Ministry of
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Ontario Geological Survey
Open File Report 5899

Geology of Bon Echo Provincial Park, Frontenac and Lennox and Addington Counties, Grenville Province

1994

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ONTARIO GEOLOGICAL SURVEY

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Geology of Bon Echo Provincial Park, Frontenac and Lennox and Addington Counties, Grenville Province

By

R.M. Easton

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FOREWORD

As part of the Ontario Geological Survey's ongoing program to improve detailed map coverage of the Grenville Province to assist both metallic and non-metallic mineral exploration, detailed mapping of the Grimsthorpe area and Mazinaw areas was undertaken in 1990 and 1991. Prior to 1990, only reconnaissance level geological information was available for this region. During the course of mapping, it became clear that the key to understanding the history of these map areas lay within the Bon Echo Provincial Park. Consequently, with the co-operation of the Ontario Ministry of Natural Resources, detailed mapping of Bon Echo Provincial Park was undertaken by the Ontario Geological Survey in 1991.

The results of this study indicate that geology of the park is controlled by a set of younger, northwest-trending faults, best represented by the fault scarp preserved at Old Walt Rock, a geological feature that was partly responsible for creation of the park in 1965. The geology of the park is dominated by meta-igneous rocks, notably granite and gabbro. This study details the complex geologic history of the park, and the unique geologic features that occur within the park. This study also highlights the fact that the geologic history of Bon Echo Provincial Park is unique within the region, and worthy of preservation. This study can also serve as the basis for developing a public educational program to help the citizens of Ontario to better understand the complex geology preserved within the park and its influence on the landscape.

John Wood, Director
Ontario Geological Survey

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ABSTRACT

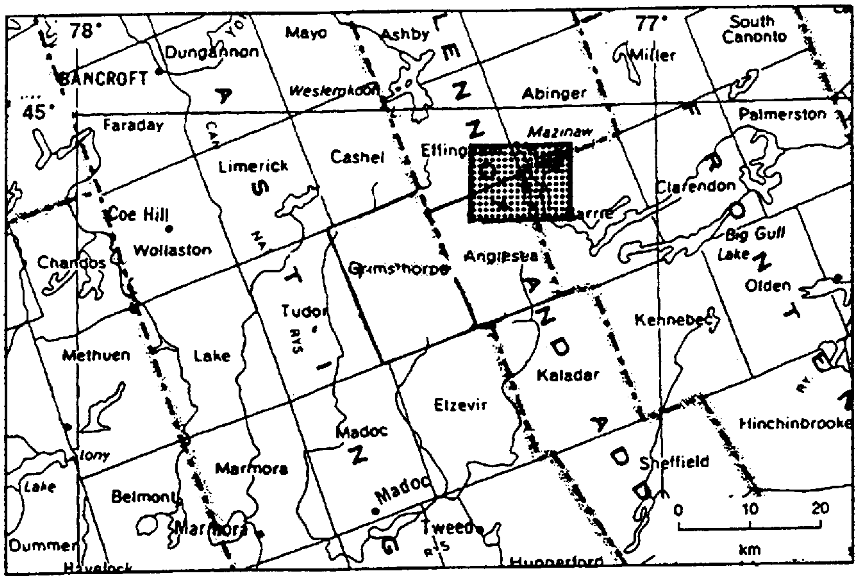

Figure 1: Location map of the study area.

Bon Echo Provincial Park covers about 66 km^2 and lies some 70 km north-northwest of the city of Napanee, approximately 230 km northeast of Toronto. Bedrock is Middle Proterozoic, and lies within the Central Metasedimentary Belt of the Grenville Province. The area straddles the boundary between the Elzevir Terrane (Grimsthorpe domain) and the Mazinaw Terrane. Metamorphic grade in the area is dominantly middle amphibolite facies. Deformation in the Grimsthorpe domain is generally not intense, however, deformation and metamorphic recrystallization are more intense within the Mazinaw Terrane. The Abinger Granite within the area approximates the extent of the Mazinaw Terrane.

The bedrock geology of Bon Echo Provincal Park is dominated by metaplutonic rocks, mainly gabbro and granite, although minor mafic matavolcanic and metasedimentary rocks are present in the Joeperry Lake area. At least 6 periods of magmatism are present, from oldest to youngest these are; i) eruption of the mafic metavolcanic rocks, ii) gabbro intrusion, iii) intrusion of the Joeperry gabbro, iv) intrusion of the Weslemkoon tonalite, v) emplacement of the Abinger Granite, and vi) intrusion of mafic dike rocks. The first four events took place

prior to 1265 Ma based on U-Pb age dating in the region, and the Abinger Granite (event v) has a U-Pb zircon age of *ca.* 1235-1240 Ma. Relative age relationships between the various magmatic episodes are well exposed within the park, particularly on outcrops along Highway 41, and the park is an excellent area to view a variety of plutonic contacts and igneous intrusive processes. Although this dominance of plutonic rocks might suggest a relatively simple geologic history for the park area, this is not the case, and the rocks of Bon Echo Provincial Park have had a complex geologic history, punctuated by late-stage regional faulting.

In addition to the complex magmatic history exhibited within the Precambrian bedrock of the park, east- and northwest-trending faults, most likely of Paleozoic-age and probably related to the Ottawa-Bonnechere graben system, cut through the park and exert a considerable control on the Precambrian geology exposed within the park. Mazinaw Lake and the famous ``Old Walt Rock'' lie along one of these northwest-trending fault traces. Old Walt Rock and the cliffs have inspired many artists, including the Group of Seven, and this natural wonder was one of the reasons for the creation of the park.

The northwest-trending faults show both apparent lateral displacements, however, vertical movement showing both normal and reverse displacement along the northwest-faults can account for all the observed lateral displacement. Calculations of fault movement suggest that the eastern section of the park has been uplifted anywhere from 0.5 to 1.5 km relative to the western boundary of the park. Thus, an increasingly deeper level of the crust is exposed from west to east across the park.

The Central Metasedimentary Belt of the Grenville Province in Ontario is divisible into a number of geologic terranes characterized by distinctive rock types, structural trends, geophysical patterns and unique geologic histories. As noted above, Bon Echo Park straddles the boundary between two such terranes, the Elzevir Terrane to the west and the Mazinaw Terrane to the east. The Elzevir Terrane within the park area (*i.e.*, the Grimsthorpe domain) is characterized by the presence of mafic metavolcanic and white-coloured metaplutonic rocks and a single low grade regional metamorphism (upper greenschist to lower amphibolite) and

the rocks within it are generally older than 1265 Ma. In contrast, the Mazinaw Terrane is characterized by a greater compositional range of metavolcanic rocks, and pink-coloured metaplutonic rocks emplaced mainly at 1240-1230 Ma. The Mazinaw Terrane has also been affected by at least two metamorphic events, with the younger, most intense metamorphism occurring at about 1030-990 Ma.

Due south of the map area, the Elzevir-Mazinaw Terrane boundary is a narrow shear zone, dipping about 75^{o} to the east, marked by the development of straight gneisses. In the park, however, the trace of the boundary is more difficult to ascertain, largely because north-northwest-trending faults run subparallel to the boundary (namely, the Joeperry fault), and in fact, may have reactivated it. The extent of the Mazinaw Terrane is approximated by distribution of the Abinger Granite, and the trace of the margin of this body indicates that the Elzevir-Mazinaw boundary is irregular. The Abinger Granite exhibits a form consistent with the Mazinaw Terrane being a thrust sheet emplaced atop the Grimsthorpe domain. Preservation of these relationships within the park, and not further south, may simply reflect the influence of the Paleozoic faults in the park.

Even with these complications, the Elzevir-Mazinaw boundary within the park is still recognized by the following criteria: (i) changes in structural orientation from east and northeasterly trends in the Grimsthorpe domain (Elzevir Terrane) to easterly trends in the Mazinaw Terrane; (ii) the presence of granitic dikes and granitic plutons within the Mazinaw Terrane which are less common in the Grimsthorpe domain; (iii) the development of biotite in mafic metavolcanic and muscovite in metaplutonic rocks in the Mazinaw Terrane; and (iv) increased deformation and higher metamorphic grade within Mazinaw Terrane rocks.

This study has indicated that the geology of Bon Echo Provincial Park is unique within the region; (1) in having a high concentration of northwest-trending faults which have been significant in shaping the regional landscape, (2) with respect to preservation of the Elzevir-Mazinaw Terrane boundary, and (3) in exhibiting the contact relationships between a wide range of plutonic suites within the Grenville Province. In this respect, the park has a unique geologic setting that was not previously appreciated.

GEOLOGY OF BON ECHO PROVINCIAL PARK, FRONTENAC AND LENNOX AND ADDINGTON COUNTIES, GRENVILLE PROVINCE

Project PU 91-08

by

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Critical Reader: P.C. Thurston, Subsection Supervisor. Manuscript approved for publication by B. Dressler, Section Chief, Precambrian Geoscience Section, May 20, 1994. This report is published with the permission of John Wood, Director, Ontario Geological Survey.

GEOLOGY OF BON ECHO PROVINCIAL PARK

by R.M. Easton

INTRODUCTION

Bon Echo Provincial Park is located within the Mazinaw Lake map area (NTS 31C/14, Easton 1990; Easton and Ford 1991a) (Figure 1), some 70 km north-northeast of Napanee, and approximately 230 km northeast of Toronto. Bon Echo Provincial Park covers about 66 km^2, and is the largest provincial park in eastern Ontario. The park is bounded roughly by lat. 44°52'N and 44°57'N and long. 77°09'W and 77°20'W. The park lies within parts of Frontenac, and Lennox and Addington Counties, and includes parts of Anglesea, Barrie, and Effingham townships. The hamlet of Cloyne is located on highway 41 roughly 10 km south of the southern boundary of the park. Access is provided by highways 41 and various park roads, trails, and canoe routes.

MINERAL EXPLORATION

Some mineral exploration activity was conducted in and near the park prior to its official opening on July 21st, 1965. Little exploration activity has occurred in Anglesea and Effingham townships adjacent to the park area prior to, or subsequent to its opening. In contrast, Barrie Township has had a long history of gold exploration and minor gold production dating back to the turn of the century (*cf.* Meen 1944, Barron 1983, Moore and Morton 1986, LeBaron 1991), however, most of this activity was conducted southeast of the park.

The only known activity in the park itself was the digging of a small shaft west of Joeperry Lake for the purpose of gold extraction. In addition, in conjunction with this study, Easton and Ford (1991a) discovered anomalous Pt, Pd, and Cr values, as well as abundant magnetite, in association with the gabbro body present on the northeast shore of Joeperry Lake. Details on the know mineral prospects in the park are given in greater detail in the economic geology section of this report.

Previous Geological Work

Detailed reviews of Grenville Province geology and metallogeny in Ontario are provided by Easton (1992a) and Easton and Fyon (1992), respectively, and the user is referred to these publications for background information.

The area covered by Anglesea and Barrie townships was first mapped by Meen (1944) at 1:63 360 scale. As part of a M.Sc. thesis at Carleton University, Ayer (1979) mapped part of the park along the Skootamatta River, highway 41, and Mazinaw Lake, at 1:15 840 scale. Ayer's work was subsequently incorporated into an unpublished map of the park, also at 1:15 840 scale, by van Haaften and Smedley (1979). The latter project did not to take into account the regional geologic setting of the park, and was not accompanied by marginal notes or a geological report.

Geological Data Inventory Folios (GDIF) cover the entire map area, as follows: Abinger Township (OGS 1984b), Anglesea Township (OGS 1984c), Barrie Township (OGS 1984d), and Effingham Township (OGS 1984a). Mineral deposit inventories of NTS 31C, which includes the park, are presented in Malczak *et al.* (1985).

An aeromagnetic map at the scale of 1:50 000 of the Mazinaw area, including the park, was released by the Geological Survey of Canada in 1952 (GSC 1952). Results of a gravity survey conducted over the Elzevir Terrane, including parts of the map area, were published by Real and Thomas (1987). Preliminary geochronologic studies in the Mazinaw Terrane, east and southeast of the park, relevant to this study are presented in Corfu and Easton (1994).

The Quaternary geology of the Mazinaw area, including the park, was studied by Henderson (1972). Aggregate resource inventories for townships in Frontenac and Lennox and Addington townships are provided in MNR (1987b) and MNR (1987a), respectively.

Present Geological Survey

Map ______ (back pocket, 1:20 000 scale) presents the results of the geological survey carried out by the authors and their assistants in the summer of 1991 (Project PU91-08), during the course of mapping the adjacent Mazinaw area to the east. A preliminary version of the maps of Bon Echo Provincial Park and, the Grimsthorpe area southwest of the park, were released at a scale of 1:20 000 in 1991 (Easton *et al.* 1991, Easton and Ford 1991b, respectively). A 1:50 000 scale compilation map of the Mazinaw area, which includes the park, was released on Open File in 1990, with a revised edition being readied for release in 1994 (Easton 1990, in prep.).

Vertical aerial photographs at a scale of 1:10 000 were supplied by the Air Photo Library, Public Information Centre, Ontario Ministry of Natural Resources, and were used for mapping control. Acetate overlays were used to record data that was collected on traverses run by the pace and compass method. Geology was not tied to surveyed lines. Traverses were not spaced at regular intervals, but were designed to include as many of the major outcrop areas as possible, particularly in areas of complex geology and along contacts between major rock units. Traverse density was greater in areas underlain by supracrustal rocks than in areas underlain by large plutons. Data from the studies of Ayer (1979) and van Haaften and Smedley (1979) were incorporated into this study.

Information from mapping was plotted on Ontario Basic Mapping (OBM) 1:10 000 base maps supplied by the Ontario Ministry of Natural Resources. The six OBM base maps were mechanically stripped together, and photomechanically reduced, with the geological information, to produce the map accompanying this report. Recent information with respect to roads, buildings, powerlines, rock and shoreline features were added to the base maps, including the location of the various hiking trails in the park (notably the Shield Trail, the Abes and Essens Trail, the Bon Echo Creek Trail, and the High Pines Trail).

Except where otherwise stated, all chemical analyses that appear in this report were done by the Geoscience Research Laboratories, Ontario Geological Survey. Reference to specific locations (photographs, samples, *etc.*) in the text are given in UTM co-ordinates because of the ability to pinpoint locations more precisely than by using latitude/longitude or lots and concessions.

Terminology

In order to avoid confusion, a number of terms used in the discussion of the general geology are outlined below.

Precambrian Time-Scale

The Precambrian time scale as subdivided by Palmer (1983) is used. Precambrian time is divided into two eons; the Archean (older than 2500 Ma), and the Proterozoic (between 2500 and 570 Ma). The Proterozoic is divided into three eras; Early (2500 to 1600 Ma); Middle (1600 to 900 Ma); and Late (900 to 570 Ma).

