

ALKALIC ROCKS OF THE SUDBURY REGION

BY

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**Frontispiece: Idealized Cross Section of a Carbonatite
Intrusion(modified from Sage, 1991)**

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This field trip guidebook would not have been possible without the assistance of Wilf Meyer, Resident Geologist, and Mike Cosec, Staff Geologist, Ontario Geological Survey, Sudbury, Ontario. Excluding the Spanish River Carbonatite, the author had no prior exposure to the many manifestations of alkaline magmatism in the region.

INTRODUCTION

Alkaline magmatism within the Sudbury region manifests itself in many forms and in differing structural settings (Figures 1 and 2). Alkaline magmatism occurs from the middle Proterozoic to Middle Cambrian and expresses itself as discrete plutons and as metasomatic events with no clearly recognizable magmatic phase. The various alkaline features are widely spaced; therefore, all will not be seen on the field trip. Due to the wide spacing of the accessible sites, two days will be spent examining the alkaline rocks. Day one will be spent examining alkaline rocks in the immediate area of Sudbury and will include the Spanish River Carbonatite, Nemag Lake fenites and the French river nepheline-cancrinite pegmatites. The Spanish River Carbonatite occurs in Archean rocks northwest of the Sudbury Igneous Complex (SIC), the Nemag Lake fenites occur in deformed rocks of the Huronian Supergroup at the western end of the Great Lakes Tectonic Zone southwest of Sudbury and the French River alkalic pegmatites occur in a syenite intrusion within the Grenville structural province. On the second day, two alkaline intrusions of lower to middle Cambrian age will be examined in the Lake Nipissing area and a visit to the Scadding mine is planned to examine the effects of regional sodium metasomatism. The visit to the Lake Nipissing area will require boat transport.

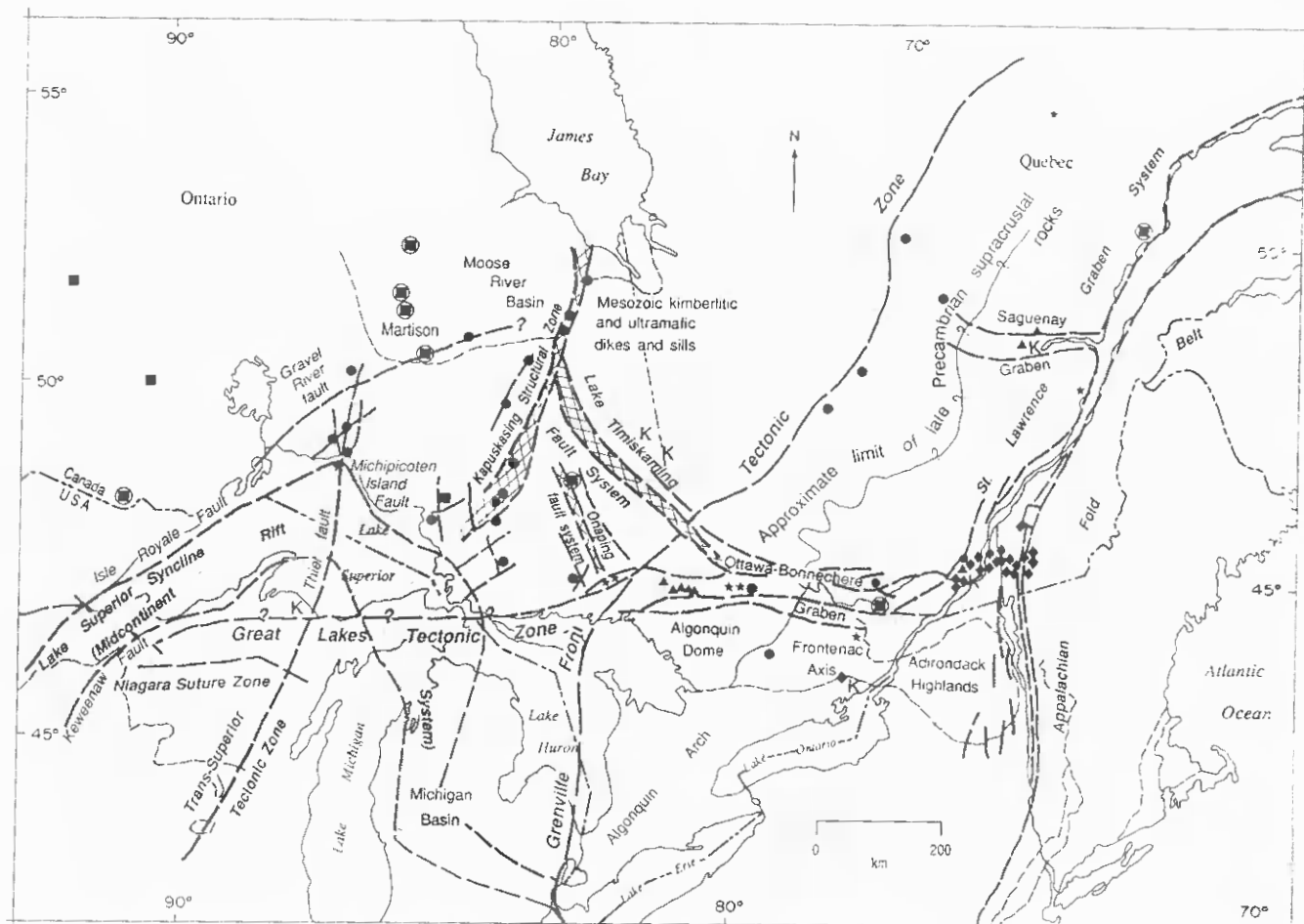
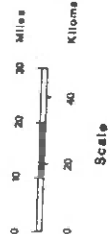


Figure 1: Regional distribution of alkaline rock-carbonatite complexes in eastern Ontario and western Quebec. Figure modified from Lumbers(1978) and Sage(1991).

LEGEND

- CARBONATITE AND RELATED ROCKS
(All Ages)
- MESOPROTEROZOIC
 - GRANITIC ROCKS
 - DOMINANTLY METASEDIMENTS
- PALEOPROTEROZOIC
 - ▨ DOMINANTLY METASEDIMENTS
 - ▤ SUDBURY IGNEOUS COMPLEX
- NEOARCHAIC
 - GRANITIC ROCKS
 - GREENSTONE BELTS



COBALT EMBAYMENT

SUPERIOR PROVINCE

SOUTHERN PROVINCE

GRENVILLE PROVINCE

PROVINCE OF QUEBEC

LAKE TIMISKAMING
STRUCTURAL ZONE

OTTAWA - BONNECHERE GRABEN



Geology modified from Ontario Department of Mines and Northern Affairs Maps 2197 and 2393

Figure 2: Distribution of alkaalic rock-carbonatite complexes in the Sudbury region. Modified from Sage (1991). (2 - Brent Crater; 3 - Callander Bay Alkaalic Rock Complex; 4 - Manitou Island Alkaalic Rock Complex; 5 - Burritt Island Alkaalic Rock Complex; 6 - Iron Island Alkaalic Rock Complex; 7 - Laverne Carbonatite; 8 - Spanish River Carbonatite; 45 Nemag and Kusk Lake Fenites; 46 - Allen Lake Carbonatite; 52 - Sullivan Island Carbonatite complex; A - French River (Rutter Pluton) Alkaalic Rock Complex and B - Scadding mine area of sodium metasomatism)

SITES TO BE VISITED

DAY 1

1. MANITOU ISLAND COMPLEX
2. CALLANDER BAY COMPLEX
3. SCADDING MINE

DAY 2

4. SPANISH RIVER CARBONATITE
5. NEMAG LAKE AND KUSK LANE FENITES
6. FRENCH RIVER ALKALIC ROCKS

FIGURES

Figure 1: Regional distribution of alkalic rock-carbonatite complexes in eastern Ontario and western Quebec. Figure modified from Lumbers(1978) and Sage(1991).

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Figure 3: Geology of the Manitou Island Complex(from Lumbers, 1971, p. 82).

Figure 4: Aeromagnetic map of the Manitou Island complex(from ODM-GSC 1965c)

Figure 5: Geology of the Callander Bay Complex(from Lumbers, 1971, p.84).

Figure 6: Aeromagnetic map of the Callander Bay Complex(from ODM-GSC 1965a,b).

Figure 7: Topographic and road map for the Callander Bay area(from topographic maps obtained from the Resident Geologist's Office, Ontario Geological Survey, Sudbury)

Figure 8: Geological sketch map of the Scadding Gold Mine(modified after Harper, 1983).

Figure 9: Topographic and road map for the Scadding Gold Mine area(from topographic maps obtained from the Resident Geologist's Office, Ontario Geological Survey, Sudbury).

Figure 10: Aeromagnetic map of the Spanish River Carbonatite(from ODM-GSC 1965d).

DAY 1

MIDDLE TO EARLY CAMBRIAN ALKALIC INTRUSIONS, LAKE NIPISSING
AREA

Introduction

Within the Lake Nipissing area there are 7 alkalic rock intrusions into the gneissic rocks of the Grenville Subprovince of the Canadian Shield or areas of extensive alkalic metasomatism (Sage, 1991). These are Brent Crater, Callander Bay, Manitou Island, Burritt Island, Iron Island, Lavergne and Allen Lake. These alkalic rock complexes occur where the Ottawa-Bonnechere Graben splits into an east-west trending deformation zone and the northwest trending Lake Timiskaming Structural Zone (LTSZ). The Ottawa-Bonnechere Graben system is a branch of the St. Lawrence valley system which Kumarapeli and Saull (1966) compare to the East African rift valley system. Existing isotopic dating of the alkalic rocks of the Lake Nipissing area indicates that these alkalic intrusions were emplaced during the middle to early Cambrian. Lying to the east of this east-west striking cluster of intrusions is the Proterozoic Sullivan Island Carbonatite intruded into the Ottawa-Bonnechere Graben (Lumbers et al., 1990). The Ottawa-Bonnechere Graben system was most likely in existence during the Proterozoic and has been periodically reactivated throughout geologic history (Sage, 1996). The St. Lawrence rift system and its many branches are seismically active to this day (Adams and Basham, 1986; Bent, 1992, 1996).

Table 1: Summary of Alkalic Rock geochronological data for the Lake Nipissing area

Intrusion	Age (MA)	Method	Reference
Manitou Island ¹			
	560	K-Ar	1
	570	K-Ar	1
	560	K-Ar	2
	568	K-Ar	3
	566 ± 38	K-Ar	4
	576 ± 45	K-Ar	4
Callander Bay ²			
	558 ± 14	K-Ar	5
	568	K-Ar	3
	575	K-Ar	3

	576 +- 3	Pb-Pb	6,4
Brent Crater	576 +- 40	K-Ar	7

Footnotes

1. The ages cited by reference 4 are the same as references 1 and 2 using different decay constants.
2. Except for the 575 Ma age on nepheline syenite the cited isotopic ages are on lamprophyre dikes interpreted to be related to the Callander Bay Complex

References

1. Gittins et al., 1967
2. Lowden et al., 1963
3. Currie, 1976
4. Symons and Chiasson, 1991
5. Ferguson and Currie, 1972
6. Kamo et al., 1989
7. Shafiqullah et al., 1968

The only regional mapping in which most of the intrusions were examined was by Lumbers(1971). Currie(1976) prepared a brief description of each of the occurrences in an abstract format but has restricted most of his field investigations to the Callander Bay complex. Extensive sampling for paleomagnetic studies has been completed by D. Symons, University of Windsor, on the Callander Bay, Manitou Island and Iron Island Complexes, however only the work on the Callander Bay complex has been completed(Symons and Chiasson, 1991).

STOP 1: Manitou Island Complex

The Manitou Island complex lies in the east central portion of Lake Nipissing and is only accessible by boat.

