	Pounds.			*Pounds.*	
June 30, 1870	....	$ 98	June 30, 1882	566.50	$6,459
1871	....	341	1833	426.25	5,079
1873	2.00	2	1884	595.00	8,416
1874	683.00	2,125	1885	439.00	4,736
1875	434.00	1,355	Dec. 31, 1886	452.10	5,369
1876	139.00	1,412	1887	1 260.00	12,119
1877	131.00	1,551	1888	1,348.53	14,086
1878	251.00	2,978	1889	998.00	4,840
1879	284.44	3,423	1890	2,051.00	7,062
1880	340.75	4,042	1891	3,906.00	6,263
1881	517.10	6,071			

CHAPTER XXXIV.

CONTENTS.

COAL.

Only a remnant of the Coal Measures exist in northwestern Georgia, constituting the plateaus of Lookout (with Pigeon) and Sand mountains. The total length of the former mountain, in Georgia, is about 35 miles, with an area of 160 square miles; and the area of Sand mountain in the State is 50 square miles. The outlying ridges of Rocky mountain and Little Sand mountain do not contain any workable coal seams.

ON SAND OR RACCOON MOUNTAIN.

This table-land crosses the extreme corner of the State, containing several workable seams of coal. The total thickness of the Coal Measures on this plateau, in Georgia, is 800 feet. A complete section of the lower 500 feet is given on page 144 in order to illustrate the structure of the Coal Measures, and as it is here considered from an economic point, it may be repeated.

	Feet
Irregularly bedded sandstone or conglomerate	70.
Castle Rock coal	wanting
Shale	40
Dade coal seam	average 3
Sandstone and sandy shale, variable	12
Coal (Reese's red ash seam)	4
Shale	6
Sandstone, or conglomerate—upper half thin bedded, lower half thicker, with shaly seams	20
Coal, variable	0.5–3

	Feet
Sandstones and shale	10
Blue shales	10
Sandstones, thin bedded, and shales or sandy shale	15
Coal, 8 to 15 inches	1.25
Shales, middle layers heavy bedded	54
Coal, smut	—
Shale	15
Coal, smut	—
Shale	4
Concretionary beds	6
Shale	15
Sandstones, thick bedded	15
Shale	10
Shale with some thin layers of sandstones	95
Shales, concealed	90
Limestones	—

The principal workings are at Cole City upon the Dade coal seam, and also upon Reese's red ash seam. The coal lies in a basin, with a trend about N. 30° E. In the mines, the beds usually dip less than two feet per hundred, although at one locality, the seam rose 70 feet at an angle of 45° (Capt. Evans). The average thickness of the Dade seam is 3.5 feet, and it is moderately uniform over considerable areas. However, in places the coal seam pinches out, whilst in others the thickness is 9 feet, and at one place it is 17.5 feet. The Sand mountain coal has been extensively worked since 1873, but it was worked a quarter of a century earlier by Mr. Cooper and by Messrs. Gordon & Russell. The earlier workings were upon Castle Rock seam about 5 miles westward of Cole City. There the seam varied from 3 to 4 feet, but it is wanting near Cole City.

Section at Castle Rock downward from the brow of the mountain:

	Feet
Conglomerate, capping table-land	35
Coal	0.5–3.4
Shale	75
Coal (red ash vein)	1.5
Shale, exposed	100

At one locality the Castle Rock and Dade seams unite, owing to the absence of intervening shales. The Castle Rock seam in the original locality, is now exhausted as a source of coal. Another seam, called Reese's red ash seam, occurs a few feet below the Dade seam, and reaches a thickness of 4 feet.

The conglomerate of Sand mountain is mostly represented by massive sandstones of variable thickness. The upper conglomerate overlies the Castle Rock seam, which in position, is perhaps the most widespread bed of Coal Measures in Georgia. A comparison with the Lookout coal will be given under the latter locality.

The three seams of the Dade Coal Company, which have been worked on Sand mountain, occur between the lower and upper conglomerate. Beneath the lower conglomerate, which is thinner than on Lookout mountain, one workable seam occurs and possibly two; besides which there are still two other seams that may be seen.

The highest of these seams, below the lower conglomerate appears to be the Etna bed of Sand mountain, situated on an insular plateau between the Georgia line and the Tennessee river. The sections at Etna* and Cole City below the lower conglomerate, have about equal thickness, and each contains four known seams. The lowest of these at Etna are from 0.5 to 3 feet, whilst at Cole City, these two are represented by a few inches, which produce a zone of smutty shale along the exposed section.

North of Cole City the table-land rises about 300 feet above the upper conglomerate. Near the Tennessee line, a mile from Mr. Liedermann's house, the ridge is capped by about 20 feet of sand-

*Geology of Tennessee, by Jas. M. Safford, p. 383.

stone, beneath which only shale was seen in the few exposures. But at 75 feet below the surface a bed of coal, from 2 to 3 feet thick, occurs. Other beds may be found, but they were not exposed. Near the Etna line, just mentioned, Prof. Safford records the occurrence of three beds of coal from 2 to 6 feet thick—the middle having the greatest thickness, but containing interbedded layers of slate. This is notable when compared with the deposits on Lookout mountain.

The upper plateau ridge of Sand mountain is limited to a small area, owing to extensive denudations, leaving the upper conglomerate of Castle Rock region most commonly forming the margin of the table-land of Sand mountain; but even this conglomerate is wanting in places upon the eastern side of the mountain. The surface of the plateau is often deeply indented by the valleys, formed during the long continued action of evanescent streams. Thus, the surface of the table-land is left more or less rugged.

Upon the eastern side of Sand mountain, several borings have been made by the New England Company; the records of which were furnished me by Mr. E. C. Stevens.

SECTION 1.

	Feet
Surface earth	18
Sandstone	46.5
Castle Rock coal	wanting
Shale	28
Dade coal	125
Conglomerate or sandstone	43.25
Coal	1
Sandstone	21.5
Shale	60.5
Sandstone	21.5
Coal	0.75
Shale	16.75

	Feet
Coal	0.33
Sandstone	5.66
Shale	106

The above section is on lot 91, tenth district.

SECTION 2.

	Feet
Surface	3
Sandstone	7
Conglomerate	41
Castle Rock coal	0.75
Sandstone	4.25
Slate	20
Dade coal	3

SECTION 3.

	Feet
Surface	3
Conglomerate	50.75
Castle Rock coal	0.25
Shale	8
Dade coal	4

SECTION 4.

	Feet
Surface	3
Sandstone	51
Conglomerate	12
Castle Rock coal	0.25
Conglomerate	6.25
Shale	2.5
Dade coal	0.5
Slate	30

SECTION 5.

	Feet
Surface	1.5
Sandstone	8.5
Conglomerate	25.5
Castle Rock coal	0.25
Conglomerate	8.75
Shale	28
Dade coal	7

SECTION 6.

	Feet
Surface	3
Conglomerate	22
Castle Rock coal	0.25
Sandstone	4.75
Shale	15
Sandstone	70.15
Conglomerate	50.5
Shale	3
Conglomerate	12
Shale	2
Coal	3.5
Shale	10.3

SECTION 7.

	Feet
Surface	5
Shale	7
Coal	1
Shale	9
Sandstone	103
Shale	6
Sandstone	4
Shale	129
Limestone	—

From these sections a considerable variation of the different strata are seen. At one place, the conglomerate is wanting owing to surface erosion, whilst at another it has been preserved to a thickness of 90 feet. Although the coal seams vary in thickness, they have a wide distribution, and vary in thickness from 0 to 7 feet. So also the strata intervening between the coal seams are constantly changing thickness, yet the general characteristics of the formation are constant. Whilst the Coal Measures occupy a long, synclinal trough, yet the individual beds are separated into basins of various extent, and represent the individual marshes of the Carboniferous period, when the region was occupied by extensive swamps more or less separated by such hummocks as rise in the extensive swamps of Florida to-day. These changes in surface features gave rise to the thinning and thickening of the coal beds. Yet many of the deposits, although separated, had doubtless a synchronous origin.

Whether represented by a thinner or thicker seam of coal, the Castle Rock bed has a remarkably wide distribution; so also has the Dade seam. The Reese's red ash seam may, in places, be mistaken for the Dade seam.

The whole surface of Sand mountain is underlaid by coal beds, but the surface erosion has deeply incised the mountain and produced many valleys, whereby the beds of coal have been extensively wasted. In fact, the extravagant waste of nature has been something enormous, destroying coal beds in Georgia far more extensive than those remaining.

The coal seams are rarely exposed at the surface, as the outcropping beds are decayed and covered or obliterated by the residual earths forming the superficial soils. Even when the streams have cut through the formations, the coal beds are often indicated only by blackened or smutty shales; the thickness of which is often reduced to less than that of the coal. Consequently, after the locations of the beds have been made, the coal must be exploited in order to tell its value. In some cases the coal seams are so intermingled with coal shales as to impair their value.

LOOKOUT MOUNTAIN.

Lookout mountain consists of a plateau encircled by a wall of the upper conglomerate, corresponding to that of Sand mountain. Above this trench, upon the central part of the mountain, portions of a higher plateau remain, having a thickness above the conglomerate, reaching 750 feet. In the upper conglomerate, near Lula lake, at Lookout point, beneath High point and elsewhere, a thin seam of coal is observed. Above this horizon there are at least five beds of coal. The best section of the upper Coal Measures may be seen along the Chickamauga and Round Mountain Railway, noticed in the scientific description of the mountain, and repeated here. It may be noted that all of these coal seams, in the following section, are in a horizon above the upper conglomerate, and therefore, above the Castle Rock seam. The coal in the vicinity of Cole City, is geologically lower, but at the same time at a higher horizon than the Etna coal fields of Sand mountain in Tennessee.

SECTION ALONG ROUND MOUNTAIN AND CHICKAMAUGA RAILWAY.

		Feet
	Laminated shales with a few layers of sandstone on Round mountain (partly concealed)	200
	Shales? (concealed)	65
	Shale	9
(b)	Coal and shale intimately interlaminated	14
	Shale and sandy shale, partly concealed	25
(c)	Coal	0.7
	Shale	18
	Sandstone, gray laminated	35
(d)	Coal (3.5 to 4.5) dips 1° E. S. E.; altitude at mouth of Durham Seam Mine, 1,849 feet above tide. There is a slaty parting in the middle of the seam. This bed is probably represented on the southwestern side of the mountain at an altitude 30 feet lower	4

		Feet
	Sandstone, irregularly and often thinly bedded and undulating	80
	Red shale	11
	Black shale	4
	Shale and sandy shale with a seam of limestone	10
	Blue shale above and variegated shale below	7
(e)	Coal (altitude 1,668 feet)	1.83
	Thin, laminated, blue shales	70
	Red shales	35
(f)	Coal	0.2
	Light blue clay	2
	Shales and sandy shales, passing into sandstones and undulating so as to appear and disappear for a distance of three miles, but characterized by some recognizable layers, estimated at	150
(g)	Coal	1.66
	Sandy shales, in steep undulations	1 to 3
	Heavy bedded sandstones	25
(h)	Coal	0.20 to 0.83
	Upper conglomerate and sandstone (this is at Eagle cliff)	150
	Shales laminated and also thick bedded	120
	Lower conglomerate and sandstone	40
	Shales, more or less concealed	250 (?)

Round mountain rises above Lookout table-land as a prominent eminence, and upon its western side there is a bed of coal 27 inches thick, and another double bed with each layer about 2 feet thick, but separated by about 4 feet of shale. These beds are above seam b (or that now being worked). The double seam may be the equivalent of c. upon the eastern side of Round mountain. There is probably another seam upon the western side of the eminence.

The dip at the mines is less than one degree; so also the dip of the beds on the western side of the upper ridge is low, although at one locality it amounted to 12°. On the eastern side of Lookout plateau the strata dip northwestward, increasing to 12° or more, bringing the upper conglomerates to the great elevation of High point, but cutting off the eastward continuation of the basin of the upper coal series, which lies in the central part of the mountain. The basin has, however, been very much eroded. In the vicinity of Eagle point, the rocks dip 20° N. 70° to 80° W. Still farther northward the strata dip at much greater angles, but again flatten out towards Lookout point. So also they flatten out to the southward; consequently the beds, at least in the central part of the mountain, lie at low angles or gently undulate. It is only in the central portion of the mountain that the Coal Measures remain. Several of the beds have a workable thickness.

Below the upper conglomerate there are at least two coal beds known at several points. The upper of these is closely related to the conglomerate, being situated immediately below or within the sandstones. It is, probably, the representative of the Castle Rock coal on Sand mountain, and appears to be one of the most widely distributed of the coal seams. It is of variable thickness and quality. Under High point the coal bed varies from one to three feet, and is shaly.

South of Moore's gap the bed is still thicker. On the western side of Lookout plateau, overlooking Rising Fawn, a bed was opened of variable thickness, from 0 to 8 (?) feet. At Stephen's gap, on the south side of Johnson's crook, a coal seam has a thickness of from 1 to 3 feet. The position of the coal at this point may be seen in the following section of the Coal Measures:

	Feet
Conglomerate, on brow of mountain	50
Shale	30
Sandstone	15
Coal	4–10 inches

	Feet
Fire clay	7
Sandstone	10
Shale	110

This seam appears to belong to the lower of the two beds noted as occurring below the upper conglomerate. The rocks dip 18° S. 60° E. The same rocks and the upper coal seam occur in the ravine at the head of Trenton gulf, but it varies from 4 to 10 inches in thickness.

Another seam of coal occurs about 30 feet below the conglomerate, and is situated in the shale beds. As there are few diggings in the shale, the development of the coal is concealed by the disintegrated shales. In position this coal seems to be near that of the Dade coal beds. Above Rising Fawn furnace some extensive openings were formerly made, where the seam was from 3 to 5 feet thick, and said to vary from 0 to 8 feet in thickness, but there were no general workings. Owing to the covering of shale on the mountain side, the exploration of this bed can only be accomplished by borings or diggings, and may be found to have an extensive development in some localities.

At various points south of High point, upon the eastern side of Lookout mountain, the coal beds reoccur, and also on Pigeon mountain. Along the stream north of Neal's gap coal occurs immediately below the upper conglomerate. About a mile and a half north of Dougherty's gap, in a small ravine trending northward on the east side of Pigeon mountain, a foot of coal occurs beneath the heavy sandstone. This is along a synclinal axis.

Whilst there is somewhat of a general correlation between the coal beds of Sand and Lookout mountains, yet the variation in the thicknesses of different portions of the same basins, give rise to changing conditions.

ANALYSES OF THE COAL.

Analysis of the Dade coal seam by Dr. Gustave Bidtel:

	I.	II. (Old veins.)
Fixed carbon	61.69	74.84
Volatile matter	27.15	15.86
Ash	10.59	9.31
Sulphur	0.58	1.45
Phosphorus		0.059

Analysis of the Reese Red Ash seam (next below Dade seam):

	I.	II. (New veins.)
Fixed carbon	66.55	83.22
Volatile matter	28.64	12.92
Ash	4.41	3.26
Sulphur	1.04	1.05

Analysis of Dade coke:

Ash	Fixed Carbon.	Volatile Matter.	Phosphorus.	Sulphur.
26.12	64.98	7.92		
22.91	71.79	5.30	.061	.63
24.74	68.15	7.11	.073	.28
16.73	76.58	6.69		
21.73	69.66	8.42		
20.15	70.48	8.88		

Analysis of Round Mountain coal (seam d), by Dr. G. Bidtel, of Chattanooga:

Fixed carbon	79.10
Volatile matter	16.03
Ash	4.81
Sulphur	0.36
Phosphorus	0.007
	100.307

Another sample of this coal was analyzed by Mr. A. S. Hewitt, of New York:

Fixed carbon	75.956
Volatile matter	21.011
Moisture	0.615
Ash (salmon colored)	1.940
Sulphur	0.478

Analysis of coke:

Fixed carbon	90.31
Volatile matter	1.20
Ash	8.53
Sulphur	0.53

The coke stands a high pressure.

ANALYSES OF RISING FAWN COAL.

	Ash.	Fixed Carbon.	Volatile Matter.	Phosphorus	Sulphur.
I.	2.93	76.59	20.01		1.09
II.	3.92	75.60	19.89		
III.	7.68	75.08	17.24	.006	1.27

For comparison the two following analyses of favored types of northern coals is given:

	Pocahontas.	Connellsville.
Fixed carbon	74.25	59.62
Volatile matter	18.81	30.18
Water	1.01	1.26
Ash	5.19	8.23
Sulphur	0.73	0.73

COAL MINES.

Dade Coal Mines have been largely worked for many years. The great proportion of the coal is made into coke at the ovens situated below the mines; it is then shipped to Chattanooga and Rising Fawn for the production of pig iron. The mines are extensive, and some of the galleries, now honey-combing the mountain, are 3,000 feet long. Two seams are being worked upon at present—the Dade and Red Ash. The output, from April 1, 1891, to April 2, 1892, was coal 9,888 tons, and coke 104,437 tons, or a total output of coal amounting to about 145,000 tons.

The Chickamauga Coal Company, operating Round mountain coal mines, commenced shipment August, 1892, and their operations indicate an output of 50,000 tons for the first year.

The Dillon Land Company, Mrs. Howard, President, owns a considerable portion of Round mountain, but no mines have been operated upon this property, which is the second largest upon Lookout mountain.

Besides the Dade Coal Company, the New England Company own extensive coal lands on Sand mountain, but have not worked any of their beds. Smaller interests are scattered over both Sand and Lookout mountain.

CHAPTER XXXV.

LIMESTONES, LIME ROCKS, CEMENT ROCKS.

CONTENTS.

CHARACTER AND COMPOSITION OF LIMESTONES.

Limestone is used for construction and road-making purposes, and for lime and cement manufacture. It is largely used as a flux in blast furnaces, etc.

The calcareous matter is also a necessity in productive soils, and if not present in them it must be added. Hence, the applications are extensive and variable.

Pure limestone is the carbonate of lime and contains lime 56, and carbonic acid 44 per cent. It is easily scratched with a knife, as the hardness is 3; specific gravity 2.50–2.80. It dissolves with effervescence in dilute acids.

Carbon dioxide or carbonic acid gas in water, dissolves the mineral or rock, to be only again deposited upon escape of the gas from the water. Upon ignition the rock gives off carbon dioxide and leaves lime.

The rock is rarely pure, but often approaches it with a semi-crystalline texture, and usually light gray color, but it may be of any color, owing to impurities.

The limestone often contains a small proportion of carbonate of magnesia, in which case its general properties are not materially affected. It is sometimes rendered harder by included silica. The most common impurity is siliceous clay. Indeed, the clayey materials are sometimes present, to even such proportions as to cause the rock to be considered a calcareous clay or shale. Sometimes the limestone and clay are naturally commingled, or again the clay, as an impurity, may occur in layers. For most purposes, the presence of clay in limestone impairs its value. Iron oxides are often present in the rock, not only enough to give it coloring matter, but in proportion sufficient to affect its character. Organic matter may amount to even several per cent. In small quantities, phosphoric acid is commonly present in the limestone, and this adds to its value for agricultural purpose.

Dolomite or Magnesian Limestone is a compound of the carbonate of lime and magnesia, and typically contains carbonate of lime 54.35, and carbonate of magnesia 45.65 per cent. But with this double compound, one or the other carbonate may be in excess. It is a little harder than limestone, being 3.5–4 degrees, and also a little heavier, with gravity 2.8–3.0.

Unless powdered, it does not readily dissolve with effervescence in cold dilute acid.

The general characteristics are similar to those of common limestone, and indeed, it is not always popularly distinguished from the latter, as it undergoes the same variations.

Hydraulic or cement rock is a limestone or dolomite containing free silica, clay and oxide of iron in such proportions that when burnt the compounds will combine and resist the action of water.

Distribution of the Limestone in Geological Formations.

OOSTANAULA LIMESTONE AND ANALYSES.

In the belt of country surveyed there are limestones occurring in the Oostanaula shales in the country west of the Oostanaula fault. These are more or less siliceous and clayey limestones, but of variable texture. Upon the western side of and not distant from the Oostanaula fault (see map), the limestone occurs in layers up to three feet in thickness, and are more or less veined with white calcite (pure limestone). As a type of this rock, partial analysis has been made from a sample, about three miles southwest of Rome. The pure veinous calcite was rejected in the sample analyzed by Mr. J. M. McCandless, which gives a type of the massive rock:

Calcium carbonate	74.38
Magnesium carbonate	8.79
Alumina	3.50
Ferric oxide	2.05
Silica	10.95

The coloring matter is organic, and consequently in burning, a light lime is produced.

Southwest of Rome bluffs of this rock rise 30 or 40 feet above the river. Elsewhere it forms extensive surface exposures.

Throughout the enormous development of the Cambrian shales, east of the Oostanaula fault, there are various beds of more or less impure bedded limestones belonging to the shale series. In color they range from dark brown or almost black to light gray; but they are usually dark colored. These deposits vary from 20 to 100 feet in thickness. Near Cunningham station a boring has been made 90 feet into the rock without penetrating it. It is sought for as a black marble, which is quite beautiful, taking a bright polish, but contains earthy matter, and is not highly crystalline.