Rock Classification

Terminology for all plutonic rocks in the area follows that of Streckeisen (1976). For metamorphic rocks, mineral prefixes are listed in order of relative abundance, starting with least abundant first. The following conventions are used regarding descriptive adjectives. A *gneissic granite* is a meta-igneous rock of granitic composition. A *granitic gneiss,* a *granite gneiss,* or a *gneiss of granitic composition* may be either a meta-igneous or a metasedimentary rock. Similarly, a *tonalitic gneiss* or a *tonalite gneiss* is a gneiss of tonalite modal composition, but may be of either meta-igneous or metasedimentary origin. A *gneissic meta-arkose* is a metasedimentary gneiss of overall granitic composition. Terminology for mylonites follows that of Higgins (1971).

The term metamorphic grade is used in the case where bulk-rock composition or other factors prevent a more detailed assignment of metamorphic conditions. Where metamorphic conditions can be outlined more precisely, the metamorphic facies terminology of Turner (1981) is used.

Foliation, Schistosity, Gneissosity, Cleavage

Foliation is used to describe all types of megascopically recognizable planar surfaces of metamorphic origin (Turner and Weiss 1963). Bedding and schistosity are the most common varieties of foliation in the map area. Bedding is a compositional difference between layers reflecting primary depositional processes (*e.g.*, sedimentation). Schistosity is a planar structure in a metamorphic rock due to abundant, preferentially oriented grains, especially micas. Schistosity is accompanied by a fissility in the rock, and is best developed in micaceous rocks. Gneissosity denotes a layering of metamorphic origin, defined by the alternation of layers, streaks, or lenticles on contrasting mineralogy or texture. The streaks or lenticles may be discontinuous. Cleavage denotes a parting in the rock resulting from the parallel growth of micaceous or elongated minerals in fine- to medium-grained rocks.

Layering Thickness Terms

Layering thickness terms used in this report are listed below. These terms apply to bedded, layered and gneissic rocks.

Very thinly layered	<3 cm
Thinly layered	3 to 10 cm
Medium layered	10 to 30 cm
Thickly layered	30 to 100 cm (1 m)
Very thickly layered	1 to 3 m
Extremely thickly layered	>3 m

GENERAL GEOLOGY

Introduction and Geological Summary

The Grenville Structural Province in Ontario consists of two major subdivisions, a northern belt dominated by *circa* 1.4 Ga to 2.7 Ga quartofeldspathic metasedimentary and metaplutonic gneisses known as the Central Gneiss Belt; and a southern belt dominated by *circa* 1.1 Ga to 1.3 Ga metasedimentary, metavolcanic and metaplutonic rocks, known as the Central Metasedimentary Belt (*see* Easton 1992a for further details). Bon Echo Provincial Park is underlain by rocks of the Central Metasedimentary Belt.

The bedrock geology of Bon Echo Provincial Park (Figure 3, Map, back pocket) differs from most of the Central Metasedimentary Belt in being dominated by metaplutonic rocks, mainly gabbro and granite, although minor mafic matavolcanic and metasedimentary rocks are present in the Joeperry Lake area. At least 6 periods of magmatism are present, from oldest to youngest these are; i) eruption of the mafic metavolcanic rocks, ii) gabbro intrusion, iii) intrusion of the Joeperry gabbro, iv) intrusion of the Weslemkoon tonalite, v) emplacement of the Abinger Granite, and vi) intrusion of mafic dikes. The first four events took place prior to 1265 Ma based on U-Pb age dating in the region, and the Abinger Granite (event v) has a U-Pb zircon age of *ca.* 1235-1240 Ma (Corfu and Easton 1994). Relative age relationships between the various magmatic episodes are well exposed within the park, particularly in outcrops along highway 41, and the park is an excellent area to view a variety of plutonic contacts and igneous intrusive processes. Figure 4 illustrates the contact relationships between major rock units within the map area, and Table 1 summarizes the general stratigraphic succession within Bon Echo Provincial Park. Table 2 summarizes the age relationships between the Elzevir and Mazinaw terranes.

In addition to the complex magmatic history exhibited within the Precambrian bedrock of the park, east- and northwest-trending faults, most likely of Paleozoic age, cut through the park (Figure 3, 5), and exert a considerable control on the Precambrian geology exposed within the park. Mazinaw Lake and the famous "Old Walt Rock" lie along one of these northwest-trending fault traces. Old Walt Rock and the cliffs have inspired many artists, including the Group of Seven (*e.g.*, A.J. Casson, 1952, *Cliffs, Mazinaw Lake*), and this natural wonder was one of the reasons for the creation of the park.

The northwest-trending faults show apparent lateral displacements, however vertical movement showing both normal and reverse displacement along the northwest-faults can account for all the observed lateral displacement. Calculations of fault movement suggest that the eastern section of the park has been uplifted anywhere from 0.5 to 1.5 km relative to the western boundary of the park (*see* Figure 6). Thus, an increasingly deeper level of the crust is exposed from west to east across the park. Figure 6 is a schematic cross-section illustrating the effects of this faulting on geological contacts within the park area. East-trending faults are more difficult to trace in the park, in part because they are subparallel to regional trends of rock units within the Mazinaw Terrane and the northern Grimsthorpe domain.

Bon Echo Provincial Park straddles the boundary between the Mazinaw Terrane and the Grimsthorpe domain of the Elzevir Terrane (Easton 1992a, 1992b)(Figure 2). Easton and Ford (1990) termed this boundary the Mooroton shear zone. Each terrane is characterized by different rock units (Figure 3, 7). The Grimsthorpe domain of the Elzevir Terrane (Easton 1992a, 1992b; Easton and Ford 1990), which underlies the western half of the park, consists of, from oldest to youngest:
(a) tholeiitic metabasalts intruded by metagabbro and metaperidotite (Canniff Complex);
(b) metaconglomerate, metawacke and metapelite rich in volcanic debris, with minor interbedded tholeiitic metabasalt flows (all representing the Grimsthorpe Group);
(c) the Canniff Complex of gabbro and tholeiitic metabasalts;
(d) metagabbro bodies younger than the Canniff Complex that intrude the Grimsthorpe Group (most common in the western part of the Park);
(e) metagabbro, with hornblendite pods and anorthositic metagabbros of the Killer Creek Gabbro Suite (Easton and Ford 1990), referred to as Killer Creek-type gabbros of >1270 Ma age. These gabbros are characterized by high TiO_2 (>2.5%) and P_2O_5 (>0.6%) contents (Easton and Ford 1994);
(f) metatonalites and minor metagranodiorites of the *ca.* 1270 Ma Elzevir Suite (Easton 1992a, Lumbers *et al.* 1990) including the Canniff, Elzevir and Weslemkoon tonalites and which locally form intrusion breccias of tonalite and Killer Creek-type gabbro; and
(g) the syenites of the Skootamatta Suite (Easton 1992a).

All of these units, except for the Canniff Complex and Skootamatta Suite plutons, are found within Bon Echo Provincial Park.

Details of folding and metamorphism within the Grimsthorpe domain are given in later sections. In general, however, rocks of the Grimsthorpe domain are preserved at medium metamorphic grade (upper greenschist facies to lower amphibolite facies) in the western part of the park. Only one major regional metamorphic event appears to have affected the

Grimsthorpe domain. Deformation in the domain is localized in shear zones, and most rocks preserve relict primary textures, including igneous layering in the gabbroic rocks and fine bedding features in the metasediments (Easton and Ford 1990, 1994).

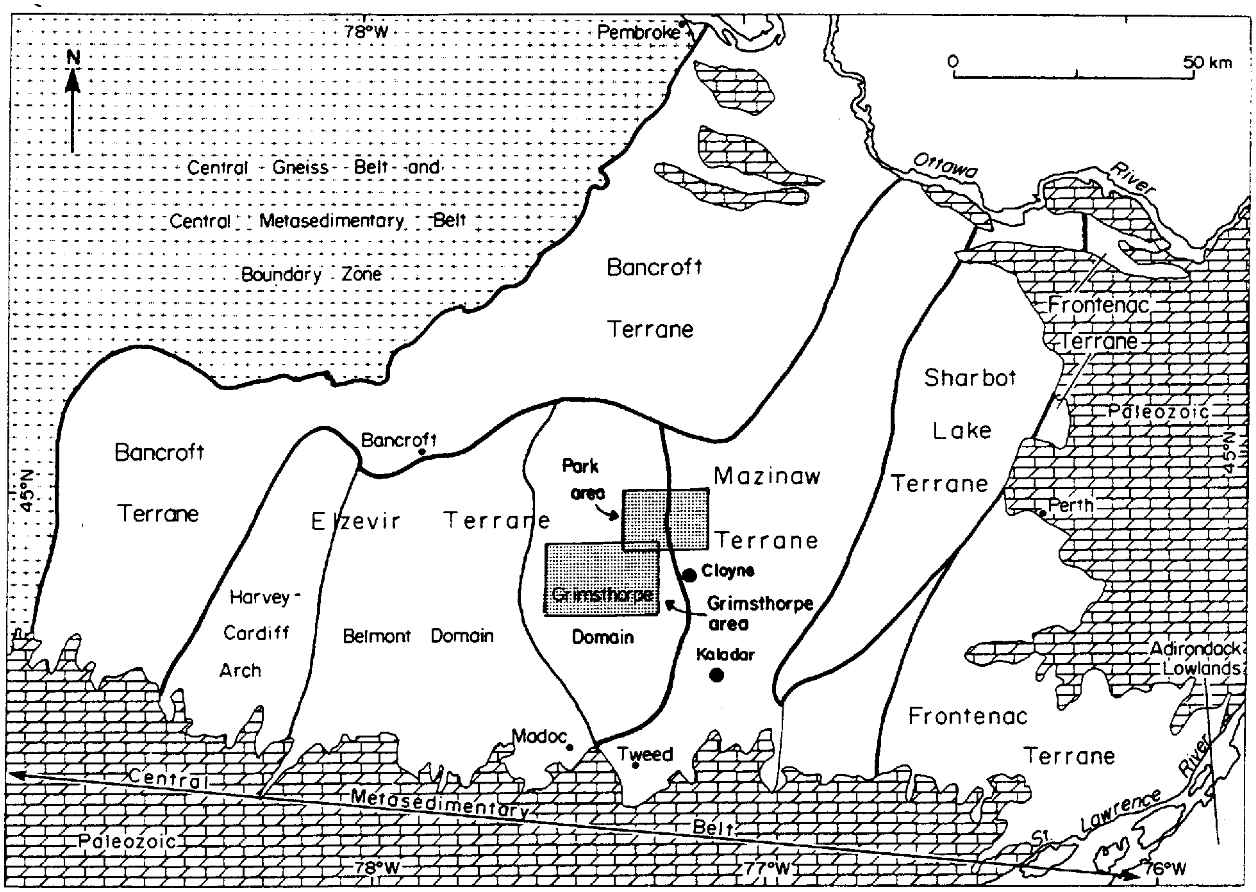
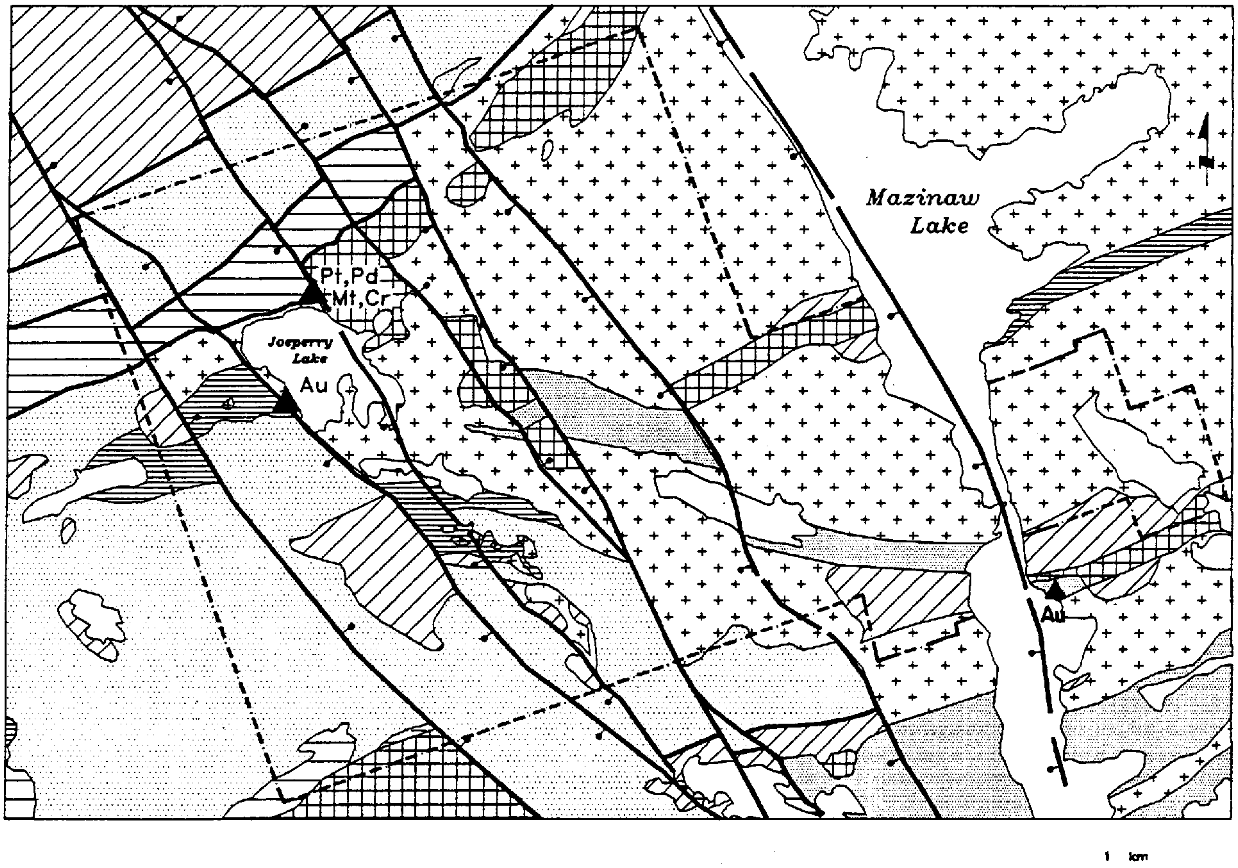


Figure 2: Terrane subdivision of the Central Metasedimentary Belt after Easton (1992a, 1992b). Shaded box shows position of Bon Echo Provincial Park.

Figure 3: Geologic sketch map showing major rock units, structures and mineral occurrences within Bon Echo Provincial Park.



BON ECHO PARK AREA

LEGEND

- Felsic Intrusive Rocks (max. 1245 Ma), Methuen suite?, Abinger Granite (unit A)
- Intermediate to Felsic Intrusive Rocks (ca.1270 Ma), Elzevir Suite (unit 8)
- Mafic Intrusive Rocks (ca.1270–1280 Ma) Dioritic to Gabbroic Rocks (unit 7) (Killer Creek Gabbro Suite)
- Felsic to Intermediate Gneisses (unit 6)
- Mafic Intrusive Rocks (ca. 1270–1290 Ma) Dioritic to Gabbroic Rocks (unit 5)
- Fault
- Park Boundary
- Mineral Occurrence

GRENVILLE SUPERGROUP METASEDIMENTARY ROCKS

- Siliceous Clastic Metasedimentary Rocks, may include Felsic and Intermediate Metatuffs and Metasedimentary Rocks of Mainly Volcanic Provenance (unit 3+4)
- Mafic Intrusive Rocks (ca. 1290 Ma) Gabbroic and Talcose Rocks (unit 2) (NOT PRESENT IN PARK AREA)

METAVOLCANIC ROCKS

- Mafic Metavolcanic Rocks (unit 1)

Figure 4: Plan view showing time-space relationships of major rock units within Bon Echo Provincial Park. Triangles designate location of intrusion breccia zones. Figure only shows intrusive relationships and does not show tectonic relationships between units.

