THE CLINTON GROUP OF EAST-CENTRAL NEW YORK

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INTRODUCTION

The only completely conformable, exposed sequence of the Clinton Group (Middle Silurian) of New York State is located in its type area in the east-central part of the state. The Group is characterized by a heterogeneous lithology that includes pebbly sandstones, impure and clean sandstones, shaly, green and gray mudstones, carbonates and ironstones. Except for the Medina Group of upper Lower Silurian age, the Clinton Group, at its type locality, contains the only major sequence of detrital clastics in the Silurian of central and western New York.

The materials that comprise most of the Clinton Group of east-central New York probably were deposited in a near-shore, shallow water environment, the shifting strand generally being located in the vicinity of the Joslin Hill area (long. 75°07'). Paleocurrent data obtained chiefly from cross beds and ripple marks, and the general coarsening of units eastward, indicate a northwesterly paleoslope and a probable eastern provenance.

Detrital albite rarely forms 1 percent of the Clinton rocks; only a trace of orthoclase was seen in two thin sections. The heavy mineral assemblage consists predominantly of rounded zircon, tourmaline, and rutile. Angular grains of epidote, diopside, and garnet are common. Provenance was chiefly a meta-sedimentary terrane.

The Shawangunk Conglomerate of southeastern New York consists chiefly of orthoquartzite, and subarkose. Orthoclase, which may form 24 percent of the rock becomes more abundant upward. Albite is absent. Chert is more common and of larger size than that found in Clinton. The heavy mineral assemblage is basically similar to that of the Clinton but there are significant varietal differences. The mineral content and evidence of an easterly transgressive Clinton sea indicate that the Shawangunk, at least from Otisville, New York, northward, is younger than the Clinton Group of central New York.

For this study (Muskatt, 1969) more than 1200 oriented samples were collected from 51 localities in central New York, and 67 samples were collected from 6 selected localities in the Shawangunk Mountains. All samples were studied under the binocular microscope. One hundred and fourteen samples from the east-central New York area and 24 from the Shawangunk Mountains were chosen for thin-section and heavy-mineral analyses.

STRATIGRAPHY

The following rock units, in ascending stratigraphic order, comprise the Clinton Group (fig. 1) of east-central New York: Oneida Conglomerate, Sauquoit Formation and its eastern facies, the Otsquago Sandstone, Westmoreland Iron Ore, Willowvale Shale, Dawes Dolostone, Kirkland Iron Ore, and the Joslin Hill and Jordanville, respectively the western and eastern members of the Herkimer Formation.

This predominantly clastic sequence grades westward into shales and limestone, except for the Sauquoit which has no western equivalent. The middle Clinton is not present in western New York (Gillette, 1947, fig. 2). North and east of its outcrop belt the Clinton has been removed by erosion, to the south it is covered by younger rocks. It dips southeast about 40 to 100 feet to the mile.

An excellent account of the history of Clinton Group terminology is given by Gillette (1940, 1947). He also gives a fairly comprehensive list of the fauna found in the Clinton of New York and their zonation. Gillette's (1947) correlations are most comprehensive and are generally adhered to today (Fisher, 1959). He placed the lower boundary of the group at the base of the Thorold Sandstone in western New York and at the base of the Oneida Conglomerate in central New York. The upper boundary of the group he placed above both the Rochester Shale in western New York and its eastern equivalent, the Herkimer Sandstone in central New York. Vanuxem, who introduced the term "Clinton" as a group name in 1842, used the same upper and lower limits.

Recent studies concerning the Clinton Group of central New York, in varying degrees of comprehensiveness, include: Alling (1947), Dale (1953), Grossman (1953), Hunter (1960), Muskatt (1969), Rickard and Zenger (1964), Schoen (1962), Yeakel (1962), and Zenger (1967, 1971).

Oneida Conglomerate

The Oneida Formation was named by Vanuxem (1842, p.75) and was designated then, as now, as the basal unit of the Clinton Group in east-central New York. Wherever exposed, the unit forms prominent breaks in slope, or rapids and waterfalls in streams. This hard, light-gray, pebbly sandstone is made up of almost pure quartz sand and gravel tightly cemented with silica and are submature to supermature orthoquartzites. It is disconformable with the Frankfort Formation of the Middle Ordovician below but is conformable with the formations above. (pl. 1) with which it is occasionally interbedded.

The thickness of the Oneida decreases, along its outcrop belt, from a maximum of 34 feet at station 8b eastward to a feather edge at station 38 and westward, to about 11 feet at station 1. (See table A, fig. 2 , and pl. 1). The Oneida ranges upward from very thick-bedded sandy pebble conglomerate near the base through the more common medium - to thick - bedded pebbly to slightly pebbly, medium to coarse sandstone. Thin - and very thin - bedded sandstones are present in places. Laminated siltstones and mudstones are rare. Near the base of the formation the modal pebble size is about 25 mm. The average maximum diameter of the ten largest vein-quartz pebbles at several different localities has a range of

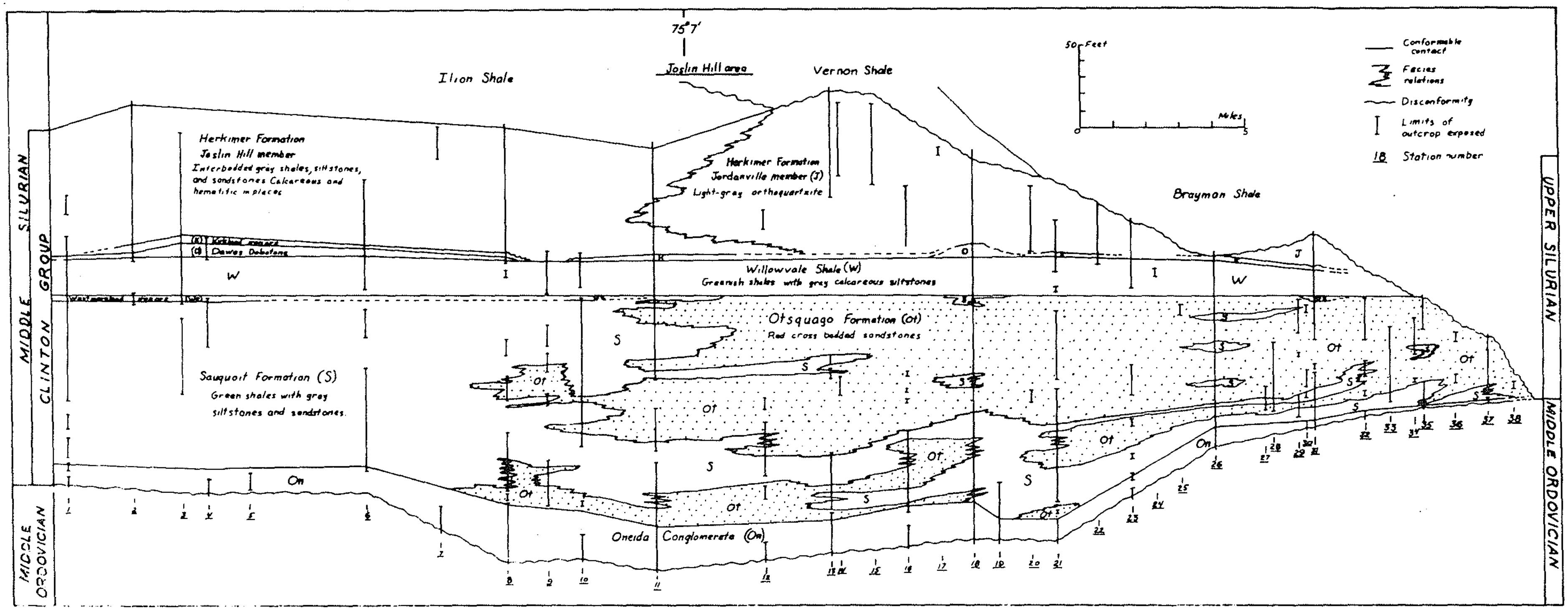


Plate 1.— Generalized east-west cross-section of the Clinton Group outcrop belt of east-central New York. Base of Willowvale is arbitrary datum. See figure 2 for station locations.

43-56 mm. with a maximum size of 63mm. Pebbles above the basal 5 feet usually have a modal diameter of about 10 mm. Most pebbles are rounded to well rounded; subangular pebbles are rare.

Pebbles of dark gray shale, which resemble the underlying Franfort, occur in the lower part of the Oneida. Greenish-gray clay galls up to 4 inches in diameter are present in places. The basal 2 to 5 inches of the unit is invariably impregnated with finely disseminated pyrite; several specimens yielded more than 50 percent pyrite by weight.

Fossils in the Oneida are scarce. The most common forms seen are Arthrophycus and fragments of Lingula. Scolithus (?) tubes and meandering trails are rare. When found Arthrophycus is generally about 5 feet above the base.

Sediments of the Oneida were probably laid down near shore. Beds accumulated under variable supply of detritus and wave or current energy. Near shore origin is suggested by a combination of the following features:

1. presence of Arthrophycus thought to be a "strand line" type of fossil whose habitat is the zone between terrestial and marine environments (Amsden, 1955, p. 68; Pelletier, 1958, p. 1057; Yeakel, 1962, p. 1526).

2. deep and vertical burrows (Scolithus?) believed to have been formed by organisms in littoral or very shallow water environments (Lochman, 1957, p. 124, 134; Seilacher, 1964, p. 313; 1967, p. 418; McAlester and Rhodes, 1967, p. 386).

3. broken and scattered fragments of linguloid brachiopods suggesting energy such as may be obtained in a near shore zone. Modern species of Lingula are most commonly found where the water is shallower than 60 feet (Craig, 1952, p. 115).

