PART SECOND.

GEOLOGICAL STRUCTURE AND FORMATIONS OF TENNESSEE.

315. In the First Part of this Report, the surface features of Tennessee have been considered. We come now, to the great rock-beds, or formations, the outcrops of which make up the surface, and the aggregate, or mass of which constitute the deep foundations of our valleys, plains, hills, and mountains.

It is proposed in this Part, to enumerate and describe the formations which occur in Tennessee, to treat of them as to their lithological character, their extent, their fossils, the minerals they hold, and the soils they yield. We will be led to consider, also, the relations the formations sustain to each other, their relative positions, the foldings and displacements they have in common, undergone, and generally, the part they play, as elements in the rocky structure of the State. It is important that the Geological Structure of the State should be known and understood. Information of this kind, in addition to other important but less practical considerations, explains many of the apparent anomalies which often present difficulties to the miner; it enables us to trace out, with facility and precision, beds of coal, iron ore, etc., and guides us, often, to the very spot where they may be found; it aids in determining the extent, position, and range, of veins and mineral deposits, and points out the most economical plan of reaching and securing their contents; it is, in fine, indispensable to the successful development of any mineral region.

A knowledge of the formations, and of the areas within which they respectively outcrop, is essential, also, to the proper appre-

ciation of the agricultural capacities of the State. A geological map, is a map of the soils, and their classification must be based upon the classification of the formations. The soils, (excepting alluvial bottoms,) are derived from the rocks which underlie them; and to these rocks, they owe, for the most part, their characteristics. This connection, is practically recognized by the farmer, when he talks of "sandstone soil," "limestone soil," "slate soil," &c., and his talk is more or less to the point, in proportion, as his acquaintance with the rocks, is more or less extended. This subject will be resumed hereafter.

CHAPTER IV.

THE GENERAL CHARACTER OF THE FORMATIONS; THEIR ORIGIN; THE CHANGES THEY HAVE BEEN MADE TO UNDERGO; HOW THEY ENTER INTO THE STRUCTURE OF THE STATE.

THE ROCKS STRATIFIED—FORMATIONS, AND THEIR CHARACTERISTICS—USE OF THE FOSSILS THEY CONTAIN—EXTENT OF FORMATIONS—ORIGIN OF THE OLDER FORMATIONS—ORIGIN OF THE SANDS AND CLAYS IN WEST TENNESSEE—DENUDATION IN MIDDLE AND WEST TENNESSEE—THE FOLDING, DISLOCATION AND DENUDATION OF STRATA IN EAST TENNESSEE—THE SEQUATCHEE FOLD—ELK FORK DISLOCATION; EASTERN SLOPE OF THE TABLELAND—CONSIDERATION OF THE FOLDING, &c., IN EAST TENNESSEE CONTINUED—FOLDS, UPLIFTS, AND FAULTS IN MIDDLE TENNESSEE.

316. *The Occurrence of the Rocks in Layers and Strata*.—It may be said, generally) that all the rocks *in Tennessee*, including the sands and clays of the Western Division, are disposed or arranged in layers and strata.* For this reason, they are said to be *stratified.* The strata are of various thicknesses, from that of thin leaves, as in the case of many States, to that of beds fifty or a hundred feet through.

317. The only rocks in Tennessee, not stratified, are masses, constituting certain *mineral veins* and *volcanic* dikes. But these

* A *Stratum* of rock may consist of many *layers*; the latter, is a subdivision of the former. A stratum is a bed of rock including all the layers of the same kind, that lie together.

are so limited, comparatively, that they need not be regarded in considering the rocky structure of the State.

The different classes of veins will be spoken of, hereafter. Those of one class, with the dikes, are fissures intersecting the strata, filled with mineral or rocky matter. In veins, this matter has been precipitated from water ; in dikes, it has been injected as melted rock, by volcanic agencies. The veins have been formed, in narrow fissures, comparatively ; the dikes are often wide, presenting great vertical walls of *granite, trap,* and other igneous rocks. A few of the latter are found in the crystaline rocks, along our North Carolina border. The most conspicuous that I have seen, are in Johnson and Carter Counties, but nowhere, are they of much importance.

317a. The mineral veins vary in thickness from one inch or less, to a score or more of feet. Small veins are common in limestone rocks. They often contain ores of lead and zinc, but rarely in sufficient quantity to be of value. The important veins will be noticed in the Third Part of this Report.

318. *Formations, and their Characteristics.*—We often meet with a series of strata, that appear to have been formed successively, in the same period, under conditions more or less the same, and consequently, presenting certain common characteristics. Such series, it has been agreed to call, *Formations.* Our Tennessee rocks are thus grouped in this report, into *thirteen formations,* a table of which is given in the next chapter.

319. As an example, the *sandstones, slates,* and *coal,* which form the upper part of the Cumberland Mountain, or table-land, (§ 169,) are grouped in a *formation* called the *Coal Measures,* with the following, among other common characteristics: *First,* coal is found at intervals, throughout the series; *secondly,* the strata are parallel; *thirdly,* the same, or closely related, *fossils,* such as, different species of petrified shells, corals, scales and teeth of fishes, leaves, branches and trunks of trees, occur, imbedded, more or less, in the rocks, from the top to the bottom of the series. *Characters* similar to these, unite the strata of all the formations.

The character last mentioned, we must refer to more particularly, on account of its great importance in designating with precision, the group to which local and isolated beds of rock belong.

320. *Fossils and their Use.*—With the exception of the first, all the formations adopted, contain *fossils* or petrifactions of

some sort; in fact, certain limestones are mostly made up of them.