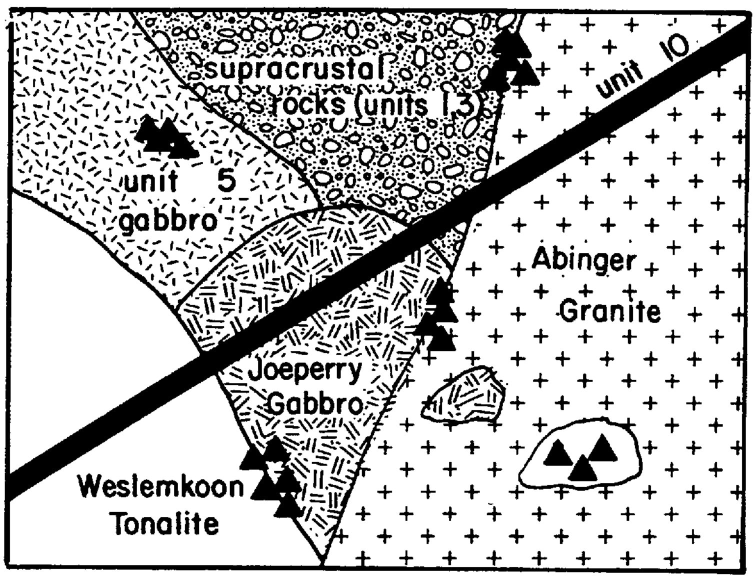


Figure 5: Distribution of major faults within Bon Echo Provincial Park.

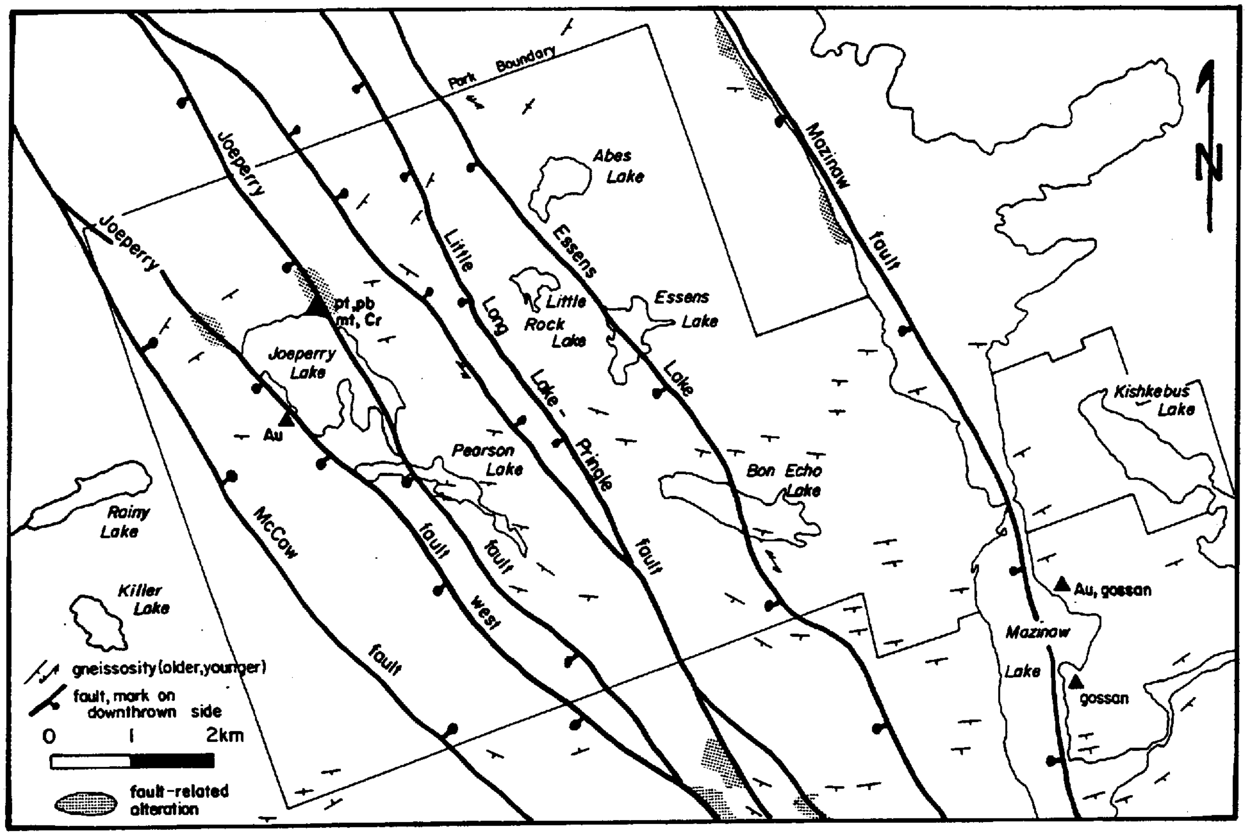


TABLE 1: Table of Lithologic Units for the Grimsthorpe Area.

PHANEROZOIC
CENOZOIC
QUATERNARY
PLEISTOCENE AND RECENT
Sand, gravel, glaciofluvial deposits, till, ground moraines, and organic swamp deposits

UNCONFORMITY

PALEOZOIC
Fault gouge (alteration along faults including addition of hematite, epidote, chlorite)

UNCONFORMITY

PRECAMBRIAN
LATE PROTEROZOIC
LATE TECTONIC TO POSTTECTONIC INTRUSIVE ROCKS
Mafic Intrusive Rocks
Fine-grained, weakly metamorphosed, diabase dikes

INTRUSIVE CONTACT

MIDDLE TO LATE PROTEROZOIC
MAZINAW TERRANE
Felsic Intrusive Rocks (*ca.* 1240 Ma) (Abinger Granite - Methuen Suite?)
Monzogranite to syenogranite gneiss, local intrusion breccia zones containing country rock fragments

FAULTED CONTACT?

FELSITES AND MYLONITES
Felsic to Intermediate Gneisses

FAULTED AND INTRUSIVE CONTACTS

MIDDLE TO LATE PROTEROZOIC
ELZEVIR TERRANE - Grimsthorpe domain
Intermediate to Felsic Intrusive Rocks (*ca.* 1270 Ma), Elzevir Tonalite Suite
Tonalite and granodiorite (includes trondhjemite, granodiorite, melanodiorite, quartz diorite, monzogranite to syenogranite, migmatite formed by tonalite veins and screens of country rock, intrusion breccia, fine-grained, sugary-textured tonalite dikes, aplite, and derived mylonites)

Mafic Intrusive Rocks (>1280 Ma)
Dioritic to Gabbroic Rocks (Killer Creek Gabbro Suite)

Fine- to coarse-grained gabbro (also includes melanocratic gabbro, gabbroic anorthosite, fine- to medium grained feldspar porphyritic gabbro, hornblendite, mylonitic gabbro)

INTRUSIVE CONTACT

Mafic Intrusive Rocks (>1280 Ma)
Dioritic to Gabbroic Rocks

Fine- to coarse-grained gabbro (also includes melanocratic gabbro, hornblendite, fine-grained gabbro dikes, mylonitic gabbro, gabbroic intrusion breccia)

INTRUSIVE CONTACT

GRENVILLE SUPERGROUP - Grimsthorpe Group
METASEDIMENTARY ROCKS
Siliceous Clastic Metasedimentary Rocks

Meta-arenite, metawacke

Siliceous Clastic Metasedimentary Rocks, may include Felsic and Intermediate Metatuffs and Metasedimentary Rocks of Mainly Volcanic Provenance

Biotite-hornblende-quartz-plagioclase gneiss (mafic meta-arenite, mafic metawacke), hornblende-plagioclase schist and gneiss (metatuff), volcanic wackes, arkose (intermediate to felsic metalitharenite), polymictic, matrix-supported conglomerate, with mafic matrix, rusty schist, minor pillow basalt and massive basalt flows

UNCONFORMITY?

CANNIFF COMPLEX (>1290 Ma) (present south of the area)
GABBROIC AND TALCOSE ROCKS

METAVOLCANIC ROCKS
Mafic Metavolcanic Rocks

Massive, fine-grained, amphibolite (massive flow?), pillowed, fine-grained amphibolite (pillowed flow), massive, fine to medium-grained, diabasic-textured amphibolite (thick flows or gabbro sills), fine-grained chlorite-amphibole schist, layered to bedded, fine-grained, amphibolite (tuff, locally lapilli tuff), rusty schists

TABLE 2: Relative and absolute ages of rock units between the Elzevir Terrane (Grimsthorpe domain) and the Mazinaw Terrane. From Easton and Ford (1994) and Corfu and Easton (1994).

Elzevir Terrane Western Block	 Eastern Block	**Mazinaw Terrane** Marble Lake area	
absent?	absent?	metamorphism (M_2) *ca.* 1030-1020 Ma	
Mount Moriah Syenite	Skootamatta Syenite (*ca.* 1075-1090 Ma)	absent	
absent	absent	Flinton Gp. (*ca.* 1150 Ma) **unconformity**	*post-Grenville Supergroup supracrustals*
absent	absent	granitic plutons *ca.* 1240-1230 Ma	
tonalite dikes	tonalite dikes (1229+11/-4 Ma)	"dacite" dikes and Cross Lake tonalite (*ca.* 1235 Ma)	
gabbro dikes	gabbro dikes	absent?	
Canniff & Weslemkoon tonalites; Lingham Lk. Diorite-Gabbro Suite	Elzevir Tonalite (*ca.* 1270 Ma)	tonalites (may be faulted in	
absent	Killer Creek Gabbro Suite	diorites gabbros	
absent	absent	carbonate & siliceous clastic metasedimentary rocks; volcaniclastic meta-sedimentary rocks; mafic intermediate, & felsic volcanic rocks (*ca.* 1275 Ma)	*Grenville Supergroup supracrustals (Kashwakamak Fm.)*
gabbro intrusions	gabbro intrusions	absent?	
volcaniclastic sediments **unconformity**	volcaniclastic sediments **unconformity**?	absent?	*(Grimsthorpe Group)*
amphibolites (metaflows?)	amphibolites (metaflows?)	absent?	*pre-Grenville Supergroup supracrustals (Canniff Complex)*
protomylonitic gabbros	absent?	absent	

In contrast, the Mazinaw Terrane, which underlies the eastern half of the park, consists of, from oldest to youngest (all ages are from Corfu and Easton 1994, except where stated otherwise):
(a) metatonalite and metagranodiorite intrusions of the *ca.* 1270 Ma Elzevir Suite (Easton 1992a, Lumbers *et al.* 1990), locally containing intrusion breccias containing the older Killer Creek-type gabbros, particularly within the park;
(b) basalt-andesite-dacite-rhyolite metavolcanics of the Kashwakamak Formation of calc-alkalic affinity (Moore and Morton 1986, Harnois and Moore 1991) of *ca.* 1275 Ma age;
(c) siliciclastic metasedimentary rocks (metawacke, semi-pelites, paramphibolites), in part derived from metavolcanic rocks;
(d) calcitic and dolomitic marbles;
(e) tholeiitic basalt-dacite metavolcanic rocks, now extensively sheared, in the vicinity of Mazinaw and Shabomeka lakes, dated at about 1240 Ma in age. Units b, c, d and e constitute the Mazinaw Group (Grenville Supergroup) of Easton (1992a);
(f) tonalitic intrusions such as the Cross Lake tonalite of $\geq$ 1245 Ma age;
(g) fine- to medium-grained, heterogeneous granitic rocks of 1240-1230 Ma age (Abinger and Norway Lake granites in the map area, Figure 3);
(h) the *ca.* 1157 Ma Flinton Group which unconformably overlies all older rock units (maximum age of deposition, Kinsman and Parrish 1990); and
(i) sheared rocks (*e.g.*, felsites) derived from any or all of the preceding units.
Only units a, e and g occur within Bon Echo Provincial Park.

A broad overview of deformation and metamorphic events affecting the rocks of the Mazinaw Terrane follows. Details are presented later in the report. The Mazinaw Terrane has been subjected to at least two regional metamorphic episodes. The first, M_1, a high grade event reaching upper amphibolite and perhaps granulite facies locally, affected all rocks older than the Flinton Group, and was accompanied by intense deformation (D_1) which formed much of the penetrative fabric currently preserved in the rocks. D_1 was accompanied by thrusting and tight (isoclinal) folding which formed regional fold structures in the area, and is >1160 Ma in age. The second metamorphic event (M_2), a low to moderate grade event in the area, affected the Flinton Group, as well as all older rocks, and is dated using metamorphic zircons at 1030-990 Ma in age (Corfu and Easton 1994). The metamorphic pattern in the Mazinaw area, adjacent to the park, reflects M_2, with low grade conditions (greenschist, *i.e.* chloritoid-staurolite) present southeast of Marble Lake to the south of the park, rising to medium grade (upper amphibolite [sillimanite] facies) along the northern and eastern boundaries of the park. M_2 was accompanied by only localized deformation (shearing, minor folding, refolding of older structures) and was responsible for the growth of randomly-oriented porphyroblasts (hornblende, microcline, staurolite, chloritoid, kyanite, tourmaline, muscovite) in most rock units, including metaplutonic rocks.

Due south of the map area, the Elzevir-Mazinaw Terrane boundary (Mooroton shear zone) is a narrow shear zone, dipping about 75° to the east, marked by the development of straight gneisses. In the park, however, the trace of the boundary is more difficult to ascertain, largely because north-northwest-trending faults run subparallel to the boundary (namely, the Joeperry fault), and in fact, may have reactivated it (Figure 2, 3). In addition, as illustrated in Figure 7, if the Abinger Granite is regarded as forming the bulk of the Mazinaw Terrane within the park, then the Elzevir-Mazinaw boundary is irregular, and exhibits a form consistent with the Mazinaw Terrane being a thrust sheet emplaced atop the Grimsthorpe domain. Preservation of these relationships within the park, and not further south, may simply reflect the influence of the Paleozoic faults in the park, as illustrated in Figures 6 and 7.

Even with these complications, the Elzevir-Mazinaw boundary within the park is still recognized by the following criteria: (i) changes in structural orientation from east and northeasterly trends in the Elzevir Terrane (Grimsthorpe domain) to easterly trends in the Mazinaw Terrane; (ii) the presence of granitic dikes and granitic plutons within the Mazinaw Terrane which are less common in the Elzevir Terrane; (iii) the development of biotite in mafic metavolcanic and muscovite in metaplutonic rocks in the Mazinaw Terrane; and (iv) increased deformation and higher metamorphic grade within Mazinaw Terrane rocks.