4. alternation of rock types and maturity of beds. Presence of clay and silt sized material in beds which alternate with beds of orthoquarlzite lacking this fine material suggests a near-shore or beach environment where winnowing varied considerably thereby yielding different rock types from initially

mineralogically similar sediment.

5. interfingering of the Oneida with marine formations several miles west of the area studied (Gillette, 1947, fig. 2).

Cut-and-fill structures, commonly encountered in recent non-marine deposits (Twenhofel, 1950, p. 312; Dunbar and Rodgers, 1957, p.64), suggest part of the Oneida may be non-marine. Variance of the Oneida cross beds (3894 = standard deviation of 62.4) is close to the lower limit for recent and ancient fluviatile-deltaic deposits (Potter and Pettijohn, 1963, p. 89).

Sauquoit Formation

Chadwick (1918, p.341) proposed the name Sauquoit for the shale and sandstone beds between the Oneida Conglomerate and the Westmoreland Iron Ore in the Oriskany and Sauquoit Valleys. The Sauquoit is conformable with the underlying Oneida and in places appears to be gradational. Light colored sandstones, similar to those of the Oneida, are present in places in the lower part of the Sauquoit, but they contain pebbles of shale and phosphate which are very rare in the Oneida. The upper contact is well defined in the western part of the area studied where it is overlain by the Westmoreland ironstone. Hematite oolites of the Westmoreland are often embedded in the upper surface of the Sauquoit. Eastward the contact is less definitive because of the absence of the ironstone and more limited exposures (pl. 1). There the contact is placed at the top of a sequence of thin-bedded, grayish-green, very fine-to medium-grained calcareous sandstones that is followed by a sequence of greenish and grayish shales assigned to the Willowvale. In places the contacts are gradational.

No complete section of the Sauquoit Formation is exposed, even in the type locality of the Sauquoit Valley. The maximum outcrop thickness of about 115 feet is found in the westernmost part of the area studied. Thickness decreases eastward by grading into and interfingering with the equivalent Otsquago red beds (pl. 1). The absence of the unit from western New York is due to its removal by erosion (Gillette, 1947, p. 77).

The formation varies from greenish-gray shaly mudstones, through grayish, fine-grained sandstones to green shale and phosphate pebble conglomerate. A few beds are calcareous; ferruginous beds are rare. Sandy dolostones are also sparsely represented. In the western part of the area studied shaly mudstones are most common with occasional interbeds of siltstones and well-sorted, very fine-grained to medium-grained sandstones some of which are calcareous. Also present are occasional thin-to medium-bedded, poorly sorted medium to coarse sandstones containing pebbles of green shale, phosphate and quartz. Conglomerates and sandy dolostones are uncommon. Occasionally some of the thicker beds wedge out. Thicker beds and coarser grains are more common in the lower part of the unit. Eastward the shale apparently grades into coarser and thicker beds of siltstone and sandstone and the number of carbonate beds decrease; however, the sandstones are more commonly calcareous.

Some clay shales contain, on the upper bedding plane surface, small clusters or clots of round to well-rounded, frosted, fine-grained quartz. Black, rounded, ellipsoidal to disc-shaped phosphatic nodules or pebbles and greenish-gray flat shale pebbles are abundant in some of the sandstones. The pebbles are usually concentrated on the top or bottom bedding plane of a given bed and are generally aligned subparallel to the bedding. Some beds contain more than 10 percent pebbles and warrant the terms clayey, sandy phosphate pebble or flat shale pebble conglomerate. Quartz pebbles are sometimes associated with them. These conglomeratic beds, although infrequent, become more common eastward and often in beds with large scale ripples.

Fossils are present in some of the mudstones and siltstones. They are rare in the sandstones. The following fossils are common in places, according to Gillette (1947, Table 3).

pelecypods

Ctenodonta mactriformis (Hall)

Cyrtodonta alata (Hall)

Leptodesma subplana (Hall)

Pterinea emacerta (Conrad)

brachiopods

Chonetes cornutus (Hall)

Coelospira hemispherica (Sowerby)

Leptaena rhomboidalis (Wilckens)

Ostracods are also present. Gastropods and trilobites are rare. Minute, laminated, fragments of *Lingula* are frequently scattered in some of the sandstones. Rare worm (?) borings penetrate some mudstones in places. Tracks of some arthropod, and organically disturbed bedding are infrequent. Interlacing, meandering feeding trails, probably of some worm, are common in some mudstones.

Sediments of the Sauquoit probably were deposited under near-shore, shallow water conditions. From west to east the environment changed as indicated by the decrease in shale and concomitant increase in calcareous siltstones and sandstones. Cross-bedding and ripple marks are also more common eastward.

Most likely the western part of the formation formed as shallow water fore-set beds of a delta. This is suggested by low sand content, laminated mudstones, rare mottling of strata by organisms, upward coarsening of the unit, occasional winnowed beds of siltstones, and rare ripple marks. The fauna present, although sparse, suggests a soft substrate in a shallow-water, near-shore environment. *Leptodesma* and *Pterinea* are pectinids which tend to be most abundant in relatively shallow waters (McAlester and Rhoads, 1967, p. 386). Pterinea presumably lived in an environment such as oysters do today (Ladd, 1957, p.35). Oysters thrive in shallow water, from approximately halfway between high and low tide levels to a depth of about 100 feet (Galtsoff, 1964, p.1). Cyrtodonta live mostly in shallow water (Moore and others, 1952, p. 418). Ziegler and others (1968, p. 12-17), in a study of Silurian marine communities, suggest that Eocoelia (= Coelospira) inhabited near-shore environments. Lingula is most commonly a shallow water fauna (Craig, 1952, p. 115).

Meandering feeding tracks and trails, numerous in the finer clastics in places, are frequently seen in the intertidal zone (McKee, 1957, p. 1739; van Straaten, 1959, p. 200). Winding, relatively horizontal, non-patterned feeding burrows and trails are generally found in shallow-water environments (Seilacher, 1967, p. 418, 421).

Sandstones are more common eastward as are cross-bedding and ripple marks. Some sandstones are better sorted than others and only rarely are the grains well rounded thereby indicating variable current velocities and rates of sedimentation.

Ripple marks of various types (wave and current, linguloid, interference, truncated, and large and small scale ripples) are present in the central and eastern part of the Sauquoit. Abundant ripple marks of different sizes and types are characteristic of intertidal primary structures (Kindle, 1917; McKee, 1957, p. 1742; van Straaten, 1959, p. 200; Klein, 1964, p. 195; Evans, 1965, p. 224). Flat-topped ripple marks have been described from the intertidal zone by McKee (1957, p. 1742), Tanner (1958), Trefethen and Dow (1960, p. 589), and Klein (1964, p. 195). Such ripple marks have not been reported from any other depositional environment. Isolated sand ripples and flat-shale pebble conglomerates, seen in places, is suggestive of sheltered strands (Allen, 1967, p. 435). They are also often formed in the intertidal zone (McKee, 1957, p. 1739; van Straaten, 1961, p. 206).

Except for the flat-topped ripple marks, none of the features seen in the central and eastern part of the Sauquoit are individually diagnostic of any one environment. Together, however, they suggest that deposition of these coarser sediments was in shallow water near-shore and on tidal flats. Meandering tracks and trails, abundant ripple marks of various types and sizes, flat-shale pebble conglomerates, and laminations of sand and mud are described from such depositional environments by van Straaten (1954, 1959, 1961), van Straaten and Kuenen (1957), McKee (1957, p. 1738), and Evans (1965). These writers also include channel floor deposits represented by large and small scale cross bedding, cut-and-fill structures, and scour marks in this environmental range; all these structures are seen in the Sauquoit. Several of these writers also state that mud cracks, also present in the Sauquoit, are occasionally associated with such deposits.

Further indication that the eastern part of the Sauquoit is a near-shore deposit is the interfingering of this part of the formation with the non-marine Otsquago red beds to the east (pl. 1) suggesting both regression and transgression of the sea.

Otsquago Formation

The name Otsquago was introduced by Chadwick (1918) for the red, frequently cross-bedded sandstones typically exposed along Otsquago Creek (sta. 31) which flows through the town of Van Hornesville. The unit forms the major part of the middle Clinton from the Joslin Hill area eastward (pl. 1) and attains a maximum exposed thickness of approximately 100 feet at station 21. Thickness is variable because of the interfingering nature of the unit as well as the effects of erosion in the east. Muskatt (1969, p. 72) considers the Otsquago to be a formation because of its extent and distinctive characteristics. The Otsquago crops out in practically every stream bed examined from the Joslin Hill area eastward, often forming rapids and small waterfalls. Extensive hillside ledges of Otsquago are also present.

The bottom contact of the Otsquago red beds with the underlying light gray Oneida is readily discernable by color and the presence of phosphate and shale pebbles in the Otsquago. In several places the unit is separated from the Oneida by the Sauquoit (pl. 1). In all cases the contacts of these units appear to be conformable.

The sharp upper contact of the red sandstone of the Otsquago with the overlying olive-gray shales of the Willowvale was seen only at station 26. At station 31 the Otsquago appears to grade into the overlying Westmoreland Iron Ore as hematite oolites are present in the uppermost part of the Otsquago. At station 35 the upper Clinton is missing and the Otsquago is disconformably overlain by grayish thin-bedded shales and carbonates of the Upper Silurian Brayman Shale. The Otsquago, due to erosion, thins rapidly to the east of station 35, and pinches out just west of Dugway Gorge approximately 0.8 miles southwest of Salt Springvale. West of station 35 the contact seems to be conformable.