Road Log

Proceed 112.9 km east along highway 17 measured from the intersection of highway 17 and the by-pass south of Sudbury.

At intersection with highway 17B in North Bay turn right.

Go 4.1 km to Memorial Street and turn right. (Note: If you turn left you will be on Murray Street)

Go 0.6 km to parking lot at boat landing.

Travel time by boat to Newman Island is approximately 45 minutes and distance is approximately 10 km or 6 miles.

Geology: The Manitou Island Complex is outlined by a circular distribution of 5 islands consisting of fenitic rocks. The actual intrusion located central to the islands is unexposed. The site to be visited is located on Newman Island where exploration for uraniferous pyrochlore took place in the late 1950s. Most of these islands are now included in the Manitou Islands Provincial Park even though the mineral rights are retained by the mining company.

Lumbers(1971) describes the fenite aureole as consisting of an outer zone of quartz fenite approximately 400 feet wide and an inner aureole of aegirine-potassic feldspar fenite as much as 1,500 feet wide. These fenites have been derived from Grenville granitic gneisses. The central portion of the complex is poorly known from scattered diamond drill holes. Lumbers(1971) states that the west central portion of the complex consists of massive coarse-grained to pegmatitic pyroxene-rich rocks younger than the enclosing fenites.

The carbonatite occurs as fine to coarse grained dike-like intrusions into the fenites and consists of aegirine, sodic amphibole, biotite, magnetite, apatite and locally pyrochlore and pyrite in addition to carbonate.

On the west side of Little Manitou Island, located northwest of Newman Island, fossiliferous lower Ordovician limestone is exposed on the shoreline. Attempts to make cement from this material were made in the early days of settlement in the region.

Figure 3 presents the geology of the Manitou Island Complex(Lumbers, 1971) and Figure 4 illustrates the airborne magnetic response of the intrusion(ODM-GSC, 1965a,b). The complex is approximately 2 miles long and 1.7 miles wide(Lumbers, 1971).

Economic Geology: Upon discovery of pyrochlore and uraniferous pyrochlore on Newman Island in the early 1950's, testing of the discovery took place. A vertical shaft 442 feet deep was sunk on Newman Island and 2,500 feet of lateral drifting completed(Lumbers, 1971). This work outlined 2,962,000 tons averaging 0.041% U_3O_8 and 0.69% Nb_2O_5 all 200 feet below lake bottom(Lumbers, 1971). The

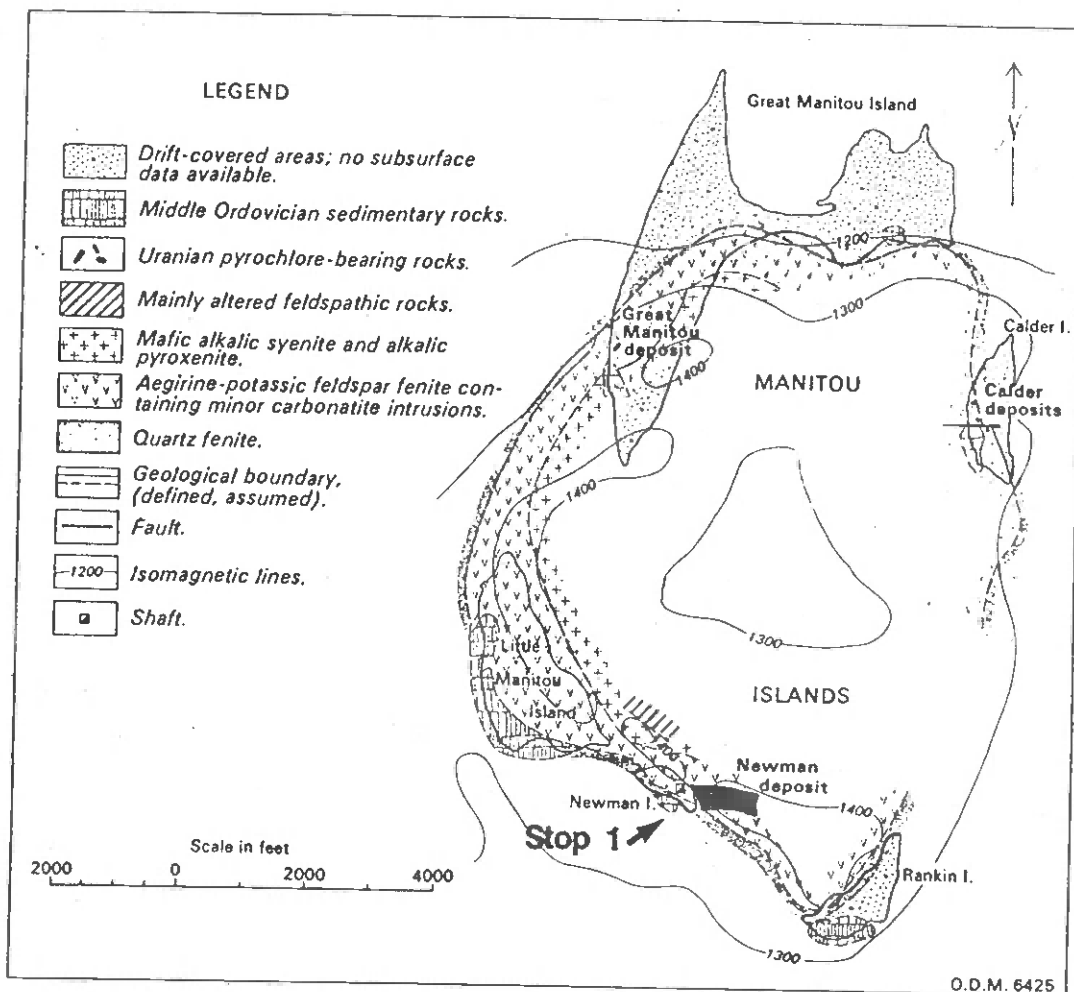


Figure 3: Geology of the Manitou Island Complex (from Lumbers, 1971, p. 82).

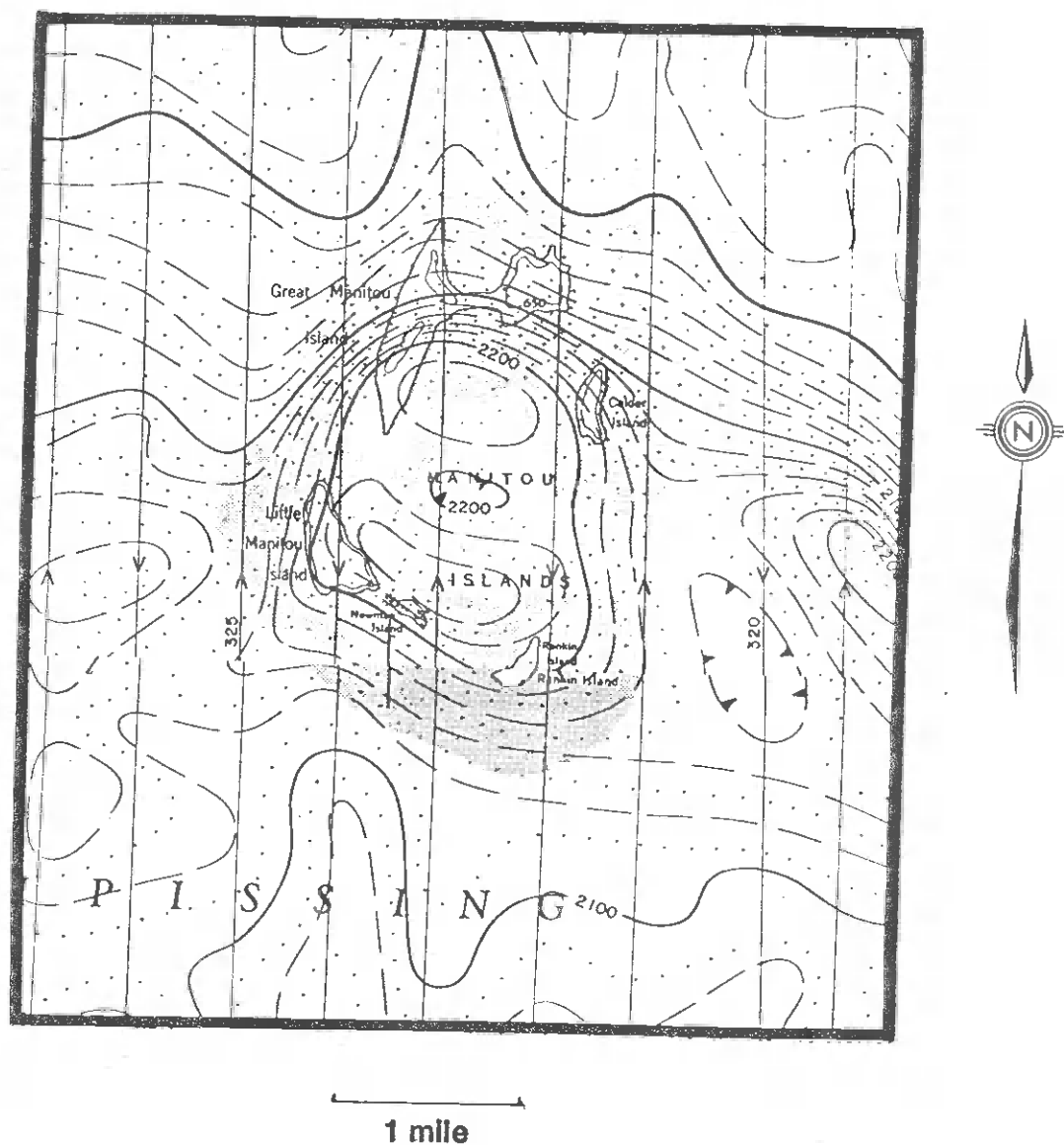


Figure 4: Aeromagnetic map of the Manitou Island complex (from ODM-GSC 1965c)

pyrochlore mineralization occurs with fenitic rocks and carbonatite.

Newman Island: On the inner or north side of Newman island brecciated, red, syenitic fenite is exposed along the lakeshore. At the shaft, blocks of fenite veined and cemented with white carbonate can be observed. Along the shoreline an occasional, narrow, yellow-brown, fine-grained carbonate dike can be observed cutting the fenite and white carbonate. Towards the east end of the island and to the south side gneissic textures are well preserved and the rocks take on the appearance of Grenville gneisses. The general gneissic trend is 260 degrees with a steep north dip. Locally these gneisses may appear brecciated and are cut by irregular white carbonatite dikes and on occasion by younger, very narrow, fine-grained, brown carbonatite dikes.

Return to the boat landing.

STOP 2: Callander Bay Complex

The Callander Bay Complex lies at the eastern end of Lake Nipissing and most of the complex lies beneath the water of Callander Bay.

Road Log

Return to highway 17 and zero the odometer

Proceed eastward 7.8 km to where highway 11 splits from highway 17. Take highway 11 to the town of Callander.

At 13.2 km take the exit to the town of Callander. The road goes right and then jogs left.

At 13.7 km turn left on Pinewood Drive and go south towards Callander(4 km).

At 17.2 km the highway splits. Take highway 94 to the left and continue south.

At 19.1 km Landsdowne St. intersects the highway.

Zero the odometer at Landsdowne St. and continue on.

At 1.65 km Main St. intersects the highway. Park at the side of the road for Stop 2A.

Geology: As with the Manitou Island Complex, the Callander Bay Complex is poorly exposed and largely lies beneath the waters of Lake Nipissing. Most exposures are of fenite border rocks with only a limited number of exposures of nepheline syenite towards the centre of the complex. Nearly all of the exposures of nepheline syenite are on private property and not easy to access.

