AMERICAN JOURNAL OF SCIENCE

JANUARY 1934

STRATIGRAPHY OF THE HAMILTON GROUP OF EASTERN NEW YORK.

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PART II.

Moscow Formation.

Happily the Portland Point, basal member of the Moscow formation, was traced into Susquehanna Valley, and from there eastward through Schoharie Valley into the red beds at Potter Hollow not far northwest of the village of Durham, Greene County. At Milford, eight miles south of Cooperstown, the Portland Point is splendidly exposed in the bed and banks of Hinman Hollow Brook, where it is a hard, coarse, bluish, massive, calcareous sandstone. In the basal bed at this exposure *Vitulina pustulosa* and *Centronella impressa* are fairly common, the latter ranging through the whole six feet of the member. Somewhat diminished in thickness the Portland Point is present in Bear Gulch just north of Summit and was traced three miles eastward to a small tributary of Panther Creek on the property of Tobias Wayman. Here it measured four feet in thickness, the lower one and one-half feet being mostly thin, calcareous sandstone lenses in arenaceous shale and containing *Vitulina pustulosa* in some abundance. From here the bed was traced into Schoharie Valley where it is exposed along the old road up Mill Creek, one and one-half miles west of North Blenheim. This locality exposes the "pebble bed" of Prosser,[12] which is the Portland Point. Thence it was followed to a gully one mile southwest of North Blenheim, on the west side of the valley, and to a gully three-fourths of a mile southeast of the same village on the east side of the valley. At these localities the Portland Point consists of coarse sandstone and quartz pebbles, some of them two inches in diameter, and contains fossils in great abundance. *Centronella impressa* was discovered but *Vitulina* could not be

[12] N. Y. St. Geol. Ann. Rep. 15, pp. 202, 203, 1897.

found. Despite the absence of *Vitulina*, all of the other fossils corroborated the identification of this bed as Portland Point. Among other species found were: *Eunella lincklaeni, Rhipidomella vanuxemi, Cypricardella bellistriata, Actinopteria decussata*, all rare or unknown elsewhere in the valley.

On a small tributary of Catskill Creek one and six-tenths miles southwest of Potter Hollow, Durham Quadrangle is an exposure of some ten and one-half feet of coarse sandstone at the base of which is about one foot of conglomerate. In this conglomerate *Centronella* occurs together with a few fossils which are of little value for correlation. Above the sandstones are soft bluish shales containing large numbers of pelecypods, among them *Cypricardella bellistriata* common elsewhere in the base of the Windom only. The writer believes that the sandstones with *Centronella* are to be correlated with the Portland Point. The basis for this correlation is:

1. These sandstones are on the strike and dip of the undoubted Portland Point which lies farther to the northwest.
2. In Schoharie Valley *Cypricardella bellistriata* was discovered at two horizons only, in and immediately above the Portland Point.
3. The Centronellas are of the large type characteristic of the Portland Point.

Against these arguments may be raised the point that *Centronella* is a facies fossil occurring elsewhere in several of the coarse sandstones, and, therefore, of little value in correlation. However, all of the centronellas observed by the writer in beds outside of the Portland Point average smaller than *C. impressa* and appear to be a new species. If the suggested correlation of the Portland Point at Potter Hollow be correct, it allows the redating of a good part of the red beds in the Catskill Front.

The Portland Point is a very valuable datum plane as it is continuous from Cayuga Lake to Schoharie Valley and Potter Hollow. Why is this bed so widespread and why does it not show the same type of facies relationships as the strata above and below it? A tentative suggestion to answer these questions follows. It is possible that this member was formed during a time of little or no deposition, a time of agitation of the sea-bottom, when fine material was swept away allowing only the coarser grains and testaceous animal debris to remain. Such an explanation may be the reason for the large amounts of crinoidal limestone and shell breccia at the base of the Portland Point. These features suggest an assorting action

on the sea-bottom, allowing the retention in situ of shell and crinoid remains only. If formed in this manner, the Portland Point may be looked upon as representing a minor break.