DESCRIPTION OF MAJOR GEOLOGIC UNITS

To aid in comparison with the map of the Grimsthorpe area, which adjoins Bon Echo Provincial Park to the south, the same map legend is used for both areas. Note, however, that not all units present within the Grimsthorpe map area occur within the park. Rocks of units 6 and unit A are restricted to the Mazinaw Terrane. Rocks of units 1 through 5 and units 7 and 8 are most common in the Elzevir Terrane (Grimsthorpe domain), but locally are present in the Mazinaw Terrane.

PRECAMBRIAN
MIDDLE PROTEROZOIC
GRENVILLE SUPERGROUP
MAFIC METAVOLCANIC ROCKS (UNIT 1)

Mafic metavolcanic rocks are only well-exposed in the northwest corner of the park, north of Joeperry Lake, and in a narrow band in the southeast corner of the park. The mafic metavolcanic rocks within the park are correlated with mafic metavolcanic rocks traced from the Grimsthorpe area south of the Park (Easton and Ford 1990, 1993). Although a variety of textural subdivisions occur within the metavolcanic sequence in the Grimsthorpe area, only three subunits occur within Bon Echo Provincial Park.

Most exposures consist of massive, fine-grained, dark green to black weathering metabasalt (unit 1a). These rocks are commonly fractured, cut by astamosing, narrow (1-10 mm wide) quartz and plagioclase veins. In outcrop, these rocks are not particularly fresh in appearance, and primary textures are not well preserved. Unit 1a can also be described as an amphibolite. These rocks most likely represent volcanic massive flows.

Figure 6: Geologic sketch showing a cross-section illustrating the effects of displacement across northwest-trending faults within Bon Echo Provincial Park. Location of cross-section shown in Figure 5. Displacement of two types of contacts across faults is illustrated. For the horizontal unit, displacement of 250 m across each fault is assumed (this approximates displacements inferred from measuring offset contacts on the map (back pocket). Horizontal dashed line shows location of unit A assuming no faulting. Approximately 500 m of uplift occurs from west to east for this unit. Effects on a dipping contact are more dramatic (e.g., Elzevir-Mazinaw terrane boundary, unit B). In this case, a 45^{o} dip to the east is assumed. Diagonal dashed line shows location of unit assuming no faulting. Approximately 1.5 km of uplift occurs across the park in this scenario.

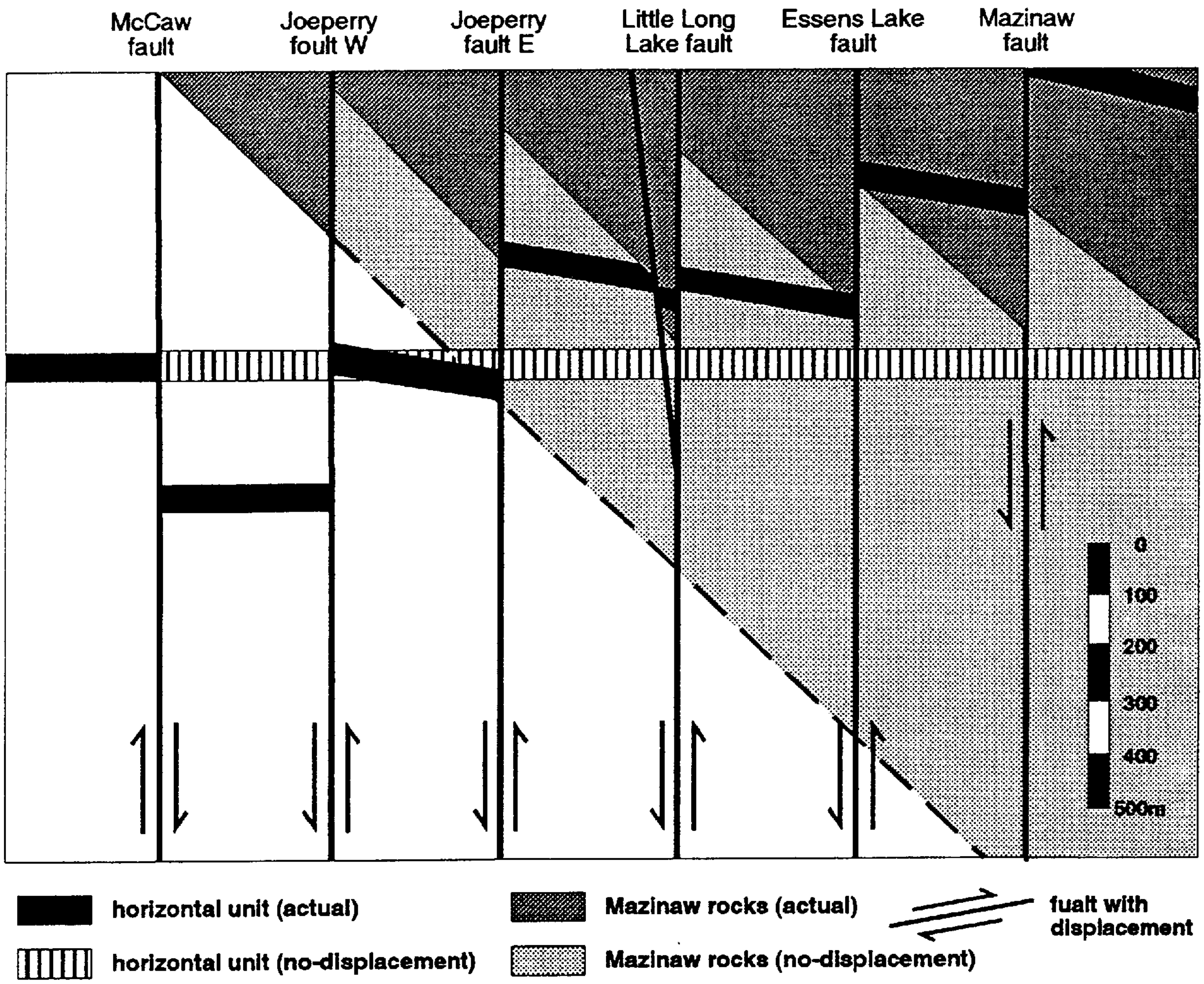
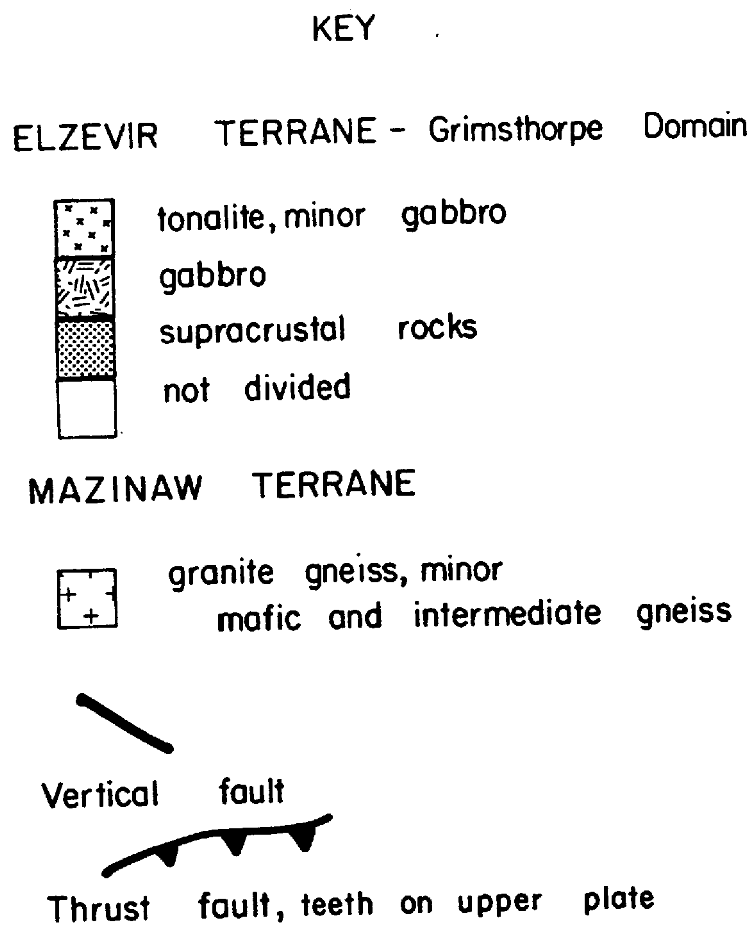
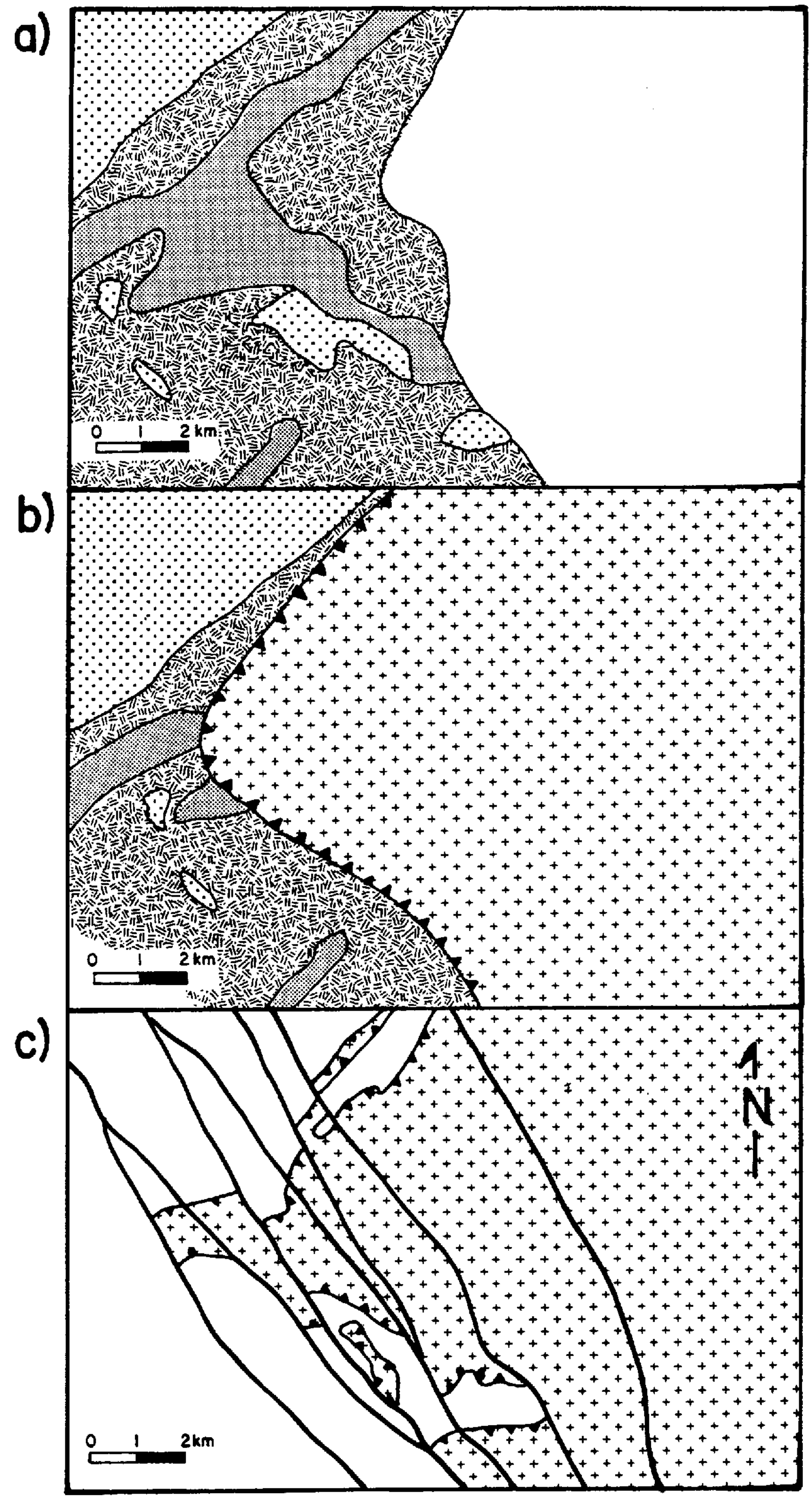


Figure 7: Sketch illustrating geologic events within the area of Bon Echo Provincial Park.
A) Pre-faulting map showing distribution of major units and contacts within the Grimsthorpe domain (Elzevir Terrane). This may approximate the area at depth prior to 1250 Ma.
B) Map showing the area following thrust faulting which transported the Mazinaw Terrane into place. This may approximate the area at circa 800 Ma.
C) Present-day geology of the area, simplified from the map, back pocket, after Paleozoic faulting and glaciation. Only the distribution of Mazinaw Terrane rocks is highlighted in order to illustrate the complicated nature of the Elzevir-Mazinaw terrane boundary in the area.




a)
0 1 2 km
b)
0 1 2 km
c)
N
0 1 2 km

Also present, particularly in the southern band, are massive, fine- to medium-grained, dark green, ophitic-textured amphibolite (unit 1d) that may represent thick flows or gabbroic sills. In small outcrops, or in dense forest, it is commonly difficult to distinguish between unit 1a, 1d, and fine-grained phases of unit 5 gabbros. Also within the belt in the southwest corner of the park, massive, fine-grained, dark green to black weathering, feldspar porphyritic amphibolite (unit 1p) is present, intercalated with unit 1a, leading credence to the suggestion that these amphibolites indeed represent metaflows.

No pillowed flows were observed, although Easton (1992a) has noted that many Grenville tholeiitic sequences are characterized by extremely thin selvedges (darker rims to the pillows, commonly recessive weathering) with little hyaloclastite (fine volcanic fragments) between the selvedges. The thin selvedges make it difficult to recognize the presence of pillows in all but the cleanest outcrop exposures, and consequently, it is probable that pillowed flows do occur locally within the park.

The geochemistry of the mafic metavolcanic rocks is discussed in Easton and Ford (1994). Briefly, the metabasalts are chemically similar to tholeiitic volcanic rocks in ocean basins in major and trace element abundances. Ayer (1979) analyzed one sample of unit 1 north of Joeperry Lake (*see* Appendix A), which was included in the dataset studied by Easton and Ford (1994).

Alteration of the basalts occurs adjacent to the northwest-trending faults in the area. Fluids migrating along the Joeperry Lake fault have changed the typical lower amphibolite facies metamorphic mineralogy of the mafic volcanic rocks to a lower temperature metamorphic mineral assemblage along the fault. These lower grade rocks are dominated by chlorite, indicating recrystalization at lower greenschist facies conditions. Such an alteration process is called retrograde metamorphism. Similar alteration is noted in Killer Creek-type gabbroic rocks along the eastern branch of the Joeperry fault. Ayer (1979) reports another style of retrograde metamorphism, namely the widespread development of pea-green epidote in metabasalts along the western branch of the Joeperry fault, and field party personnel have noted epidotization along the Mazinaw fault south of the park.