"The dust we tread upon was once alive!"

They are, generally, parts of petrified plants, shells, corals, crustaceous animals ; sometimes, the teeth and bones of fishes, and even of quadrupeds. With but few exceptions, they are the remains of animals and plants, whose species, or kinds, do not exist at present, upon the globe. The part of Geology which treats of them is called *Paleontology.*

321. Now, every formation has, in great part, its own species of fossils. *Most of those found in one do not occur in any other.* Upon this fact depends the great utility of fossils. They furnish, when known well enough to be recognized, unmistakable evidence of the geological position; and hence the general character, of the formation in which they occur. By means of them, for example, it is often easy for a geologist, traveling in a country wholly unexplored, to know certainly when he is in the midst of a coal-region, without having seen a trace of coal. The shells in the limestone, the fossil branch or trunk in the sandstones, the leaf-impressions in the slates, he recognizes at once as those belonging to the rocks associated with and including the beds of coal ; they can belong nowhere else in the geological series, and better evidence often of the presence of coal-bearing rocks is not required.

322. *Extent of the Formations.*—The formations are generally of wonderful extent. The great rocky and comparatively very thin sheets, one upon another, often spread over thousands of square miles. A few examples will illustrate this.

323. One of our formations is a *black slate,* or *shale,* not at any point in Tennessee much over a hundred feet in thickness. This formation is found in the western part of the State, cropping out along the hills on both sides of the Tennessee River. Going eastward, it appears again all around the slopes of the Central Basin; runs under the Cumberland Table-land, and issues from beneath the mountain in the Sequatchee Valley ; thence it runs under Walden's Ridge and Lookout Mountain, and reappears at the base of the Cumberland, all along its eastern slope, with but few interruptions, from Georgia to Virginia. We find it, too, as far east as the narrow valley which

lies along the eastern base of Clinch Mountain, as well as in the vicinity of Montvale Springs, in Monroe. It thus extends, though comparatively very thin, almost from one end of the State to the other, always occupying the same relative position with reference to the formations above and below. But this is not all; this *"black slate"* reaches beyond Tennessee, extending northward to the Lakes and southward far into Alabama. I have seen it well developed at Blount Springs in the latter State, presenting the same appearance that it does at many points in both Middle and East Tennessee.

The formation next above the one mentioned—which is a very different rock—is nearly as extensive. And so it is with many of them.

324. The stratified sands and clays of the Western District—-which are also called, technically, *rocks*, although for the most part unconsolidated—spread out southward to great extent, and are found represented in Mississippi and Alabama, some even in the Atlantic States as far north as New Jersey.

325. The formations, however, though in a general way of great extent, are not continuous and unbroken; they have been cut more or less into great patches, or sections, by the action of water in the excavation of basins and valleys; in East Tennessee they have in addition, been *folded* and *displaced* by great disturbing forces.

326. In one period of the Earth's history nearly all the rocky formations of Tennessee were *continuous* and comparatively *horizontal* over the whole State, West Tennessee and the valley-plain of the Mississippi not excepted. The *sands* and *clays* of West Tennessee are later formations and have never reached east of the Tennessee River, to any considerable extent. They rest in a great deep trough cut out of the older solid strata. This trough, with one of its rocky sides far over in Arkansas and the other on the east washed by the Tennessee River, holds, not only the sands and clays referred to, but also the bottom-plain of the Mississippi through which the great river winds its way. (§ 296.)

327. *Origin of the Older Formations*.—Most of the strata of these formations contain the remains of marine animals and

plants abundantly. This fact, together with others which it is unnecessary to mention here, indicates their origin, and compels us to believe that they were formed, at a much lower level than they now have, beneath the surface of an almost worldwide ocean. That such an ocean did exist, covering not only the area occupied by Tennessee, but the larger part of America, there can be but little question.

328. The rocks we are considering are the consolidated sediments which, in layer after layer, accumulated at the bottom of the Ancient Ocean. The material was in part the washings of the land that then existed, in part the remains of dead marine animals and plants, and in part chemical precipitations from the waters. The matter brought from the lands was not at all times the same; at one time it was argillaceous mud which ultimately became slate; then, it was sand for a sandstone, or gravel for a conglomerate; then again, calcareous matter for a limestone, or it was two or all of these in varying proportions, giving rise in the end to mixed rocks. In all these sediments the remains of life, shells, corals, and other hard parts of animals and plants became entombed, all hardening into rock.

329. Thus the formations were built up successively in the order in which we now find them, each the product and representative of a certain long period—being, in fact, a *stony record*—tables of stone recording the kind and condition of marine life, the physical condition of the Ocean, and to a certain extent of the lands at the time.

They have been elevated to their present inland position by the upheaval of the land, the sea, at the same time, retiring.

330. The strata of the last of our older formations—the *Coal Measures*—were deposited, under conditions, in some respects, different from those attending the deposition of the strata of the others. In the rocks of this formation, we find the remains, not only of marine, but also of fresh water and land life. The land had become more extended—it covered a larger area. The ocean had grown shallow—that part, at least, covering the submerged portion of North America—its bottom had become subject to slow, alternate elevation and depression,

giving sometimes land and sometimes sea.* When land existed, beds of vegetable matter accumulated, either in vast swamps, or otherwise; when the sea prevailed, these beds were flooded, and covered with layers of mud and sand.

Thus, alternately, may have been formed the strata which have since become the coal, shale and sandstone of our Coal Measures.

