KIMBERLITES OF THE FINGER LAKES REGION

SUZANNE MAHLBURG KAY
Institute for the Study of the Continents (INSTOC)
Cornell University
Ithaca, New York 14853

BRAYTON P. FOSTER
Consulting Geologist
Lower Covert Road
Trumansburg, New York 14886

INTRODUCTION

Phlogopite-bearing ultramafic dikes in the Finger Lakes region were first reported in the literature by L. Vanuxem in 1837. Although not called kimberlites at the time, these were the first kimberlites described in the world (Dawson 1980). Over the years, numerous papers and theses have been written on their location (Table 1), age, field setting and mineralogy, but many questions regarding the dikes remain unanswered. The dikes have generated interest in each generation of geologists because they are the only manifestations of igneous activity in the Mesozoic in the region; and the timing of their intrusion cannot be easily related to the regional tectonics. These dikes and similar intrusions in Pennsylvania and to the south are the only windows into the lower crust and mantle in the Appalachian basin. The existence of such small ultramafic intrusions from deep within the mantle has caused interest in the mechanism of emplacement of these and similar intrusions. Not incidently, the designation of the Finger Lakes dikes as kimberlites has generated interest in the possibility of diamonds being found in the region.

LOCATION AND AGE OF THE FINGER LAKES DIKES

Eighty-two dikes and two diatremes have been reported from the Central Finger Lakes region south and west of the city of Syracuse. The greatest concentration of dikes occurs in the glacially cut gorges in and immediately north of the city of Ithaca. Most of the localities are shown in Figure 1 and described in Table 1. Localities to be visited on this trip include Cascadilla Gorge (17), Williams Brook (10), Taughannock Creek (5), Poyer Orchard (8) and Portland Point (20).

The dikes are generally vertical and occur in the prominent north-south joint set in the Devonian sedimentary rocks (see stratigraphic section in introductory part of this guide). Most of the dikes are narrow with widths ranging from several centimeters to about 0.75 meter. Exceptions are dikes near Poyer Orchard and in Cascadilla Creek (localities 8 and 17, Table 1) which are close to a meter wide and the Williams Brook dike (locality 10) which is 3.5 meters wide. Even the thin dikes can extend vertically for great distances. For example, a dike that is only 3-4 cm. wide extends almost 100 meters up the gorge wall at Taughannock Falls (Table 1, locality 4; Foster 1970). Evidence for multiple injections in the same dike occurs in dikes at the Portland Point Quarry and at Taughannock Creek (Foster 1970).

