ART. XII.—*Recent Explorations in the Wappinger Valley Limestone of Dutchess County, N. Y.;* by WILLIAM B. DWIGHT.

No. 5.—*Discovery of fossiliferous Potsdam Strata at Poughkeepsie, N. Y.* (Illustrated by a map, Plate VI.)*

THE presence of rocks of the Potsdam group in association with the limestones and shales of Dutchess County, N. Y., has long been suspected on stratigraphic grounds, but until the present time this fact has never been proved by positive paleontological evidence.

At the bases of Fishkill and Stissing Mountains, a thick stratum of quartzyte is found between the underlying Archean of those mountains, and the overlying limestones, now known to be respectively Calciferous and Trenton. This quartzyte shows planes of stratification, and is conformable to the overlying strata of limestone. Obviously, by its stratigraphic position, it appears to represent the Potsdam group, and this assignment has been made for it, in the localities mentioned, by Professor Mather, Professor J. D. Dana and others.

Notwithstanding that considerable search has been made, no fossils have yet been found in this quartzyte stratum, by which this reasonable hypothesis might be established. I am not aware that any geologist has heretofore found reason to suspect the presence of a Primordial stratum among the limestones of the region, and certainly I have had no such expectations myself. The observations made during the last few years in the Wappinger Valley (or "Barnegat") limestones, have definitely proved them to be composed extensively and continuously of conformable strata of the Calciferous and Trenton groups. In carrying out the work, in which I have for several years been engaged, of preparing a detailed stratigraphical chart, on April 25th of the present year, to my great surprise,

* Read before the American Association for the Advancement of Science, at Ann Arbor.

I struck a ledge of rock in the Wappinger Valley limestone belt, which proved rich in Potsdam fossils.

This remarkable locality is on an estate owned by Mr. Albert K. Smiley, proprietor of the Lake Mohonk House. It is in the outskirts of the city of Poughkeepsie, to the southeast. It is about one mile southwest of Vassar College, 850 feet south of the southwest corner of the Driving Park on Hooker avenue, and about 2200 feet west of the road which passes south along the east side of the same.

The Potsdam rocks are found in a series of low hills or ridges trending northeasterly and southwesterly in parallel lines. The most interesting paleontological features appear to be concentrated in a ridge lying at the northeast corner of the group (Hill A, Plate VI). This is situated immediately to the southwest of Smiley's detached barn, which is itself south of the southwest corner of the Driving Park. This hill is about 300 feet wide and 1400 feet long; it is mostly covered with soil, the rock cropping out on each side, but chiefly on the east, in a few narrow, quite inconspicuous ledges; it would never have attracted my attention but for its occurring within the range of a systematic survey.

Lithologically this Potsdam rock is exceedingly variable, and all the varieties described occur within the small compass of a few acres of ground. It is everywhere (so far as already examined) calcareous, all its varieties effervescing with acids. It is also everywhere more or less arenaceous; often conspicuously such. Large portions of it are a tough, compact limestone, often quite dark, and frequently filled with a conspicuous fucoid-like tracery; the weathered surfaces are often rough with sand-grains. This variety passes into one which differs chiefly in being fissile into more or less thin slabs; this variety often alternates with layers of exceedingly thin and friable shale, the folia of which are covered with loose sand as they decompose.

The rock also passes on the one hand into argillaceous varieties represented by a smooth, fine-grained, massive argillaceous limestone well exhibited on the west side of the main fossiliferous hill; and represented also by a very fissile and smooth calcareous shale, well shown in a hill (E) which is a continuation, in the second field south, of the above-mentioned hill. Although nearly as fissile, this variety differs essentially in appearance from the closely adjoining Hudson River shales, which are much darker, and more glazed or shining on their surfaces. On the other hand, this Potsdam rock passes into a very solid, massive quartzyte, the fine sand-grains of which are everywhere in absolute contact, so that in appearance it is only a grade less compact than the quartzyte of Stissing Mountain;

but the minute interstices are occupied by calcareous material, so that the rock effervesces a little under acids.

