FAULTING IN VIRGINIA

By E. R. Woolfolk

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History of the Development of Ideas of Appalachian Structure.

Prior to the inauguration of geological work by Massachusetts in 1830, there had been little or no study of the attitude or structure of the rocks in the Appalachian region. The Massachusetts Survey under the direction of Professor Hitchcock of Amherst College issued the first statement concerning Appalachian structure. In his report of 1833 Hitchcock merely noted that the rocks dip generally to the east. His explanation was that the rocks constitute a series of unconformable deposits all dipping in the same direction, but at different angles.

The next important contribution to the knowledge of the structure of the Appalachian region was that of H. D. Rogers in 1840. In this report he first called attention to the unsymmetrical shapes of the anticlines in northern New Jersey, as well as in the general Appalachian Valley as far south as Tennessee, as follows - "This departure from a central position in the synclinal axis of the valley is a very usual feature in the axes of the Appalachian chain. It results as a necessary consequence from the northwestern dips belonging to the anticlinal axes lying next to the southeast, or that of the Shooley Mountain chain, being steeper than the southeastern dips from the axis of elevation northwest of it. This want of symmetry in the dips of the strata would not claim a special mention in this place but for the truly remarkable circumstance that throughout nearly the whole length of the Appalachian chain, embracing many hundred anticlinal axes, the same rule prevails with scarcely an exception, the northwestern dips being steeper than the opposite southeastern ones".

This recognition by Rogers of the general unsymmetrical character of the folds was really the first light that was shed on the structure of this region. Professor Hitchcock in his "Elementary Geology", published the same year, offered a new explanation for the prevailing southeastward dips of the Appalachian region. In this book Hitchcock attributes the prevailing southeast dips to an actual inversion of all the strata involved.

In 1841 the Rogers brothers, in an oral communication made before the American Philosophical Society, stated that in their opinion the southeast dips so common in the Appalachian are not due to general inversion of the strata but to closely compressed folds in which the strata on the two limbs are essentially parallel, and hence dip in the same direction and at approximately the same angle. This statement plus the one given the year before by H. D. Rogers gave the key by which Appalachian geologic structure could be interpreted. This statement was followed by Hitchcock, who, in the second edition of his textbook, published in 1841, was the first to advocate in print the idea that closed folds with limbs parallel and dipping in the same direction, are due to forces compressing a mass of strata from opposite directions. This is the first attempt that in any way approaches the present conception of the manner in which the general southeastward dips of the Appalachian region were produced.

The Rogers brothers stated their final conclusions on this subject in a paper entitled "The Physical Structure of the Appalachian Chain". In this paper they make the following statement: "The above-described phenomena of the dips in the Appalchian range may, we think, be really accounted for by the peculiar character of the flexures of the strata. These flexures, unlike the symmetrical curvature usually assigned to anticlinal and synclinal axes, present, in almost every instance, a steeper or more rapid arching on the northwest than on the southeast side of every convex bend; and, as a direct consequence, a steeper incurvation on the southeast than on the northwest side of every concave turn;........ On the southeastern side of the chain, where the curvature is most sudden and the flexures most closely crowded, they present a succession of alternately convex and concave folds, in each of which the lines of greatest dip on the opposite sides of the axes approach to parallelism, and have a nearly uniform inclination of from 45 to 60 degrees toward the southeast".

The statement just quoted gives a fairly clear picture of Appalachian folds, as they are known today. In the same paper is given the first recognition of the presence of faults in this region. Stated as follows:

"A feature of frequent occurrence in certain portions of the Appalachian belt is the passage of an inverted or folded flexure into a fault. These dislocations, preserving the general direction of the anticlinal axes, out of which they grow, are usually prolonged to a great distance, having in some instances - for example, in southwestern Virginia - a length of about 100 miles. These lines of fault occur in all cases along the northwestern side of the anticlinal, or the southeastern side of the synclinal axis, and never in the opposite situation".