If reference be made to this formation on the map, the occurrence of the limestone may be expected at points not distinct from the margins of the various belts of the shales, and in the valleys.

It is also exposed in nearly every stream flowing over the formation.

Some of these beds form fairly good building stones, others are rich in clay or iron, but they have all withstood the action of the weather. Sometimes these rocks form low bluffs.

The limestone is found at numerous places in the narrow belt near the East Tennessee, Virginia and Georgia Railway, from Cave Spring entirely across Floyd county.

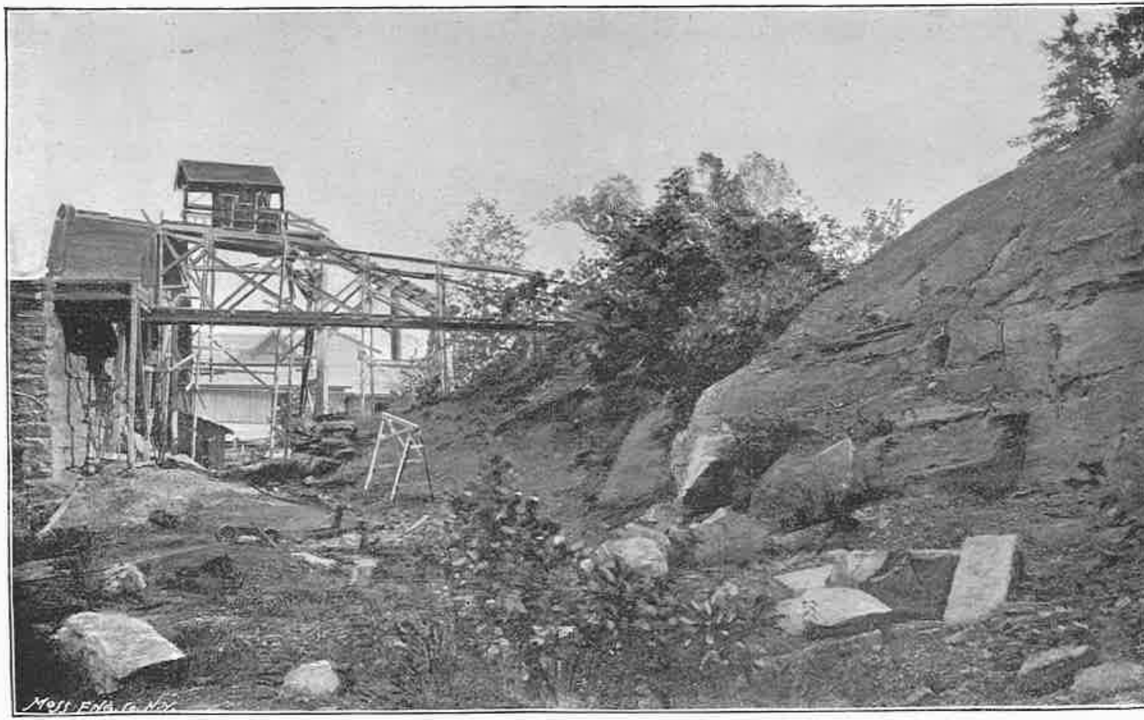
In the northeast portion of Bartow county, the limestone is shown along most of the streams, and also on the sides of some of the ridges. From near Kingston to east of Adairsville there is a belt of about 45 feet of this limestone forming a ridge (a section is given in the geological description of the formation, page 100). The rock varies in character; some of the beds produce a light-colored cement, which is extensively manufactured by Major George Waring, at Cement. The composition of this rock is seen in the analysis by the late Mr. William J. Land. The best bed for hydraulic purposes is a fine grained compact earthy rock, about seven feet thick:

	I.	II.
Calcium carbonate	43.50	55.00
Magnesium carbonate	26.00	26.10
Silica	22.10	10.00
Alumina	5.45	6.10
Ferrous oxide	1.80	2.00
Organic matter	0.15	0.50
Water	1.00	0.30

Only a very few beds produce hydraulic cement. The cement bed contains much more magnesia than this limestone formation generally does. Its hydraulic properties are derived from the silica uniting with the lime, magnesia, alumina and iron to form a cement.

Some of the beds of the limestone could be used for construction purposes. Non-hydraulic lime was formerly made from some of the layers.

The lime works on this belt were started in 1845 by Mr. Charles A. Howard. In 1851 the manufacture of cement was commenced, and is now largely operated under Major G. H. Waring. The ridge is shown on plate X. (opposite), where also two of the kilns are shown.



LIMESTONE BLUFF OF THE OOSTENAULA SHALES AND KILNS AT CEMENT.

The value of cement-making rock depends upon the above named constituents, which may be regarded as impurities in ordinary limestones, being in such proportions, that when the rock is burnt they will combine and set into impervious cement. There is no reason why at many other points on the limestone beds of the Cambrian shales, cement-making rock may not be found, as well as that where it is already operated.

Indeed, some of the earthy beds of the succeeding Knox dolomite series may be found valuable for hydraulic purposes.

In the valleys of the various narrow belts of the Oostanaula series, west of Rocky Face and Taylor's Ridge, similar limestones also occur.

LIMESTONES OF THE KNOX DOLOMITE SERIES AND ANALYSES.

Most of the calcareous beds of this series are magnesian limestones or dolomites. The structure of the formation is described in the first part of the report; only from the economic standpoint are these rocks considered in this chapter. Whilst some limestones are in thick layers, others do not show well defined and uniform bedding (see plate II.), consequently the compact rocks have often a thickness of many feet. Some of the belts are earthy in texture, others are semi-crystalline. They are commonly more or less siliceous. In color the rock varies from dark to light gray, so that in any quarry a variety of shades is obtainable.

The dark coloring matter is partly organic, so that the lime made from the rocks is of a light shade. The more crystalline beds are capable of yielding good building stone and good magnesian lime. The character of the more crystalline but dark dolomite may be inferred from Mr. McCandless' analysis of the rock at Cave Spring:

Calcium carbonate	53.44
Magnesium carbonate	41.15
Alumina and ferric oxide	1.50
Silica	3.75

The coloring matter is partly organic.

Along the western border of the Knox series, there are heavy beds of dolomitic limestone exposed on ridges for a thickness of 200 to 300 feet. It is mostly a magnesian limestone and often of dark color. Its composition is variable, sometimes sufficiently pure for furnace uses, or again containing much clayey matter. This is the same rock formation which occurs east of Cunningham station, and near Hermitage, in Floyd county. East of Cunningham quarries have been opened, as also on another ridge a short distance to the northeast belonging to Mr. Gibbons. At these places the rock is dark brown and mottled with calcite veins. The coloring is from organic matter, and consequently the lime is of light color. It makes a very handsome ornamental stone when polished. As it is somewhat earthy, it is most suitable for inside work, where the polished surface is not exposed to the weather. The following sample is from the "Egyptian Quarry," on the farm of Mr. Gibbons:

The composition of this rock is seen from the analysis by Mr. J. M. McCandless.

Calcium carbonate	52.05
Magnesian carbonate	36.32
Alumina	2.68
Ferric oxide	2.10
Silica	6.47

The rocks of this horizon have been used for flux at the Ridge Valley furnace, near Hermitage.

All the other rocks of the Knox series to the eastward have different physical appearances and characteristics.

Of the fine grained, light gray dolomite of Dyke's creek, Mr. McCandless obtained the following composition:

Calcium carbonate	52.64
Magnesian carbonate	39.44
Alumina and ferric oxide	1.76
Silica	6.25

Three or four miles east of Adairsville, various dolomitic limestones occur on the ridges. Some of these are suitable for building purposes. At only a few points in Gordon county do these rocks occur exposed upon the ridges.

Just west of Spring Place, in Murray county, and at other points northward these rocks occur in high bluffs. Some of the dark varieties constitute a kind of black marble susceptible of high polish. It is, however, a more or less impure limestone. Again the same rocks form a bluff at Cedar Ridge in Whitfield county.

On many of the ridges of the Knox series, the limestone may be discovered at or near by the summit or upon one of their sides, and also adjacent to the valleys. Still more earthy ridges are found than on the ridges just described.

Exposures are made at several places along the Rome Railway; at the Kingston lime quarry (in operation); at old kiln southwest of Kingston; at Hardin's Cave, and on many ridges north of the Etowah river. In some cases, these are covered with cherty mantles, but streams often expose the beds of magnesian lime rock at a depth of a few feet.

On Ladd's mountain (see plate IV., page 44) three miles south-west of Cartersville, is one of the most extensive quarries opened, which supplies three large lime kilns. Here, an exposure of more or less imperfectly bedded, compact limestones, of various textures, is seen to a height of 150 feet. The analysis of the lime was made by Mr. Pratt for the company:

Lime	34.070
Magnesia	55.736
Alumina and ferric oxide	1.236
Silica	7.252
Moisture	1.622

Occasional layers contain flinty matter which has to be rejected. Some of the layers are suitable for building materials.

At various locations, situated on the ridges of the Knox series in Catoosa, Walker and other northwestern counties, the dolomite rises in cliffs as near the end of John's, and near the Tennessee line at Grayville, where high bluffs have been cut into by quarrying for lime (see local geology), as there are extensive kilns situated there.

LIMESTONES OF THE CHICKAMAUGA SERIES AND ANALYSES.

These rocks are mostly pure limestone, non-magnesian. They occur adjacent to the branches of the Cedar creek, from Cedartown southward, along Fish, Camp and Euharlee creeks.

On a number of ridges, in the Rockmart district, the limestones rise up to form bold bluffs, but except in this region, they do not form high ridges. The rock is often in compact, thick beds. Many portions are of light gray color. The texture is compact and semi-crystalline, as the limestone is semi-metamorphic. Some of the beds are suitable for building stones. For lime or for furnaces, their quality may be inferred from the analysis.

Sample from Cedartown, analyzed by the late Mr. W. J. Land:

Calcium carbonate	94.37
Magnesian carbonate	2.10
Alumina	2.23
Undetermined	1.30
	100.00

Sample from Devitte lime quarry, on side of a bold ridge, analyzed for the Cherokee Iron Company. This limestone is extensively used in fluxing and for lime:

Calcium carbonate	95.203
Magnesian carbonate	2.171
Alumina and ferric oxide	0.400
Insoluble	2.300
	100.074

Various other ridges are favorably situated for the extraction of limestone, but they do not occur outside of the district given.

This rock affords our best non-magnesian lime.

The limestones exposed in the valleys at the edges of the Rockmart series, in the narrow basin of Murray and Whitfield counties, are of similar character to those in Polk county, although less extensively developed, but they are available for local uses.

In the belts of the Chickamauga series in Walker, Dade and other counties the limestones are sometimes in thick, compact beds, but more frequently the laminations are more developed than in the Polk district, as also their earthy character. Still there is considerable variation, from quite pure limestone to others very impure as may be seen south of Trenton. In the valley of Lookout creek there is a fine grained, compact, light-colored limestone, which yielded Mr. McCandless the following analysis:

Calcium carbonate	55.47
Magnesian carbonate	25.33
Alumina and ferric oxide (mostly alumina)	9.50
Siliceous residue	8.16
	98.46

This rock has the appearance of lithographic stone, but breaks with a conchoidal fracture.

Near by (south of Trenton) another light-colored, but crystalline rock, is of much greater purity.

Calcium carbonate	91.40
Magnesian carbonate	3.75
Alumina and ferric oxide	1.80
Siliceous residue	2.82
	99.77

The limestones of the Chickamauga series furnish abundance of road material, and by selection good lime and building material, which last is often in layers of convenient thickness.

DEATON LIMESTONES.

As a building material, this series does not furnish a source for limestone. But some of the ferruginous beds, as at the Deaton mines, contains 30 per cent. of iron and are self-fluxing and may yet be used in that connection.

RED MOUNTAIN LIMESTONE.

Amongst the shales of this series only occasional thin layers of limestones are seen above the drainage level. But in mines below the drainage beds level, a foot or more in thickness occur. They are commonly earthy and siliceous and usually somewhat ferruginous. Except in connection with mining iron ore, they are of no economic value.

FORT PAYNE LIMESTONES.

These limestones are too much commingled with chert to form good building material, but they produce excellent road material. They usually occur at the edge of the Mountain Limestone, and on ridges succeeding the "fossil" ore beds.

FLOYD LIMESTONES.

West of Rome, and elsewhere, there are limited exposures of heavy bedded limestones, occurring in this formation, forming good building material and also lime. But the exposures are not numerous.

MOUNTAIN LIMESTONES.

This rock is of enormous development upon the sides of Sand, Lookout and Pigeon mountains, being most uncovered at the northern end of Pigeon mountain. It occurs in thick beds, and is available for building purposes of all kinds. The color is often attractive. The rock has usually a compact texture. It varies in degrees of purity. High up upon the eastern side of Sand mountain, a variety with crystalline texture yielded Mr. McCandless the following analysis :

Calcium carbonate	80.60
Magnesian carbonate	2.45
Alumina and ferric oxide	3.20
Siliceous residue	12.70
	98.95

The upper beds are often the more earthy. Near the base of the series, at Rising Fawn, the rock yielded (J. M. McCandless):

Calcium carbonate	96.13
Magnesian carbonate	2.05
Alumina and ferric oxide	1.00
Siliceous residue	0.95
	100.13

From these analyses it may be seen that there is a great range in the varieties of limestones, but such as yield excellent lime, good for furnace use and of qualities suitable for building purposes, with often a fine gray or bluish color.

CHAPTER XXXVI.

SANDSTONES.

CONTENTS.

OOSTANAULA AND CHILHOWIE SERIES.

Quartzite or crystalline sandstone, of beautiful fine grained texture, is found on uncovered cliffs, in abundance, on Indian mountain, near Etna. Owing to its hardness, the cost of building material is high, but when needed, the quantity and availability of this durable material is unlimited.

At a few points in the ridges south of Rome, along the eastern side of the Oostanaula fault, sandstones occur, but the beds are rarely two feet thick, and are not generally exposed at the surface in quantities sufficient for building purposes.

RED MOUNTAIN SERIES.

Massive and thinner bedded gray sandstones occur on Rocky Face, Chattoogata, Horn's, John's, White Oak, Taylor's and Lavender mountains, as also on Horseleg mountain, and near Loughridge (Murray county). At many localities the rock is sufficiently uncovered and in abundant quantities for building purposes. The texture varies from fine to coarse grained. Whilst the rock is available upon the surface of many portions of Taylor's ridge and White Oak mountains, yet on the mountain sides, and on the western ridges it is not so abundant as in the more eastern ridges. West of Taylor's ridge these sandstones are less important.

Brown sandstone, making a beautiful building stone, is more or less associated with the gray sandstone in the ridges named, and some workings have been commenced on White Oak mountain, where blocks three feet thick can be obtained. Amongst the shales in many places on the ridges above named beds of brown sandstone, from one to ten feet thick, can be quarried, as in Lavender mountains northwest of Rome; in Taylor's ridge, east of Summerville and of Lafayette, on Rocky Face and many other localities.

Flagstones or sandstones in thin beds are frequently interbedded amongst the shales. These are usually from two to eight inches thick. They occur not only on Lavender, Taylor's and other eastern ridges, but are well developed in Shinbone ridge, and in the cuts of the Chattanooga Southern Railway across the end of Pigeon mountain and elsewhere. These flagstones are mostly of a reddish tint, sometimes brown, and occasionally gray. They are locally used for chimneys, and may be applied more extensively. Wherever the formation occurs, there are some uncovered flags, but they are often covered so as not to form surface features.

SUB-CARBONIFEROUS SERIES.

The rocks of the Fort Payne formation are limestones, but with siliceous deposits in some places, developed to such an extent as to cause them to be varieties of sand rocks which resist weathering processes. They are, however, too concretionary and otherwise unfit for building purposes, but make good road material.

COAL MEASURES.

In this formation there is an abundance of beautiful gray sandstone suitable for any structural purposes. It is sometimes fine grained, but passes to coarse grain, or fine conglomerate when the scattered pebbles are half an inch in diameter. These sandstones occur in massive beds, and produce bold cliffs along the margins of Sand, Lookout, Pigeon, Rocky and Little Sand mountains.

On other beds they vary in thickness of six to twelve inches, and have often a great degree of purity, but again other layers are somewhat earthy. The supply is inexhaustible, and at some points railroad facilities are already available, as along the Chickamauga & Lookout railway, upon the eastern side of Lookout mountain, where it passes the bold sandstone beds of Eagle Cliff.

CHAPTER XXXVII.

SLATES.

As a geological formation, the Rockmart slates are described in Part I. As an economic product, only the ridges form suitable locations for quarries. The slates in the ridges are hard, and are frequently very little affected by weather, except the thin surface coating. At other times the surface slates are weathered to a depth of twenty feet. In many localities, the slates are consequently unavailable, or where available, they are found to be unsuitable for splitting. But in the ridge, at Rockmart, good, cleavable slates have been extensively quarried for many years. When viewing the vast heaps of waste material, unfavorable impressions might at first be formed; but the wastes in every slate quarry are equally large. These, however, might be somewhat reduced with more systematic methods of working. The available slate deposits at Rockmart belong to various individuals, and the quarrying could be more effectively carried on if the boundary lines were removed by a combination of interests. The three principal owners are: Col. T. F. Dever, the Seaborn Jones Estate and the Rockmart Land Improvement Company.

There are other slate ridges in this district, but none have so far been found as suitable for extraction and splitting, which is a most important consideration, for even the best quarries only yield a rock in which there are great wastes.

In several localities, as Etna, slates of the Oostanaula series occur. In some places those may be valuable, but in other localities the metamorphism has not rendered the slates sufficiently durable.

CHAPTER XXXVIII.

CLAYS AND BRICK PAVEMENTS.

CONTENTS.

NOTE.

The subject of clays is one of the most important in connection with the survey. Not merely are the clays of interest in the manufacture of common brick for local purposes, but there are favored localities, where material suitable for fine qualities of pressed brick and terra cotta are obtainable, and from which shipments to other localities can be made. Another rising industry in the country is vitrified brick for roadways, and only certain clays are suitable for making this popular paving material. Modern improvements in the manufacture of roof tiling are leading to the return to the ancient fireproof and picturesque roofing. Other clays for coarse pottery, and kaolin for fine pottery, are in demand. No subject of economic geology is more important, and consequently this chapter was delayed in its preparation until the last, in the hope that adequate time and means could be given for a satisfactory and elaborate chapter. This time and means have never been at the author's disposal, and, accordingly, only a few notes, without sufficient study, can be given; but these few notes are better than no report at all.

BRICK PAVEMENTS AND KINDS OF CLAY REQUIRED.

USE OF BRICK.

In connection with roads, the question of brick pavements in cities and towns is notable, on account of the rising importance of this material and the consequent demand for suitable clays.

In Holland, and other countries of Europe, brick pavements have long been in use, on account of the absence of stone. The durability of vitrified bricks in Europe, has led to their introduction into America. In Charleston, W. Va., brick pavements were first laid down eighteen years ago, and are still perfectly good and smooth. Since their introduction in that city, brick pavements have grown steadily in favor; and during the last four or five years, so rapid has been the revolution in street making, that bricks are now used in 275 cities and towns.

The merits of different pavements have been thus compared:

"GRANITE BLOCKS—Merits: Durable, clean, healthy.
Defects: Noisy, uncomfortable, slippery when worn, expensive first cost.

"STREET ASPHALTUM—Merits: Comfortable, noiseless, healthful.
Defects: Short-lived; expensive to repair; slippery on grades; expensive first cost.

"BRICKS—Merits: Comfortable, durable, clean, non-slippery, healthy, easy to repair.
Defects: Moderate first cost when supply is local.

The cost of brick pavements varies from $1.05 per yard at Wheeling, W. Va., to $2.32 at Memphis, whilst the cost of granite ranges from $2.50 to over $4.50, according to location, except at Atlanta, where it is reduced to $1.50 per yard.

The bricks form a pavement almost as smooth as asphaltum, non-slippery, clean, and being durable, are rapidly growing in popularity, to the exclusion of rough stones. Thus, the bricks not merely supply paving materials in cities, where no stones are available, but replace them in their natural market. As brick paving is a great future question for Georgia, a few notes are here given to call attention to it and to the required clays, which come into the field of this survey.

The bricks must be vitrified; that is, made out of clays, or admixtures of clays, which will slightly fuse, so that the components are more or less melted together throughout the mass. This requirement necessitates the burning of the clay in closed, down-draft kilns, and at higher temperature and for a longer period than ordinary bricks. The bricks, to be good pavers, must absorb little or no moisture; be hard, tough, dense, and stand a pressure of 6,000 pounds to the square inch. Such bricks have been used for four years at Burlington, Iowa, and show no perceptible wear.

The testimony of 275 cities and towns, in population ranging from Philadelphia, Detroit, Cincinnati and Wheeling to small towns, show the favor into which brick pavers are growing.

In many places, bricks of ordinary size are recommended, so that those rejected for paving purposes can be used for ordinary constructions. In other localities, larger blocks are used. In the former case, the product is somewhat more certain.

