# THE LITTLE FALLS DOLOSTONE (LATE CAMBRIAN): STRATIGRAPHY AND MINERALOGY

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The Late Cambrian Little Falls Dolostone is well known for the occurrence of exceptionally clear, doubly terminated quartz crystals, known as "diamonds", and for the irregular hemispherical masses of algal stromatolites, known as "cryptozoons". The areal relations of the Little Falls Dolostone in the field trip area is shown in Figure 1.

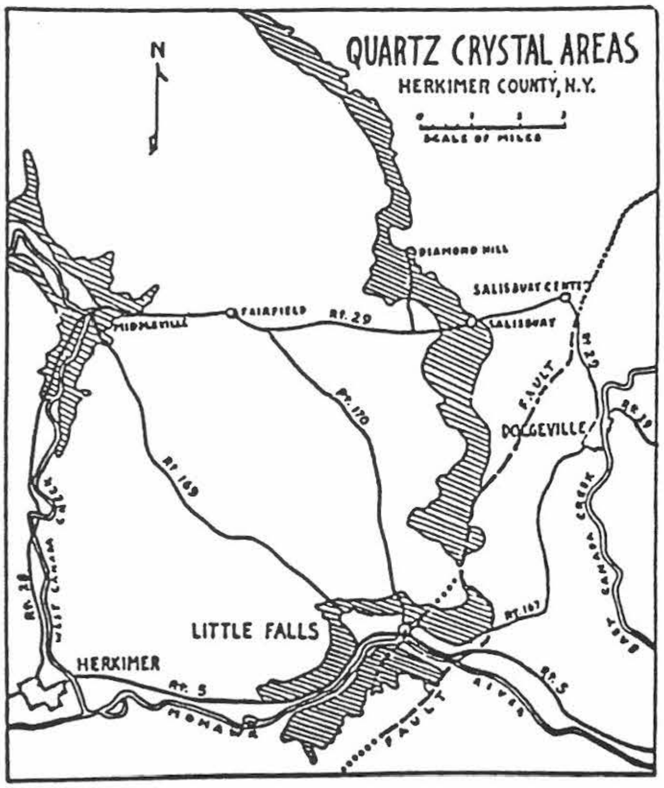


Figure 1.

Areal relations of the Little Falls Dolostone (diagonal lines) in the Little Falls, New York, region. (From Tuttle, 1973, after Cushing, 1905).

Clarke (1903, p. 16) formally designated the Little Falls Dolostone for the "...highly magnesian, sparsely fossiliferous phase of the Calciferous Sandrock in the Mohawk Valley...". The type area was first indicated by Hartnagel (1912, p. 29) as "...the pass in the Mohawk Valley at Little Falls, Herkimer County". Zenger (1976) designated a composite type section (Figure 2), and his definition is reproduced here in its entirety for the convenience of the reader.

## Definition of Type Section

(From Zenger, 1976, p.1571)

The composite type section consists of the following.

*Loc. 13*—Section exposed along south-flowing stream south of Little Falls Reservoir and east of Top Notch Road, in and above Buttermilk Falls; W ½ Little Falls 7 ½-minute quadrangle. Upper 90 ft (29 m) of Little Falls and contact with overlying Tribes Hill Formation (Ordovician) exposed at about 750-ft (230 m) elevation.

*Loc. 14*—Partly covered section exposed along secondary road (leading to Burrell's Mansion) and along hillside north of road beginning at elevation of about 590 ft (180 m) at northern end of Williams Street; W ½ Little Falls 7 ½-minute quadrangle. Approximately 205 ft (62 m) of section with neither lower nor upper contact exposed.

*Loc. 15*—Exposures at top of south side of railroad cut just south of old Jefferson Street School, on south side of Mohawk River and Barge Canal; top of cut at about 400-ft (122 m) elevation; northernmost part of SW ½ Little Falls 7 ½-minute quadrangle. Exposed is basal part of Little Falls and nonconformable contact with underlying Proterozoic gneiss.

*Loc. 16*—Section exposed in steep face just south of New York Route 167, 0.5 mi (0.8 km) east of north-flowing tributary at loc. 17 (see below); base of measured section at about 410-ft (125 m) elevation; SW ½ Little Falls 7 ½-minute quadrangle. About 65 ft (20 m) of lower Little Falls exposed.

