

ART. IV.—*Notes on the Cambrian Rocks of Pennsylvania, from the Susquehanna to the Delaware;* by CHARLES D. WALCOTT.

IN a former paper a report was made of an examination of the lower Paleozoic rocks,\* from the Susquehanna to the Potomac, and now attention is called to some observations, made during the past field season, relating to the basal quartzites and limestones of the lower Paleozoic rocks that extend across Pennsylvania, from the Susquehanna river to the Delaware river and across New Jersey to Orange county, New York, on the north, and into Chester county, Pennsylvania, on the east.

In the paper mentioned it is stated that *Hyolithes communis* and fragments of *Olenellus* were recognized in the material collected from limestones in Lancaster county, on the east side of the Susquehanna river,† and that, from the closely related stratigraphic arrangement of the rocks of Lancaster county, it is probable that all the Lancaster limestones will fall within the Cambrian, unless it be that some portion of the upper series may pass into the Ordovician. This generalization will also apply to the limestone in 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.‡

Prof. A. Wanner, of York, Pa., accompanied me in the examination of the limestones about the city of Lancaster. His familiarity with the positions of the quarries and natural outcrops enabled us to make a rapid examination of the limestones along Conestoga creek, and, although no fossils were found, I saw no reason to think that the limestones were not of Cam-

\* Notes on the Cambrian rocks of Pennsylvania and Maryland, from the Susquehanna to the Potomac, this Journal, vol. xlv, 1892, p. 469.

† Loc. cit., p. 474.

‡ Loc. cit., p. 475.

brian age. We next proceeded to the eastern side of the county, where the southern division of the limestone passes into Chester county. An examination was made of the lower quartzites and the superjacent limestones at Gap, Limeville and towards Compassville. A few *Scolithus* borings were noted in the quartzites northeast of Gap, and fragments of *Olenellus* and specimens of *Obolella* were found in sandy layers embedded in a shale one mile N.NE. of Gap. The section from the top downward, from a point a little east of Gap northwest, is:—

5. Massive-bedded, light-colored limestone with partings and small, interbedded, flattened nodules of mica schist.
4. Narrow belt of hydromica schist, with thin layers of hard calcareous sandstone containing *Obolella* and fragments of *Olenellus*.
3. Massive beds of bluish-black and nearly white limestone, extensively quarried at Limeville.
2. Narrow belt of shale altered to a hydro-mica schist.
1. Quartzite, in the hill northeast of Gap.

We next visited the extensive quarries at Bellemont, on the main line of the Pennsylvania railroad, four miles west of Gap. In the quarries the conglomerate limestone, so characteristic of the Cambrian at Stoner's station in York county, are beautifully exposed, and numerous photographs were taken of the conglomerate beds, showing their positions between the evenly-bedded limestones. The limestones and conglomerates belong to (3) of the Gap section, and are overlain by a belt of shale in which massive beds of a fine, limestone conglomerate occur. No time was given to searching for fossils.

The discovery of the *Olenellus* fauna in the limestone in the eastern portion of Lancaster county, north of Gap, taken in connection with the eastern section in York county, compels the reference of the so-called Potsdam rocks of Chester county with their superjacent limestones to the Cambrian. As mentioned in the previous paper, it is quite probable that the limestones towards the Triassic area, in the northern portion of Lancaster county, may be of Ordovician age, but this can only be proven by the discovery of the fauna.

*Northern belt of Limestone.*—As shown by the geological map of Pennsylvania (1884), the northern belt of limestone enters the State in Franklin county and then turns to the northeast in Cumberland county, crosses the Susquehanna at Harrisburg and extends on eastward across Dauphin, Lebanon, Berks, Lehigh and Northampton counties, to the Delaware river. The *Olenellus* fauna was found in the quartzites of South mountain in Adams county, as well as in the lower por-

tions of the limestone in Franklin county.\* From this and the fact that the lower portions of these limestones and the superjacent quartzites or sandstones were known to be of lower Cambrian age in their extension into New Jersey, I began the examination of them in the vicinity of Reading, where their relations to the Reading sandstone are well defined. The *Scolithus linearis* occurs abundantly in the quartzites of Penn mountain, east of Reading, and on the south side of Neversink mountain across the Schuylkill. In the upper layers of the sandstone or quartzite I obtained *Hyolithellus micans* and fragments of a species of *Olenellus*. This locality is about one-half mile above Klappenthal station, on the Philadelphia & Reading railroad, and the terminal station of the electric road running out of Reading over the Neversink mountain. West of the first railroad cut above the station thinner beds of quartzite are met with, between the cut and the stone-crusher that carry fossils. The quartzites are more or less contorted and folded, but their stratigraphic relations to the main quartzites of the mountain and to the adjoining limestones are readily determined. No fossils were observed in the limestones.

