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Art. LXIV.—*Notes on the Cambrian Rocks of Pennsylvania and Maryland, from the Susquehanna to the Potomac;* by Charles D. Walcott.

[Read before the Philosophical Society of Washington, Oct. 29, 1892.]

The special study of the Cambrian rocks of the Southern Appalachians* was limited during the past field season to an examination of some of the more important exposures of the group in central Pennsylvania and Maryland. Within this area between the Susquehanna and the Potomac rivers two points have been the subject of investigation by geologists, and decided differences of opinion exist in regard to the stratigraphy and the geological age of the rocks embraced within them. One is that of South Mountain as it occurs in Franklin, Cumberland, York and Adams counties, in Pennsylvania. The second is the area about Harper's Ferry, Virginia. After an examination of the published literature, including geological sections and maps, it was decided to begin work in York county on the Susquehanna and to extend it southwest to the Potomac. Prior to this three days were spent at Mount Holly Springs, in the northwestern part of South Mountain, in a preliminary examination of the quartzites exposed at that point. The discovery of the lower Cambrian or Olenellus fauna in a synclinal trough near the western foot of the mountain, gave an important datum point which was afterwards of great service in work to the south in Franklin county.

York County.

Dr. Persifor Frazer considers the Lancaster limestones as probably the equivalent of the Calciferous and Trenton limestones of the New York series, and mentions that the York limestone is a slender offshoot.† The Hellam quartzite of York is called the "Chikis" quartzite, and is described as a basal formation upon which a series of schists occur that to the south "are, at all events, those slates in which the iron ores of Lancaster and York are invariably found, the transition series between the Primal and Auroral."‡ Professor Lesley describes in his final report§ the "Chiques" sandstone as the same formation as the Hellam quartzite of York county (as

* Notes on the Cambrian rocks of Virginia and the Southern Appalachians, this Journal, vol. xliv, 1892, pp. 52–57.

† 2d Geol. Survey of Penn. Report of Progress in 1877. Geology of Lancaster County, 1880, p. 4. ‡ Loc. cit., p. 7.

§ Geol. Survey of Penn. Summary Description of the Geology of Penn., vol. i, 1892, p. 165.

named by Frazer) and equivalent to the upper Cambrian quartzite of Walcott. He prefers to use the older name "Chiques" for these sandstones, stating that it is best to get rid of the old name "Potsdam" sandstone, as there does not seem to be any satisfactory evidence that the proper Potsdam sandstones of the Canada line and Lake Champlain extended as far south as southern Pennsylvania. He says that the section at "Chiques Rock" is not quite comprehensible at one or two points. I found that it was so complicated by thrust faulting that it is not a typical section. It exposes, however, the lowest of the Cambrian rocks now known to me in central Pennsylvania. The "Chiques Rock" proper, near Chiques, is the Scolithus quartzite, and is in an unbroken section at the summit of the series of the quartzites and slates of the Chiques section although now apparently at the base of the section. The quartzites to the south, between "Chiques Rock" and the limestones at Columbia, are older and have been raised up from beneath and thrust over on the Scolithus quartzite at "Chiques Rock." This is determined by the succession shown in the section exposed on the flanks of South Mountain, in Franklin county west of Monterey, reference to which is made in the notes on the geology of South Mountain. In relation to the stratigraphic position of the slates, etc., beneath the Lancaster limestone, I will quote the statement of Professor Lesley, "The geographical proof that the slates *overlie* the quartzite is complete; and establishes the correctness of Professor Rogers' *Upper Primal slate* formation. The geological evidence is equally conclusive; for the general dip in the Chiques rock is southward, under the slates; and of the slates southward under the limestone."*

The continuation of "Chiques Rock" to the westward, in York county, forms the Hellam hills† and shows a broad anticlinal of quartzite surrounded by schists. Numerous sections along the southern and western sides of the Hellam hills show that the quartzites pass beneath a series of shales, slates, sandy and calcareous layers that, in turn, pass beneath the limestones of the valley.