The Otsquago varies from claystone in partings, through sandstone, to slightly pebbly sandstone. Typical Otsquago is poorly sorted, to moderately sorted, medium-grained, hematitic and chloritic orthoquartzite. Usually it is submature but rarely is it sorted and mature or very poorly sorted and immature. Grains are subangular to subround as a rule, but angular, round, and well rounded grains are not uncommon.

The great majority of beds in the Otsquago are very thin-bedded to thin-bedded; these are normally fine-to medium- grained, occasionally coarse-grained ferruginous sandstones. In places they are slightly calcareous. Siltstones are less frequent. Medium beds are composed of medium to very coarse, ferruginous sandstone often containing abundant flat shale pebbles and phosphate nodules; quartz pebbles are less common. Cross bedding, predominantly of the planar type, is commonplace in the Otsquago (table 1) and is a major structural characteristic of the formation. Cross-bedded units range in thickness from 7 inches to 11 feet. Current ripple marked surfaces are often found within a few feet above the cross-bedded units.

A few fossils are present in some of the darker beds (dark grayish red, 5 R 3/2 and 10 R 3/2) of the Otsquago. These include a pelmatazoan columnal, several badly worn valves of some articulate brachiopod, and fragments of Lingula. Also present in some of these darker beds and some of the shaly interbeds are arthropod walking tracks (Diplichnites) and probable feeding trails of meandering worms (?) . Casts of resting burrows (Rusophycus) and elongate crawling trails (Cruziana) are not uncommon in some of the shaly interbeds. Dr. Richard Osgood of Wooster College is presently studying these trace fossils.

The Otsquago Formation was probably formed mostly by fluviatile deposition, possibly in deltaic distributary channels, under oxidizing conditions as is indicated by the red color, the essentially unidirectional dispersal pattern, interfingering with the western marine facies, the Sauquoit, and is consistent with the paucity of fauna.

Otsquago cross-bedding measurements (Table 1) have a variance of 3,484 (standard deviation of 59) thereby indicating a fairly constant direction of flow and suggests fluviatile deposition (Potter and Pettijohn, 1963, p. 89). Small scale cross-stratification and asymetrical ripple marks are common in point-bar sands where large scale cross-stratification is the dominant sedimentary structure (Allen, 1965 b, p. 140, 142, and Table IV). The Otsquago sandstone is composed of very fine sand to pebbly sand with rare silt. Stratification is mostly regular but some lenticular masses and irregular layers are present. This and the large and small scale cross-bedding, the large and small scale asymmetrical ripples, and the cut-and-fill structures indicate that the formation accumulated by lateral accretion through point bar growth in meandering streams. Allen (1964 b, p. 166; 1965b, p. 138) has found similar characteristics in stream deposits and Coleman and others (1964, p. 246) report similar features from deltaic distributary deposits.

Structures similar to those in the Otsquago are found in channel floor deposits in intertidal flat areas (van Straaten, 1961, p. 206), and in deposits in an estuary (Land and Hoyt, 1966). It is difficult to differentiate fluvial from estuarine point-bar deposits except by the presence of marine fossils (Land and Hoyt, 1966, p. 206). A very few marine fossils are present in the blacker beds and interbedded shales of the Otsquago.

The red color of the beds suggests an environment in which the sediments were exposed to the atmosphere. The red beds owe their color to the presence of hematite, which forms as much as 30 percent of the rock but generally ranges from 5 to 15 percent, whereas the blacker beds have lower hematite content but more abundant chlorite and finely disseminated pyrite. The relationship between the red and black beds suggests reduction during the temporary encroachment of the sea into the area of red bed deposition.

Phosphate nodules in some of the blacker beds of the Otsquago are similar to those found in some beds of the Sauquoit and Herkimer formations. Pevear (1966, p. 252) found that dissolved inorganic phosphate concentrations in estuaries are commonly high enough to cause phosphatization of calcium carbonate. This may account for the presence of the nodules in the very shallow near-shore deposits of these rock units. Some may be fecal pellets.

In view of the above, the Otsquago Formation is considered to be a river or distributary channel deposit that occasionally was partly drowned by a shallow sea or encroached into the sea. The blacker sandstones are probably brackish, possibly estuarine.

Westmoreland Iron Ore

The term "Westmoreland" was introduced by Gillette (1947, p. 90) as a designation for the oolite iron ore of Smyth (1892, p. 104). Wherever exposed the Westmoreland rests on the Sauquoit or Otsquago and is overlain by the Willowvale Shale. All contacts are sharp but appear to be conformable and occasionally transitional.

Maximum thickness of the unit is about 3 feet, seen at Clinton, New York (station 3), but diminishes both eastward and westward. The easternmost exposure, at station 31, is only one inch of ferruginous, calcareous sandstone that contains hematite oolites; it may be part of the Otsquago.

The Westmoreland is a calcareous, oolitic-hematitic iron-ore. Oolites are generally layered, showing alternating bands of hematite and chamosite. They are subspherical to slightly flattened; about 80 percent are approximately 1 mm. in diameter. Nuclei are usually subround to well rounded quartz grains; some are either an aggregate of chlorite, calcite, or of hematite. Some oolites are composed entirely of hematite. Space between the oolites is filled with hematite, sparry calcite, and euhedral dolomite grains. Small subangular grains of quartz are scattered about. Hematite occurs as an earthy red cement for oolites as well as other grains. Hematite, as oolites and cement, averages about 55 percent and carbonate forms about 20 percent of a given specimen.

Gillette (1947, p. 94, and Table 3) found, along with some trilobites and ostracods, the following brachiopod fauna in the intercalated shales:

Chonetes cornutus (Hall)
Coelospira sulcata (Prouty)
Dalmanella elegantula (Dalman)
Eospirifer radiatus (Sowerby)
Leptaena rhomboidalis (Wilckens)
Sowerbyella transversalis (Wahlenberg)

The Westmoreland probably is a shallow water near-shore deposit that probably formed in relatively warm water. The highly irregular bedding in the ironstone suggests aggitated waters in the area of deposition. Most areas of oolite formation are thought to be in shallow, agitated waters. James (1966) believes warm and humid conditions would be most reasonable for the formation of this type of ironstone.

Willowvale Shale

Gillette (1947, p.94) applied this name to those rocks which occupy a position between the Westmoreland and the Kirkland iron ores. Thickness is relatively constant across the outcrop belt, ranging from 23 feet at station 3 to 21 feet at station 26, but decreases to 16 feet at station 21. The contact of the Willowvale with underlying rock units is sharp and seems to be conformable. The unit appears to be transitional upward into the Dawes, the Kirkland, and the Joslin Hill member of the Herkimer Formation. Contact with the overlying Jordanville member of the Herkimer is disconformable.

The Willowvale Shale may be divided into an upper and lower part with a transition zone about 4 feet thick approximately 10 feet from the base of the unit. The lower part is predominantly greenish shaly claystone with only a few beds of silty claystone and calcareous siltstone, and rare very fine - to fine grained, calcareous sandstone. This grades upward into mainly grayish silty shale; thicker and coarser interbeds are more common and sandy dolostone beds are present.

Fossils are more common and abundant in the Willowvale than in any other rock unit of the Clinton group in east-central New York. The fossils in the upper part of the Willowvale commonly are fragmentary. Among the more common fossils found are the following:

brachiopods

Atrypa reticularis (Linnaeus)

Camarotoechia neglecta (Hall)

Chonetes cornutus (Hall)

Coelospira sulcata (Prouty)

Dalmanella elegantula (Dalman)

Eospirifer radiatus (Sowerby)

Leptaena rhomboidalis (Wilckens)

<u>Lingula</u> <u>lamellata</u> (Hall)

<u>Schuchertella</u> <u>subplana</u> (Conrad)

<u>Sowerbyella</u> <u>transversalis</u> (Wahlenberg)

pelecypods

<u>Ctenodonta</u> <u>mactriformis</u> (Hall)

<u>Leptodesma</u> <u>rhomboidea</u> (Hall)

<u>Pterinea</u> <u>emacerta</u> (Conrad)

The Willowvale appears to represent a near-shore, deltaic transgressive clastic wedge with a regressive sea and concomitant shallowing of water as the sea filled with sediment. This is suggested by the upward coarsening and thickening of the beds of the Willowvale as well as the fragmented fauna found in the upper part of the unit. Most of the fauna listed for the Willowvale, as with the Sauquoit and Westmoreland, suggest a soft substrate in a shallow-water, near-shore environment.

Dawes Dolostone

This unit was named Dawes Sandstone by Gillette (1947, P. 99) for the "... light gray, slightly calcareous sandstone which underlies the Kirkland Iron Ore and overlies the Willowvale Shale". Dawes Quarry Creek, station 3, is the type locality. Muskatt (1969, p. 122) suggests that the name Dawes Sandstone be dropped and replaced by Dawes Dolostone. On cursory examination the unit appears to be sandstone with shale interbeds but microscopic examination shows the Dawes consists predominantly of sandy dolomitic limestone and dolostone. Thickness of the unit varies and has a maximum of 7 feet 8 inches at its type locality. Both the upper and lower contacts appear to be gradational in the type locality. Because of the transitional nature of the contact between the Willowvale and Dawes, Muskatt (1969, p. 126) considers the Dawes as a local member of the Willowvale. Although the Dawes also grades upward into the Kirkland Iron Ore the distinctive characteristics of the ironstone make it easy to recognize.

The Dawes consists predominantly of medium-gray or medium dark-gray (N5 or N4) sandy dolostone and dolostone with some interbeds of dark-gray (N3) shales, and N4 or N5 siltstone and calcareous, very fine to fine sandstone. The several sandstones examined are on the borderline between sandstone and limestone because their carbonate content ranges from 40 to 50 percent. With decrease in quartz carbonate, particularly dolomite, increases. Quartz content in the carbonate rocks ranges from less than 1 percent to 50 percent. Most of the Dawes contains less than 10 percent quartz, chiefly in angular grains. Quartz content decreases and dolomite content increases upward in the Dawes. Most, if not all of the thicker, beds are dolostones.