*Loc. 17*—Section along northwest-flowing tributary of Mohawk River, directly southwest of steep bluff termed "Rollaway;" measured section begins at 420-ft (129 m) elevation, few hundred feet southeast of Route 167; SW ½ Little Falls 7 ½-minute quadrangle. Nearly 300 ft (92 m) and contact with overlying Tribes Hill exposed.

*Loc. 18*—Section along another northwest-flowing tributary of Mohawk River, about 1.2 mi (1.9 km) southwest of city hall and 0.5 mi (0.8 km) west of loc. 17; section begins just southeast of New York Route 167 at about 410-ft (125 m) elevation; SW ½ Little Falls 7 ½-minute quadrangle. About 200 ft (61 m) of middle part of formation exposed.

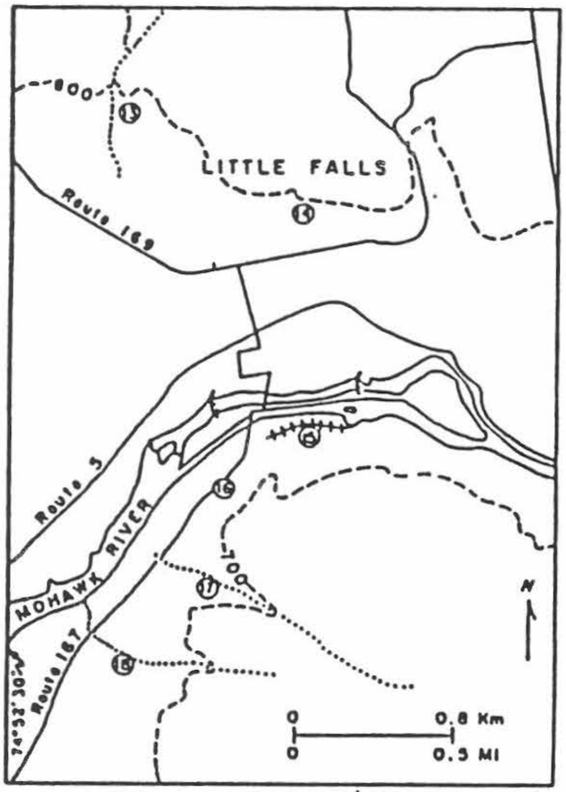


FIG. 2—Sketch map showing location of composite type section at Little Falls. Locality numbers referred to in text. Except for outline of Mohawk River, solid lines are roads; dashed lines are contour lines; dotted lines are streams.

(From Zenger, 1976, p.1571)

The lithology of the Little Falls Dolostone is quite varied. Although no one lithology is typical of the entire formation, dolostone is predominant, with sandstone and mixed dolostone-sandstone varieties. The beds are commonly gray, medium-to thick-bedded, with vuggy beds containing dolomite, calcite, anthraxolite, and of course the famous quartz crystals.

With the exception of the algal stromatolites, the Little Falls Dolostone very rarely yields fossils. The algal structures are more common in informal unit B, and range in thickness from less than a foot to three feet. Note there are several different stratigraphic levels of occurrence. As for other fossils, Zenger (1976, 1981) reported the linguid brachiopod *Lingulepis*? from unit B at several localities, including the quarry at Middleville, New York.

The stratigraphic and lateral relationships as determined by Zenger (1981) are shown in Figure 3. Zenger (1981) has demonstrated that the environment of deposition was a series of subtidal and peritidal conditions on an inner shelf area.