It was my good fortune to have the acquaintance of Prof. A. Wanner, superintendent of public schools at York. He volunteered to be my guide to localities where there were good exposures of the quartzites, schists and limestones, and he gave me valuable assistance. A reconnaissance was first made of the section at "Chiques Rock" south to Colum-

* Loc. cit., p. 172.

† I did not learn of any local name for this ridge of hills when in York county, and as most of the ridge is within the township of Hellam I shall speak of them as the Hellam hills.

bia, and then on the western side of the river from Wrightsville north to the quartzites. On the western side of the river the section appeared to be unbroken from the Hellam hills to Wrightsville, and to be as represented by Dr. Frazer* in his section along the right bank of the Susquehanna. In this the succession is from a quartzite (1) to shales (2) and to limestone (3), the latter in Wrightsville, at the Columbia bridge; the sandy shales and argillites (2) pass conformably beneath the massive limestone (3) which forms a deep synclinal fold before being cut off to the south by a fault.

The second section examined was No. 2 of Dr. Frazer's, extending from Emigsville south through Red Lyon station.† In the description of this section ‡ he refers the sandstone in the railroad cut just north of Emigsville to the Triassic New Red sandstone. At the northern end of the cut he noted a fine-grained sandstone, dipping 15° west, north 52 degrees. To the southward of this he describes a calcareous, sandy, pink shale, dipping south 5°, east 20°. This is subjacent to 27 feet of blue, finely laminated limestone, with white streaks, upon which rests a red bed of calcareous conglomerate two feet thick: this in turn is subjacent to a belt of reddish shaly sandstone, nine feet in thickness, which is capped by 156 feet of arenaceous shales of a somewhat flaggy character.

He says: "There would seem to be, therefore, an anticlinal in the Triassic measures—the only instance of one recorded within the limits of this district. The contact line of limestone and Mesozoic sandstone lies within or just north of the town of Emigsville. The first recorded dip in the older formation when projected upon the line of section is 2,160 feet, or a little more than a third of a mile from the last dip."§ I mention the details of Dr. Frazer's section as it is the one which led me to the determination of the stratigraphic position in the geologic series of the Chiques quartzites and the York shales‖ which are subjacent to the Lancaster limestone.¶ The fault betweeen the Paleozoic (Lower Cambrian) rocks and the New Red sandstone of the Mesozoic occurs in the railroad cut, at the point indicated in Dr. Frazer's section as the crest

*Second Geol. Survey of Penn.. 1876. Section 1, accompanying Report of Progress in the district of York and Adams counties for 1874.

† Loc. cit., Section 2. ‡ Loc. cit., p. 88. § Loc. cit., p. 89.

‖ The name York shale is proposed for the band of shales resting upon the quartzites surrounding the Hellam hills. It is peculiarly well developed in York county, and appears to be absent in many of the sections about South Mountain and about the same series of quartzites in Lancaster county.

¶ The term York limestone was proposed by Dr. Frazer for this limestone; but as he states that it is a prolongation of the Lancaster limestone into York county, and that it is more fully developed in Lancaster county, I think it best to retain the term Lancaster limestone, as it is hardly necessary to call the same limestone by two different names in adjoining counties.

of the anticlinal in the New Red sandstone. No such anticlinal exists. The southern leg of Dr. Frazer's anticlinal is formed of rocks that bear no resemblance to the Mesozoic Red sandstone, and fossils of lower Cambrian age are abundant in the nine feet of compact, fine grained sandstone described by him. The section, from the fault line southward, is as follows:

	Thickness. Feet.
1. Gray, banded and mottled limestones, with purplish bed of limestone at summit three feet thick. This limestone weathers into a more or less arenaceous shale. Strike, E. & W. (Mag.) Dip, 25° S.	33
2. Gray and buff sandy shales passing (at 21 feet) into shaly sandstone and then into sandy shale, where a belt of calcareous quartzite occurs in layers varying in thickness from 2 to 12 inches	105
Fossils:—*Camerella minor*, and fragments of Olenellus, showing portions of the head and thoracic segments.*	
3. From the fossiliferous beds just mentioned, for a distance of 500 feet the hillside on the east of the railroad is covered with the debris of sandy shales, and several exposures occur along the wagon road. From the last of these to the first outcrop of limestone, a distance of 250 feet, the debris of sandy shales and thin-bedded calcareous quartzite occur abundantly in the southward-facing hillslope. As the last observed dip was 25° S., it is assumed that the section is unbroken, and a thickness is assigned to this division of	315
Fossils:—Numerous fragments of Olenellus and casts of *Camerella minor* occur in the calcareous quartzite interbedded in the shale.	
4. Massive-bedded, dove colored, banded limestones. Strike N. 20° W. (Mag.) Dip, 25° S.† near base of series. Although the section is more or less concealed by soil, numerous outcrops occur in quarries to the south. These show a banded limestone in the lower portion of the section with numerous irregular, small, concretionary bits of limestone, usually elongated with the bedding plane. The average dip of the beds is from 20° to 25° S. A beautiful section is shown in a quarry about one-fourth of a mile east of Emigsville, and in a quarry on the turnpike west of the railroad in the outskirts of the town. A little higher up in the section the limestones are massive, light colored, and, in places, almost a white crystalline marble.	

* On the line of strike of these beds, two miles northwest of Emigsville, the following fauna was found in the calcareous sandstones: *Camerella minor*, *Obolella crassa*, *Hyolithes communis*, and fragments of Olenellus.

† Dr. Frazer's section indicates a dip of 85°. I was not able to discover the locality where he observed it.

At a quarry in a field east of the railroad track and near where the roadway turns to the eastward towards Codorus creek, the strike of the limestone is N. 15° W. (Mag.), and dip 15° S. One of the layers is quite fossiliferous and gave fine specimens of a species of Salterella and Kutorgina, heads of small trilobites of the genera Solenopleura and Zacanthoides, and numerous fragments of the head and thoracic segments of a species of Olenellus.

Further to the westward in an old quarry east of the Northern Central R. R. track, massive layers of limestone are shown that have a strike N. 20° W. (Mag.); dip 20 S., and contain fragments of the genus Olenellus and Protypus. The next higher exposure in the section is in a large and deep quarry just west of the R. R. track, between one-fourth and one-half mile south of Emigsville. About 60 feet of limestone is exposed. The strike is E. and W. (Mag.), with a dip of 10° to the south. In the lower portion of the quarry there are massive layers of arenaceous limestone, and about ten feet from the summit of the section, alternating bands of earthy and pure limestone in which numerous fossils occur. In the collection obtained I have recognized:

Plates of Cystids.
Kutorgina, n. sp.
Orthisina festinata Billings.
Olenellus (fragments).
Protypus senectus Billings.

The fragments of Olenellus indicate individuals as large as any known. The fossils range through about twenty to twenty-five feet of the limestone. The layers above the fossiliferous band are largely brecciated and form a limestone conglomerate. The estimated thickness of the entire series of limestone is 750

In the railroad cut the limestone is shown, and, a little to the south of them, cleaved slates the bedding of which strikes east and west (Mag.) and dips 10° south. There is an interval of 20 feet between the limestone and slates covered by debris. The limestone appears to pass beneath the slates, and from the areal distribution of the slates and limestone to the south and southwest it is probable that this upper band of slates has a wide distribution; its thickness is unknown.