Fragments of thin-shelled articulate brachiopods, pelecypods, gastropods, cephalopods, bryozoa, and palmatazoan columnals are present in the Dawes. Recognizable were Atrypa, Leptaena, Lingula, Hormotoma, and Dawsonoceras.

Sediments of the Dawes probably were deposited in a shallow near-shore zone with relatively strong currents. This is suggested by the irregular bedding, cross stratification and lamination, general absence of clays from the moderate to well-sorted siltstones, sandstones, and carbonates, and the presence of carbonate clasts and sparse broken and rounded marine fossils. Considering variations in thickness of the Dawes, regular to irregular bedding planes, and the above mentioned characteristics the Dawes may have formed as part of an offshore bar.

Kirkland Iron Ore

Chadwick (1918, p. 349) proposed the name Kirkland Iron Ore for the "red flux iron ore" of Smyth (1892, p. 104). Zenger (1971, p. 9) has introduced "Kirkland Dolostone" for the unit because the dominant lithology is dolostone. Although the unit is a highly fossiliferous, hematitic dolostone, hematite, which is not uniformly distributed, is rarely less than 10 percent and occasionally more than 40 percent thus making the grayish red unit easily recognizable as an iron ore. It is recommended that the term "Kirkland Iron Ore" be retained.

The Kirkland attains its maximum thickness of $5\frac{1}{2}$ feet at Dawes Quarry (station 3). From there it pinches out 3 miles to the west and thins erratically eastward to Otsquago Creek (station 31). The lower contact is conformable and it it also gradational with the Dawes Member of the Willowvale. Contact with the overlying Herkimer is gradational from the Joslin Hill area westward, eastward the contact appears to be unconformable except at station 22, where it appears to be gradational.

The irregular, discontinuous beds of the Kirkland is composed of fossils replaced by hematite. Occasionally the non-uniformly distributed hematitie gives the beds a patchy appearance. Thin interbeds of greenish shale are present in places. Poorly sorted quartz forms from 1 to 15 percent of the unit and chlorite content ranges from 1 to 10 percent.

Some of the more common fossils found in the Kirkland are:

brachiopods

- *Leptaena rhomboidalis* (Hall)
- *Sowerbyella transversalis* (Wahlenberg)

bryozoans

- *Acanthoclema asperum* (Hall)
- *Eridotrypa solida* (Hall)
- *Fistulipora crustula* (Bassler)

coelenterata

- *Palaeocyclus rotuloides* (Hall)

The Kirkland was probably deposited in waters similar to those in which the Westmoreland formed. Why the Kirkland is fossiliferous and the Westmoreland is much less so is not known. Perhaps the oolitic ironstone formed in shallower water and was subjected to greater continuous agitation than the fossiliferrous ironstone.

Herkimer Formation

Zenger (1966) changed the "Herkimer Sandstone" (Chadwick, 1918, p. 351) to "Herkimer Formation" and introduced the "Joslin Hill" and "Jordanville" as members of the formation, representing the western and eastern lithofacies respectively. Interfingering of the two facies occurs in the Joslin Hill area (pl. 1). West and east of this area the change in facies is abrupt. Thickness of the Herkimer in the western part of the area is about 80 feet. East of the Joslin Hill area the thickness is about 100 feet, the unit thinning rapidly to the east because of post-Clinton pre-Cayugan erosion. Both the top and bottom contacts of the Joslin Hill member seem to be gradational. Basal contact of the Jordanville with both the Willowvale and Kirkland is sharp and probably is disconformable except for the contact at station 22 where the Kirkland appears to grade into the overlying Jordanville. The upper contact is disconformable (pl. 1).

The Joslin Hill member consists of interbedded grayish mudstone, calcareous siltstone and very fine-to coarse- grained sandstone, and sandy dolostone. Mudstone decreases and calcareous sandstone increases eastward. Sandstones are generally moderately sorted to well-sorted, mature, dolomitic, medium-grained orthoquartzites. Flat shale pebbles and phosphate nodules are present in some of the coarser sandstone beds. The Jordanville Member is chiefly light-gray, mature, medium-grained orthoquartzite; supermature orthoquartzite is not uncommon. Quartz content is rarely less than 99 percent.

Small and large scale ripple marks are common in the dolostones and sandstones of the Joslin Hill Member (Table 1). Also present are cross beds, channels, and mud cracks.

Only three individual fossils have been found in the Jordanville. Scolithus (?) tubes have been observed in places. Fossils in the Joslin Hill Member are abundant in places. A listing is given by Gillette (1947, Table 3) and Zenger (1971, Table 2). Brachiopods and pelecypods are the fossil groups best represented, cephalopods, trilobites, bryozoans, ostracods, and plants are less common. Pelmatazoan columnals are abundant in many dolostones. Worm (?) trails and borings are seen in some mudstones. Rusophycus is common in some of the calcareous sandstones, particularly at Dawes Creek (station 3). Among the more common fossils listed by Zenger (1971, Table 2) are the following:

brachiopods

- Coolina subplana (Conrad)
- Leptaena rhomboidalis (Wilckens)
- Stegerhynchus neglectus (Hall)

pelecypods

- Cornellites emaceratus (Conrad)
- Modiolopsis subcarinata (Hall)
- Mytilarca mytiliformis (Hall)

The well sorted white sands of the Jordanville Member probably represents beach and shallow parts of the infralittoral environment. Sediments of the Joslin Hill sequence probably accumulated further offshore in a moderately to strongly agitated environment. This is suggested by the presence of abundant and rounded fossil fragments, large-and small-scale ripple marks, and cross-beds. That the western facies accumulated in shallow water is shown by the presence of mud cracks and small channels indicating that, at times, the shallow sea retreated leaving the area of deposition exposed at times to the atmosphere. Flat-shale pebbles are often formed in the intertidal zone. Most of the fauna found also suggests a shallow-water, near-shore environment.

PALEOCURRENT ANALYSIS

Although the several rock units that comprise the Clinton Group in east-central New York were deposited under different environmental conditions, similar in some cases, they are interrelated and in most cases transitional. Paleocurrent examination of each rock unit has shown similar trends (Table 1).

Cross-bedding

The Clinton cross-bedding is dominantly of the torrential or planar type and appears to be typically of fluviatile nature. Trough-like cross-laminated units form only 5-6 percent of all the cross-bedding. Cross-bedded units of the Clinton Group range in thickness from 2 inches to 12 feet. Cosets range from an accumulated thickness of 16 inches to as much as 35 feet.

Figure 2 depicts the moving average of the flow directions of the grouped sections and is the best estimate of the regional paleocurrent pattern for the Clinton Group of central New York. Uniformity of transport to the northwest is evident from the map pattern. Current directions were generally consistent through Clinton time in central New York (Table 1).

The resultant mean vector of the foreset dip azimuths is 284° with a variance of 4038 (standard deviation, 63.6). The most common variance of fluvial-deltaic deposits is in the range 4,000 to 6,000, and for marine deposits in the range 6,000 to 8,000 (Potter and Pettijohn, 1963, p. 89). All the rock units in the Clinton Group fall below 6,000 the suggested upper limit for fluvial-deltaic deposits. The high variance for the Sauquoit (5839) is close to the lower limit for marine deposits (6,000).

Ripple Marks

All of the rock units studied, except the ironstones, contain ripple marks (Table 1). Many ripple marks seen in cross-section were not measured. Seventy percent of the ripple mark current directions recorded show a preferred westward direction. The calculated mean ripple trend is 358° (fig. 2) with a standard deviation of 43.9 (variance = 1925). As shown by Table 1, trends in the various rock units are relatively similar and the variances relatively close. It is generally assumed that ripple marks define depositional strike.

Seventy-two percent of the ripple marks measured fall in the range from $\frac{1}{2}$ inch to 7 inch wave length whereas the remaining 28 percent range from 14 to 52 inch wave length. There is no apparent preferred orientation of trend by any given ripple mark wave length or by the grouped small-or large-scale ripple marks.

MINERALOGY

Although the proportions of mineral constituents may vary considerably from one rock unit to another, as well as one bed to another within an individual rock unit, generally the same mineral species are present. Because of controversy regarding the age of the Shawangunk Formation of southeastern New York, some data from the Shawangunk is included. See Muskatt, 1969.

Transported detritus, which forms the framework of most of the rocks, is relatively similar among the various rock units but even here differences are seen. For example, the Clinton contains a small percentage of detrital plagioclase and only a rare trace of orthoclase whereas the Shawangunk contains abundant orthoclase but no plagioclase.

Quartz is the most common mineral species. In places, in some units, carbonate and hematite are very abundant. Micaceous minerals such as illite or sericite, muscovite, sparse biotite, and in places abundant chlorite are present in most thin sections. A number of species and varieties of heavy minerals are common in almost all units, and there are only minor differences from one unit to another as shown by tables **2** and **3** . In almost all cases zircon and tourmaline are most abundant.

Light Minerals

Quartz

Quartz is ubiquitous in the Clinton Group of central New York, and, except for the Oneida Formation, generally increases in abundance and modal size to the east thereby indicating an eastern source. The Shawangunk is relatively similar to the Clinton in quartz types and their relative proportions.

The quartz grains are colorless and transparent, occasionally turbid. Most contain minute liquid and vapor inclusions and also mineral inclusions. Extinction is highly variable. All six quartz extinction types described by Folk (1968, p. 71) are present. About 90 percent of the quartz pebbles are vein quartz. "Deformation" lamellae are present in some quartz grains.