With the correlation of the Portland Point established it was an easy matter to follow the Windom member, which is the interval from the Portland Point to the top of the Hamilton. In Susquehanna Valley the Windom member is essentially like that of Unadilla Valley, but the faunal zones which are so clear in Chenango Valley become less easy to trace in Unadilla Valley and are nearly unrecognizable south of Milford in Susquehanna Valley. Traced eastward the Windom member becomes sandier and its fossils less abundant. In Summit Hill, one mile north of Summit, along Bear Gulch Pond and its outlet, the entire Windom is exposed. In this section there is a preponderance of argillaceous sandstone, much of it cross-bedded. Plant fragments are abundant. East of Summit the bulk of the Windom passes laterally into continental beds, the layers with the famous tree-stumps being near the middle of the member. Of interest, too, is the presence of the fresh-water clam *Amnigenia* (*Archanodon*) some sixty feet above the Portland Point.

In Otego and Susquehanna Valleys the top of the Windom is marked by the *Hypothyridina-Leiorhynchus mesacostale* zone of the Tully formation. The *Leiorhynchus* zone can be traced definitely as far east as Schenevus, and is recognizable, but not clearly so, to Summit Hill. East of here the top of the Windom could not be traced easily but is thought to be in the red beds on the Manorkill at West Conesville.

The *Vitulina* zone of the upper Windom can be traced continuously from Otisco Lake to Summit Hill, thus forming an exceedingly valuable datum plane for tracing the top of the Hamilton. Since *Hypothyridina* and *Leiorhynchus mesacostale* are difficult to find east of Susquehanna Valley the *Vitulina* zone was relied on for the detection of the top of the Hamilton. In Otego Valley the *Hypothyridina-Leiorhynchus* zone occurs sixty feet above the *Vitulina* and east of here as far as Schenevus *Leiorhynchus* alone occurs just below a storm-roller bed about sixty feet above *Vitulina*. At Summit Hill a storm-roller bed was found thirty-five feet above the *Vitulina* zone but no fossils were collected from it. *Leiorhynchus mesacostale* was seen fifty to sixty feet above *Vitulina* at the same place. East of Summit the writer failed to find *Vitulina* although an exhaustive search was made for it. The

determination of the top of the Hamilton, therefore, could not be made precisely. It has been drawn above a zone containing peculiar terebratuloids in abundance which is on the strike and dip of the *Vitulina* zone projected from Summit into Schoharie Valley.

The estimated thicknesses of the Windom member are: Susquehanna Valley, 409 feet; Bear Gulch to Summit Hill, 440 feet; and Schoharie Valley, 519 feet. East of Schoharie Valley the Windom has passed into red-beds and the thickness is unknown.

RED AND GREEN BEDS.

The subject of red and green beds is always one of interest and those of Schoharie Valley and eastward are no exception. In eastern New York the lowest red sediments have always been taken as the beginning of Oneonta sedimentation. Most geologists have been aware that these red beds increase in age as they are followed to the east, but few would be prepared to admit that some of them are of Hamilton age and actually rather early in the Hamilton. The lowest red beds seen in Schoharie Valley are those of the upper part of the Panther Mountain division exposed near the summit of Moheganter Mountain. The next red beds observed in the Hamilton are those along the road to Grand Gorge about three and one-half miles south of North Blenheim, which are in the position of the *Vitulina* zone and the Hamilton interval between this zone and the true top of the Hamilton. The red beds of Manorkill gorge are in the top of the Windom member.

On Berne Quadrangle the red beds appear still lower in the Hamilton than in the Moheganter Mountain section. In the ravine at Rensselaerville the fossiliferous Hamilton is succeeded by some forty feet of green beds. It is then followed by a mottled zone, and then by red beds. These red sediments are stratigraphically in the lower part of the Skaneateles formation. From this uppermost fossiliferous bed at Rensselaerville to the Portland Point at Potter Hollow there is a considerable thickness of red and green beds. On the road from Potter Hollow to Manorkill over Van Steenburg Mountain are numerous outcrops of red and green beds, all of which overlie the Portland Point. A little west of Catskill village the fossiliferous Hamilton (not the same as fossiliferous Hamilton on the Berne Sheet) is known as the Mount Marion beds and is about eight hundred feet thick. This is succeeded

by the Ashokan beds, mostly flaggy sandstones for about three hundred feet. The Ashokan division is followed by a great thickness of red beds, and intercalated greenish, cross-bedded sandstones, the Kiskatom beds of Chadwick, beautifully displayed along the highway up the Kaaterskill to Haines Fall and Tannersville. Much of this section undoubtedly belongs to the Hamilton and Gilboa (see page 6) divisions. At the present writing it is impossible to give the equivalents of the Mount Marion and Ashokan beds in the section southwest of Albany, but from thickness alone, it would appear that these two divisions do not represent more than the Marcellus.