An area of quartzite, No. 2 of section, is colored on the map two miles N. W. of Emigsville as of the same age as the Hellam quartzite. It is, as we now know, a thinner belt of quartzite resting in the calcareous and sandy shales above the quartzite of the Hellam hills. The next point determined was the actual relation of the Olenellus quartzite at Emigs-

ville with the massive Scolithus quartzite of the Hellam hills. In passing from Pleasureville towards York, on the steep side hill two miles west of York there are exposures in the roadside of shales and calcareous sandstone above the massive quartzite of the Hellam hills. At a point probably 100 feet beneath the ferriferous shale in which the numerous ore pits occur on the south side of the Hellam hills, a species of *Obolella*, very closely allied to *Obolella crassa*, and fragments of Olenellus were found in the decomposed calcareous sandstone. At a locality about one mile south of Mt. Zion church, in Hellam township, and four miles northeast of York, numerous specimens of *Camerella minor* and fragments of Olenellus occur in a calcareous quartzite identical in character with that of the Emigsville section. These two localities prove that the Scolithus quartzites of the Hellam hills and of "Chiques Rock" are beneath the Olenellus calcareous quartzite of the Emigsville section and, therefore, of Lower Cambrian age.

Search was next made for fossils near the base of the limestone above the ferriferous shales resting on the quartzites of Hellam hills. They were found at a short distance above the shales in a small quarry of thin-bedded limestone by the roadside, one and one-eighth miles north of Stoner's station on the York & Wrightsville railway. The strike is a little north of west, and dip 45° south. Finely preserved specimens of Linnarssonia, closely allied to *Linnarssonia sagittalis* are abundant, and easily recognized fragments of a species of Olenellus are associated with them. Crossing the section to the south, occasional exposures were seen of massive bedded, light-colored limestones, much of the same character as those exposed in the quarries north of Wrightsville three miles to the eastward. The dip increased to 85° at the railroad track, which indicated that a compressed synclinal had been passed over in the section. The only locality where fossils were found within the main body of the limestone in York County was one and one-half miles southwest of the public square at York, Pa., on the north side of Highland Park. The species recognized are: one closely allied to *Olenoides Marcoui*, *Protypus senectus*, and two species of Ptychoparia, all of which belong to the Lower Cambrian fauna. When examining the section on the east side of the Susquehanna, in Lancaster county south of Columbia and north of Washington Manor, with Messrs. A. Wanner and Arthur Keith, a locality of lower Cambrian fossils was found in a narrow belt of limestone about half a mile north of Washington Manor. *Hyolithes communis* and fragments of Olenellus showing portions of the head and thoracic segments were recognized in the material collected.

A glance at Dr. Frazer's map of York county shows that it is probable that all of the limestones, quartzites and schists of the central portion of the country are of Lower Cambrian age. The Hellam quartzite ridge is, as stated by Dr. Frazer, evidently an anticlinal ridge broken on the northwest side by a fault that has brought the quartzite up against the higher horizons of the shales and limestones. The anticlinal structure apparently extends to the southwest past York and towards Hanover.*

The discovery of Lower Cambrian fossils in the compressed synclinal of limestone in Lancaster county, south of Columbia, indicates that the limestone on the west side of the river is of the same geological age; and that the shales and schists beneath it (called chlorite schists, etc., by Frazer) are of Lower Cambrian age; and I doubt if there is a sedimentary rock,—other than the Mesozoic New Red sandstone—of later age than the Cambrian in York county, unless it may possibly be the Peach Bottom slate and chlorite schists of the southeastern corner of the county; and from the closely related structure of Lancaster county it is probable that all of the Lancaster limestones will fall within the Cambrian unless it be that some portions of the upper series of limestone may pass into the Ordovician. This generalization will also apply to the limestones of the adjoining counties of Berks and Chester and, in fact, to the entire extension of this series northeastward, to the Delaware. All of the quartzites, that have been referred to the Potsdam, will necessarily fall into the Lower Cambrian, as they are beneath the limestones.

When it is once considered that the quartzites, called the Potsdam by the Pennsylvania Survey, are of Lower Cambrian age; that a series of shales and limestones, superjacent to these, are of Lower Cambrian age: that the Potsdam horizon of the New York series is represented by limestones in the Auroral series of Rogers; and that the Calciferous-Chazy terrane of the New York section is represented only by the upper portions of the Auroral limestones, geologists will have little difficulty in determining the geologic horizons of the various outcrops of quartzites, schists, shales and limestones,—provided careful attention is paid to their sedimentary character and to the discovery of occasional localities of fossils.