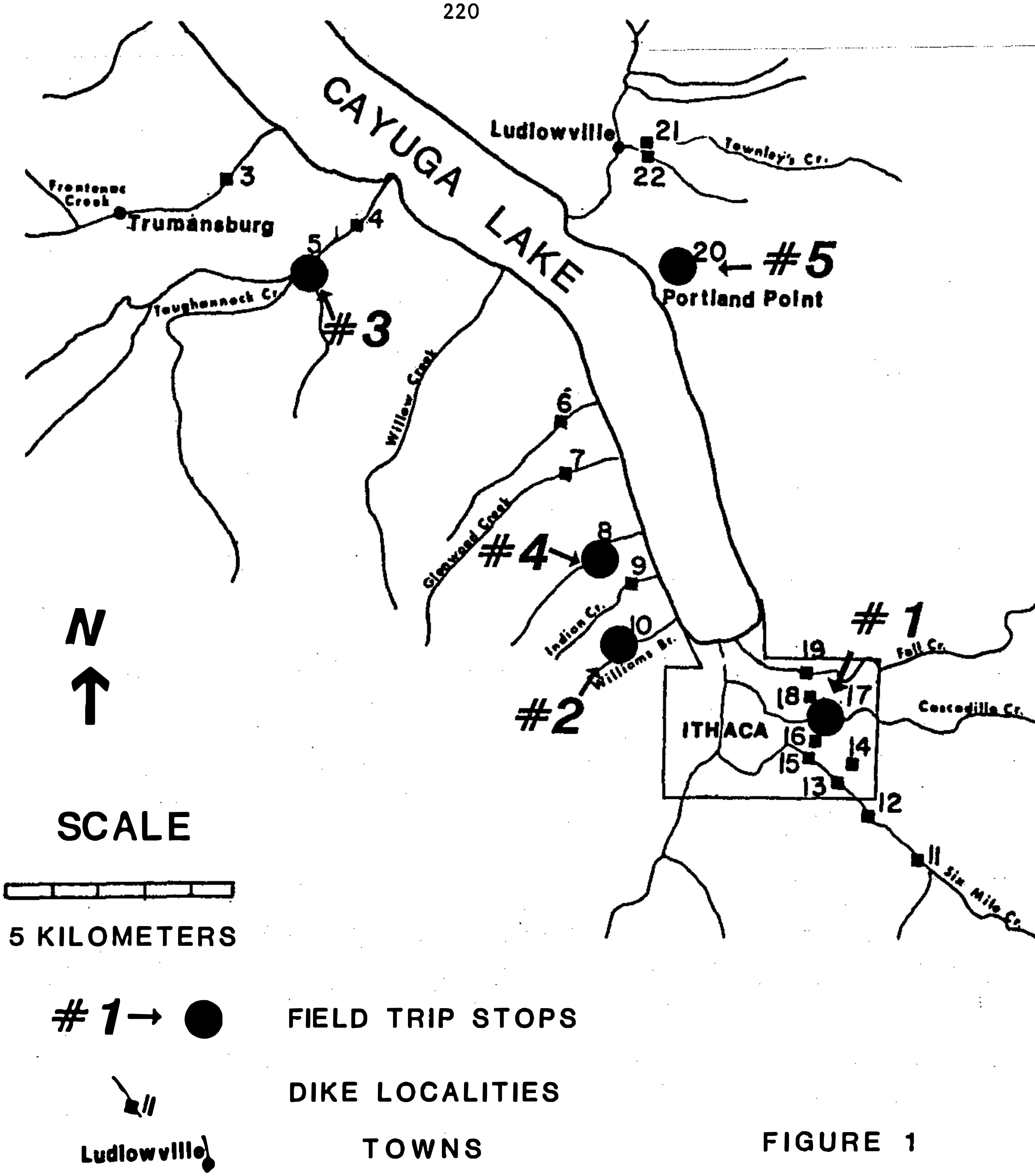

FIGURE 1

Map showing locations of most of the known kimberlite dikes and diatremes outcropping around Cayuga Lake near Ithaca, New York. Dike localities are keyed to localities described in Table 1. Field trip stop numbers refer to localities discussed in this guide. Figure modified from Foster (1970).

TABLE 1 - REPORTED LOCATIONS OF DIKES IN THE CENTRAL FINGER LAKES

(Further information and other references can be found in cited references, table modified from Foster 1970)

1 - Small quarry, 400 m. west of intersection of NY 96 and NY 336, one dike in quarry floor, maximum width is 0.4 m., strike N35W, (Wells 1961).

2 - Lively Run Creek, 425 m. east of NY 89. Four narrow dikes, 61 m. east of two dikes which are 12 m. apart, maximum width is 5 cm., strike N10W (Martens 1924).

3 - Frontenac Creek, 460 m. west of NY 89. Cluster of 3 dikes, the widest is 0.6 m. across. 150 m. upstream to west is a dike, 0.2 m. wide, all strike N10W (Foster 1970).

4 - Taughannock Creek, base of falls in Taughannock State Park. Five closely spaced dikes with a maximum width of 5 cm., strike N-S (Martens 1924).

5 - Taughannock Creek, 1 km. east NY 96 bridge (Stop 3). Ten dikes in creek over distance of 0.5 km. (Figure 2), maximum width is 0.25 m., strike N10W (Martens 1924, Foster 1970).

6 - Unnamed creek north of Glenwood Creek, where creek meets bend in Glenwood Hts. Rd. One dike, 0.45 m. wide (Filmer 1939), not located by Foster (1970).

7 - Glenwood Creek, 365 m. east of Duboise Rd. on south side of creek. One dike, 2.4 m. wide, strike N5E (Martens 1924).

8 - Ravine, 1.2 kilometers south of Glenwood Creek in Poyer Orchard. a) Diatreme exposed for about 60 m. along ravine, strike N1-5W (Stop 3 and Figure 3). b) Dike, 0.9 m. wide, 150 m north of diatreme. c). Dike, 0.45 m. wide, 180 m. north of diatreme (Filmer 1939). Dikes 8b and 8c not located by Foster (1970).

9 - Indian Creek, north of old hospital along road to old heating plant. Three dikes, widest is 0.6 m. wide, strike N8W. Poor exposures (Martens 1924, Foster 1970).

10 - Williams Brook, 60 m. west of NY 96 (Stop 2). One dike, 3.7 m. wide on north side of creek, strike N3W (Filmer 1939).

11 - Six Mile Creek, 1.2 km. south of 30 foot dam. One dike, 5 cm. wide, strike N5E. (Martens 1924). Not located by Foster (1970).

12 - Six Mile Creek, 90 m. north of 30 foot dam. One dike, 5 cm. across, strike N2W (Martens 1924).

13 - Six Mile Creek, 80 m. south of pumping station. Two dikes, 25 cm. and 10 cm. wide, 9.5 m apart in stream bed, strike N1E (Martens 1924).

14 - Near Six Mile Creek, 60 m. up ravine near small lake (now covered by Ithaca reservoir), at base of falls. Weathered igneous mass, (diatreme ?), 3 m. by 2.4 m. (Filmer 1939). Not located by Foster (1970).

15 - Six Mile Creek, 180 m. north of old pumping station. Two dikes, 25 cm. and 10 cm. wide, 10 m. apart in stream bed, strike N3E (Martens 1924).

16 - Quarry on Brandon Place, near Six Mile Creek in southeast part of City of Ithaca. No longer accessible. Four dikes, widest is 20 cm., N2E (Martens 1924).

17 - Cascadilla Creek in gorge below Central Ave. on Cornell University campus (next to Snee Hall - Dept. of Geol. Sciences, Stop 1).
a). 15 m. east of bridge at foot of steps, one dike, about 1 m. across, N2E. b). 3 m. E of bridge, 7 cm. wide, not visible, c). 40 m. west of bridge below falls, two dikes, 5-25 cm. wide, N-S strike. d). North of Eddy Gate, two dikes, spaced 0.6 m. apart, widest is 25 cm., strike N10W (Martens 1924, Foster 1970).

18 - Ravine, Cornell University campus south of Willard Straight Union. One dike, 35 cm. wide (Sheldon 1927, Filmer 1939).

19 - Fall Creek gorge, South side in first deep notch east of Stewart Ave. One dike, 10 cm. across, strike N-S (Martens 1924).

20 - Portland Point at Cayuga Crushed Stone Quarry (Stop 5). South and east walls of quarry. Two dikes of varying width, widest is 0.7 m., strike N5W (Martens 1924, Foster 1970). A dike, 0-25 cm. wide, about 600 m. below in the Cargill salt mine may connect with one of these dikes, strike N14W, dip N75W (Broughton 1950).

21 - Townley's Creek east of Ludlowsville. a). About 70 m. east of falls over Tully ls., two dikes with maximum width of 20 cm., strike N10E. b). Five dikes about 335 m. east of dikes in 20a, on second step of falls, maximum width is 18 cm., strike N2W (Martens 1924).