Quartz grain shape varies from angular to well rounded. Angularity increases with decrease in grain size. In places, alternating beds show variations in rounding of grains in the same grain size suggesting varying rates of deposition and reworking by currents.

Clear secondary quartz overgrowths are present in optical continuity with the detrital sand grains and usually distinguishable by "dust" rings of clay, chlorite, or hematite. Authigenic quartz crystals are present in the carbonate rich rocks. Replacement of quartz by dolomite, pyrite, hematite, and calcite is not uncommon.

The average maximum diameter (a.m.d.) of the ten largest quartz pebbles at each locality was calculated. The a.m.d. range in the Shawangunk was 52-65 mm, the maximum pebble measurement being 75 mm. The a.m.d. of the Oneida Conglomerate has a range of 43-56 mm with a maximum size of 63 mm. Chert grains in the Clinton are sparse and rarely larger than medium sand; in the Shawangunk chert is more common and occasionally is of pebble size.

Feldspar

Albite, absent from the Shawangunk, is present in all rock units of the Clinton Group but the ironstones. The mineral is scarce, only a few slides contain as much as 1 percent by volume.

Potash feldspar is very rare in the Clinton. Orthoclase in trace amounts was found in only two thin sections after staining. Two grains of microcline were noted, prior to staining, one in each of two different thin sections than contained the orthoclase. All these grains are of silt size.

Orthoclase is common in the Shawangunk, in places forming as much as 24 percent by volume of the sample. The grains are angular to subangular and vary from fresh to almost completely altered. They are frequently as large, if not occasionally larger than the associated quartz.

Mica

Sericite (illite ?) occurs in varying amounts. It forms as much as 30 percent of the siltstones and larger amounts of the shales. Muscovite rarely forms more than a few percent of a given sample. Normally only a trace of muscovite exists; biotite is rare.

Clay Minerals

Illite (?), chlorite, and chamosite are present. Illite (?) content generally decreases with increase of quartz grain size.

Chamosite, absent from the Shawangunk, is confined to the ironstone beds. It is present as chamositic oolites with concentric sheaths composed entirely of golden yellow or green chamosite, or as pale-yellow sheaths alternating with hematite.

Chlorite is not restricted to a particular lithology among the rocks studied, and ranges from either a trace or total absence to 30 percent by volume as determined from thin sections. Where hematite is present, chlorite is often associated in lesser amounts. Where chlorite is abundant hematite is generally absent.

Carbonate Minerals

Calcite and dolomite are the only carbonate minerals observed. Calcite is present in all of the rock units and lithologic types studied. Dolomite is absent only from the Shawangunk. Schoen (1962, p. 46 and 47) in his study of the ironstones of the Clinton Group, found calcite to be rare and most of the carbonate to be dolomite. Zenger (1971, p. 29) found a similar relationship for the Joslin

Hill Member.

Heavy Minerals

The average heavy mineral content, excluding pyrite and hematite, of the samples examined from both the central New York and Shawangunk areas is about 0.1 percent by weight, with a range from slightly less than 0.01 percent found in the dolostones and shaly mudstones to as much as 0.3 percent in some of the coarser, cleaner sandstones.

Twenty different detrital and five different authigenic heavy minerals were found; their relative frequencies, excluding pyrite and hematite, are shown in tables 2 and 3. The average heavy-mineral content of the formations studied in the central New York area does not vary enough to be of diagnostic stragraphic value. Slight variation in heavy-minerals between the Clinton and Shawangunk exists.

Grain size measurements of zircon, tourmaline, rutile, and garnet show that the largest grains are present in the Clinton. Only the relatively uncommon pink zircons from the Shawangunk are of greater size than those in the Clinton. Rounded zircon grains with inclusions are much more common in the Clinton Group. Also absent from the Shawangunk are large, well-rounded black tourmaline grains and rare pink to red tourmaline seen in the Clinton. Other significant frequency differences just mentioned, may be seen in table 2.

Zircon

Zircon is the most abundant of the heavy minerals and was found in all samples studied. The zircon is predominantly colorless, but some is pink and some brownish. A few have a yellowish tinge. Mineral inclusions are common. Zoned zircons are not uncommon, particularly in the brownish variety. The grains show a considerable variation in form, from idiomorphic to well-rounded. Most are rounded to well-rounded. Euhedral and round zircons may contain round or euhedral inclusions.

Tourmaline

Tourmaline was found in almost all the samples studied. Numerous varieties are present. Shapes range from a few which are idiomorphic to perfectly rounded. Over 90 percent are rounded. Colors are very variable but were grouped into six categories: colorless-orange, brown, brown-green, green, blue, and black. Inclusions are common. All of the first four major varieties include grains that may or may not have inclusions. Inclusions were not seen in the blue variety.

Rutile

Rutile is relatively common. The grains are red, reddish-brown, or yellow. In the central New York area, the frequency of rutile by color is: red = 28 percent, reddish brown = 45 percent, and yellow = 27 percent, whereas the Shawangunk showed red = 46 percent, reddish brown = 30 percent, and yellow = 24 percent. Rutile grains range from a few slightly worn crystals to generally well rounded. Most are rounded to well-rounded. Most grains show very weak pleochroism, a few are distinct brown to yellow. Some grains show striations and some show well developed geniculated twinning. Several grains had inclusions.

Garnet

Light pink to colorless, subangular to subrounded, irregular grains of garnet are found in both areas studied. A few pale yellow grains and a few reddish grains are also present in the Clinton. Some grains contain small mineral and liquid inclusions as well as cavities. No euhedral crystals of garnet or rounded to well-rounded forms nor any degree of alteration was observed.

Pyrite

Pyrite is common in all the rock units and in most of the samples. In the Shawangunk it rarely forms as much as 10 percent of a sample, normally it is considerably less than 5 percent. Rock units in the Clinton Group contain variable amounts of pyrite. Most samples from the basal 2 inches of the Oneida contain as much as 50 percent pyrite by weight. The mineral occurs most commonly as isolated euhedral cubic or pyritohedral crystals, rarely octahedral. It is also found in spongy masses composed of minute cubes or spheres. Most of the pyrite is closely associated with organic material. Pyrite has replaced quartz, dolomite, chlorite, fossil debris, and hematitic oolites.

Hematite

Hematite is present, in varying amounts, in all of the rock units studied, but is most abundant in the Westmoreland and Kirkland ironstones which contain up to 55 percent hematite by volume. Schoen (1962, table 2) reports up to 85 percent hematite in the Westmoreland. The Otsquago contains, in places, up to 30 percent hematite chiefly as films and stains on grains, or as interstitial cement. Often the hematite is concentrated with fossil debris.

The hematite occurs chiefly as an earthy light-red cement. Where abundant it apparently has replaced quartz, dolomite, and fossil debris. In several thin sections thin scales or plates of authigenic specular hematite, blood red in color by transmitted light, were seen under high magnification. These crystals have replaced parts of fossils and grains of quartz, dolomite, and other pre-existing minerals, and may possibly be one of the last diagenetic minerals to form in the rocks of the Clinton Group.

Other heavy minerals

Leucoxene is fairly common but how much of it is of detrital origin and how much, if any, is of diagenetic origin is uncertain. Other detrital heavy minerals listed in table 2 are present in lesser amounts and are generally angular to subangular. Barite occurs as a cement in some rocks.

PROVENANCE

The heavy minerals in the Clinton Group of central New york and the Shawangunk Formation of southeastern New York indicates that these strata were derived chiefly from the erosion of low grade metasediments with some contributions from clastic sedimentary rocks, gneiss, granite (?), pegmatite, and possibly basalt. In view of the abundant pebbles of vein quartz present in both areas, the source area may have contained an abundance of pegmatitic or hydrothermal veins. Abundant potash feldspar in the Shawangunk indicates that "granitic" rocks were present in the source area.

Paleocurrent data and an eastward coarsening of rock units suggests an eastern or southeastern source for the Clinton Group or, at the very least, a western or northwestern paleoslope in the vicinity of the area of deposition. Yeakel's work (1959, 1962) suggests a similar interpretation for the Shawangunk Formation. Although both areas received their detritus from the east it does not indicate that one source area supplied both the Clinton and the Shawangunk.

CLINTON-SHAWANGUNK RELATIONSHIP

Relationship of the Clinton and its source of supply with that of the Shawangunk is not clear. Grain size measurements and mineral differences suggest either different source areas or that the Clinton received additional material from some closer source, possibly some part of the southern extension of the Adirondack arch. At least the lower part of the Clinton, if not all of the Clinton is probably older than the Shawangunk (Muskatt, 1969, p. 287). Drill hole data brings the two units to within 40 miles of each other; however, both units are readily identifiable with no evidence of transition between them. There is no evidence that the units are continuous.

DEPOSITIONAL HISTORY

Sedimentary structures, petrology, and the fossils examined in the Clinton Group suggest that the type Clinton was deposited chiefly in shallow-water infralittoral to transitional environments which were at or near the eastern margin of the New York Clinton sea. The Clinton rock units in New York that formed west of that margin were deposited for the most part in a shallow marine sea.

The Clinton Group of east-central New York, for the most part, shows a history of shifting environments about a fluctuating strand. The Joslin Hill area acted as the general strand line which marks the eastern marine edge throughout most of Clinton Group deposition in central New York. Its importance was probably also felt during post-Clintonian time. That such a strand existed is shown by the following features seen in the vicinity of the Joslin Hill area (see plate 1).

1. Interfingering of the near-shore shallow water and tidal flat deposits of the Sauquoit with its eastern facies, the Otsquago, which formed under fluviatile and estuarine conditions.
2. Interfingering of the near-shore shallow water deposits of the Joslin Hill Member of the Herkimer Formation with the white beach sands of its eastern facies, the Jordanville Member.
3. All but one of the Dawes outcrops are located west of the area.
4. In the Joslin Hill area, and westward the Ilion Shale conformably overlies the Herkimer. Eastward the Ilion has been removed by erosion and the Vernon Shale disconformably overlies the Herkimer.