South Mountain.

Prof. Lesley states that "the South Mountains," separating the Cumberland valley from the lower country of York and

*Southeast of the Hellam hills the limestones appear to form a compressed synclinal and this structure may extend to Hanover and beyond to the S.W. My time was too limited to study the details of structure off of the line of the sections mentioned in these notes.

Adams counties, form the northernmost end of the Blue Ridge range of Virginia. . . . . The whole measures upon the map ten miles in breadth by fifty in length upon a curve extending from the Maryland line to its eastern edge, fifteen miles west of Harrisburg.*

From the Pennsylvania line southwest across Maryland, South Mountain extends, as the Blue Ridge, to Harper's Ferry, and thence southwest across Virginia. It, also, practically includes the Cotoctin range, on the eastern side, which extends south from the southwestern portion of Adams county, Pennsylvania, and crosses the Potomac at the Point of Rocks, and from thence extends south a little west of Leesburgh, Va. The Blue Ridge and the Cotoctin Ridge are the eastern and western sides of the mountain uplift of which the South Mountain, Pennsylvania, is the northern terminus.

The classification of the rocks of Pennsylvania was summed up by Prof. H. D. Rogers as follows:—The Hypozoic rocks, or those *underneath* any life-bearing strata; Azoic, or those destitute of any discovered relics of life; and Paleozoic, or those entombing the remains of the earth's most extinct forms once living beings.†

It is evident from Prof. Rogers' definition of the Azoic group, that it included what we now recognize as the lower Cambrian sedimentary strata beneath the Scolithus quartzite and, also an extended series of altered rocks that form the nucleus of the Blue Ridge, and which are now included in the Algonkian of the classification of the U. S. Geological Survey. He regarded the sandstone with *Scolithus linearis* as at the base of the Paleozoic series, and considered that the Primal slates beneath the sandstone, and in intimate alternation with it, did not possess a vestige of organic life.

The conclusions of the geologists of the second geological survey of Pennsylvania, are that there are two groups of rocks forming South Mountain.

Prof. Lesley says: "The northwestern (Mt. Holly) ridge is made by several thousand feet of the lower quartzite and quartz conglomerate beds. The southeastern (Adams county) ridges are made by several thousand feet of an overlying feldspathic, micaceous and chlorite series, intersected by veins of milky quartz."‡ . . . . "It is hard to avoid the inference that our South Mountain rocks represent the Huronian section of Murray and Logan. It is impossible not to compare them also with

* Second Geol. Survey of Penn. A summary description of the geology of Penn., vol. i, 1892, p. 142.

† The Geology of Pennsylvania, vol. i, 1858, p. 64.

‡ Second Geol. Surv. of Penn. A summary description of the geology of Pennsylvania, vol. i, 1892, p. 144.

the great quartzite masses, the roofing slates, etc., of Walcott's upper, middle and lower Cambrian system."*

When I began the investigation to ascertain, by stratigraphic and paleontologic evidence, the geologic age of the South Mountain quartzite and the associated schists and slates, I soon discovered that there was very little prospect of finding the true geologic succession in the northern portion of the mountain, in Cumberland and York counties, owing to the folding of the strata and also to the fact that there were a number of westward thrusts of lower on higher beds, and that as a result of this the central core of the Blue Ridge had been broken and thrust over on the Lower Cambrian beds and, also, in places, resting apparently conformably upon the latter,—all having an eastward dip. The discovery of Olenellus with *Hyolithes communis* in the massive quartzite series in the Mt. Holly ridge, just above Mt. Holly Springs in Cumberland county, proved that the great western mass of quartzites of South Mountain, with the interbedded shales, slates and conglomerates, were of *Lower* Cambrian age; but it did not throw light upon the geologic age of the orthofelsite series of Frazer and the epidotic rocks of Rogers. In company with Mr. Arthur Keith, of the U. S. Geological Survey, who had mapped the Harper's Ferry sheet, an examination was made across the ridges, from Mechanicstown, Md., to Monterey and westward to Pikesville, in Franklin county, Pennsylvania.