Easton and Ford (1993) noted two ages of mafic metabasalts in the Grimsthorpe area, an older sequence of massive flows within the Canniff Complex, and a younger sequence of flows within the Grimsthorpe Group, although it was not always possible to distinguish the two sequences readily in the field. The mafic metavolcanic rocks within both belts in the park cannot be clearly assigned to either stratigraphic package with certainty, although the presence of Grimsthorpe Group volcanic conglomerates west of the northern belt, and the association of the lavas with unit 5 gabbros, suggests that the mafic metavolcanic rocks in the park should be assigned to the Grimsthorpe Group.

GRENVILLE SUPERGROUP
METASEDIMENTARY ROCKS
GRIMSTHORPE GROUP (units 3-4)
Introduction

Most supracrustal rocks in the Grimsthorpe Domain consist of mafic metasedimentary rocks derived mainly from erosion of volcanic rocks (*i.e.* volcaniclastic metasediments), rusty-weathering schists, with subordinate, interbedded mafic, commonly pillowed, flows, and minor siliciclastic metasedimentary rocks. These metasedimentary and metavolcanic rocks are termed the Grimsthorpe Group (Easton 1992a, Easton and Ford 1994). The Grimsthorpe Group is in probable unconformable contact with the Canniff Complex (unit 2, not present in the park) and is roughly correlative with the Tudor Formation, Basal Group, Grenville Supergroup (Easton 1992a). Important characteristics of the Grimsthorpe Group are its dominantly mafic (basaltic) composition and the lack of carbonate metasedimentary rocks which are typical of the Grenville Supergroup outside of the Grimsthorpe domain.

Clastic Metasedimentary Rocks of Dominantly Volcanic Provenance (unit 3)

Clastic metasedimentary rocks derived mainly from erosion of a volcanic source region (unit 3) are well exposed in a belt along the shores of Pearson Lake and due west of Joeperry Lake. In the Grimsthorpe area, a crude stratigraphic sequence appears to be present, forming a uniformly southwest-younging, or, homoclinal, succession. This succession consists of, from stratigraphically lowest to highest, gabbro-clast conglomerates with a tuff matrix, which grade upward into conglomerates consisting of basaltic volcanic detritus. These conglomerates are locally intercalated with a few rare pillowed flows, in turn, overlain by basaltic composition tuffaceous sandstones and pebble conglomerates, overlain by basaltic composition mudstones with some tuffaceous conglomerate and volcaniclastic sandstone lenses, which then grade into more aluminous siltstones and mudstones, and metawackes and metarenites. Graded bedding in the tuffaceous sandstones and the conglomerates provided top indications throughout the sequence. Rusty schists are metamorphosed mud-rich sediments containing abundant (1%-15%) pyrite and other minor sulphide minerals. They are typically associated with deeper-water, oxygen-poor depositional environments. Rusty schists with associated gossan zones are common in all of the above rock types, but primarily in the tuffaceous mudstones and conglomerates. In addition, there seems to be a fining of the sedimentary sequence with distance from the tonalite plutons in the Grimsthorpe area.

Metasedimentary rocks within the park consist of the central part of this homoclinal succession, mainly volcanic derived sandstones and tuffaceous mudstones. Some of the volcanic derived sandstones (unit 3b) grade into slightly more aluminous metawackes (unit 4b); however typical aluminous metasediments are rare within the park. Volcanic metaconglomerates do not occur within the park, but are found within 1 km of the west-central and southwest boundaries of the park.

Sand-sized tuffaceous metasediments consist of volcanic wackes and tuffaceous sandstones (unit 3d) and black, green and dark grey weathering, biotite-hornblende-quartz-plagioclase gneiss (unit 3b) probably representing mafic tuffaceous arenites and wackes. These units are medium-bedded, show graded bedding, and were probably deposited as turbidites. Turbidites are a compositional heterogeneous sandstone contain textural features indicating deposition from a water-sediment suspension. Turbidites typically have a sandy base and a fine-grained sand or muddy top. Turbidites form in environments where there is an unstable slope; collapse of the slope generates water-sediment suspensions (turbidity currents) which flow downslope and deposit sediment as they slow at the base of the slope. Euhedral magnetite porphyroblasts occur locally within unit 3b along Pearson Lake. Tuffaceous mudstones and tuffs are present locally, consisting of dark green to green weathering, thinly bedded, hornblende-plagioclase schists (unit 3c).

MAFIC INTRUSIVE ROCKS (unit 5)
Gabbroic to Dioritic Plutons and Dikes

Unit 5 consists of gabbroic sills, plutons and stocks as well as basaltic and gabbroic dikes intrusive into both the Grimsthorpe Group and the Canniff Complex. Unit 5 also comprises gabbroic and dioritic dikes that cross-cut Elzevir Suite tonalites in the area, but which have been metamorphosed. A variety of ages of dikes are present in the park and the Grimsthorpe map area, based on cross-cutting relationships, lithology, and degree of preservation. Larger gabbroic masses intrude rocks of the Grimsthorpe Group and may be subvolcanic intrusions. Dikes cutting the tonalite plutons in the area are among the youngest rocks in the area, however, in the field it proved difficult to assign relative ages to the dikes, or to even recognize distinctive dike swarms in all but a few instances. As a consequence, unit 5 consists of a variety of rock units of different ages and petrogenesis, but of similar bulk composition.

Large, fine-to medium-grained, gabbroic masses intrude the Grimsthorpe Group, for example, north of Skootamatta Lake and 1-2 km west of the western boundary of the map area in Effingham Township (Figure 2; map, back pocket). The latter body is well exposed on the hydro-transmission corridor in that area. These large gabbro masses continue into the southwestern and northwestern parts of the park. The large gabbro mass in the southwest corner of the park is probably also of this suite. Contacts between the gabbros and the older supracrustal rocks are sharp, with dikes common in the vicinity of the contact. Locally, intrusion breccias are present near the contacts.

Unit 5 gabbro bodies are overall finer grained, and generally more melanocratic (darker coloured), than either the Canniff Complex (unit 2) gabbros within the Grimsthorpe area, or the Killer Creek-type metagabbros northeast of Joeperry Lake. North of Skootamatta Lake, in the Rainy Lake area west of the park, intrusion breccias occur in the cores of unit 5 gabbros, with veinlets of anorthositic gabbro to tonalite forming the matrix to the brecciated gabbro fragments (unit 5x) (Photo 1a, 1b). These intrusion breccias appear to be the result of migrating interstitial fluids that formed during the differentiation of the gabbro bodies, as little movement between gabbro blocks has occurred, the thin nature of crosscutting veinlets, and the absence of larger accumulations of the interstitial liquid. In fact, Wiebe (1993) describes similar textures with silicious material invading cumulate gabbros (Figure 8). In contrast, intrusion breccias associated with emplacement of the Elzevir Suite tonalites have angular fragments, show a mixing of fragment types, and in general, matrix is equal to, or more abundant than, the gabbroic blocks. Minor phases, found only in the largest gabbroic bodies, are anorthosite and anorthositic gabbro (unit 5c), coarse-grained gabbro (unit 5d), and feldspar porphyritic fine- or medium-grained gabbros (unit 5f, 5g).

Unit 5 dikes consist dominantly of fine- to medium-grained gabbro (unit 5a), feldspar porphyritic gabbro (unit 5f), and fine-grained gabbro to basalt (unit 5e). Dikes range from a few centimetres to 10 metres in width, most are 30 to 100 cm wide. Many small dikes (< 1 m across) are not distinguished on the map face because of scale. Most dikes are vertical to sub-vertical, and have sharp contacts with country rocks. A variety of trends are present, however, 060° is the dominant dike trend in the area, regardless of dike composition and texture. This may reflect the regional stress-field at the time of dike emplacement, and may suggests that many of the dikes were emplaced in a short time-interval. The dike trend does not parallel regional structural trends, and it is unlikely that it reflects any pre-existing structure.

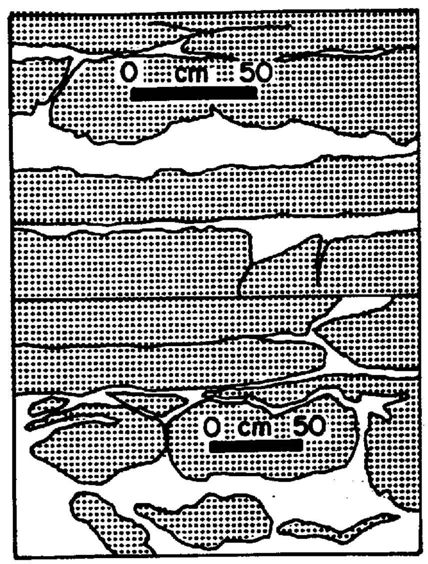


Figure 8: Sketch from Wiebe (1993) showing textures produced by silicious material (light) infiltrating gabbroic rocks (patterned). Compare with textures shown in Photo 1.

FELSITES AND MYLONITES (unit 6)

Felsic to Intermediate Gneisses

Mylonites are fine-grained rocks derived from crushing and recrystallization of exiting units by faulting processes. Felsite is a generic term for any fine-grained, quartzofeldspathic rock of uncertain parentage (protolith). Felsites may represent felsic metavolcanic rocks, volcanic-derived metasediments, or mylonitic metavolcanic, metasedimentary or fine-grained metaplutonic rocks. These terms have been used in the map area for rocks whose parentage can not be unequivocally determined, primarily due to the effects of metamorphism and deformation. Within the map area, unit 6 consists of recrystallized mylonitic rocks that represent the westward extension of two extensive shear zones documented by Easton and Ford (1991a) in the adjacent Mazinaw area. Unit 6 rocks occur mainly near Pringle Lake, immediately adjacent to the south-central corner of the map area, in the roadcut just south of the main entrance to Bon Echo Provincial Park, and along the shores of Bon Echo Lake. Easton and Ford (in prep.) provide a more exhaustive description of these rocks.

Rivers (1976) interpreted these rocks as mylonites because the layering in the rocks is much finer (<2 mm) in scale than typically observed in metamorphosed sedimentary or volcanic rocks in the area, the grain size of calcite in calc-silicate and marble units varied by an order of magnitude between layers (0.2-200 mm) and the rock types displaying the layering varied in character along strike. These observations are similar to those of Easton and Ford (1991, in prep.). Further, quartzofeldspathic gneiss containing coarser porphyroclasts of plagioclase is present, indicating that grain size reduction did occur in the mylonites. These gneisses also contain intercalated garnet and magnetite porphyroblasts bearing units (unit 6h), with the porphyroblasts probably developing during the second regional metamorphic event affecting the Mazinaw Terrane (but which had little or no effect in the Grimsthorpe domain). Rivers (1976) suggested that the protoliths were either fine-grained when mylonitization occurred, or mylonitization was very intense. Both suggestions probably apply.

Three main rock types are present within the shear zones. (1) Finely-laminated, pink, buff, or grey weathering, quartzofeldspathic gneisses ("felsites"), locally containing garnet, plagioclase or magnetite porphyroclasts (unit 6a). (2) Finely-laminated, green to dark green biotite-hornblende-plagioclase mafic gneisses (unit 6b). The mafic gneisses are commonly intercalated on a 5 to 30 m scale with the quartzofeldspathic gneisses. (3) Foliated, grey weathering, hornblende-biotite-plagioclase gneisses which contain randomly oriented garnet+/-magnetite+/-hornblende porphyroblasts (unit 6h). These gneisses are sugary-textured, and resemble metawackes, although they shown no obvious bedding, and form thick, homogeneous units. They may represent a mylonitized dioritic protolith, or a mylonitized sequence of compositionally homogeneous volcanic-derived metawackes. In addition to these units, protomylonites derived from granitic, gabbroic and supracrustal rocks (marbles, metawackes) are found locally within the shear zones.

In the Pringle Lake area due south of the park, and along highway 41, 1.5 km south of the southern park boundary, is a unit of distinctive, grey to dark grey, massive, biotite-hornblende-quartz-plagioclase gneiss, commonly containing euhedral magnetite, and locally garnet, porphyroblasts (unit 6h, Photo 2). No primary textures are preserved in this unit, and it is unclear if the unit is bedded. If bedded, bedding is on the scale of 3-10 m. This unit probably represents a metawacke, subsequently sheared and recrystallized, and based on its homogeneous nature and map distribution, it was likely of volcanic provenance.

Unit 6h has a colour index of 15-25, and a mineralogy dominated by albite, quartz, microcline, biotite and hornblende. Accessory minerals include magnetite, titanite, carbonate, and apatite. Ayer (1979) reports rare garnet and fluorite in this unit. Average matrix grain size is 0.4 mm.

Although unit 3b (volcanic-derived metasandstones) locally contains magnetite, it is much more common in unit 6h. Unit 6h is common throughout the Mazinaw area to the east. There is some uncertainty as to whether unit 6h might be correlative with unit 3b, particularly near Pearson Lake. It is probable that the rocks near Pearson and Joeperry lake represent typical Grimsthorpe Group metasediments, preserved between pluton margins because of their slightly siliceous character. In contrast, unit 6h may represent a different, possibly younger, now extensively sheared and recrystallized metasedimentary or metavolcanic package belonging to the Mazinaw Terrane.

A chemical analyses of unit 6h from along highway 41 collected by field party personnel, as well as samples collected by Ayer (1979), are listed in Appendix A. Figure 9 is a chondrite-normalized rare earth element (REE) plot comparing unit 6h with a Mazinaw Group turbidite and typical Grimsthorpe Group volcanic wackes. Unit 6h is distinctly different, having higher total REE abundances, particularly the heavy REE, and notably high Y and Zr contents, suggesting the presence of a detrital zircon and monazite component, or a significant primary spinel content, now represented as magnetite. The small Eu anomaly and high heavy REE's suggest abundant zircon or hornblende in the original sample prior to metamorphism. The REE pattern reflects a mafic source region, as do the high Fe, Ti, Na and P contents relative to volcanic-derived turbidites of the Mazinaw Group.

Ayer (1979), who mapped the Pringle Lake area and the southern part of Bon Echo Provincial Park, interpreted many of the fine-grained rocks of unit 6 as metavolcanics of andesitic and dacitic composition. Primary textures indicative of a volcanic origin are absent in these rocks. It should be noted that when Ayer (1979) conducted his mapping, ductile mylonite zones had been little studied, and were poorly documented from the Grenville Province. Hence, interpretation of these fine-grained rocks as metavolcanic rocks was reasonable at that time.

Geochemistry sheds some light on the origin of samples within unit 6. This subject is only briefly discussed herein, a more exhaustive review can be found in Easton and Ford (in prep.) In some instances, geochemical data, particularly rare earth element (REE) data, shows a similarity between the composition of some felsites (unit 6a) and the Abinger Granite, suggesting that some felsites may represent mylonitized granite (Figure 10). Major element data is more ambiguous, (Figure 11a, 11b, 12), although a clear distinction can be made between mafic and intermediate composition gneisses of unit 6 and more felsic end-members (unit 6a), and there is considerable overlap of the albite granite, granite, and felsite fields (Figure 11a, 12). Felsites of unit 6a have slightly higher Fe contents than Abinger Granite samples (Figure 11b), an observation also made by Ayer (1979), however, the margins of the Abinger Granite generally include considerable mafic country rock and consequently, any sheared rocks derived from the margin of the body might be expected to have slightly higher Fe contents than samples from the core of the body.