22 - First ravine south of Townley's Creek. a). 300 m. east of falls over Tully ls. Three dikes, maximum width is 5 cm., strike N10E. b). 400 m. east of dike 22a above single falls. Seven dikes, maximum width is 15 cm., strike N10E (Martens 1924).

23 - South of Moravia, Fillmore Glen State Park, 120 m. above Pinnacle lookout. One dike, 40 cm. wide, strike N12E (Wells 1961).

24 - Clintonville dikes, north of Otisco Lake, first stream north of US 20 that flows east to Nine Mile Creek, 366 m. upstream in south wall. Six dikes in two groups separated by 60 m., maximum width is 30 cm, strike N5E (Smith 1931).

Well-developed, closely spaced joints often occur in the country rocks parallel to the dikes. These joints are spaced from a few mm. to several cm. and the width of the jointed zones are usually about the width of the enclosed dike. They have been related to the emplacement of the dikes by Sheldon (1927).

The diatreme at Poyer Orchard (locality 8a, Table 1) crops out as a breccia for about 60 meters along a ravine, but is known to extend both to the north and south from magnetic surveys. The other possible diatreme was reported by Filmer (1939) near the present Ithaca Reservoir and may be covered by it. Kimberlite models (see Dawson 1980) suggest that diatreme facies are emplaced at shallower levels than dikes and that the diatremes have interacted with groundwater. This suggests that a limited amount of erosion has occurred from the top of the Paleozoic section in the Ithaca region since the emplacement of the diatremes.

The relation between the dikes and jointing and faulting in the Finger Lakes region was first studied by Sheldon (1927). Comparison of the dike orientations with recent work on jointing in the region (Engelder and Geiser 1980) suggests the dikes are in the north-south 1A joint set. This makes sense as the 1A joints are the earliest and most through-going of the joint sets and were tectonically induced by high pore pressures. The concentration of the dikes in the 1A joints suggests that the north-south 1B and east-west joint sets were not open at the time of dike emplacement. The emplacement of dikes in the north-south joints gives little tectonic or age information as it is consistent with the predominantly east-west extensional stresses that have existed in the Finger Lakes region since the Paleozoic (north-south compression during Appalachian folding, east--west extension associated with the opening of the Atlantic).

Isotopic dating indicates a lower Cretaceous age for the dikes. An age close to 140 m.y. is suggested by a Rb-Sr date of 136 ± 8 m.y. on the large mica fraction and a 145 ± 7 m.y. K-Ar date on the small mica fraction from the western dike at Portland Point (Table 1, locality 20) (Zartman et al. 1967) and by whole-rock K-Ar ages (Basu et al. 1984) for the Williams Brook (locality 10) dike (139 ± 7 m.y.), the Frontenac Creek (locality 3) dike (140 ± 8m.y.) and the Cascadilla Gorge (locality 17) dike (146 ± 8 m.y.). Younger ages reported by Basu et al. (1984) on dikes from Taughannock Creek (121 ± 23 m.y.) (locality 5) and Portland Point (113 ± 11 m.y.) (locality 20) have large error bars, but could suggest a second period of intrusion.

An early Cretaceous age is also consistent with pole positions inferred from magnetic polarities (DeJournett 1970). At least two periods of intrusion were postulated by DeJournett (1970) as both normal and reversed magnetic polarities were observed in the dikes. Normal polarities (62.2° inclination and 346.9° declination) were found for dikes from Williams Brook, Taughannock Creek and Cascadilla Gorge and a reverse polarity (inclination -50.4° and declination 167.5°) was measured for a dike from Portland Point. Later work by DeJournett (personal communication to A. Bloom, 1971) indicates that both normal and reverse polarities occur in multiply intruded dikes at Portland Point. Detailed timing information has not been extracted from this data due to the large number of magnetic reversals which occurred in the lower Cretaceous.

TECTONIC FACTORS CONTROLLING THE EMPLACEMENT OF THE DIKES

Emplacement of the Finger Lakes dikes may be related to a northeast-southwest trending zone of crustal weakness inferred from geophysical data (Snedden 1983, Parish and Lavin 1982). As discussed by Snedden (1983), the zone is indicated by changes in Bouguer gravity (see also Parish and Lavin 1982) and aeromagnetic signatures across the region and the location of structural lineaments inferred from satellite imagery. This lineament is not the prominent New York-Alabama lineament of King and Zeitz (see Dennison 1983) which is east of this region. Dennison (1983) suggests that the Finger Lakes dikes as well as a string of dike localities that extend from Norris Lake, Tennessee to Quebec are controlled by the axis of the deepest part of the mid-late Paleozoic Appalachian Basin. The basin axis may be controlled by a preexisting basement feature.

Parish and Lavin (1982) further suggest that the dikes are concentrated in zones of crustal weakness where the regional northeast-southwest lineament intersects northwest-southeast trending fractures. However, as pointed out by Dennison (1983), some of the proposed cross-trending basement faults in Pennsylvania are not convincing. Furthermore, similar cross-trending features are not apparent in association with the Finger Lake dikes. Snedden (1983) points out that dikes are absent where granitic bodies are inferred in the basement and suggests that these granites control where the dikes reach the surface.

The mechanism that triggered the eruption of the Finger Lakes dikes remains unclear. Crough (1981) suggested that regional uplift and kimberlite emplacement occurred when the Finger Lakes region passed within 5 degrees of the Great Meteor hotspot. Although the timing fits, the distance is great and the model does not explain the occurrence of similar dikes in Pennsylvania. Likewise, a hotspot track has been suggested from the New England Sea Mounts to Quebec (most recently by Foland et al. 1986 who obtained a 124 m.y. age on the Quebec intrusions). The Finger Lakes are even farther from this proposed hot spot track. Several authors (i.e., Taylor and Hunter 1982, Parish and Lavin 1982) have related the intrusion of the dikes to the opening of the Atlantic ocean. The correlation is not straight-forward as the Finger Lakes dikes were intruded long after rifting initiated, during a period of steady-state spreading of the central North Atlantic south of Newfoundland (160-135 m.y. ago) (see synthesis of McHone and Butler 1984). The explanation of the triggering mechanism is tied to understanding the cause of the widespread, post-rifting alkaline and ultramafic igneous activity in the eastern US.