On entering the gorge, a little west of Mechanicstown, on the line of the Western Maryland R. R., an extended series of shales and slates was passed,—all having a very high dip to the southeast. About two miles from Mechanicstown, massive quartzites were observed with a high dip to the east, and, higher up in the gorge, there was a repetition of the slates found east of the quartzites. This section, from the dip of the quartzite, indicated a synclinal resting on a considerable thickness of slates and shales. A series of sections, by Mr. Keith, of the western, or Blue Ridge ridge extending from a point eleven miles south of Mechanicstown to Harper's Ferry, shows that this same synclinal structure prevails all along the ridge, and that a synclinal fold of massive sandstone forms the summit of the ridge, below which a series of shales rests unconformably upon the subjacent crystalline rocks.† The synclinal structure is also shown for the quartzites of the eastern or Cotoctin ridge.

From a point two and one-half miles west of Mechanicstown to Monterey, the road led across the epidotic schists of

* Loc. cit, pp. 147, 148.

† The structure of the Blue Ridge near Harper's Ferry. Bull. Geol. Soc. America, vol. ii, 1891, pls. 4 and 5.

the central mass of the range, which is now a mountain valley between the Cotoctin and Blue Ridge ridges. The schist extends to a point one-fourth to one-half a mile beyond the Blue Ridge station, on the Western Maryland R. R. Fragments of a rhyolite-like, porphyritic rock* were also seen, that probably represent the "bedded petrosilex" of Dr. Hunt, as shown two miles south of this Monterey road, near Foxville, Maryland. Going down the road beyond Pen Mar towards Pikesville, there was an apparent repetition of the section on the eastern side of the ridge, near Mechanicstown. Subsequently, an examination was made of the section from Monterey, Franklin county, Pennsylvania, to the valley on the line of the Waynesborough turnpike. Just west of Monterey a massive quartzite forms a plateau, upon which the Monterey hotel is situated. The dip of the quartzite is slightly to the northwest. A short distance beyond the toll-gate the dip to the northwest increases, and a series of sandy and argillaceous shales succeeds the quartzite. Following down the turnpike toward Waynesborough and near the foot of the ridge, these shales were found to pass beneath a light-colored, hard, compact quartzite dipping northwest, in which numerous remains of *Scolithus linearis* occur. By breaking the white quartzite many fragments of Olenellus showing parts of the head and thoracic segments were also found. In calcareo-arenaceous layers, just beneath the quartzite, fragments of Olenellus occur associated with specimens of *Camerella minor*. A series of more or less sandy shales next appears resting upon the Scolithus quartzite and having a northwesterly dip, toward the valley. Along the foot of the ridge, low hills of sandy shale and slate appear, capped with a thin-bedded calcareous quartzite or sandstone. In the latter, *Camerella minor*, *Hyolithes communis*, and fragments of Olenellus are abundant. A little west of these hills the limestones of the valley appear. In this limestone, *Kutorgina* n. sp., and fragments of the head and thoracic segments of Olenellus were found a little east of the road leading up the east branch of Little Antietam creek and about three miles east of Waynesborough.

If reference is now made to the York county section it will be seen that the upper portion of the Monterey section is essentially a repetition of it—from the Scolithus quartzite to the limestones of the valley. The same fossiliferous Scolithus quartzite passes beneath sandy shales and slates, in which are interbedded calcareous quartzites carrying the Olenellus fauna; these pass beneath the limestones of the valley in York county in which the Olenellus fauna occurs. In the Monterey

* The description of the volcanic rocks of South Mountain by Dr. G. H. Williams is contained in the following article, p. 482.

section, however, there is in addition a series of shales beneath the Scolithus quartzite. that rests upon a massive quartzite forming the summit of the Blue Ridge, west of Monterey and beneath this a bed of slates unconformable to the subjacent crystalline rocks.