In many places, again, the material takes the form of brecciated conglomerate; this is well shown in the western Potsdam hill at the northern extremity of the tract under consideration (Hill B), and its extension south into the next field (Hill D); also in the western marginal Potsdam ridge just south of T. A. Hinkle's house in the next field.

The southeastern extremity or fork of the main fossiliferous hill (A) is a solid mass of peculiar oölyte, made up of spherules which are simply aggregations of rhomboidal calcite crystals imbedded in the interstitial mass of quartzyte or calcareous quartzyte. I have found pebbles of this peculiar oölyte in the conglomerate above mentioned in the ridges of the western margin, suggesting a later date of deposition for the latter. In many places these Potsdam rocks exhibit very distinctly oblique lamination.

The strike and the dip are quite variable. The most general strike of these Primordial strata appears to be about N. 21 E. (true), and the most general dip about 55° easterly. Some further statements as to local variations will be given subsequently.

In order to determine the true stratigraphic relations of these Potsdam and related strata, I have made a special detailed examination of a district covering about a mile and a half square in the vicinity of this locality, and embracing about a mile and a quarter of longitudinal extension in the direction of the strike. This district is mapped in Plate VI.

This Potsdam rock is one of the component members of the most western, and by far the broadest of three parallel belts of the Wappinger Valley limestones, which, in this vicinity, rise between the Hudson River shales. In general, all these limestones and shales lie in a series of abraded folds, having usually a conformable strike of from N. 20° E. to N. 30° E. These folds are closely compressed, and pushed over to the west, so that the earlier limestones usually overlie by inversion the later shales lying to the west of them.

The particular belt of limestone which stretches southwest from the Driving Park is about 3500 feet in width at its northern extremity, and about 6000 feet wide at the southern portion of the limited district now under consideration. This southern transverse line of 6000 feet passes through the middle of the estate of W. S. Johnston on the Albany Post Road.

This belt terminates toward the north, quite abruptly, along an almost straight line which cuts it apparently at a right angle to the strike. This line runs along the southern margin of the Driving Park, continues east through the fields parallel to Hooker avenue till it meets the Hudson River shale in the

meadows of Casper Creek. Immediately north of the Driving Park, in fields on the north side of Hooker avenue (locality O, plate VI), in place of limestone there are hills of Hudson River shale, and this same rock crops out along Hooker avenue to the west all the way to Casper Creek and beyond. From this line these shales continue unbroken many miles to the north beyond Hyde Park. Along this northeasterly and southwesterly line, the intervening space between the outcrops of shale on the north and of limestones on the south consists of a mostly level strip of drift having bogs and springs along its southern edge. Evidently this is a line of fault, across the strike, between the Hudson River shales on the north and the Potsdam, with its associated Calciferous and Trenton, on the south. This trough, cut through the hilly ridges, is a conspicuous feature in the local landscape. It is made available for traffic by the avenue that passes through it obliquely into the city; it furnishes the long and smooth plat (mostly underlain by the shales) which constitutes the Driving Park.

The stratigraphic relations of the western margin of the belt of Potsdam have proved far less obvious than those of its northern extremity. But after a careful detailed inspection of the ground, a correct solution, as I believe, has at last been reached. During the earlier examinations, Calciferous or Trenton strata were naturally looked for, in intervening folds, between the Potsdam and the Hudson River shales to the west. The western hill of conglomerate above mentioned (Hill B) and its southern extensions, were at first taken to be the Trenton coralline conglomerate which occurs abundantly in the vicinity. But on further investigation, two facts were developed which opposed this supposition. The first fact was that the lithological constitution differed entirely from that of the Trenton wholly-calcareous conglomerate, in being highly arenaceous, as also in the entire lack of the microscopic corals which abound in the Trenton. On the other hand, its lithological characters are quite in harmony with those of the adjoining ledges known to be Potsdam.