MECHANISM OF DIKE EMPLACEMENT

Foster (1970) and Reitan et al. (1970) concluded that the dikes could not have been emplaced as magmas. This conclusion is supported by the sharp contacts and lack of visible metamorphism in the adjacent sediments, the textures of the dikes and the vertical extent of very thin dikes. Based on determination of Curie temperatures, DeJournett (1970) estimated temperatures of emplacement to be much in excess of 525°C (Curie temperature of dike) for the normally polarized dikes and between 490°C (Curie temperature of dike) and 580°C (Curie temperature of shale) for the reversely polarized dikes.

The probable mechanism of emplacement of the Finger Lake dikes is by fluidization which occurs when fragmental material is transported in a fast-moving gas stream (Reitan et al. 1970). Such a mechanism has also been suggested for other kimberlites (see Dawson 1980). Entrained oriented country rock xenoliths in the dikes and the closely spaced joints in the country rocks along the margins of some dikes support the fluidization mechanism.

THE FINGER LAKES INTRUSIONS AS KIMBERLITES

A question that has been asked about the Ithaca dikes is "Are they really kimberlites?" The question revolves around the evolving definition of kimberlite (see Dawson 1980) and whether or not, the mineral melilite occurs in the dikes, in which case they are more properly designated alnoites.

Melilite was first reported in the Finger lakes region in the Syracuse dikes by Smyth (1902) and was subsequently reported in the Ithaca dikes by Martens (1924) and Foster (1970). Reexamination of the samples studied by Martens and Foster has failed to confirm the presence of melilite. Basu et al. (1984) also were unable to find melilite and point out that the major element compositions of the New York kimberlites are essentially similar to South African kimberlites and dissimilar to olivine melilites. Until melilite is positively identified by microprobe analyses, the occurrence of melilite in the Ithaca kimberlites is an open question.

Mineral components in the Ithaca dikes consistent with their classification as kimberlites are olivine, phlogopite, diopside, opaque oxides, perovskite, sphene and calcite. Unstrained olivine grains with compositions near FO88 are interpreted as phenocrysts, while strained olivine grains with higher FO contents (FO91.5) are interpreted as xenocrysts (Basu et al. 1984). Most phlogopite compositions are like those in normal kimberlite groundmass micas and clear diopside rims overgrown on corroded clinopyroxene xenocrysts have compositions similar to groundmass diopside in other kimberlites (Kay et al. 1983). Both phlogopite and diopside compositions are slightly more Al-rich than those in the South African kimberlites (see Dawson 1980 for references). Opaque oxides are ilmenite and titanomagnetite which have reacted with the melt to form perovskite (Jackson et al. 1982; Basu et al. 1984). High Mg-ilmenite, a phase common in many kimberlites, is absent in the Ithaca dikes.

Basu et al. (1984) report that the Finger Lakes dikes have a range of Nd isotopic compositions (ϵNd = +1.2 - +4.2; Williams Brook and Portland Point, ϵNd +4.2; Cascadilla Gorge, ϵNd = +1.2) similar to that in 90 m.y. kimberlites from South Africa (ϵNd = +0.8 - +2.1). This range of Nd isotopic composition does not overlap that of other known groups of volcanic rocks and supports the interpretation of the Finger Lakes dikes as kimberlites. The range of values in the Finger Lakes region is interpreted as reflecting mantle heterogeneity (Basu et al. 1984).

Using a model proposed by Wyllie (1980) as a basis, Kay et al. (1983) proposed that the Ithaca kimberlites represent the early stages of kimberlite eruption and never achieved the eruptive maturity of larger kimberlites such as those in South Africa. This suggestion was based on the narrow, one or two-stage dikes typical of the region and the relatively shallow mantle origin of the fragments contained in the dikes (see below).

On the other hand, as summarized by Dawson (1980), kimberlites in circum-cratonic orogenic belts are generally diamond-free and tend to be associated with other rare, high-volatile ultra-alkaline rock types of limited volume, while those in cratons tend to be diamond-bearing. The Finger Lakes dikes are of the former type petrologically and lie on the western margin of the Appalachian fold belt. The correlation between kimberlite type and location suggests the type of kimberlite erupted is dependent on the age, composition and thickness of the lithosphere, as well as the volume of the kimberlite.

THE LOWER CRETACEOUS UPPER MANTLE AND CRUST IN THE ITHACA REGION

Xenocrysts and rare crystalline xenoliths in the Ithaca dikes are consistent with derivation from depths of less than 150 km. (Snedden 1983, Kay et al. 1983). Reconstructed mantle assemblages include spinel and garnet peridotites and garnet pyroxenites (Kay et al. 1983, Schultze et al. 1978). Eclogite xenoliths have been reported from the Taughannock dikes by Jackson et al. (1982) and Basu et al. (1984). Secondary pargasitic amphibole associated with the peridotite assemblages are attributed to mantle metasomatism (Kay et al. 1983). The Cr-rich assemblages which include sub-calcic diopsides common in many kimberlites (see Dawson 1980) have not been observed.