331. *Origin of the Sands and Clays of West Tennessee*.—The formations peculiar to West Tennessee, were formed long after the others had been raised from their mother ocean. Nevertheless, the materials of these, too, were deposited from water.

The Atlantic, at one time, owing to the lower level which the Southern States once had, appears to have covered a wide strip of country next to the seaboard, from Virginia around to Texas, and to have extended an arm up the Mississippi basin, nearly as far as the mouth of the Ohio. Almost the whole of West Tennessee, and a great extent of country beyond the Mississippi, were thus covered. (§ 326.)

Then it was that most of the *sands* and *clays* were deposited; then, too, the shell fish, the remains of which now constitute the great "shell-banks" of McNairy and adjoining counties, lived and flourished in their sea-water home. (§§ 263-4.)

332. Subsequently, by the gradual upheaval of the land, and the consequent retiring of the sea, the width of this arm was contracted until it covered but a third of the district. And now the fresh water from the North began to prevail, and soon expelled that of the sea, or in other words, the Mississippi, wide and lake-like, at first began its career; the arm of the sea becomes the river.

Then were deposited, over the whole area covered by the

* It may appear strange to some, that we speak so freely of the *elevation* and depression of land. It is, nevertheless, in perfect accordance with what is now occurring. Although our own coasts are, at this time, stable—although no changes in the relative level of land and sea have been observed with reference to *them*, for the last three hundred years—yet no reason can be assigned, why, long before, they might not have occurred.

It is certainly true, that just such movements are now going on at many points upon the globe. It has been demonstrated that six hundred miles of the west coast of Greenland has been slowly sinking, for the last four centuries, and that what was once dry land, is now sea-bottom. On the other hand, parts of Sweden are experiencing a contrary movement. Many like examples of *upheaval* and *subsidence*, known to have taken place, or to be taking place, might be mentioned.

fresh water, the strata of sand, lignite, gravel, clay and loam, which are to be seen in the Mississippi Bluff. (§279.)

333. By still further upheaval, these strata, too, were elevated above the waters, the Mississippi was drawn into narrow limits, and, with increased velocity and greater power, commenced the work of carving out or excavating from the sandy and loamy strata just formed, the present Valley, many miles wide, in which are the low "bottoms" and the ever-changing channel of the river.

Remnants of the strata cut away, crop out along the “Bluff," and run back eastward, to the second range of counties parallel with the Mississippi.

The *bottoms* have been formed, removed, and formed again, time after time, during the progress of the excavation of the Valley, and are still subject to similar changes.

334. *The Denudation of the Formations of Middle and West Tennessee*.—The cutting and washing away, or, as geologists express it, the *denudation* of certain strata by the Mississippi, has just been referred to. The *older rocks*, at many points, show the effects of such cutting and removal on a stupendous scale. (§ 325.) The agent has been water, but when and how it acted, to effect these results, it is not always easy to determine. Many of the small valleys have been cut out by the streams which flow through them, but there are no *existing* causes to which can be referred the excavation of the great rocky basins of Tennessee, and of the adjoining States. Much, doubtless, has been done by oceanic currents, just before, or during, the time of the upheaval of the formations.

335. The denudation of the formations in *Middle* and *West Tennessee*, is more easily understood than that of those farther east. In the former divisions, the rocks are approximately horizontal; but in East Tennessee they have been folded, or *wrinkled, on a grand scale*, and in many cases, dislocated and thrown upon their edges, on account of which, the geological structure of this part of the State is complicated, and the action of denuding agencies less simple.

336. The Central Basin of Middle Tennessee, (§ 227,) is a fine example of denudation. It has been dug out of the strata of six of the formations. Originally, when continuous, the strata

rose up in a slightly elevated *dome,* the summit of which was over the central part of Rutherford County. Taking the formation of the flat highlands around the Basin as the topmost of the dome, the amount of matter removed at this point, could not have been less, in vertical thickness, than 1300 feet.

337. Throughout this Basin, remnants of the Strata have been left in the hills and ridges ; these remnants always occurring in a certain order, building up the hills, and giving to them a like geological structure. All sides of the Basin present the out-cropping edges of the same strata in the same order. That the hills have a like structure, results, necessarily, from the nature of the case, the Basin having been scooped from horizontal strata, and the hills and ridges being simply portions left by the denuding agencies.

338. What these agencies were, is a question of interest. The simplest theory is, that the work has been done by running water, aided, more or less, by frost. The waters of the Cumberland, Duck, and Elk Rivers, are *now* at work, washing down the hill sides, and deepening the lower areas; and it is not improbable, that the same waters commenced the excavation of the Basin, each branch, creek, and rill, doing its part of the work. This, of course, has required long ages of time, during which, the streams have been constantly changing and deepening their channels, and their immediate local valleys. The Basin is the aggregate result of the work of all the streams, small and great.

339. In the First Part of this Report, I have spoken of the narrow, deep valleys, or gorges, through which many of the streams flow as they enter the Basin on its eastern side. (pp. 82 and 83.) The water falls spoken of, are at the heads of these gorges. The deep valleys have been cut out, doubtless, by the streams which now run through them.

In each, the cutting has extended as far up as the "falls;" and here, the work is still going on, the falls receding year after year, more or less. The recession of these falls and cascades is exceedingly slow, but not the less real. The water and sand wear away the rock to some extent, but most of the work is accomplished by undermining. The series of strata over which the water falls, presents, at top, hard flinty layers, but below,

shale and limestone. The latter strata yield to the action of water, and are removed, undermining the flinty beds, and causing detached masses of them, to fall at intervals.