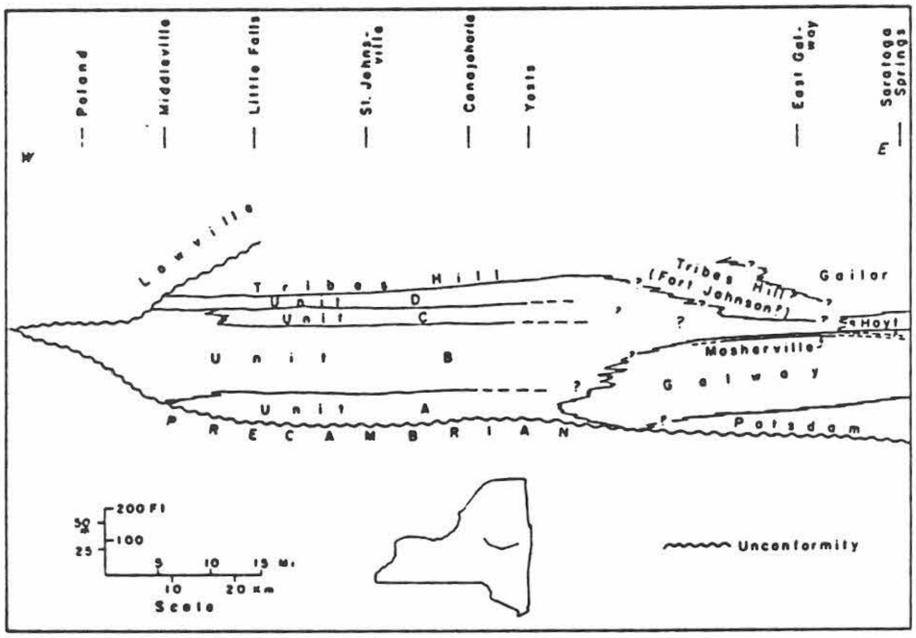


Figure 3. Generalized stratigraphic and lateral relations of the Little Falls Dolostone in east-central and eastern New York State. (From Zenger, 1981, figure 27, p.48).

Interest in the mineralogy of the Little Falls Dolostone, especially in the quartz crystals, goes back a long time. According to Ulrich (1989) the earliest documentation of the quartz crystals is a notice by Silliman (1819). According to Beck (1842) and Tuttle (1973), an article by Hadley (1823) was the first account to emphasize the abundance of the quartz crystals. The variety of external crystal morphologies was illustrated by Beck (1842, p. 261-264) and Ulrich (1989, p. 112-113). A complete list of minerals known from the Little Falls Dolostone is given in Table 1. The most commonly occurring minerals are dolomite, calcite, quartz, and the solidified hydrocarbon, anthraxolite.

The origin of the minerals is complex and as yet unresolved. According to Ulrich (1989, p. 116), the occurrences of the secondary dolomite and quartz crystals, and the anthraxolite, overlap considerably. His suggested paragenesis is shown in Figure 4. Just where the remaining minerals fit into this paragenesis is not known. An earlier paragenesis by Dunn and Fisher (1954) includes aspects of the regional geological history (see Table 2).

TABLE 1. MINERALS OF THE LITTLE FALLS DOLOSTONE

Quartz - Exceptionally clear, equant, doubly terminated. Occurs as rather large (up to 4") crystals in pockets, as smaller (up to 1") in vugs, and as linings of pockets and vugs.

Calcite - Usually yellow to brown in relatively well-formed crystals.

Dolomite- Usually cream to gray to light pink, as well-formed crystals with curved faces. Is the most common mineral.

Pyrite- Usually found as crusts up to 1/4 inch thick. Also reported as solid inclusions in the quartz crystals.

Marcasite-Usually found as solid inclusions in the calcite, mostly as wire-like bladed crystals.

Galena-Reported as very small masses. No crystals.

Sphalerite-Occurs as small (up to 1/4 inch) crystals. Also reported as solid inclusions in the quartz.

Limonite-Occurs as a weathering product of pyrite, marcasite, chalcopyrite, and hematite.

Chalcopyrite-Occurs as small, dark, rusty-looking isolated crystals and as thin, dark, rusty-looking crusts.

Hematite-Reported as solid inclusions in both the dolomite of the matrix and in the quartz crystals.

"Glauconite"-Occurs as blue to blue-green spots and stringers. Analysis by Zenger (1981) shows less iron than expected for this mineral.

Anthraxolite-Occurs as either small (less than one inch) black lustrous masses, or more commonly as a fine powder in some of the vugs. Analysis by Dunn and Fisher (1954) shows this to be a hydrocarbon. Two forms of this hydrocarbon were noted by Keith and Tuttle (1952), and may indicate two episodes of mineralization.


Figure 4. Paragenesis of some minerals of the Little Falls Dolostone, as suggested by Ulrich (1989, p.116).

TABLE 2. SEQUENCE OF EVENTS AS DETERMINED BY DUNN AND FISHER (1954).

1. Precipitation of limestone.
2. Silicification.
3. Dolomitization.
4. Formation of pyrite and sphalerite.
5. Entry of liquid anthraxolite.
6. Folding.
7. Formation of secondary dolomite.
8. Formation of secondary calcite.
9. Loss of gas, and solidification of anthraxolite.
10. Origin of the quartz crystals.
11. Block faulting.