THE KINDS OF CLAY REQUIRED.

At Fort Smith, Arkansas, the vitrified bricks are made from a shale containing (Branner):

Silica	58.43
Alumina	22.50
Oxide of iron	8.35
Magnesia	1.14
Potash	2.18
Soda	1.03
Sulphur	1.16
Loss on ignition	6.20
	100.99

At Bucyrus, Ohio, an exceptionally fine quality of vitrified bricks is made from shale containing:

Silica	66.66
Alumina	19.20
Iron sesquioxide	6.18
Magnesia	none.
Organic matter	none.
Lime carbonate	0.72
"Free alumina"	7.24
	100.00

The color of the bricks is immaterial. Mere fusion is not alone required, but this combined with toughness and hardness. In order to effect this fusion, the clays require iron, or this with small quantities of alkalies. Fire clays are by themselves valueless. On the other hand, clays containing lime in quantities, akalies, or an excess of iron, are unsuitable, as these give too great fusibility, so that the bricks will not stand the high temperature of the kilns, or become too brittle. Shales are often more desirable than clays, as they contain less grit, which causes the brick to wear more rapidly away. Again, good pavers are made from an admixture of fire clays or semi-fire clays, which will fuse the whole together; but the less mixed materials are those preferred.

These notes on brick paving, are added as an accompaniment to good roads, which belong to the province of the engineer, but the question of clays belongs to geology.

CLAYS OF NORTHWESTERN GEORGIA AND ANALYSES.

COMPOSITIONS OF CLAY.

Pure clay or kaolin contains:

Silica	46.3
Alumina	39.8
Water	13.9
	100.00

It is primarily derived from the decay of feldspar or similar minerals. Comparatively little clay has the above simple composition. Generally a portion of the feldspar is only partially decomposed, and contains potash or soda. So, also, lime and magnesia may be present in traces. Iron, with smaller portions of manganese, is commonly present even in light colored clays, and in colored clays the quantity of iron is often large. In our Georgia clays there is often a remarkably large per cent. of titanic acid. In addition to all of these constituents, which are present in only small percentages, there is an admixture of free silica. Indeed, the clayey character of these superficial earths is maintained when the quantity of alumina is diminished to only a few per cent., owing to the excess of free silica. In nature, the silica often increases so that the earths pass into clayey sands rather than sandy clays. In northwestern Georgia, there are several types of clay—(1) the kaolin-like clays, (2) the clays derived from the decay of limestones and calcareous shales, (3) those formed from the disintegration of shales, and (4) alluvial deposits.

KAOLIN TYPE.

These clays occur as "horses" (see figure 22, page 155) or in sheets or pockets in the residual earths, derived from the decay of the Knox dolomite and Fort Payne chert series. Sometimes they are pure white, with occasional stains of iron, or the stains may pervade the mass in the form of streaks. Again, the clays are of purple tint. They often occur in large bodies. In the cherty remains of other portions of the Knox dolomite, the siliceous nodules are imbedded in white, siliceous, chalky clay, as near Cave Spring; or in Lookout valley, in Fort Payne chert. From this siliceous matter, the white clay could be mechanically separated, if the price would warrant the labor. Some of these clays are of fine quality, as at Woodlands. Halloysite, as noted before, occurs under similar conditions in the Fort Payne chert, and can be used for fine porcelain ware. Composition of the white clay is shown in the following analysis by Mr. McCandless—the sample being taken from beauxite beds on Flowery Branch, Floyd county:

Alumina	38.60
Ferric oxide	1.45
Potash	0.09
Soda	0.02
Lime	0.00
Magnesia	0.30
Titanic acid	1.95
Silica (combined)	40.40
Silica (free sand)	0.80
Water (combined)	16.35
Water (hydroscopic)	0.35
	100.31

This is a kaolin of nearly theoretical composition, with small proportions of impurities. It contains only the smallest trace of undecomposed feldspar, and alkalies, and consequently would form an infusible clay with even the amount of iron present. The iron is, however, not uniform in the clay, but occurs in crevices.

Such clays are of very common occurrence in association with beauxite beds, and with some iron ore beds. In the latter case, however, iron is apt to be present in larger quantities. A type of the clays as seen in the "Horses" of the iron ore beds is given in the following analysis (Mr. McCandless) of a sample from Grady.

Alumina	15.41
Ferric oxide	6.06
Potash	4.55
Soda	0.34
Lime	0.00
Magnesia	1.29
Titanic acid	1.35
Silica (combined)	20.10
Silica (free sand)	46.10
Water (combined)	4.75
Water (hydroscopic)	0.20
	100.15

In this clay, nearly half the mass is composed of free sand, and otherwise indicates a condition of rapid deposition, in that it contains much undecomposed feldspar, as shown from the large quantity of potash and soda present. The clay is colored purple-white. It would be somewhat fusible, but it is worth the experiment for the manufacture of vitrified bricks. From other clay horses, I have seen clay which can be made into white stoneware, but only where the iron is in much smaller quantities would the color be fit for the finer wares. Some of these deposits are suitable for fire clay purposes.

These clays would justify experimentations, which are necessary before their full value can be determined.

The clays of the above types occur in residual earths, yet they are not themselves residual of the limestones, as they occur in distinct pockets or beds, in which condition they originally occurred amongst the limestones, out of which they have been disinterred by the decay and degradation of the calcareous matter. Their original source, however, was from the metamorphic rocks to the east, which were remarkably free from calcareous minerals, and not from the limestones, although occurring with them.

RESIDUAL CLAYS.

These clays are derived from the decay of earthy limestones and calcareous shales belonging to various series of the Paleozoic group. There is a marked difference in the character according to their source or formations. These clays also form the soils, and are described in that part of the report. In some cases these clays produce fair common brick. However, many of them are too poor in alumina and too rich in fusible materials to make fine products. The clays derived from the shales are very siliceous, as also those from the cherty limestones, whilst those derived from the decay of the more calcareous rocks are much more aluminous; but at the same time they are commonly very rich in iron. In some localities, however, fair brick can be made, when not burned at too high a temperature, which would tend to melt the product. Thus, at Cartersville, a fair brick is made from residual clay of the following composition (analyzed by Mr. McCandless):

Silica	58.63
Alumina	20.47
Ferric oxide	8.58
Lime	Trace
Magnesia	1.42
Potash	3.86
Soda	0.14
Titanic acid (with alumina)	
Water (hygroscopic)	0.20
Water (combined)	7.06
	100.36

The fusibility arises from the large amount of potash in addition to the iron, but it requires a higher temperature to melt the product than if the fusible material were mostly lime. The absence of the lime is commented on elsewhere. The red clays derived from the Knox dolomite often contain not only a fair amount of lime, but along with it so much iron that brick made from it would be of very poor quality.

CLAYS FROM DISINTEGRATED SHALES.

These shales are of variable character, and whilst many of them retain a shingly appearance, yet in composition they are often similar to clays from which good bricks are made. Indeed, to-day some of the finest bricks are made by the modern machinery from ground shale in preference to their manufacture from plastic clay. In this connection a few analyses have been made and are here given, without a detailed study.

An analysis is given of a light colored hydromica shale on the ridge above the Etowah iron bridge south of Cartersville. It is on the border of the metamorphic zone from which many of the clays originally came, whether to form the shales or to be incorporated in calcareous rocks. Their economic value justifies further investigation (Mr. McCandless analyst):

Silica (free sand)	62.30
Silica (combined)	9.30
Alumina	11.50
Ferric oxide	5.59
Manganese dioxide	0.60
Lime	00.0
Magnesia	1.30
Potash	4.20
Soda	0.35
Titanic acid	1.10
Water (combined)	3.80
Water (hygroscopic)	0.15
	100.19

In the valley a mile southwest of Cartersville a light red shale, at first regarded as belonging to the Oostanaula series, yielded to Mr. McCandless an analysis similar to the last:

Silica (sand)	39.20
Silica (combined)	19.40
Alumina	18.05
Ferric oxide	8.31
Lime	0.00
Magnesia	1.55
Potash	4.63
Soda	0.33
Titanic acid	0.68
Water (hygroscopic)	0.40
Water (combined)	7.60
	100.15

Evidently these clays are of the same formation as on the mountain, and their economic value will require testing, but their composition is such as to be of interest.

The less calcareous of the Oostanaula shales about two miles northwest of Cartersville were analyzed and the composition was found by Mr. McCandless to be as follows:

Silica	52.82
Alumina	26.17
Ferric oxide	9.46
Lime	trace
Magnesia	1.08
Potash	2.71
Soda	0.20
Titanic acid with alumina	
Water (hygroscopic)	0.23
Water (combined)	7.00
	99.67

As this analysis is closely that of vitrifying brick clay elsewhere, the practical test should be made.

Caën stone (*?*) At Rockmart, certain of the slates upon the upper portion of the ridges have decomposed, producing a buff colored hard slate or clay banded with a ligneous structure. It is capable of being sawed or turned into ornaments.

The following analysis was made by Dr. Robert Peters of Kentucky (sample air dried):

Silica	61.66
Alumina	19.64
Ferric oxide	7.54
Soda	1.05
Potash	1.27
Lime and magnesia	trace
Moisture not estimated	
	91.16

Samples of the bricks made from this clay were amongst the most beautiful that I have seen, also the clay vitrified, producing apparently a good paving brick.

Clays making good common and also vitrified bricks have been obtained in other States from the shales of the Coal Measure. Analyses of these in Georgia have not been made, nor of the shales of the Red Mountain series, both of which are well located for railway facilities. An approach to the composition of the Red Mountain shale is seen in the analysis of the soil on a future page. That sample, however, is more ferruginous than the normal shales.

A light colored plastic clay from near the head of McLamore's cove, obtained from the Sub-Carboniferous series yielded (Mr. McCandless analyst):

Silica	69.33
Alumina	19.01
Ferric oxide	2.02
Lime	trace
Magnesia	0.87
Potash	2.10
Soda	0.18
Titanic acid (with alumina)	
Water (hygroscopic)	0.26
Water (combined)	6.88
	100.65

ALLUVIAL CLAYS.

Most of the bricks of northwestern Georgia are made from alluvial clays.

Good brick clay at Cartersville occurs along the Etowah river. Mr. McCandless' analysis shows:

Silica	69.18
Alumina	15.43
Ferric oxide	5.83
Lime	0.00
Magnesia	0.71
Potash	1.83
Soda	0.15
Titanic acid (with alumina)	
Water (hygroscopic)	0.22
Water (combined)	6.61
	99.96

This clay is derived from the washes of the metamorphic rocks along the Etowah river, and is remarkable for the absence of lime. Its composition shows a less degree of fusibility than the same clay at Rome which makes very beautiful brick. It is possible that at a few feet beneath the surface a still less fusible clay may be obtained.

The Etowah river clays are almost entirely derived from the metamorphic rocks to the east, and consequently they have a similar composition throughout the lower reaches of the river. At Rome the surface clay contains (Mr. McCandless, analyst):

Silica (free sand)	50.80
Silica (combined)	17.00
Alumina	13.82
Ferric oxide	5.74
Lime	0.00
Magnesia	0.81
Potash	2.00
Soda	0.55
Titanic acid	1.67
Water (hygroscopic)	0.25
Water (combined)	7.35
	99.99

This clay is more or less fusible, but makes good pressed brick. At a depth of about ten feet below the surface, a light colored clay less fusible occurs. This is of value alone or mixed with the upper clay. In composition it is (Mr. McCandless, analyst):

Silica (free sand)	63.30
Silica (combined)	14.30
Alumina	10.90
Ferric oxide	2.25
Lime	0.00
Magnesia	0.63
Potash	1.83
Soda	0.32
Titanic acid	1.98
Water (hygroscopic)	0.20
Water (combined)	4.70
	100.41

Such clay alone or mixed with the upper clay ought to make vitrified brick.

The analyses of these clays and shales will be of some interest in connection with the analyses of the soils in studying the history of the clays, and in investigating their economic importance. The facts are here given without deductions, as the study is imperfect, for want of means of research, and the writer is not called upon to make deductions from insufficient data. The river clays, in many places, show two distinct types, as along the Etowah the lower clays are the lighter and less fusible. These clays or admixtures of them are capable of making sewer tiles, and upon the eastern side of Lookout mountain, a few miles south of Chattanooga, and elsewhere, roofing tiles can also be made from them.

CHAPTER XXXIX.

NOTES ON WATERPOWERS AND TIMBERS.

WATERPOWERS.

There are many rivers and streams flowing over the Paleozoic belt, but these have generally a slope not much above the base level of erosion, and consequently the shoals are not high; consequently the head of water on any dam would never be high, and seldom range more than five or six, or sometimes ten feet, but the discharge of water is often greater. On the edge of the metamorphic belt the streams descend much more rapidly, and there greater heads of water could be obtained. Many of these streams furnish power for numerous small mills, and others could be further utilized. Their capacity has not been determined, yet it has been deemed best to give the generalized note as to the character of the shoals.

TIMBERS.

This is another economic subject which will be passed over in this report. For local uses there is generally an abundance of short-leaf pine and various oaks, and away from the present lines of railway much timber, including mountain oaks for tan bark, still remains for future shipment. The varieties of these timbers is noted in the chapter on soils.

CHAPTER XL.

THE LOCATION OF ROADS AND THEIR RELATIONSHIP TO THE PHYSICAL AND GEOLOGICAL FEATURES.

CONTENTS.

NOTE.—RELATION OF ROADS TO GEOLOGICAL STRUCTURE.

As the topographical features and agricultural capabilities of any region are dependent upon the geological structure, so the roads bear an equal relation thereto. The roads give access—the features of the country favor or impede road-making.

The country of the Coosa basin is a great valley occupied by many longitudinal ridges trending from a little east of north to the opposite direction. These ridges are not constant, but are frequently broken, cut off, or thrown literally out of their natural positions. The smaller streams have added to the rugged features. Thus, there are great valleys extending longitudinally without important interruptions. Also, there are subordinate and parallel valleys, between the heads of which there are secondary divides. Some river valleys are 150 feet or more in depth, but the time since they were occupied by the waters to those heights dates back so far that they are greatly modified by atmospheric erosion, so that the greater valleys are generally bounded by more or less broken hills, and do not form rock-bound *canons,* like the upper Mississippi valley of to-day. The lower lands of these valleys are rolling, and the streams usually flow near the surface. Along the greater river, the banks are seldom more than thirty feet above ordinary water. Such are the general conditions of the county through which the roads are needed.

The country west of Taylor's Ridge is of similar character, to which, however, must be added some mountain ridges and high plateaus.

ROADS ON THE OOSTANAULA SHALE.

Adjacent to the Coosa river the country is generally undulating. The ridges are not great obstacles to road-making, but there are steep descents to the great rivers, which can be modified by hill-side roads. In this region there are often gravel beds suitable for road metal. The sandy shales do not give rise to deep muds, but the more clayey soils hold the waters where the drainage is bad.

East of the Oostanaula Fault the border is characterized by crested ridges, eastward of which the shales generally form valleys. This is true in most places, where the shales are in belts from one to four miles wide. In the northeastern portion of Bartow, and thence northward, the shales form many valleys, but there are numerous shale-covered intervening ridges. Speaking generally, the roads running in a northeastern and opposite direction have good or fair gradients, and on the ridges the gradients are not difficult. Except on crossing the ridges, upon the western border of the series, the roads of this formation have gradients that are generally fair

However, on passing from the heads of some subordinate valleys to others, the divides are characterized by rough features, not seen along the principal highways. The sandy shales do not give rise to the heavy muds seen in some other sections. The more calcareous portions of the river produce muddy roads like the red Knox lands.

West of Taylor's Ridge, the shales give rise to valleys of moderate width, with characteristic roads similar to those to the east.

ROADS ON THE KNOX DOLOMITE SERIES.

There are two classes of gradients over this formation. In the red land-valleys, and on some of the ridges, the gradients are good, but in wet weather the muds are deep. Some of the valleys are broad, but in the country characterized by cherty ridges (the western portion) in Polk, Floyd, Bartow, and to a small extent in Gordon and Whitfield counties, and in the counties to the westward, the valleys are often narrow. The roads trending longitudinally have good gradients in most of the large valleys, but in the narrow valleys, their heads are marked by heavy gradients. Roads crossing these ridges from east or southeast to the westward can sometimes be built so as to pass around the hills; but more frequently they cross some portions of them, and then the grading may be very bad, as ridges from 200 to 300 feet have to be ascended, and not always by gentle inclinations. These roads, apart from the main thoroughfares, are often very difficult of travel. And the "bad road" in a given region is only a relative expression; for on a so-called good mountain road, I have had a carriage wheel broken by weight of the load thrown obliquely upon it.

These sharp ridges have commonly loose cherty rock upon their surface, which could be used for road metal. Amongst the red lands of the Knox formation, the conditions obtain for good roads, but the mud may often be deep, the gray lands are more siliceous, and much less muddy.

ROADS ON THE CHICKAMAUGA SERIES.

The limestones usually form valleys, often broad, with good gradients; however, there are some bold knobs or ridges in the Rockmart district. The residual clay of these limestones forms deep, sticky mud when wet, and afterward leaves hard rutted ground. In many places the limestones, in variable beds, floor the valleys and form rough stony roads, where these are not properly built, as seen in Walker and other counties.

The shaly lands, in places, are in gentle undulations, but other slates form bold ridges, as near Rockmart. These soils are commonly shallow, and seldom produce deep mud. There is usually limestone for road-making in proximity to the Chickamauga soils, which, more than any, need macadamized roads. The shale roads are often fairly good, without artificial improvement.

ROADS OVER THE RED MOUNTAIN SERIES.

Roads upon this formation are almost invariably across narrow ridges, along which there are no longitudinal highways. Amongst the shales, there is much siliceous material, and the muds are naturally deep. There are always enough sandstones, or flaggy sand rocks at hand for making good road material. This formation gives rise to the bold ridges—Taylor's, Lavender and others noted—across which there are only occasional roads, which are steep, owing to the ascent, of several hundred feet. Across the lower ridges, such as Shinbone, these roads are needed at only few localities, and the gaps are generally low.

ROADS OVER FORT PAYNE CHERT AND FLOYD SHALE.

This chert gives rise to crested hills which are often steep. Along these ridges roads are seldom constructed, but highways often cross them. The surface is usually covered with cherty fragments or gravel. Roads along the foot of such ridges are gravelly. The Floyd shale gives rise to sandy clays which do not produce deep muds, but often these are flat lands, and the soil holds water. Some of the calcareous shales form a good road material.

ROADS ON THE MOUNTAIN LIMESTONE SERIES.

The residual clayey lands derived from these limestones occur only on the sides of the mountains and in the narrow valleys between them, and ridges covered with Fort Payne chert. These clays produce heavy roads in wet seasons. Owing to the proximity of the gravel on the cherty hills good road-making material is at hand. On the mountain sides, where the limestones come to the surface, the roads are commonly rough, as the ledges of rock are not properly graded.

ROADS ON THE COAL MEASURES.

On the plateaus of these deposits, the roads are usually very sandy, but occasionally cross flat exposures of rough sandstones. On ascending the mountains, the sandstones have to be crossed by the roads winding along the mountain sides to the top of the plateaus. As these passes are not generally well built, or when built, are subject to the greatest damage from rains, we find some of the roughest roads in the state—this condition arising from want of properly constructed roadways, for the materials are at hand for building good highways.

SUMMARY.

Roads running northeastward and southwestward have been or could be located with good gradients. At right angles, the ridges can often be avoided, but very commonly such is not the case, where the crossings are often poorly located and badly constructed. The roads on the soils derived from the Oostanaula shales have often good gradients, and the mud may not be deep.

The gray Knox dolomite ridges form a broken country, but the mud is siliceous and not deep. The roads on the red lands of the series have better gradients, and are muddy in wet seasons, followed by ruts through hardened mud.

The muds of the Chickamauga limestones are apt to be deep. The roads in the Rockmart slates are not deeply muddy. Materials for road-making are often conveniently near the highways.

The roads on Red Mountain series only cross the ridges, and the quality depends upon their gradients, as the material generally produces fine road beds, except when there are sandstone ledges, which produce rough roads that ought to be properly broken and macadamized. The Fort Payne chert gives rise to gravelly roads, which only cross the ridges. The Floyd shales produce sandy clay roads over flat lands.

The Mountain Limestones form muddy clay roads upon the mountain sides and in narrow valleys.

The Coal Measures originate sandy roads upon the plateaus; and upon the mountain sides the sandstones produce rough, stony roads, where not properly built.

NOTES ON CONSTRUCTION OF ROADS.

The two greatest impediments in gradients of the roads are: (1) the crossing of spurs in valley roads, when there is no obstruction that would have prevented the road being built around it; this condition is a too common blunder; (2) in crossing ridges or spurs the crest of the ridge is cut thus:

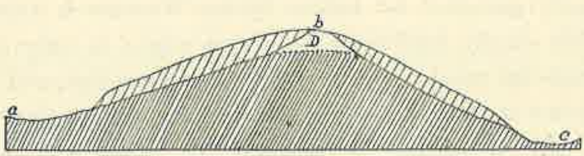


FIGURE 27.—Showing bad gradients of roads (a b c), especially at the summit (D), which is rarely graded in keeping with the rest of the work.