The Rogers brothers did not specifically state that these faults are overthrusts, they nevertheless so describe them that it is perfectly clear that they understood their character. Their description of the great fault, later called the Pulaski fault, shows that they understood its character. Their description is as follows: "But a few miles further toward the southwest, the whole of this enormous mountain mass (North Mountain) sinks from view, excepting an isolated knob here or there, of the harder rocks, which for a short distance serve to mark the irregular progress of the fault. At length, the dislocation attains what may be called its maximum intensity; the slate, and not infrequently, the limestone of the valley, resting in an inverted attitude, with a gentle southward dip, directly upon the southeasterly dipping grits and shales of the formation next beneath the Carboniferous limestone here constituting the southeastern slope of the Brushy Mountain. The seam of semi-bituminous coal generally embraced between these strata is, in virtue of the dislocation, made to assume the anomalous condition of passing under the valley limestone at a distance of only a few hundred feet, dipping in the same direction with that rock".

The great stumbling block in the way of all of the early geologists was the accounting for the succession of parallel folds that had been produced in the Appalachian region. As stated by the Rogers brothers, it seemed inconceivable that such folds could have been produced by tangential pressure and that it was necessary to appeal to waves on a molten mass below the strata that was folded.

The correct explanation of the method of formation of overturned rock folds and the development of overthrust faults from the breaking of these folds under strong tangential pressure, was made by James M. Safford, State Geologist of Tennessee. In his report on the "Geology of Tennessee", published in 1869, he gave the following explanation of the peculiar geologic structure of East Tennessee:

"The formations of East Tennessee were originally 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 overlapping the adjacent edge of the other".

The next forward step was the recognition that in many places the development of faults was much more complicated than

Safford had supposed.

C. W. Hayes[1] next showed that the movement on some fault planes had been much greater than was formerly supposed and that the formations in contact with the overthrust mass would depend largely upon whether or not there had been preliminary folding and erosion before faulting occurred. Hayes' introduction is as follows:

"Through the work of the Rogers brothers in Pennsylvania and Virginia and of Safford in Tennessee, the characteristic forms of Appalachian structure have long been familiar to geologists. The unsymmetrical fold has been recognized as the normal structural form through Pennsylvania, Maryland and a portion of Virginia. In East Tennessee the overthrust fault becomes common".

Hayes' paper showed that broad overthrust faults might be expected whenever the rocks have been severely compressed and the conditions such that rock folds were produced.

In 1893 Bailey Willis[2] published his paper "The Mechanics of Appalachian Structure" which is a very important contribution to the theoretical study of Appalachian structure. In this paper he introduces the principle of competent and incompetent strata and structures as follows:

"If we describe the sufficiently firm stratum by the word

1/ The Overthrust Faults of the Southern Appalchians, Bull. Geol. Soc. Am., Vol. 2, 1891

2/ The Mechanics of Appalachian Structures. 13th annual report of the U. S. G. S., 1893 competent, we may formulate the law of anticlinal development, as deduced from these experiments, as follows: In strata under load an anticline arises along a line of initial dip, when a thrust, sufficiently powerful to raise the load, is transmitted by a competent stratum. The resulting anticline supports the load as an arch, and being adequate to that duty it may be called a competent structure. From the conditions of the case it follows that none other than a competent structure can develop by bending. If the thrust be not powerful enough to raise the load there will be no uplift; and if the layers be so plastic that they yield to the thrust by swelling, then the principal result of deformation is change of form other than by simple flexure, and it assumes some form of flowing. This is incompetent structure".

Arthur Keith 1/ in his paper "Outlines of Appalachian Structure" makes the following statement in regard to "Competency of beds": "The individual rocks of the Appalachians vary enormously in the manner of their yielding to pressure. The geologist in the field soon perceives that thin-bedded rocks, like shales, slates, and schists, yield readily in small folds with dimensions from a few feet down to minute wrinkles. Heavy beds of solid quartsite, sandstone, or dolomite are bent in broad folds measured by hundreds of feet or by miles. The arch of Powell's Valley for instance is six miles across and is maintained by massive dolomite capped by massive limestone, conglomerate and sandstone".