The spinel peridotite inferred from the high-Al mineral assemblage is the type commonly found in alkali basalts and associated with high geothermal gradients or undepleted mantle. No other geologic evidence suggests that heat flow has been high in the Ithaca region since the PreCambrian. As discussed by Kay et al. (1983), several interpretations are possible. First, the spinel peridotite could represent unequilibrated upper mantle of Pre-Cambrian Grenville age. Second, if the mantle below Ithaca is very undepleted in basalt-producing elements, the whole rock composition- dependent spinel to garnet peridotite transition may be at a greater depth than assumed in determining the geothermal gradient. In this case, a high geothermal gradient is not necessarily implied by the xenocrysts. Third, the implied geothermal gradient could be a transient geotherm related to the rise of the diapers and therefore, not reflect conditions in the surrounding mantle. With the information available, there is no easy way to choose between these alternatives.

Crystalline fragments of presumed crustal origin include a suite of Mg-rich minerals which may belong to a granulite carbonate assemblage, small mafic syenite xenoliths and clinopyroxene and garnet xenocrysts similar to minerals found in basic to intermediate composition granulite facies rocks (Kay et al. 1983). These fragments are all compatible with a granulite facies metamorphic basement similar to the Grenville terrain in the Adirondacks beneath the Paleozoic section and a granulite facies lower crust in the Ithaca region. The high-Mg assemblage could also be from hydrated ultramafic rocks in the upper mantle or lower crust, but the proximity of the Grenville marbles to the north in the Adirondacks and the presence of marbles in basement drill holes (see introductory chapter of this guide) lend support to the metamorphic carbonate interpretation.

The most abundant xenoliths in the dikes and diatremes are from the Paleozoic section described in the introductory part of the guidebook.

COMMENT ON THE PROBABILITY OF FINDING DIAMONDS

The absence in the Ithaca dikes of the suite of Cr-rich xenoliths and xenocrysts associated with mantle depths below the diamond-graphite transition and usually found in diamond-bearing kimberlites, makes the prospect of finding diamonds in the Ithaca dikes unlikely. The recognition of graphite in several dikes (Martens 1924) also supports this conclusion. The rotting remains of the unsuccessful sieving operation in the ravine at Poyer Orchard diatreme attests to the lack of success in finding diamonds in the Ithaca region.

ACKNOWLEDGEMENTS

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Ten dikes crop out in Taughannock Creek (Figure 2) over a distance of 0.8 kilometer upstream from the road bridge above the high falls. You are even with dikes 2-5 at the parking area. These dikes outcrop best on the ledge on the south side of the creek. Dikes 4 and 5 are 1.2 meters apart. Dike 3 is about 16 meters east of dike 4 and dike 2 is about 3.5 meters east of dike 3. Dikes 6-8 crop out above the stream in a closely spaced cluster, a short distance to the west of the parking area. Dikes 9-10 are upstream about 30 meters east of a stress-release "pop-up" in the Devonian shale in the middle of the stream. Dike 10 is exposed under a tree on the south bank of the river. The outcrop has been considerably reduced by sampling in recent years. Dike 9 is very difficult to find.

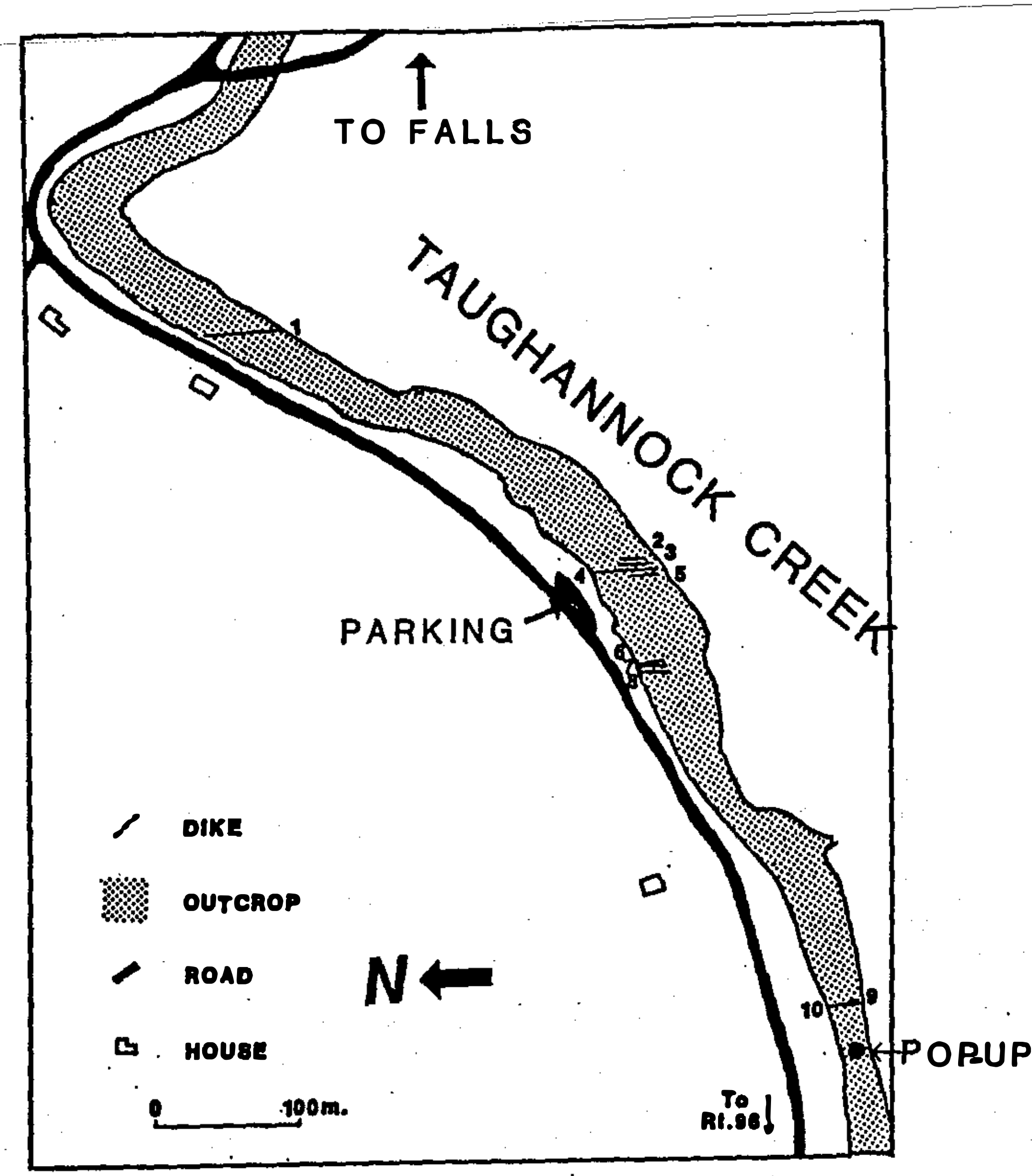
The control of the dike orientation by the prominent N-S joints is particularly well exhibited at this locality. In addition, the closely spaced joints that typically occur in the country rocks parallel to the dikes are well developed along several of the dikes. Dikes 1, 4 and 10 extend across the exposed bedrock outcrop while the other dikes pinch out rapidly in both directions. The occurrence of the dikes in clusters (1; 2-3; 4-5; 6-8; and 9-10) suggests branching by one or more feeder dikes near the present surface. A large shale xenolith in the center of dike 8 suggests how this divergence occurs. The composite width of each dike group appears to remain constant across the outcrop width as illustrated by the northward thickening of dike 4 and the southward thinning of dike 5. Dike 10 shows (or did show) evidence for three possible injection episodes in which material was deposited along the contacts and not completely removed by later events.

