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PETROLOGY OF THE NIAGARA GORGE SEDIMENTS

BY

HAROLD L. ALLING

AND

NEW YORK GEOGRAPHIC PUZZLE

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Harold L. Alling
The University of Rochester

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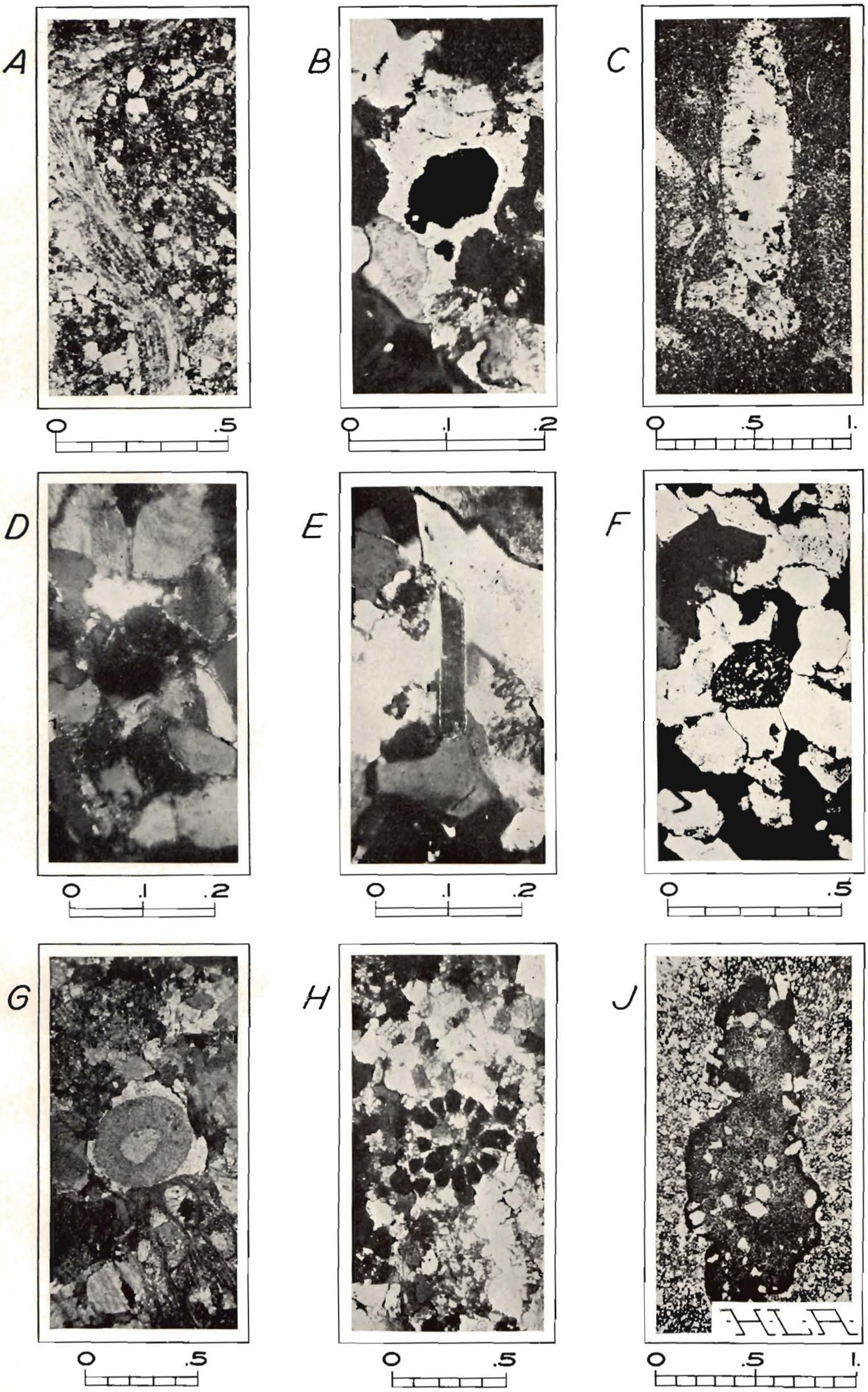

FIGURE 1

INTRODUCTION

The sedimentary rocks of the Niagara Gorge have long been a classic for stratigraphers and paleontologists. For years I have been interested in these rocks, primarily as a source of material for petrographic thin sections. I have desired to get some conception of what unmetamorphosed sediments are like as an aid in investigating the Adirondack Grenville meta-sediments. As I have read and listened to the discussions about correlation, the conditions under which these Silurian rocks from Niagara were deposited, and the proper nomenclature that should be employed, I have reached the conclusion that additional information would be welcomed. I have long believed that the methods of the igneous petrographer, if applied to such rocks, would assist. While there is much more that can be done with the material at my disposal, I have devoted considerable time and thought to it, and desire to bring this study to some kind of conclusion even though this paper should be regarded merely as a preliminary report.

This paper is the result of investigating fifty slides from specimens taken at measured intervals in the gorge. Through the interest and helpfulness of John T. Sanford, the Buffalo Society of Natural Sciences, and the University of Rochester, these thin sections have been made available.