1/ Arthur Keith, Outlines of Appalachian Structure. Bull. Geol. Soc. Am., Vol. 34, 1923.

Keith in the above mentioned paper gives a summary of various theories of mountain structure that have been advanced from time to time and their application to the Appalachians. These theories are: contraction, suboceanic spread, isostasy, geosynclines, continuity relations, continental creep. Numerous calculations have been made as to the amount of contraction that would follow from condensation due to loss of heat. These calculations are based on the observed increase of heat downward in the earth and known conductivities of the substances of the crust and of the atmosphere. The amount of lateral shortening obtained in this way is seriously short of the requirements. The same difficulty is met in the theory of suboceanic spread, as this theory really goes back to contraction of the earth for its cause. The chief obstacles to the theory of isostasy are: first, isostasy is not itself an initiating cause, but requires some other force to start its operation. Second, isostasy is a continuing process, but the existence of peneplains produced during long periods of erosion and quiet on the land disproves the idea that the land is continually in motion and completely responsive to isostasy. Third, the thick sediments whose weight is supposed to depress the sea-floor and cause the underflow are the very masses which are folded and raised the highest. It can not be denied that geosynclines played some part in mountain building, for their thick deposits gave character to the folding. The facts of geology determine the relative time of the great movements of the earth's crust. These are not continuous but are periodic and separated by unequal intervals. They therefore require simple steady storing up of strain. This is a continuous process and its release should be continuous, this condition is opposed by the large facts of mountain building.

The theory of lateral movement of great masses is an old one; it is a necessary consequence of the shortening observed in folded mountain ranges. The theory of continental creep merely extends the movement over vastly greater areas. The most serious objection to the theory of continental creep, is that of friction due to the moving of the crust on the interior of the earth. Daly even went so far as to postulate a layer of glass between the crust and the deeper earth which would afford a minimum of friction. This seems to be a rather far fetched idea and can hardly be supported by evidence.

Batholith Intrusion as Cause of Folding.-

The analysis of some of the current theories of mountain-building has shown that each theory has serious drawbacks. Therefore Mr. Keith has been led to the conclusion that another force has been responsible for mountain-building. These forces are heat, which is shown by metamorphism and the growth of new minerals, and the force exerted by igneous intrusions.

Keith opens his argument as follows: "The association of igneous intrusions and extrusions with periods of mountain-building has been observed and commented on by many writers, but in all cases known to the author the intrusions have been regarded as results of mountain-building forces and not their cause. It seems to the writer that the case is reversed and that igneous intrusions, which are the greatest examples of heat and force known to us, and which are definitely associated with mountain-building, should be rated as the cause of the building of mountains, which show to us the greatest known results of heat and pressure".

This theory sounds plausible when we consider the following facts; the association of igneous intrusions with mountain-formation, and that in the Appalachians large batholiths were intruded at the time of their formation. Most intrusions show great force. This is particularly true of batholiths, laccoliths and sills, which plainly have forced apart large rock masses or have lifted tons of overlying strata. That they were intruded under great pressure is shown in many places by the shattering and rending of the country rock. The width of the now visible portions of individual batholiths (as great as 30 miles) is proof of an enormous amount of separation of the country rocks. The ground plan of the batholiths in relation to that of folding is suggestive. The two main seats of intrusion are at the north and south ends of the Appalachians. Parallel to these intruded areas is seen the greatest development of thrust faulting.

We usually think of magmas as simply lifting up the overburden, but a horizontal motion is just as plausible when we remember that theoretically magmas are fluid. Therefore, hydrostatic conditions must have prevailed in the magma as a whole. That being the case, whatever was the direction of initial pressure, the pressure transmitted would be at right angles to all confining surfaces, thereby pushing the confining walls apart.

The combination of included gases and growing crystals is another means of accounting for a part of the pressure necessary to this theory.

In summing up, the theory of batholithic intrusion seeks to explain the folds and faults of the Appalachians by pressure from intrusions of magma.