In the second place, an outcrop of the Hudson River shales was discovered close to the western base of this hill, within a few feet, thus marking the line as the actual western limit of the limestone. This limit is at the most but 300 feet west of the fossiliferous Potsdam strata, a space by no means sufficient to allow the presence of Calciferous and Trenton strata of the usual thickness exhibited in the region. A further study of all the phenomena makes it quite certain that the Potsdam extends to the western margin of this belt of limestone, in its entire southern extension through the district examined. This limestone margin (as traced from the north) is broken by three

or four jogs, as the belt widens to the west, until the field next south of T. A. Hinkle's cottage is reached; from that point it is nearly straight. Close to this line, at the distance of a few feet throughout its entire length, there are many outcrops of Hudson River shale which continue west to the Hudson River, unless Utica shales may occur at some points. The shales are in many places separated from the Potsdam limestone by lines of springs and ponds, or by dry gullies. From the extreme northern end, the plane of contact is marked by a line of ponds nearly to Hinkle's house. Close to this house, to the west of it, there is a deep gully, with the limestone on which the house stands, on the east, and the shales, standing nearly vertical in a bold exposure, on the west. This gully continues to mark the line to the southwest as far as the turn in the Ferris road, beyond which the demarcation is produced by a different but no less striking plan; for south of this point the limestone remains a high conspicuous ridge, abruptly steep on the western side, while the shales, mostly covered by drift, form a level plain at its base.

These facts make it evident that there is also a line of fault between the Potsdam and the Hudson River shales at the western margin of the limestone belt, more or less parallel to the strike. The general direction of this line of fault is about N. 40° E. The Potsdam strata near the line of contact are generally deflected in such a way as to have less easting in the strike, which is in such places from N. 4° E. to N. 11° E. Thus at the extreme north end of the main fossiliferous hill (A) the strike varies between the limits just given, while the dip becomes as low as 20°. At the hill of calcareous quartzyte in the third field south of the Driving. Park (Hill F) the strike is in some places N. 11° E., and the dip 35°.

On the other hand, the Hudson River shales incline to acquire more easting in the strike, in the vicinity of the plane of contact. In such cases they have quite frequently a strike of N. 46° E. (their general strike in the vicinity being about N. 31° E.). They also, in such positions, are often found inclined at a very high angle. These phenomena seem to indicate considerable friction by a lateral motion in a northeasterly and southwesterly direction, as well as in the upward motion, at the time of the uplift of the Potsdam. This fault is the more interesting, because it is evidently related to the great fault described by Sir William Logan and Professor James Hall as extending from Quebec to the Hudson River near Rhinebeck. If, as has been suggested by Professor J. D. Dana, this should more properly be regarded as a series of more or less parallel faults, the present one would constitute the most southern one of the series yet described.

With regard to the eastern boundary line of this strip of Potsdam nothing definite can be determined from present data. There are no fossils to indicate the points of transition to the Calciferous and Trenton, which doubtless lie in abundant development to the east. The uncertainty is increased by the fact that a great part of the rock is deeply buried under drift. Thus, at the northern extremity, east of the fossiliferous Potsdam, after about six hundred feet of strata (which are probably to some extent at least of the same group), the limestone entirely disappears under a large hill of more than fifty feet depth of drift in A. Vanderberg's farm. (This hill is so covered with debris of Hudson River shale that one might readily suppose it to be the rock in place.) The limestone does not reappear until the southeastern base of Richmond Hill on Casper Creek is reached. That this eastern margin of the belt is Trenton is proved by a distinct outcrop of fossiliferous Trenton filled with *Solenopora compacta* ("*Chætetes compacta*") appearing in a small patch on a hillside 520 feet from the house of R. J. Kimlin on a course of N. 101° E. The Calciferous is doubtless extensively represented between the Trenton and the Potsdam, but this has not been paleontologically determined.

In view of the above facts, I can make only the general statement that the minimum width of the belt of Potsdam strata, measured on the surface of the ground, is somewhat over 600 feet. If, as seems probable, there is at least one compressed fold, the actual thickness of the deposit must be over 300 feet.

It is my present impression that the Potsdam folds occupy, as indicated on the accompanying map, a strip of about 1400 feet in width, and that the high and continuous limestone hill (K) on the east of this strip may form the western margin of the Calciferous strata. In this case the small quarry in the field of W. S. Johnston, at the southeastern portion of the district (H), would be near the eastern edge of the Potsdam. This view is strengthened by the fact that lines of ponds and springs exist conspicuously along the base of this long eastern hill, indicating a possible break or slip between strata along this line. But as fossils have not yet been found in the last mentioned hill, nothing more positive can be asserted in this connection at present.