Lumbers(1971) interpreted the Callander Bay complex to be approximately 2.25 miles in diameter and to consist of cone sheets of fenite and nepheline syenite(Figures 5, 6). Lumbers(1971) predicts the centre of the intrusion may consist of carbonate-rich rocks and alkalic mafic rocks. Lamprophyre, basaltic and phonolitic dikes cut across rocks of the fenite zone and these are in turn cut by barite and calcite veins(Lumbers,1971). Currie(1976) has also interpreted the Callander Bay Complex to consist of cone sheets of fenite and alkalic rocks enclosed in a crescentic zone of nepheline syenite. The fenitic rocks were observed by Currie(1976) to be cut by dikes of carbonatite, lamprophyre, trachyte and nepheline syenite. The alkalic dikes intruding the fenitic rocks are considered coeval with the Callander Bay complex and have been the most intensely studied rock group within the complex.

The fenitic rocks are derived from Grenville gneissic rocks of adamellite(granitic) composition and form a zone up to 1000 m wide along the eastern margin of the complex where they are well exposed(Currie and Ferguson, 1971, 1972). Currie and Ferguson(1971) subdivide this metasomatic halo enclosing the Callander Bay Complex into inner, middle and outer zones. The inner zone is characterized by a loss of gneissosity, igneous textures andmiarolitic cavities and the outer zone is characterized by regional gneissosity, reddening of the rock, hematized fractures and rare brecciation(Currie and Ferguson, 1971). The middle zone is transitional between the outer and inner zones. The alkalic dikes were studied by Ferguson and Currie(1971) and interpreted by them to have formed by liquid immiscibility. On the basis of the studies on the dikes the Callander Bay complex has been interpreted to result from a carbonated, mantle-derived, nephelinitic magma(Ferguson and Currie, 1971, 1972). The fenitic rocks were derived by fluids emanating from the fractionating nephelinitic magma which

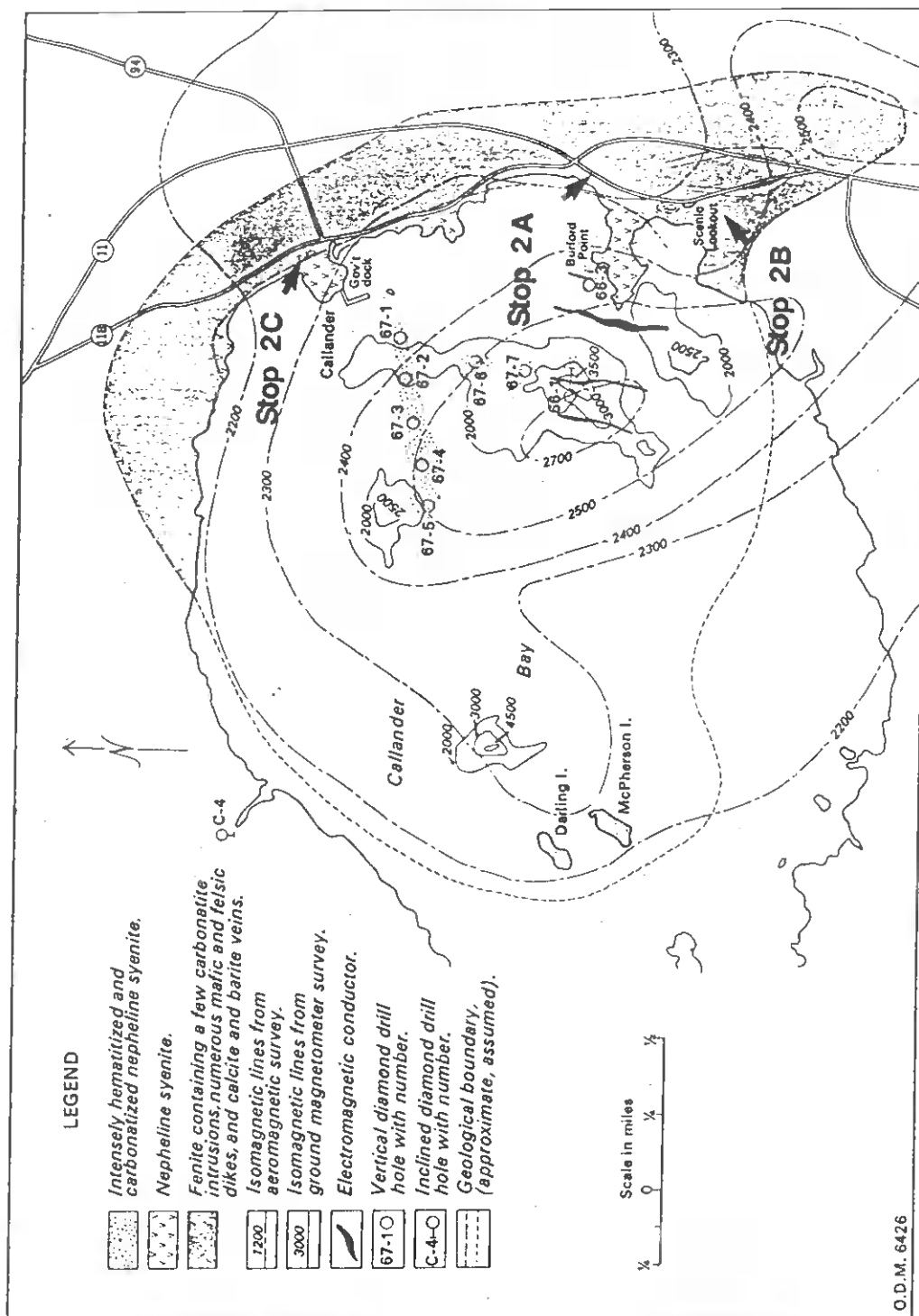


Figure 5: Geology of the Callander Bay Complex (from Lumbers, 1971, p.84).

underwent liquid immiscibility in its late stages giving rise to a carbonate magma (Ferguson and Currie, 1971, 1972; Cullers and Medaris, 1977).

Since the Callander Bay Complex is of middle to lower Cambrian age and untilted, it has been the subject of recent studies in paleomagnetism (Chiasson, 1989; Symons and Chiasson, 1991).

Economic Geology: The Callander Bay Complex has undergone prospecting and some diamond drilling. While anomalous niobium values have been encountered nothing of potential economic interest has been identified to date.

STOP 2A: Stop 2A is located within the inner to middle fenite zone (Figure 7). Numerous alkalic dikes cut the fenites and can be observed in the road cut on the east side of the highway. One should observe the diverse rock textures within the fenites and the variety of dike rocks available to study.

STOP 2B: Continue south from Stop 2A for 2.3 km. A scenic lookout occurs on the right hand side of the road and provides a good parking spot. Opposite the lookout is an outcrop of granitic gneiss intruded by biotite porphyry lamprophyre. The biotite phenocrysts are up to 4 mm and the dike trends 010 degrees and dips approximately 45 degrees east. The dike may be up to 5 metres in width and is one of the widest dikes observed in the road cuts. The outcrop shows many sample sites and it is obvious that it has served as a source of material for a number of studies on dike rocks in the area.

Continue south along the east side of the highway for approximately 760 feet and a small point outcrop of nepheline syenite can be found. Contact relations are not exposed but this is likely one of the nepheline syenite cones sheets of Lumbers (1971).

STOP 2C: Return to the junction of Main Street and highway 94 (Stop 2A) and turn left onto Main Street towards the town of Callander. Proceed for 1.8 km and on the right side (east) of Main street an outcrop of medium to coarse grained, massive, equigranular nepheline syenite can be found. This is one of the very few outcrops of this rock type that is currently accessible to sampling. To avoid problems with flying rock chips since this is a highly travelled street I would strongly recommend collecting the samples you wish,

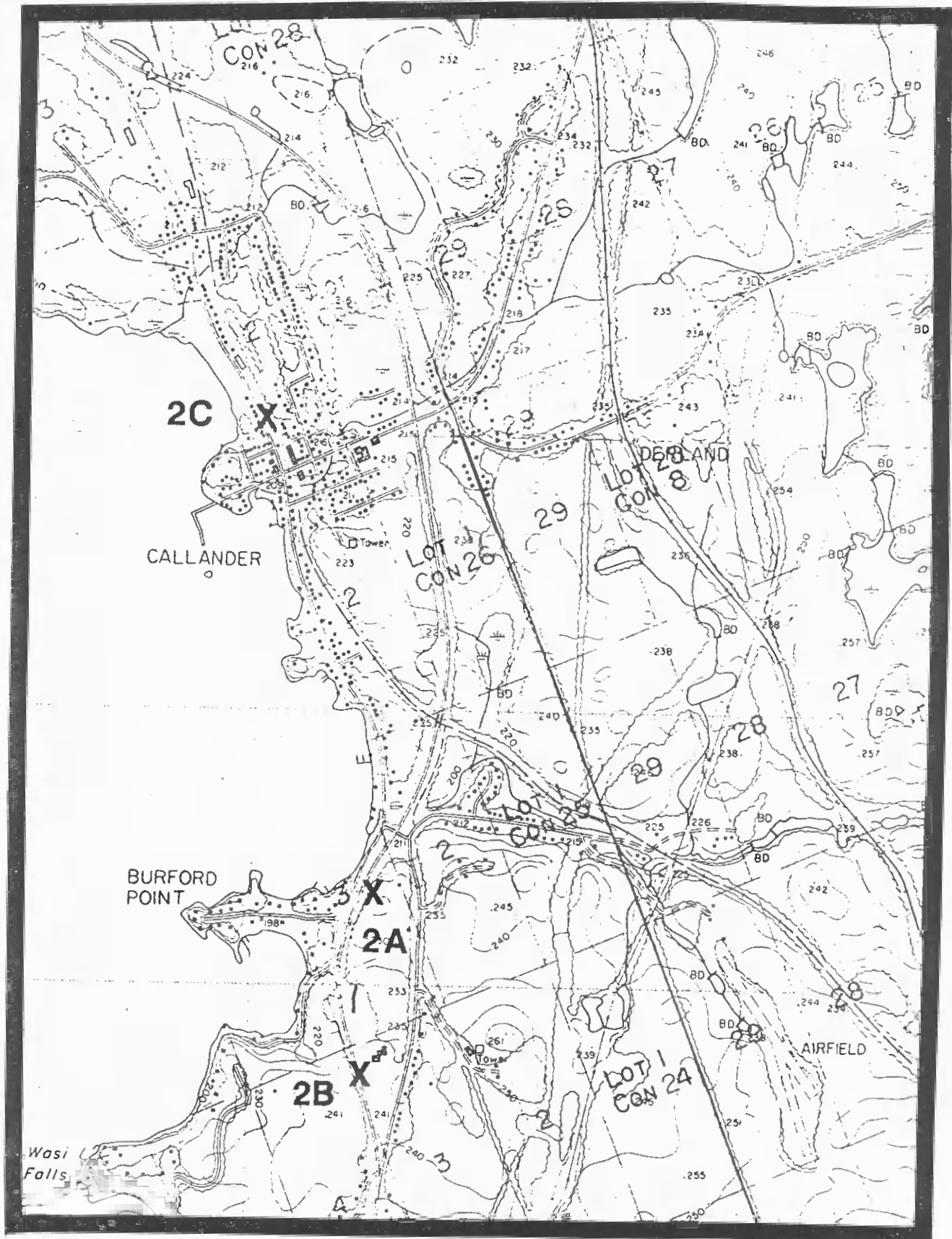


Figure 7: Topographic and road map for the Callander Bay area (from topographic maps obtained from the Resident Geologist's Office, Ontario Geological Survey, Sudbury)

and we will transport them to another site for trimming and selection.