Red beds were not seen west of Schoharie Valley, but along the highway between Richmondville and Summit about one and one-half miles south of Richmondville the first beds of green, crumbly, sandy shale appear in the upper part of the Skaneateles. In Schoharie Valley beds of this kind occur at many horizons in the Ludlowville and Skaneateles. These are well exposed along the Grand Gorge highway (30) at North Blenheim and for about three-fourths mile to the south.

BEDS SUPERJACENT TO THE HAMILTON.

In eastern New York the overlying beds are so closely linked to the Hamilton both faunally and lithologically that a brief discussion of their relationships is not out of place here.

Laurens member.—This name is suggested for the interval of rock located between New London and Schenevus which carries a *Hypothyridina* and a modified Ithaca fauna. The name is needed because the *Hypothyridina* zone in eastern New York is a different facies from that of the Tully and actually represents the basal portion of the Tully only according to present knowledge of the relationships. In Cazenovia and Morrisville Quadrangles *Hypothyridina* is restricted to the basal bed of the Tully limestone, a bed averaging a little more than one foot in thickness and composed of hard, sandy limestone. Above this zone in Morrisville Quadrangle are eighteen feet of argillaceous limestone in which *Hypothyridina* has never been found. At West Brook on the east side of Chenango Valley about three miles south of Sherburne, *Hypothyridina* is restricted to a ferruginous oölite four inches thick, which is followed by sandstones carrying a modified Hamilton fauna. The Tully interval has never been identified in Unadilla Valley except for the discovery by the writer of a layer

of calcareous lenses containing *Hypothyridina*. So far as known the whole Sherburne, including the part of it assignable to the Tully, is quite unfossiliferous.

In eastern New York, from New Lisbon eastward, *Hypothyridina* is abundant in the shaly sandstones above the Hamilton. The vertical range of *Hypothyridina* in Butternut Valley, next valley east of Unadilla valley, is wholly unknown. Prosser[13] reports the presence of *Hypothyridina* above the Hamilton but does not give its vertical range. In Otego Valley, between Butternut and Susquehanna Valleys, *Hypothyridina* ranges vertically for seventy feet and is associated with a few other fossils, notably *Leiorhynchus mesacostale* which occurs in great numbers in the lowest bed. In Susquehanna Valley *Hypothyridina* was not found in the basal bed with *Leiorhynchus* but was found in some abundance fifty-two feet above the top of the Hamilton. At about the same level, *Hypothyridina* was found as far east as Schenevus, but east of here it was lost. It appears from present knowledge that the eighty-eight[14] feet of Laurens member in Otego Valley is the equivalent of the four-inch thick oölite with *Hypothyridina* in Chenango Valley. A possible explanation of this remarkable relationship is that the region now the site of Unadilla Valley and adjacent territory for short distances to the east and west was at wave-base during the time of deposition of the Laurens.

If the reader will not admit the correlation of the four-inch oölite of West Brook with the eighty-eight feet of Laurens member in Otego Valley an alternative may be suggested, as follows: The Laurens may be the shaly sandstone facies of the Tully-Geneseo formations. According to this scheme the Geneseo replaces the Tully to the west, the replacement being complete at Canandaigua Lake. The Laurens, on the other hand, replaces the Tully and Geneseo eastward, the passage beds lying between Chenango and Butternut Valleys. The relationship of the facies would be similar to that shown below in the Hamilton by westward replacement of the shaly sandstone Hamilton by the black shale or Marcellus facies.

Equally as remarkable as the vertical range of *Hypothyridina* in Susquehanna Valley is the fauna associated with this familiar Tully fossil. On both sides of the Portlandville

[13] N. Y. St. Geol. Ann. Rep. 15, p. 183, 1897.