PRELIMINARY COMMENT

I have found that these rocks are not merely aggregates of fragmental grains; they are not just sands, limes, and slimes, but are indurated and cemented sediments of complex nature unmistakably exhibiting subsequent changes and introduced materials. Recrystallization and crystal growth are observed to such an extent that the terms and principles of metamorphosed rocks can be applied with assurance. The difficulties I meet are multiplex; the rocks themselves are difficult to understand but perhaps what is more perplexing is the nomenclature that is to be applied to them. For these are not metamorphic rocks, and yet they have experienced incipient metamorphism; they are on their way but have not arrived. It is possible, therefore to catch a glimpse of what the early stages are. The true clastic grains, particularly of quartz, garnet, zircon, ilmenite, tourmaline, and other relatively stable minerals, can be readily recognized. Not so confidently, however, can the calcareous constituents be so designated. Some calcite in the limestones is fragmental;

pieces deposited mechanically and regarded as clastic in origin. There are fragments of fossils. Many sections would seem to be capable of being identified, but apparently only a few paleontologists have had experience in fossil determination in petrographic thin sections. Still other calcite areas are different in appearance and are believed to be different in origin. Some are extremely fine grained. I have thought of this type as a chemical precipitate, perhaps biochemical in origin. This, however, I am unable to demonstrate. On the other hand, it may be pulverized lime washed into the sediments. But I am more certain, however, about the recrystallized calcite. Some slides of limestone consist largely of it. What it was originally is not positive in every case, but clastic calcite seems to have furnished most of it. In addition there is calcite cement, some of it is recognized as elastic, some is regarded as having been precipitated, and some is clearly introduced.

The dolomite usually consists of rhombs. It is much later, in its present form, than the rest of the rock. I am inclined to accept the theory of late dolmitization for many of these rocks. Dolmitic rhombs are not necessarily confined to the limestones. They occur throughout the Queenston, in certain beds of the Whirlpool, the Medina, and the Neahga shale.

The argillaceous constituents proved to be difficult material to identify. There is a good deal of colloidal clay-paste groundmass, isotropic, of various indices. Every gradation exists from these so-called amorphous substances to well crystallized and recrystallized clay minerals such as montmorillonite, sericite, and possibly kaolinite. I was surprised to find that a good deal of the argillaceous matter is in reality chlorite, serpentine, epidote, uralite, and other decomposed ferromagnesian minerals. Some clay has been formed in place from the decomposition of clastic grains, but most of it seems to be an original constituent. From slides cut parallel and perpendicular to the bedding, most of the flaky clay minerals are found to have a definite orientation, accounting for the "shaly" structure of the argillaceous rocks. Furthermore, the development of this shaly structure is caused by a surprisingly small amount of clay matter. The clay coats the individual clastic grains. Some beds of the Queenston in the hand specimen are shales, while in thin section they are sandstones if the relative amounts of the argillaceous and siliceous substances constitute the distinction between them.

Grain Size

The matter of grain size in thin section has interested me. It is obvious that such slides are random cuts which do not reveal the maximum diameter of individual grains. The third dimension is lacking. To reduce the attendant "error" as much as possible, I have drawn distribution curves instead of calculating the average. The size of each grain was determined by measuring the area of each and from this calculating the diameter of a circle of the same area as the grain. I prefer this to the average of diameters. The areal method gives a better conception of the size as the variation in shape is to some degree reduced. Unquestionably the grains are actually larger than I have measured them. This cannot be helped.

Grain Roundness

This element proved to be one of the most interesting and at the same time one of the most perplexing problems in this investigation. The ratio of the area of the grain to the area of the smallest circumscribed circle gives a very imperfect concept of the true roundness. What this really shows is the degree of approach to a circle, that is, circularity. Roundness can only be determined by ascertaining how much the corners of the grains have been rounded. This requires the comparison with some "standard," as yet largely a matter of individual preference, or by measuring the radii of circles, some portions of the circumference of which fit the rounded surface of the grain. This can best be done on a camera lucida drawing or on a photograph. The average of such radii is helpful but leaves much to be desired. Still another method is to extend lines tangent to flat places on the grains and measure lengths of such flats and the totals of intersecting lines. Ratios can then be calculated.

In dealing with fragments, in the form of loose grains, it is possible to determine the sphericity, which is usually designated by Φ. In thin section this relationship is limited to circularity, sometimes symbolized by Ψ. Wadell[1] expresses circularity as follows: "$\frac{c}{C}$ = Degree of circularity, where c is the circumference of a circle of the same area as the plane figure, and C is the actual circumference of the plane figure."

I have preferred the ratio of the area of the smallest circumscribed circle to the area of the grain. My concept is $\frac{a}{A}$, where a is the area of the grain and A is the area of the smallest circumscribed circle.

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[1] Wadell, Hakon, "Sphericity and Roundness of Rock Particles," Jour. Geol., vol. XLI, 1933, p. 321.

PETROGRAPHY

THE QUEENSTON SHALE

The proportion of the argillaceous materials to the siliceous constituents is about nine to one. The latter are dominantly quartz, with minor amounts of perthite, plagioclase, garnet, zircon, rusty and leucoxenized ilmenite and opaline silica.

Small fragments of shale, although argillaceous in composition, are clastic and appear to represent detrital pieces of some pre-Queenston argillaceous sediment. There are well formed flakes of muscovitic mica, evidently recrystallized since deposition and in all probability since cementation. Likewise rhombs of dolomite which appear as "porphyry blasts," which certainly crystallized late.