A thin section prepared from a sample collected of this outcrop displayed a coarse grained inequigranular seriate allotriomorphic texture with lobate to serrate grain boundaries. The potassium feldspar is a string perthite that sometimes displays Carlsbad twining. The nepheline is fresh with sericite alteration along grain boundaries and cleavage planes. The mafic mineral is a dark greenish brown amphibole that appears interstitial to the feldspar and nepheline. One possible grain of clinopyroxene was noted that was mantled with amphibole. Biotite, sphene, apatite and chlorite are present as accessory or alteration phases. The rock is visually estimated to consist of 10 to 15% amphibole, 45 to 55% potassium feldspar and 35 to 45% nepheline.

Return to Sudbury

ALKALIC ROCKS OF THE IMMEDIATE SUDBURY REGION

Within the immediate area of Sudbury there are three distinct alkaline events which are not likely coeval. The events are represented by the Spanish River carbonatite, regional sodium metasomatism and the development of the Nemag Lake and Kusk Lake fenites. The age relationships of these three events remains speculative since only one feature has been accurately dated, one has been dated in a general fashion and no attempt to age the third has been undertaken. The existing isotopic studies suggest these alkaline rocks are of middle Proterozoic age.

STOP 3: Scadding Mine

NOTE: THIS SITE WILL LIKELY BE VISITED ON THE RETURN TRIP FROM NORTH BAY

Road log from the intersection of highway 17 and the by-pass around Sudbury near the town of Coniston.

Proceed 19.7 km east from the bypass along highway 17 to Kukagami Road. Turn left(north).

16.8 km north along the Kukagami Road there is a skid road or overgrown road to the left (west).

Turn left and go 0.6 km to the Scadding Mine Site

Geology: Sodium metasomatism is common within the Sudbury region but has been poorly documented and has been the subject of only one serious attempt to interpret the phenomenon. Sodium metasomatism is characterized by the development of albite feldspar which imparts a tan, pink, buff, grey, white to yellow color to the rocks. Occurrences of sodium metasomatism are found as far east as Cobalt and as far west as Bruce mines, a distance of approximately 400 km (Meyer, 1995). Occurrences of sodium metasomatism are perhaps best developed between Espanola and the area immediately east of Lake Wanapitei (Meyer, 1995). Meyer (1995) reports that the sodium metasomatism affects the Proterozoic rocks more than the Archean rocks. The effects of sodium metasomatism varies from incipient to nearly 100 percent albite replacement with sodium contents of some altered rocks approaching 11.0% Na_2O indicating a rock of nearly pure albite composition.

Meyer (1995) describes the effects of sodium metasomatism as occurring in vein-like or dike-like features up to several kilometres in length associated with faults or fractures and as irregular shaped masses.

The extensively altered rock can easily be mistaken for chert due to the development of a conchoidal fracture and very fine-grained nature and can be missed in outcrop if color contrast is absent (Meyer, 1995). The tan to pink color of sodium metasomatism (albitization) blends into or with the normal colors of arkoses and granites.

Within the Sudbury region breccias are of common occurrence. With respect to sodium metasomatism three breccia types have been recognized by Meyer (1995). These are 1) in-situ brecciation of metasomatically altered rock, 2) metasomatic alteration of a pre-existing breccia and 3) breccias that contain fragments of altered rock mixed with fragments of other rock types.

When sodium metasomatism is associated with other alteration events it is always the earliest, followed by carbonate, quartz, chlorite and possibly the introduction of Fe, As, Cu sulphides and gold (Meyer, 1995). Schandl et al., (1994) have completed the only detailed study on the sodium metasomatism within the region. Two generations of hydrothermal REE

minerals were identified in albitized Huronian sediments. The minerals found were monazite, bastnasite, synchysite and gadolinite. An U-Pb isotopic age of 1700 ± 2 Ma was obtained on hydrothermal monazite and on hydrothermal rutile (Schandl et al., 1994).

The very high light REE enrichment within the albitized rocks prompted Schandl et al., (1994) to propose that the sodium-rich fluids were derived from a carbonatitic or alkali intrusion at depth. The isotopic age is approximately 150 Ma younger than the formation of the Sudbury Igneous Complex (SIC) that was emplaced at approximately 1850 Ma (Krogh et al., 1984; 1996).

Economic Geology Mapping of the mineral occurrences east of Lake Wanapitei by Gates (1991) has shown most mineral occurrences in the area display associated sodium metasomatism. Gates (1991) proposed that the sodium metasomatism has developed a hard brittle rock which upon fracturing produced channelways for the introduction of chlorite, gold and sulphide minerals.

The Scadding Mine (gold) is one of two small mines in the region that display associated sodium metasomatism, the other being the Norstar gold-copper mine. The Scadding Mine extracted gold from four chlorite zones containing pyrite and arsenopyrite within the Serpent Formation arkose near the contact with Espanola Formation limestones (Gates, 1991). The chlorite zones are within carbonate-rich, argillaceous siltstones near the base of the Serpent Formation. The zones are described as breccias (Gates, 1991) and the east-west zone had an approximate dimension of 100-300 metres in length and 30-50 metres in width. The other zones were much smaller (Meyer, 1996, Resident Geologist, Sudbury, personal communication).

At the site of the Scadding mine, samples of the metasomatized Serpent Formation are abundant and large blocks of altered rock display reddish-brown weathering carbonate rhombs up to 1 cm or more. The carbonate alteration post dates the albitization. Samples of sulphide-bearing chlorite rock that formed the gold ore can also be collected at the site. At the Scadding Mine site, Gates (1991) reported total rock analysis of 8.40 and 8.15% Na_2O and Schandl et al. (1994) reported values of 7.68 and 7.65% Na_2O from albitized rocks. One of the Scadding mine samples (SC-5) was used in U-Pb isotopic dating of the sodium metasomatism (Schandl et al., 1994).

The Scadding Mine operated from September 1987 to February 1988 and milled ore until July 1990. Estimated production is 11,000 ounces from ore grading 0.159 ounces per ton (Canadian Mines Handbook, 1990-1991, p. 347).

Figure 8 presents the geology as reported by Harper (1983) and Figure 9 presents the local road and geographic features.

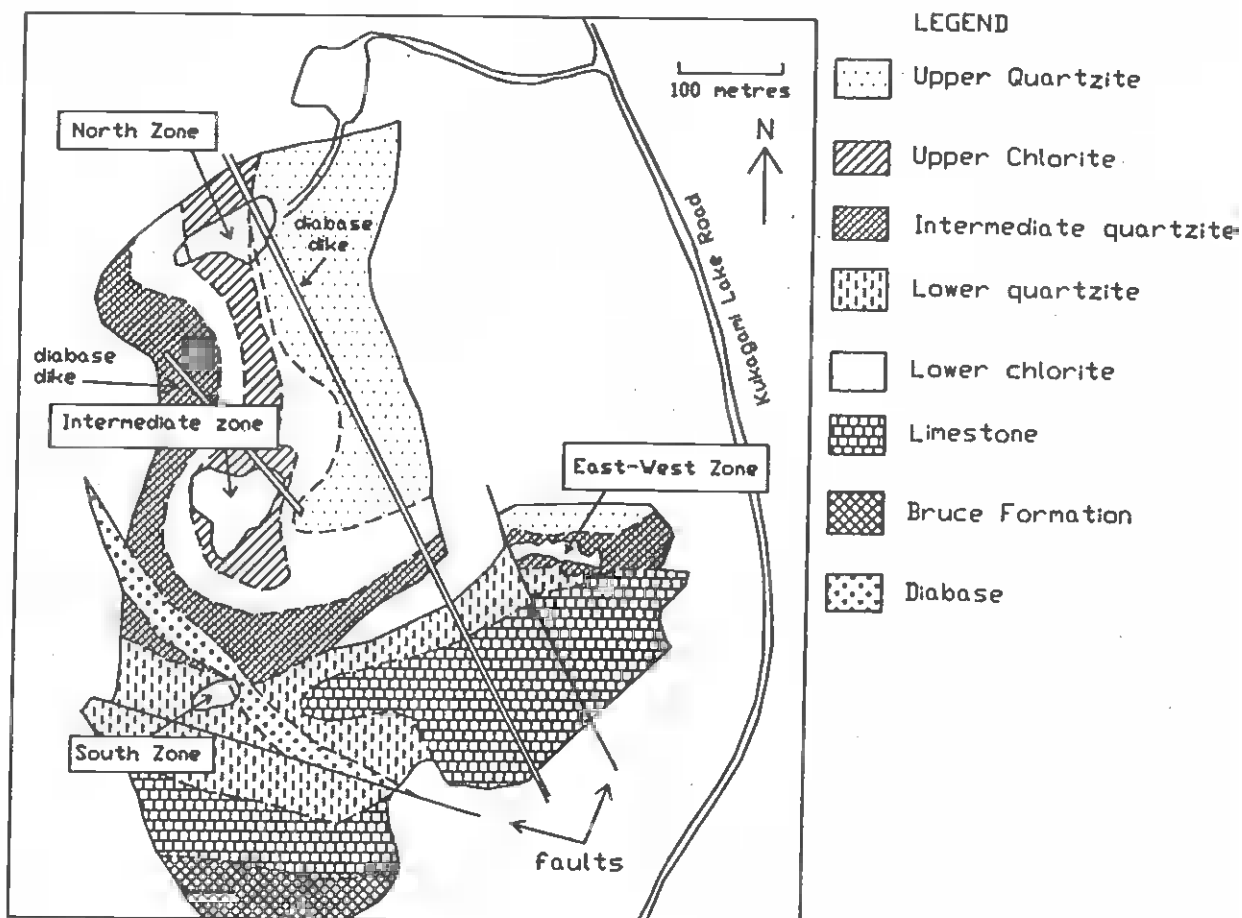


Figure 8: Geological sketch map of the Scadding Gold Mine(modified from Harper, 1983)

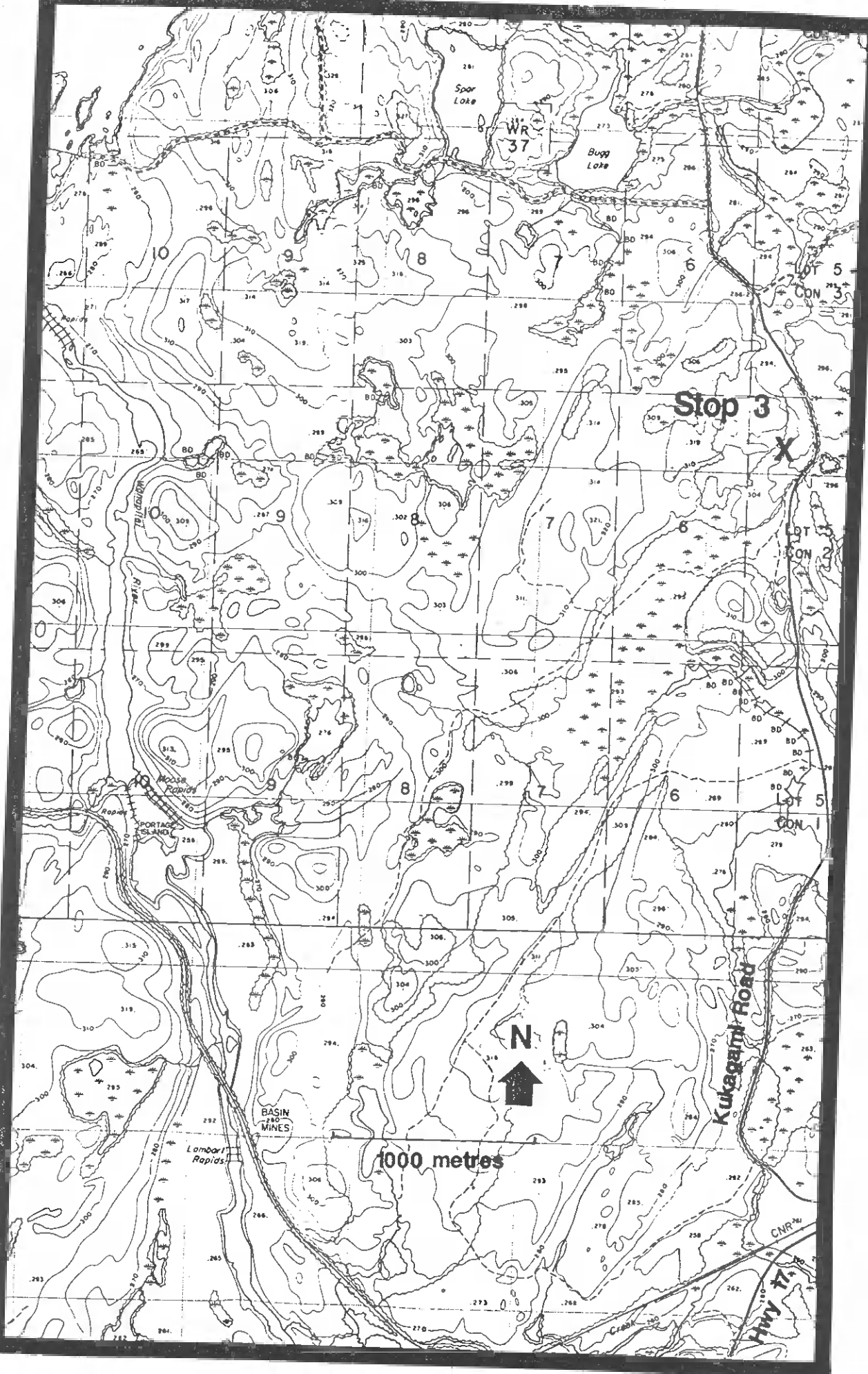


Figure 9: Topographic and road map for the Scadding Gold Mine area (from topographic maps obtained from the Resident Geologist's Office, Ontario Geological Survey).