[14] Fossils occur for eighteen feet above the highest *Hypothyridina* in Otego Valley.

Reservoir, a little south of Milford Center, Susquehanna Valley and in a ravine a short distance south of Chaseville *Paracyclas lirata* and *Actinopteria boydi* were found associated with the *Hypothyridina*. In the Hamilton of Chenango Valley *Paracyclas lirata*, according to the writer's knowledge, is restricted to the Marcellus and Skaneateles divisions, reappearing in the base of the Ithaca some three hundred feet above the Hamilton. In eastern New York this fossil occupies the beds from the top of the Hamilton into the Ithaca.

Sherburne formation.—At West Brook on the east side of Chenango Valley the Geneseo is doubtfully represented by some black shales and dark sandy shales of the Sherburne. The Sherburne can be traced into the region around Schenevus, after which it is lost. There is absolutely no Sherburne in Schoharie Valley in the vicinity of North Blenheim, as reported by Prosser,[15] and there are no beds referable to this formation in the Berne Quadrangle although this formation, much diminished in thickness, has been reported in the ravine at Rensselaerville. Between Sherburne village and Schenevus the Sherburne consists of dark gray, sandy shales and flaggy sandstones, without fossils, so far as known. But in the vicinity of Schenevus fossils occur, which are those of the Ithaca facies, *Sp. mesastrialis* appearing frequently, together with *Actinopteria boydi* and other pelecypods. Still farther eastward this fauna has not only occupied the pre-Ithaca Sherburne but has also invaded the Tully equivalent, *Sp. mesastrialis* being common in the sandstones about seventy feet above the *Vitulina* zone in Summit Hill. In Unadilla Valley the thickness of the Sherburne has been estimated to be 253 feet. In Susquehanna Valley it is 213 feet thick.

Gilboa beds.—In Schoharie Valley in the vicinity of Gilboa and southward along the shores of Gilboa Reservoir *Sp. mesastrialis* and other Ithaca fossils are common in the sandstones. This division, about 250 feet thick, is the equivalent of the Tully (Laurens) and Sherburne sandstone, or in other words, is the Ithaca facies of the Sherburne, Geneseo, and Tully. A nearly complete section of these rocks can be studied in the west face of Reed Hill. Other exposures are in the huge quarry in Stevens Mountain and along the road leading from the Intake Building at the base of Pine Mountain to Hardenburgh Falls on the Bear Kill. The exposures in Reed Hill have been selected for the type section.

[15] N. Y. St. Geol. Ann. Rep. 15, pp. 197, 313, 1897.

Ithaca formation.—Along the Grand Gorge road to Schoharie (Highway 30) about two miles northeast of Grand Gorge, at an elevation of 1,406 feet above sea-level, there are lenses of shell-breccia composed chiefly of *Sp. mesastrialis*, *Tropidoleptus* and a few other fossils. These calcareous lenses apparently are at the base of the Ithaca although the fauna can scarcely be separated from that of the Gilboa beds below. West of Schoharie Valley similar beds occur at the undoubted base of the Ithaca and the beds on the Grand Gorge-Schoharie road are on the dip and strike of the base of the Ithaca as determined elsewhere. Similar lenses to those described above can be found at many localities in the vicinity of Gilboa and for some distance to the north, all lying near the same level. Good exposures can be studied at Hardenburgh Falls on Bear Kill, in a ravine just north of Ruth, and in an outcrop one mile due west of Conesville. Above the *Sp. mesastrialis* beds on the Grand Gorge road (Highway 30) and elsewhere is a succession of red shales, sandstones, greenish-gray sandstones and green shale and sandstone which are the equivalent of the lower Ithaca (Otselic) and thus not to be correlated with the true Oneonta red beds, but are below them, though here of similar facies.

Prosser[16] erred in his determination of the Ithaca in Schoharie Valley. The beds about North Blenheim, which he assigned to this formation and to the Sherburne, belong in the upper part of the Skaneateles, the Ludlowville and the Moscow. This explains the statement that appears in Prosser's writings and has been quoted in other books, that the Sherburne east of its type locality becomes fossiliferous and the fossils are those of the Hamilton.[17] It also explains the great abundance of Hamilton fossils placed in faunas assigned to the "Ithaca" in eastern New York, fossils unknown in the Ithaca of the type region and Chenango Valley. The present work appears to invalidate the well-known Sherburne bar theory of Grabau.