Removal of the iron stain from the argillaceous groundmass paste with acid reveals a fine network of a flaky material, believed to be in part one of the chlorites. Possibly it is partial oxidation of this chloritic mineral that is the cause of the iron oxide stain. It is possible that this iron was originally a hydroxide.

A study of the grain size of the quartz content of the Queenston has been made in the form of frequency distribution curves. The curve, based upon measurements on 69 grains reveals two peaks, one at .0275—.0300 mm. and another at .0400—.0425 mm. Double peaked curves are universal except for the limestones. Does this mean that the clastic quartz came from two sources? If not, what other explanation is there?

THE WHIRLPOOL SANDSTONE

This is a feldspathic sandstone with a number of accessory minerals. Besides the dominant quartz there are perthite, microcline, plagioclase, garnet, chlorite, leucoxene, magnetite, phosphate pebbles, apatite, tourmaline, and zircon. There are fragments of shale as distinct clastic masses. Their microscopic characters show them to be similar to and in some cases identical with the argillaceous matters in the Queenston below. It is quite possible that they are Queenston fragments. The quartz grains are very largely "secondarily" enlarged. The added silica does not seem to fill completely the space between grains and the rock is cemented by chlorite and other unidentified argillaceous matters as well as by silica. I suggest that the bulk of the quartz has been derived from a pre-existing sandstone. This is in conformity with Grabau's suggestion that the New York Queenston-Medina is the re-worked Tuscarora-Juniata of Pennsylvania.[2] The frequency curves of quartz grains in the Whirlpool reveal double peaks as is the case with the Queenston, but a single peaked one for the feldspars. The peaks in the quartz curve occur at .200—.225 mm. and .300—.350 mm., corresponding to fine and medium sand respectively. The grains are therefore about ten times the size of the Queenston. The feldspars peak at .125—.150 mm., which is fine sand according to Grabau and very fine sand to fine sand on Wentworth's scale.

The argillaceous materials did not lend themselves to size analysis by camera lucida measurements alone.

Perhaps the most interesting mineral noted in the Whirlpool is the tourmaline. It shows a deep green color and considerable abrasion. One grain showed a distinct "secondary" growth. It is authigenous. Authigenous tourmaline has been noted from the Oriskany[3] and the Thorold.[4] I believe this is the first report of it in the Whirlpool.

The lack of purple red color, which in part distinguishes the Whirlpool from the Medina appears to be a transitory criterion, which petrographically is not sufficient to justify formational rank. Stratigraphically, however, it may be. The colorization in the Medina is on the grains but inside the quartz cement. If some of this cement quartz was deposited before becoming a part of the Whirlpool then the red color is not all Medinian but pre-Medinian. Perhaps the Queenston and the Medina are red because they were derived from red sediments.

THE MEDINA SANDSTONE

In the accompanying charts, distinction is made between the gray and the red. The gray portion contains more argillaceous and calcareous minerals, while the gray is more siliceous. Petrographically the two grade into each other. Phosphatic masses occur in both members but perhaps more abundantly in the gray. The accessory minerals make a long list: perthite, orthoclase, plagioclase, usually an andesine, muscovite, garnet, augite, hornblende, tourmaline, ilmenite, pyrite, spinel, sillimanite, titanite, zircon, magnetite, apatite and several as yet not positively identified.

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[2] Grabau, A. W., "Early Paleozoic Delta Deposits in North America," Bull. Geol. Soc. Amer., vol. 24, 1913, pp. 431–433.

[3] Stow, M. H., "Authigenic Tourmaline in the Oriskany Sandstone," Am. Min., vol. 17, no. 4, 1932, pp. 150–152.

[4] Kremer, L. A., Unpublished M.S. thesis, University of Rochester, 1932.

THE THOROLD SANDSTONE

At Niagara, the Thorold consists of 70% quartz, 6% feldspars, 20% argillaceous materials. Various kinds of feldspars are common—microcline, perthite, albite, oligoclase, andesine, and some untwinned feldspar which is probably plagioclase. The argillaceous materials include chlorite, muscovite, rusty biotite, and uralite. Some of the mica has experienced "secondary" growth. The list of accessory minerals is particularly extensive including recrystallized grains of calcite, calcite as a cement, opaline silica, ilmenite with attendant leucoxene, chromite, garnet, magnetite, zircon, apatite, and tourmaline.

The frequency-distribution curve of the quartz grains shows a double peak.

The grains of quartz are more angular than in the Medina, and smaller, and do not as a rule show enlargement. The size would permit the application of the theory that the rock is reworked Medina sand, the red hematitic coating of the Medina being removed by abrasion or chemical environment. If this is so, then the Thorold represents a condition rather than a distinct formation. This renders lateral correlation less certain.

UNNAMED SHALE

Between the Thorold and the Neahga green shale is a bed, a foot thick, which apparently has not received a stratigraphic name. Under the microscope it is seen to be a calcareous argillaceous sandstone with marked resemblances to the Thorold. 55% of the rock is quartz, about 7% feldspar. The calcareous constituents are fine grained calcite 7%, recrystallized calcite 17%, cementing calcite 6%. There appears to have been some introduction of lime. One would suppose that the overlying formation would be a limestone such as the Reynales which the calcareous components resemble. But the Neahga green shale intervenes.