This outline has in part arisen from some attempts at grading, which is often very good to near the crest, where the gradient is so steep as to demand the greatest possible strain upon the horses in order to gain the summit, and then only to plunge down a declination of the same shape. This outline is not alone due to bad construction, but is the fault of nature and negligence of man. It arises, in part, from the road washings during heavy rains. In every case the crest should be removed, for in its upper portion the strain is greater upon the animals than the tension upon the remainder of the ascent.

On the roads, crossing the ridges, oftentimes more gradual ascents could be made. Throughout the belt surveyed, it may be generally said that the roads running parallel with the ridges are fairly well located, with the exceptions mentioned.

The roads do not generally, except as stated, become so "bad" as in many clay districts of the north, or elsewhere, even in the state, owing to the more or less sandy constituents of the residual soil; still they need great improvements. With a supply of road metal much of the district is provided already.

SOURCES OF ROAD MATERIAL.

In the region of the large rivers some gravel is available. The limestones of the Oostanaula shales afford numerous local supplies. The chert ridges of the Knox dolomite series, and Fort Payne chert, are covered with loose macadam of excellent quality already broken up (see Part I. on the geology of the ridges). It has already been largely gathered for ballast by the Western & Atlantic Railway. This cherty mantle on so many ridges is only superficial, and its removal would be of agricultural advantage, and the day is coming when it will all be used for road-making, as there is not an excess of it. When this is consumed, or where it is too distant, the limestones already described will supply many localities with material for constructing roads. Especial attention is called to the limestones of the Chickamauga series, which commonly traverse belts of deep, muddy soils. Sandstones are inferior to limestones for road metal, and such belonging to the Coal Measures are adjacent to limestones which can be used in preference.

In a few districts attempts have already been made for improving the roads. More has been done in road-making in the vicinity of Rome than elsewhere. The roads leading out of that city may well afford pride to the citizens.

But where the natural materials for road-making are not at hand, the day is coming when a denser population will demand better highways, and not only in cities but also villages will brick pavements be resorted to as in the numerous cases in other states.

CHAPTER XLI.

GOOD ROADS VERSUS BAD ROADS.

As a condition of good roads, the location and gradients must be properly chosen, and after that the road bed, the local materials of which have been indicated.

In Europe, there are few regions, even in the remotest country districts, from Sicily to Norway, where the worst roads are not as good or better than most of our own best roads. Apologetically, it has been said that it has taken generations to accomplish this, with a denser population. In France, the majority of the departments are more thinly populated than our northeastern States, and in Norway the population is more sparsely scattered than even in any parts of our own mountain regions. The old Romans had care for building good roads, it was necessary for their military operations, even then long before the days of heavy artillery, still only during the last two or three generations in most of Europe have good roads been common. Indeed, in old Europe, general good road making is younger than the American nation, therefore, our infancy cannot be pleaded as our excuse.

Why has Europe generally built good roads? Because the people have discovered its necessity and profit. It is a paying investment, and no luxury. Would it be a luxury if a poor farmer, with a poorer mule, capable of drawing only a few hundred pounds of wood to a town, and getting fifty cents for it and his half day's or day's time, could with the same animal draw double or treble the amount? This is what they do in Europe. Is it a luxury to have roads such that the same animals, which bring two or three bales of cotton, could bring double, and save the time of man and beast? This is what good roads permit. Are roads good enough, if animals can creep along and spend a day for what could be done in a few hours, when the road is passable? In our field work, and on good roads, I sometimes drive my camp wagon, etc., twenty or twenty-five miles in the day, and do also seven or eight hours of field work besides. But sometimes, it happens that the roads do not admit of traveling even this amount without accomplishing any other work than changing locations. Do such roads pay? Is it profitable to travel on roads, which rack the wagons to pieces, so that in a year they require rebuilding. All of these roads are in this State, although many are in fair condition. But to-day the general feeling is everywhere alive, not in Georgia alone, but over the whole country, that the waste of money and labor is enormous, simply because of our national bad roads.

In moderately dry seasons, with the roads well graded and ditched, many of our leading valley roads, owing to the commonly sandy character of the clays, are or could be as good and better than in many parts of the north, where the clays are stiffer and more liable to be cut into deep ruts. But the gradients and drainage of the roads is often indifferent, and the crossings of the ridges are mostly indifferent, and often bad. In wet seasons, however, most of the roads are rendered difficult of travel, and when cut into ruts or "holes," the effects are left after the season becomes dry.

The relative value of different kinds of roads may be seen from the following table derived from experiments (Haswell's tables).

The traction or force required to pull each ton of a wagon load over:

	Pounds
Good railroad	7 to 12
Broken stone road in perfect order	30
Broken stone road in fair order	56

Broken stone road, rutted	104
Macadamized road (more or less rough)	66
Common by-road	212
Sandy road, good	126
Gravel road, new	166
Loose sand road	500

In wet weather the mud roads become far worse than the sandy

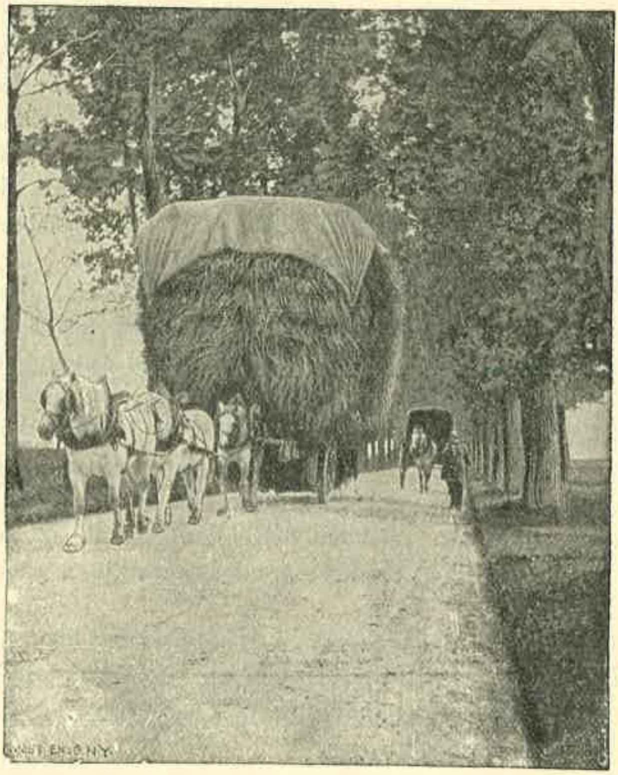


FIGURE 28.—Country Road in France (after Potter).

roads, so that in the long run even these are expensive. On sandy roads the traction is always so high as to make the roads very costly. In Georgia, seldom are loads carried which exceed a ton. Upon the hard roads in France a team of three horses draws a load of four tons, and consequently, the cost is proportionally reduced. (See figure 28.)

FIGURE 29.—Mud Road in America (after Potter).

FIGURE 30.—A common country road—"rather good." (After Potter).

The poor roads not merely reduce the load carried but lessens the distance which can be traveled, and the life of the animal. Even on a good sandy road, it takes more than twice the force to draw a load, as it does on a fair stone road, or four times as much as on a

FIGURE 31.—Country road in France (after Potter),

good stone road, both of which are available in all weather. But in wet seasons, the roads may become impassable, and even an empty wagon can scarcely be transported through the mud.

Figure 29 represents a road almost in sight of a $25,000,000 capitol, voted for by the farmers; but it can be reproduced in Georgia.

A common type of fair road is represented in figure 30.

In contrast, one may see almost anywhere in France a common, hard, smooth roadway, and such are often shaded with trees, giving comfort to the animals, so necessary in our warm climate (figure 31).

Does such a condition as pictured in figures 31–33 occur here?

FIGURE 32.—Country road in Italy (after Potter).

Even where trees are still standing by the road side, how often has one seen them ruthlessly removed for fear of shading a cotton or a corn field, although they cannot do harm, as when located upon the southern sides of highways, with casting shadows upon the roads and not upon the fields, giving breath and refreshment to the panting mule or horse.

Such an idea as cutting through the spur of a ridge in place of a difficult climb over the hill has not yet obtained amongst us, as is the case in rural France (figure 33).

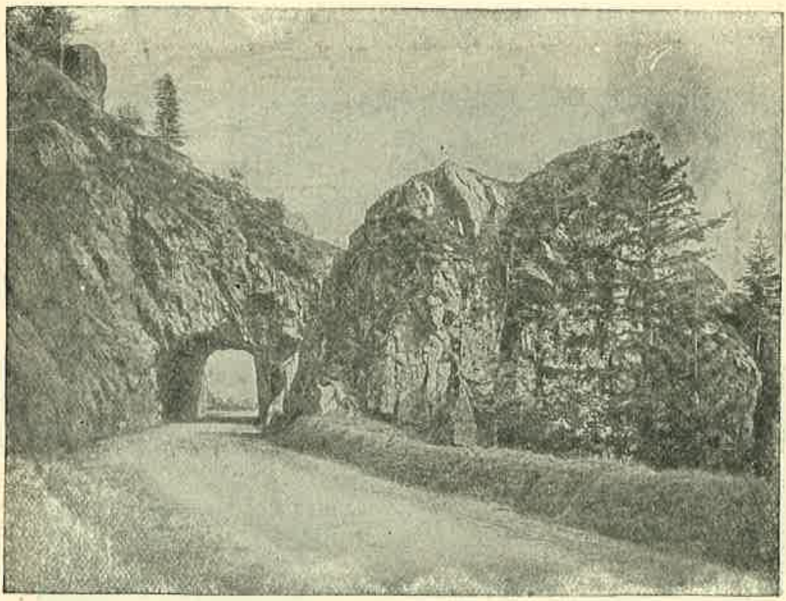


FIGURE 33.—Country road in France (after Potter).

If the stone roads are badly constructed and allowed to be rutted, they are scarcely better than sandy roads, and much worse than clay roads, except in wet weather.

In transportation, a team cannot convey a load greater than it can draw over the worst part of the roads. It is not saying too much that the cost of bringing much of the cotton to market is double or treble what it should be, if all the roads were in good order. Indeed, the cost of these few miles of transportation is commonly greater than that of conveying it from the market to the seaboard. If the time of the man and mules were allowed for, the cost of marketing every one of the 900,000 (?) bales of cotton, sold in Georgia in 1890–'91, would not fall below a million dollars. Half of this cost, at least, could be saved with good roads, and thus, one application of poor roads alone is seen to cost the State $450,000 a year. But this question of loads of inferior weight is not all, for on muddy roads, the conveying of heavy loads must temporarily cease entirely, with a loss of time that is reducible to money. Not to be invidious, let us quote from roads of another State, where however, the conditions for continuous bad roads prevail to a greater extent than in the section of Georgia under survey. In one county there were ten thousand horses, the feeding of which at twenty-five cents a day, cost $70,000 for four weeks. During four weeks the roads were in such a condition that teaming was out of the question. The horses were idle in the stable. It cost the county at least this amount—the bad roads did. Are there not also many examples in our State? A student of good roads has calculated that in Indiana bad roads cost at least fifteen dollars per horse per annum. This is not an extravagant estimate, allowing for food and loss of time.

In 1890 there were over 721,000 horses and mules in that State. This loss from bad roads amounted to $11,000,000 to the State of Indiana for one year. Apply the same estimate to Georgia which had 271,329 horses and mules, and over $4,000,000 worth of feed and labor were lost, because of bad roads.

Another point may be emphasized, the common absence of bridges over many streams. The sides of the streams are often steep, and the approaches to the fords are difficult and dangerous. The bottoms of the creeks are covered with large stones, which rack the vehicles, as they cannot be avoided. The strain on the horses, the wear on the wagons, and discomfort to the traveler, are nothing compared with the loss in utilizing the animal power. Often with an excellent pair of horses, it has been the greatest labor to cross streams with a load of half a ton weight; and this for horses that could easily pull three tons on a first class road. These fords ought to belong to the past. The approaches to the ferries are commonly little better, and these ought to give place to bridges, as they are frequently doing. Besides the difficulty of the fords, in high water, long detours, or even delays of days, are necessary. On one occasion, a storm came up at night. We were assured that the ford across a branch, thirty feet wide, was safe at the higher stage. We entered it; one horse was floated off his feet, and the body of the carriage and contents submerged; with difficulty the opposite bank was reached. The delay, owing to the bad roads, caused us to miss the train. This incident and the damage and delays cost the State alone more than enough to build a bridge over this stream.

The good roads of Europe are often modern. The generally excellent roads of Britain date back no farther than seventy years ago; and those who advocated them were satirized as visionary. Many of Italy's best roads have been made in the last quarter of a century.

Most European countries place the roads under the control of the government. France is a republic of small farmers, and they get something from their government in the form of $18,000,000 a year for road repairing, etc. If our State would only expend for a few years as much money as is lost every year to the farmers by bad roads, then Georgia would have highways equal to those of any country. What was good enough for our grandfathers and our fathers, will not do in the age of progress and competition, when the greatest amount of work must be done for the least amount of labor.

About Rome, there has been the application of convict labor to the public roads, under competent direction, and this district shows what may be done. It is an object lesson, and one can ride with some comfort in stormy weather and not find himself belated. But whether road improvements be made at State or local cost, they must be laid out by competent engineers, and constructed under responsible supervision, and not under neighborly direction at a semi-picnic frolic.

It has been estimated that the loss occasioned by bad roads costs the United States no less than $350,000,000 a year. What people do not directly pay for, they do not feel, but he who provides against losses is the thrifty and well to do man, and so with States; for extravagant wastes and the gloomy side of bad roads ought not to be perpetuated.

The bright side of good roads is not merely in direct profits, but the increased value of lands and the increased comfort in travelling. A country without railroads is cheap to-day. A district from which it costs more to convey the product to the nearest market than from it to the markets of the world must also be cheap. This cheapness is overcome by good roads.

In another State, cranks, we are told, wanted good roads. They were ridiculed; one man built a mile of good road at his own expense. This object lesson, rising above laughter, soon resulted in seven good roads through his county. Not far from a great city a farm was worth fifty to seventy-five dollars an acre, but could not be sold. The owner farmed at a loss. At last, a good road was built, and the land was then sold for $200 an acre, with facilities for turning it into a truck farm.

As this question of roads is one now attracting great attention, both in Georgia and elsewhere, the digression of the subject may be excused, as duty has carried me into the question of the relations of the roads to the geological formations of northwest Georgia, and the materials for their improvement.

PART III.

SOILS

OF THE

PALEOZOIC GROUP

OF

GEORGIA,

IN

POLK, FLOYD, BARTOW, GORDON, MURRAY, WHITFIELD,

CATOOSA, CHATTOOGA, WALKER AND

DADE COUNTIES.

BY

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AND

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AGRICULTURAL FEATURES

REPRESENTED ON THE

GEOLOGICAL MAP.

COAL MEASURES.........	Table lands, poor sandy soil.
MOUNTAIN LIMESTONE .	Mountain sides and valleys, fair soil.
FLOYD SHALES...........	Flats or valleys, thin soil.
FORT PAYNE CHERT.....	Gravel ridges, little soil.
CHAT. BLACK SHALES...	Narrow valleys, no surface soil.
RED MOUNTAIN SERIES.	Crested ridges, little soil except on sides, there fair.
CHICKAMAUGA SERIES.	Valleys and some ridges; good soil.
KNOX DOLOMITE..........	Gray cherty ridges, gray and red plain and valley lands; latter very good soils.
OOSTANAULA.	Wide valleys, good soil; ridges, thin and poor soil.
METAMORPHIC FORMATIONS..................	Mountain ridges and valleys, on the border of the Paleozoic group of rocks; this soil often thin and poor.

CHAPTER XLII.

FORMATION AND CHARACTERISTICS OF SOIL OF THE PALEOZOIC BELT OF GEORGIA.

CONTENTS.

COLOR DISTINCTIONS.

There is a popular classification of Georgia soils into gray, mulatto and red lands. In limited regions, this distinction is descriptive, where the superficial earths are derived from the same general rock formations.

But to apply the terms generally, whether to the Pleistocene soils of southern Georgia, formed by sedimentation in great bodies of water; to residual soils of central Georgia, derived directly from the decay of gneisses and other crystalline rocks; or to soils made out of decayed limestones or shales in northwestern Georgia, is to imply that the value of the soils is independent of the components or of the formations to which they naturally belong. However, in the price of land, there is a differentiation, for under equally favorable conditions, the same colored lands are much more valuable in some districts than in others, and this difference is dependent upon their composition, which may not appear to the eye.

The deep color is given to the land by oxides of iron, or modified by traces of manganese, and by organic matter. This color is associated with certain textures which have general influences in absorbing the solar heat and consequently affecting radiation. All of these conditions bear upon plant growth; but the heat effects are independent of mineral food, hence the color designations are of value only when applied to soils as indicating that they are derived from different rocks, in the same region and that these rocks and their decomposed products have different components. Thus in central Georgia a red soil may indicate its derivation from a hornblende gneiss or granite, whilst a gray soil is formed out of ordinary gneiss or granite, which has a different composition from the former; accordingly this color definition has only local values; as for illustration, in portions of northwestern Georgia, red and gray soils are both derived from the decomposition of the Knox dolomite; the dark soil, however, is formed out of the less siliceous beds and are more calcareous, with more phosphoric acid, etc., than the gray soil derived from the cherty and siliceous beds which are sandier, stonier and poorer in certain plant foods. But these two classes of soils in middle and northwestern Georgia cannot be correlated or separated by their color lines. Indeed, locally, there are other conditions which render their generalized classification still weaker: as an example; there are red loams upon many hills adjacent to the greater rivers. These soils are often very difficult of distinction from the red lands of the Knox dolomite, when the former have no gravels associated with them, but the derivation and composition are quite different.

THE ORIGIN OF THE MATERIALS OF THE SOILS.

Primarily, the clayey, the sandy, and part of the calcareous components of the soils are derived from the decay of the metamorphic rocks of the east and were laid down along the western coast of the ancient lands of middle Georgia. The calcareous matter, however, was in a great part absorbed directly from the sea water through the agency of animal life and converted into limestones. But the question now is, not the origin of the rocks of northwestern Georgia, but of the soils from these rocks. These rocks were largely limestones, shales and some sandstones, and these materials were commingled in various ways, so as to form impure beds of various kinds; accordingly we find that the shales are usually more or less calcareous. The magnesian limestones often predominate over the simple limestones; but in either case, they are of various degrees of impurity. The sandstones are also more or less argillaceous. From these rocks the soils have been formed.

HOW THE SOILS WERE FORMED.

Nearly all the soils of northwest Georgia are residual, that is, the remains of the rocks decayed in place.

THE FORMATION OF LIMESTONE SOILS AS ILLUSTRATED BY THE KNOX DOLOMITE SERIES.

The Knox dolomite formation occupies a very broad country, and to the formation of its soils prominence is due. From the analysis of the limestones given (pages 263-271), it may be seen that many of the dolomites, which contain even a smaller amount of impurities, hold as much as 3.75 per cent. of silica or sand, and 1.5 per cent. of alumina (with a trace of iron). Other compact rocks consist of as much as 6.25 per cent. of sand, whilst the impure earthy limestone, such as produces cement, contains 22 per cent. of silica, 5 or 6 per cent. of alumina, 1.5 to 2 per cent. of ferric oxide. Here, then, are the materials for the red soil of the formation. The action of carbonic and of organic acids dissolves away the calcareous matter, leaving the silica, alumina and oxide of iron, etc. This decay is unequal upon even the same bed of rocks, as is seen in plate III., opposite page 43, or in figure 34.

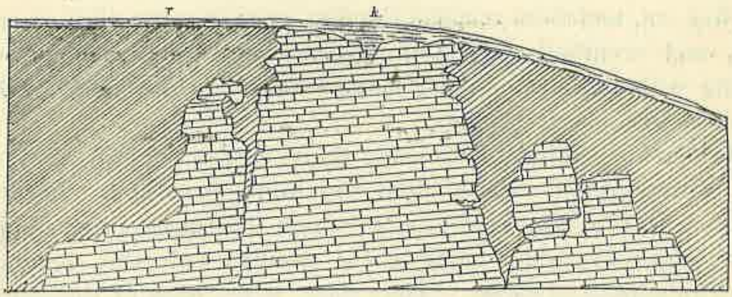

Figure 34.—Formation of Soil from decay of Limestone. Shaded portion represents the residual earth (r) derived from the decay of Limestone (k).

Upon studying the analyses of the soils it appears that those formed from the ordinary Knox dolomite contains about ·67 per cent. of silica, and some 5 or 6 per cent. of alumina, whilst others contain 12 to 15 per cent. of alumina, besides iron, etc.

