HAMILTON CORRELATIONS.[1]

BRADFORD WILLARD.

ABSTRACT.

The term Hamilton group is here expanded to include all of the Middle Devonian, and the group is discussed in New York, New Jersey, Pennsylvania and Maryland. The Hamilton has long been recognized in these states, but only recently have modern stratigraphic principles been applied in its study. From these we learn that the group in eastern Pennsylvania and central New York is very similar faunally and lithologically and here represents the most complicated sequence. In New Jersey changes are observed as the sediments pass from pelitic in eastern Pennsylvania through neritic and continental facies eastward. Through central and southern Pennsylvania into Maryland the numerous subdivisions of eastern Pennsylvania are gradually lost, giving a much simpler succession. Nevertheless, there is throughout a close faunal unity, and the succession in eastern Pennsylvania serves as a means of uniting the otherwise somewhat dissimilar regions north, east and south.

INTRODUCTION.

The New York and Pennsylvania Geologic Survey this year celebrate their centennials. The New York Survey came into existence by legislative action of the fifteenth of April, 1836. The Pennsylvania Survey was created by act of the Legislature at Harrisburg, March 29, 1836. It would be most interesting to present a detailed comparison between the interpretations of the Paleozoic Stratigraphy by the two surveys but time limits my account to the Hamilton group. I shall try to show the development of understanding of its stratigraphy in Pennsylvania and its relations to New York, New Jersey and Maryland.

The term Hamilton is used here as I use it in my most recent work with the Pennsylvania Topographic and Geologic Survey to include all strata between the top of the Oriskany formation and the base of the Portage group. Because this usage makes the Hamilton equal to or synonymous with the Middle Devonian, the question will be raised whether, under such an expanded definition, the term Hamilton should be retained at all. Is this application of the name to the whole Middle Devonian valid? Probably it is not. I prefer to leave the

[1] Read before Section E, American Association for the Advancement of Science at Rochester, N. Y., June 19, 1936, at the Centennial Celebration of the New York Geological Survey. Published with the permission of the State Geologist of Pennsylvania.

question open until a general agreement may be reached between those interested in Middle Devonian terminology of the eastern United States.