Unlike the Thorold below, the grains of quartz are a little larger and show in addition enlargement by silica. Zircon is surprisingly common although making up a small portion of the bulk of the rock are garnet, apatite and tourmaline. Ilmenite is another common accessory and in some instances the alteration product, leucoxene, acts together with quartz, argillaceous matters, and calcite as the cement.

THE NEAHGA SHALE

Above the Thorold is a green shale. From analogy from Rochester, one would suppose it to be the Maplewood. It is perhaps wiser at the present time to refer to it as the Neahga[5] shale, deriving the name from an Indian term for the Niagara River. It is six feet thick in the Niagara Gorge. Petrographically it consists of very fine flaky argillaceous minerals which show definite orientation parallel to the bedding. The shaly material is a good deal like the Maplewood shale of Rochester. If the Neahga shale of Niagara is not the Maplewood the similarities above noted would imply similar conditions of sedimentation.

Set in the groundmass of flaky, argillaceous paste are a few rather small (averaging .0125 mm.) recrystallized rhombs of calcite, small pillets of carbonaceous matter, sometimes bunched together. Pyrite is identified with difficulty. There are a few well recognized flakes of muscovite that appear to have developed idiomorphic shapes at a late stage. No fossil indications were noted in the thin sections, although several species have been collected from the Neahga in the field.

THE REYNALES LIMESTONE

The iron ore member of the Reynales is absent at Niagara so the Neahga green shale is superseded by a limestone. Near the base it is a medium grained siliceous limestone consisting of fine-grained calcite, recrystallized calcite, clastic grains of dolomitic calcite, fossil fragments, quartz, and plagioclase. The base is more siliceous than a foot higher. Here the quartz and feldspar content has dropped off to less than one per cent. The rest of the rock is much the same.

The fine-grained calcite is particularly interesting. Masses exhibit dusty centers with comparatively clear margins. The latter probably represent cementing material of a "chemical" origin. See Figure 1G. More information is needed on such structures.

The same type of sediment appears to continue to the top of the formation, consisting of clastic grains, fossil fragments, recrystallized grains and fine-grained calcite, in the order named, contrasting in relative proportions to the basal portion although composed of the same constituents. The larger per cent of clastics and the falling

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[5] Sanford, John T., "The 'Clinton' in Western New York," Jour. Geol., vol. XLIII, 1935, pp. 173, 174.

off of fine-grained calcite foreshadow the coming of the Irondequoit sedimentation.

There are relatively large grains of recrystallized calcite within masses of fine-grained calcite. These rhombs show idiomorphic forms and are undoubtedly the result of late development. It is possible that they were potentially present in the chemically precipitated lime mud and developed at the expense of some of the fine-grained material.

There are two forms of pyrite at the top of the Reynales. One type is associated with fossil fragments and is regarded as of organic origin. The other form is involved with the clastic grains. These are much smaller and appear rounded. It is quite likely that they are clastic fragments.

The Irondequoit Limestone

On the whole the Irondequoit formation at Niagara is a coarse-grained limestone, without the argillaceous content characteristic of the rock at Rochester. The clastic grains are dominant and contrast with the Reynales below. Again the pyrite exhibits two forms. One type is small and rusty, associated with fossil forms and is believed to be organic. The larger grains are fresh and show development of crystallographic outlines. Their association is not confined to any one type of calcitic constituent but occurs along lines of weakness, such as bedding planes and along micro-cryto-faults. It has been introduced into the rock by later solutions. Very little quartz occurs.

This same coarse limestone with clastic calcite, fine-grained calcite, recrystallized grains and fossil fragments continues apparently to the top of the formation without much variation.

Reef in the Irondequoit

As the top of the Irondequoit is a reef whose petrographic characters justify separate treatment. It consists, not of corals nor of their fragments, but essentially of fine-grained calcite, and to a minor degree of fossil fragments of which crinoids and brachiopods are recognizable.

The Rochester Formation

At Niagara the Rochester is much more calcareous than it is at Rochester and petrographically does not justify the term shale.

The base of the formation contains the usual limestone constituents: fine-grained calcite, recrystallized calcite, clastic calcite, fossil fragments, and in addition, the argillaceous materials. The last contrasts with the calcareous constituents so that the rock can be regarded as composed of two distinct portions. The argillaceous substances can only be determined in part. Seemingly embedded within the argillaceous component are quartz grains and small recrystallized grains of dolomitic calcite. The quartz is without question clastic in origin. The rhombs are believed to be clastic as well, but they have experienced later recrystallization. The calcareous portions of the rock possess larger rhombs of recrystallized calcitic material directly associated with the fossil fragments. This material appears to have been deposited along with the fossil remains as lime mud adhering to them. The fine-grained calcite is associated not with fossil fragments but with the argillaceous constituents and appears to be embedded in it. This would seem to suggest that the chemically (bio-chemically, perhaps) precipitated calcite was formed before or during the deposition of the clay matters.

The Diagrams

Quantitative Analyses

Figure 2 shows the composition of the Niagara Gorge rocks, the result of quantitative graphic analyses by means of the Wentworth stage. Many of these were made by Bernard Dollen, for which my sincere thanks are due. Such a graph, I think, is more effective than a mere tabulation. It has the disadvantage, however, of not showing all of the details that were observed in some slides. For example, it was possible to recognize in some, but unfortunately not in all, the quantitative amounts of clastic calcite, fine-grained calcite, cement calcite, and fossil fragments. Likewise clastic quartz and cement quartz could be distinguished and measured. To maintain continuity these interesting determinations could not be made.