340. The removal of shale below the upper hard layers, very often forms along the sides of these gorges, and especially near the cascades, and sometimes under them, sheltered places called locally, "rockhouses." Where the upper flinty layers project out boldly, the rockhouses are of considerable size. Their most interesting feature is, that, in them, are often found *native alum* and *copperas.* These salts form incrustations on the crumbling surface of the shale, and also lumps or irregular masses, on the floors of the rockhouses.

341. The Western Valley, (p. 104,) is another interesting example of denudation. Here, the Tennessee and its local tributaries, have washed a rough and broken valley, out of very much the same strata, cut into, in the formation of the Central Basin.

342. But these examples become small affairs when we come to consider the vast denudation which preceded, and which swept away the formations, above those out of which the Basin and Valley mentioned, were excavated.

The two great formations of the Cumberland Table-land, (p. 66,) —the *Coal Measures* above, and the *Mountain Limestone* below— once spreading out westward, covered the whole of Middle and West Tennessee, and connected toward the northwest, in Kentucky, with the same formations. But now—taking the uppermost formation first—of this great expanse of Coal Measures, with the exception of the extensive remnant left in the Table-land, and a few inconsiderable fragments or outliers associated with it, nothing now remains in Tennessee; by far the greater part, has been swept away, perhaps, before the denuding power of submarine rivers.

343. So too, the Mountain Limestone has, to a great extent, disappeared. Patches of it remain here and there, in the hills and ridges near the western side of the Table-land. But west of these, from the entire area of Middle Tennessee, it has been almost wholly removed.

344. *The Folding, Dislocation and denudation of Strata in East Tennessee.*—I have already referred to the folded or wrinkled, and dislocated condition of the strata in East Tennessee. (§ 340.)

These features are due to great disturbance, and need elucidation.

The strata of the western side of the Cumberland Table-land, though much cut up by the action of water, are, approximately horizontal, which position they retain, with a few local exceptions, more than half way across the Table-land. Approaching the eastern limit of this division, however, we meet with indications of a remarkable action. The strata begin to lose their horizontal position; they are more or less inclined, or in technical language, they *dip,* and otherwise, exhibit clear evidences of having been *crowded up in long straight folds.* Proceeding eastward, into the valley of East Tennessee, the evidences of this folding, become more marked. Not only, have the strata been folded, but, in many cases, in efforts to form folds, they have been split into long ribbon-like masses, or blocks, which, yielding to the force producing the action, have been crowded, one upon another, like thick slates or tiles on a roof, the edge of one overlapping the opposing edge of the other. (See §§ 360 and 444.) The folds, the ribbon-masses, and the lines of junction, all run lengthwise, to the northeast and the southwest.

345. To conceive the better of the force concerned, and the effects produced, let us go back to the time when the formations of East Tennessee were horizontal. If, now, we suppose, a vast force to be applied along the south-eastern edge of these horizontal formations, and to act in a northwesterly direction, the strata, if not able to resist, would yield and rise up, like thick cloth, in great wrinkles or folds, or else, lacking the proper degree of flexibility, would break along lines of least resistance, in long parallel bands or ribbons, which would be crowded together, the edge of one overlaping the adjacent edge of the other. In this way, indeed, have the formations been acted upon, and such the folds and dislocations produced.*

Examples of these folds and dislocations are given below.

346. In passing eastward across the Table-land, the first important fold of the strata met with is in a line with *Crab Orchard Mountain* (§ 188) and *Sequatchee Valley.* (§ 140.) Crab Orchard Mountain is nothing more nor less, than the nearly *unbroken back* of *one end* of this first great fold. The mountain, though a ridge several miles long, presents but a very small part of the fold. In the highest part of the mountain the fold rises up a thousand feet above the level of the Table-land, the

* The lines along which dislocation and lapping have occurred, are called faults.

strata arching over in a striking manner. (See section on the map.) Sequatchee Valley, though a great trough in the bosom of the Table-land and so different from the mountain, is intimately related to the same fold. To this indeed, as a fundamental cause, they both alike owe their existence.

It remains to trace out this grand flexure, and to speak of it in more detail. I have designated it throughout as

347. *The Sequatchee Fold*.—It commences near the Emery River, in Morgan County, and running in a direct course to the southwest, forms the Crab Orchard Mountain and all the high points between it and the head of Sequatchee Valley.

348. At "Crab Orchard House" it is intersected by a gap, which gives a pass for the Sparta and Kingston road, and exposes the *Mountain Limestone elevated by the fold* above the general level of the Table-land.* A few miles further southwest there is another break and depression, called *Grassy Cove,* which also exposes the limestone, This cove is a curious basin surrounded by mountains. Its existence is due to the denudation of a section of the fold. Between this cove and Sequatchee Valley is a high mountain.

349. Proceeding southwesterly we find the fold following the long and straight Sequatchee Valley from one end to the other, (§ 140,) and continuing in the same direction, to the Alabama line. Remarkable as it may appear, the valley has been cut out along the back of this great flexure. This portion of the fold appears to have been rent open along its summit; water has thus had access to the limestone below, and by its denuding power has excavated the valley.