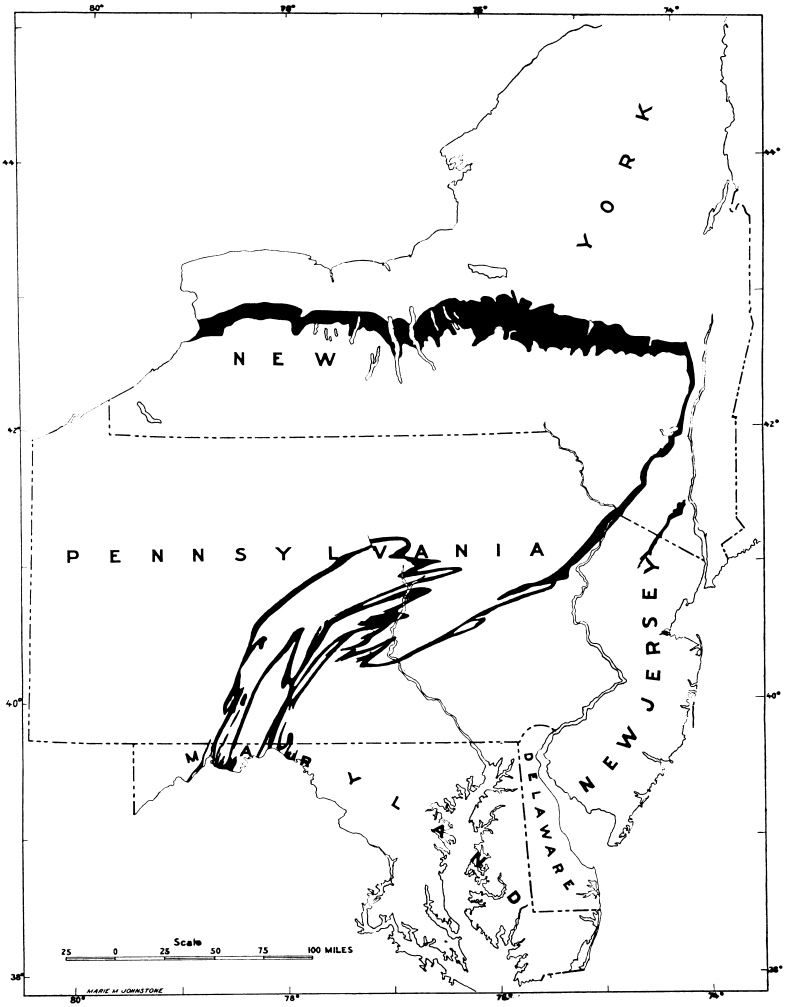

Fig. 1. Sketch map showing distribution of the Hamilton in New York, Pennsylvania, New Jersey and Maryland. Data for New York were taken from the published accounts of G. A. Cooper, those for New Jersey and Maryland from the latest State maps, for Pennsylvania from the published accounts of Willard and Willard and Cleaves.

EARLY WORK ON THE HAMILTON IN PENNSYLVANIA.

First Pennsylvania Survey.

With the creation of the First Geological Survey of Pennsylvania in 1836 and the appointment of Henry D. Rogers as State Geologist, systematic studies of the geology of the State began. Starting with two field assistants and a chemist, a corps which was gradually expanded, Rogers did a remarkable piece of work in a region of few roads, fewer canals, and almost no railroads; a region sometimes so wildly primitive that even pack-horses were impracticable, and the only means of transporting supplies, equipment and instruments was on the backs of hired porters. When Rogers published his First Annual Report in December, 1836,[2] he had already recognized most of the major Paleozoic divisions. Among them we find the "olive slate and sandstone" which included the Hamilton and later non-red Devonian formations. In the second annual report, 1838,[3] Rogers first recorded the Onondaga limestone in the Delaware Valley, and described its continuation across New York to Niagara Falls. This limestone he placed at the base of formation VIII whose top included the beds now assigned to the Chemung. Further subdivisions of VIII were suggested in the Fourth Annual Report, 1840.[4] Rogers failed to distinguish the Onondaga in central Pennsylvania but included it with the "black slate" (Marcellus) which he recorded over wide areas at the base of the "gray sandstone and olive slate" (later Middle and Upper Devonian).

In 1858, after discouraging delays but necessary revisions, Rogers published his monumental "Geology of Pennsylvania"[5] with its splendid geologic map. Previous to this time he had wavered on nomenclature and at times just missed assigning geographic names to the Paleozoic systems and some lesser units. In 1858 he committed himself. His dissatisfaction with the then current terminology had been voiced in the Second Annual Report (page 20):

"For the present I have studiously abstained from framing a nomenclature for the several formations of the extensive system of rocks here enumerated, preferring (until I become entirely

[2] Rogers, H. D.: First Annual Report of the State Geologist, 1836.
[3] Rogers, H. D.: Second Annual Report on the Geological Exploration of the State of Pennsylvania, 1838.
[4] Rogers, H. D.: Fourth Annual Report on the Geological Survey of the State of Pennsylvania, 1840.
[5] Rogers, H. D.: Geology of Pennsylvania, 1858.

familiar with the many modifications which they undergo in their course through the Appalachian region) to designate them as well by their numerical position, counting from the bottom of the group, as by distinctive features in the rocks, and a reference to their geographical distribution. . . . . While our researches are pending, no mode of specifying the strata, appears to be so practically useful as that which expresses the relative situation of each rock to all the others of the region, and none certainly so free from ambiguity, when combined with a reference to their several geographical positions."