It will be noticed that some uniformity in composition is exhibited by the Queenston, the Reynales, the Irondequoit, and the Rochester, and to a lesser degree by the Whirlpool, but not by the Gray and the Red Medina. It is of interest to note the presence of calcite in the Gray Medina. The diagram would suggest that oscillatory conditions of sedimentation prevailed during these times.

Lack of specimens prevents a complete study of the Lockport.

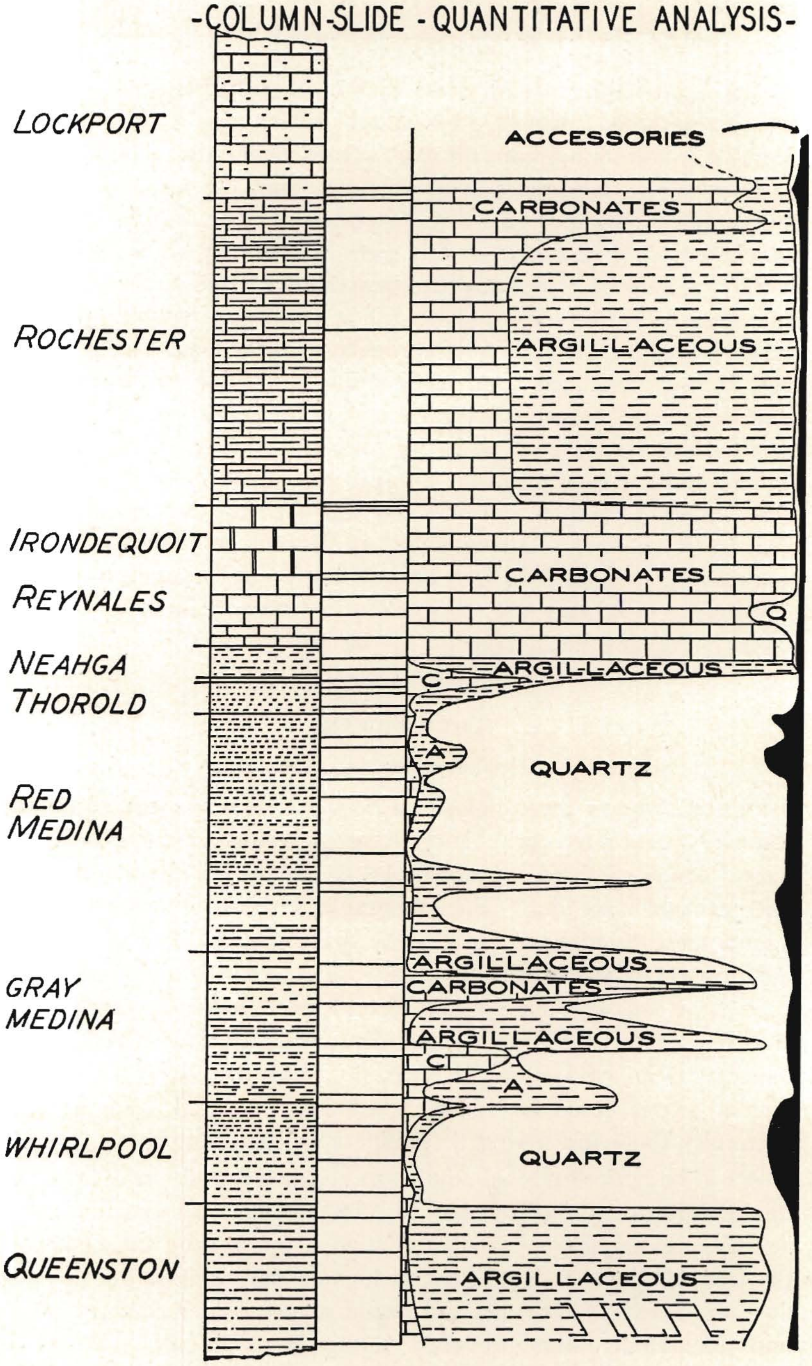


FIGURE 2

Diagram showing the quantitative composition in percent by weight of the sedimentary rocks from the Niagara Gorge, based upon linear intercepts by the use of a Wentworth stage. Many of these were made by Bernard Dollen, to whom my sincere thanks are due.

GRAIN SIZE

Figure 3 shows frequency distribution curves of quartz grains measured in thin section. Unquestionably if more grains per slide had been measured less irregular curves would have resulted. As it