It seems that the chief objections to this theory are: first, that a large part of the apparent separation of the country rock is merely substitution of the batholith for the country rock, by magmatic stoping and the digestion of it.[1]

1/ Daly: Igneous Rocks and Their Origin, a textbook. 1914.

Second, if crystals do exert a pressure sufficient to move large masses of strata, it would be a very limited motion and comparatively insignificant when we think of the great amount of motion necessary to result in the great folds and thrust faults of the Appalachians. The third and chief objection to the theory of batholithic intrusions causing the folding and faulting is in the age of these intrusions. There are many faults in southwestern Virginia that break through strata of Carboniferous age and therefore must be post-Carboniferous faults. While most of the igneous intrusions, especially the batholiths, are of pre-Cambrian or lower Cambrian age.

Structure of Western Virginia Appalachian Mountain Province.

The sedimentary rock layers of this region have been extensively folded, the folds having their elongated axes parallel and trending northeastward. Erosion has worn off many of the upper layers of rock, so that their edges now appear at the surface in narrow nearly parallel belts. The layers of sandstone and quartzite resisted erosion, but the shale and limestone layers have been deeply eroded, and form valleys between ridges of the harder rock. These generally strike northeast, being controlled by the structure, and form the belt of valleys and ridges which occupies the western side of the Valley of Virginia.

The folds usually extend for long distances, rising and falling throughout their length, and at their ends generally pitch sharply, their places being taken by other folds on either side.

Generally only one side of a fold is seen in an outcrop, the layers dipping in one direction, either into a syncline or away from an anticline. Only where the strata pitch or rise at the end of a fold are larger synclines or anticlines recognizable by the looping of the ridges around the end of the fold. Many wrinkles or small folds may be seen in the outcrops of the larger ones, especially where streams have cut through the larger structures thus giving a better exposure.

The folding is most intense on the southeastern side of the Appalachian Valley and becomes less intense northwestward. The closest folding therefore is in limestones and associated shales of Ordovician and Cambrian age. These folds do not have so marked an effect on the topography as do those of the northwestern part, due to the absence of hard beds at the surface to make ridges. The most outstanding exception to this rule is Massanutten Mountain. This mountain is produced by a synclinal fold of such great depth that the hard Tuscarara sandstone which overlies the other rocks was brought so low that it was protected from complete removal by erosion. So these hardbeds form an outlying mountain in the valley.

A long narrow infold of Carboniferous rocks lies southwest of Fincastle and extends southwestward nearly as far as Marion, its hard rocks forming Little Walker Mountain most of the distance. Opposite the point where this syncline shallows and the Carboniferous ends, another long synclinal fold to the west deepens and encloses Carboniferous rocks which extend southward to the State line. These rocks are soft and do not form such high mountains as do the Carboniferous sandstones to the north.

Many of the folds in the Appalachian Valley are so tightly compressed that the beds have broken and the rocks on the southeast side have been pushed over those on the northwest along a thrust fault plane.

Stose and Miser have the following to say in regard to faults in western Virginia:[1] "Although some faults of considerable

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1/ Manganese Deposits of Western Virginia. Va. Geol. Surv. Bull. 23, 1922.

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horizontal displacement occur within the valley ridges, particularly one at the southeast foot of the Appalachian

Plateau escarpment in Wise, Russell and Tazewell counties, the greatest faults occur in the limestone valley or within the adjacent Appalachian Mountains. A major fault which enters the State from the north lies within the Blue Ridge or at its western foot as far south as Roanoke. Here it enters the open valley of the Valley of Virginia, which is narrow at this point, crosses to its western side, and then follows the southeast foot of the first range of the Valley Ridges southwestward, where Ordovician and Cambrian limestones are faulted against Carboniferous rocks. The fault plane which was originally nearly horizontal, has itself been strongly folded by later warping of the rocks, and in places the overthrust rocks have been eroded from the upfolds and mountains of younger over-ridden rocks and now appear thru breaks, as "fensters", in the overthrust rocks".