Petrographic differences occur among the dikes at this locality. The general mineralogy of all the dikes is similar to that in the Cascadilla Gorge dike (Stop 1), but the modal percentages are variable (Foster 1970). Dike number 10 is the widest and freshest dike at this locality and has 37% serpentine, 7% phlogopite, 5% magnetite and perovskite and 51% groundmass (Foster 1970). Most of the other dikes show considerably more alteration. All of the dikes have high concentrations of calcite in the ground mass (dike 1 - 35% calcite, 2 - 25%, 4 - 36%, 7 - 23%, 10 - 23%) (Foster 1970).

The xenocryst assemblage in the Taughannock dikes consists of pyrope garnet, green chrome diopside, augite and spinel. Dikes 6, 7 and 8 are anomalous is that they are very calcite rich (up to 30%), yet contain abundant xenocrysts of unaltered olivine, Cr-diopside, augite and garnets (Foster 1970). Garnet is particularly abundant in dike 8. Small eclogite xenoliths have been reported by Basu et al (1985) and Taylor and Hunter (1982). Mineral compositions for xenocrysts in these dikes are reported by Kay et al. (1983). Martens (1924) reports finding graphite in dike 10.

DeJournett (1970) reports that dike number 10 has a normal magnetic polarity with a pole position consistent with a lower Cretaceous age. Basu et al. (1984) obtained a whole rock K-Ar age of 121 ± 23 m.y on one of the dikes from this locality.

13.6	0.0	Turn around and return to NY 96.
14.5	0.9	Turn left (south) on NY 96.



Sketch map of the dikes occurring in Taughannock Creek upstream (east) of the falls (Stop 3). Stippled pattern shows outcrop of the Devonian shales. The width of the river is not indicated. Dike locations are approximate. Dikes 2 and 3 are farther from dikes 4 and 5 than suggested by map (see description in discussion of Stop 3). The maximum widths and strikes of the mapped dikes are shown below. Data and map is from Foster (1970). Pop-up refers to Devonian bed in stream that has been uplifted and cracked as a result of stress release due to former quarrying of the flagstones in the creek.

	Maximum Width	Strike
1	4	N 10 W
2	2	N 10 W
3	7	N 9 W
4	10	N 9 W
5	8	N 9 W
6	6	N 19 W
7	6	N 10 W
8	6	N 14 W
9	1	N 15 W
10	10	N 15 W

FIGURE 2

21.7	7.2	Turn left (east) on Duboise Road. Note sign to Poyer Orchard.
22.5	0.8	Poyer Orchard sales office. Ask permission to enter orchard. Permission may be denied due to insurance risks.
22.6	0.1	Return west on Duboise Road to Orchard entrance. Park.

STOP 4. POYER ORCHARD DIATREME (Locality 8a, Table 1)

Walk about 500 meters along the orchard road to the old part of the orchard. Head north north-east to the ravine about 50 meters beyond the orchard boundary. The diatreme is exposed in the bottom of the ravine where it is particularly wide due to the preferential erosion of the diatreme relative to the surrounding shales. Remnants of the sluicing operation are visible near the diatreme.

The amount of visible exposure depends on the intensity of recent storms. In the original report on the locality, Barnett (1905) was uncertain whether two dikes (7.6 and 4.0 meters across respectively) or a single intrusion (46 meters across) occurred. After an exceptionally large storm in the late thirties, Filmer (1939) described the intrusion as a breccia pipe or a swelling in a single large dike that extended 58 meters in an east-west direction and 24 meters in a north-south direction.

In subsequent literature (i.e. Foster 1970), the outcrop has been called a diatreme. The petrology of the unit is consistent with its classification as a tuff breccia of the kimberlite diatreme facies (see Dawson 1980). The outcrop is composed of extremely abundant xenolithic fragments surrounded by a very altered groundmass consisting of hydrothermal-type minerals. The groundmass has not been studied in detail. The outcrop is cut by several irregular tuffaceous dikes about 15 cm. across. An x-ray diffraction scan of the tuffaceous dike material by Foster (1970) indicated the presence of microcrystalline calcite and phlogopite.