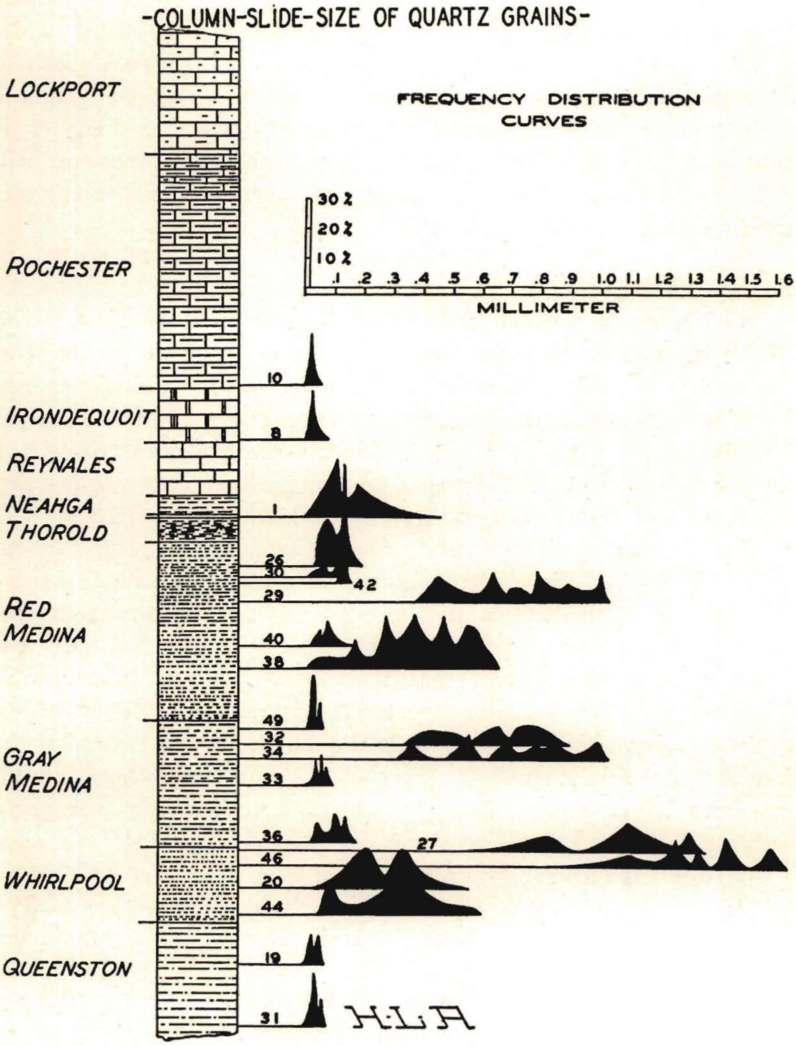


FIGURE 3

Frequency-distribution curves of the size of quartz grains in the sedimentary rocks of the Niagara Gorge. Determined in thin section by the circumscribed circle method. Many measurements were made by Bernard Dollen.

was the images of 40 to 50 grains of each slide were drawn with the aid of a camera lucida, the areas measured by a polar planimeter and the diameter of the circle, whose area is equal to the area of the grain in question, calculated. In many cases it was possible to recognize the extent of enlargement by quartz cement and confine the size measurements to true grains themselves. In one slide, from the base of the Thorold, nine grains were measured twice, once to determine the size of the true grain and the second time to include cementing quartz as well. The average diameter of these grains is .180 mm., while with cement quartz in addition the diameter is .216 mm. Slides will reveal some facts that loose fragments will not. The multiple peaked curves suggest several sources of the materials composing these sediments.

CIRCULARITY

The degree of roundness of clastic grains would give some idea of the vigor of the transportational history back of these rocks. Unfortunately no simple satisfactory method seems available as yet. Lacking this I employed the scheme of measuring the "circularity." This is not true roundness. 25 freshly crushed grains of quartz give an average of 53% circularity. One suggestion is to regard this figure as zero. But each mineral would have a different zero. 25 freshly crushed grains of albite from Amelia, Va., gave a circularity of 49.6%. There is a difference between the cleavage of these two minerals. In spite of this obvious discrepancy between circularity and roundness, the former concept is used. Naturally the value of most of the quartz grains in the Niagara are above 53%. They range from 36 to 87% ; the average is 65. It is not the largest grains that have high circularity, nor the the small ones, but rather the intermediate and the smallest. Some small grains are obviously splinters from larger ones. Studies of enlarged grains show that introduced quartz cement reduces the circularity. 9 grains in a slide (from the base of the Thorold) have a true circularity average of 64.6% while the value of those which include the cement is 61.3%.

Double or multiple peaked circularity curves are common and are comparable with size distribution curves. Also the curves of the quartz grains in the Thorold, Neahga, and the Irondequoit are simpler than those based upon measurements from stratigraphically lower beds.

I offer this paper with full knowledge that it does not solve many of the problems presented by the Niagara Gorge rocks; it does, however, suggest a number of lines of investigation that are worth further study. After all, it is well to recognize that sedimentary petrology is still in the descriptive stage.