The most remarkable fensters of which I can find record are three in the vicinity of New River. The best known fenster in the New River region is that of Price Mountain, a low ridge about five miles long, lying midway between Christiansburg and Blacksburg. The ridge extends east-west and is not over 400 feet high. The structure of the ridge is that of an elongate dome with the rocks dipping in general away from the central part. Not only do the Carboniferous rocks comprising the mountain dip in this manner, but the Shenandoah limestone surrounding it also dips away from the center of the dome. The most important structural feature observed in this fenster is the almost perfect parallelism between the beds of limestone and the beds of the coal-bearing rocks upon which they rest. This fact makes it possible to correlate the fault surrounding it with some other faults of the region.[1]

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[1] Campbell and Holden: The Valley Coal Fields of Virginia, Va. Geol. Surv. Bull. 25, 1925.

There is only one other major overthrust fault that has been described in the northern portion of western Virginia. This fault developes near Buffalo Gap and extends northward to the State line. The amount of its throw varies considerably; for 12 miles the lower portion of the Massanutten sandstone is overthrust on the Romney shale, except near Stribling Springs, where the Monterey sandstone and the Lewistown limestone come in for a short distance along the west slope of Buck Hill. North of the hill the Martinsburg shale lies against the Romney shale, and then with an increase in the amount of throw, the Shenandoah limestone is brought against the Jennings formation.[2]

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[2] Darton, N. H., Staunton Folio, U.S.G.S. No. 14, 1894.

The greatest width of the faulted area in southwestern Virginia is about 40 miles, measured on a line passing through Wythe, Bland, and Tazewell counties. These faults are separated by varying distances, and show Knox limestone on the southerly or upthrow side, while the beds on the northerly or downthrow side may belong anywhere from Lower Silurian to Upper Carboniferous. "Thus the region is broken into a series of "rich" and "poor" valleys, underlaid in the former by Lower Silurian limestones and in the latter by Upper Silurian and Devonian shales".[3]

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[3] Stevenson, J.J.; Faults of Southwest Virginia. Am.Jour. Sci. 3rd series, Vol.33, 1887.

There are at least seven major faults that enter Virginia from Tennessee and traverse the region in a northeast-southwest direction. Several of these faults have been described in detail in some one of the Virginia Geological Survey series of reports on the coal fields of Virginia. The Pulaski fault is typical of the faults of this region and will be described in some detail.

The full extent of the Pulaski fault has not been determined. It has been traced from Pulaski southwest to the vicinity of Timberridge, a village 6 miles southwest of Greenville, Tennessee. In the opposite direction it extends to a point 5 miles northwest of Fincastle, Virginia. The fault may extend farther toward the northeast but all evidence at present indicates that its termination will be found near Eagle Rock on the James River. This fault is about 200 miles long, its length is not as great as some other faults of the region, but as determined by the amount of known and measurable overthrust it is one of the largest that has been described.

In a general way the faults of the Appalachian Province are rudely parallel, but the Pulaski fault is an exception, for in places it departs widely from the general trend of the geologic structures. The course of this fault from its southern end to Abingdon, Virginia, conforms to the general structure of the area, but it shows no relation to the fault immediately west of it, sometimes known as the Bland or Saltville fault, as this fault when it approaches the State line veers off to the west in its course into Tennessee. The cause of this divergence of the two faults is that in Tennessee they lie on different sides of a great syncline.

From the eastern edge of Wythe County to the eastern boundary of Montgomery County the Pulaski fault is very irregular, crossing a number of anticlines and synclines. At the point where Montgomery, Craig, and Roanoke counties come together the Pulaski fault is joined by a subordinate fault, that extends down the Valley of Craig Creek. The termination of this fault has not been established.

The Pulaski fault is essentially the same as the other overthrust faults of the region, differing only in the extent of movement that has taken place on its fault plane. In the vicinity of Pulaski the horizontal displacement of this fault is n not less than 9 miles, and may be greater.