As the calcareous matter is dissolved out of the rocks, the alumina and silica remaining form clay and free sand, easily acted upon by the rains and rills, in which case much of the clay is carried off the surface as mud into the rivers, leaving an excess of sand to form sandy loams. Thus, it may be seen that the ordinary soils derived from the limestones contain about ten times as much silica as the original rocks did. Accordingly, the conclusion is reached that at least ten times as much limestone as there is silica in the residual earth has been removed. In one case the residual clays are known to be two hundred feet deep. These would accordingly, represent the remains of two thousand feet of limestones that formerly existed in this locality. Some of the silica has been washed off with the alumina, and so this estimate may be below the mark. Other soils derived from the Knox dolomite formation contain from 80 to 82 per cent. of silica. Such are derived from the flinty portions of the series, which were much richer in silica. These flints were concretions in the limestones, and contained crystalline particles of the magnesian limestones. Upon weathering, the calcareous matter has leached out, and there remains the flint or chert matter full of cavities, and eventually, much of it disintegrates into a sandy soil. Along with this comminuted matter, the soil is also more or less charged with cherty gravel.

As the Knox dolomite has many layers rich in the chert, so there is a variety of soil arising from the same formation. The less siliceous beds of the rock usually contain the largest proportion of iron compounds, which produce the residual red soils, generally more aluminous or clayey. Here then, is the basis of the soil derived from the limestone, but the plant food is not yet mentioned.

SOURCES OF PLANT FOOD IN LIMESTONES.

The calcareous matter of the sea water is secreted by shells, crinoids, corals, etc., and the remains of these animals form the limestones built beneath the sea.

Except portions of the flinty matter, which are also of organic origin, the siliceous matter or sand and clay have been carried down as silt and deposited along with the growing limestone. This clay arises from decomposed feldspars, and contains the alkalies—potash and soda still in a state of combination. So also some phosphatic matter is derivable directly from the crystalline rock, and is held in the mud. But a considerable proportion of it is also secreted by the organisms forming the limestone. The iron and manganese were chemical deposits amongst the forming rocks, the materials being carried down by streams. The sulphuric acid may be of chemical origin, directly or indirectly derived from the sea water, or sometimes of organic origin and may exist as the sulphate of lime, or as the sulphide of iron. The magnesia, so commonly combined with the lime, is directly derived from the sea water, by a process not known.

We now see how the plant food is locked up in the limestone rocks. Upon the decay of the rocks more or less of these constituents are not leached out, and upon their presence the value of the soils in a large measure depends.

Usually the limestone contains some organic matter, often a considerable percentage, but this original organic matter is in the condition of bitumen-like compounds, and is not in the form of plant food. There are other limestones, such as that of the Chickamauga series, which gives rise to heavy clayey soil.

THE FORMATION OF SHALE SOILS.

The shales in the country under examination are all calcareous, and many of them contain beds of limestone. From this calcareous matter, the fertile constituents are principally derived. These shales are highly siliceous, and in some places the subsoils are mostly made up of small shaly fragments or shingle. In other cases, it is a sandy clay, resembling the Knox dolomite soils, and deeply stained with iron.

THE FORMATION OF SANDY SOILS.

These are usually formed from the disintegration of sandstones, which, if they contain clay impurities, become more or less loamy; if not they are usually light and poor. However, some of the shale and especially the Lafayette soils, are very siliceous, and from them much clay is often washed away, leaving sandy surfaces. Overflows along the river lowlands also leave local sandy deposits.

THE FORMATION OF CREEP SOILS.

In the lower parts of the valleys, and upon the hillsides, there are various clay soils which owe their origin to the gradual creeping down of the more clayey materials from the higher ridges. In characteristics, the soils partake somewhat of the nature of alluvial deposits, but the materials are not assorted to the same extent.

FORMATION OF ALLUVIAL SOILS.

Such soil is formed out of the muds deposited by rivers or in estuaries. On the hills adjacent to the larger streams, in the belt surveyed, to an elevation of one hundred and fifty feet above them, there are the remains of alluvial deposits with often a bed of gravel beneath. These accumulations represent the remains of a sheet of mud belonging to recent geological times, which has been correlated with the Lafayette series of southern Georgia (see part I. of this report). The heavy loams do not usually extend more than two miles from the large streams. Since their deposition, they have been greatly denuded, and only remain in broken patches. They are often liable to be mistaken for the red residual clays of the Knox series (when no gravel is associated with them). These loams are apt to contain more aluminous matter than the residual clays, and hence, they are somewhat heavier soils.

There are other and more modern alluvial deposits formed by the overflow of the rivers, but such are not widespread, and are very local.

Under these conditions, almost all the soils throughout northwestern Georgia are simply those formed out of the remains of rocks decayed in place.

ACCUMULATIONS AND EFFECTS OF ORGANIC MATTER IN SOILS.

It has now been seen how the physical body and mineral plant foods of soils have been derived from the rocks. For the growth of the higher plants, they need nitrogen in a form which can be assimilated. In course of time the rock dirt becomes soil through the agency of plants. The living plants send out their roots and loosen the earth and render it more porous. They also mechanically prevent the washings of the surface. The covering of the surface prevents escape of carbonic acid and other excretions, which act upon the underlying materials and render them more soluble. Part of this assimilated mineral food, gathered often from depths in the ground, is thus accumulated at the surface; and upon the decay of these plants, this food is in the most favorable conditions for absorption by new growths. Trees often bring the food from depths of four, six or occasionally fifteen feet below the surface. The conditions of greater availability of plant food from the surface soils, than from greater depths, is best shown from the systematic analyses of the earth of different depths. In our report upon the soils of the Agricultural Experiment Station of Georgia several analyses of earths taken at different depths are given. (See that chapter as a sequel to the report on northwestern Georgia.) From these results, we find that the soluble lime, potash and phosphoric acid diminish rapidly with depth from the surface. This solubility was determined by allowing the soil to digest for thirty days in diluted hydrochloric acid. These soluble portions of the constituents may be considered as available for plant food, the insoluble only after long action of decomposing acids arising from vegetable decay.

At the Experiment Station, in descending from the surface soil to 42 inches, the proportion of lime which is soluble diminishes from 83 to 47 and then to 37 per cent.; the available phosphoric acid from 50 to 25 and then to 8.5 per cent.; and the the soluble potash diminishes from 42 to 13 and then to 8.5 per cent. of the total amount. A second set of analyses shows similar results, except in the phosphoric acid, which is more soluble at lower depths, but there, the character of the strata changes from mixed soil to decayed and porous rock.

In a series of experiments conducted by Mr. D. W. Langdon at Tuscaloosa for the Alabama survey on soils ranging from the surface to a depth of fourteen feet, the total amount of soluble lime, potash and phosphoric acid diminished from the surface to 7.5 feet, below which the available elements were in scarcely more than traces. His report did not give the total amount of the constituents in the insoluble condition. Some analyses on the soils and subsoils by Prof. Loughridge in Polk and Bartow counties gave the same results.

This greater availability of the plant food in the surface soils than below arises from the solvent effects of carbonic and vegetable acids upon the necessary elements—not only those named above, but other mineral constituents which are equally necessary for plant growth, and which are usually present in sufficient quantities in the soil.

From some of the analyses we find that there are absolutely larger quantities of the elements which form plant food at the surface than at greater depths. This, in some cases, may arise from the variations of the soils at different depths, being derived from somewhat different sources, but as the increase is largely amongst the soluble constituents it is evident that the greater quantity has in part been accumulated by the long successions of decaying plant life which has flourished at the surface.

The organic substance called humus is a mixture of decomposing matter, forming transition products which often act energetically upon the soil. The name humus is given to the yellowish or dark brown pulverulent organic matter. This dark humus has the power of absorbing moisture, and the soluble substances contained in it. The humus when combined with clay forms a moist pulverulent soil or vegetable mould. In contact with alkalies or lime it absorbs oxygen, both from the air and from oxygen compounds in the soil, thus acting as a reducing agent. Accordingly this humus has the power of fixing in the soil many of the necessary compounds of plant food. In this oxidation a series of organic acids is found which ultimately ends in carbonic acid and water. Prof. A. A. Julien's experiments on rock decay show that these vegetable acids have greater decomposing effects upon minerals than even carbonic acid, and also dissolve various alkalies, silicates, etc.

The decomposition of the vegetable components also converts parts of the nitrogen into ammonia and nitric acid, from the compounds of which it is again absorbed by the succeeding generation of plants. Humus also acts as a solvent of ammonia derived from the atmosphere.

KINDS AND PHYSICAL PROPERTIES OF SOILS.

Sandy soils are composed of rounded or angular grains of sand, which are usually quartzose, but often with particles of other undecomposed rocks, or with an admixture of clays. Pure sandy soil is sterile, but when it contains clay or minerals which make clay upon decomposition it may become fertile. The sand is porous and permits the escape of water. It also absorbs solar heat quickly and cools quickly, but if the grains are fine, or it becomes earthy, this property of sudden absorption decreases, and the power of retaining heat increases. The sandy soils are warm and dry, and when they contain humus or clay they may suffer from drouth. The available plant food is in a condition of easy absorption, but without a supply of foreign food the soils are not durable.

Clay Soils.—Pure clay or hydrous silicate of alumina is not a fertile soil. Clay soils contain more or less free sand (when in excess this forms a sandy loam), and various other constituents, as lime, iron, etc. Clay has the property of not only retaining plant food, but when such is in solution it absorbs a large percentage of it from water passing through the earth.

Clays are colored yellowish, brown or red by ferric oxide in different conditions; blue or green by ferrous oxide; pink, brown or black by manganese; gray to black by humus. Clay absorbs moisture and swells up, thereby retaining its water and producing cold soil. But the dry clay retains heat. Moist clay is usually plastic, but this plasticity is reduced by the presence of lime. These plastic clays are tough when wet, but crack upon drying and expose the roots of the plants. During long wet seasons the heavy clays favor the reduction of iron compounds to the condition of ferrous oxide, which is injurious to plants. Few of our clays are heavy, but they are mostly mixed with free sand, which reduces them to the condition of loams, with the accompanying advantages over both heavy clays or loose sandy soils. But these loams vary greatly.

Calcareous and Marly Soils.—Every fertile soil is more or less calcareous. This calcareous matter may be in the form of grains, constituting calcareous clays or loams. But the lime is often in the form of an impalpable powder intimately mixed with the clay, constituting a marl, by which name it usually goes when it contains 10 per cent. of lime. Calcareous soils are stiff, but they are pulverulent when moderately moist, and very productive on account of the mineral promoting decomposition of organic matter, as well as easily supplying this element to the plants. Lime also renders clay more porous.

Ferruginous Soil.—Most soils contain an abundance of iron. The iron in the condition of ferric oxide giving it the red color favors the absorption of solar heat. In its hydrated state it absorbs moisture and retains the soluble plant food. It is apt to form hard concretions in the clays. The ferric oxide is beneficial, except when it is more or less protected from the atmosphere and in contact with vegetable matter and moisture, when the ferrous salts are generated, which blight plant life. In such cases drainage is particularly necessary.

These conditions prevail in swampy lands, so that they are seldom productive until long after drainage, when the iron has been exposed and converted into ferric oxide.

RELATIONS OF HEAT AND MOISTURE TO PHYSICAL STRUCTURE AND COLOR OF SOILS.

These have been summed up as follows:

"*Sandy soils,* when of dark colors, are most heated during the day, and cool down most during the night, and, in consequence, condense most dew; but sandy soils of light colors are rapidly heated because of the coarseness of the grain, while they retain well the heat so absorbed because of their color, and such soils condense comparatively little dew.

" *Calcareous soils,* well pulverized, when of dark color, are strongly heated during the day and retain their heat well at night in consequence of their fine grained texture, and condense little dew; when of light colors, are very slowly heated by day and cool very slowly at night, and so also condense little dew.

" *Clayey soils,* when very dry and of dark colors, are strongly heated by day and retain their heat at night; when of light colors, are slowly heated by day but retain their heat.

" Clay soils, when well moistened and of fine pulverulent texture, soon allow the moisture to evaporate and then become warm and remain so; but when of light color retain the enclosed moisture because they absorb less readily the heat necessary to its evaporation, and remain long cold.

"Clay soils, thoroughly wet, and of the consistence of soft mud, are very slowly warmed, but once heated, remain warm, while those of light color remain long cold and wet." (Prof. E. A. Smith.)

He also adds that:

"A sandy soil is kept uniformly warm and moist for a long time by a subsoil of clay; whilst a cold, wet clay soil is warmed and dried by a subsoil of sand. A loose covering of stones as well as vegetable matter protects the ground from both extremes of heat and cold, and then shallow soil *per se* is subject to extremes of temperature."

NECESSARY CONSTITUENTS OF PLANT FOOD.

Elements.—Plants contain the following chemical elements: carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, chlorine, iron, magnesium, calcium and potassium. Besides these elements, silica, alumina, manganese, sodium, etc., in small quantities are found in plant ashes.

Medium of Supply.—Of these substances, the carbon, as carbonic acid, is mostly absorbed from the air; the hydrogen and oxygen in the form of water, are a main supply of plant food derived through the soil; nitrogen, as ammonia and nitric acid, or compounds of these, are derived directly or indirectly through organic remains.

The other elements are chiefly mineral, and are taken from the soil which contains them in small quantities.

Fixing of Plant Food.—In writing of the original sources of the soil, a portion of the constituents of plant food has been shown to come from the decomposition of the rocks. But this is not the only source. In the soil the hydrous clays, hydrated ferric oxide, hydrous silica, etc., can absorb and fix mineral constituents—dissolved in waters percolating through them. Thus potash, ammonia, lime compounds, phosphates and silicates are largely absorbed, whilst those of soda and magnesia, chlorine, sulphur and nitric acid are absorbed only to a very small extent. But some of the solutions of the above substances have the power of displacing others; or most of them may be more or less washed out again by an excess of water passing through the soil. The surface soil fixes a larger amount of salts than the deeper earths.

In our soils the compounds which are most affected by growing crops and soonest need replacement—exclusive of organic compounds—are phosphoric acid, potash and lime, especially the two former.

Superphosphate of lime soon becomes insoluble in the soil, owing probably to the excess of lime in the soil. It is rendered still more insoluble by the reaction of the iron and alumina, but it is left in an extremely finely divided state, in which condition it is easily absorbed by the plant.

Potash Salts are absorbed by hydrous clays, ferric oxide, hydrous silica, etc. Accordingly, in the formation of soils, and leaching by atmospheric waters, plant foods are left in a greater or less quantity.

Ammonia Salts are mostly absorbed in a way similar to those of potash.

ESTIMATING THE VALUE OF SOILS.

Value of Analyses.—Soil analyses of themselves are not always indicative of the quality of the soil, as the plant food may not be available. It is this temporary property that leads agriculturists to turn out fields to rest, or better still to fallow, or plow the fields without cropping; thus affording opportunity for disintegration of mineral ingredients, and the rendering of them available for plant food.

Analyses are valuable when they prove the absence of plant food below the limit of fertility, and they show what is most needed. Prof. Hilgard's long careful studies have shown that a valuation of the soils may be derived from the analyses, when based upou solubility of the components, and in this case rejects those portions of the elements of plant food which are not soluble in diluted hydrochloric acid. In the analysis of the soils given in this report we have the quantity of both the soluble and insoluble lime, potash and phosphoric acid, upon which deductions can be based.

Lime.—Prof. E. W. Hilgard has found that the percentage of available lime present in productive soil must not fall below 0.100 per cent. in the lightest sandy soil; in clay loams not below 0.25; and in heavy clay soils not below 0.5 per cent., and better still, with even 2 per cent., above which it is of no special value, except mechanically.

Phosphoric Acid.—If the phosphoric acid be less than 0.05 per cent. there is a serious deficiency. In sandy loams, with lime 0.10 per cent. of phosphoric acid renders soil fairly productive for eight or fifteen years; if lime be deficient, double the amount is required. He has found the soluble phosphoric acid present in splendid table-lands of the Mississippi river to the extent of .30; whilst on the black prairie of Texas, it has amounted to 0.46 per cent.

Potash, if present to less than .06 per cent. in soils, shows them to be deficient in alkali. Deep sandy soil with less than 1.00 per cent. may be productive. With the amount of clay in the soil, the potash increases. In sandy loams it fall below .30; in clay loams it ranges from .30 to .50 per cent.

Soda to the extent of from one-eighth to one-third as much as the potash is sufficient.

Sulphuric Acid to the extent of 0.02 or 0.04 is adequate. It rarely amounts to more than 0.1 per cent.

Chlorine is of only slight importance. It is always present in sufficient quantities.

Ferric Oxide is a necessary plant food perhaps, but Hilgard finds its greatest benefit derived from the absorptive power of ferric hydrate. Red lands resist drought better than light colored lands. (The moisture also depends upon humus, clay and lime.) The percentage of iron varies. From 1.5 to 4.00 per cent. in some conditions may only slightly tint the soils. But the red lands may contain 12 or even 20 per cent. of ferric oxide as previously noted. Red lands also appear to be a carrier of oxygen and facilitate nitrification, even though the soil contains a high percentage of humus. But damp red lands (from bad drainage or overflows) reduce the ferric oxide to ferrous salts which blight the crops.

Moisture.—At 60° Fah. cultivatable soils contain from 1.5 to 23 per cent. of moisture. Pure clay seldom exceeds 12 per cent., ferruginous clays and also calcareous clays 15 to 21 per cent.; and in peaty soil it may rise to 23 per cent.

Physical Condition.—Beside the chemical composition of the soil, its physical characteristics have a strong bearing upon its agricultural value, such as texture, absorption of moisture, heat, etc.; and the physical features of the land, bottoms, plains, hillsides (steeper than 20° are almost unavailable), etc.

THE CONSUMPTION OF MINERAL CONSTITUENTS OF PLANT FOOD BY COTTON, CORN AND WHEAT.

The consumption of mineral constituents by cotton, corn and wheat has been calculated by Prof. E. W. Hilgard; the area producing the crop is assumed as an acre in each case. The determination here given explains agricultural phenomena in connection with the soils of northwestern Georgia.

	Potash.	Phosphoric Acid.
ONE BALE OF COTTON.		
1,350 Pounds of seed cotton: (400 pounds of lint) make four pounds of ash containing....................	1.6	0.5
950 pounds of seed cotton make 41 pounds of ash, containing....................................	14.7	15.2
Total in seed cotton..............................	16.3	15.7

Of the 41 pounds of the ash in the seed:

The hulls, weighing	475 pounds, containing	9.5 pounds of ash.
The oil cake, weighing	368 pounds, containing	31.0 pounds of ash.
The oil weighing....	107 pounds, containing	0.5 pounds of ash.
	950	41.0

	Potash.	Phosphoric Acid.
FIFTEEN BUSHELS OF WHEAT.		
The grain makes 18 pounds of ash	5.5	9.0
Two tons of straw make 200 pounds of ash (silica 128 pounds), containing..........................	8.0	3.0
Total..	13.5	12.0
THIRTY-FIVE BUSHELS OF CORN.		
The grain makes 25 pounds of ash, containing...........	6.0	13.0
Two tons of stalks, etc., make 200 pounds of ash (50 pounds of silica), containing.....................	15.0	16.0
Total..	21.0	29.0

From these tables the following conclusion is drawn: if nothing be returned to the soil—

A bale of cotton (seed and lint) withdraws..........	16.3	15.7
Fifteen bushels of wheat (grain and straw) withdraw..	13.5	12.0
Thirty-five bushels of corn (grain and stalk) withdraw..	21.0	29.0

If the cotton seed, wheat straw, and cornstalks be returned, then there is permanently withdrawn:

The cotton lint (of one bale), containing............	1.6	0.5
The wheat (grain of 15 bushels), containing.......	5.5	9.0
The corn (grain of 35 bushels), containing.........	6.00	13.0

This chapter is not intended as a treatise on agricultural geology, nor will time permit of a full consideration of the subject, which may be found in the reports of Johnson, Hilgard, Smith and many others; but this epitome will make the report on the soils of Northwestern Georgia more intelligible.

CHAPTER XLIII.

GEOLOGICAL AND CHEMICAL RELATIONSHIP OF THE SOILS OF THE PALEOZOIC FORMATIONS.

CONTENTS.

SOILS OF THE OOSTANAULA SERIES WITH ANALYSES.

Note.—In all cases not specified the samples of soils taken for analyses were from the edges of fields or roadsides, so as to ascertain the value of original soils rather than those of variable degrees of exhaustion or of fertilization.

COOSA VALLEY PHASE.

Distribution.—This phase is confined to the Coosa valley, southwest of Rome, and a belt along the Oostanaula river extending into Whitfield county (see map). This is the Cambrian phase of what is popularly known as the "flatwoods." It is characterized by more or less level tracts with local undulations. The drainage is often defective and soil thin. This is derived from arenaceous shale, which in places is highly calcareous. The southern end of the belt is generally uncultivated and often covered with large short-leaf pine, post-oak, some black-jack and other oaks. Its northern extension is characterized by many low ridges, and the soils resemble those of the overlying Oostanaula series.

The soil is greenish-yellow, or dark, or sometimes red (especially towards the northern end). Below the surface the yellowish color is apparent. It is highly siliceous, and the microscope shows some grains of sand $\frac{1}{125}$ of an inch in diameter, but the great proportion is less than $\frac{1}{500}$ of an inch in diameter, so that the character of the sand favors the retention of water, which often accumulates upon its surface. There are several beds of impure limestone crossing the formation, as at Thomas' mills, and in such localities the soil is better than in the more shaly belts.