DAY TWO

The second day of investigating alkali rocks of the Sudbury region will be spent examining genetically and structurally unrelated occurrences northwest, southwest and south of Sudbury.

Stop 4: Spanish River Carbonatite

The Spanish River Carbonatite occurs northwest of Sudbury and west of Levack. The road log to the intrusion is measured from the turn off to Levack on highway 144 (Figure 10).

Proceed north along highway 144 for 16.4 km to Cartier.

Turn left (south) along a road from the centre of Cartier and go 10.2 km towards the Fox Lake Lodge where road splits.

Take right fork to Macaulay Lake (Fox Lake) and continue to 24.0 km. There is a short dirt road to the extreme northeast corner of Macaulay Lake at this point.

Continue to 24.2 km and turn right on an unmarked skid road through former cut over area.

At 26.1 km road splits, take right fork.

At 26.2 km a skid trail to the left leads to several trenches recently dug into carbonatite regolith.

Continue to 26.4 km where weathered carbonatite outcrops on the left (west) side of the road.

If one continues along this skid road to 27.2 km one comes to a popular local campsite on the elbow of the Spanish River.

Return to the fork in the road at 26.1 km and take the right fork (you are now on the return trip traveling south).

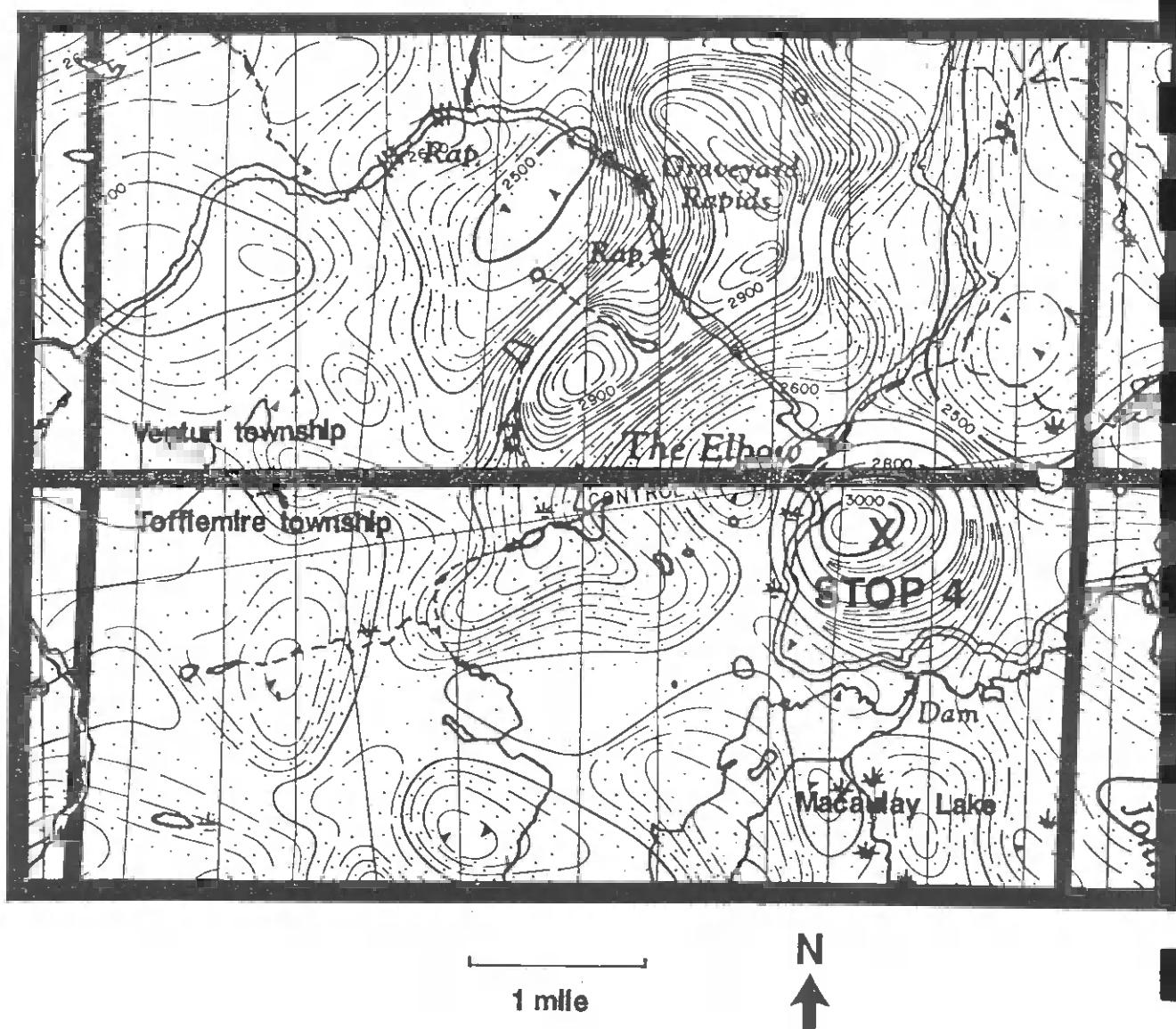


Figure 10: Aeromagnetic map of the Spanish River Carbonatite (from ODM-GSC 1965d).

At 0.4 km a skid road on the east side of the road leads to several recent trenches in carbonatite regolith at the top of the hill.

Geology: The Spanish River Carbonatite lies within the Abitibi Subprovince of the Superior Structural Province and is one of 6 known middle Proterozoic carbonatites within the Province of Ontario (Sage, 1987; Sage and Watkinson, 1991). On the basis of isomagnetic contours the carbonatite is elongated in a direction east of north, however the lack of outcrop, brecciation and fenitization make the positioning of the contacts difficult (Sage, 1987) (Figure 11). The carbonatite has been emplaced into Archean granitic rocks of quartz monzonitic composition and the process of fenitization has desilicated these rocks close to the carbonatite intrusion creating syenitic compositions. The carbonatite occurs within a regional trend of Proterozoic outliers suggesting some regional structural control along the northern margin of the Sudbury Igneous Complex that is not well defined (Sage, 1987) (Figure 12). Isotopic studies by Bell and Blenkinsop (1980), using the Rb-Sr system, obtained an age of 1838 ± 95 Ma which, due to the large calculated error, brackets the U-Pb isotopic age of 1850 ± 1 Ma obtained on the Sudbury Igneous Complex by Krogh et al. (1984). The Spanish River Carbonatite and the Sudbury Igneous Complex could be coeval within the present limits of isotopic age dating.

Within the past year, deep trenches have been dug into the weathered (regolith) surface of the carbonatite making it one of the best if not the best exposed carbonatite in Ontario. This will be a very short lived feature since the regolith will collapse and the trenches will quickly fill returning it to its former mysterious presence. Over the years, this intrusion has been largely represented by the single weathered outcrop along the access road to the Elbow on the Spanish River. The one other outcrop area was exposed by the trenches of Johns Manville Company Ltd., but which in recent years became filled, overgrown and essentially nonexistent. The present trenching has re-exposed this earlier area of weathered outcrop and removed all traces of the earlier work.

Samples of carbonatite and related rocks can be collected from the regolith for study. In general terms the rock types recognized are syenite, sovite, silicocarbonatite, ijolite, pyroxenite and biotitite (glimmerite). The syenitic rocks are likely the product of extreme fenitization of granitic wall rocks and the biotitites are likely derived from the pyroxenites. The relationship of the pyroxenites to the carbonatite is uncertain and the ijolite is likely an early

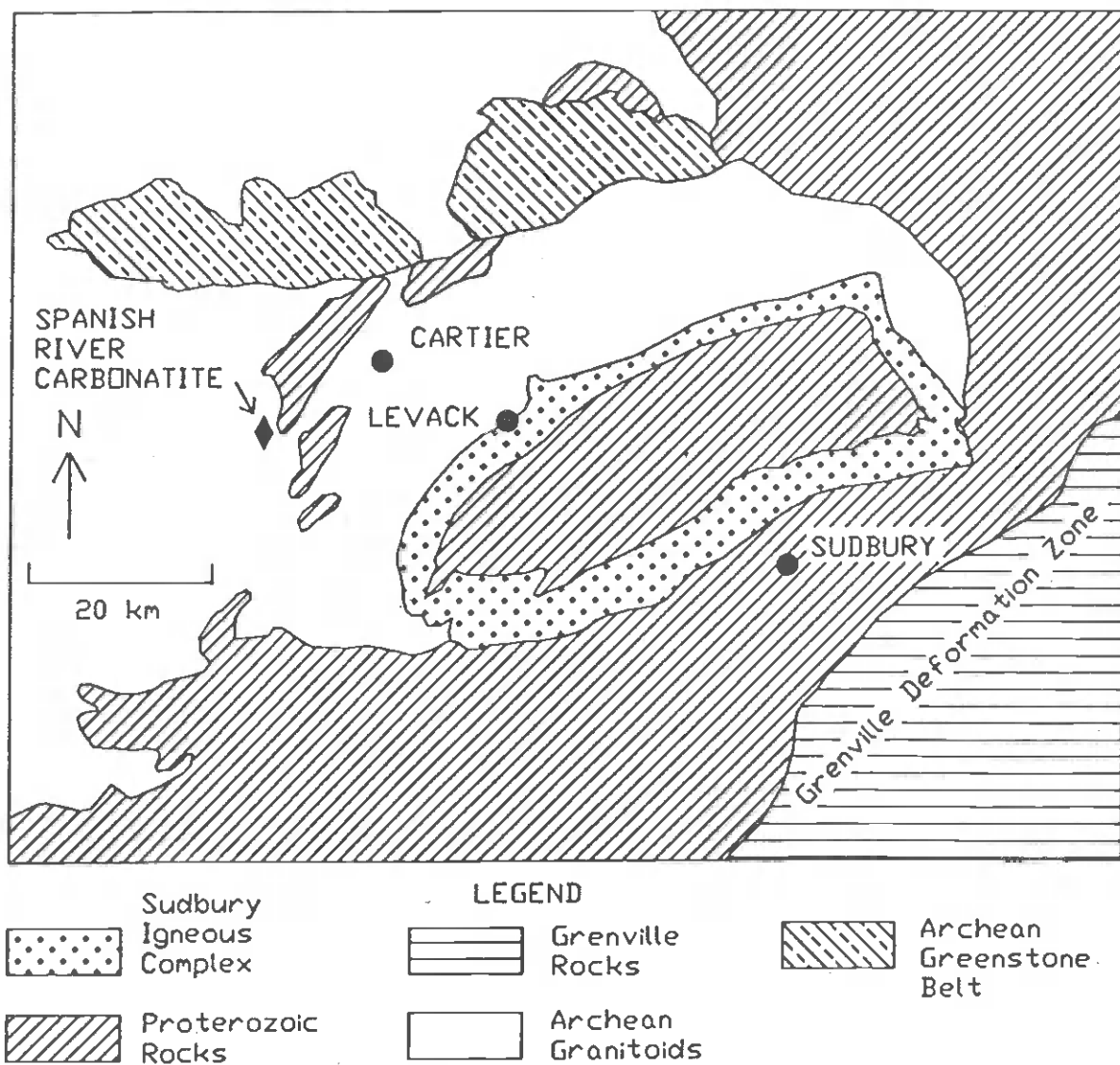


Figure 11: Regional geological setting of the Spanish River Carbonatite (compiled from Ontario Geological Survey Compilation Map 2543)