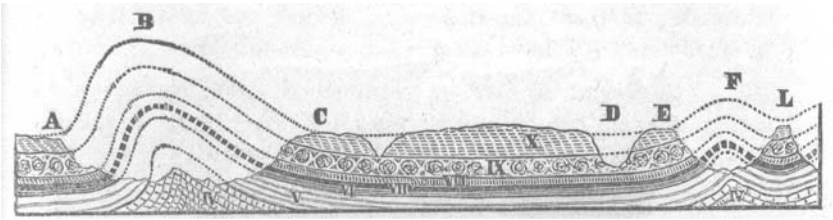
In the Crab Orchard portion the hard cap rocks were not thus rent, the softer strata in consequence, were protected and the fold left nearly intact in a mountain ridge.

350. The following diagram will throw light upon the character of the fold we are considering. It is a section of the formations and country from a point eight miles north of Jasper, in Marion County, to the eastern base of Lookout Mountain, its length being about twenty miles. There are several

* The two great formations of the Cumberland Table-land are the *Coal Measures* and the *Mountain Limestone.* The first is every where the cap formation of the Table-land, the latter is beneath it. (§175.) The *fold* brings up the limestone above the general level, and at the point mentioned it is uncovered by the superior formation and exposed.

points illustrated by this section, to which reference will be made hereafter. What concerns us *mostly* now, is the portion representing Sequatchee Valley and its formations.

SECTION ACROSS SEQUATCHEE VALLEY, &c., TO LOOKOUT MOUNTAIN.



The following are the formations represented:
IV, Knox Dolomite, 2, c; V, Trenton and Nashville, 3 and 4; VI, Dyestone Group, 5, c; VII, Black Shale, 7; VIII, Siliceous, 8, a; IX, Mountain Limestone, 8, b; X, Coal Measures, 9. See Chapter V.

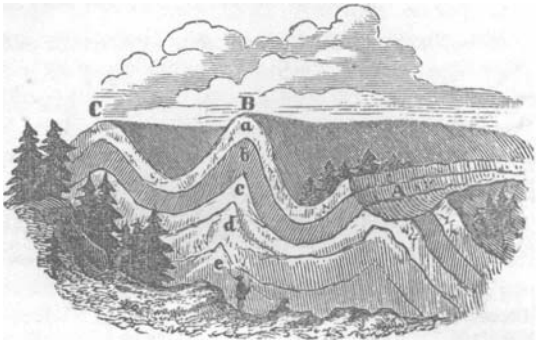
The bands between the lines represent the formations; these are numbered in accordance with the tables in the next chapter. The shaded portions between the unbroken lines are the formations as now found; the blank portions between broken lines the parts of formations removed by denudation. Two restored folds are represented—the larger A B C the Sequatehee Fold ; the smaller E F L that of the valley of Lookout Creek. The depression in the shaded part, between A and C, is Sequatchee Valley. A is the edge of the Table-land on the northwest side of the valley; C, the edge on the opposite side. The portion of the Table-land between C and D is *Walden's Ridge.* (§182.) D, narrow valley of the Tennessee River; the section crosses a few miles above Kelly's Ferry. E, portion of Raccoon Mountain. Depression between E and L, Lookout Valley. L, Lookout Mountain.

In this section the Sequatchee Fold is well represented; its summit B, was greatly elevated above the level of the Tableland. The amount of matter removed has been enormous. No attempt has been made to represent the rents made, doubtless, in the strata when elevated. The imagination of the reader can supply these.

It is essential to state, however, that, in the region of Jasper and *southward* the strata have been *fractured* along the northwestern side of the fold, and, in consequence, have been more or less thrown out of the positions they would have, had the flexure been regular as represented in the diagram.

351. The following cut, taken from Lyell's Elementary Geology, will be useful in illustrating the structure of Sequatchee Valley, as well as that of

other valleys and ridges in East Tennessee. The cut was intended originally to exhibit the structure of the Swiss Juras, but it will answer as well for some of our mountains and valleys.



a, b, c, d, e, Great rocky layers, or formations, which by lateral pressure have been crowded up into the folds A, B, and C. Both B and C are unbroken and undenuded, forming long straight ridges. A, however, has been fractured and denuded along its summit; thus a trough or valley has been formed along the line of elevation.

The structure of Sequatchee Valley resembles that of the trough A. The former valley has, however, been subjected to greater and deeper denudation. In the cut, the valley between B and C has a geological structure very different from that at A; it is a trough between two great folds. Many of our East Tennessee valleys have a similar structure.

352. Before presenting the above illustrations we had traced out the Sequatchee Fold to the Alabama line. It does not stop here. It extends on a long way into Alabama. In fact, the greater part of it is in this State, its southwestern end being near the junction of the two Warriors within forty miles of Tuscaloosa. The whole length of the fold, commencing at the Emery, in Tennessee, and extending to the junction mentioned, is about 225 miles. And for this whole distance, in longitudinal direction, it is straight, or at most, curving, as we enter Alabama, a little to the west.

353. The fold, including its geographical and geological features, is beautifully symmetrical. It terminates at both ends in mountain ridges, these ridges sinking away with the two extremities of the fold. The denuded part (Sequatchee Valley being the northeastern end) is a canoe-shaped, beautiful trough, in which are small, characteristic ridges and valleys. This trough has a rim of Coal Measures all around it. Its

length is about 160 miles, a little more than 60 of this being in Tennessee; its greatest width is from five to six miles. It has a fault along the middle part of its western side, the displacement bringing the Knox strata in contact with the Lower Carboniferous rocks.

The Tennessee River bears symmetrical relations to this trough. This stream, soon after leaving Chattanooga, breaks through the mountains into the trough, and then, turning to the southwest, flows in it for more than 50 miles. At Guntersville, Ala., the river again changes its course, cuts through the mountain barriers, and escapes to the northwest. (§ 149.)