The sample of drab soil for analysis was taken from two miles east of Coosaville, along the river road, at an elevation of more than 150 feet above the river. Here the land was productive.

Analysis No. 1.

Lime (total)	3.029
Magnesia	0.965
Potash (total)	0.624
Soda	1.115
Sulphuric acid	0.329
Phosphoric acid (total)	0.416
Ferric oxide	4.621
Silica	67.245
Alumina	7.215
Water	3.715
Organic matter	9.762
Undetermined, loss, etc.	0.964
	100.000
Lime (soluble in acid)	2.274
Potash (soluble in acid)	0.376
Phosphoric acid (soluble in acid)	0.262

The locality of this soil is near the margin of the formation, and is apparently the more fertile part of the belt. The same character is noted north of Rome, as in Gordon and Whitfield counties where the belt in more generally cultivated than southwest of Rome.

The analysis indicates fertility. But portions of this formation are characterized by stiff, cold soils, which favor the reduction of the iron to the condition of ferrous oxide, which is an objectionable condition. There is considerable variation in the soils, whether in the vicinity of the more calcareous or the more siliceous members of the Coosa series, as shown in comparing the above analysis with one made by Mr. J. M. McCandless from a sample taken at Bell's ferry on the Oostanaula river above Rome:

Analysis No. 2.

Lime (total)	0.248
Magnesia	0.691
Potash (total)	1.428
Soda	0.689
Sulphuric acid	0.033
Phosphoric acid (total)	0.112
Ferric oxide	4.451
Silica	77.189
Alumina	9.429
Water (hygroscopic)	1.110
Water combined and organic matter	4.060
Loss	0.560
	100.000

Lime (soluble in acid)	0.125
Potash (soluble acid)	0.424
Phosphoric acid (soluble in acid)	0.077

Under cultivation and drainage the lands ought to be improved. On approaching the State line the features are similar to those of

Alabama, where the State survey finds plant food also present, with the physical conditions unfavorable, and with a deficiency of phosphoric acid in places.

CONNASAUGA VALLEY PHASE.

The soils of this geological series cover only a narrow zone in the western part of Polk and Floyd counties. In Bartow, the eastern and central portions are occupied by different belts. Half of Gordon, Murray and Whitfield counties are covered by the same series; narrow fertile belts cross Chattooga, Walker and Catoosa counties. The series presents three phases:

(a) Adjacent to the Oostanaula fault there is a chain of crested ridges composed of shales with some thin sandstones (the Knox sandstone of Safford, or the Rome sandstone of Hayes). The soil is in part, light colored throughout the rugged portion of the belt, but often red in the depressions between the interrupted ridges, and in the valley west of Taylor's ridge.

On the Georgia-Alabama line a sample of the soil was taken from the roadside. It is a stiff, hard, compact, yellowish grey soil, composed of very fine round grains of quartz, coated with earthy matter in a matrix of clayey and angular siliceous particles. The physical conditions of the soil are unfavorable for agriculture; but sufficient plant food is present as shown by analysis.

Analysis No. 3.

Lime (total)	1.321
Magnesia	0.752
Potash (total)	0.315
Soda	0.162
Sulphuric acid	0.085
Phosphoric acid (total)	0.312
Ferric oxide	3.654
Silica	77.993
Alumina	6.720
Water	2.421
Organic matter	5.404
Undetermined, loss, etc	0.861
	100.000

Lime (soluble in acid)	1.068
Potash (soluble in acid)	0.161
Phosphoric acid (soluble in acid)	0.183

Another sample of soil from the same horizon as the last in the lower members of the Cambrian shales near Ringgold yielded the following analysis (Mr. McCandless):

Analysis No. 4.

Lime (total)	0.220
Magnesia	0.482
Potash (total)	0.579
Soda	0.314
Sulphuric acid	0.033
Phosphoric acid (total)	0.143
Ferric oxide	3.385
Silica	84.181
Alumina	7.075
Water (hygroscopic)	0.334
Water combined and organic matter	3.156
Loss	0.098
	100.000

Lime (soluble in acid)	0.116
Potash (soluble in acid)	0.377
Phosphoric acid (soluble in acid)	0.052

This sample is much more siliceous than that further south, and also much poorer in lime and phosphoric acid, although richer in potash.

The area of this soil, however, is small, as it forms only a narrow belt, but in Gordon and Whitfield counties, it approximates in character to red shale lands, and is covered with the same timber.

(b) The shales have had their calcareous matter leached out, leaving siliceous splinters, in the form of great beds of shingle covered with only a thin soil and often almost bare. The color is brown, red, greenish and gray. The shales form ridges in the greater valleys, which are often well wooded. To some extent, these ridges border the valleys of section (c), but are most largely developed in eastern Bartow, Gorden and parts of Murray and Whitfield counties, where the belts are many miles in width. These hilly shale lands are not very extensively settled, as the soil, although fairly productive, is subject to drought. The shales are wooded with pines, red, spanish and white oak, hickory and chestnut, with occasionally black-jack.

(c) Other portions of the shale series are more calcareous with beds of limestone often in thin seams. These limestones appear in most of the valleys, and the shales weather into clays from five to fifteen feet deep; resembling the residual clays of the Knox series. These soils are of red color and amongst the best in the state. They form the valley, two or three miles wide, extending from Etna to Cave Spring, Rome and to Calhoun; also other narrow valleys in Whitfield, Catoosa, Walker and Chattooga counties. A small anticlinal valley of these soils occurs at Woodland; another belt extends from Kingston to Adairsville and Calhoun. Eastward valleys of the shales of both sections (b) and (c) occur in the broad belt extending through northeastern Bartow, across Gordon, and occupying most of southern Murray and Whitfield, and narrower belts further north. On both the eastern and western sides of this broad belt soils of section (c) occur, as also in the principal valleys of this zone, which is shown on the map. Thus about Cassville, there is a good farming section and also to the northward. This is equally the case at the foot of the mountains forming the western borders of the metamorphic zone.

As the soils of the shale zones often border those of the succeeding Knox dolomite series, which they closely resemble, the line of demarcation is not always well defined, and indeed, is agriculturally unimportant.

A type of the soil is seen in the analysis from a field of Mr. Hugh Montgomery, at Cunningham Station. There the soil was a clayey loam overlying the splintery shale. Its color is red, of medium tint. It is composed of free quartz grains, hardly rounded ($\frac{1}{250}$ of an inch in diameter and smaller), embedded in an earthy matrix.

Analysis No. 5.

Lime (total)	3.250
Magnesia	1.060
Potash (total)	0.326
Soda	0.218
Sulphuric acid	0.214
Phosphoric acid (total)	0.152
Ferric oxide	3.212
Silica	68.427
Alumina	5.873
Water	3.106
Organic matter	12.486
Undetermined loss, etc	0.762
	100.000
Lime (soluble in acid)	2.736
Potash (soluble in acid)	0.204
Phosphoric acid (soluble in acid)	0.114

The soil is decidedly arenaceous and more loamy than clayey. It contains a large supply of plant food in an available form. The field was covered by an excellent crop of corn when seen.

Another analysis of soil (by Mr. McCandless) from the same formation at Summerville is here given. It shows this western belt as much more siliceous than that from which sample 5 was taken. It is also richer in potash, but poorer in phosphoric acid and lime.

Analysis No. 6.

Lime (total)	0.295
Magnesia	0.619
Potash (total)	0.521
Soda	0.833
Sulphuric acid	0.081
Phosphoric acid (total)	0.833
Ferric oxide	3.403
Silica	78.230
Alumina	9.277
Water (hygroscopic)	0.695
Water combined and organic matter	5.765
Loss	0.148
	100.000
Lime (soluble in acid)	0.151
Potash (soluble in acid)	0.514
Phosphoric acid (soluble in acid)	0.075

From Mr. Haskin's farm, a mile north of Cave Spring, a sample of dark red soil was taken alongside of a valley which was bounded upon the eastern side by Knox dolomite ridges. The soil appeared to have been derived not only from the shale, but seems to have crept down the hillsides by washes, on account of its structure, and also of its aluminous or clayey character. It possesses high fertility. Its composition is seen in Analysis No. 7.

Analysis No. 7.

Lime (total)	3.561
Magnesia	0.932
Potash (total)	0.654
Soda	0.420
Sulphuric (acid)	0.212
Phosphoric acid (total)	0.136
Ferric oxide	3.862
Silica	60.084
Alumina	15.691
Water	4.320
Organic matter	3.104
Undetermined, loss, etc	0.536
	100.000
Lime (soluble in acid)	3.028
Potash (soluble in acid)	0.419
Phosphoric acid (soluble in acid)	0.094

Many of the shales of the Oostanaula series are calcareous. The limestones of the Knox series are aluminous and sandy. In the weathering of the latter, the removal of the calcareous and magnesian matter leaves a residual clay not very different from that derived from the calcareous shales.

SOILS OF THE KNOX SERIES.

RED SOILS.

These soils form most of the lands of Polk, eastern Floyd, south and west Bartow, central Gordon, and elongated basins in Murray, Whitfield, Catoosa, Chattooga, Walker and Dade counties. The lower beds of the geological formation give rise to fertile red lands, whilst the higher and more siliceous members originate gray, cherty ridges and undulating gray plains.

These two groups of Knox soils are very strongly marked. The first consists primarily of red loamy lands, from yellowish to deep orange red loams and heavier underlying clays. The surface is sometimes more sandy and of light color, where a portion of the red clayey matter has been washed out. When of deep color, granules of brown ore or limonite are scattered through the soil. These soils are usually stoneless, or in occasional localities contain chert, as on some red ridges and hillsides.

These lands, together with the shale valley lands just described, form the best soils of northwestern Georgia, which are amongst the best in the State. They are commonly adjacent to the shales of the valleys, but, again, the erosion has not removed them to depths sufficient to expose the shales, as in the valley of Cedar creek, in Polk county, or along the broad red belt from Fish creek extending into southeast Floyd and onward to the Etowah river in Bartow county. In the large valleys, and adjacent to the neighboring formations, shown on the map, such lands prevail.

Again the red lands appear upon the margin of the series south and near Dalton. The red lands prevail on the ridges and in the valleys of the south and central portions of Knox belt in Murray county.

East, near Varnell, the red Chickamauga lands resemble the red Knox soils. On portions of Missionary ridge and other ridges west of Taylor's ridge limited areas of the Knox soils are red, but the gray generally prevail.

Red alluvial deposits occur on some of the hills in the river regions to an elevation of from 80 to 150 feet, which is liable to be mistaken for residual red soils derived from the dolomite series. These have a character of their own, and when they contain rounded gravel they are readily identified; but without gravel they are liable to misidentification. Such deposits are on hills within from one to three miles of the rivers.

The red soils are widespread on subordinate ridges, adjacent to the valleys where they occur. On the summits of some of the higher crested gray ridges they also occasionally occur, in which case they are more stony than in the valleys. The red ferruginous ridges are often poor in phosphoric acid and humus. In the valleys the available acid may be sufficient. Only this one mineral element of fertility is necessary to be added where the soils have been examined. But on the iron ore bearing knobs the red soil is deficient in organic matter as well as in phosphoric acid.

The following analyses were taken as types. No. 8 is soil from the farm of Dr. W. I. Benham, situated in a broad valley about four miles west of Cartersville. It is deep red loam and composed of very small earthy granules and free quartz. It is highly fertile. No. 9 is a deep red soil on an ore bank four miles southwest of Kingston. It is composed of rounded grains of quartz ($\frac{1}{50}$ to $\frac{1}{100}$ of an inch in diameter), coated by a large amount of clay. It is very deficient in available phosphoric acid and organic matter, but contains a fair share of unavailable acid.

No. 10 is from the surface of an ore bank southwest of Cedartown. It is composed of rounded grains ($\frac{1}{100}$ of an inch) of quartz in much clayey matter. It is very deficient in phosphoric acid and organic matter. In both No. 9 and No. 10 the ferric oxide is in great excess, the clayey matter is in abundance, and the soil is stiffer than usually seen on Knox soils.

Analysis Nos. 8–10.

	No. 8.	No. 9.	No. 10.
Lime (total)	6.708	3.111	3.040
Magnesia	3.214	1.021	0.876
Potash (total)	0.821	0.671	0.462
Soda	0.732	1.101	0.112
Sulphuric acid	0.114	0.420	0.238
Phosphoric acid (total)	0.321	0.063	0.042
Ferric oxide	3.750	10.356	10.213
Silica	69.135	64.500	66.619
Alumina	6.110	12.680	12.340
Water	3.720	4.310	3.600
Organic matter	4.654	1.204	2.104
Undetermined, loss, etc	0.731	0.563	0.354
	100.000	100.000	100.000

Lime (soluble in acid)	5.619	2.570	2.493
Potash (soluble in acid)	0.509	0.408	0.272
Phosphoric acid (soluble in acid)	0.242	0.044	0.030

In the value of the red valley lands, derived from the shales or the dolomites, the variation is not so great as between them and the red ridges, some of which, however, are rich, but generally poorer in phosphoric acid and humus than at lower levels. The ore-bearing ridges are, agriculturally, the poorest of the red lands.

The growth of timber is red, black, post and spanish oaks, hickory and dogwood; and some short-leafed pines, black-jacks, etc., on the poorer ridges; also some walnut, chestnut, gums, etc., on the lower lands.

GRAY SOILS.

These are derived from the siliceous members of the upper Knox dolomite series. The surface usually is covered with chert, left upon the solution of the calcareous matter, on or in the gray soil. Beneath the subsoil may be yellowish or reddish. Where the chert is abundant the soil is often almost sterile. Upon the western side of the Knox belt the gray lands occur mostly upon ridges of a broken character, some of which are surmounted with a red soil upon their summits, that are sometimes stony. The intervening valleys are often narrow, but many contain fertile soils. These ridges have been protected from erosion by the cherty gravel covering, which, however, is more or less superficial.

The eastern side of the Knox belt, in Polk and Bartow counties is characterized by more gentle, undulating country, with less cherty gravel, and indeed, it is often entirely free from it.

In proceeding northward, this characteristic increases in importance, so that in northern Bartow and across Gordon county, the gray lands are mostly stoneless (except ridges upon their western border). This undulating character prevails on various belts in Catoosa, Whitfield, Chattooga, Walker and Dade counties, but with interrupted ridges and valleys. In these counties the gray land is seen in valleys as well as on sides and tops of the ridges. There are many lime sinks scattered over the formation. The rolling lands are sandy loams, with often little or no cherty gravel, and with a yellowish subsoil, with sometimes the character intermediate between the red and the cherty gray lands. The soil is often of very fair quality (as shown in analysis No. 11).

The composition of some types of the soils may be seen from the analyses. No. 11 is from near Seney. It is gravelly land with little depth of soil. It is composed of particles of semi-glossy earth, and some rounded quartz grains ($\frac{1}{200}$ to $\frac{1}{250}$ of an inch in diameter). It is very siliceous soil with a small amount of iron. It is badly deficient in phosphoric acid and low in humus.

No. 12 is a sample of gray soil two miles south of Cedar creek, in north Bartow. It is composed of a glossy matrix, the particles of which are less than $\frac{1}{500}$ of an inch in diameter, in which there are rounded quartz grains $\frac{1}{200}$ of an inch. Here the available potash is low and the phosphoric acid very deficient.

On the farm of Mr. Osburne Shaw, three miles north of Wooley's ferry, No. 13, is a drab, gray, mellow siliceous soil composed of rounded grains of quartz ($\frac{1}{80}$ of an inch in diameter) loosely embedded in a small amount of earthy matter. This gray land is on the summit of a rolling country and produces good crops. The analysis shows a soil with more than sufficient available mineral food, but the humus is not abundant; still the crops are good.

No. 14 is a dark gray soil near Wooley's ferry. It is composed of crystalline particles in an opaque matrix composed of very small grains. It also contains some rounded particles of quartz ($\frac{1}{125}$ of an inch in diameter). This soil is not stony. It is low in available lime; deficient in available potash, and very poor in phosphoric acid. The quantity of iron is large, and the objectionable condition of ferrous oxide favoring the light color prevails.

No. 15 is a gray soil (analyzed by Mr. McCandless) just west of Taylor's ridge, on the road from Lafayette to Greenbush. There is considerable variation in all of the soils of the same formations between those situated east and west of Taylor's ridge.

Analyses Nos. 11–15.

	No. 11.	No. 12.	No. 13.	No. 14.	No. 15.
Lime (total)	1.240	1.625	2.964	1.042	0.160
Magnesia	0.092	0.732	1.213	0.021	0.133
Potash (total)	0.262	0.156	0.436	0.092	0.546
Soda	0.314	0.210	0.287	0.064	0.359
Sulphuric acid	0.092	0.096	0.183	0.014	0.056
Phosphoric acid (total)	0.015	0.034	0.240	0.028	0.071
Ferric oxide	2.962	3.212	3.231	10.350	2.306
Silica	82.018	79.326	79.039	84.781	86.435
Alumina	5.352	6.821	4.794	4.222	5.224
Water	3.115	2.312	2.648	2.606	0.766
Organic matter	3.675	5.111	4.113	3.561	3.534
Undetermined, loss, etc.	0.863	0.365	0.872	0.354	0.410
	100.000	100.000	100.000	100.000	100.000
Lime (soluble in acid)	0.943	0.304	2.611	0.769	0.089
Potash (soluble in acid)	0.141	0.072	0.251	0.043	0.197
Phosphoric acid (soluble in acid)	0.008	0.019	0.171	0.018	0.041

From the analyses a great variation in the value of the gray land may be seen; yet it is thought by many to be better than red land for cotton (with use of commercial fertilizers), as the bolls develop well upon a smaller growth of the weed.

These lands are warm, and, in wet seasons favor the growth of cotton lint which consumes very little mineral food; still much of this gray land, especially the more rugged, is not cultivated, whilst the less stony in Gordon county is largely under cultivation.

THE SOILS OF THE CHICKAMAUGA SERIES.

These soils vary from red to bluish clays. When derived from the limestone they are confined to narrow belts from Cedartown southward, in the Fish creek district and also in the Rockmart district. They also occupy many long basins in Murray, Whitfield, Catoosa, Chattooga, Walker and Dade counties. They often border and join the soils of the Knox series and have similar characteristics to the red soils, but form heavier clay soils. They form some of the best soils in Georgia. During wet seasons the roads across them are the muddiest in the State.

The shales or slates from which some of the soils are derived, are closely connected with the limestone members of the series. The more shaly beds occur principally in Polk county; and although they occupy those elongated belts in the northwest counties, as shown upon the map, the separation from the limestone soils are less marked.

These soils are grayish or sometimes reddish and shallow, when the splintery slates come near the surface. When they have disintegrated into mellow land, the soils are loamy. The better soil contains an abundance of lime and potash, with sufficient phosphoric acid to produce fair crops, but rather low in availability. Analysis No. 16 is a sample from a mile east of Berry in Polk county. It is thin and of dark gray color, and mostly made up of subangular grains of quartz ($\frac{1}{250}$ of an inch in diameter) in a small amount of earthy matrix. No. 17 is of the same kind of soil as No. 16. It lies on a low ridge, one and a half miles east of Cohutta station in Whitfield county, and occurs immediately above disintegrated shale. Soils in Murray and Whitfield counties are derived from beds more calcareous than in Polk county. It is composed of vitreous particles and rounded grains ($\frac{1}{125}$ to $\frac{1}{500}$ of an inch and less in diameter) in opaque earthy matrix. The soils in both cases are fairly productive, but need more or less phosphoric acid. In the former sample, the organic matter is rather low; in the latter, it is large and the land more productive.

Analyses Nos. 16 and 17.

	No. 16.	No. 17
Lime (total)	2.643	1.536
Magnesia	1.106	0.648
Potash (total)	0.520	0.243
Soda	0.231	0.108
Sulphuric acid	0.164	0.193
Phosphoric acid (total)	0.067	0.104
Ferric oxide	4.204	4.126
Silica	77.826	74.723
Alumina	4.252	4.762
Water	3.516	2.455
Organic matter	4.710	10.623
Undetermined, loss, etc.	0.761	0.743
	100.000	100.000
Lime (soluble in acid)	2.209	1.307
Potash (soluble in acid)	0.311	0.132
Phosphoric acid (soluble in acid)	0.049	0.058

SOILS OF RED MOUNTAIN SERIES.

Soils of this formation occur only on the ridges as shown on the geological map. The soils are somewhat similar in productiveness to those of the red variety of the Knox series, but with the lime very much leached out, as would be expected from their occurrence on the hillsides. The land is sometimes shingly. A type of these soils of deep red color is seen in an analysis (by Mr. McCandless) of a sample from the eastern side of Taylor's ridge on the Lafayette-Greenbush road.

Analysis No. 18.