A brief description may now be given of the paleontological features of these strata.

In the fossiliferous hill above described (A), organic remains are found chiefly on the eastern side near the summit in the southern half, though not in the oölytic portion. They occur both in the solid fissile limestone, and in thin layers of shale

associated with it. The fossils are present in considerable numbers, but so much scattered through the rock that large masses must be broken up to obtain a few organisms.

I have also found a few specimens of Lingulepis in the extension of the western fork of this hill in the second and third fields beyond, where it becomes a blue calcareous shale (E).

No fossils have yet appeared south of Mr. Smiley's property, that is, south of the fourth field from the Driving Park, except some Stromatoporoid forms which are not infrequent throughout the Potsdam strata. From these localities I have already collected over 500 fossils; some of these are in a perfect state of preservation, while many are in a very imperfect and fragmentary condition. There is no doubt whatever as to the presence among them of several well-known and well-marked Potsdam fossils, while the whole group appears to belong to that geological horizon. Since, in my explorations among these limestones during seven years, all of the abundant fossils found have indicated the presence of either the Calciferous or of the Trenton formations alone, I have not failed to consider the question carefully whether the present fossils, though of a Potsdam type, may not after all exist here in Calciferous strata. But I have found no facts to favor the latter supposition. The rock is lithologically considerably different from any known fossil-bearing Calciferous in Dutchess County. The fossils are all of the type so well known in the Potsdam rocks of New York State and of Wisconsin, while no single Trenton or Calciferous fossil of the vicinity or of any locality, has appeared among the hundreds here collected.

These fossils will require a very careful study for a full determination as to the number of genera and species. The following preliminary statement will indicate their nature in general.

1. *Lingulepis pinniformis;* several specimens of both valves, some of which are quite perfect.
2. *Lingulepis minima;* many specimens of both valves.
3. *Lingulepis acuminata*, probably; several good specimens.
4. *Obolella* (*Lingulella*) *prima;* several specimens.
5. *Obolella;* a minute species resembling "*Nana;*" one or two specimens.
6. *Platyceras;* undescribed species; one or two.
7. Remains of small encrinal columns; several.
8. *Ptychoparia* (*Conocephalites*); n. sp. resembling *Iowensis*, but possessing an occipital spine; several glabellas and pygidia.
9. *Dicellocephalus;* two or more species; undetermined; numerous specimens.
10. *Ptychaspis;* one or more undetermined species; several specimens.
11. *Stromatocerium?* undetermined; abundant.

The more abundant of these fossils are the *L. minima*, whose fragments are thickly scattered through some portions of the shaly limestone, and next the movable cheeks of trilobites.

It will be observed, as has been suggested to me by Mr. R. P. Whitfield, that the fauna of this locality forms a connecting link between the known fossils of the Appalachian region and those of the Western States. Thus with the *Lingulepis minima* and *L. acuminata* of the New York Potsdam is found the *Lingulepis pinniformis* of Wisconsin and other western localities.

It may also be remarked that the fauna of this Poughkeepsie locality, as far as at present developed, is quite distinct from that of the Potsdam strata recently discovered by Mr. S. W. Ford at Schodack Landing and other places in the town of Stuyvesant, N. Y. From these localities, lying about fifty miles north of Poughkeepsie, Mr. Ford reports (this Journal, July, 1884) the following eleven species: *Paleophycus incipiens*, *Obolella crassa*, *Stenotheca rugosa*, *Hyolithes Americanus*, *H. impar*, *Hyolithellus micans*, *Microdiscus lobatus*, *M. speciosus*, *Conocoryphe trilineata*, *Olenellus asaphoides*, and *Fordilla Troyensis*.

No one of the above list has been found at Poughkeepsie; the distinctive character of the two faunæ is evident, the latter apparently representing an earlier stage of life.

The discovery of the presence of fossiliferous Primordial rocks among the Wappinger Valley limestones, while it adds an extremely interesting feature to the geology of the region, contributes another complication to the difficult task of mastering the stratigraphy of Dutchess County.