The range of *Spirifer mesastrialis* in Schoharie Valley is interesting and important. It is found all through the Gilboa member and consequently is Tully, Geneseo and Sherburne in age as well as Ithaca. It is not, however, confined to the Gilboa beds but ranges down into rocks that are clearly in the upper Hamilton. This species has been found along the

[16] Prosser, op. cit., p. 313, and map.
[17] Grabau, A. W., Bull. Geol. Soc. Amer., 30, p. 426, 1919.

Grand Gorge-Schoharie road four and one-half to five miles south of North Blenheim in beds underlying the "Terebratuloid" zone, which are known to be at the level of the *Vitulina* zone. It has been doubtfully identified from a hard sandstone bed overlying the upper tree horizon on the Manorkill. Thus, it is certain that this element of the Ithaca fauna has invaded the upper Hamilton.

The Ithaca fauna is a recurrent Skaneateles fauna and represents the *Tropidoleptus* or Hamilton facies which replaces the Portage *Leiorhynchus* or black shale (Marcellus) facies in an easterly direction. The facial conditions of the Hamilton are thus repeated in post-Hamilton time, but the faunas are essentially the same as those that lived in Hamilton time. It is thus not surprising to find spirifers almost indistinguishable from *Sp. mesastrialis* appearing in the Marcellus-Skaneateles rocks. And with these spirifers are other familiar Ithaca species: *Actinopteria boydi, Paracyclas lirata,* and *Palaeoneilo emarginata.* In like manner the black shale facies of the Marcellus-Skaneateles contain *Buchiola* and *Pterochaenia.*

REGIONAL STRATIGRAPHY.

The foregoing discussion has centered around the stratigraphic units small and large. There has been no attempt made to orient the reader as to the geographic distribution of the various Hamilton strata in this little known region. The following is a brief description of the geographical distribution of Hamilton beds in Susquehanna and Cherry Valleys, Bear Gulch between Summit and Richmondville, and the Schoharie Valley.

In Susquehanna Valley the Onondaga limestone is exposed at the north end of Otsego Lake in and about the villages of Springfield and Springfield Center. The southernmost exposure is about one-half mile south of the north end of the lake and the limestone must disappear by dip about one mile still farther south. The Chittenango, Otsego, and Solsville shales and sandstones are exposed on both sides of the lake as far south as Cooperstown, which is underlain by the Solsville. The Panther Mountain shales and sandstones are exposed in the hills on each side of the lake north of Cooperstown and on both sides of the valley south of Cooperstown to Milford, eight miles to the south. In Cherry Valley, which joins the Susquehanna at Milford, the Onondaga is exposed in the vil-

lage of Cherry Valley and the Marcellus beds up to the Solsville are exposed in the hills to the north and south. The top of the Solsville is exposed in the little village of Pleasant Valley and descends beneath the valley floor about three miles south of Roseboom. The Panther Mountain division is then exposed in the ravines and hillsides south to Milford. In the lower part of the ravines about Milford the Portland Point is well exposed and descends beneath the valley floor a little more than a mile south of the village. The Moscow is exposed from this point almost to Milford Center about six miles south of Milford. The Laurens member of the Tully is exposed on both sides of the Portlandville Reservoir; the Sherburne occurs in the ravines about Colliers (Colliersville).