So, in 1858, appeared that remarkable system of chronologic nomenclature which has long been one of the curiosities of the geologic literature of North America. Yet, Rogers was justified in his day for proposing such a scheme. He was acquainted with correlations beyond Pennsylvania. Hall's "Geological Map of the Middle and Western States" (1843),[6] the result of Rogers own work as State Geologist of New Jersey in 1835 and that of his brother who was State Geologist of Virginia, must have been at his disposal. The Paleozoic nomenclature used in New York was becoming fastened upon the literature to his evident disapproval, for Rogers wrote in 1858 (Vol. I, pp. VI-VII):

"The nomenclature of the Palaeozoic Formations employed in this work demands a word of explanation here. After a mature analysis of the whole system of Ancient Secondary (Palaeozoic) Rocks embraced in the Appalachian Chain, conducted in accordance with their organic remains and mineral composition, it became apparent to the State Geologists of Virginia and Pennsylvania, Professor W. B. Rogers and myself, that none of the existing systems of nomenclature—neither the imported British ones, nor the narrowly local geographical ones of New York—were applicable to our strata, under the average types they manifest in the mountain-chain and the broad basin of the States to the West of it. It was found that these Appalachian Rocks were far from being sufficiently co-ordinate with the European Palaeozoic strata, under their British types, to bear their names; while, on the other hand, the special titles assigned to them in New York were deemed too local and too inexpressive, either of their position in the scale of Formations, or of their ruling characters, to be usefully applicable. The fifteen Formations, or series of deposits, defined by their prevalent organic remains, and the physical horizons which separate them as sediments, extending from the lowest deposited in the dawn of animal life to those formed at the end of the Coal

[6] Hall, James: Geological Map of the Middle and Western States, to accompany Geology of New York, Part IV, Fourth Geological District, 1843.

Period, are called by names significant of their relative ages, the words employed suggesting metaphorically the different natural periods of the day."

Rogers has been quoted at length, partly to justify his stand at a time when the nomenclature of our geologic column was in a formative state and partly to illustrate the philosophic background of this early stratigraphic work in Pennsylvania. For all his curious terminology, Rogers carefully recorded the New York correlates of his divisions, thereby tacitly admitting their value. The Middle Devonian was divided into four units:

CADENT SHALES (*Hamilton group of New York*).
CADENT LOWER BLACK SLATE (*Marcellus slate of New York*).
POST-MERIDIAN LIMESTONE (*Upper Helderberg or Corniferous limestone of New York*).
POST-MERIDIAN GRITS (*Caudi-Galli and Schoharie Grits of New York*).

Rogers included in the CADENT series an "upper black slate" member, our present day Burket ("Genesee") correlated with the basal Upper Devonian Geneseo black shale of New York. This is obviously incorrect, and he recognized no Tully limestone. On the other hand he grouped under the heading POST-MERIDIAN the equivalents of the Onondaga ("Corniferous") and the Esopus ("Caudi-Galli"), and in so doing recognized a relationship which has been largely ignored since.

SECOND PENNSYLVANIA SURVEY

The Second Geological Survey of Pennsylvania was authorized in 1874 and remained active until 1887, after which it slowly died. Under the able but autocratic Joseph P. Lesley, it produced in the county reports and other volumes an appalling number of contributions which contain disappointingly little new on the Middle Devonian. However, Lesley did drop the Latin nomenclature of Rogers, substituting terms taken mostly from the New York succession, but retaining much of Rogers system of formation numbers. Rogers had published little on the application of paleontology, not because he doubted its value, but because he felt that James Hall had done or was doing all that could be done with the Paleozoic faunas. Lesley ignored the science, if indeed he was not actually hostile to its

application. No member of his staff was competent to handle Devonian faunas, and woeful were the errors of correlation. In his final report Lesley made a valiant but futile attempt to smooth over the confusion, but it was well-nigh hopeless.