Vassar College, Poughkeepsie, N. Y., June 25, 1885.

NOTE.—Since the above paper was written I have conducted these researches further, and have traced the continuation southerly of the fault between the Potsdam and Hudson River shale to the bank of the Hudson River. This line, which had been traced previously only into W. S. Johnston's farm, has been found to continue, well marked as before by ponds and gullies, in a straight line till it crosses the Albany post road at the corner of the New Hackensack road near School House No. 2. On the west side of the post road it passes straight across R. T. Gill's farm, then crossing the road leading to the Milton Ferry, and striking between the two roads leading in a southwesterly direction to the river. It terminates finally in a high bluff on the river near Mallory's Moulding Sand Dock and about one mile north of Clinton Point post office. Throughout this course the Primordial limestone and the shales show themselves frequently in close proximity in outcrops. In Gill's farm both formations are mostly covered by hills of drift, but on this farm, just north of the Milton Ferry road, both the Potsdam limestone (here as calcareous shale) and the Hudson River shales crop out distinctly. The latter yield at this locality some very excellent and characteristic fossils, as encrinal columns, *Leptæna sericea*, etc. The terminal bluff at the river is composed of *both* formations, the fault running along its summit, but near the northwestern edge. As the extreme southwestern point of the bluff is reached, the line of fault drops down its northwestern side, and the shales at last disappear, leaving the point in possession of the limestone. After careful examination I am satisfied that some, if not all, of the moulding sand is produced by the decomposition of the arenaceous Potsdam. Indeed, the process may now be seen going on

in the layers of the sandy limestone. It is very probable that the Potsdam may now be further traced across the Hudson River somewhere near Marlborough.

In Plate VI will be found a small map showing the entire extent of the fault above described.

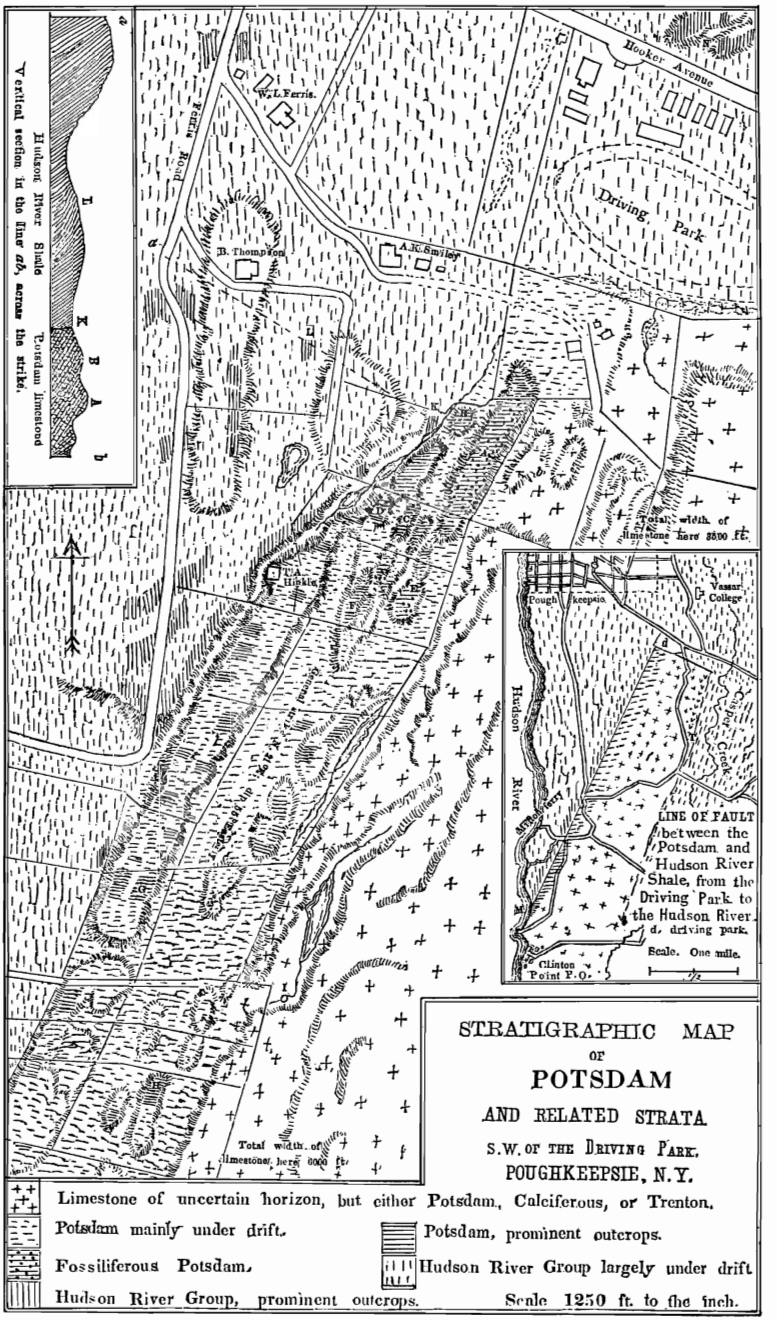
It is proper to state here that I have strong reason to suspect the presence of a parallel belt of Potsdam limestone, more than a mile to the east of the present one, in the most eastern of the three belts of limestone. The particular locality which has furnished grounds for the above statement is on the summit of the ridge about half a mile southerly from the mansion on the MacPherson (late Boardman) place. The rock corresponds closely in its lithological characters with that of the Smiley locality. I have found here but a single fossil—about half of one valve of a brachiopod, which as far as it goes corresponds perfectly with *Lingulepis pinniformis*. I believe it to be this fossil, and that consequently the rock is Primordial, but cannot say that the evidence is absolutely conclusive.