As illustrated in Figures 11b and 12, the mafic and intermediate gneisses overlap fields defined for other rock units within the Grimsthorpe and Mazinaw map areas (Easton and Ford 1994, in prep.), and thus, they could simply represent sheared equivalents of other rock units in the area. Unfortunately, the geochemical data are equivocal, and an alternative interpretation of these plots is that they represent a unique volcanic succession not previously described from either the Grimsthorpe or Mazinaw map areas. It is apparent from Figures 11 and 12 that there is a compositional gap between the more mafic and felsic end-members of unit 6. This could indicate that the mafic and felsic mylonites were derived from distinct end-members (*e.g.*, Killer Creek Gabbro Suite *vs*. Abinger Granite), however, as tholeiitic volcanic successions within the Grenville Province are bimodal (*see* Easton 1992a), this gap is also consistent with Ayer's (1979) interpretation of these rocks as volcanic in origin.

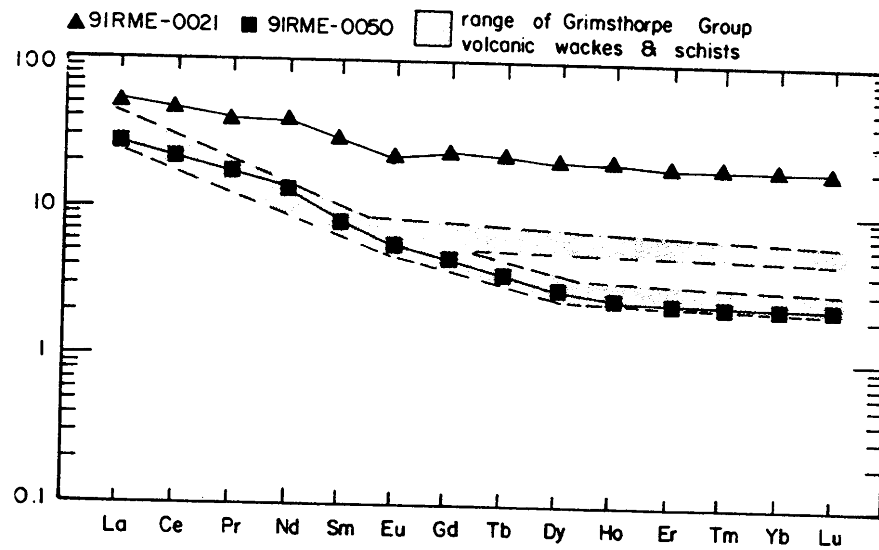
In most cases, however, samples from unit 6 show unique chemical signatures, as illustrated in Figures 9 and 10. Figure 10 also shows a second felsite sample (unit 6a) that is characterized by low total REE abundance, suggestive of introduction of a material such as quartz into the rock which would reduce total REE contents. As previously noted, Figure 9 shows the REE signature of a metawacke of unit 6h, which has moderate heavy REE values, in sharp contrast to both Grimsthorpe Group and Mazinaw Group metawackes. The patterns of unit 6 samples shown in Figures 9 and 10 show REE signatures that are not characteristic of metavolcanic or metasedimentary rocks of either the Canniff Complex, the Grimsthorpe Group or the Mazinaw Group (*see* Easton and Ford 1994, Condie and Moore 1977) for comparative data). This suggests either a unique source for these rocks, or elemental mobility during subsequent metamorphism and deformation.

In summary, although some of the unit 6 rocks present in the Pringle Lake and park areas may at one time have been intermediate to felsic volcanics or volcaniclastic sediments, intense mylonitization in this area has destroyed primary textures, and original geochemical signatures, in these rocks, making protolith identification problematical.

KILLER CREEK AND JOEPERRY LAKE GABBROS (unit 7)

The Killer Creek Gabbro (Easton and Ford 1990, 1993) within the Grimsthorpe domain is a multi-phase intrusion ranging in composition from hornblendite (mainly hornblende rock) to anorthosite (mainly plagioclase rock), that is intruded by the *ca.* 1267 Ma Elzevir Tonalite (L.M. Heaman, geochronologist, Royal Ontario Museum, personal communication, 1990). The term Killer Creek Suite is used in this report to refer to bodies of similar composition and age present elsewhere in the map area that are geographically separate from the main Killer Creek Gabbro.

Figure 9: Chondrite-normalized rare-earth element plot showing unique geochemistry of unit 6h magnetite-porphyroblastic metawackes (sample 91RME-0021) compared to a Mazinaw Group turbidite (91RME-0050) and Grimsthorpe Group volcanic wackes and schists.



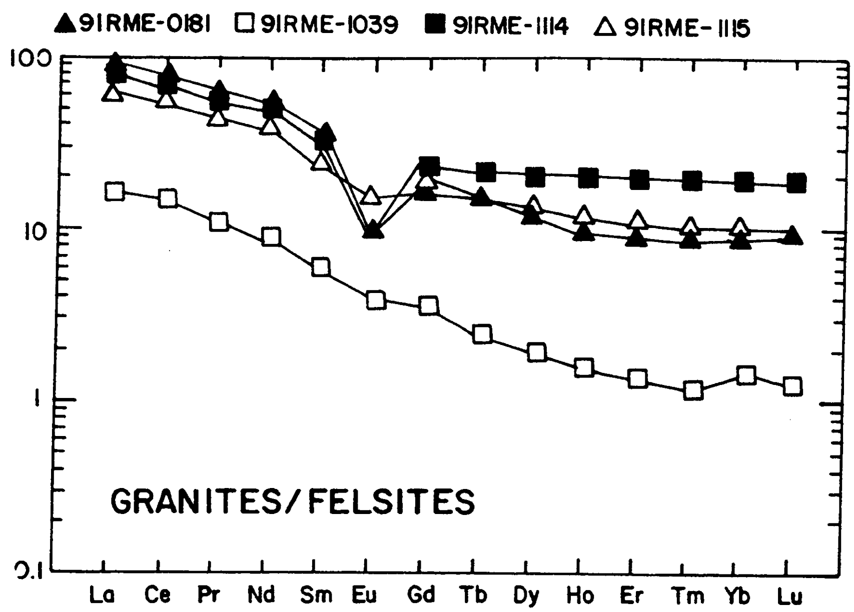
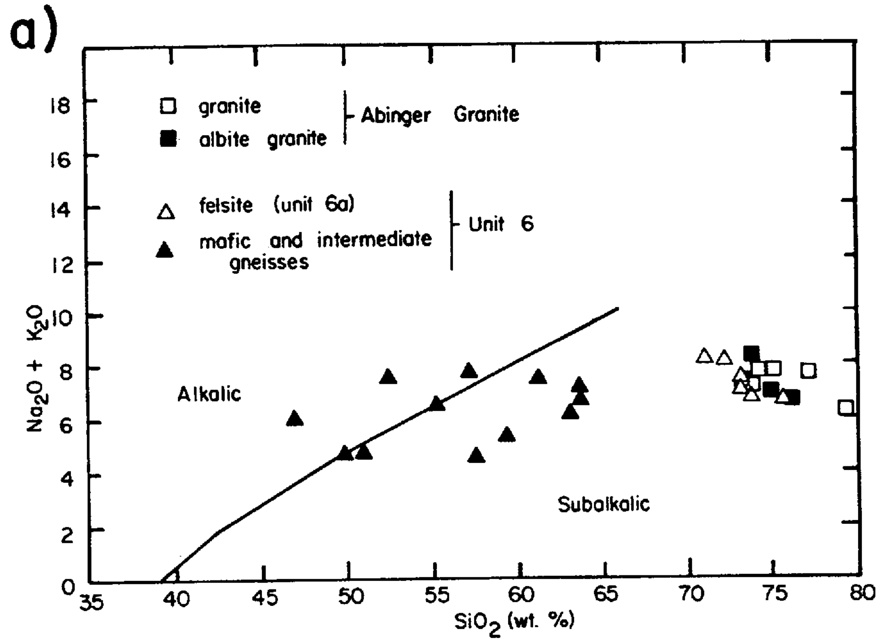


Figure 10: Chondrite-normalized rare-earth element plot showing similarity in geochemical signature between some felsites (unit 6a, 91RME-1114) located adjacent to the Abinger Granite, the Abinger Granite (sample 91RME-1115) and the Norway Lake Granite (sample 91RME-0181). Sample 91RME-1039 is also a felsite (unit 6a), however, it is distal to granite bodies in the area. It shows low total rare-earth abundances, possibly due to addition of quartz (silicification), and a pattern not typical of felsic volcanic rocks in the area (cf. Condie and Moore 1977).

Figure 11: Geochemical variation within unit 6 rocks in Bon Echo Provincial Park and the Mazinaw area.
A) Alkali versus silica plot (Irvine and Baragar 1971) showing geochemical variation in unit 6 gneisses and the Abinger Granite.
B) FeO + MgO versus FeO/MgO plot showing geochemical variation in unit 6 gneisses and the Abinger Granite. Symbols as in Figure 11a. Note distinct chemistry of albite granites and slightly higher Fe content of felsites versus Abinger Granite samples. Fields of other major rock units are shown for comparison.



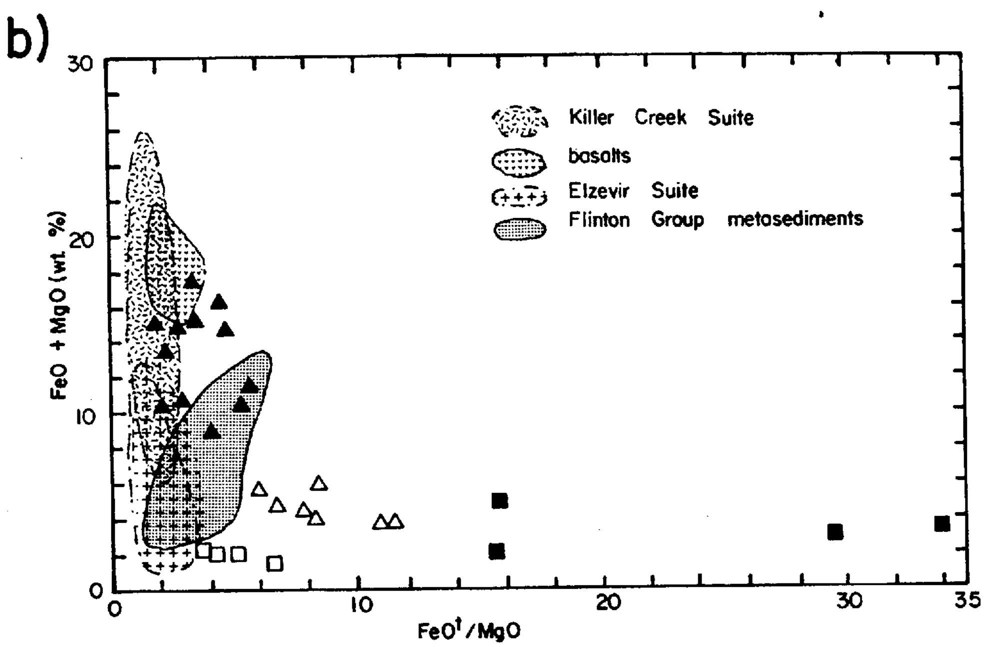
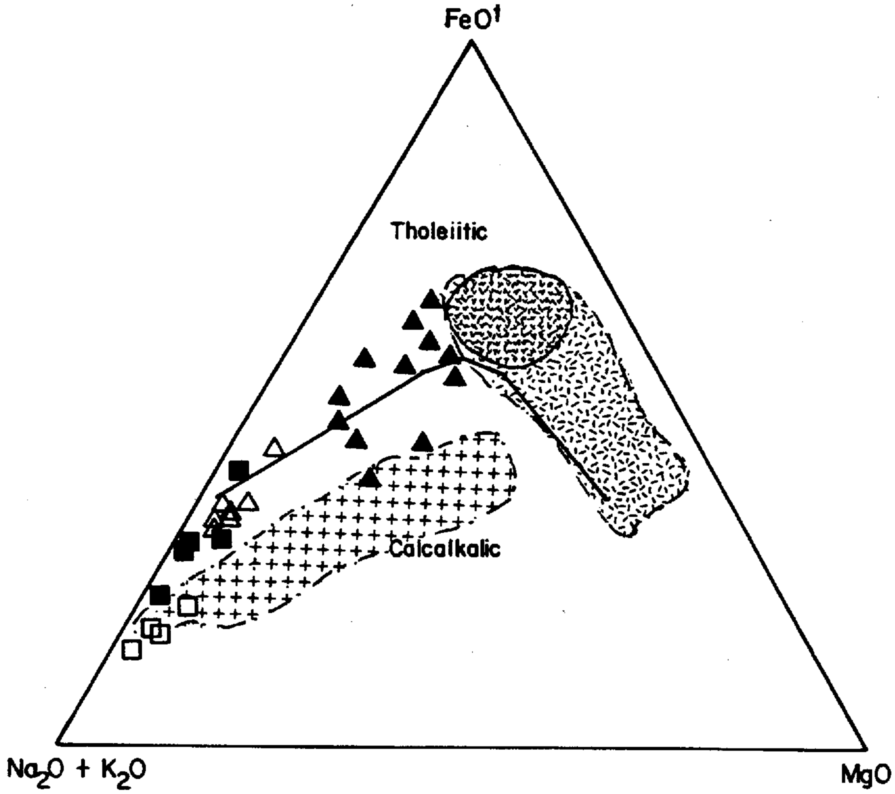


Figure 12: AFM diagram (Irvine and Baragar 1971) for unit 6 gneisses and Abinger Granite samples from Bon Echo Provincial Park and the Mazinaw area. Symbols and fields as in Figure 11.



Rocks of the Killer Creek Gabbro Suite occur in three main areas of the park, northeast of Joeperry Lake, along the Skootamatta River south of Pearson Lake (mainly hornblendite pods), and along highway 41 near the north boundary of the park. The gabbro mass northeast of Joeperry Lake is henceforth referred to as the Joeperry Gabbro. Contact relations with country rocks are sharp, and few xenoliths of country rock are incorporated into gabbros of the Killer Creek Gabbro Suite.

The most abundant rock type within the park, including the Joeperry Gabbro, consists of medium-grained, hornblende gabbro with a colour index of 35-40 (unit 7a, Photo 3a). Other varieties of gabbro common in the Joeperry Gabbro and south of Pearson Lake include medium-grained melanocratic gabbro (colour index 40-60, unit 7b), generally found in association with hornblendite pods (unit 7h). Several pod-like masses of hornblendite (unit 7h), commonly magnetite-bearing, that are several hundred metres in diameter, occur south of Pearson Lake and within the Joeperry Gabbro. Anorthositic gabbro (unit 7c), abundant in the Grimsthorpe area, is uncommon within the park. The gabbros are commonly cut by fine- to medium-grained gabbro dikes (unit 7f, Photo 2b) which appear to late-stage phases of the Killer Creek Gabbro Suite.