Most research on the minerals has concentrated on the origin of the quartz crystals. Recently, Chamberlain (1988) has suggested that organic hydrocarbon complexes were of substantial importance for the long-term, low-temperature formation of the quartz. This suggestion follows the discovery by Bennett and Siegel (1987) that the solubility of quartz in water can be greatly increased when it is complexed by organic molecules According to Chamberlain (1988), the "Herkimer diamonds" formed while the organic complexes were broken down by bacterial or thermolytic mechanisms. Ulrich (1989) implies that the algal stromatolites may have been the original source of the hydrocarbons.

Unfortunately, little work has been done on the remaining minerals. It would be interesting to known if the temperatures and pressures of formation of the sphalerite are in agreement with the quartz data (approximately 50°C; based on fluid inclusion studies (Roedder, 1979), and inferred burial depths (as much as 7km of overlying sediments; Friedman, 1987)). It would also be interesting to ascertain time of formation of the galena and if it is in agreement with the inferred age of the quartz (presently accepted as Carboniferous).

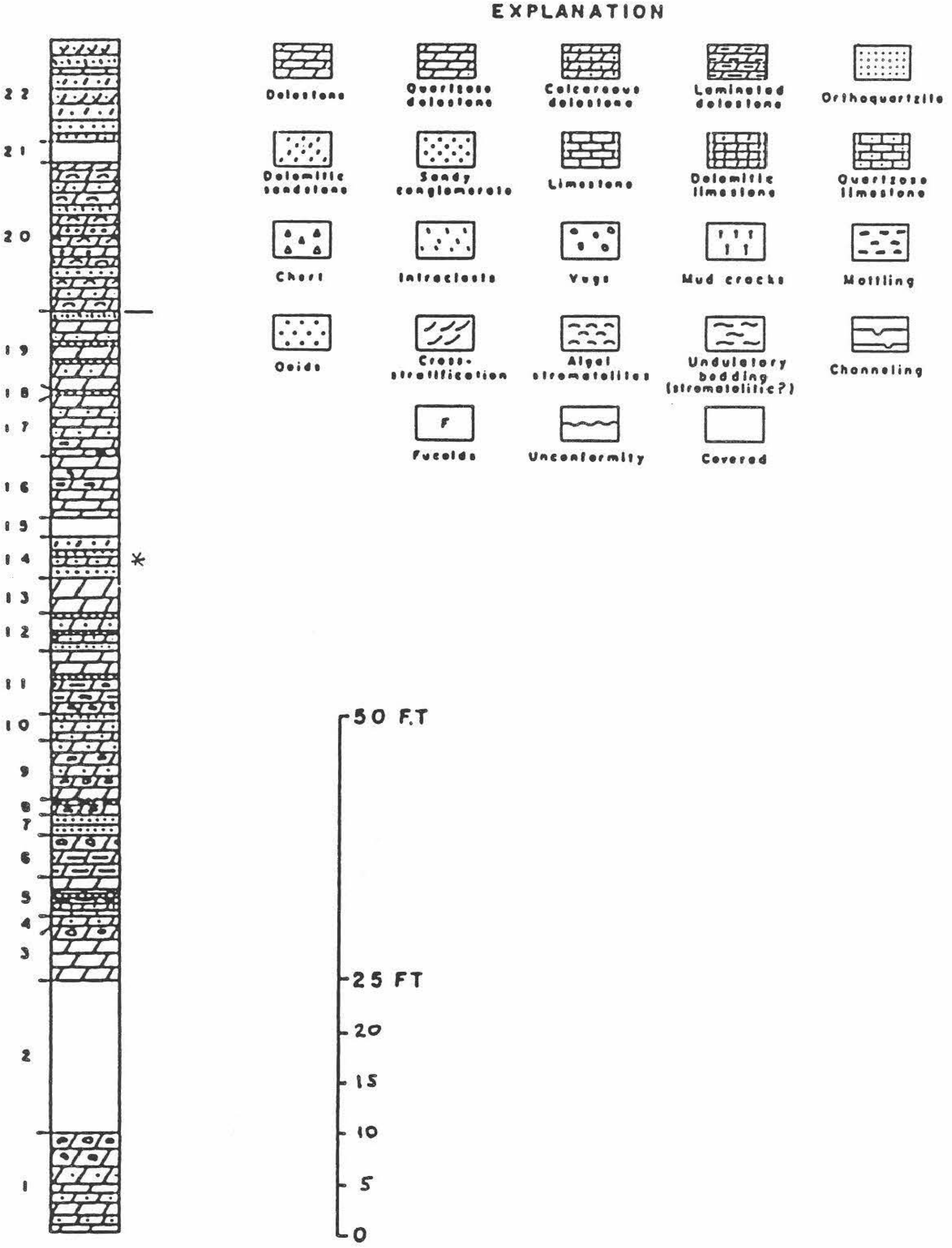


Figure 5. Columnar section for the Eastern Rock Products, Inc., quarry, Middleville, New York. (From Zenger, 1981, Plate 1).