The Onondaga was badly bungled by Lesley's staff, except for I. C. White. White worked it out in the Delaware Valley,[7] where he rightly grouped the cherty limestone with the Esopus whose separation from the Oriskany he recognized. In central Pennsylvania, too, he recorded equivalents of the Onondaga limestone and the Esopus shale,[8] but his work was so contradicted by reports of others in neighboring counties, chiefly those by Stevenson[9] and Claypole,[10] that the value of his observations was lost. Because of failure to recognize the distinctive Onondaga faunas widely distributed and abundant from New Jersey to Maryland, the base of the Hamilton group was improperly defined in most counties. Nor did the Second Survey do any better in determining the upper limits of the Hamilton. White, throughout his work in the northeastern counties persistently tacked the name Tully to any prominent Hamilton coral bed he happened to discover, although he honestly admitted finding no Tully fossils. Because of this mistake he fell into error in defining his "Genesee." The true Tully, thick and fossiliferous in the central part of the State, passed unrecognized. In fact in several counties the Second Survey failed to distinguish between the Middle and Upper Devonian. The "Genesee" and Marcellus were confused, the Portage shales were taken to be the "Hamilton" (old usage), and 1000 to 1500 feet of true Hamilton and older formations were completely omitted from the stratigraphic succession. The fairly uniform character and wide distribution of the Marcellus black shale in the east were recognized, but it was not always clear which was Marcellus and which black shale in the Onondaga, especially where thin, local limestones occur in

[7] White, I. C.: The Geology of Pike and Monroe Counties, Pa., Second Geological Survey, vol. G6, 1882.

[8] White, I. C.: The geology of the Susquehanna River region in the six counties of Wyoming, Lackawanna, Luzerne, Columbia, Montour and Northumberland, Pa., Second Geol. Surv., vol. G7, 1883.

[9] Stevenson, J. J.: The geology of Bedford and Fulton Counties, Pa., Second Geol. Surv., vol. T2, 1882.

[10] Claypole, E. W.: A preliminary report on the palaeontology of Perry County, Pa., Second Geol. Surv., vol. F2, 1885.

the former. Claypole[11] did recognize and name the Montebello sandstone of upper Hamilton age in Perry County, but went astray over similar sandstones in the Marcellus.

RECENT CONTRIBUTIONS.

Since the expiration of the Second Survey up to very recent years little has been done with the Hamilton of Pennsylvania. An exception is Prosser's work[12] which straightened out some of I. C. White's misconceptions regarding the presence of Tully in the Delaware Valley. Williams and Kindle [13] performed a similar service in the Susquehanna Valley at a somewhat later date. During the early Twentieth Century, Devonian studies were going on in the States nearest Pennsylvania, but only a few papers appeared at that time dealing with the Hamilton group in the State. In 1912 came the results of Kindle's Onondaga studies.[14] Covering the region from New York to Virginia, he presented a comprehensive account, which, for the first time, gave us a correct picture of the distribution of the Onondaga in Pennsylvania. Kindle showed that it continues completely across the State and has a distinctive and abundant fauna. The following year, 1913, saw the publication of a full account of the Devonian of Maryland.[15] The Maryland Survey's interpretations had been hinted only a year before by Stose and Swartz.[16] This work to the south clarified the understanding of the Hamilton in Maryland and south-central Pennsylvania also. The brief classification adopted is:

ROMNEY FORMATION.
Hamilton member.
Marcellus black shale member.
Onondaga shale member.

The top of the Hamilton was drawn upon lithologic and faunal data at the base of the "Genesee" black shale. The base was

[11] *loc. cit.*
[12] Prosser, C. S.: The Devonian system of eastern Pennsylvania and New York, U. S. Geol. Surv., Bull. 120, 1895.
[13] Williams, H. S., and Kindle, E. M.: Contributions to Devonian Paleontology, U. S. Geol. Surv., Bull., 244, 1905.
[14] Kindle, E. M.: The Onondaga fauna of the Allegheny region, U. S. Geol. Surv., Bull, 508, 1912.
[15] Prosser, C. S., Kindle, E. M., and Swartz, C. K.: The Middle Devonian deposits of Maryland, Maryland Geol. Surv., 1913.
[16] Stose, G. W., and Swartz, C. K.: Pawpaw-Hancock folio 179, Maryland, West Virginia, Pennsylvania, U. S. Geol. Surv., atlas, 1912.