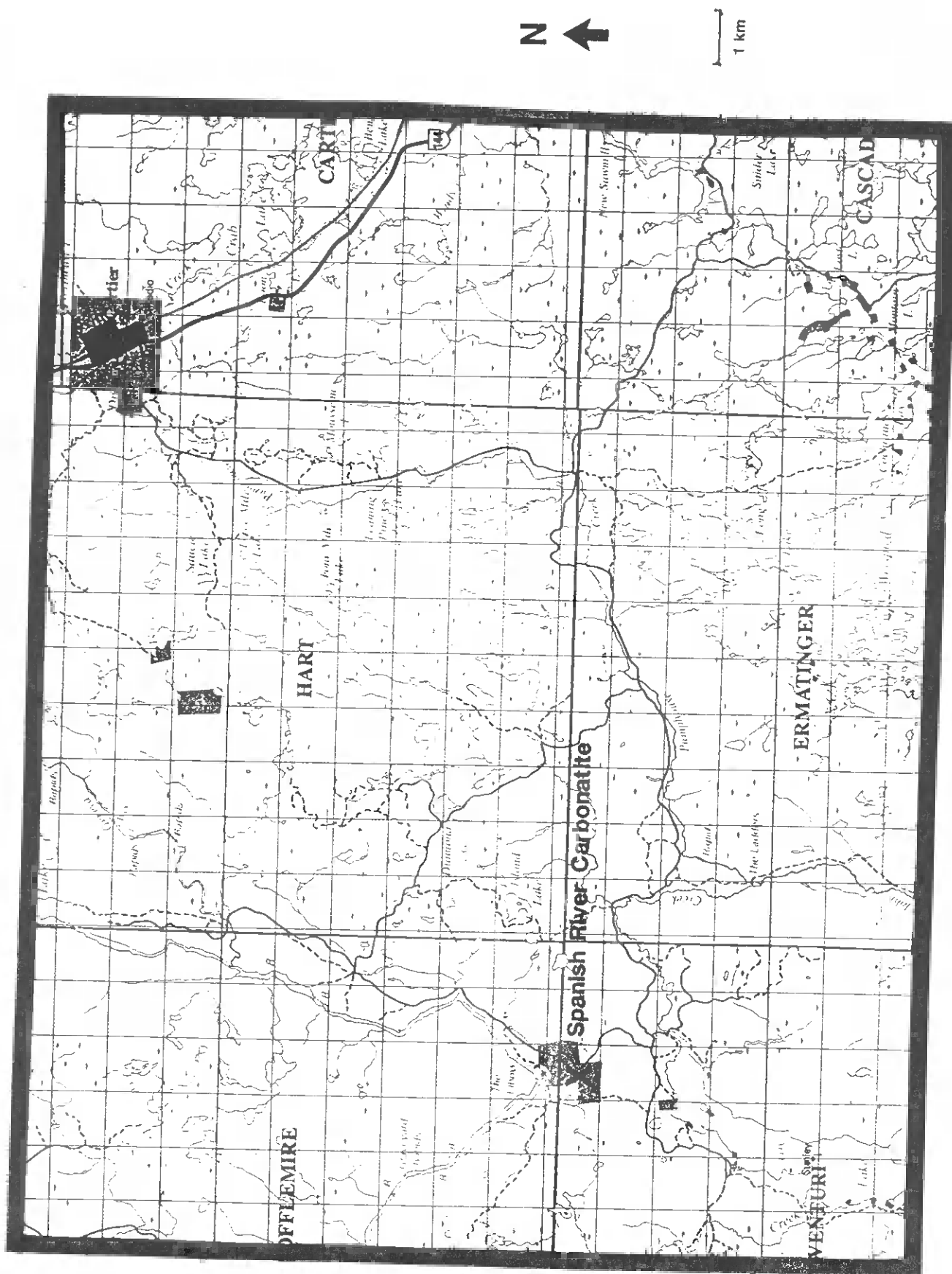


Figure 12: Topographic and road map for the area of the Spanish River Carbonatite (taken from topographic map 41 I/NW).

phase of the carbonatite intrusion. The silicocarbonatite likely has several origins; ie: sovite with high accessory mineral content and as a carbonate-rich alteration product of xenolithic fragments from several sources.

Economic Geology: The Spanish River Carbonatite has been prospected over the years for asbestos, niobium, vermiculite and phosphate. The present efforts are directed towards vermiculite of which examples can be seen in some of the trenches.

Stop 5: Nemag Lake Fenites

The Nemag and Kusk Lake Fenites lie within the boundaries of Whitefish Lake Indian Reserve 6 and cannot be accessed without permission of the residents. We will be visiting only the Nemag Lake occurrence.

The road log starts at the intersection of Highway 55 and Regional Road 24. From the stop light at the intersection Regional Road 24 goes north across the CPR railroad tracks into Lively and south of the intersection the road is known as Black Lake road.

Go 3.6 km west along highway 55 towards Naughton to the turn off to the Whitefish Lake First Nations settlement. This will be a left turn going south(see Figure 13).

At 0.6 km is the Administration building for the Whitefish Lake First Nations on the left side of the road.

At 3.0 km there is a culvert on the road between Fly Lake and Whitefish Lake.

At 5.1 km Whitefish Lake can be seen on the left hand side of the road and at 7.1 km, opposite Makada Lake, a logging road splits from the main road and goes west. Turn right onto this logging road.

Continue on the rough logging road till you reach 12.9 km where a skid trail leads north from the logging road. Turn right on the skid trail and continue to 14.15 km where you may wish to park the vehicle at the top of the hill and



Figure 13: Topographic and road map for the area around the Nemag Lake fenites (taken from topographic map 41 I/6).

continue on foot. The road will be swinging almost due west as you continue north from the parking site.

At approximately 850 metres from the parking site one must walk 90 to 100 metres south into the bush and up to the top of a ridge of outcrop consisting of Nemag Lake Fenite. If you reach Nemag Lake you have gone too far.

NOTE: If the roads are muddy the site may be inaccessible. A four wheel drive vehicle is recommended.

Geology: One of the best, if not the best, example of fenitization occurs within Proterozoic feldspathic quartzite of the Mississagi Formation southwest of Sudbury. The fenite occurs in an explosive breccia and represents extensive replacement of the Mississagi Formation by aegirine, riebeckite, albite, potassium feldspar and rutile (Siemiatkowska and Martin, 1975; Figure 14). The brecciation and fenitization are part of the same event and represent alteration by sodium-rich fluids under subsolidus conditions perhaps derived from a magma of essexite or ijolite composition (Siemiatkowska and Martin, 1975). Siemiatkowska and Martin (1975) subdivide the brecciation and fenitization in great detail into seven stages. For the details of this subdivision the reader should refer to Siemiatkowska and Martin (1975). The fenitizing fluid was poor in CO_2 and potassium appears to be significant only in the late stages of the fenitization process. The Nemag and Kusk Lake fenites are dominantly a process of desilication accompanied by extensive additions of iron and sodium (Siemiatkowska and Martin, 1975). Siemiatkowska and Martin (1975) report a K-Ar isotopic age of 1196 ± 11 Ma on biotite obtained from the fenite. This age would place the fenitization event within Grenville time or development of the mid continent rift.

The discovery of the Nemag and Kusk Lake fenites was made during regional mapping of the Ontario Geological Survey and they occur on opposite sides but near the northeast trending Kusk Lake Fault (Card et al., 1975). The region contains numerous faults. The northeast trending faults display a tendency to swing to more east-west strikes in the western portion of the map area perhaps parallel to the trend of the regional Murray Fault (Card et al., 1975). Northwest trending faults are also common in the area and they are oriented approximately orthogonal to the Grenville Deformation Zone.

In Figure 1, a very broad regional interpretation by Lumbers (1978), the Nemag and Kusk Lake Fenites would occur