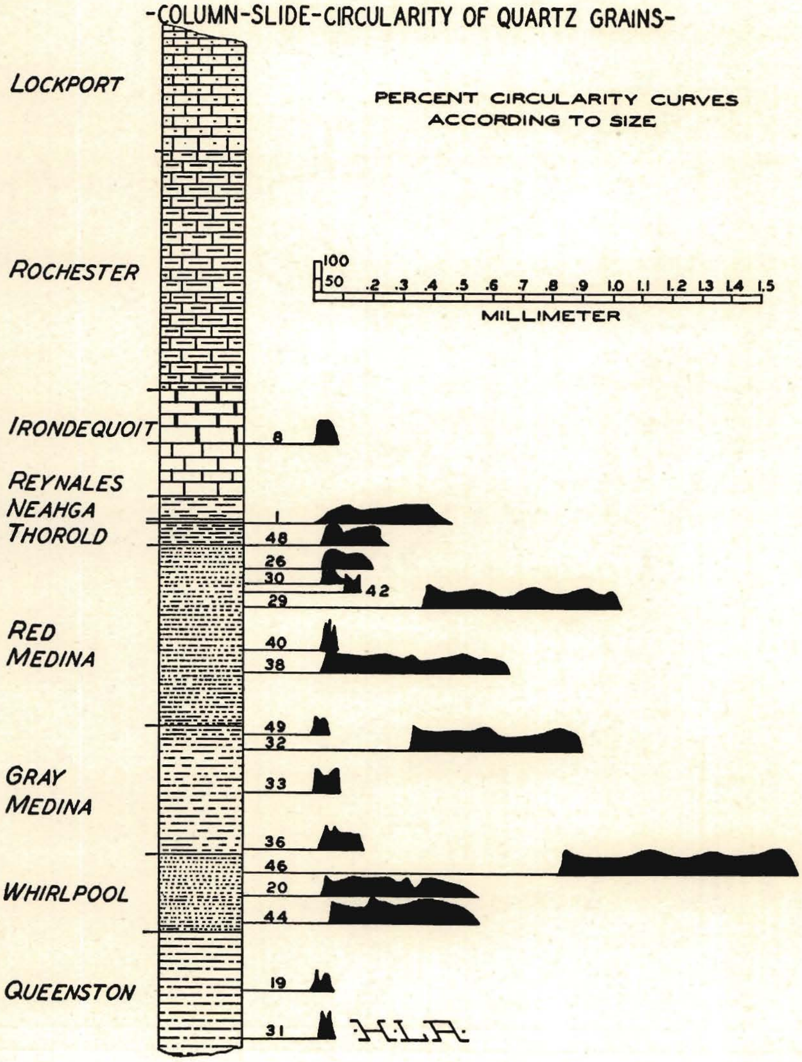
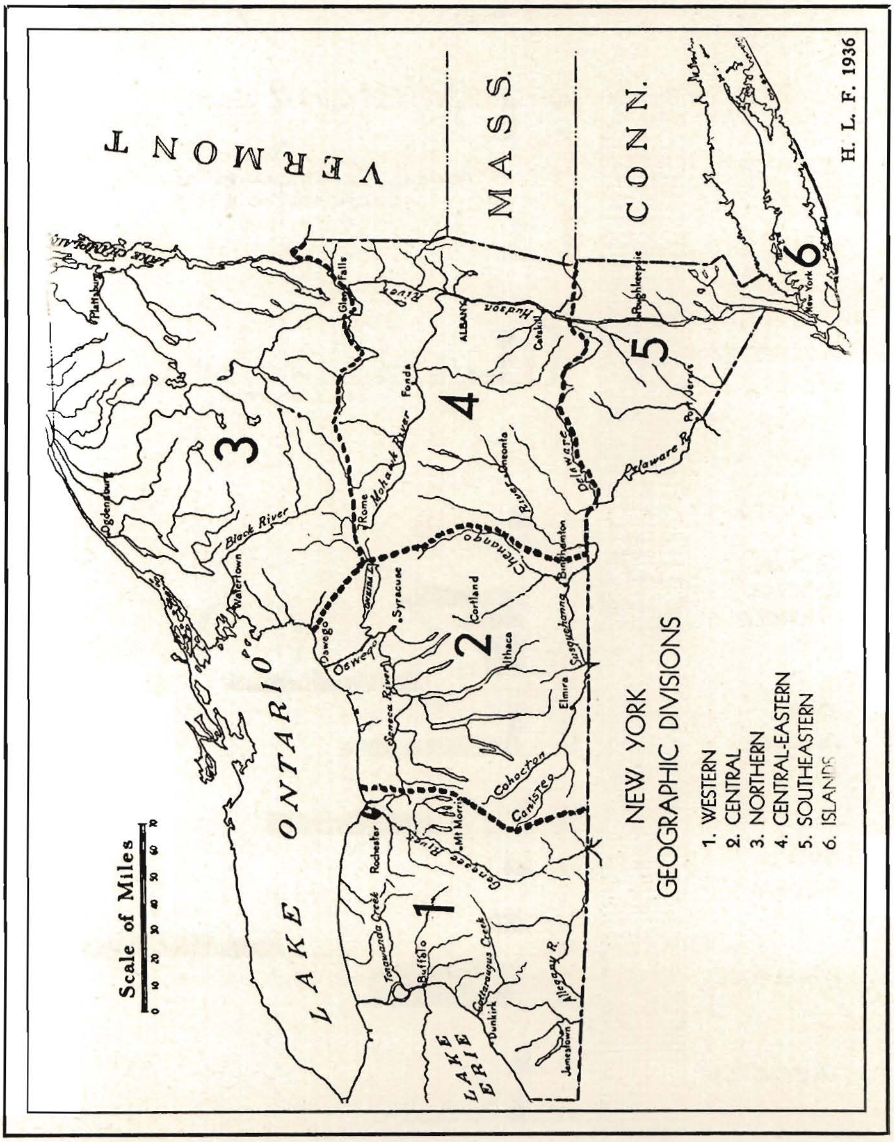


FIGURE 4

Percent circularity curves according to the size of quartz grains in the sedimentary rocks of the Niagara Gorge. Determined in thin section by calculating the ratio of the area of the smallest circumscribed circle to the area of the grain.