Points in support of the statement that the Pulaski fault is an ordinary overthrust fault that has developed from and overturned fold are as follows: A study of the southwest termination of the Pulaski fault as shown in the Greenville folio makes it clear that this fault developes in an anticline of Knox dolomite and anyone familiar with the geology of the Appalachians will at ? once recognize that the Knox dolomite is probably the most nearly competent of any of the beds or formations present in the paleozoic column. The second point in favor of the fold theory is the succession of formations in the overthrust mass. In a fault developed from an overturned fold there is, after erosion has removed the fold at the extreme edge of the overthrust mass, a general agreement in the dip of the overthrust beds and that of the fault plane and the oldest rocks are found along the trace of the fault. The field evidence shows this to be the condition.[1]

1/ Campbell, M.R., Valley Coal Fields of Virginia, Va.Geol.Surv. Bull. 25, 1925.

There is a general impression that broad overthrust movement is directly connected with great longitudinal extent, but such is not necessarily the case. The general rule seems to be that the stresses from the southwest of the Appalachian Valley were relieved in one place by great movement on a certain fault and in another place by equally great movement on another fault, or a distribution of the displacement among several faults, no one of which is great enough to be out of the ordinary class. Such a condition is known as "En echelon arrangement of faults". The result of such an arrangement of the faults is that the movement in different parts of southwestern Virginia has been practically the same though distributed throughout a number of faults of varying amounts of overthrust.

It must not be inferred that faults are equally abundant in all parts of the Appalachian region. In the southern part faults are the rule and open folds are the exception, but in the central and northern part of the province, open folds are the rule and faults are the exception.

On the James River in the vicinity of Eagle Rock there is an irregular anticline of large dimensions overturned to the northwest and pitching to the northeast. On the far side of the river it is nearly six miles wide. Mays Mountain is an erosion remnant of its southeast limb and Rat Hole Mountain of its northwest limb. In Rat Hole Mountain the Clinch and associated sandstones, overturned to the northwest, are duplicated by faulting which occurred before the formation of the great anticline. Ten miles to the northeast there is relatively little faulting. This point,

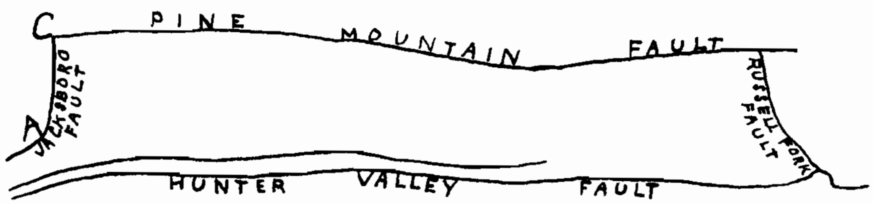

Fig. 1. Showing the bounding faults of the Cumberland block.

therefore, may be considered the dividing line between the region of little overthrusting on the northeast and an area of great overthrusting on the southwest.

The most remarkable feature develpped in southwestern Virginia as the result of thrust faulting is the great Cumberland block. This remarmable quadrilateral block was first recognized by Safford who described its southwestern extremity. It extends from Cave Creek in Campbell County, Tennessee, northeastward for 125 miles to the valley of Russel Fork of Big Sandy River in Dickenson and Buchanan counties, Virginia, and lies in parts of three states: Virginia, Kentucky, and Tennessee. The block is very uniform in width, averaging about 25 miles. It is bounded on the northwest by the Pine Mountain fault and on the southeast by the Hunter Valley fault and the closely associated parallel fault which is developed only from Big Stone Gap southwestward. The southwest end is marked by the Jacksboro cross fault and the northeast end by the Russel Fork cross fault. The relations of these boundary faults may be more clearly seen by reference to the map which accompanies this paper and to figure 1.