The Blue Ridge was followed south into Maryland and crossed at several points before reaching Harper's Ferry. All of the section shows the synclinal structure of the slates and quartzites as represented by Messrs. Geiger and Keith, in their paper upon the structure of the Blue Ridge near Harper's Ferry.* South of Keedysville, Washington county, Maryland, the quartzite, capping the slate hills west of the main ridge, was observed to pass conformably beneath the limestone at Eakle's Mills, and *Hyolithes communis* and fragments of Olenellus were found in the calcareous quartzite. The relatively simple stratigraphic structure of the Monterey section is complicated at, and near, Harper's Ferry by the lower massive quartzite forming a synclinal and being thrust to the westward over the more recent shales, slates and limestones. The structure is still more complicated by the fact that the hills of sandy shale and slate (capped by the upper Olenellus quartzite) are thrust, on the line of a fault, over on to limestones which, in an unbroken section, rest upon the quartzites.

It was this primary folding and subsequent westward thrusting, on the line of two or more faults, of the older upon the more recent strata at and to the north and south of Harper's Ferry that led Messrs. Geiger and Keith to consider that the lower quartzites rested conformably upon the limestones and were of Silurian age.†

Returning to South Mountain with the information gained between the Potomac and the line of the Chambersburgh and Gettysburgh pike, in Pennsylvania, and studying Dr. Frazer's sections (Nos. 7, 8, 9, 10, 11 and 13)‡ and also reading the descriptions of them, as well as Professor Lesley's description of South Mountain (contained in Vol. I of his final report), it is evident that they have misinterpreted the true geologic structure of the mountain and the relations of the rocks composing it. Professor Lesley states that a massive fault must run along the foot of the mountain, along the low drift-filled valley of Yellow Breeches creek; and this I think is correct, as the Olenellus fauna of the Scolithus quartzite zone occurs but a short distance east of the foot of the mountain, in a syn-

* Bull. Geol. Soc. America, vol. ii, 1891, pls. 4 and 5.

† Loc. cit., pls. 4 and 5. A paper by Mr. Arthur Keith describing his present view of the structure will be found in the Dec. No. of the Am. Geologist for 1892.

‡ Second Geol. Surv. Pa. Report of Progress in the counties of York, Adams, Cumberland and Franklin for 1875 published 1877.

clinal fold, at Mt. Holly Springs. Their error, however, is in considering that the "orthofelsite" series is superior to the conglomerates, quartzites and schists which they referred to the Lower series. The Monterey section shows that the epidotic schists are inferior to the quartzites and slates and, a section west of Wolfsville, Md., that the "petrosilex" or rhyolite-like eruptive occupies a similar position. This type of section is repeated many times, both on the Cotoctin and Blue Ridge sides, from the Maryland line to the Potomac and south through Virginia.

Professor Rogers and also Professor Lesley, referred the offsets of the ranges of hills of South Mountain, as shown in Franklin county and also on the north end of South Mountain, to the terminations of successive folds of the rocks forming the mountain. My impression is that these offsets and also the complicated structure of the mountain arise partly from folding, but more largely from the westward thrusts of masses of strata along the line of faults of a low hade. This westward thrusting on the fault planes, complicated by previous foldings of strata, leaves masses of the subjacent pre-Paleozoic rocks resting, in various places, on different members of the lower Cambrian series, and also appears to interbed the quartzites and slates of the Cambrian in the schists, eruptives, etc., of the Algonkian.*

The key to the succession of the lower sedimentary rocks of Maryland and Pennsylvania is contained in the Balcony Falls section of Virginia, although it can now be determined by a study of the section at Monterey and to the south, along the Blue Ridge toward Harper's Ferry.