At Richmondville railroad station the top of the Solsville is exposed along the tracks and rises rapidly to the northeast. Along the Delaware and Hudson Railroad tracks opposite Warnerville the Solsville beds are well displayed. In the gorge and falls of Bear Gulch Creek in the village of Richmondville the top of the Solsville is again exposed. From Richmondville southward up the hill toward Fly Pond on the west side of Bear Gulch are good exposures of the lower part of the Panther Mountain beds which here roughly correspond to the Pecksport, Mottville and Skaneateles. Along the main road to Summit, on the east side of the Gulch, are outcrops of the upper Panther Mountain which correspond very closely to the Ludlowville. This same interval is exposed along the road, on the west side of the Gulch, which makes the steep descent from Bear Gulch Pond to Richmondville. The Portland Point is exposed in Bear Gulch at an elevation of 1,960 feet above sea-level. Excellent outcrops of the lower Moscow may be studied in Bear Gulch above the Portland Point and on the shores of Bear Gulch Pond. These Moscow (Windom) exposures extend to 2,340 feet above sea-level in Summit Hill, at which level the *Vitulina* zone appears. Above this zone are about forty-five feet of rock belonging to the Hamilton Group. At the top of Summit Hill is a huge flagstone quarry which represents a portion of the eastern equivalent of the Laurens at the base of the Gilboa. The latter is exposed southward from Summit to Jefferson where the base of the Ithaca is known to occur.

In Schoharie Valley the Onondaga limestone is exposed in Schoharie Creek about one mile northwest of Middleburg village. The Chittenango member and the beds containing the

Meristella-Coral zone are exposed in the headwaters of Stony Creek, one and one-half miles southeast of Schoharie village. The Otsego member of the Marcellus formation outcrops in the hills to the northeast and northwest of Middleburg. Excellent exposures are in "The Cliffs" just northeast of the village and the lower three hundred feet of Vromans Nose, one and one-half miles southwest of Middleburg. The top of the Otsego bed descends beneath the valley floor about three-fourths of a mile south of Fultonham. Then follows the Panther Mountain division to a point about one and one-half miles south of North Blenheim. The lower part of the Panther Mountain is exposed in the cliffs along the "Towpath," in Boucks Falls and the falls of the Keyser Kill, one mile east of Breakabeen. The middle and upper beds are to be seen about North Blenheim. The Panther Mountain division in Schoharie Valley includes the Marcellus beds from the Otsego to the Mottville, the Skaneateles and the Ludlowville. On the basis of faunas the Marcellus formation extends from the top of the Onondaga north of Middleburg to a point about one and one-half miles south of Breakabeen; the Skaneateles extends from here to a point probably less than one-half mile south of North Blenheim; the Ludlowville on the basis of faunas extends from about one-half mile south of North Blenheim to a point about one mile north of Gilboa.

The Portland Point and the Windom are exposed southward from Mill Creek to Manorkill. The Portland Point passes under the floor of the valley about one mile north of Gilboa. The supposed top of the Hamilton is exposed on the banks of the Manorkill at West Conesville and along the North Blenheim-Grand Gorge highway (30) three and one-half miles south of North Blenheim.

The Gilboa beds, representing the combined Laurens and Sherburne, are exposed in the hills to the north of Gilboa and along the shores of the reservoir south of the Gilboa dam. The Ithaca is exposed along the road to Grand Gorge from Gilboa, in Pine Mountain, and in Hardenburgh Falls near the mouth of the Bear Kill.

NOTE TO THE CORRELATION CHART (FIGURE 3).

The correlation chart has been prepared on such a small scale that it was impossible to record much detail. For example, it was not possible to illustrate the many thin green beds of the Panther Mountain or all of the subtle lithologic

changes which can be distinguished in the field and which are useful to identify certain of the beds. In this eastern New York Hamilton there are few rocks that can be called shales, for practically all of the beds contain considerable sand, and what is frequently called shale is actually a fine sandstone. There is no group of rocks in which a classification of rock types is more needed than in the Hamilton. For these reasons the writer has generalized the columnar sections, frequently indicating them to be composed mostly of argillaceous sandstone. It must be understood by the reader that the sequences are highly diversified as to lithology and must be illustrated later in sections drawn on a larger scale.

A note regarding the Bear Gulch section is also needed. The writer did not actually see any of the rock of this section between the Chittenango and the lower part of the Solsville members. In other words, the entire Otsego member was not seen. In the vicinity of Warnerville, Lawyersville and Richmondville, there has been some disturbance of the rocks, increasing the dip of the Onondaga notably. The average dip of the Onondaga in this region must be close to that determined in the Schoharie Valley. Consequently, the thickness of the Otsego was obtained on the basis of a dip of 137 feet per mile to the southwest.

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