According to Zenger (1976), the Little Falls Dolostone is about 200 feet thick at Middleville, New York. The formation non-conformably overlies the Precambrian gneiss and disconformably underlies the Ordovician Lowville Formation. The measured section (Figure 5) is from Zenger (1981) and is our major field stop. According to Zenger (1981), this section occurs entirely within his informal unit B (see Figure 3). Zenger's (1981) detailed description of this section is included here for the convenience of the reader. His terms for crystal size and crystallization fabrics follow the classification of Friedman (1965).

Unit 22. Sandstone and quartzite, light-gray to light brownish-gray, medium- to coarse-grained, medium-bedded and cross-laminated; intercalated light-gray, decimicron-sized dolostone laminations; some dolomitic sandstone; two feet above base is blackish sandstone in stylolitic contact with underlying dolostone; clasts as well as laminae of dolostone in upper bed; some sandstone very porous; some ripple marks; cross-laminations generally SW, S or SE, very rarely have northerly azimuth. 10 feet.

Unit 21. Dolostones, medium dark-gray to brownish-gray with some vugs, fine-grained (decimicron-sized); stylolitic contact with overlying sandstone sequence. 2 feet.

Unit 20. Sandstone and dolomitic sandstone, grayish-orange to brownish-gray and medium dark-gray, medium- to coarse-grained, commonly cross-laminated; some beds include dolostone clasts, some calcite; alternating stromatolitic dolostone biostromes which are generally abruptly terminated by the sandstone; bedding or parting is of medium thickness; stromatolitic dolostone is fine-grained, brownish-gray to medium dark-gray; about 7 cycles of stromatolitic biostromes capped by snady beds; two of the cycles have oolites above the stromatolites (oolites in moderate brown to moderate yellowish-brown dolostone; many oolites are hollow); matrix of sand and/or oolite in the biostromes with larger heads; relatively few vugs in biostromes - practically none in sandstones; some contacts between sandstone and stromatolitic layers are greenish glauconite(?). 15 feet.

Unit 19. Sandstone, light-gray to olive-gray or medium-gray, medium- to coarse-grained, medium- to thick-bedded, dolomitic, alternating with medium beds of vuggier, medium-gray to brownish-gray, in places laminated, decimicron-sized dolostone; cyclical nature, i.e., three couplets of dolostone overlain by sandstone; sandstones contain rounded dolostone clasts and seams of more dolomitic material; middle sandstone capped by coarser layer which is slightly green (glauconitic ?); upper sandstone has dolostone clasts. 8 feet.

Unit 18. Sandstone, pale yellowish-green, glauconitic, medium-grained; grades upward to sandy dolostone; darker "quartzite" seams within the greenish sandstone. 0.2 feet.

Unit 17. Dolostone, centimicron-sized, saccharoidal with quartzose dolostone intercalations, both being medium dark-gray; within and capping the unit are two medium beds of decimicron-sized, silty dolostone weathering a bit more olive; vugs present but not nume rous. 6 feet.

Unit 16. Dolostone, dark-gray to medium dark-gray with some brownish-gray splotches; thick parting to massive; quartz present but minor; some light greenish, circular to oblong mottles or clots; distinct dark weathering. 6 feet.

Unit 15. Inaccessible. 2 feet.

Unit 14. Sandstone, dolomitic, and quartzite; light-gray to medium light-gray, mostly medium-grained; conspicuous laminations; sharp contact with overlying dark bed; stylolite at contact with underlying dolostone; in lower layers are thin elongate quartzite bodies, forms prominent light band around entire quarry. 4 feet.

Unit 13. Dolostone, medium dark-gray to dark brownish-gray, saccharoidal, medium to thick parting, appearing massive due to weathering, weathers darker than conspicuous sandstone above; mineral filled vugs most abundant in lowest part; convex up laminae - may represent stromatolites (separated). 3.5 feet.