EXPLANATION OF PLATE.

A, Hill of fossiliferous Potsdam on Smiley's farm.
B, Hill of Potsdam, partially conglomerate, on Smiley's farm.
D, C, extensions of hill B. D is largely conglomerate.
E. Hill containing much fine-grained, blue, thinly fissile calcareous shale of the Potsdam group: a few specimens of *Lingulepis pinniformis* have been found here.
F. Calcareous quartzyte, Potsdam group.

The lane between the wall and fence just south of the hills E and F is the southern boundary of Mr. Smiley's farm; at present date no Potsdam fossils, except stromatocerium, have been found in this belt south of this line.

G, one of the best localities for inspecting the Potsdam limestone and calcareous shale composing this long hill. Stromatocerium is found here. From the summit of this hill a good view is presented of the wide plain of Hudson River shale which extends westward from its base.
H, a small quarry of arenaceous limestone apparently Potsdam, in the field belonging to W. S. Johnston.
I, a high ridge of light- and dark-colored limestones, well exhibited at the spring here indicated; horizon of the rocks doubtful.
K, outcrops of Hudson River shale at the surface of the ground within a few feet of the Potsdam hill B.
L, small quarry of compact, gritty layers of the Hudson River group, dipping at a low angle.
O, hilly outcrops of Hudson River shale in field north of the driving park.
M, (in small included map), molding sand, and dock.
T, (in small included map), outcrops of fossiliferous Trenton on the eastern margin of this limestone belt.


Booker Avenue
W. L. Ferris.
Driving Park
B. Thompkins
A. C. Smiley
Total width of limestone here 3500 ft.
Vassar College
Poughkeepsie
Hudson River
LINE OF FAULT between the Potsdam and Hudson River Shale, from the Driving Park to the Hudson River.
d. driving park.
Scale. One mile.
Clinton Point P.O.
Total width of limestone here 9000 ft.
Hudson River Shale
Potsdam limestone
Vertical section in the line ab, across the strike.
STRATIGRAPHIC MAP
OF
POTSDAM
AND RELATED STRATA
S.W. OF THE DRIVING PARK,
POUGHKEEPSIE, N.Y.
Limestone of uncertain horizon, but either Potsdam, Calciferous, or Trenton.
Potsdam mainly under drift.
Potsdam, prominent outcrops.
Fossiliferous Potsdam.
Hudson River Group largely under drift
Hudson River Group, prominent outcrops.
Scale 1250 ft. to the inch.