Most of the xenoliths are angular pieces of sedimentary rock derived from the enclosing Devonian shale. These inclusions average about 5 cms. in diameter, but some as large as a half meter in diameter have been observed (Foster 1970). Fossils in inclusions reported by Filmer (1939) have not been studied. Other sedimentary inclusions are rounded sandstone and quartz pebbles. Rounded pieces of kimberlite similar to those found in nearby localities also occur as inclusions. Several syenite xenoliths, approximately 12-15 cm. across, were found during the sluicing operation (Wells, 1977, personal communication) and similar smaller xenoliths were analyzed by Snedden (1983). A fragment containing actinolite, chlorite, potassium feldspar and sphene reported by Kay et al. (1983) suggests that lower grade Precambrian rocks overlie the granulite facies in the basement in this locality. The heavy mineral fraction of the diatreme contains relatively abundant garnet, spinel and pyroxene xenocrysts (Foster 1970, Snedden 1983, Kay et al. 1983).

A magnetic anomaly map of the locality (Figure 3) produced by Angerani and Hangus (1978) as a term project in a geophysical methods course at Cornell gives additional information on the extent of the body. The map shows that the body is elongate north-south and continuous along the length of the survey (150 meters). The most intense magnetic anomaly occurs just to the north of the stream and a second smaller anomaly occurs parallel to the main anomaly about 20 m. to the east. Angerani and Hangus modeled the anomalies as vertical dikes and suggested that the width of the main dike varies from 1.4-4.0 meters and that its top is buried from 1.6 to 5.1 meters below the surface. In the model, the maximum depth and widest part of the intrusion occur at the maximum anomaly. Their model predicts the second dike is 4.1 meters wide and 11.1 meters deep.

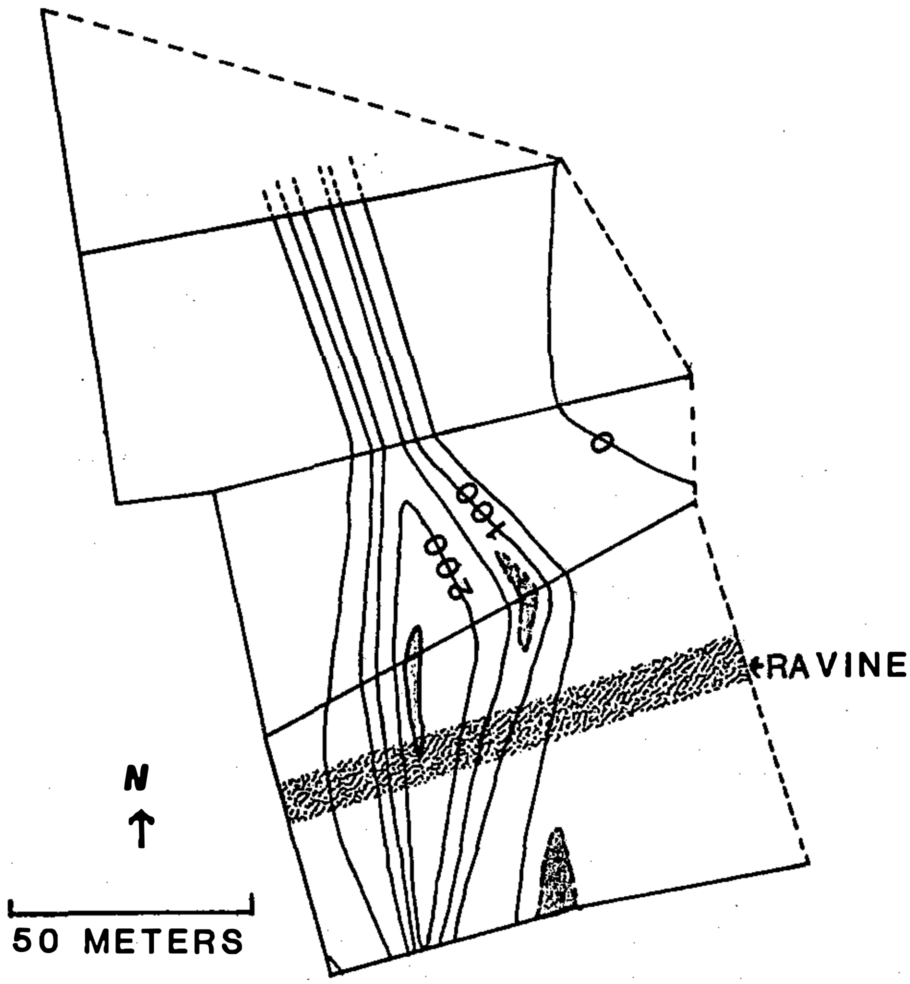
The magnetic model does not take into account that the stream exposure is in the diatreme facies. Combining the magnetic information with the petrography of the outcrop suggests that the diatreme represents a wide spot in a dike which along strike is similar to other larger dikes in the region (i.e. those in the same ravine, see localities 8b and 8c in Table 1). Although the magnetic data may indicate that two dikes occur, the discontinuous nature of the smaller anomaly is consistent with the magnetic pattern indicating the irregular configuration of the diatreme. The magnetic modeling in the narrow part of the anomaly north of the stream (Figure 3) is consistent with a dike 1.4 meters wide, striking N5W (Angerani and Hangus 1978).

As reviewed by Dawson (1980), diatreme facies kimberlites are, in general, interpreted to result from explosions resulting from the rapid cooling by groundwater of fluidized mixtures rich in exsolved high pressure gas. This suggests that the Poyer Orchard diatreme formed as part of the dike encountered groundwater and an explosion occurred. This interpretation is supported by the abundance of angular fragments from the surrounding country rock. The tuffaceous dikes would then result from the explosion. If the diatreme formed by this mechanism, the present erosion surface at Poyer Orchard was within the groundwater table in the lower Cretaceous.