Mineral enrichments in rocks of the Killer Creek Gabbro Suite include magnetite or chromite, or both, and are concentrated in the hornblendite and melanocratic gabbro phases. High Ti contents of the Killer Creek-type gabbros also suggests the presence of ilmenite. All of these minerals belong to the spinel group, and their close association suggests that they most likely crystallized from the original gabbroic magma. Regional aeromagnetic surveys, summarized in Easton and Ford 1994), indicate slight magnetic highs associated with the Killer Creek Gabbro Suite. These surveys have a line spacing much greater than the extent of most magnetite-rich hornblendite pods, and thus most of these magnetite-rich zones do not have a distinctive aeromagnetic expression on the regional surveys (*e.g.*, GSC 1952).

The most significant magnetic anomaly associated with these gabbros is located over the Joeperry Gabbro, within Bon Echo Provincial Park, where a significant aeromagnetic high (GSC 1952) is underlain by a body of melanocratic metagabbro containing abundant hornblendite pods. Assay sample 91RME-060 (Table 3) is from one of these pods and, shows elevated concentrations of Cr and V. The Joeperry Gabbro has a fine-grained phase of chlorite-hornblende-magnetite (unit 7k) around its northern margin, and along the west branch of the Joeperry fault, which may be the product of metamorphic reaction related to fluid interaction with surrounding rocks during M_2 or subsequent fluid movement along the Joeperry fault, or both. This magnetite-rich rim may be largely responsible for the intense aeromagnetic signature of this body which is atypical of the suite elsewhere in the Grimsthorpe domain or the Mazinaw Terrane. In addition to the magnetite-hornblende-chlorite schist, magnetite-talc-actinolite-chlorite schist is also developed within the Joeperry Gabbro adjacent to the Joeperry fault.

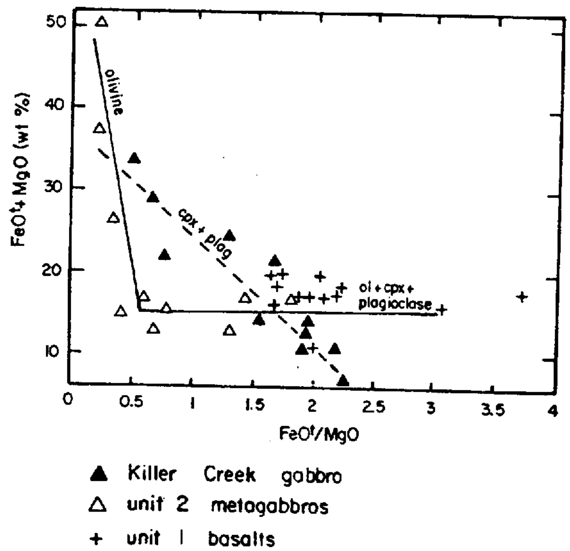
Geochemistry

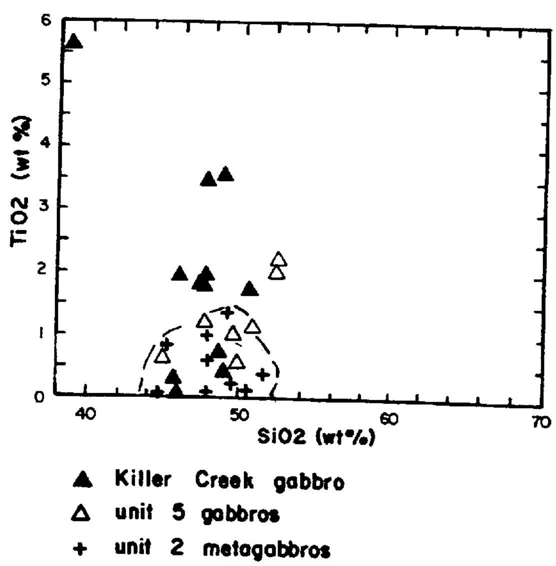
The chemical variation within the Killer Creek Gabbro Suite has been discussed by Easton and Ford (1993), who compare it with the Canniff Complex and unit 5 gabbros. Figure 13 summarizes this comparison. The Killer Creek Gabbro shows two differentiation trends (Figure 13a) and has higher TiO_2 and P_2O_5 values than Canniff Complex metagabbros (Figure 13b). This may indicate derivation of the Killer Creek Gabbro within a calcalkalic tectonic setting, possibly an arc, and is consistent with subsequent intrusion by the arc-derived tonalite magmas of the Elzevir Suite. In contrast, the unit 5 metagabbros probably formed in an extensional, possibly oceanic or back-arc, environment (Easton and Ford 1994).

ELZEVIR TONALITE SUITE (unit 8)

Tonalitic to granodioritic rocks of the Elzevir Tonalite occur throughout the Grimsthorpe domain, forming larger, homogeneous plutonic masses, include the Elzevir, Canniff and Weslemkoon tonalites. The tonalite has a colour index of 5 to 15, and is fine- to medium-grained, light grey, and moderately foliated. It typically preserves a hypidomorphic-granular texture, and gives the appearance of being better preserved than the finer-grained Abinger Granite (unit A) that intrudes it. Locally, trondhjemite (*sensu stricto*) is present. Ayer (1979) reports several tonalite analyses from intrusion breccia zones within the Abinger Granite (Appendix A), both within and outside the confines of the park.

Figure 13: Geochemical variation within the Killer Creek Suite.
A) FeO + MgO versus FeO/MgO plot of metagabbroic rocks from the Canniff Complex (unit 2), the Killer Creek Gabbro (unit 7), and mafic metavolcanic rocks (unit 1). Mafic metavolcanic rocks show plagioclase-dominated fractionation trends, as would be expected from oceanic basalts. The Killer Creek Gabbro shows a distinct fractionation trend, dominated by a combination of clinopyroxene and plagioclase fractionation during its evolution.
B) TiO_2 versus SiO_2 plot for metagabbroic rocks from the Grimsthorpe area. Note clustering of unit 2 metagabbros and generally higher Ti contents of Killer Creek and unit 5 gabbros.





The intrusion breccias consist of a metatonalite "matrix" and amphibolite, paraamphibolite, or Killer Creek-type metagabbro "clasts" (Photos 4a, 4b). These older inclusions do not form any coherent masses, but occur as lenses, belts, and layers within, and along the margins of, the younger Abinger Granite that underlies most of the eastern part of the park. Only the larger of these older intrusive breccia zones are indicated in Figure 3, however, these zones are relatively continuous and some can be traced for several kilometres along strike. The intrusion breccias locally shown evidence of folding and shearing (Photo 4d) which is not always reflected in cross-cutting granitic dikes. Intrusion breccias are particularly well developed where the tonalite intrudes melanocratic gabbro (unit 7b) and hornblendite (unit 7h) of the Killer Creek Gabbro Suite. This may reflect difficulty in assimilation of these mafic to ultramafic rocks by the tonalite masses, or may indicate that the tonalite was emplaced by stopping.

The chemistry of these tonalites is not significantly different from the chemistry of Elzevir Suite plutons found within the Grimsthorpe domain (*cf.*, Pride and Moore 1983, Lumbers *et al.* 1990, Easton and Ford 1994). Gravity modelling suggests the plutons extend to a depth of 3-5 km (Real and Thomas 1987). The Weslemkoon tonalite lies immediately adjacent to the northwest boundary of the park, and may underlie the western part of the park at depth in the Rainy Lake-Killer Lake-Joeperry Lake area. Within the park, tonalite of unit 8 occurs primarily in the form of intrusion breccias, as illustrated in Photos 4a-d.

ABINGER GRANITE (unit A)

The most abundant metaplutonic rocks in the eastern half of the park are the fine- to medium-grained, heterogeneous granites of the Abinger Granite (Figure 3). Late, post-foliation muscovite porphyroblasts are prevalent throughout these granite rocks, and are probably a product of the late stages of M_2 metamorphism, and are not likely a product of igneous crystallization.

The bulk of the Abinger Granite within the park consists of uniform, pink, fine-grained gneissic granite. The granite has a colour index of 10 or less, and is composed of plagioclase (albite or oligoclase), quartz and microcline. Common accessory minerals are biotite, magnetite, titanite, epidote, zircon and apatite. As noted, late, fabric-cutting muscovite porphyroblasts are common within the granite. Locally hypidomorphic-granular texture is preserved in the granite where it is medium-grained and weakly foliated..

The Abinger Granite, or Abinger gneiss, (Hewitt 1964, Rivers 1976) is also commonly referred to as the Mazinaw Lake granite. The original term Abinger Granite is preferred here because the granite underlies large tracts of Abinger township east of the park, and the term better reflects the distribution of this plutonic body. The Abinger Granite intrudes the older tonalitic and gabbroic rocks in the map area, as well as all supracrustal rocks older than the Flinton Group. This is consistent with the recently obtained U-Pb zircon age of *ca.* 1240 Ma obtained from the Abinger Granite east of the park (Corfu and Easton 1994), indicating that the body is some 25 to 30 Ma younger than the tonalites of unit 8.

Ayer (1979) reported late "albite trondhjemite" veins within the Abinger Granite. These veins consist of very fine-grained, light pinkish grey biotite-microcline-albite-quartz rocks. Chemistry on these rocks, reported by Ayer (1979) and reproduced in Figures 11 and 12, and in Appendix A, indicate high silica contents in these ``trondhjemites''. The high silica content suggests that they may be related to the albite granites that Lumbers *et al.* (1990) report from both Elzevir and Methuen suites plutons. The low K_2O contents reported by Ayer (1979), however, remain as an unexplained curiosity. The geochemical variation within the Abinger Granite is indicated in Figures 10, 11 and 12, and has been discussed under the section on *Felsites and Mylonites (unit 6)*.

The Abinger Granite was probably intruded as a series of closely spaced sills (Photo 5, 6). Evidence for the sill-like character of the Abinger Granite is best seen on the east shore of Mazinaw Lake, south of Old Walt Rock, where cliff-exposures provide cross-sections through the Abinger Granite (Photo 5, 6). This sill-like injection pattern explains the local heterogeneity present within the granite, as well as the presence of mappable screens of older country rock throughout the Abinger Granite east of the park (Photo 5). It is also consistent with the preservation of large areas of granodiorite and tonalitic intrusion breccias within the granites where older units are mixed with injections of the Abinger Granite. Gossans are locally developed along granite-country rock contacts and in granitic intrusion breccias where zones of sulphides occur.

Lumbers *et al.* (1990) correlate the Abinger Granite with the 1245 Ma (van Breemen and Davidson 1988) Addington Granite (alaskite suite of Lumbers *et al.* 1990). U-Pb geochronology by Corfu and Easton (1994) suggests this correlation is correct, with the Abinger Granite being emplaced at roughly 1235 to 1240 Ma. Bell and Blenkinsop (1980) reported a whole-rock Rb-Sr age of 1185+/-25 Ma from the Abinger Granite. This age could be a metamorphic age (M_1), or the result of partial resetting during the second metamorphic event.

DIKE ROCKS (unit 10)

A variety of metamorphosed dike rocks are present in the map area, cutting all rock units except metasedimentary rocks of the Flinton Group. These include metagabbro dikes (unit 5), metadiabase dikes (unit 10), and quartz feldspar porphyry dikes (unit 8f) and plagioclase-porphyritic mafic dikes.

Fine-grained, weakly metamorphosed, shallow-dipping to subvertical, east-northeasterly trending, diabase dikes of unit 10 crosscut the Abinger Granite throughout the park, but are particularly abundant in the section exposed along Old Walt Rock. These fine-grained, greenish weathering dikes exhibit chill margins and sharp contacts, and are generally slightly recessive weathering. In the field, they are greener and finer-grained than unit 5 gabbro dikes.

In thin section, these dikes consist of fine-grained aggregates of hornblende and plagioclase, weakly foliated, and preserving a poorly preserved ophitic texture. The relationship of these dikes to other dike swarms in the area (*e.g.*, the *ca.* 1160 Ma Kingston (Frontenac) dike swarm) is unknown.

CENOZOIC
QUATERNARY

Most Cenozoic sediments in the map area were deposited during the Pleistocene epoch, and consist of till, and glaciofluvial deposits located along major streams and rivers in the area. Henderson (1972) provides a brief summary of the surficial geology of the Kingston area, including Bon Echo Provincial Park. Overburden (till and soil) cover is moderate in thickness (1-2 m) over most of the map area, increasing slightly in thickness over the Abinger Granite. Till is thinnest in the northern part of the park, where mafic metavolcanic rocks (unit 1) and the Abinger Granite are particularly well exposed. Areas underlain by moderate to thick overburden cover are well-forested, and include most of the areas underlain by the Abinger Granite. Glaciofluvial deposits consist mainly of sand and gravel deposits located along Mazinaw Lake near Park Headquarters, and appear to be fan-delta deposits related to drainage of a once much larger Bon Echo Creek into a once much larger glacial lake occupying the Mazinaw Lake valley. Aggregate resources in the area are described in detail in MNR (1987a, 1987b). The only significant resource in the park is fan delta area located along Mazinaw Lake near Park Headquarters, which includes both coarse and fine granular B & C aggregate. As this reserve underlies much of the park's prime recreational areas, it is not available for extraction.

The glacial deposits are overlain by Recent deposits in the map area composed of organic swamp and alluvial deposits. Most swamps are located in lineaments which parallel major geologic contacts and fault zones. Alluvial deposits of Recent age are associated with the Skootamatta Creek drainage, and include minor stream sediments, and reworked glaciofluvial sands and gravels.

STRUCTURAL GEOLOGY

The structural history of Bon Echo Provincial Park is difficult to ascertain, because of the dominance of metaplutonic rocks within the park. Few regional fold structures have been identified, and most foliations dip to the east-southeast at between 45° and 75°, with dips generally being steeper in the northern reaches of the park. The lack of well layered supracrustal units within the park area has hampered structural analysis. Little control is available on the orientation at depth of plutonic contacts within the area, however, opposite trends of displacement of plutonic contacts across Paleozoic faults in the area suggest that some plutonic contacts are shallowly (0° to 30°) to moderately (30° to 60°) dipping, and that no consistent dip direction is present along these contacts. As noted during mapping of the Grimsthorpe area, most rocks within the Grimsthorpe domain are little strained, as evidenced by the preservation of fine igneous textures (*e.g.*, Photo 1), despite metamorphic recrystallization within units 5, 7 and 8.

In contrast, the Abinger Granite shows higher degrees of strain, and is in many places, gneissic, and lineated, particularly in the more mica-rich portions of the body. It is unclear if the fine-grained size of the Abinger Granite is an original igneous feature, or an artifact of metamorphic recrystallization. In either case, in hand specimen and thin section, igneous textures are much poorly preserved within the Abinger Granite than in Grimsthorpe domain rocks, or within Killer Creek Gabbro Suite gabbro or Elzevir Suite tonalite pods preserved within the Abinger Granite. Although these pods are much more deformed than the equivalent rocks within the Grimsthorpe domain, characteristic textures are still partially preserved, and are critical to mapping these units within the Mazinaw Terrane.