From Norton, Virginia, northeastward, coal measure rocks are exposed at the surface throughout the entire width of the block; but from Norton southwestward the block may be divided into two parts, that part lying northwest of Stone and Cumberland mountains being synclinal in structure and composed of coal measure rocks, whereas that part southeast of these mountains is anticlinal in structure and composed of rocks of much greater age. The syncline, generally known as the Millsboro syncline, is a broad, flat-bottomed trough at the northeast end of the block, but further west near Dante an arch appears which develops rapidly westward into the Powell Valley anticline that constitutes the southern part of the block. Both the Millsboro syncline and the Powell Valley anticline are characterized by steep dips on the northwest limbs and gentle dips on the southeast limbs. The erosion by Powell River and its tributaries of the top of Powell Valley anticline accounts for the exposure of pre-Carboniferous rocks in the southern portion of the block and the narrowing of the coal measure portion on the north.

The topography of the block is intimately related to the structure. Pine Mountain throughout its entire length is a barrier, especially on its northwest face where at many points it rises in less than a mile, 1,000 to 2,000 feet above the streams which parallel it. For nearly 90 miles no stream crosses it and in the entire distance of 125 miles not over half a dozen roads give a difficult passage across it. Its crest is the hard conglomerate of the Lee formation which marks the edge of the overthrust block. Black Mountain and parts of Sandy Ridge are residual mountains left in the dissection of the flat lying coal measures. Big A Mountain is composed of resistant sandstones of the Rockwood formation, overthrust on the coal measures.

The surface features of that portion of the block within the coal field are those of a maturely dissected plateau with sharp crested ridges and deep valleys. The surface of the pre-Carboniferous portion is rolling, with sinkholes developed in the limestone portion.1/

1/ Wentworth, C. K., Geology and Coal Resources of Dickenson County, Virginia. Va. Geol. Surv. Bull. 21, 1921.

The cause of the formation of the remarkable Cumberland Block is thought to be as follows: The rocks of the block were subjected to strong lateral compression from the southeast. The thicker sedimentary rocks west of A (Fig.1.) seem not to have yielded as did those to the east, and therefore acted as a buttress against which the rocks to the east were deformed. The result was the formation of the bounding faults and the skewing or twisting of the great block to the west about C (Fig. 1.) as a pivot.

Normal Faults.

Most geologists are of the opinion that practically all of the faults of the Appalachian region are of the overthrust variety. But many normal faults have been observed by Campbell in the Devonian shale of the various fensters on or near New River. Ordinarily these faults are not recognized because the displacement is small and the rocks are of such a character that it is difficult to identify on the surface a given bed for any distance, and so an offset can not be detected.[1]

1/Campbell, M. R., The Valley Coal Fields of Virginia, Va. Geol. Surv., Bull. 25, 1925

Normal faults are also common in the coal fields of the region, as they are mentioned in all of the coal reports. Generally the amount of movement on the fault plane has been so slight that the coal bed is displaced only a few inches or a few feet, however in places normal faults of a much greater magnitude have been found. One of the larger normal faults occurs in the Slurser mine, described by Campbell[1] in Bulletin 25 of the Virginia Geological Survey. Here the offset of the coal bed is about 15 feet and it is clear that it was caused by tension and not be compression.

1/ Campbell, M. R., The Valley Coal Fields of Virginia. Bull. 25, Va.Geol. Surv., 1925.

Structure of Central Virginia

Piedmont Province

The Piedmont Province lies between the Coastal Plain and the Appalachian Mountains. It extends from the eastern slope of the Blue Ridge eastward to the western margin of the Coastal Plain. The nearly horizontal and unconsolidated sediments of the Coastal Plain lie across the bevelled edges of the highly crumpled crystalline rocks of the Piedmont, presenting a sharp geologic boundary between the two provinces. The boundary on the west is less sudden and well marked.

Lack of systematic study of the Piedmont region forbids more than a general description of its structure at this time. The rocks comprising the region are the oldest in the State and, excepting the areas of Triassic rocks, they are all crystalline. They are made up of both sedimentary and igneous masses so greatly altered from metamorphism, chiefly by pressure and recrystallization, that many of them bear but very slight resemblance to the original masses. This metamorphism has induced secondary foliation in the rocks by arranging the mineral constituents along somewhat parallel lines or planes; the foliation of which, deposition of ore minerals in sufficient abundance to be of commercial importance.

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