Lime (total)	0.078
Magnesia,	0.128
Potash (total)	0.463
Soda	0.321
Sulphuric acid	0.073
Phosphoric acid (total)	0.135
Ferric oxide	6.655
Silica	73.304
Alumina	12.305
Water (hygroscopic)	1.858
Organic matter and combined water	4.542
Loss	0.138
	100.000
Lime (soluble in acid)	0.032
Potash (soluble in acid)	0.298
Phosphoric acid (soluble in acid)	0.096

SUB-CARBONIFEROUS SERIES.

The Fort Payne chert forms a poor stony soil which is mostly confined to the ridges that are shown upon the map or bordering the other Sub-Carboniferous series in belts too narrow to be shown upon the map. These stony belts are unimportant.

The Floyd shales constitute a considerable portion of the "flat-woods" of the lower basins and are poor lands and ill drained. This deficiency does not rise entirely from the absence of plant food, although the phosphoric acid is often low. The region is often uncultivated. Amongst these shales there are various calcareous beds. This formation extends up into the west Armuchee valley where a sample of soil was analyzed by Mr. McCandless:

Analysis No. 19.

Lime (total)	0.158
Magnesia	0.223
Potash (total)	0.508
Soda	0.315
Sulphuric acid	0.089
Phosphoric acid (total)	0.085
Ferric oxide	2.541
Silica	87.092
Alumina	4.099
Water (hygroscopic)	0.689
Organic matter and combined water	3.561
Loss	0.640
	100.000
Lime (soluble in acid)	0.082
Potash (soluble in acid)	0.236
Phosphoric acid (soluble in acid)	0.051

Mountain limestones upon the sides of the Coal Measure plateaus and in parallel valleys give rise to drab clay lands, which contain sufficient plant food, but often most deficient in lime which has been leached out. A sample, analyzed by Mr. McCandless, was taken from the land at the head of McLamore's cove:

Analysis No. 20.

Lime (total	0.143
Magnesia	0.778
Potash (total)	0.996
Soda	0.270
Sulphuric acid	0.022
Phosphoric acid (total)	0.121
Ferric oxide	2.991
Silica	77.195
Alumina	10.249
Water (hygroscopic)	1.812
Organic matter and combined water	4.998
Loss	0.425
	100.000

Lime (soluble in acid)	0.071
Potash (soluble in acid)	0.413
Phosphoric acid (soluble in acid)	0.058

SOILS OF THE COAL MEASURES.

These give rise to light sands of variable compositions, which are very poor in phosphoric acid and lime, as shown from the analysis (Mr. McCandless) of a sample from the top of Sand mountain. This soil also occurs on Lookout mountain:

Analysis No. 21.

Lime (total)	0.115
Magnesia	0.244
Potash (total)	0.541
Soda	0.355
Sulphuric acid	0.053
Phosphoric acid (total)	0.053
Ferric oxide	2.058
Silica	88.627
Alumina	4.412
Water (hygroscopic)	0.405
Organic matter and water combined	2.925
Loss	0.232
	100.000

Lime (soluble in acid)	0.067
Potash (soluble in acid)	0.201
Phosphoric acid (soluble in acid)	0.017

LAFAYETTE AND ALLUVIAL SOILS.

These soils are confined to hills and flats adjacent to the rivers, and seldom reach more than one or two miles from them.

The Lafayette deposits are red or dark brown loams, which occur at elevations up to from 80 to 150 feet above the principal rivers and on eroded hills. These are genetically former alluvial deposits.

In many cases, they are recognized by containing rounded gravel at the base of the deposit; when the gravel is absent, it is liable to be mistaken for Knox red lands. Situated on the much-washed hills, the phosphoric acid is apt to be more or less removed. There is also a deficiency of humus. The clayey matter is abundant, making a somewhat heavy soil. A sample was taken near Stilesboro, in Bartow county, and its character is seen in Analysis No. 22. The color is deep red with an abundance of iron. It is composed of free transparent rounded grains of quartz ($\frac{1}{250}$ to $\frac{1}{500}$ of an inch in diameter) as adhering to the earthy matrix.

Analysis No. 22.

Lime (total)	1.674
Magnesia	0.120
Patash (total)	0.748
Soda	0.436
Sulphuric acid	0.094
Phosphoric acid (total)	0.082
Ferric oxide	12.214
Silica	62.229
Alumina	15.962
Water	4.213
Organic matter	1.582
Undetermined, loss, etc	0.646
	100.000
Lime (soluble in acid)	1.381
Potash (soluble in acid)	0.382
Phosphoric acid (soluble in acid)	0.043

The alluvial soils characterize broad flood plains of irregular outlines. These along the Coosa, Etowah, Oostanaula, Coosawatta and Connasauga rivers rise about 20 or 25 feet above mean low water. In width, they vary from one to one and a half miles, and are usually fertile lands. Above the level, only occasionally indistinct remains of terraces are seen. The lowlands along the smaller streams are less defined, but the bottoms of the valleys are generally fertile.

Superficial sandy soil is occasionally met with on the slopes, arising from the washings of a portion of the clayey matter out of the soil, leaving a lighter soil, also of a lighter color than that from which it is derived. Approaching the greater rivers the surface of the red Lafayette deposits are thus connected with gray sandy lands.

GENERAL NOTES ON COMPOSITION AND PHYSICAL PROPERTIES OF SOILS.

The availability of the plant food is based upon the easy solution of lime, potash and phosphoric acid. That which is insoluble cannot be regarded as plant food in the near future. In order to estimate this solubility, the samples were digested in cold dilute hydrochloric acid (ratio, one of acid to twenty of water) for thirty days. The lime is derived from earthy limestones and calcareous shales, and the soils now contain from 50 to 85 per cent. of it in the easily soluble condition. The samples being taken from practically virgin soil show a large percentage of lime in all cases. A great portion of this lime is probably in the form of easily decomposed silicates. The potash is also soluble to the extent of about 50 per cent., showing the highly decomposed state of the feldspar in the clay of the soil.

More than 50 per cent of the phosphoric acid is soluble.

In most cases, the magnesia is present in much smaller proportions than the lime. The quantity of sulphuric acid is variable, but sufficient, being much depleted in the washed alluvial soil of the Lafayette series. The ferric oxide, in all but the red soils, falls below 5 per cent., except in No. 10, where it is over 10 per cent., and here it probably occurs to a large extent in the objectionable ferrous form.

In the hilly red soils, the proportion of alumina rises sufficient to form more or less stiff clay. At the same time, the quantity of iron is usually high; hence, the silica is still further reduced in its ratio.

The organic matter varies, being less upon the hilly lands than in the valleys.

The flatwood soils often hold water, and are cut up into heavy, rutted roads.

The ridges and higher lands of the Oostanaula series, owing to the splintery character of the siliceous shales, form dry roads with no depth of mud. The valley red lands of the series, as also the red soils of the Knox series, form moderately muddy roads, but when dry, the ruts soon disappear, or the clay is siliceous and not very heavy and stiff.

The red lands of the Knox, the Chickamauga clays, and Lafayette series on the hillsides form the stiffest clay of northwestern Georgia.

The grey Knox and Fort Payne chert lands are siliceous and cherty, and therefore, not deeply muddy, except locally, where chert is in smaller quantities. The muds of the Maclurea series are particularly stiff and deep. The shales of the Rockmart series in Polk are similar to those of the splintery Oostanaula section; but, in Murray and Whitfield counties and west of Taylor's ridge they approach more nearly to the richer shale and red Knox lands.

CHAPTER XLIV.

GEOLOGICAL RELATIONSHIP OF THE SOILS OF THE AGRICULTURAL EXPERIMENT STATION OF GEORGIA AND OF THE COLLEGE FARM.

CONTENTS.

GEOLOGICAL CHARACTERISTICS OF THE VICINITY OF THE STATION.

The Georgia Experiment Station at Griffin is situated on a belt of Archæan or metamorphic rocks, which here forms a gentle undulating plain. The surface rocks are decayed, and only occasionally do they appear at the surface. The character of the gneiss in this region is best seen in the railway cut between the farm and the neighboring railway station, where it is foliated and passes into a quartzose mica schist, that is, a rock with very little feldspar. It lies in beds dipping from 20° to 25° S., 20° to 30° E. This inclination gives some variety to the lands formed out of it, as different strata varying somewhat in character are successively brought to the surface in passing from southwest toward the opposite direction. The dip is favorable to the decay of the rocks.

About half a mile from the farm toward the southeast, rounded hummocks of gray granite rise through the gneiss. Whilst these granites are characterized by partial internal decay they are hard rocks which do not disintegrate like the gneisses, and consequently do not give rise to the soils to the same extent as the latter.

The granites and gneisses are composed of the same minerals, but the latter is laminated or in beds, whilst the former is compact and homogeneous; yet the proportions vary. In lands formed from the decay of stratified limestones the earths may have a heterogeneous structure without traces of any bedding to depths of one hundred feet or more. This has arisen from the removal of perhaps ten times as much calcareous matter as there is now clay and sand; consequently the original structure is obliterated in the gradual settling of the earths. In the case of gneisses and mica schists, as at the Experiment Station, the original rock contained such large proportion of siliceous and only a small proportion of soluble matter, that upon removal of the latter it did not permit of enough settling of the remaining mass to obliterate the original bedding; and thus below a depth of from five to fifteen feet the materials still show the stratification, although the partial decay may reach one hundred feet or more.

ORIGIN OF THE SOILS.

The mineral constituents of gneiss are quartz (giving rise to sand), feldspar (yielding clays with potash, etc.), micas (producing also clays, with iron, potash, etc.), and sometimes hornblende (yielding lime, iron, etc.).

In the neighborhood of the farm the quartz predominates in all the rocks, and in some cases to such an extent that when the other constituents, which are those that decay, weather out, beds of quartzose rock remain, as shown in a depression upon the back part of the farm. This quartz rock is rich in iron, which colors it red. But usually the feldspars and micas are so intimately mixed with the quartz that this mineral separates into grains and makes more or less loamy soil.

Throughout the original gneiss, veins of compact quartz ramify. Upon disintegration these give rise to angular gravel covering the surface of the ground or producing gravelly soil. Thus it is that the sand of this region is simply the residual materials left upon the decay of the gneisses and the granite, from which most of the alkalies have been leached out, as also some of the finer clayey matter is washed away, leaving loam of varying characteristics. This process of washing out the clay is carried on to such an extent upon the slopes of some of the low ridges that even a very light sandy soil is left, for the clay is more easily carried away by washes than the sand. At the same time, owing to the action of vegetable acids upon the soil, the red lands are superficially converted into gray, on account of the partial removal of the iron compounds. The red color of the soils arises from the oxidation of the iron contained in them. This reddening process commonly extends only a few feet (eight to twelve feet) in depth, but it is sometimes seen to a depth of thirty feet, fading out, however, upon receding from the surface; consequently, the lighter earths from a depth are not always the equivalent of the gray land at the surface.

The soil of the station is derived from gneiss containing hornblende, which has furnished part of the iron and most of the lime of the soil, which is decidedly calcareous. The variations are all local, and dependent to some extent upon the change of rocks underlying the surface, but more particularly upon the effects of the washings of the surface by rains and rills, in presence of vegetable matter, giving rise to variable amounts of sand, clay and iron, and also of the plant foods which are held in the earth.

STRUCTURE OF THE SOIL.

When the rains have washed the surface, then the more sandy soil is composed of coarse grains of quartz. However, beneath the heaviest washes the grains are mostly small. As a general feature, the soil is made up of subangular (but not water-worn) transparent grains of quartz in a matrix of decomposed rock earth, composed of clay, feldspar, a small proportion of silvery, shining scales of mica, ferric oxide (coloring matter), etc. This earthy powder frequently coats the grains of quartz and adheres to its surface. The grains of quartz are small, ranging mostly from $\frac{1}{250}$ to $\frac{1}{500}$ of an inch in diameter and smaller, with a very small proportion of large grains, which appear in superficial washes. In descending below the surface the amount of clay increases, as is shown by texture and analysis.

TYPE OF SOILS.

All of the station soils belong to the "red land" type, but modified by organic matter and surface washings, so as to produce varieties from light-colored sandy land to the heavier red loams. In order to illustrate the geological variations four localities were chosen: (a) In a well, with samples taken at from surface to 7 inches in depth (No. 23); at 2 feet (No. 24); at 4 feet (No. 25); and at from 8 to 10 feet (No. 26). (b) In the pear orchard, at from surface to 7 inches (No. 27); at from 20 to 27 inches (No. 28); and at from 36 to 42 inches (No. 29). (c) At side of ditch, below the pond, from the surface to 12 inches (No 30); and (d) a surface washed soil in division (a), between sections 12 and 17 (No. 31). In this choice of locations the well shows the changing characters of apparently the same red land to a depth of eight feet, below which apparently a different earth shows stratification of decayed rock. In the pear orchard the earth is of one horizon, but the character changes with depth. In the ditch, near the pond, the naturally deeper earths are brought to the surface, owing to the erosion of the land into a small valley, but the soil has undergone only partial superficial weatherings. In the sandy soil is found a type of washed Archæan soils.

CHARACTERISTICS AND COMPOSITION OF THE SOILS AT THE FOUR TYPE LOCALITIES.

A. *In the Well.*—Samples were taken at time of its excavation in August, 1890. Its location is on a plain. The surface soil is dull red, showing a few silvery scales of mica. It is mostly composed of subangular grains of transparent quartz, in size ranging from $\frac{1}{250}$ to $\frac{1}{500}$ of an inch in diameter, coated or embedded in an earthly matrix (No. 23). Below the surface the color becomes a bright red and more micaceous than above. The amount of clay also increases. This character, with slight changes, continues to a depth of eight feet. Below this level, the earth is grey and composed of more angular and smaller grains of quartz, and passes into decayed rock, showing bedding.

The variations in the composition are seen from four analyses: No. 23 is surface soil, reaching to a depth of seven inches; No. 24 is from two feet; No. 25 is from four feet, and No. 26 is from eight to ten feet. In the analyses the amount of lime, potash and phosphoric acid, soluble in dilute hydrochloric acid (in proportion 1 to 20), after thirty days' digestion, is determined, and this portion may be regarded as available plant food at the present time or in the near future.

The size of the grains of quartz has an important bearing upon the absorption and retention of heat and moisture and the retention of plant food.

Analyses Nos. 23–26.

	No. 23.	No. 24.	No. 25.	No. 26.
Lime (soluble in acid)	2.312	1.538	0.832	0.549
Potash (soluble in acid)	0.094	0.420	0.238	0.069
Phosphoric acid (soluble in acid)	0.018	0.061	0.058	0.039
Lime (insoluble in acid)	0.824	0.012	1.564	1.948
Potash (insoluble in acid)	0.579	0.620	1.520	1.963
Phosphoric acid (insoluble in acid)	0.020	0.009	0.002	trace.
Magnesia	0.125	0.312	0.429	0.510
Soda	0.324	0.411	0.387	0.410
Sulphuric acid	0.252	0.286	0.260	0.210
Ferric oxide	7.621	6.040	5.863	5.924
Silica	67.647	74.125	74.900	73.824
Alumina	6.482	3.523	7.654	8.211
Water	6.215	4.280	3.580	4.224
Organic matter	6.656	1.738	2.121	1.636
Undetermined, loss, etc.	0.831	0.675	0.592	0.483
	100.000	100.000	100.000	100.000

B. *In the Pear Orchard.*—It is on a slight undulation. The color is light reddish with very few particles of mica. The soil is loamy with some of the clay washed out, leaving a preponderance of free quartz, similar to that in the earths at the well. The grains are mostly from $\frac{1}{250}$ to $\frac{1}{500}$ of an inch in diameter, and even smaller, coated or embedded in earthy matter; that is, more or less decomposed rocky matter. Below the surface the clay increases in quantity and the color becomes redder.

The samples were taken from the surface to a depth of seven inches; from twenty to twenty-seven inches, and from thirty-six to forty-two inches. Their analyses may be compared in the table:

Analyses Nos. 27–29.

	No. 27.	No. 28.	No. 29.
Lime (soluble in acid)	1.635	0.832	0.912
Potash (soluble in acid)	0.315	0.126	0.104
Phosphoric acid (soluble in acid)	0.065	0.024	0.011
Lime (insoluble in acid)	0.326	1.210	1.560
Potash (insoluble in acid)	0.432	0.834	1.112
Phosphoric acid (insoluble in acid)	0.060	0.072	0.103
Magnesia	0.115	0.131	0.214
Soda	0.622	0.315	0.410
Sulphuric acid	0.310	0.365	0.372
Ferric oxide	6.119	4.831	5.321
Silica	71.930	75.813	75.140
Alumina	5.123	8.215	7.692
Water	3.460	4.560	4.320
Organic matter	8.752	2.109	2.236
Undetermined, loss, etc.	0.736	0.563	0.625
	100.000	100.000	100.000

C. *In the Depression near Pond.*—The color is light grayish buff with very little mica in the soil. The quartz grains are smaller than in most of the samples and are embedded in much clayey matter. The soil may have arisen from a bed similar to that deep down in the well (No. 30). The sample (No. 31) was taken from the surface to a depth of twelve inches.

Analysis No. 30.

Lime (soluble in acid)	1.004
Potash (soluble in acid)	0.065
Phosphoric acid (soluble in acid)	0.020
Lime (insoluble in acid)	1.214
Potash (insoluble in acid)	0.586
Phosphoric acid (insoluble in acid)	0.094
Magnesia	0.120
Soda	0.210
Sulphuric acid	0.268
Ferric oxide	3.525
Silica	79.436
Alumina	7.218
Water	2.321
Organic matter	3.590
Undetermined, loss, etc	0.329
	100.000

D. *In Division A. between Sections* 12 *and* 17.—It is located on a sloping surface. This is a light colored washed soil, formed from earth similar to that in the pear orchard. The large superficial grains of sand covered the surface where the rains produced the greatest washes, but the sample was taken where less exposed. It is a light sandy loam, mostly made up of semi-rounded grains of quartz ($\frac{1}{250}$ to $\frac{1}{500}$ of an inch in diameter) coated with a small proportion of earthy matter, with a large quantity of organic matter.

Analysis No. 31.

Lime (soluble in acid)	1.024
Potash (soluble in acid)	0.120
Phosphoric acid (soluble in acid)	0.042
Lime (insoluble in acid)	0.463
Potash (insoluble in acid)	0.356
Phosphoric acid (insoluble in acid)	0.011
Magnesia	0.098
Soda	0.533
Sulphuric acid	0.415
Ferric oxide	4.215
Silica	69.702
Alumina	6.320
Water	5.111
Organic matter	10.654
Undetermined, loss, etc	0.936
	100.000

DEDUCTIONS FROM THE OBSERVATIONS AND ANALYSES.

Note.—As this chapter is a sequel to Chapter XLII. (on the Formation and Characteristics of Soils), much repetition becomes unnecessary.

Organic Matter.—In the surface soils, except No. 30 in the depression, there is a good supply of organic matter. As most of the land is highly cultivated, part of this is due to artificial application. That at the well is not under cultivation at present.

Clay.—All the surface samples show a smaller proportion of clay than at a depth, except No. 30. This arises from its partial removal by washings; still the proportion is such as to form only clayey and not heavy clay soil.

Iron.—The ferric oxide is in greater quantities at the surface than below, where the color given to the soil is modified by original matter; still the soils are all ferruginous.

Lime.—It is notable that the total amount of lime increases in one case and diminishes in another upon descending to a depth. But in both cases it is in abundant quantities, yet its availability rapidly diminishes upon descent from the surface, at the pear orchard, from 83 per cent. above 7 inches, to 47 per cent. between 20 and 26 inches; and to only 37 per cent. at 36 to 42 inches. At the well the analyses show 74 per cent. of the lime as available at the surface; 58 per cent. at 2 feet; 35 per cent. at 4 feet, and 22 per cent. at 8 to 10 feet. In the depression near the pond only 45 per cent. is available at the surface; and about 66 per cent. on the sandy surface of Division A. Accordingly, the lime appears more and more locked up as insoluble silicates upon descending below the surface. Still the quantity is abundant, and further addition would prove of little value.

Potash.—The absolute quantity of potash rapidly increases upon descent from the surface, as does the clay, showing that it has not been extracted from the original feldspar to the same extent, as the alkali is removed by surface-action of carbonic and vegetable acids.

In the pear orchard this decrease progresses from 42 to 13, and to 8½ per cent. in descending from surface to 42 inches. At the well the surface potash is abnornally low (probably from former exhaustion), yet from 2 to 10 feet the available potash decreases from 40 per cent. to 13, and finally to 3½ per cent. at 8 feet; whilst the total amount rapidly increases from two feet below the surface downward. Only in the cases of No. 30 and No. 26 is the quantity of soluble potash low; but in the latter case, it is at a depth of from 8 to 10 feet, and therefore unimportant. The analyses indicate that the soil needs no addition of this food.

Phosphoric Acid.—In the pear orchard the total quantity of phosphoric acid decreases somewhat in descending below the surface. This superficial excess may be due to artificial fertilizers, or perhaps to the accumulations from the ashes of long succeeding generation of plants. Its solubility at the surface amounts to 50 per cent. of the total phosphoric acid; 25 per cent. at from 20 to 27 inches, and only 8½ per cent. at from 36 to 42 feet.