22.6	0.0	Return to NY 96 via Duboise Road.
23.3	0.7	Turn left (south on NY 96) and return to the city of Ithaca.
26.2	2.9	Stoplight. Continue on NY 96 through light and cross bridge over Inlet Creek.Continue straight ahead to intersection with NY 13 and NY 34.
26.6	0.4	Turn left (north) on NY 13 and NY 34 (N. Meadow Street). Continue north on NY 13 and NY 34.
28.2	1.6	Follow ramp on right to NY 34 North.
28.4	0.2	Turn left (west) at stop sign onto NY 34 North. Continue north on NY 34 to South Lansing.

MAGNETIC MAP

POYER ORCHARD DIATREME



CONTOUR INTERVAL – 50 GAMMAS

Magnetic map of kimberlitic intrusion in Poyer orchard (locality 8, Figure 1; locality 8a, Table 1) modified from Angerani and Hangus (1978). See discussion for stop 4. Survey was made with two portable proton precession magnetometers. Measurements were taken at 2 meter intervals along the solid straight control lines and corrected for lateral and diurnal variations in the earth's magnetic field measured at 3 minute intervals. The zero contour was arbitrarily chosen as that for the initial reference value (56882 gammas). Shaded area on left is region of maximum anomaly (266 gammas). Shaded regions in dashed areas on right are minor anomalies above the smooth gradient (52 and 127 gammas respectively).

FIGURE 3

34.0	5.6	Junction with of NY 34 with NY 34B at Rogues Harbour Inn. Turn left (west) towards King Ferry on NY 34B.
34.7	0.7	Turn left (west) on Portland Point Road.
35.1	0.4	Main entrance to Portland Point Quarry.

STOP 5. PORTLAND POINT QUARRY (Locality 20, Table 1)

THIS IS PRIVATE PROPERTY. YOU MUST OBTAIN PERMISSION TO ENTER. Collecting is allowed. Fossil collecting is also good in the quarry (see guides for other trips). The quarry is complex and constantly changing. Ask quarry personnel for best places to view kimberlite dikes.

Walk south 1 kilometer along the main quarry road to the east-west trending southern quarry wall (parallel to the north side of Falls Gulf Creek). In August 1986, this was the southern part of the main pit. Quarrying was complete and the region was being backfilled. The slag heaps near this area of the pit had blocks of kimberlites.

Two segments of north-south striking dike are exposed in the east-west trending wall of the quarry, above and below the nearly horizontal trace of a thrust fault which strikes east-west and has a shallow dip to the south (third dimension of fault is exposed in adjacent north-south trending quarry wall). The fault, which is marked by a slickensided surface above a brecciated zone, is associated with the crest of the Firtree anticline, a late Paleozoic Alleghenian fold (i.e. Engelder and Geiser 1979). Slickensides dipping 20° to the south can be seen on the east-facing dike surface adjacent to the country rock indicating some post emplacement differential slip between the dike and the wall rock.

As discussed earlier, the dike segments have an early Cretaceous age (Zartman et al. 1967, DeJournett 1970, Basu et al. 1984). They are not offset by the fault, which apparently constituted a discontinuity in the north-south joint system across which the dike was diverted. The upper dike segment, which is about 1.5 meters to the east of the lower segment, is uniformly about 20 cm. wide and terminates in the fault zone. The lower segment tapers from a maximum width of about 20 cms. to about 12 cms. at the fault. As it passes through the rubble zone below the fault, the dike bends and shows at least one minor offset of about 20 cm. to the east. The lower dike segment also tapers to about 20 cm. in width near the bottom of the exposure that outcropped in August.

Another exposure in the quarry where dike segments are bounded by a fault zone was described by Sheldon (1927) and may have been along strike of the present exposure. On the basis of the geometry of pinching and swelling of dikes in that exposure, Sheldon argued that dike intrusion was contemporaneous with the latest stages of faulting. The relationship of the dike segments to the fault zone in the modern exposure, and the observation that pinching and swelling occur in discontinuous dikes in other localities where evidence of faulting is not observed (Stop 3 and below), strongly suggest that the dikes observed by Sheldon were also not offset by the fault.

The exposed dikes may be along strike of the locality where DeJournett (letter to A. Bloom 1971) mapped dikes extending about 120 meters across the quarry floor in 1970-71. He indicated that these dikes showed normal magnetic polarity in the interiors and reverse magnetic polarity on the exteriors. He also stated that the dikes showed textural evidence consistent with two episodes of intrusion and that these textures correlated with the magnetically distinct zones. His map clearly shows that the dikes pinch and swell and are discontinuous. These features were not visible in 1986.

Leave the main pit and head north and east along road to the older inactive part of the quarry. The road to the bottom of the pit of interest is blocked by a small slag heap. This pit is in the eastern part of the quarry, southeast and across a large slag heap from the quarry lake that is visible from the hill above the pit (see Ludlowville 7.5 minute topographic map). In August 1986, this pit had much less mud and grass on the floor than surrounding pits.

In this pit, a N-S dike about 5-7 cm. wide can be followed across the quarry floor. The exposure has deteriorated considerably in recent years due to sedimentation on the quarry floor and the weathering of the dike. Blocks of the kimberlite that have sedimentary xenoliths and show textural inhomogeneities can be found in the surrounding slag heaps, particularly along the northwest wall of the pit. Some of these blocks show possible evidence for multiple intrusion.

Return to quarry entrance.

35.1	0.0	Main entrance to Portland Point Quarry. Turn around and head east on Portland Point Road to NY 34B.

END OF ROADLOG