In a letter received from Professor Lesley and dated February 22d, 1891, he asks: "Is it impossible that there should be agreement between the Balcony Falls section of Virginia and the Mt. Holly Springs section, three hundred miles apart?" He says, further, after commenting upon the possible relations between the Balcony Falls section and that at South Mountain, in speaking of the strata of the Balcony Falls section: "But what is 2,000 feet or 2,500 feet to 10,000 feet to 20,000 feet of quartzites and slates making (apparently—not certainly—) the South Mountains? We are still in the dark about *super-* and *sub-*positions; about absence or presence of overturn rolls, etc. I am only greatly impressed with the broad fact that we seem

* From the finding of fragments of the eruptive rocks in the conglomerates at the base of the quartzite series, and from the numerous synclinals showing that the epidotic rocks and also certain rhyolitic eruptives are beneath the quartzite series I refer the similar rocks of South Mountain to a pre-Paleozoic age; and, as they are not of the character of the Laurentian crystalline complex, I would refer them to the Algonkian, but *not* correlate them with the Huronian or with any known division of that group of rocks.

to have the Huronian mass rising to view in the South Mountains of the Atlantic States."

I think that the view of Messrs. Frazer and Lesley that such great thicknesses of strata occur in South Mountain arises from the fact that these "great thicknesses" are but repetitions of both the Cambrian and pre-Cambrian strata from foldings and overthrust faultings and also from their not differentiating between the cleaved schistose eruptives of the Algonkian and the bedded and often cleaved sedimentaries of the lower Paleozoic.

The section at Monterey and along that portion of the Blue Ridge is roughly, as estimated from the data obtained by Mr. Keith to the south and from the Monterey section, reading from below upwards, as follows:

	Feet
1. Shales and slates, well shown near Mechanicstown, Maryland, and in numerous sections along the Blue Ridge ..... 300 feet to	400
2. Coarse-grained and bluish-gray quartzite ..... 1000 to	1200
At several localities the shales of (1) appear to be replaced by bands of conglomerate and shale; and many of the layers of (2) are conglomeritic to a greater or less extent.	
3. Sandy shale, with interbedded layers of quartzite	800
4. Scolithus quartzite, with interbedded calcareous sandstones and shales	500
Fossils:—*Camerella minor*, and fragments of Olenellus.	
5. Sandy shales, with a series of calcareous quartzite near the summit; about	450
Fossils:—*Camerella minor*, *Hyolithes communis*, and fragments of Olenellus.	
6. Mottled limestone, with intercalated sandy and shaly layers ..... 800 to	1000
Fossils:—*Kutorgina* n. sp., and fragments of Olenellus	
This portion of the section is succeeded by the valley limestone, more or less of the lower portion of which is probably of middle and upper Cambrian age.	

The section includes from 3,000 feet to 3,500 feet of sandstones and shales before reaching the limestones. In a number of localities a conglomerate was observed in the Lower sandstone series, in which fragments of the pre-Paleozoic crystalline rocks were imbedded. This phenomenon was observed on South Mountain, in the conglomerates mentioned by Prof. Lesley, and also along the Blue Ridge and the Cotoctin ridge to Harper's Ferry; the conglomerate character of the rock

varying very much in the character and size of the coarser material. The feldspathic character of these shales and sandstones is very distinctly marked beneath the Scolithus quartzite, both in the Balcony Falls and the Monterey sections.

If these two sections are compared with that at "Chiques Rock" and south to Columbia, in Lancaster county, Pa., it will be at once observed that the Scolithus quartzite, while the highest band of quartzite in the Balcony Falls and the Monterey sections, is the lowest in the "Chiques Rock" section which has the lower feldspathic sandstone and shales apparently above the Scolithus quartzite. It is from this fact that it is stated, in the first part of this paper, that the feldspathic sandstones and shales were thrust over on the Scolithus sandrock in the "Chiques Rocks" section.