At the well the amount of phosphoric acid at the surface is far below the normal condition (as is also the potash), of which one half is soluble. Beneath this most of the low amount of phosphate is equally soluble throughout and varies with the kind of beds it occurs in. These analyses indicate a great superficial exhaustion of the land at this point. On a previous page it was noted that the appearance of the soil of No. 30 indicated this earth to have only recently become the surface of the little valley. Now, the amounts of the lime, potash and phosphoric acid by the analyses indicate that it has been exposed to the superficial action of carbonic and vegetable acids, compared with the rolling lands of the farm, only a short while, as the plant foods contained in it are much less available than where the rills have not washed the lands into valleys. This case illustrates the agricultural loss by land washes, not by merely removing the superficial organic accumulations, but by exposing earths containing plant food not yet available for absorption.

CONCLUSIONS.

From the analyses and geological structure the soil at the wel represents a very badly worn out surface, particularly poor in phosphoric acid, and with the potash greatly depleted; but yet the latter is sufficient for good farming. There is an abundance of lime and other constituents.

The soil in the depression (No. 30) has comparatively recently been exposed. It is poor in available potash and very poor in available phosphoric acid, although there is an abundance of both elements in a form which cannot for a long period be absorbed by plants, but this could be made more available by cultivation.

The potash in the washed sandy soil of No. 31 is sufficient, and there is plenty of lime. The phosphoric acid falls much below the mark.

In the pear orchard there is an abundance of available lime and potash, but the phosphoric acid is low.

On the present cultivated portion of the farm the lack of phosphoric acid appears to constitute its only mineral poverty, but to the old soil at the well an addition of potash might be advantageous.

THE RELATION OF PHYSICAL FEATURES.

The amount of humus or vegetable matter in these soils reaches a fair proportion. As to physical characteristics, the dark color causes a great amount of absorption and little reflection of heat. The granular character of the soil renders it porous, with a comparatively easy escape for the excess of rainfall, whilst the smallness of the grains increases its capillarity and aids the iron, clay and humus in the retention of the moisture and its gradual supply to the growing plants.

CONFORMATION OF RELATION OF PLANT GROWTH TO THE SOIL VALUE.

Since this chapter was written, Col. Redding, Director of the Experiment Station, in reply to the query, "Is the location of the well on the site of an old field," says: "It is 'trod land,' with now and then an oak and hickory grove. The impression is that it was an old field, but there is no record." This section of country has long been settled, and, by the analyses, the surface soil is shown to be badly depleted of phosphoric acid, and, to a less extent, of potash.

In reply to the second query: "Have potash fertilizers been applied to the pear orchard and Division A (sample analyses No. 31 and No. 27), and if so with what agricultural effect?" "Yes; under cotton, the additional potash does not produce good results; nor did it with potash and nitrogen fertilizers mixed. But with phosphoric acid, or this with nitrogen, there were fine results." Hence the practical demonstration by actual plant growth that there is enough potash and mineral foods in the soil, as above set forth, but there is a great mineral deficiency in phosphoric acid.

The question of nitrogen food apart from natural humus is outside the scope of this report, as it is artificially supplied.

THE SOILS OF THE COLLEGE FARM AT ATHENS.

This is situated on the summit of a rolling plain, built out of gneisses of the ordinary type, but containing much biotite mica, with very little hornblende.

The decayed rocks come to the surface at a few points. The soil is of the red type, but not of dark color. Microscopically, the soil is composed of sub-angular grains of quartz, $\frac{1}{250}$ of an inch in diameter and less, in an adhering earthy matrix. The analysis (No. 32) gives the composition of the soil to a depth of twelve inches.

Analysis No. 32.

Sand, clay, silica acid, carbonic acid, etc	88.000
Water	4.030
Organic matter	4.580
Lime	0.290
Magnesia	0.270
Potash	0.780
Soda	0.680
Phosphoric acid	0.035
Sulphuric acid	0.076
Ferric oxide	1.204
Total	99.945

Of the organic matter, the nitrogen amounted to about one-fourth, or over one per cent. of the soil.

In this series of experiments, the washings of the land were shown by digesting the soil in ordinary water, repeated for thirty days, when it was found that even from the silicates 0.8 per cent. of the potash, 6 per cent. of the lime, 2 per cent. of the magnesia and over 2 per cent. of the phosphoric acid were washed out besides other substances. These percentages would have been largely increased had the water contained carbonic or humic acids.

The soil analysis shows a low percentage of lime, and the soil is poor in phosphoric acid ; otherwise there is sufficient plant food present in the land.

In comparison with the Experiment Station, the smaller quantity of lime is due to the greater absence of hornblende from the original rocks.

IV.—ACKNOWLEDGMENTS AND PROGRESS OF THE SURVEY.

CONTENTS.

BIBLIOGRAPHY OF GEORGIA'S SURVEY AND ACKNOWLEDGMENTS.

"REPORT ON A GEOLOGICAL AND AGRICULTURAL SURVEY OF BURKE AND RICHMOND COUNTIES BY JOHN RUGGLES COTTING, AUGUSTA, 1836," was the first official geological report made in Georgia. This little 16 mo volume of 198 pages was addressed to the citizens of those counties under whose patronage the survey was made. It is an interesting and, at this day, curious little volume, professedly devoted to economic geology of both crystalline and tertiary formations, but in which speculation is given free rein at the hand of a man well read in the scientific literature of the day. The little volume remains a worthy monument of the early efforts at extending and diffusing geological knowledge in the State.

A few years later Sir Charles Lyall rendered southern Georgia classic geological ground by his observations recorded in his "Travels in North America" in 1841–42.

The reports of the next geological survey of Georgia, 1874–9, were published as follows:

REPORT OF PROGRESS OF THE GEOLOGICAL SURVEY OF 1875, PP. 1—36, BY GEORGE LITTLE, STATE GEOLOGIST.

SECOND REPORT OF PROGRESS OF THE GEOLOGICAL SURVEY OF 1876, PP. 1—16, BY GEORGE LITTLE, STATE GEOLOGIST.

REPORT OF THE GEOLOGICAL SURVEY, PP. 17—143, WITH MAP, BY GEORGE LITTLE, in Handbook of Georgia, 1876.

CATALOGUE OF ORES, ROCKS AND WOODS, Selected from the Geological Survey Collection for the Paris Exposition by GEORGE LITTLE, STATE GEOLOGIST, 1878, PP. 1—16.

THE TOPOGRAPHY, GEOLOGY, ETC., OF GEORGIA, BY A. R. MCCUTCHIN, ASSISTANT STATE GEOLOGIST, PP. 3—158, with maps; In Commonwealth of Georgia, 1885.

TOPOGRAPHY, GEOLOGY AND AGRICULTURE, BY MESSRS. LOUGHRIDGE AND MCCUTCHIN. In Cotton Report of Tenth Census, pp. 11—64, with maps.

These last two reports were from the unpublished results of the geological survey, which ceased its operations in 1879 for want of appropriations, before the reports were published.

GEOLOGICAL SURVEY ALONG THE MACON AND BIRMINGHAM RAILWAY, by J. W. Spencer Whilst Acting State Geologist, 1889, pp. 1—86, with plates and map.

This economic survey crossed the Archæan and Paleozoic formation in Georgia and Alabama.

REPORT OF PROGRESS OF THE GEOLOGICAL SURVEY, 1890-91, pp. 1—128, by J. W. Spencer, State Geologist.

(This report is mostly devoted to the Geology of the Cretaceous and Tertiary formations of southwestern Georgia. The detailed report of Polk county therein is now superseded by the present report.)

GEOLOGICAL SURVEY OF GEORGIA—THE PALEOZOIC GROUP, 1893, PP. 1—406, BY J. W. SPENCER, STATE GEOLOGIST.

(This report embraces geological and physical characters, economic resources and soils of all the unaltered Paleozoic formations of Georgia, accompanied by geological map, ten plates and thirty-four cuts.)

Although unofficial in Georgia, the bibliography of Georgia geology would not be complete without mentioning: "*The Lafayette Formation*," by W. J. McGee, which is an admirable and distinct chapter of geological history, in which much of the newer geology of Georgia is described. "*Correlation Papers on the Eocene System*," by W. B. Clark, contains a few references. "*Correlation Papers on the Miocene System*," by Dr. Wm. H. Dill and G. D. Harris, also needs special notice. "*Correlation Papers of the Cambrian System*," by C. D. Wolcott, contains references which have been used and acknowledged in the report on the Paleozoic group. These publications have been issued (1891–1893) as bulletins by the United States Geological Survey.

"*Overthrust Fault of the Southern Appalachian*," by C. Willard Hayes, in bulletin of the Geological Society of America, 1890, pp. 141–154. Due reference to this valuable paper has been made in the text of the report.

"*Geology of Tennessee*," 1869, pp. 1–550, by James Safford, State Geologist. This report, although not covering Georgia, has been the foundation of all subsequent geological work in Paleozoic regions of this State. So, also, several of the Reports of Alabama under Prof. Eugene A. Smith have been of material aid in the study of Georgia. Amongst the reports upon the newer formations of southern Georgia, especially has the work by Mr. D. W. Langdon along the Chattahoochee river been of great use. (*Bulletin Geological Society Am., Vol. II., 1890.*) The work of Mr. Lawrence C. Johnson on the Southern Tertiaries of the neighboring States has given assistance. Prof. Smith's report, upon the Cahaba Coal Fields, and upon northeastern Alabama (by Dr. C. Willard Hayes, October, 1892) have also contributed to the literature of Georgia geology and been duly acknowledged in the revision of this report.

A special acknowledgment of geological assistance is due to Dr. C. Willard Hayes, of the United States Geological Survey. This assistance consisted of access to his manuscript geological maps from Tennessee to Alabama, covering portions of northwestern Georgia. These incompleted maps were unaccompanied by any report with permission to use, but not to publish. Thus the credit due to my survey and Dr. Hayes' work becomes much more complicated than if his maps had been published. This condition forced me to re-examine his work while I was traveling over almost the whole area in order to report upon the local geology and economic resources. This work was greatly facilitated both by Mr. Hayes' work and the topographic maps by the United States survey. Accordingly the map accompanying this report is the result of our own survey with extensive verified adoptions or modifications of Mr. Hayes' work. The report of Prof. Safford, of Tennessee, was of primary importance in the study of the geological structure. The topography of the map is from the sheets of the United States survey.

In the preparation of this report I have to acknowledge the valuable assistance of Dr. H. C. White, president of the State College, who has rendered so much assistance by his chemical contributions. Not merely do I acknowledge the value of his scientific contributions, but his financial assistance in making hundreds of chemical analyses without charge to the State, otherwise this report would have fallen sadly short.

A tribute of praise is due to Mr. J. M. McCandless, the well-known Atlanta chemist, who has been chemist to the survey, for his careful chemical analyses, which are scattered throughout this report.

To Prof. J. E. Willet, of Mercer University, I have also to acknowledge special indebtedness for his assistance in the survey, especially of South Georgia, and in his valuable contribution to the geology of South Georgia in a paper before the American Association for the Advancement of Science, New York, 1887.

From numerous gentlemen scattered over the country I have received local assistance and to them collectively I herewith express my thanks.

In the conduct of the survey I have carried out so far as lay in my power the provisions of the governing law of the survey, herewith given :

TO REVIVE THE OFFICE OF STATE GEOLOGIST, AND PROVIDE FOR GEOLOGICAL, MINERALOGICAL AND PHYSICAL SURVEY OF THE STATE.

No. 688.

An act to revive the office of State Geologist, and to provide for a geological, mineralogical and physical survey of the State of Georgia, and for other purposes.

SECTION I. *Be it enacted by the General Assembly of Georgia*, That the office of State Geologist is hereby revived, and the Governor, as soon as practicable after the passage of this act, shall appoint, with the consent of the Advisory Board, a competent person to this office, who shall have a thorough, scientific and practical knowledge of the science of geology and mineralogy, and who is not connected with any school or college as an instructor. The State Geologist shall enter upon the duties of his office on the first day of July, 1890, and shall hold until removed by the appointing power for inefficiency, incompetency, or misconduct, or until the office is abolished by the General Assembly. The office of the State Geologist shall be at the seat of Government.

SEC. II. *Be it further enacted*, That there shall be an Advisory Board, consisting of the Governor of the State (who shall be President of the Board), the Commissioner of Agriculture, the State School Commissioner, the State Treasurer, the Comptroller-General and the Attorney-General. Four members present at any meeting shall constitute a quorum for the transaction of any business.

SEC. III. *Be it further enacted*, That two competent Assistant State Geologists shall be chosen by the Advisory Board, who may be removed at any time, by the appointing power, for incompetency, inefficiency, or misconduct. It shall be the duty of the State Geologist and his assistants to divide the State into three geological sections, as nearly equal in area as may be expedient, to be known as North Georgia, Middle Georgia, and South Georgia Geological Sections; the Northern Section shall extend from the State line southward to the 34th degree of latitude; the Middle Section shall extend from that degree southward to the 33d degree of latitude; the Southern Section shall extend from the last mentioned degree to the southern boundary of the State line; the survey and exploration of each of said sections shall commence simultaneously by said State Geologist and his assistants, and one thousand dollars of the foregoing appropriation, or so much thereof as may be necessary, shall be applied to each of said sections for an outfit and necessary expenses incident to the prosecution of the work in each section. So soon as a general outline of geological survey of the entire State shall have been made, the State Geologist shall enter upon one of these sections, and assign one to each of his assistants, and under *the control of the first named,* the corps shall proceed to make a careful and complete geological, mineralogical and physical survey of the State; *to enter upon record, to be kept for that purpose in his office,* an accurate statement of the extent of all water-powers, woods, roads, springs and water courses, and the climate, topography and general physical character of the country, and locate the belts of ores and useful minerals, building material; report characteristics and composition of the soils, and the deposits of marls and phosphates; to collect, analyze and classify specimens of minerals, plants and soils, and enter the same upon record; to cause to be preserved in a museum specimens illustrating the geology, mineralogy, soils, plants, valuable woods, and whatever else may be discovered in Georgia of scientific or economic value, and shall make a report of the survey of every county of this State, accompanied with all necessary maps and illustrations. For the purpose of making the analyses contemplated in this act, the State Geologist shall have access to the chemical laboratory of the State. The State Geologist *shall have supervision of the entire work,* and shall *be responsible for the accuracy of the same.* It shall be the duty of the *State Geologist to make reports to the Advisory Board* as often as required by them, and they shall report to each General Assembly the progress and condition of the survey; an accurate account of money spent; and such reports of the *State Geologist and his assistants* as have been completed, together with all such information as may be deemed necessary and useful.

SEC. IV. *Be it further enacted,* That the Advisory Board shall have the supervision of the money expenditures in the prosecution of the work contemplated by this act. *The State Geologist* shall make to the Advisory Board monthly statements *under oath* of all incidental expenses necessarily incurred by *himself and his assistants*, accompanied by proper vouchers, in the discharge of their labors. The board shall audit such accounts, item by item, and approve or reject the same, as in their judgment may be right. When an account is allowed, the Governor shall draw his warrant for the amount thereof upon the funds appropriated by the provisions of this act. The Governor, with the advice and consent of the board, may, at any time, suspend the field operations of the Geological Corps until the next meeting of the General Assembly.

SEC. V. *Be it further enacted*, That the State Geologist shall keep his office in a room to be set aside for that purpose by the Governor, and the Commissioner of Agriculture shall furnish the clerical work required by the State Geologist.

SEC. VI. *Be it further enacted*, That the salary of the State Geologist shall be $2,500 (twenty-five hundred dollars) per annum, and the two assistants shall each receive a salary of $1,250 (twelve hundred and fifty dollars) per annum, to be paid as now provided by law for the payment of other State House officers.

SEC. VII. *Be it further enacted*, That the State Geologist, with the consent of the Board of Advisement, may employ a specialist, or specialists, at any time.

SEC. VIII. *Be it further enacted*, *That neither the State Geologist, nor his assistants, shall disclose to any person*, except to the owner of the land, the result of a survey, until the same is made public by publication of the report by the Advisory Board, which shall be monthly or quarterly.

SEC. IX. *Be it further enacted*, That the State Geologist and his assistants shall deposit in the office of the Governor, all maps, surveys, notes, or memorandum of surveys, when the surveys are completed, which are hereby declared to be the property of the State.

SEC. X. *Be it further enacted*, That the sum of $8,000 (eight thousand dollars), or so much thereof as may be necessary, be, and the same is, hereby appropriated, annually, for the period of five years, to carry out the purposes of this act, and this appropriation shall take effect annually, commencing on July 1, 1890.

SEC. XI. *Be it further enacted*, That all laws in conflict with this act are hereby repealed.

Approved November 12, 1889.

THE PROGRESS OF THE GEOLOGICAL SURVEY OF GEORGIA.

In the previous bibliography a considerable number of titles appear. Still very little of survey work has been published, for most of the reports are generalized and do not give either detailed or local information, for few of them were written, as more than preliminary or synoptical papers. Moreover the State reports are entirely out of print, and of some not one copy retained in the State is known to me.

With the fragmentary geological progress of Georgia a few distinguished names are connected, whose work has been epoch-making. Of them Sir Charles Lyall stood first in his notes written fifty years ago. Georgia produced Prof. Joseph LeConte, whose great prominence is unfortunately for Georgia associated with other States and countries. The work of Mr. W. J. McGee is epoch-making in the investigations of the late geological history of the State, and in honoring him Georgia reflects the greater glory to herself. Although professedly incomplete, his work is the greatest of any geological investigations that have been made in the State, and its amplification and local application have been a special subject of my study, the full results of which may not now be published.

In southwestern Georgia I have investigated the general geological formations of an extensive region extending from Columbus to Florida, and from Milledgeville and Macon to the southern limit of Georgia. Of a large and the best portion of this survey no report has been made; only that of the western portion has been published in a small edition of 500 copies by the State. Of these, copies are now almost unobtainable. In this report the character and distribution of the Cretaceous, Eocene and Miocene systems of the region are described with some notice of the Lafayette and Pleistocene formations. In this work I have to acknowledge the invaluable assistance of Dr. W. H. Dall in connection with paleontological studies. From the economic standpoint special attention was given to the building materials, fire and pottery clays, marls and phosphates, and to the most important of all geological questions relating to southern Georgia, the artesian wells. In that report I have laid the foundation of the knowledge of the geological structure, which admits of rendering the often malarial regions healthful in a county which otherwise is frequently the most favored portions of Georgia. In these investigations I have carried on the work so far as means were at my disposal; and my last field work was in connection with building materials and phosphates of southeastern Georgia. But all of this work is now almost unavailable.

A considerable amount of preliminary work has been done in middle Georgia, but as yet not sufficient to make a satisfactory report.

This report upon the Paleozoic belt, as it is to appear in an edition of 2,500 copies, will probably be distributed sufficiently widely to make known the features of that part of the State. Whilst this report is primarily an economic survey, it is yet more or less scientific and educational. Every State geologist, or any geologist, has to constantly contend against the ignorant, or the schemer, who suppose that the geologist's primary duty is to simply give a list of mining property, which promoters can jump upon, obtain for a song, and sell to somebody else. If nature has not put valuable deposits where desired, then the geologist is reproachable for not having controlled nature. There can be no greater abuse than such as is hurled against a geologist and his science, when his quiet testimony condemns a "*fraudulent*" gold, coal or other mine (?).

The legitimate work of a survey is to discover and make known the structure of the rock formations and the relations thereto of everything of economic or scientific interest—not alone precious ores, but building materials, supply of water, the character of the soils and everything that can be made useful. In the deposits of useful ores, etc., his duty is not so much to give a catalogue of properties, but of the belts of their occurrence, and how they are related to the rock formations, so that private interests can start where he leaves off and develop the resources with the smallest chance of failure. The work is also educational, so that the student can learn something of the region and extend the knowledge of the science.

The report upon Northwest Georgia is essentially economic. But in order to understand local developments, the geological structure, apart from utilitarian value, had to be determined. In this connection the report is also educational, for the general principles of the science are applied to the local variations. By this means, the distribution and modes of occurrence, and character of Red and Brown Iron ores, Manganese and Aluminium ores, Coals, Building Materials, or Limestones, Sandstones, Flags, Clays and Paving Materials, Variability of Soils, and the Physical Features and Water-powers of the country, are set forth—in short, an attempt at giving all the resources of the country which bear upon its habitability and progress, as based upon its geological foundation. Besides these positive advantages of the survey, still greater arises from the negative, in saving people foolish search for what they cannot obtain. Thus I have seen the mining of shale for coal, working gold (?) mines in limestone, and numerous other works as impossible, although not so apparently absurd. In impossible artesian wells in Georgia alone, the advice of geologists would have saved more than the cost of an elaborate survey of the State, and has actually saved much money.

With this report of northwestern Georgia there is a general record of its character, and the resources which can be obtained without the cost of making special surveys. Private interests will develop these resources, but this report will be the basis of all future work.

The present report has been written for the people of Georgia, with the omission of as many technicalities as possible, so that it may be used by any one with ordinary education.

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(Note.—The above engravings are from photographs by the author.)

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Atlanta, July 15th, 1893.