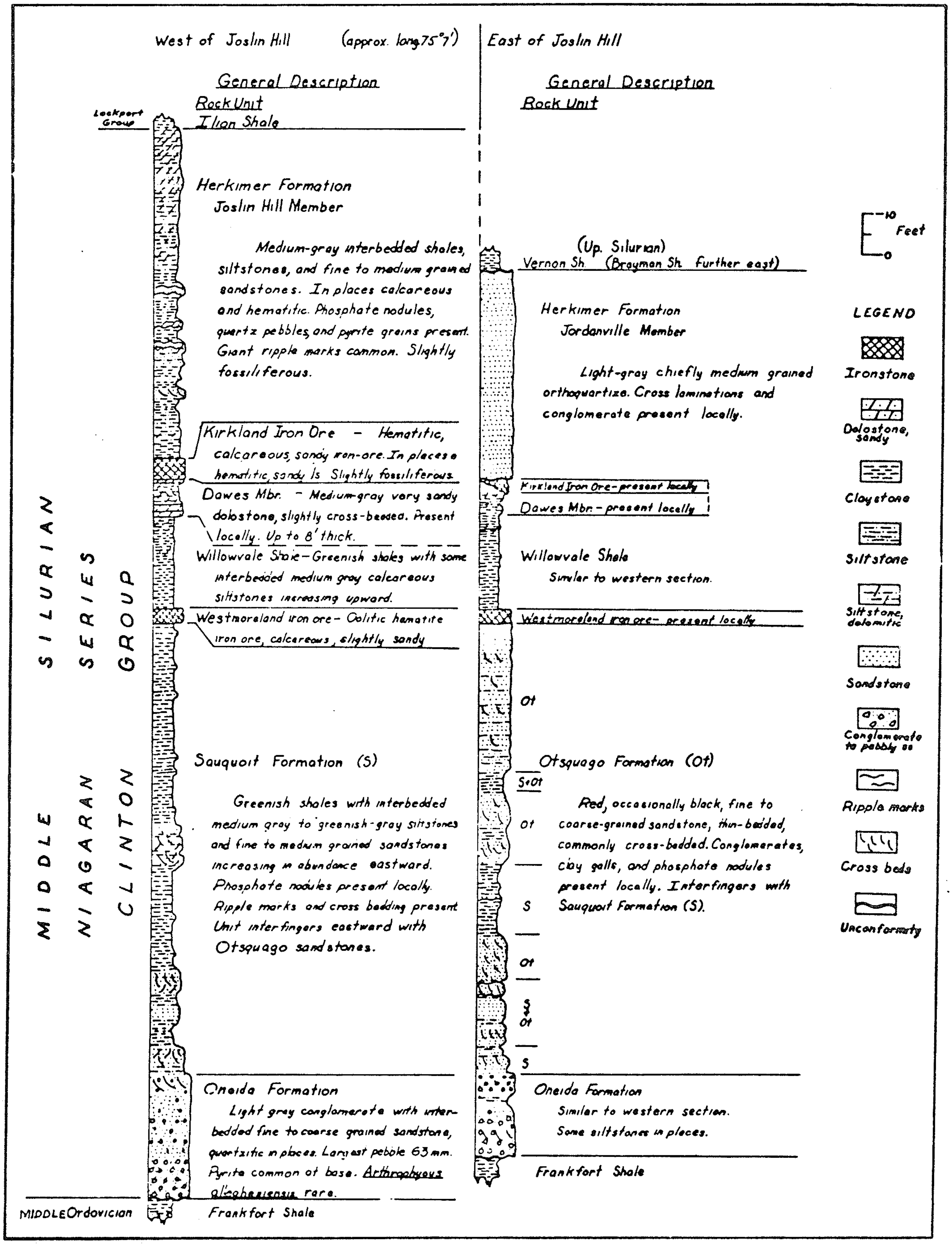
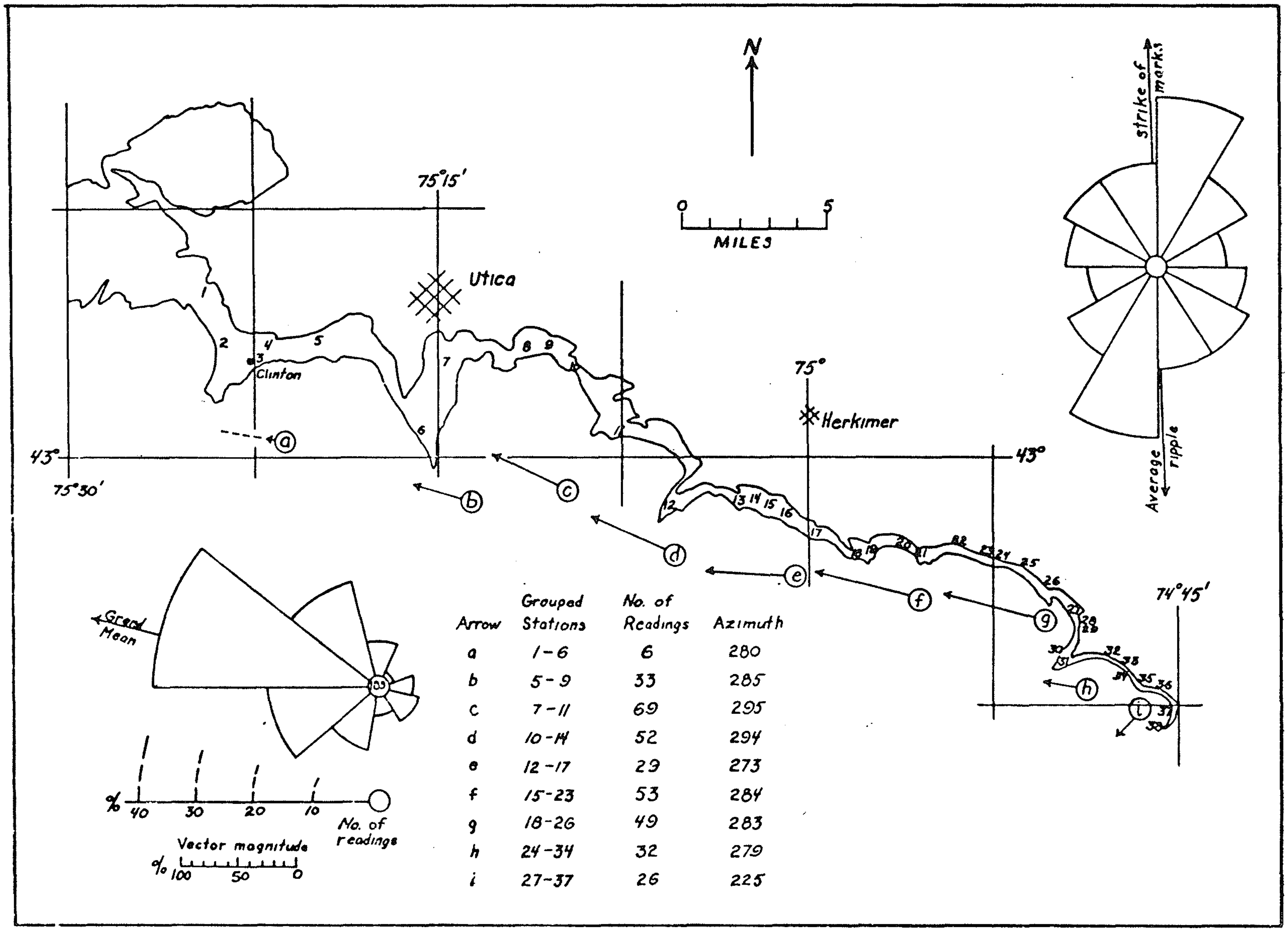


Fig. 1. - Generalized Stratigraphic Columns of the Clinton Group in East Central New York.



Arrow	Grouped Stations	No. of Readings	Azimuth
a	1-6	6	280
b	5-9	33	285
c	7-11	69	295
d	10-14	52	294
e	12-17	29	273
f	15-23	53	284
g	18-26	49	283
h	24-34	32	279
i	27-37	26	225

Figure 2.– Moving average of east-central New York Clinton Group cross-bedding vector means and composite current rose. Outcrop outline shows station locations. Histogram, upper right, shows trend of ripple marks in area. (See Table A for geographic locations.)

Table 1

Paleocurrent trend relationships in the Clinton Group of central New York

	Mean Cross-bedding dip azimuth (from north)	n	S	V	Variance	Mean Ripple Mark Trend	n	S	V	Variance
Composite	284°	183	63.6	22.4	4038	358°	79[a]	43.9	12.3	1925
Oneida	254°	39	62.4	24.6	3894					
Sauquoit	295°	16	76.4	25.9	5839	0°	32	36.0	10.0	1292
Otsquago	289°	119	59.0	20.4	3484	344°	22	55.3	16.1	3057
Joslin Hill	318°	6	37.6	11.8	1414	16°	22	35.6	9.5	1270
Jordanville	301°	3	38.6	12.8	1489					

n = Number of readings. S = Standard deviation. V = Coefficient of variation.

[a] Includes one set of ripple marks from the Oneida, Willowvale, and Dawes.