The sections in the vicinity of Allentown and Bethlehem were examined and found to be essentially the same as at Reading, the quartzites passing beneath the limestone. In the quarries at Catasauqua, four miles north of Allentown, I noted the occurrence of a large *Pleurotomaria*, of the type of *Pleurotomaria canadensis*, of the Calciferous horizon in New York and Canada. In the report of the Second Pennsylvania Geological Survey of Lehigh and Northampton counties the localities of fossils are all on the northern side of the outcrop of limestone, in the strata that dip to the northward beneath the superjacent shales. The Trenton horizon is represented in the limestone immediately beneath the shales (called "Hudson"), and lower down, in massive limestone, species of *Maclurea* or *Euomphalus* have been found that indicate the Chazy horizon. This distribution of faunas is the same as in Franklin county, where the lower Cambrian fauna occurs at the base of the limestone near the quartzites, and the Trenton fauna at the summit, near the base of the superjacent shales.

The limestones were examined in the vicinity of Easton, along Bushkill creek and the shores of the Delaware river. No fossils were found with the exception of a species of *Cryptozoan*: but from the similarity of the limestone to that of the lower portion of the series near Allentown, Reading and in Lancaster country, it is quite probable that they represent the lower or Cambrian portion of the section. Five or six miles north of Easton, in the vicinity of Churchville, fossils were

\* Loc. cit., p. 478.

discovered by the Pennsylvania survey that indicate the Trenton horizon. I think it is only a matter of detailed search and patience to discover localities of fossils, both in quartzites and limestones throughout this belt, from where it enters the state from Maryland and crosses the Delaware into New Jersey.

If we follow on the line of the strike of the limestones across the Delaware into New Jersey, the same type of section is found to extend northeasterly across the state and into Orange county, N. Y. At Hardistonville, Sussex county, New Jersey, Dr. Beecher discovered the *Olenellus* fauna in the blue limestones resting on the basal quartzite.\* The fossils are found on the southeastern side of the limestone belt; and on the northwestern side the limestones dip beneath the shales as in the Pennsylvania section. In the geological report of New Jersey for 1868, pp. 131, 132, numerous localities of the fossiliferous Trenton limestone are described, and a section given showing the limestone passing beneath the shales to the westward.

The discovery of the *Olenellus* or lower Cambrian fauna in the Reading sandstone practically completes the correlation of the South mountain, Chickis and Reading quartzites of Pennsylvania and establishes the correctness of the early correlations of McClure, Eaton, Emmons, and Rogers. They all considered the basal quartzite as the same formation from Vermont to Tennessee; and the discoveries of recent years have proven that the basal sandstone of Alabama, Tennessee, and Virginia (Chilhowee quartzite); Maryland, Pennsylvania and New Jersey (the Reading quartzite); New York and Vermont (Bennington quartzite); were all deposited in lower Cambrian time, and that they contain the characteristic *Olenellus* fauna throughout their geographic distribution. The superjacent limestones carry the *Olenellus* fauna in their lower portions, in northern and southern Vermont, eastern New York, New Jersey and Pennsylvania. To the south of Pennsylvania the lower portions of the limestones appear to be represented by shales, and the upper and middle Cambrian faunas are found in the lower half of the Knox dolomite series of Tennessee, and they will probably be discovered in the same series in Virginia and Maryland, when a thorough search is made for them. The same may be predicted, but with less assurance, for the Northern belt of limestone crossing Pennsylvania and into New Jersey, as the limestones between the *Olenellus* zone and the Trenton zone represent the intervals of the middle and upper Cambrian and the lower Ordovician, or the Calcareous and Chazy zones, of the New York section. The working out of

\* Geol. Surv. New Jersey: Ann. Rep. State Geologist, 1890, pp. 31, 43, 49.

the details of this section in southeastern Pennsylvania is an interesting problem, left for solution to some geologist who has the necessary paleontologic training and who will not be discouraged by the prospect of a good deal of hard work before the desired result can be obtained.

The problem of where to draw the line in this series of limestones, on a geological map, between the Cambrian and Ordovician, is one that will seriously embarrass the geologist, but I anticipate that either lithologic or paleontologic characters will be discovered by which the two groups can be differentiated. If not, the limestones must be colored as one lithologic unit or formation and the approximate line of demarkation between the Cambrian and Ordovician indicated in the columnar section accompanying the legend of the map.