drawn where an equally sharp break occurs at the top of the Oriskany. No Esopus was recognized. My own recent studies show that it is represented by the lower part of the Onondaga at least.[17]

This account would be incomplete without reference to the all-too-brief description by Charles Butts of the "Altoona Section"[18]. This is the first modern discussion of the Middle Devonian of central Pennsylvania.

While these developments in Pennsylvania and Maryland were going on, work was progressing in New Jersey. Weller published his "Paleozoic Faunas" in 1903,[19] and in 1915 Lewis and Kümmel issued their "Geology of New Jersey,"[20] which summarized concisely the stratigraphy of the State. Aside from describing the Esopus and Onondaga of the Upper Delaware Valley, the only "normal" Middle Devonian in the State, these reports present an interesting exposition of the curious Devonian succession found in the Green Pond Mountain syncline of north-central New Jersey and adjacent parts of New York.[21] This area had been interpreted earlier by Kümmel and Weller,[22] but that work required revision. Recently further changes in stratigraphic nomenclature have been introduced.[23] The Green Pond Mountain succession now proposed is as follows:

GREEN POND MOUNTAIN, NEW JERSEY.

Upper Middle Devonian.
- Skunnemunk conglomerate, lower part only.

Marcellus formation.
- Bellvale sandstone.

Onondaga formation.
- Cornwall shale.
- Kanouse sandstone and conglomerate.

[17] Willard, Bradford: The Onondaga formation in Pennsylvania, Jour. of Geol., vol. 44, pp. 578-603, 1936.

[18] Butts, Charles: Geologic section of Blair and Huntingdon Counties, central Pennsylvania, This Journal, 4th ser., vol. 46, pp. 523-537, 1918.

[19] Weller, Stuart: The Paleozoic Faunas, N. J. Geol. Surv., Rpt. on Paleontology, vol. III, 1903.

[20] Lewis, J. V., and Kümmel, H. B.: The Geology of New Jersey, N. J. Geol. Surv., Bull. 14, 1915.

[21] Ries, H: The geology of Orange County, N. Y. State Mus., An. Rpt., 49, 1898.

[22] Kümmel, H. B., and Weller, Stuart: The rocks of the Green Pond Mountain Region, N. J. Geol. Surv., An. Rpt., pp. 1-51, 1902.

[23] Lewis, J. V., and Kümmel, H. B.: Geologic map of New Jersey, 1910-1912, revised 1931, N. J. Dept., Conservation and Development, 1931.

In the main I agree with the correlation suggested by the New Jersey Geologists, but would introduce a few slight changes based upon my recent studies of the Onondaga. Below the Kanouse sandstone and conglomerate is the Decker limestone, basal Helderberg (Lower Devonian). The rest of the Helderberg and the Oriskany are not represented, for the Kanouse formation is now taken to be the coarser equivalent of the Esopus sandy shale of the Delaware Valley, not the Onondaga as Weller once suggested. It, like the Esopus, carries an Onondaga fauna with no Oriskany elements. The unconformity at the base of the Esopus in the Delaware Valley and of the Kanouse in the Green Pond Mountain region supports this view. The Cornwall shale with its Onondaga fauna thus becomes the clastic equivalent of the Onondaga limestone of the Delaware Valley, and the succeeding Bellvale sandstone is taken to be of Marcellus age. It carries a Hamilton fauna (*senso stricto*) and passes gradually upward into the continental Skunnemunk conglomerate of characteristic, coarse Catskill continental facies whose lower part must be of late Marcellus or early Skaneateles age. This New Jersey sequence is our one clue to the shoreward equivalents of the Middle Devonian of eastern Pennsylvania.