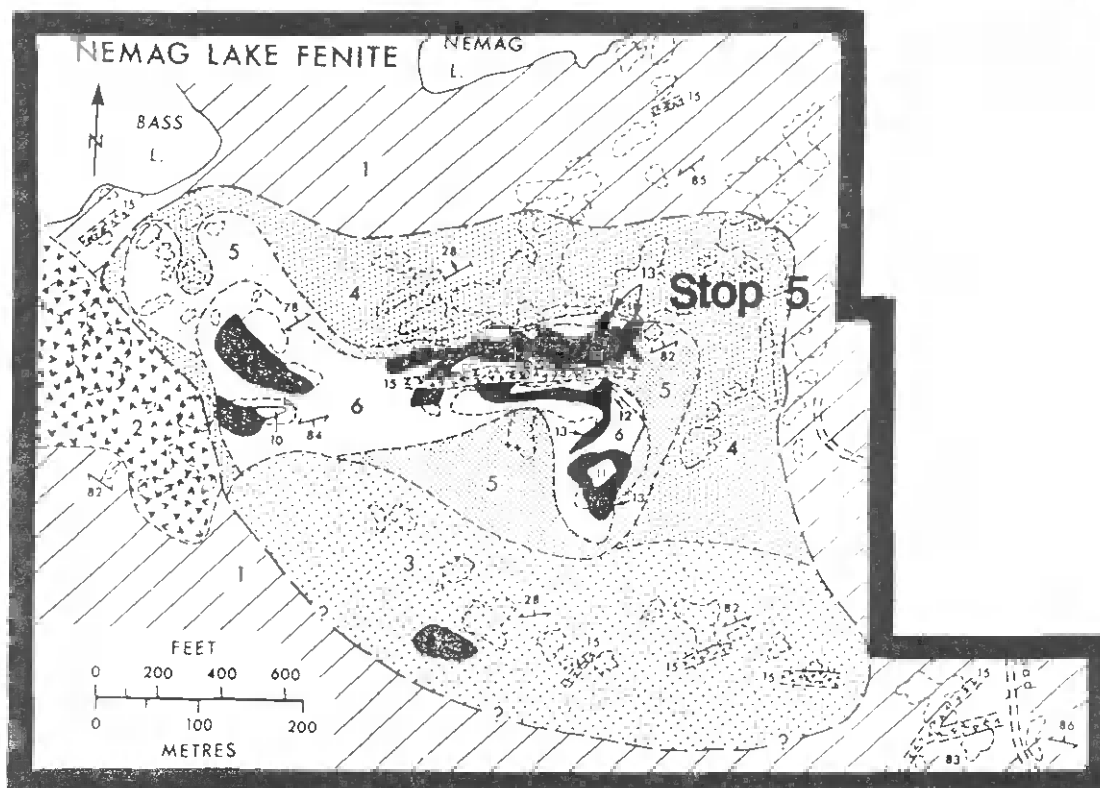
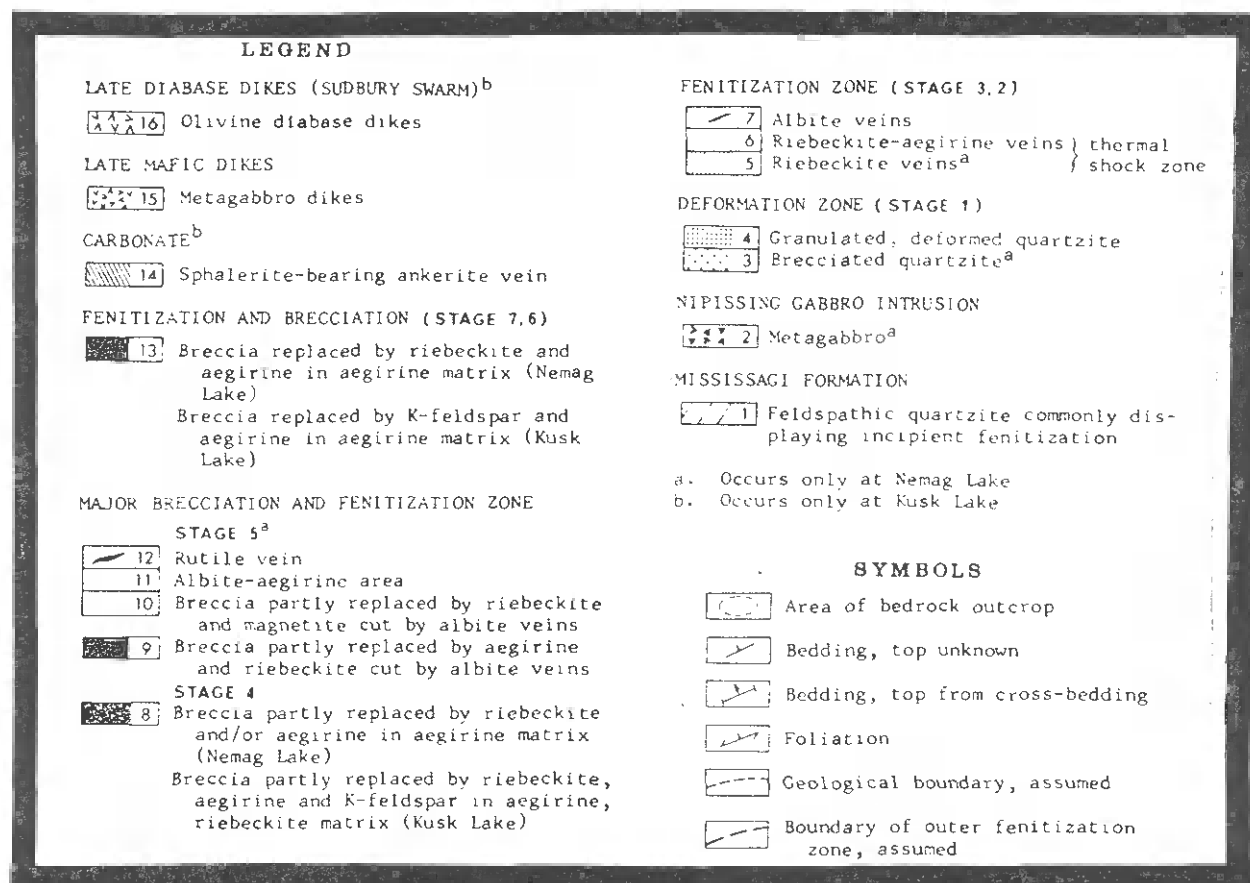


Figure 14: Geology of the Nemag Lake Fenites(modified from Siemiatkowska and Martin, 1975; Card et al., 1975).

at the intersection of the eastern extension of the Great Lakes Tectonic Zone and the Grenville Deformation Zone. Siemiatkowska and Martin(1975) suggest that the fenites may in some way be related to the Murray fault system which would follow the trend of the Great Lakes Tectonic Zone.

At the Nemag Lake Fenite site, fragments up to a metre in maximum dimension can be observed concentrically mantled with aegirine and riebeckite. Late stage pegmatitic albite with riebeckite and aegirine are present as well as late stage breccia veins.

Economic Geology: The fenites are geochemically anomalous in niobium but under existing conditions they are not likely to be of economic interest. One small occurrence of sphalerite has been reported(Meyer, 1996, Resident Geologist, Sudbury, personal communication)

Stop 6: French River Alkalic Rocks

The French River Alkalic rocks occur within the Grenville Structural Province on private property. Permission to access the site should be obtained from the property owner before entering.

The road log starts at the intersection of the Sudbury bypass and highway 69 south of Sudbury.

Drive south on highway 69 for 59.9 km to Bigwood and turn right on to Hartly Bay Road(see Figure 15).

Continue along the Hartly Bay Road until a distance of 65.2 km is reached and turn left towards a camp on the French River. This is a private road.

At a final distance of 66.6 km a dump appears just to the east of the road. Park at this dump site and examine the exposed syenite outcrops in the eastern portion of the cleared area.

Geology: The alkalic rocks have been described by Hewitt(1960; Figure 16) and Lumbers(1975). The alkalic syenites were subdivided into the French River nepheline syenite, French River alkaline syenite and Rutter nepheline syenite by Hewitt(1960); however, Lumbers(1975) refers to

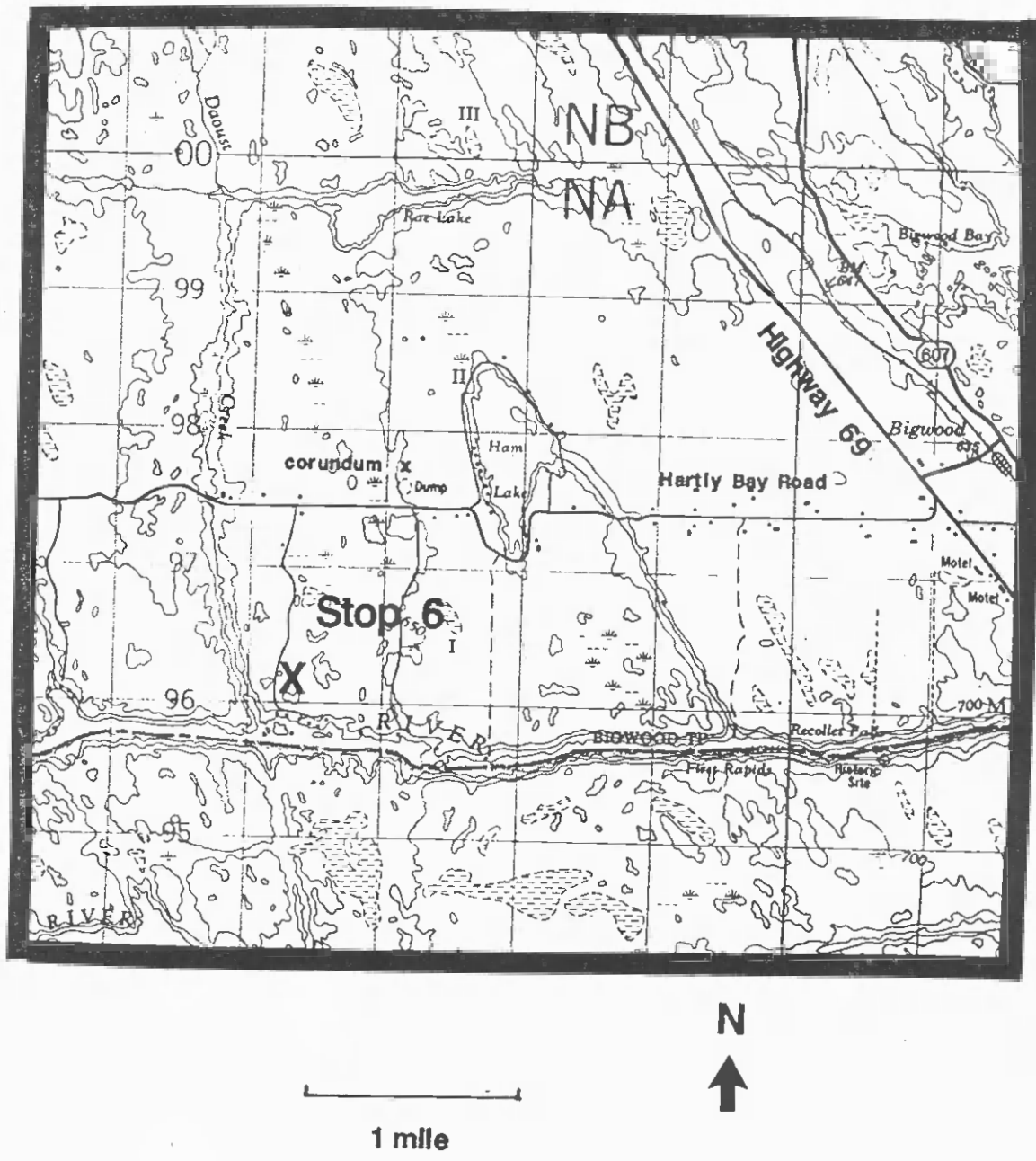


Figure 15: Topographic and road map of the area around the French River alkalic syenites taken from topographic map 41 I/2)

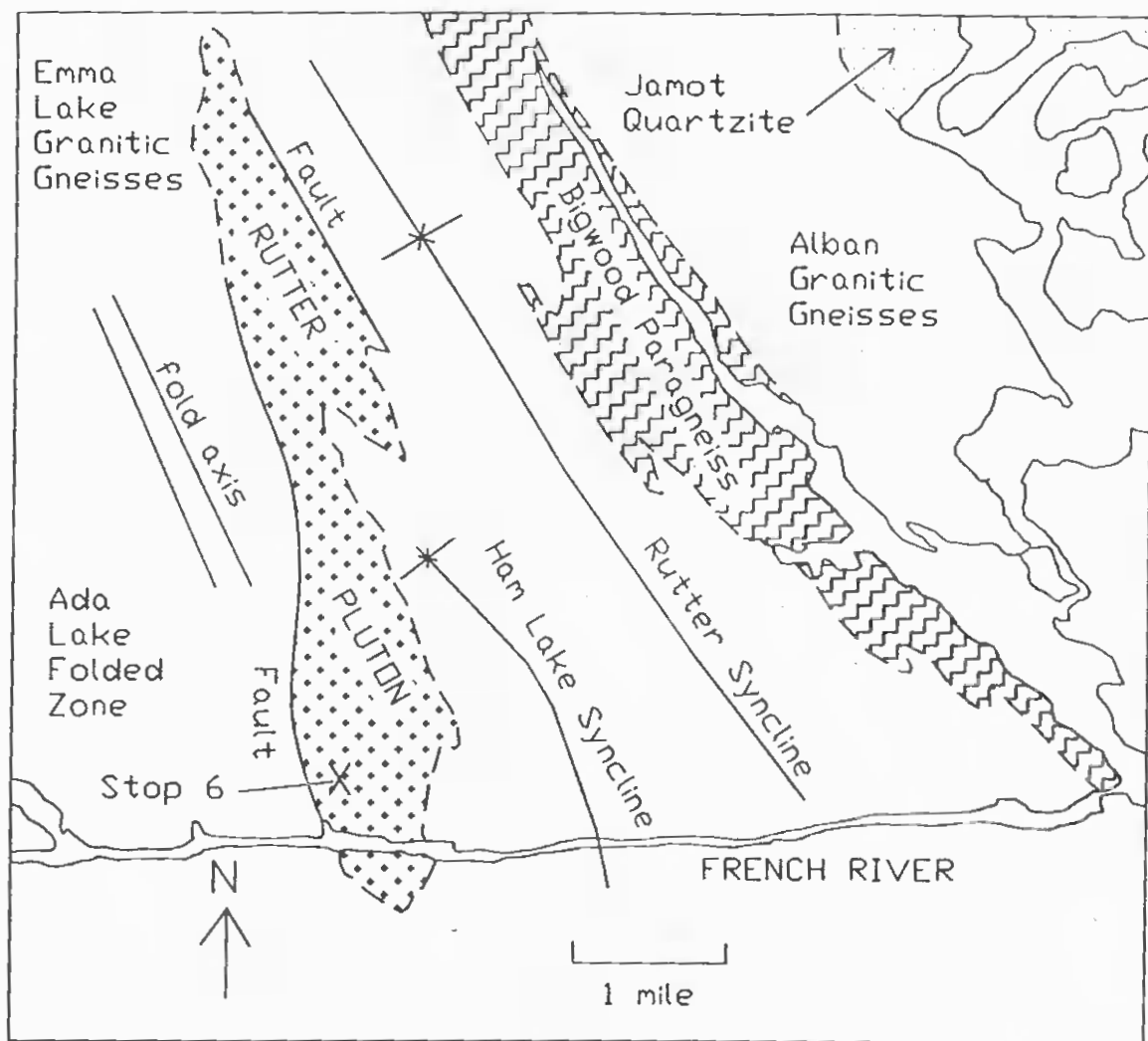


Figure 16: Simplified geologic sketch map of the Rutter alkalic syenite intrusion(modified from Hewitt, 1960, p. 167)