NEW YORK
GEOGRAPHIC DIVISIONS
1. WESTERN
2. CENTRAL
3. NORTHERN
4. CENTRAL-EASTERN
5. SOUTHEASTERN
6. ISLANDS
Scale of Miles
0
10
20
30
40
50
60
70
H. L. F. 1936
LAKE ONTARIO
LAKE ERIE
VERMONT
MASS.
CONN.
1
2
3
4
5
6
Buffalo
Dunkirk
Jamestown
Rochester
Mt Morris
Tonawanda Creek
Cattaraugus Creek
Allegany R.
Genesee River
Cohocton
Canisteo
Elmira
Ithaca
Cortland
Syracuse
Oswego
Oswego
Seneca River
Oneida L.
Chenango
Susquehanna
Binghamton
Oneonta
Rome
Mohawk River
Fonda
Black River
Watertown
Ogdensburg
Plattsburg
Lake Champlain
Glens Falls
Albany
Hudson
Catskill
Poughkeepsie
Delaware
Delaware R.
Port Jervis
New York

NEW YORK GEOGRAPHIC PUZZLE

By Herman L. Fairchild

The University of Rochester

Royal grants, Indian concessions and Colonial treaties have given the state of New York a map figure which is difficult to describe and quite impossible to dissect or apportion by cardinal compass directions.

The subject is interesting as a problem in descriptive geography; and with differing opinions, suggestions are helpful. Political or county divisions are useless. The politicians divide the entire State into two divisions: New York City (metropolitan district) and the "upstate." Arbitrary lines, like the river systems and highland tracts are interlacing and confusing.

Neglecting the State's island appendages, extending northeast from Staten Island for 115 miles, to near the shore of Connecticut, the outline of the State suggests the neck and head of the Hammer-head Shark; or, to extend the homely comparison, that of a clumsy scraper of some sort. The western part of the State is relatively too large to merit the term Panhandle, as applied to West Virginia and Texas.

On account of its peculiar shape the State cannot be clearly divided into north, south, east and west portions, and no names for the large divisions have been proposed. The expressions "northern New York," "central New York" and "western New York" are in common use but without any clear application or definite limits. Geologists and geographers find difficulty in stating the location of areas or districts. The writer has used the terms western, central and west-central without precise application or limitation.

For the purpose of clearer discussion of this subject the accompanying map shows a dissection of the State into five provinces. The boundaries are arbitrary. Any dividing of the State by drainage systems or by physiographic features is complex and confusing.

The simplest compass division of the State would be into:

> Western New York, to include provinces 1 and 2; and Eastern New York, including provinces 3, 4 and 5.

Such division is entirely accurate, and useful in a broad way, but of no value in general use. And it eliminates northern, western and central divisions.

Another method of division, also correct but too comprehensive, is

> Northern New York, including province 3 and southward to the Mohawk River.
>
> Southeastern New York, including provinces 4 and 5 and perhaps the islands.
>
> Western New York, provinces 1 and 2.

This scheme leaves no space for eastern and central divisions.

The more detailed and feasible compass divisions may be taken as follows:

Northern New York

The only division of the State with fairly accurate compass designation without requiring description is that of northern. Province number 3 of the map suggests a definite area, although the common usage appears to include as "northern" all of the territory north of the Mohawk River. As limited in province 3 the area is wholly north of all the rest of the State, even provinces 1 and 2.

Eastern New York

The term eastern is so comprehensive that it is very indefinite and is used only loosely. The term with correctness must include all of the provinces 3, 4 and 5, or about two thirds of the State. That is the only fair application of the term. An arbitrary western limit by some meridian, say 75° 30′, would cut off the western part of province 3, and would leave no area for "southern." The term eastern is impractical.

Southern New York

The only portion of the State which can appropriately use the term "southern" as against the remainder of the State is the province 5. The chain of islands could be included; but would better make a sixth province.

This application of the term southern deprives provinces 1 and 2 of any claim on such division. A common usage speaks of the counties bordering on Pennsylvania as the "southern tier." As noted below province 5 is more correctly designated as Southeastern New York.

Central New York

The term central is in common use, but with no precise limitation. It has frequent reference to the Finger Lakes district; and also to the area east and west of Syracuse.

As a physiographic district the Finger Lakes region is properly called central, although partly west of the middle of the State. The term is elastic and no better limits than suggested for province 2.

Western New York

In the broad way the term "western" would certainly include all of the provinces 1 and 2, thus leaving no place for "central." In the precise and restricted division western is province 1. This includes the Genesee drainage area, and the four "Thumb" lakes, Conesus, Hemlock, Canadice and Honeoye, as distinguished from the Finger Lakes, all on the left hand.

Central-eastern New York

In the above division of the State "eastern" finds no place in the final division, and province 4 has been neglected. This illustrates the difficulty in apportioning the State.

Province 4 is certainly "eastern," yet no more so than 3 and 5. Hence it must be recognized by some distinctive term if we recognize any eastern area by name.

The tentative divisions of the map now appear to be the best that we find. These are:

1. Western New York.
2. Central New York.
3. Northern New York.
4. Central-eastern New York.
5. Southeastern New York.
6. Islands of New York.

In the lack of any well-known and universally recognized map of the divisions of the State, accepted for popular use, the general public will continue the practice of indefinite, inaccurate and careless reference to location of place names. But students in geographic science should strive for precision.