Unit 12. Dolostone, medium dark-gray with brownish-gray splotches, quartzose; intercalated laminae (up to 2" thick) of yellowish-gray, fine- to medium-grained sandstone; lowest half foot has small, slit-like vugs; capping thin sandstone continuous around quarry. 3.5 feet.

Unit 11. Dolostone, medium-gray and brownish-gray, decimicron- to centimicron-sized, slightly quartzose; laminated and mottled; some laminations of light-gray sandstone; thin to thick parting (1" to 1'+); vuggy, especially lower bed; top marked by less resistant zone. 6 feet.

Unit 10. Dolostone, dark medium-gray, centimicron-sized, medium to thick parting, very quartzose; some blebs; vugs practically absent; capped by this light-gray to very light-gray, medium-grained sandstone in white matrix (chert ?). 3 feet.

Unit 9. Dolostone, centimicron-sized, medium- to thick-bedded, slightly quartzose, brownish-gray to medium dark-gray, saccharoidal; very vuggy with secondary calcite and dolomite rhombs and quartz crystals; some pockets and stringers of dolomite rhombs in light, dense matrix, some of which is glauconitic (?). 6 feet.

Unit 8. Dolostone, decimicron-sized, medium-bedded, medium dark-gray; numerous vugs with predominantly quartz crystals and dolomite rhombs; unit exposed near base of main face. 1.7 feet.

Unit 7. Sandstone, fine- to medium-grained, light-gray to yellowish-gray, even surfaced; darker (cherty) pods within more quartzitic material. 2 feet.

Unit 6. Dolostone, medium-gray to dark-gray, decimicron- to centimicron-sized, thick-bedded, laminated, vuggy, particularly in upper bed; some brownish-gray, sandy pods in lower part. 4 feet.

Unit 5. Dolostone, medium dark-gray to brownish-gray, centimicron-sized, slightly quartzose; sandstone laminations; vugs contain common secondary minerals and anthraxolite; some finer-grained beds of laminated, decimicron-sized, silty dolostone; upper fine-grained beds contains *Lingulepis*? 3.5 ft.

Unit 4. Sandstone, medium-grained, dolomitic and calcareous (?); irregular, medium parting; no vugs. 1 foot.

Unit 3. Dolostone, dark-gray to dark brownish-gray, centimicron-sized, medium-bedded; upper 2 feet rather vuggy and contains abundant calcite. 5.5 feet.

Unit 2. Concealed. 15 to 20 feet.

Unit 1. Dolostone and quartzose dolostone, thin- to medium-bedded, medium light-gray to greenish-gray, fine centimicron-sized; upper part thicker bedded, light brownish-gray in splotches and layers alternating with dark-gray dolostone, low in quartz and more vuggy; dark color due to disseminated anthraxolite (?), exposed along West Canada Creek by Eastern Rock Products, Inc. office. 10 feet.

Total thickness, 120 +/- feet.