Recognition of the numerous and excellent reports by the geologists of New York on the Hamilton has been given in the able revision and summary of the group in New York by G. Arthur Cooper.[24] This splendid work of reinterpretation requires no introduction here. To go into all the details which Cooper has given us and to review the extensive and exhaustive studies which he has carried on so thoroughly completely across the Empire State, would be superfluous before a New York audience. Of the many units which Cooper recognizes, some are local and confined no doubt to New York, but many are of wider geographic distribution and enter into our correlations between New York and Pennsylvania. I would not imply that Cooper has introduced a multiplicity of local terms of interest only to the extreme specialist. On the contrary he has kept his terminology down to a minimum, a restriction highly to be commended in these days when the tendency seems to be to multiply names beyond all reason. The following

[24] Cooper, G. A.; Stratigraphy of the Hamilton group of New York, parts I and II, This Journal, 5th ser., vol. 19, pp. 116-134 and 214-236, 1930. Stratigraphy of the Hamilton group of eastern New York, parts I and II, *ibid.*, vol. 26, pp. 537-551, 1933, and vol. 27, pp. 1-12, 1934.

tabulation illustrates Cooper's most significant Hamilton successions:

TABLE I.

New York Hamilton Sections, after Cooper.

Lake Erie	*Casenovia Quadrangle*	*Schoharie Valley***	
Moscow formation	Moscow formation	Moscow formation	
	Vitulina-S. tullius zone	Tree beds	
Windom member	Windom member		
	Portland Point member	Portland Point member	
Ludlowville formation	Ludlowville formation,	Ludlowville formation,	
Tichenor member	undivided	undivided	
Wanakah member			
Ledyard member			
Centerfield member			
Skaneateles formation	Skaneateles formation*	Skaneateles formation,	Panther Mountain
	Berwyn member	undivided	
Lavenna shale	Pompey member		
Stafford member	Delphi member		
	Mottville member		
Marcellus formation	Marcellus formation	Marcellus formation	
	Cardiff shale	Solsville member	
Oatka Creek shale	Chittenango member	Otsego member	
	Cherry Valley member	Chittenango member	
	Union Springs member	Union Springs member	
Onondaga limestone	Onondaga limestone	Onondaga limestone	

* The Colgate member occurs at the top of the Skaneateles farther east.
** Cooper reports that red and green beds dominate above the middle Skaneateles farther east.

These successions show the change from off-shore, marine conditions shoreward. Further tabulation would show the downward displacement of marine by continental facies as mentioned in the second footnote of the table. This change is precisely that inferred for the region of the Upper Delaware Valley, between Pennsylvania and New Jersey, and north-central New Jersey. The New York sections better exemplify this due to their bridging the gap between the Delaware Valley and Green Pond Mountain in New Jersey where no Devonian has been preserved.

Cooper has not included the Onondaga formation in his Hamilton group because of an unconformity between the Onondaga and Marcellus in eastern New York. However, he suggests that this unconformity is *marginal*, since, farther

west, he recognizes that these two formations interfinger. The inclusion or exclusion of the Onondaga therefore seems still to be in the balance in New York.

PRESENT STATUS OF THE HAMILTON IN PENNSYLVANIA.

Since the beginning of the 1930 field season I have been involved in a study of the Devonian of Pennsylvania. A good proportion of my work has been concentrated upon the Hamilton group. In the early years I enjoyed the able coöperation of Arthur B. Cleaves who worked in Perry County. Otherwise, I have carried on solo. Extraterritorial excursions have been made for the purpose of studying the Devonian in Maryland, New Jersey, the Hudson Valley, Massachusetts and New Hampshire. It has twice been my good fortune and privilege to visit the type region of the Hamilton with Doctor Cooper.