The town of Pikeville is near the northeastern end of the trough, and Blount Springs, in Alabama, near its southwestern.*

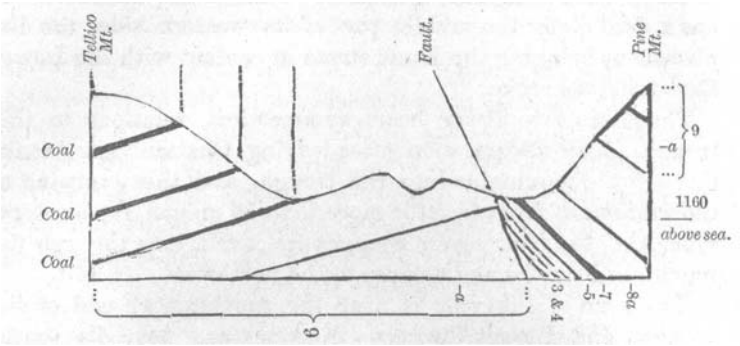
Were this the proper place, I might add much more with reference to this most interesting fold and range. I have, myself, traversed it, and stood upon its terminal mountain at each end, traced out its formations and studied their changes, and I desire to add that, in the investigation of but few special fields have I had more pleasure, or have I met with more to point me to the great Creator, whose work it is.

354. *The Elk Fork Dislocation.*—This is an example of a broken fold, resulting in a *dislocation* or *fault.* In going eastward, across the Table-land near the Kentucky line, the first noteworthy disturbance of the strata met with, is seen in the Valley of the Elk Fork, a tributary of the Clear Fork of Cumberland River. This valley is narrow, and deeply set in the Table-land. Its head is at "Elk Gap," in the very midst of high mountains, and at a point about eleven miles a little north of west from Jacksboro; from this point it extends northeastward, into Kentucky. (See § 144.)

On the next page is a cross section that this valley presents at one point. The section shows the relative positions of the mountains bounding the valley, the formations outcropping in it, and the great *fault,* on one side of which, the lower formations have been forced up many feet out of place.

* The following towns are also within it: Blountville, Warrenton, Guntersville, Bellefonte, Stevenson and Bridgeport, Ala., and Jasper and Dunlap, Tennessee.

Horizontal scale 4000 *feet to the inch.*
Vertical do 2000 *do. do. do.*



On the right is *Pine Mountain,* a high, straight ridge, (§180,) running parallel with the course of the valley; in fact, the valley and the ridge owe their existence to the same ultimate cause—the special elevation and dislocation we are considering.

The place of the *Fault* is indicated. The lowest formation appearing at the surface on the right hand side of the fault, has been raised between 2000 and 3000 feet. Its counterpart on the left, is that distance below the surface. Great as this displacement is, there are some in East Tennessee exceeding it. Faults are by no means rare east of the Table-land, some of which are more than a hundred miles in length.

The Elk Fork elevation is about in a line with the Sequatchee Fold, but forms no part of it; the two are separated by a great area of undisturbed horizontal rocks.

355. The Valley of *Cove Creek,* (§§ 145 and 146) has a geological structure similar to that of Elk Fork, but the fault has not displaced the formations to so great an extent. It has, on its northeastern side, corresponding to Pine Mountain, a sharp roof-like ridge, which is mostly made up of sandstones, highly inclined. This remarkable ridge, as it escapes from the narrow valley, curves around to the northeast and skirts the mountain into Virginia. (§ 181.)

356. The fault of the Elk Fork Valley (extending, however, beyond the valley proper, into Kentucky) and that of Cove Creek, cut off, as I have before stated, (§ 146,) a large block of the Table-land. To the lateral movement of this great mass, by a vast power acting in a westerly direction, is to be attrib-

uted the partial elevation and the fracture of the strata in the valleys, as well as the upturning of the rocks in Pine Mountain.

357. The Sequatchee fold, and the broken folds just mentioned, are the only *great* disturbances of the kind that I have observed within the area of the Table-land. At a number of other points, as, for instance, near the Davis coal bank, in Cumberland County, disturbances have been observed, but they are comparatively local. These local uplifts and breaks are exceptional, but they foreshadow the greater ones further east, where folds and faults are the rule.

358. *The Crested Slope of the Eastern side of the Table-land.*—The eastern margin of the Table-land is composed, generally, of the upturned edges of the formations. The strata are horizontal back, but approaching the margin, they bend, more or less, upward, and form the sharp crest which so distinctly defines the Table-land on the east. The sandstones of the *Coal Measures* generally form the crest of the margin, while the *Mountain Limestone,* the *Silicious Group* and the *Niagara*-formations to be noticed further on—outcrop along its slope and base. In some few cases, great blocks of the *Coal Measures* have been detached and thrown over the crest, and now rest against the slope, or lie flat in the valley. Such fragmentary masses yield coal at several points, as at Kimbro's, and at points in the "Tennessee Valley" further south.

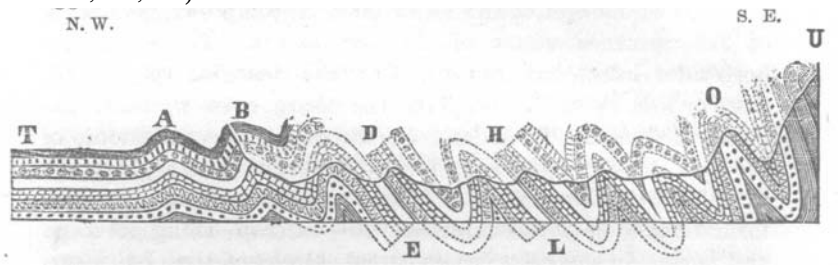
In the northern part of the State, the crest formed by the upturned edges of the strata becomes, in great part, detached from the body of the mountain back, and forms a sharp skirting ridge, of which I have already spoken. (§§ 182 and 183.)