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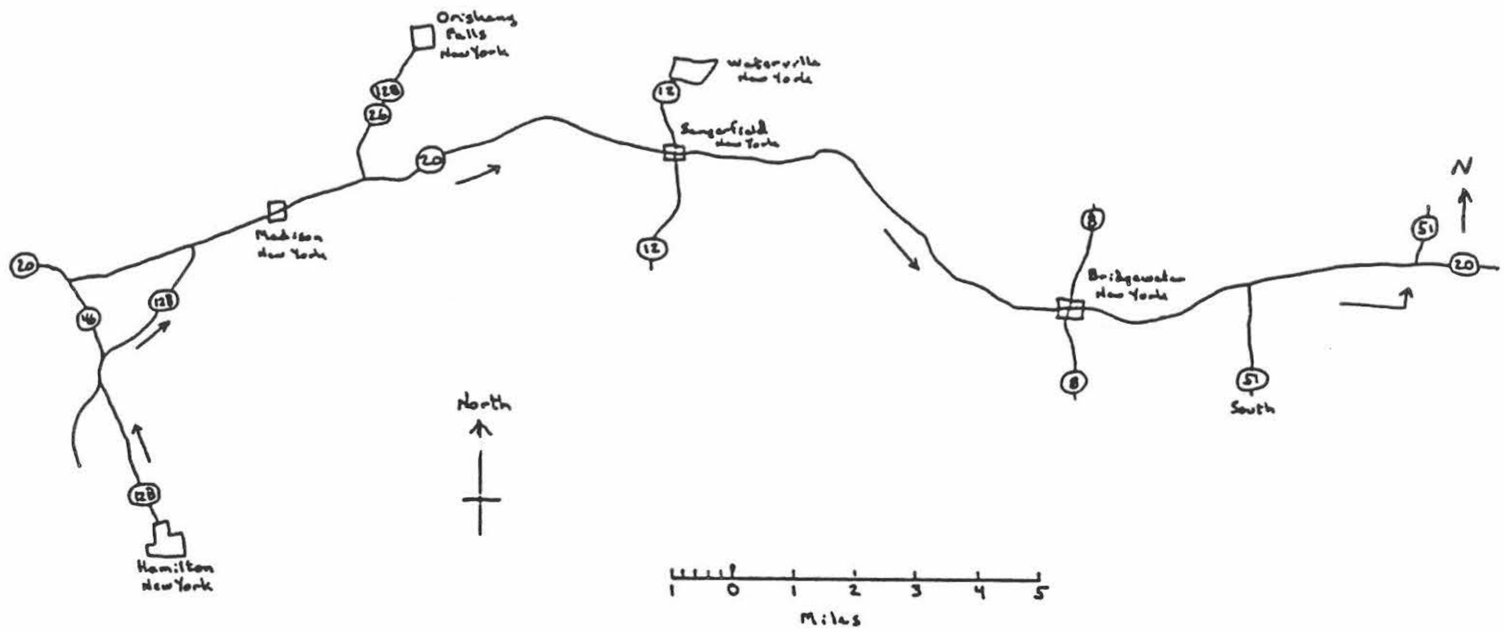


Figure 6. Generalized map for directions to start of road log.

## ROAD LOG

Although this field trip departs from Colgate University, the road log starts at the junction of New York Routes 51 and 20. Proceed north on Route 12B to Route 20. Turn right, heading east on Route 20 for approximately 21 miles to the junction of Route 20 with Route 51 North. Turn left, heading north on Route 51. Refer to figure 6 for the general route directions to the start of the road log.

| Cumulative mileage | Incremental mileage | Route description and remarks |
|---|---|---|
| 0.0 | 0.0 | Junction of Routes 51 and 20. Proceed north on Route 51 (this will be a left turn from Route 20 as we head east). |
| 3.2 | 3.2 | Junction of Route 51 with Jordanville Road in Cedarville, New York. Turn left (heading west) and continue on Route 51 for one-tenth of a mile. |
| 3.3 | 0.1 | Turn right (heading north) on Route 51 North. This section of road, known as Ilion Gorge, is somewhat narrow and quite winding. The road follows Steele Creek. |
| 4.8 | 1.5 | Junction of Route 51 with Holcomb Gulf Road (on the left). Continue north on Route 51. |
| 5.05 | 0.25 | Outcrop (on the right) of gray Syracuse Fm. (Upper Silurian). |
| 5.6 | 0.55 | Outcrop of the red Vernon Shale (Upper Silurian). See Treesh, 1972, for more details. These exposures of the Vernon Shale continue for the next 0.3 mile. |
| 5.9 | 0.3 | Junction of Route 51 with Jerusalem Hill Road on the left. This section of Jerusalem Hill Road is closed. See Treesh (1972) for more details on the units exposed along this closed road. Continue north on Route 51. |
| 7.6 | 1.7 | Short stop. Pull off CAREFULLY to the very wide shoulder on the left. Two items of interest. 1) is the small 15' thick outcrop of Otsquago Sandstone (Middle Silurian, Clinton Group; see Muskatt, 1972, for more details). 2) is the damage to trees caused by a tornado in the late 1980's (1989?). Continue north on Route 51, CAREFULLY. |