The Hamilton succession in eastern Pennsylvania is nearly identical with that which Cooper reports in central New York, but I have included the Onondaga in the group.[25] This sequence is illustrated in the third column of Table II. Westward and southwestward across central Pennsylvania, the resemblance to the New York sections fades. Curious lithologic anomalies obscure the higher divisions, and new subdivisions split up the middle portion of the group. In the Susquehanna Valley the post-Marcellus divisions are no longer clearly defined, but the beds have been separated upon faunal aspects into what appear to correspond to the Moscow, Ludlowville and Skaneateles of the east.[26] Where the post-Marcellus beds are a monotonous series of olive shales and thin sandstones, I have named them the Mahantango formation. It is dominated by much coarse sandstone, the Montebello member, in the lower Susquehanna and Juniata valleys. The Mahantango formation corresponds to the Hamilton member of the Romney formation of the Maryland Survey. Below it the Marcellus is usually black shale, but it, too, becomes coarsely arenaceous in the Susquehanna and Juniata valleys and is split into four members, not to mention local, thin limestone lenses.

[25] Willard, Bradford, and Cleaves, Arthur B.: Hamilton group of eastern Pennsylvania, Geol. Soc. Am., Bull., vol. 44, pp. 757-782, 1933.
Willard, Bradford: A Hamilton coral reef in Pennsylvania, Penna. Acad. Sci., Pr., vol. 10, pp. 30-36, 1936.
————: The Onondaga formation in Pennsylvania, Jour. of Geol., vol. 44, pp. 573-603, 1936.

[26] Willard, Bradford: Hamilton group of central Pennsylvania, Geol. Soc. Am., Bull., vol. 46, pp. 195-224, 1935.

The Onondaga formation is widespread in central Pennsylvania, though locally cut out by unconformity. Its upper part is a chert-free limestone corresponding to and correlated with the cherty limestone of the east. Below the limestone a limy shale, also of Onondaga age, rests unconformably upon the Oriskany. It is correlated with the Esopus of Monroe County. Typically, the succession for central Pennsylvania runs:

HAMILTON GROUP*.
- Mahantango formation, ± the Montebello sandstone.
  - Moscow faunal facies.
  - Ludlowville faunal facies.
  - Skaneateles faunal facies.
- Marcellus formation.
  - Mahanoy black shale member.
  - Mexico platy sandstone member.
  - Turkey Ridge massive sandstone member.
  - Shamokin black shale member.
- Onondaga formation.
  - Non-cherty limestone member.
  - Limy shale member.

* Several local subdivisions, not mentioned in this list have been recognized. In Dauphin and Perry counties the actual divisions of eastern Pennsylvania are probably still valid, and at the base of the Skaneateles is a massive sandstone, the Rockville member. The probable equivalents of the Deep Run, Colgate and Union Springs members of New York may, too, be present. See Table II.

Still farther southwest, the group is even less differentiated. In south-central Pennsylvania it approaches the Maryland status.[27] The Mahantango formation can be locally divided into certain thin sandstone and shale members, and it appears quite probable that the equivalent of the Moscow to the east is cut out by a disconformity of some magnitude. The Marcellus consists of black shale, but may carry calcareous nodules or thin limestones. The Onondaga is usually limy shale with thin limestones prevalent in the upper part. Black shale is also present, sometimes as a thick, middle division.

The lower limit of the Hamilton group in Pennsylvania is everywhere drawn at a disconformity marked by a faunal and lithologic change at the top of the Oriskany. The top of the Hamilton group is ill-defined in the east where it intergrades with the Portage in Pike and eastern Monroe counties. How-

[27] Willard, Bradford: Hamilton group along the Allegheny Front, Pennsylvania, Geol. Soc. Am., Bull., vol. 46, pp. 1275-1290, 1935.

TABLE II.

Hamilton Correlations, Maryland, Pennsylvania, New York.