359. *Consideration of the Folding, etc., in general, Resumed.*—The fact has been referred to, that, passing from the margin of the Table-land, eastward, the folds and faults become great, and occur in rapid succession. (§§ 344 and 345.) Having reviewed the features of several special examples, we go back to the consideration of the subject more in general.

Entering the *Valley of East Tennessee,* we get truly into the *region of disturbance.* This Valley and the Unaka division, constitute a part of Tennessee in which folds and dislocations

and, in consequence, *dipping strata*, are the rule. Here the faults and the *position* of the rocks, together with the more or less destructible nature of the latter, have determined the physical characteristics of the surface. (§§ 93 and 94; also 18 and 19.) They have given *direction* and *form* to the scores of minor valleys and ridges, which make up the *fluted* area of the Great Valley, as well as to the subordinate ranges and deep coves of the Unaka division.

360. The following general section, (and in part ideal,) from the Table-land across the valley to Unaka Range will illustrate the present arrangement of the formations and the movements to which they have been subjected. (Compare real sections §§ 350, 354, 444, &c.)



The vertical scale of this section, it must be recollected, is much greater than the horizontal. The number of folds and faults is less, too, than would be found in an actual section.

T, A, B, is the Table-land. At T the formations represented by the differently shaded bands, are horizontal ; at A they rise in a moderate fold, as at Crab Orchard Mountain, (§ 346;) at B is a more abrupt fold, and partly denuded. At this point the valley commences. U, principal Unaka Range.

The valley lies between Band U ; its present surface is represented by the line dividing the light and heavy-shaded portions. The folding of the formations and their dislocations explain themselves. At D, E, and H, L, are dislocations. D and E were once united, the formations being continuous ; but in the great movement they were broken, and the edge D pressed up and over E. This will serve as an example of a *fault.*

The light-shaded portions above the line representing the surface of the valley are parts of folds, &c., supposed to have been removed by denudation.

361. One feature illustrated by this section is, the folding of the rocks, and the great scale upon which it has been done. The great flexures thus formed differ in magnitude ; most of those of the Table-land are moderate in elevation; many of

those of the valley and of the Unakas are thrown up and over to the *northwest* in enormous plaits.

In addition to the greater folds, multitudes of subordinate ones occur in the strata. Thus the formations are often extensively corrugated as they rise in the great flexures.

362. Another feature illustrated is the dislocation of the formations. Two dislocations, or *faults,* are introduced. The displacements in many faults are very great, in some cases amounting to five or six thousand feet, or even more. Thus the two edges of a broken stratum may be separated more than a mile in vertical, or nearly vertical, distance. One edge may form the crest of a mountain, while the other is a mile below, buried beneath a valley.

The physical and geological characteristics of East Tennessee are now easily accounted for.

1st. A striking one is the *parallelism* of valleys and ridges. (§ 93.) The direction of these conforms to that of the folds and dislocations. The strata, thrown up edgewise, and cropping out in bands of unequal hardness, have given direction to denudation. Along the lines of rocks easily removed by water, such as blue limestones and soft shales, the *valleys* have been washed out; but along those of sandstones, hard slates and flinty limestones, *ridges* have been left. All the *mountain* ridges within the valley are, at least, capped off with hard *sandstones,* which have protected the softer rocks below. To these protecting sandstones the ridges owe their existence. A number of them, including Clinch and Powell's Mountains, have a great sheet of sandstone, forming one slope from top to bottom, and protecting the softer rocks seen on the other slope. (See also §§ 103, 104, and on.) The sharp-crested, and "comby" ridges, (§ 105,) have a *thin* sheet of hard material, sandstone or slates; this, when broken down at intervals, give rise to the notched or comby structure. The red and slaty knobs (§§ 106, 110, 112, and 113) are accounted for much in the same way. Some of the layers are hard, and have resisted denudation more or less, but being thin, have not been able to form continuous ridges.

2d. The occasional vertical position, and the more general dipping of the rocks to the southeast, is accounted for. By the crowding of the folds *over* to the north-west, and the subse-

quent denudation of their summits, the strata have necessarily been left dipping, as we now find them.* It is, too, a necessary result of the overlapping of the formations along the lines of fracture and dislocation, urged as they have been from the southeast.

3d. The frequent recurrence of the same formation, or rather of the same *series* of formations, seen in crossing East Tennessee, is accounted for. This, also, is a necessary result of the peculiar structure developed. In traversing the edges of the formations, from the southeast to the northwest, a very great variety of such series is observed.

In the first place, crossing the denuded *summit* of a *fold*, we pass successively from newer to older formations, until we reach the turning line, or axis; then the order is reversed. Representing the formations by numbers, and the axes of folds by a dot, the series thus passed over will be indicated by combinations like the following: 8,7,6,5,4,3,2,•2,3,4,5,6,7,8; 6,5,4,3,2,•2,3,4,5,6,7; 7,6,5,•5,6,7,8, etc.

In crossing a *trough*, or concave flexure between two folds, the order is likewise reversed, but the upper or newer formations are nearest the axis, as follows: 1, 2, 3, 4,•4, 3, 2; 4, 5, 6,•6, 5, 4, 3, etc., etc.