| | | |
|---|---|---|
| 8.05 | 0.35 | Bridge over Steele Creek. On the left, in the stream, are thick layers of the Oneida Conclomerate (Middle Silurian, Clinton Group; see Muskatt, 1972, for more details). |
| 8.3 | 0.25 | Historical marker on the right, to mark the place where Eliphalet Remington 2nd made the first Remington gun. |
| 8.4 | 0.1 | Exposures of Frankfort Shale (Upper Middle Ordovician). These road cut and stream bank exposures on the left and right, continue for 1.4 miles. |
| 10.1 | 1.7 | Junction of Route 51 and Spinnerville Gulf Road (on the right). Continue north on Route 51. |
| 10.3 | 0.2 | Sign (on right) marking the village limits of Ilion. At this point, Route 51 becomes Otsego Street. Continue north on Route 51. |
| 10.8 | 0.5 | Route 51 (Otsego Street) bears to the right at the Y-intersection. Continue north on Route 51. |
| 11.1 | 0.3 | Traffic signal. Continue north (straight) on Route 51. |
| 11.6 | 0.5 | Junction of Route 51 with Route 5S (East). Route 5S in Ilion is Clark Street. Continue north on Route 51. (After crossing Clark Street, Route 51 becomes Central Avenue). |
| 12.1 | 0.5 | After going under the underpass, and crossing the Mohawk River, make a right turn onto the ramp for Route 5 heading for Herkimer, New York. |
| 12.7 | 0.6 | Exposure of glacial fluvial deposit in a sand and gravel pit. |
| 14.1 | 1.4 | Junction of Route 5 with Route 28. At this point, Route 5 becomes Main Street, and Route 28 South becomes Caroline Street. This is the first of eight traffic signals in downtown Herkimer. Continue east on Route 5 to the seventh traffic signal (junction of Route 5 and Route 28 North). |
| 14.8 | 0.7 | Junction of Route 5 and Route 28 North. Turn left (heading north on Route 28) and proceed about 8 miles to the village of Middleville. |
| 15.5 | 0.7 | Traffic signal at the junction of Route 28 and E. German Street. Continue north on Route 28. |
| 15.8 | 0.3 | P&C supermarket on the left. Behind the houses on the right is the levee system for flood control of the West Canada Creek. |

| | | |
|---|---|---|
| 17.5 | 1.7 | Small exposure of the Dolgeville Fm (Middle Ordovician) on the left. |
| 17.9 | 0.4 | Sign on the right for Kast Bridge. Continue north on Route 28. |
| 18.2 | 0.3 | On the left for 0.4 mile is an abandoned stream meander of West Canada Creek. The stream channel was diverted by the DOT. Note also the braided nature of West Canada Creek as it tries to adjust to the changes. |
| 18.6 | 0.4 | On the right in the hillside, note the undercutting of the glacial material by a meander of West Canada Creek. |
| 22.1 | 3.5 | On the left is one of two commercial collecting localities for the quartz crystals known as "Herkimer Diamonds". Continue north on Route 28. |
| 22.4 | 0.3 | This is the second commercial site for "Herkimer Diamonds". Note also the exposure of the Little Falls Dolostone (Upper Cambrian) on the left. Continue north on Route 28. |

Optional side trip

| | | |
|---|---|---|
| 0.0 (22.9) | 0.0 (0.5). | Sign on the right for the junction of Routes 28, 29, and 169. Turn left onto Fishing Rock Road, NOT Summit Road. |
| 0.4 (23.3) | 0.4 (0.4) | On the left is a large exposure of a glacial kame deposit. Also of note are the glacial striations on an exposure Precambrian syenite gneiss. |
| 0.5 (23.4) | 0.1 (0.1) | On the left is another exposure of the Precambrian syenite gneiss. These two exposures are part of an uplifted block of Precambrian bedrock. It is similar to the material exposed on Moss Island (see Muskatt, 1978, for more details). Note also the nonconformable contact of over 1 billion years. Turn around and return to Route 28. |
| 1.0 (23.9) | 0.5 (0.5) | Junction of Fishing Rock Road with Route 28 North. Turn left (heading north) onto Route 28. |

End of road log for optional stop. Cumulative mileage in parentheses are those if you took the optional side trip.

| | | |
|---|---|---|
| 23.0 (24.0) | 0.1 | Bridge over West Canada Creek. |
| 23.05 (24.05) | 0.05 | Junction of Routes 28, 29, and 169. Turn left (heading west) onto Route 28 North. |
| 24.2 (25.2) | 1.15 | Entrance on the left for the Eastern Rock Products, Inc. Quarry. Park here. We will be crossing the road (on foot) to enter the quarry. There are no further field stops, and you may leave at your leisure. PLEASE, stay away from the water-filled areas, and DO NOT CLIMB THE QUARRY WALLS. |

To reach the New York State Thruway, return to Herkimer, New York, via Route 28 South. When you get to Route 5 in Herkimer, turn right, and follow the signs for the Thruway.