Table 2

Stratigraphic variation of detrital heavy-mineral frequencies in percent of total heavy minerals

	Oneida	Sauquoit	Otsquago	Willow-vale	Dawes	Herkimer	Central N.Y. average	a.	Shawan-gunk	b.
Zircon (range) (average)	76-87	74-88	72-83	76-85	70-90	71-82	70-90 82	100%	87-95 93	100%
Tourmaline	9-24	4-18	5-20	1-8	3-15	15-23	1-24 13	100	0-5 4	96
Rutile	2-8	3-7	3-6	0-7	2-10	2-10	0-10 4	79	0-6 2	79
Leucoxene	3-9	4-10	2-8	1-5	5-10	2-7	1-10 4	76	1-7 3	70
Garnet	0-2	0-T[c]	0-T	0-4	0-2	0-4	0-4 2	40	0-T	14
Sphene	0-1	0-1	0-1		T-2	T-1	0-2 T	37	0-1 T	25
Diopside	0-2	0-1	0-T		0-T	0-2	0-2 T	29	0-1 T	37
Hornblende	0-T	0-T		0-T	0-T	0-2	0-2 T	29	0-T	29

Table 2 —Continued

	Oneida	Sauquoit	Otsquago	Willow-vale	Dawes	Herkimer	Central N.Y. average	a.	Shawan-gunk	b.
Epidote	0-1	0-2	0-1	0-T		0-1	0-2 T	26	0-2	42
Apatite	0-T	0-T	0-T	0-T	0-T	0-T	0-T	21	0-T	17
Topaz	0-T	0-T	0-T	0-T		0-T	0-T	18	0-T	4
Andalusite	0-T	0-T				0-T	0-T	13	0-T	17
Augite	0-T	0-T	0-T				0-T	10	0-1 T	37
Corundum	0-T	0-T		0-T	0-T		0-T	10	0-T	8
Staurolite					0-T	0-T	0-T	10		0
Zoisite	0-T	0-T				0-T	0-T	8	0-T	4
Monazite				0-T		0-T	0-T	5	0-T	4

Table 2—Continued

	Oneida	Sauquoit	Otsquago	Willow-vale	Dawes	Herkimer	Central N.Y. average	a.	Shawan-gunk	b.
Clinozoisite		0-T					0-T	3	0-T	4
Tremolite								0	0-T	8
Kyanite								0	0-T	4

Table 3
Stratigraphic variation of authigenic heavy-mineral frequencies in percent

	Oneida	Sauquoit	Otsquago	Willow-vale	Dawes	Herkimer	Central N.Y. average	a.	Shawan-gunk	b.
Anatase	0-T	0-T	0-1	0-T	0-T	0-1	0-1 T	26	0-T	17
Brookite	0-T	0-T				0-T	0-T	13	0-T	37
Barite	0-T	0-T	0-T			0-T	0-T	5	0-T	4

a. Percent of heavy-mineral mounts from central New York containing this mineral.

b. Percent of heavy-mineral mounts from the Shawangunk mountains containing this mineral.

c. T indicates less than 1 percent present.

Table A

Location of outcrops examined in east-central New York

Station	Map[a]	Coordinates[b]	Geographic Location
1	Clinton	810.8-125.0	Lairdsville Gulch
2	do.	815.0-116.9	College Hill Creek
3	Utica W.	825.1-113.0	Dawes Creek
4a	do.	828.4-114.8	Mud Creek
4b	do.	827.1-117.5	Utica Rd.
5	do.	834-118	Girl Scout Camp "Stone Ledge"
6	do.	849.8-107.5	The Glen
7a	Utica E	259.5-117	S. Reservoir
7b	do.	259.7-112.5	Tilden Ave.
8a	do.	269.3-114.3	Wilson Rd.
8a[1]	do.	269.3-116.9	N. Minden Turnpike
8b	do.	269.1-113.8	Wilson Rd.
8b1	do.	268.7-110.7	Wilson Rd.
8c	do.	271-118	Cliff N. of Brockway Rd.
9	do.	276.0-115.3	Stream N. of Brockway Rd.
10	do.	280.3-111.0	Stream N. of Camp HiHo
10a	do.	282.2-110.1	Stream S. of Frankfort Center
10b	do.	284.0-109.2	Road S. of Frankfort Center

Table A—Continued

Station	Map	Coordinates	Geographic Location
10b1	do.	284.2-108.8	Road S. of Frankfort Center
11	do.	287.6-100.6	S. Moyer Creek
11a	Ilion	293.0-99.0	Stream S. of Joslin Hill Rd.
11b	do.	(296-297)-(95.7-98)	Joslin Hill Rd.-Clemons Rd.
11c	Millers Mills	302.7-92.2	Barringer Rd.
$11c_1$	do.	299.8-90.2	do.
12	do.	(294-299.5)-(82.4-88)	Ilion Gorge
13	do.	308.8-88.0	Spinnerville Gulf
14	do.	(310-88)	NW Bell Hill
15	do.	314.5-85.0	Warren Rd. between 1020-1240 contours
16	do.	(317-321)-(80-87)	Vickerman Hill and Rte. 28
17	Jordanville	324.8-78.8	N.E. of Brown School
18	do.	329.4-74.7	Flat Creek
19	do.	332.3-77.0	Day Creek
20	do.	(338-77)	Rock Hill Rd.
21	do.	342-77	Stream E. of Rock Hill Rd.
22	do.	348.0-76.0	Aney-Tri Town Rds.
23	do.	353.4-75.5	Stream at Deck

Table A—Continued

Station	Map	Coordinates	Geographic Location
24	Van Horns-ville	357.5-73.2	Upper Deck Road (Spring)
25	do.	360.3-71.6	Rd. S. of Smith Corners
26	do.	365-68	Ohisa Creek
27	do.	370.7-62.5	Travers-Cramers Corner Rds.
28	do.	370.5-60.8	Travis Rd.
29	do.	369.2-57.8	Travis Rd.
30	do.	368.3-56.7	Stream N. of Van Hornsville
31	do.	368.0-55.5	Otsquago Creek
32	do.	375.0-55.0	Stream N. of Wiltse Hill Rd.
33	do.	378.8-55.0	Wagner Hill Rd.
34	do.	380.0-52.0	Stream N. of Willse Four Corners
35	Van Horns-ville	381.3-51.0	Stream N. of Willse Four Corners
36	do.	(385-386)-(49.5)	3 Streams E. of Gros Rd.
37	E. Spring-field	386.8-44.0	Stream N. of Salt Springville
38	do.	383.8-41.5	Stream .7 mi. SW Salt Springville N of Dugway Gorge

a. All maps refer to U.S.G.S. Topographic Maps, Scale 1:24,000

b. N. Y. State coordinate system

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TRIP I: EAST-WEST FACIES CHANGES IN THE CLINTON GROUP (MIDDLE SILURIAN) OF EAST-CENTRAL NEW YORK

H. S. Muskatt

Total Miles	Miles from last point	Route Description
0.0	0.0	Assembly point: Treadway Inn parking lot on New Hartford Street, .4 mi. north of Utica North-South Arterial (rtes. 5 & 12). Use N. Y. Mills exit.
		Departure time: 7:45 SHARP! One hour to STOP 1.
		Leave parking lot and turn left (S) onto New Hartford Street.
.3	.3	Cross North-South Arterial (rtes. 5 & 12) you are now on rte. 8 traveling south through Sauquoit Valley, a glacial trough.
10.7	10.4	Cassville (Oneida Street = rte. 8).
		Outwash plain with kettle holes
15.7	5.0	Rte. 20, Bridgewater, turn left (W) onto Rte. 20.
18.9	3.2	West Winfield, intersection with rte. 51.
30.2	11.3	Richfield Springs, intersection with rte. 167
33.4	3.2	Warren
35.1	1.7	Petrified Creatures on right.
36.2	1.1	Springfield Four Corners, intersection with rte. 80.
39.1	2.9	East Springfield, turn left (N) onto Otsego Co. rte. 30 (Clinton Rd). Right turn (S) off rte. 20 goes to Glimmer Glass State Park located on the northern end of Otsego Lake. Cooperstown and the Baseball Hall of Fame is located on the southern end of the lake.
40.1	1.0	Wiltse Hill Rd. "T-inters.", turn left (W)
40.5	0.4	"T-inters., turn right (N) and continue on Wiltse Hill Rd.
43.5	3.0	Wiltse Four Corners inters., continue N on Wiltse Hill Rd.
44.7	1.2	Wagner Hill Rd. inters., turn right (N). Nice view of Mohawk Valley in middle distance and Adirondacks in far distance.
45.0	0.3	STOP 1 (30 min.) Wagner Hill Rd., Sta 33 (Van Hornesville 7½' Quad)

Otsquago Formation (Picture Stop)

Nine feet of cross-bedded, ripple marked Otsquago red beds are exposed on the east side of the road. Another 35 feet of the unit is exposed in the woods across the road, northwest of the stop.

The outcrop is small but spectacular. Please stand back to allow others to take photographs first. This is a picture stop.

Continue down hill along Wagner Hill Rd. to intersection

45.1	0.1	Beebe Hill Rd. inters., turn left (W).
46.3	1.2	Rte. 80 inters., turn left (SW).
47.6	1.3	Travis Rd. inters., turn SHARP right (N). Van Hornesville
47.8	0.2	Outcrops of Otsquago ss on left (W) side of road station 29
48.4	0.6	STOP 2 (45 min.) Travis Rd., Sta. 28 (Van Hornesville 7½' Quad.)

Otsquago Formation

Forty-two feet of the Otsquago is exposed. The first 15 feet, on the east side of the road, shows medium-to coarse-grained, cross-bedded red sandstones with some interbeds of green and gray shales which may be part of the Sauquoit. The remainder of the section is found on the west side of the road. Tracks and trails are common in this exposure, particularly *Cruziana*.

Continue north on Travis Rd.

48.8	0.4	STOP 3 (30 min.) Travis Rd. at intersection with Cramers Corner Rd, sta. 27 (Van Hornesville 7½' Quad.)