*Maryland**	*Central Pennsylvania*	*Eastern Pennsylvania*	*Central New York*
Romney formation	Hamilton group	Hamilton group	Hamilton group
Hamilton member	Mahantango formation Montebello member and other minor or local subdivisions may be present. Moscow, Ludlowville and Skaneateles faunal facies but not lithologic divisions are recognized.	Moscow formation *Vitulina-Sp. tullius* zone Windom member Ludlowville formation "Centerfield" coral reef Skaneateles formation Berwyn member Delphi member Mottville member	Moscow formation *Vitulina-Sp. tullius* zone Windom member Portland Point member Ludlowville formation Centerfield member Skaneateles formation Berwyn member Pempey member Delphi member Mottville member
Marcellus member	Marcellus formation Mahanoy member Mexico member Turkey Ridge member Shamokin member	Marcellus formation Cardiff shale Chittentango member	Marcellus formation Cardiff shale Chittentango member Cherry Valley member Union Springs member
Onondaga member	Onondaga formation Non-cherty ls. member Limy shale member	Onondaga formation Cherty limestone member Esopus shale member	Onondaga limestone

* In the 23 years which have passed since the Maryland succession was published, so much new has been learned elsewhere that a restudy of this region might yield data for greater refinements in correlation.

ever, in central Monroe County, Tully fossils have been found marking the base of the Portage immediately above the highest beds of Moscow shale. From Carbon County westward the Burket black shale is a distinctive marker for the basal Portage; and, beginning with a single outcrop in Northumberland County and becoming increasingly prevalent westward, Tully limestone is encountered. This unit continues southwestward nearly to the Maryland line where the Burket shale again rests upon the uppermost beds of the Hamilton.[28]

The Hamilton group is well-knit. The Esopus and limy shales and the limestones of the Onondaga are all closely bound together lithologically through the transitional contacts, and close faunal affinities obtain. All, including the Esopus, which is usually thought of as barren, carry an Onondaga fauna devoid of Oriskany fossils, but of the total number known over 60 *per cent* are Hamilton species (*senso stricto*). Only in Central Pennsylvania, in the Juniata and Susquehanna valleys, is there an unquestioned Onondaga-Marcellus disconformity. It is attributed to local uplift and erosion in early Marcellus time. Elsewhere throughout Pennsylvania these two formations intergrade. The disconformity I regard as marginal just as does Cooper regard analogous ones in eastern New York. It is a near-shore feature. The true or normal Onondaga-Marcellus relations are completely conformable. The Marcellus in turn grades upward into the succeeding unit, be it Skaneateles or Mahantango, and the highest divisions of all are separable only upon careful observations of their lithologies or detailed faunal studies. Sharp lithologic differences and abrupt faunal separations are wanting.

SUMMARY AND CONCLUSIONS.

I have tried to summarize the correlations of the Hamilton group for New York, New Jersey, Pennsylvania and Maryland. I have used the terms "Hamilton Group" to include all beds between the subjacent Oriskany formation and the superjacent Portage group. By this use the Hamilton group becomes synonymous with the Middle Devonian. The members of the group all display close faunal affinities; and, under normal conditions, all contacts within the group are intergra-

[28] Willard, Bradford: Portage group in Pennsylvania, Geol. Soc. Am., Bull., vol. 46, pp. 1195-1218, 1935.
———: Middle-Upper Devonian contact in Pennsylvania, Penna. Acad. Sci., Pr., vol. 9, pp. 39-44, 1935.

dational. On the other hand, its upper and lower limits are usually sharply defined. Although the relative number of subdivisions recognized increases from Maryland to New York, three important divisions are almost everywhere present. At the base is the Onondaga, above this the Marcellus, and the upper part is the Mahantango or its equivalent, the "Hamilton" of the Maryland Survey and earlier writers. The transition from one to another of these divisions is intergradational. The change from marine types of sedimentation, indicative of relatively deep water or remoteness from the coast, eastward into strand or continental facies is recognized. The correlations from Maryland to New York are summarized in the following sections given in Table II which should be compared with the additional New York sections quoted in Table I and the New Jersey section which appears on page 271.

HARRISBURG, PENN.