If we traverse a *dislocation*, a *part* or the whole of the series is repeated in the *same* order. Representing the line of displacement by a hyphen, such series may be thus indicated: 7, 6, 5, 4, - 7; 6, 5, 4; 9,8,7,6,5,4, - 6, 5, 4; 4, 3, - 6, 7, 5, 4,4, etc., etc. Combinations of these different classes, in great variety, are presented in nature.

363. *Folds, or Uplifts, and Faults in Middle Tennessee.*—It has been stated that the formations are *approximately* horizontal in Middle Tennessee. (§ 335.) The word approximately was properly used, since, in tracing out the formations, they are often seen to sink and rise in gentle local undulations, and moreover, are found to have a general, though small, inclination or dip in some direction or other. Yet, notwithstanding this, when we compare their position with that of their counterparts in East Tennessee we can almost say they are horizontal.

* When the *summit* of a fold is cut by the surface, the rocks on each side may dip in opposite directions, etc., etc.

But there are exceptions to this general approximate horizontal position in the formations of the Middle Division. I have met with localities here in which are presented, though on a small scale comparatively, the folding and faulting and high inclination of strata so characteristic of East Tennessee.

364. The most interesting of these localities is in the region of Cumberland City, a small town on the Cumberland River, in Stewart County. This town is on the side of an elliptical area, or basin, containing six or seven square miles, and surrounded by hills. The river cuts through the northern end of the basin. Wells Creek enters it on the south, and flows through it to the river. From this circumstance I have named it the *Wells Creek Basin.* Within this area the strata are highly inclined. We have here indeed, a very considerable upheaval of the formations. The strata were lifted in a high dome, the top of which has been worn and washed away. The elevation was so great as to bring to the light, through the subsequent denudation, certain low strata (upper part of Form. 2, c) no where else to be seen in Middle Tennessee.* These strata occupy the central part, and a large part, of the Basin. They dip at high angles and, at some points, are even vertical, forming low "hog-back" ridges. Outcropping around the strata of Form. 2, c, are those of the higher formations, each group appearing successively in order, the rocks dipping away from the centre of the Basin. The hard rocks of the *siliceous* (8, a) form the encircling hills, and, with the *Mountain Limestone* above, (8, b,) constitute the formation of the whole country outside.

865. The disturbance, however, has not been confined to the area of the Basin ; it has extended to the strata beyond its limits. This is seen in the bluffs on the river, both above and below Cumberland City. In these, the strata show small and great folds, fractures, dislocations, and inclinations at all angles, all, however, so far as seen, being confined to the rocks of the Lower Carboniferous. Coming up the river, the first bluff in which these disturbances are seen to have occurred is the one several miles be-

* When I first saw these rocks I recognized them at once as East Tennessee *acquaintances,* but was greatly surprised to meet with them here, a point where, of all other points in Middle Tennessee, I least expected to find them, as in all this country one of the higher formations, the *Lower Carboniferous,* is brought down to the level of the Cumberland River. By the uplift the top of Form. 2, c, has been thrust up through the Lower Carboniferous, as well as through all the intervening beds, the elevation of the lowest strata being not less than 2500 feet.

low Cumberland City, known to river-men as the *Checkered-house* bluff. In the upper part of this, the strata are boldly bent and faulted.

366. Another area of disturbance is in the upper part of the valley of Flynn's Creek, in Jackson County. This area is limited in extent, and has comparatively little importance, yet the formations are greatly disturbed. The rocks are seen to dip at high angles, and are occasionally almost vertical. The valley is narrow, and the hills on each side high. In their normal position the *siliceous* (8, a) is at the top of the series of formations, and the *Black Shale* (7) next below. In several places both are brought down, by great folds and faults, to the bottom of the valley, and, at one point, may be seen abutting against the Nashville Formation. One fault shows a displacement of a thousand feet. The lines of disturbance run nearly north and south.

367. But, by far the most important elevation of the strata in Middle Tennessee was the wide dome, the decapitation and denudation of which have given us the *Central Basin.* (pp. 81 and 97.) This can hardly be considered a local disturbance; it covers too great an area. The strata were not folded abruptly, nor broken and displaced; they were elevated not more than six or seven hundred feet in a dome, whose cross-section is about a hundred miles in length. The highest part of this was over a point not far from Murfreesboro', in Rutherford County. From above this point, as stated before, (§ 336,) not less than 1300 feet of rock have been removed. Here the lowest strata of the Central Basin are to be seen, and, with the exception of Formation 2, exposed in the Wells Creek Basin, (§ 364,) the lowest in Tennessee west of the Cumberland Table-land. From this central point the strata dip at a low angle in every direction, but less in the northeasterly and southwesterly than in other directions. In passing from the central area of the Basin, in any course to its rim, we cross in succession, the formations seen in this part of the State. (§ 208.) These outcrop approximately in concentric bands. The formation of the rim is the same as that of the hills which encircle the comparatively small Wells Creek Basin.

368. This dome like elevation of Middle Tennessee is sometimes associated with a similar elevation of the strata further

north, within an area divided among the States of Kentucky, Ohio and Indiana. The City of Cincinnati is about the centre of this area. The elevation in Tennessee, and that in the Cincinnati area, doubtless occurred at the same time, and are *perhaps* parts of a single line, or axis, of elevation extending from Tennessee to Ohio. The elevation, however, was greater in the Cincinnati and Tennessee parts than in the intermediate portion. This line of elevation is sometimes called the *Cincinnati axis.* (p. 8, *note.)*