Otsquago Formation

Fifteen feet of cross-bedded, pebbly, coarse-grained sandstones are exposed. Three cross-bedded units are present. Lenses of conglomerate and some phosphate pebbles are also seen. Graded beds, fining upward, is evident.

Continue west on Travis Rd.

51.2	2.4	Bush Rd. inters., turn left (W)
52.3	1.1	Aney Hill Rd. inters., turn right (N)
54.6	2.3	STOP 4 (1 hr.) Aney Hill Rd at intersection with Tri-Town Rd., station 22 (Jordanville 7½'Quad.)

Willowvale Shale, Kirkland Iron Ore, and

Jordanville Member of Herkimer Formation.

This outcrop was recently exposed by a new road cut and has not been previously reported. It is one of the very few readily accessible exposures where contact of the Kirkland with the underlying Willowvale and overlying Jordanville may be seen. The contacts are located at the northern end of the exposure, downhill. A little digging and weeding may be required.

The Kirkland is approximately 11 inches thick and is fossiliferous. Palaeocyclus is common. (PLEASE DO NOT STRIP THE EXPOSURE. ABUNDANT SAMPLES OF THE KIRKLAND MAY BE TAKEN AT THE LAST STOP). Digging exposed about 2 feet of Willowvale below the Kirkland.

About 40 feet of Jordanville is exposed above the Kirkland; the uppermost 5 feet is in the field to the east. The lower 8 feet of the Jordanville is a "transition" zone showing alternating beds of reddish, blackish, and greenish sandstones with some thin grayish shale interbeds. Above this zone is the "typical" white orthoquartzite of the member. A 2 inch thick layer of gray shale is seen about 8 feet above the "transition" zone. No fossils were seen in the shale. Cross bedding, channeling, ripple marks, shale pebbles, and lenses of pebbly sandstone and conglomerate are present. A few trails were found. Glacial strial and chatter marks on the Jordanville in the field strike N85W.

LUNCH (45 min.) Mr. Aney has kindly offered the use of his front lawn for our use. PLEASE KEEP IT CLEAN.

Continue north on Aney Hill Rd.

55.3	0.7	Rte. 167 inters., turn right (N).
55.4	0.1	Rte. 168 inters., Paines Hollow, turn left (W). CAUTION - There are a number of one lane bridges along this route.
58.4	3.0	Frankfort Shale (Middle Ordovician) exposed on both sides of road.
62.0	3.6	Rte. 28 inters., turn right (N).
62.6	0.6	Rte. 5S inters., Mohawk, turn left (W).
64.3	1.7	Ilion, inters. rte. 51 (Home of Remington Arms)
66.8	2.5	Frankfort, inters., rte. 171, turn left (S) at light onto to rte. 171.
67.6	0.8	Cross on overpass above new rte. 5S
68.5	0.9	Frankfort Gorge, rte. 171, Exposures of Frankfort Shale (Middle Ordovician) along the route.
70.6	2.1	STOP 5 (1 hr.) Rte. 171, Frankfort Gorge, Moyer Creek, station 11 (Utica East 7½' Quad.).

CAUTION
This road is fairly well traveled and is one of several in the area considered as the racers delight.

Frankfort Shale, Oneida Conglomerate, Otsquago Sandstone

Exposures are seen on both sides of the road. The Oneida disconformably overlies the Frankfort Formation (upper Middle Ordovician). A minor amount of channeling may be seen at the contact.

Pebbles of Frankfort Shale are incorporated in the lower part of the Oneida. The basal 5 feet of the Oneida is conglomeratic with the lowermost few inches containing abundant pyrite. The remaining 22 feet of Oneida is mostly medium-to coarse- grained white sandstones with some interbeds of pebbly sandstone and conglomerate. On the south side of the road some thin greenish shale lenses and clay galls to 4 inches are present.

Twenty-seven feet above the Oneida-Frankfort contact the Oneida grades into the reddish to blackish Otsquago. Cross bedding is very common. A few unidentifiable brachiopods are present in some beds.

The well known South Moyer Creek section (Grossman, 1953) starts about 300 yards south of the junction of that tributary with Moyer Creek about 100 yards west of the bridge over Moyer Creek.

Continue west along rte. 171

72.5	1.9	Gulf Rd. inters., turn right (N)
73.5	1.0	Highland Airfield on right (N)
73.7	0.2	Albany St. (Minden Turnpike) inters., continue north on Albany
74.7	1.0	Higby Rd. inters. (Stewart Corners), turn left (W) onto Higby
75.8	1.1	Graffenburg Rd. inters., continue on Higby
77.5	1.7	Sessions Rd - Tilden Ave. inters., continue on Higby
77.9	0.4	Mohawk St. inters., continue on Higby
78.4	0.5	Chapman Rd. - Valley View Rd. inters., turn left (West) onto Chapman
		Chapman - Valley View Inters., w/ Higby Rd. Turn onto Chapman Rd. down hill, west. Heading down east wall of Sauquoit Valley, a glacial trough.
79.7	1.3	Cross Oneida St. and continue on Kellogg Rd. (Washington Mills)
80.1	0.4	Turn left onto Tibbitts Rd.
80.3	0.2	Cross Oxford Rd and continue west on Tibbits Rd. Climbing west wall of Sauquoit Valley, look behind to east for a view of the glacial trough.
82.2	1.9	Rte. 12 inters., turn right (N)
82.3	0.1	Brimfield St. inters., turn left (W)
84.4	2.1	Building foundation at left is that of the last operating iron mine in the central New York area which closed in the early 1960's.

84.5 0.1 Dawes Ave. inters., continue along Brimfield

84.9 0.4 New St. intersection, turn left (S)

85.2 0.3 STOP 6 (3 hrs.) New Rd, Dawes Creek, station 3 (Utica West $7\frac{1}{2}$' Quad).

Sauquoit Formation, Westmoreland Iron Ore, Willowvale Shale, Dawes Dolostone, Kirkland Iron Ore, Joslin Hill Member of the Herkimer Formation.

This section starts below the bridge on New Rd. that crosses Sherman Brook but locally referred to as Dawes Creek.

WE WILL REBOARD BUSES UPSTREAM WHERE IT CROSSES DAWES AVE.

Going upstream, 46 feet of the Sauquoit is exposed. The unit consists of greenish shales with discontinuous interbeds of calcareous sandstones and very-fine grained sandstones. Some of the interbeds show cross lamination on a fresh surface.

About 15 feet above the last exposure of Sauquoit turn left (N) up a normally dry tributary valley.

At the foot of the tributary 3 feet 3 inches of the oolitic Westmoreland Iron Ore is exposed. (Abundant ore for samples may be taken at the top of the tributary.) Above the Westmoreland 23 feet of the Willowvale Shale is exposed. The lower part of the Willowvale is predominantly greenish shale with a few beds of calcareous siltstone and sandstone. The upper part is mainly grayish silty shale with some interbeds of calcareous siltstone, sandstone and sandy dolostone. Between the upper and lower parts of the unit is a 4 foot transition zone which starts approximately 10 feet from the base of the unit. Fossils are present.

At the top of the tributary turn left (W) about 25 feet.

Dawes Dolostone

Contact of the Dawes with the underlying Willowvale is not seen here. Across the valley the contact is visible and the Dawes, there, as well as upstream, is cross-bedded. Here 7 feet 8 inches of the Dawes is exposed. The unit consists predominantly of sandy dolomitic limestone and dolostone with some interbeds of shale, siltstone, and calcareous sandstone. Some fossils are present.

The Dawes grades into the overlying fossiliferous Kirkland Iron Ore. Only 3 feet 2 inches of the ironstone is exposed here. Further upstream the Kirkland (5 feet thick) is seen to grade from the Dawes and into the overlying Joslin Hill.

Turn around and follow the path east along the valley top to Dawes Picnic Grove. Go past the buildings and follow the road to the parking lot.

The floor of the parking area is on the Joslin Hill. Abundant Rusophycus is scattered about. North of the parking area is an abandoned quarry. The Joslin Hill is composed chiefly of gray intercalated shale, siltstone, dolomitic sandstones, and sandy dolostone. Ripple marks and fossils are present.

(IF TIME PERMITS RETURN TO PICNIC TABLES FOR OPEN DISCUSSION)

Continue upstream along the Joslin Hill. A total of 36 feet of Joslin Hill is exposed along the stream. Ripple marks are fairly common and mud cracks rare. Go directly upstream until you reach the first waterfall east of the bridge that is on Dawes Ave. Several ripple marked beds are present as you continue upstream. The wave length of some reach 44 inches.

Climb up the slope to Dawes Ave., board the buses and return to start.

Continue south on New St.

85.3	0.1	Kellogg St. inters., turn left (E) onto Kellogg
85.8	0.5	Dawes Ave. inters., turn left (N) onto Dawes
85.9	0.1	Bridge on Dawes. Ripple mark sets beneath bridge and continuing upstream. Wave lengths to 44 inches.
86.0	0.1	Dawes Grove entrance on left (W) dirt road.
86.3	0.3	Brimfield St. "T-inters.", turn left (W) onto Brimfield
86.7	0.4	New St. inters. on left. Continue on Brimfield
86.8	0.1	Clinton Rd - Rte. 12b "T-inters." Clinton N.Y. to left. Turn right (N)
88.4	1.6	Inters. with rte. 5b, continue on 12b
90.4	2.0	Genesee St. (rtes. 5 & 12) inters. Cross inters. and continue on rte. 5 (E), 12 (N), Utica North-South Arterial
91.3	0.9	New York Mills exit to New Hartford St., North on New Hartford
91.7	0.4	Treadway Inn on New Hartford St.

END OF TRIP