all the alkali syenites in this pluton as the Rutter Pluton. The alkaline syenites occur in an elongated body of approximately seven miles length with its long axis just west of north. The maximum width is approximately one mile (Hewitt, 1960; Lumbers, 1975).

The syenites are dominantly leucocratic, medium-grained, gneissic with streaks and lenses of mafic minerals (Lumbers, 1975). A pink leucocratic phase is the latest in the sequence. The mineralogy of the syenites is albite, nepheline, potassium feldspar and biotite with accessory hastingsite, aegirine-augite, magnetite, sphene, zircon, apatite, graphite, corundum, carbonate, sodalite and cancrinite (Lumbers, 1975). Hewitt (1960) proposed that a regional potassium metasomatic event has occurred; however, Lumbers (1975) reported that he found no evidence for this event and that rarely exposed contacts were sharp and display no evidence for a potassium metasomatism. Hewitt (1960) reports that a lead alpha decay age of 975 Ma was obtained on zircons from this body. This method of age dating is no longer in use and additional geochronological study is warranted.

The syenites at the site display a strong fabric that strike west of north and dip east. Within these syenites are very coarse-grained alkali pegmatites containing potassium feldspar, nepheline, cancrinite, sodalite, aegirine and magnetite. The pegmatites display a well developed pinch and swell structure along strike with the gneissosity, however the coarse-grained minerals in the pegmatites do not appear deformed or fractured. Samples of graphite-bearing syenite have been found at the site and molybdenite flakes over 1 cm in diameter are occasionally found. Pockets of weathered very coarse-grained biotite are exposed at several locations within the stripped area.

Corundum is present at the community dump site north of the road leading to this stop, however it is not abundant and no plans have been made to visit the location.

BIBLIOGRAPHY

Adams, J. and Basham, P., 1986. The Seismicity and Seismotectonics of Canada East of the Cordillera; Geoscience Canada, v. 16, p. 3-16.

Bell, K. and Blenkinsop, J., 1980. Ages and Initial $^{87}\text{Sr}/^{86}\text{Sr}$ Ratios from Alkali complexes of Ontario; p. 16-23, in Geoscience Research Grant Program, Summary of Research, 1979-1980, Ontario Geological Survey, Miscellaneous Paper 93, 263p.

Bent, A.L., 1992. A Re-examination of the 1925 Charlevoix, Quebec Earthquake; Bulletin of the Seismological Society of America, v. 82, n. 5, p. 2097-2113.

Bent, A.L., 1996. An Improved Source Mechanism for the 1935 Timiskaming, Quebec Earthquake from Regional Waveforms; Pure and Applied Geophysics, v. 146, n. 1, p. 5-20.

Canadian Mines Handbook, 1990-1991. Northern Miner Press Inc.; 588p.

Card, K.D.; Palonen, P.A. and Siemiatkowska, K.M., 1975. Louise-Eden Area, District of Sudbury; Ontario Division of Mines Geological Report 124, 66p.; Map 2299, scale 1 inch to 1/2 mile.

Chiasson, A.D., 1989. Paleomagnetism of the Callander Bay Alkaline Carbonatite Complex, Ontario and revision of the Cambrian segment of the North American apparent polar wander path; unpublished BSc thesis, University of Windsor, Windsor, Ontario, 42p.

Cullers, R.L. and Medaris, G., 1977. Rare Earth Elements in Carbonatite and Cogenetic Alkaline Rocks: Examples from Seabrook Lake and Callander Bay, Ontario; Contributions to Mineralogy and Petrology, v. 65, p. 145-153.

Currie, K.L. and Ferguson, J., 1971. A Study of Fenitization Around the Alkaline Carbonatite Complex at Callander Bay, Ontario, Canada; Canadian Journal of Earth Sciences, v. 8, p. 498-517.

Currie, K.L. and Ferguson, J., 1972. A Study of Fenitization in Mafic Rocks, with Special Reference to the Callander Bay Complex; Canadian Journal of Earth Sciences, v. 9, p. 1254-1261.

Currie, K.L., 1976. The Alkaline Rocks of Canada; Geological Survey of Canada Bulletin 239, 228p.

Ferguson, J. and Currie, K.L., 1971. Evidence of Liquid Immiscibility in Alkaline Ultrabasic Dikes at Callander Bay, Ontario; Journal of Petrology, v. 12, p. 561-585.

Ferguson, J. and Currie, K.L., 1972. The Geology and Petrology of the Alkaline Carbonatite at Callander Bay, Ontario; Geological Survey of Canada Bulletin 217, 103p.

Gates, B., 1991. Sudbury Mineral Occurrence Study; Ontario Geological Survey Open File Report 5771, 235p.

Gittins, J., MacIntyre, R.M. and York, D., 1967. The Ages of Carbonatite Complexes in Eastern Canada, Canadian Journal of Earth Sciences, v. 4, p. 651-655.

Harper, G., 1983. The Geology of the Scadding Gold Deposit; Presented at the Sudbury Mineral Kaleidoscope on September 21, 1983.

Hewitt, D.F., 1960. Nepheline Syenite Deposits of Southern Ontario; Ontario Department of Mines Annual Report, v. 69, pt. 8, p. 1-194; Map 1960F, scale 1 inch to 1/2 mile.

Kamo, S.L.; Heaman, L.M. and Lumbers, S.B., 1989. Age for a Lamprophyre DiKE, Callander Bay, Ontario: Use of Ti-bearing Minerals as a Potential Geochronometer; Geological Association of Canada Program with Abstracts, v. 14, p. A41.

Krogh, T.E., Davis, D.W. and Corfu, F., 1984. Precise U-Pb Zircon and Baddeleyite Ages for the Sudbury Area; p. 431-446, in The Geology and Ore Deposits of the Sudbury Structure, edited by E.G. Pye, A.J. Naldrett and Giblin, P.E.; Ontario Survey Special Volume 1, 603p.

Krogh, T.E., Kamo, S.L. and Bohor, B.F., 1996. Shock Metamorphosed Zircons with Correlated U-Pb Discordance and

Melt Rocks with Concordant Protolith Ages Indicate an Impact Origin for the Sudbury Structure; American Geophysical Union Geophysical Monograph 95, p. 343-353.

Kumarapeli, P.S. and Saull, V.A., 1966. The St. Lawrence Valley System: a North American Equivalent of the East African Rift Valley System; Canadian Journal of Earth Sciences, v. 3, p. 639-658.

Lowden, J.A., Stockwell, C.H., Tipper, H.W. and Wanless, R.K., 1963. Age Determinations and Geological Studies; Geological Survey of Canada Paper 62-17, p. 93-94.

Lumbers, S.B., 1971. Geology of the North Bay Area, Districts of Nipissing and Parry Sound; Ontario Department of Mines and Northern Affairs Geological Report 94, 104p.

Lumbers, S.B., 1975. Geology of the Burwash Area, Districts of Nipissing, Parry Sound and Sudbury; Ontario Division of Mines Geological Report 116, 158p.; Map 2271, Scale 1 inch to 2 miles.

Lumbers, S.B., 1978. Geological setting of alkali rock-carbonatite complexes in eastern Canada; p. 81-89, in Proceedings of First International symposium on Carbonatites; Pocos de Caldas Minas Gerais, Brazil; Ministerio Das Minas E Energia, Department Nacional de Producao Mineral, 324p.

Lumbers, S.B., Heaman, L.M., Vertolli, V.M. and Wu, T.-W., 1990. Nature and Timing of Middle Proterozoic Magmatism in the Central Metasedimentary Belt, Ontario; p. 243-276, in Mid-Proterozoic Laurentia-Baltica, Geological Association of Canada Special Paper 38.

Meyer, W., 1995. Soda Metasomatism in the Southern Province; unpublished manuscript prepared for the Ontario Geological Survey, 2p.

ODM-GSC, 1965a. Sturgeon Falls, Ontario Department of Mines-Geological Survey of Canada Map 1488G, Scale 1 inch to 1 mile.

ODM-GSC, 1965b. Nipissing; Ontario Department of Mines-Geological Survey of Canada Map 1487G, Scale 1 inch to 1 mile.

ODM-GSC, 1965c. Powassan; Ontario Department of Mines-Geological Survey of Canada Map 1477G, Scale 1 inch to 1 mile.

ODM-GSC, 1965d. Cartier; Ontario Department of Mines-Geological Survey of Canada Map 1524G, Scale 1 inch to 1 mile.

Sage, R.P., 1987. Geology of Carbonatite - Alkalic Rock Complexes in Ontario: Spanish River Carbonatite Complex, District of Sudbury; Ontario Geological Survey Study 30, 62p.

Sage, R.P., 1991. Chapter 18; Alkalic Rocks, Carbonatite and Kimberlite Complexes of Ontario, Superior Province; p. 683-709, in Geology of Ontario; Ontario Geological Survey Special Volume Number 4, pt. 1, 711p.

Sage, R.P. and Watkinson, D.H., 1991. Alkali rock-carbonatite complexes of the Superior Structural Province northern Ontario, Canada; Chronique de la Recherche Miniere N. 504, p. 5-19.

Sage, R.P., 1996. Kimberlites of the Lake Timiskaming Structural Zone; Ontario Geological Survey Open File Report 5937, 435p.

Schandl, E.S.; Gorton, M.P. and Davis, D.W., 1994. Albitization at 1700 $\pm$ 2 Ma in the Sudbury-Wanapitei Lake Area, Ontario: implications for deep-seated alkali magmatism in the Southern province; Canadian Journal of Earth Sciences, v. 31, p. 597-607.

Shafiqullah, M.; Tupper, W.M. and Cole, T.J.S., 1968. K-Ar Ages on Rocks from the Brent Crater, Ontario; Earth and Planetary Science Letters, v. 5, p. 148-152.

Siemiatkowska, K.M. and Martin, R.F., 1975. Fenitization of the Mississagi Quartzite, Sudbury Area, Ontario; Geological Society of America Bulletin, v. 86, p. 1109-1122.

Symons, D.T.A. and Chiasson, A.D., 1991. Paleomagnetism of the Callander Complex and Cambrian apparent polar wander path for North America; Canadian Journal of Earth Sciences, v. 28, p. 355-363.