GEOCHRONOLOGY

Relative and absolute age constraints on units within the map area are summarized in Table 2. Few rocks within the Grimsthorpe domain of the Elzevir Terrane have been dated. U-Pb ages are the least susceptible to metamorphic and structural events, and therefore generally reflect the time of emplacement or extrusion. Rocks of the Elzevir and Weslemkoon Tonalites are dated using U-Pb zircon methods at *ca.* 1267 Ma (L. Heaman, geochronologist, Royal Ontario Museum, Toronto, personal communication 1989, Lumbers *et al.* 1990). Relative age relationships indicate that units 1 through 7 are older than the Elzevir Tonalite. Silver and Lumbers (1966) dated the Tudor Formation metavolcanics using zircons at 1286$\pm$15 Ma. The location of this sample is not described, so it is unclear if it dates rocks now assigned to the Canniff Complex or the Grimsthorpe Group. Regional stratigraphic correlations (Easton 1992a) suggests that the age on the Tudor Formation approximates the age of Grimsthorpe Group deposition. Fine-grained tonalite dikes adjacent to the Elzevir Tonalite, possibly equivalent to unit 8f, have been dated at 1229+11/-4 Ma (Connelly *et al.* 1987). Similar dikes occur in the Mazinaw Terrane, suggesting that the two terranes may have been contiguous at that time. Skootamatta Suite plutons elsewhere in Ontario and Quebec have been dated using U-Pb zircon methods at *ca.* 1085-1075 Ma (Easton 1992a), although none of the plutons within the Elzevir Terrane have been directly dated.

Ar-Ar ages are more susceptible to resetting during metamorphic and structural events, and thus provide ages on post-metamorphic events. Hanes *et al.* (1988) present Ar-Ar ages on muscovites and feldspars from the Elzevir Tonalite, the Skootamatta Syenite and the Killer Creek Gabbro. Muscovite ages from the Elzevir Tonalite cluster at around 900 Ma, and suggest that development of the late muscovite within the Abinger Granite and within some Elzevir Suite plutons may have occurred as early as 900 Ma. Hanes *et al.* (1988) also report Ar-Ar plagioclase feldspar ages of *ca.* 400 Ma, which they attributed to a hydrothermal alteration event related to Acadian-Caledonian events in the Appalachian orogen or activity on the Ottawa-Bonnechere graben. The presence of Paleozoic faults within the map area, along which alteration has occurred, suggests that low-temperature Paleozoic age events map be preserved within Bon Echo Provincial Park. Ar-Ar studies within the park may be useful in dating the development of the fault system within the park and related alteration events.

Corfu and Easton (1994) have recently dated over a dozen units within the Mazinaw area southeast and east of the park. Their preliminary data indicates an age of *circa* 1240 Ma for alaskitic granites (Methuen Suite) within the Mazinaw Terrane, and effectively bracket the peak of the M_2 metamorphic event at 1030 to 990 Ma, considerably younger than metamorphic ages reported from the Elzevir Terrane (*circa* 1070 Ma based on titanites in marbles, see Easton 1992a for summary).

GEOPHYSICS

Airborne Gamma-Ray Spectrometric Data

The abundance of mafic metavolcanics and metagabbroic rocks, as well as potassium-poor felsic plutonic rocks within the Grimsthorpe area gives the area a distinctive low signature on airborne gamma-ray spectrometric maps of the area (Ford *et al.* 1992). The scarcity of pegmatites in the area, the nature of the bedrock, and the lack of large anomalies on the airborne gamma-ray spectrometric maps suggest that the area has little uranium potential.

Aeromagnetic Data

As seen on the detailed 1:50 000 scale aeromagnetic map (GSC 1952), and the 1:1 000 000 scale aeromagnetic maps of southern Ontario (Gupta *et al.* 1991a, 1991b), the Grimsthorpe domain is characterized by relatively low magnetic relief, with generally smooth, wide-spaced magnetic contours, and represents a regional magnetic low. In contrast, the Mazinaw Terrane shows moderate to high magnetic relief, characterized by tight magnetic contours with considerable variability in scale and orientation.

Detailed plots of the park area where also made using the Ontario Single Master Aeromagnetic dataset of the Ontario Geological Survey. Plots made include both image and shadow presentations of the total magnetic grid and the vertical gradient of the total magnetic grid. These plots were not notably different from the published aeromagnetic map (GSC 1952), although the vertical gradient plot does highlight some of the more subtle magnetic features within the map area, as illustrated in Figure 14.

As shown in Figures 14a and 14b, three magnetic highs occur within the park area: (i) an intense magnetic high over the Joeperry Gabbro; (ii) a linear, east-to northeast-trending magnetic anomaly that follows a band of unit 6 and 6h gneisses, and (iii) a magnetic high just south of the park associated with the Skootamatta Syenite. Figure 14b shows a linear, not a contoured plot, of the vertical gradient field, showing that the anomalies over the Joeperry Gabbro and Skootamatta Syenite are more intense than the anomaly associated with the zone of unit 6h gneisses.

The magnetic anomaly associated with the Joeperry Gabbro is noteworthy, as in the Grimsthorpe area to the south, no regional magnetic anomaly is associated with the Killer Creek Gabbro, even in areas dominated by hornblendite and melanocratic gabbro (Easton and Ford 1994). In fact, some previous workers (*cf.* Lumbers 1967, Easton 1990) suggested that the northeast shore of Joeperry Lake was underlain by Syenite, because of the similarity of the

Joeperry Lake anomaly to the magnetic signature of Skootamatta Suite Syenite plutons. The reason for this difference in magnetic signature between the Killer Creek and Joeperry gabbros may be related to the presence of the magnetite-chlorite schist (unit 7k) that occurs within the Joeperry Gabbro. It is unclear if this schist is the result of alteration along northwest-trending Paleozoic faults or to fluid interaction along the Mazinaw (Abinger Granite) - Elzevir Terrane boundary. In either case, interaction with fluids probably resulted in oxidation of iron previously found in mafic minerals to form magnetite grains and consequently a distinct magnetic anomaly.

Gravity Data

Real and Thomas (1987) conducted a detailed gravity survey over part of the Central Metasedimentary Belt, covering mostly the Grimsthorpe Domain and the Mazinaw Terrane. As illustrated in Figure 15, profiles 1 lies within the park, and profile 6 lies immediately south of the park. The two profiles a provide an indication of the regional crustal structure beneath the Grimsthorpe domain and the Mazinaw Terrane.

Two points should be noted. First, gravity modelling of plutons within the Grimsthorpe Domain indicate a depth extent of roughly 4-5 km. This suggests that the supracrustal sequence in the area may be thin, and that the tonalite plutons coalesce at depth. This is consistent with the aeromagnetic pattern over the domain. Second, crustal structure changes east of the Mooroton shear zone. Plutons in the Mazinaw Terrane are modelled as thin sheets of roughly 1 km thickness. This is consistent with the interpretation of the Mazinaw Terrane in the park area as a relatively thin, thrust sheet (Figures 6, 7).

FAULTS

North-northwest-trending faults are prevalent throughout the Mazinaw Terrane in the park area, but are most prevalent near the Elzevir-Mazinaw Terrane boundary (Figure 3). Both right and left-lateral displacement on the faults are present, and sizable offsets are present; 500 m along the left-lateral fault through Mazinaw Lake and 500 m along the right-lateral fault running along the east shore of Joeperry Lake (Figure 5). Although the existence of this fault set had been recognized previously (*e.g.*, Plevna Fault, Smith 1958, Pauk 1987), the abundance of faults of this trend in the area, and the scope of movement along them was previously unknown.

Easton (1993) has shown that faulting and fracturing of the crust associated with formation of the Ottawa Graben in eastern Ontario is more widespread than previously noted. In addition to previously known west-trending faults in the area (*e.g.*, Plevna, Clyde and Calabogie faults), northwest-trending faults are also prevalent, generally spaced about 4 km apart. The two fault sets divide the area into numerous independent fault blocks, across which major changes in geology and metamorphic grade can be documented. The northwest-trending faults show apparent dextral and sinistral offsets (*e.g.*, 500 m along the dextral Plevna fault and 500 m along the sinistral Mazinaw fault at Bon Echo). As sharp contrasts in metamorphic grade occur between adjacent fault blocks, it is likely that much of the apparent sinistral and dextral movement along these faults is actually due to vertical movement. Further, most of the west to east increase in metamorphic grade across the Mazinaw Terrane can be explained by vertical uplift along the faults of the northwest-trending set. Until recently, the age of the northwest-trending faults was not known, however, the recent discovery of a Grenville swarm diabase dike along a northwest-trending fault (Easton 1993) suggests that they are related to the Ottawa Graben. This is supported by the observation that the Plevna fault, which offsets Paleozoic strata in the east, rotates from a west to a northwest orientation along its trace.

As illustrated in Figure 14, east-trending faults may also occur within the park area, but their orientation and the lack of directly measured offset within the confines of the park make tracing of these faults difficult. Because of these uncertainties, these faults were not illustrated on the map (back pocket). As previously illustrated in Figures 6 and 7, the northwest-trending faults have had a significant influence on the geology of Bon Echo Provincial Park, and they contribute greatly to the unique character of this nature preserve.

Figure 16 illustrates the location of the park with respect to the main part of the Ottawa-Bonnechere graben system. The abundance of faults in the park, which is well distant from the graben system, indicates that the Precambrian Shield in eastern Ontario has been affected by post-Precambrian faulting to a much greater extent than previously documented.

At present, the faults are not known to have any economic significance, although the development of hematite, chlorite, and epidote is common in rocks located adjacent to these faults. In addition, talc and serpentinized actinolite is developed locally in the margin of the Joeperry Gabbro where it is cut by the west branch of the Joeperry fault (map, back pocket).

ELZEVIR-MAZINAW TERRANE BOUNDARY

Due south of the map area, the Elzevir-Mazinaw Terrane boundary (Mooroton shear zone) is a narrow shear zone, dipping about 75^{o} to the east, marked by the development of straight gneisses. In the park, however, the trace of the boundary is more difficult to ascertain, largely because north-northwest-trending faults run subparallel to the boundary (namely, the Joeperry fault), and in fact, may have reactivated it (Figure 2, 3).

As previously discussed, and illustrated in Figure 7, the Abinger Granite can be considered to approximate the Mazinaw Terrane within the park. The map form of the granite suggests that it represents a thin wedge, thickening to the east, that has been tectonically emplaced ontop of the Grimsthorpe domain supracrustal and gabbroic rocks. As illustrated in Figure 6 and 7, differential vertical movement along the northwest-trending faults in the area have modified the shape of this wedge, and assisted in its preservation within the park. Offset along east-trending faults in the region may also have been a factor in controlling the present-day geometry, but their affect is difficult to quantify at present.

Figure 14: Sketch showing vertical gradient of the total magnetic field over the map area. Area shown is slightly larger than that shown in Figure 3. Major rock units related to anomalies are identified. Figure (A) shows a smoothed field. Figure (B) shows linear data, and more clearly discriminates the signature of the Joeperry Gabbro from that of unit 6h. Sketch is simplified from a plot made from the Ontario Geological Survey Single Master Aeromagnetic dataset.

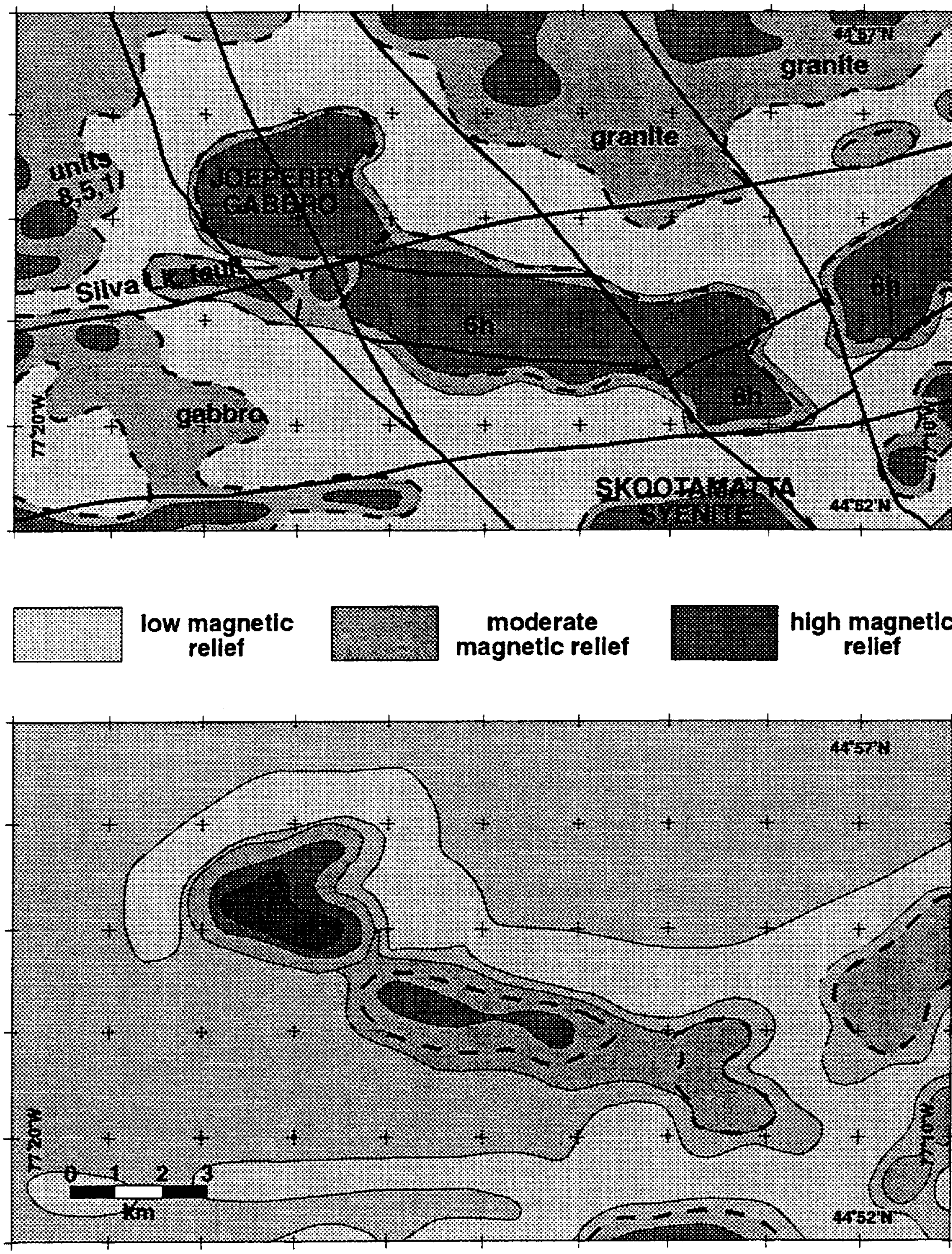


Figure 15: Gravity profile, surface geology, and gravity models for profile 6 across the Grimsthorpe domain. Model matches observed profile within +/- 1 mGal. Inset shows location of the profile with respect to the map area. Note greater depth extent of plutons in the Elzevir Terrane versus the Mazinaw Terrane, suggesting different tectonic juxtaposition of the two areas and indicating different structural histories between the two terranes. The northern boundary of Bon Echo Provincial Park would lie on Profile 1 where the profile crosses the Elzevir/Mazinaw boundary. After Real and Thomas (1987).

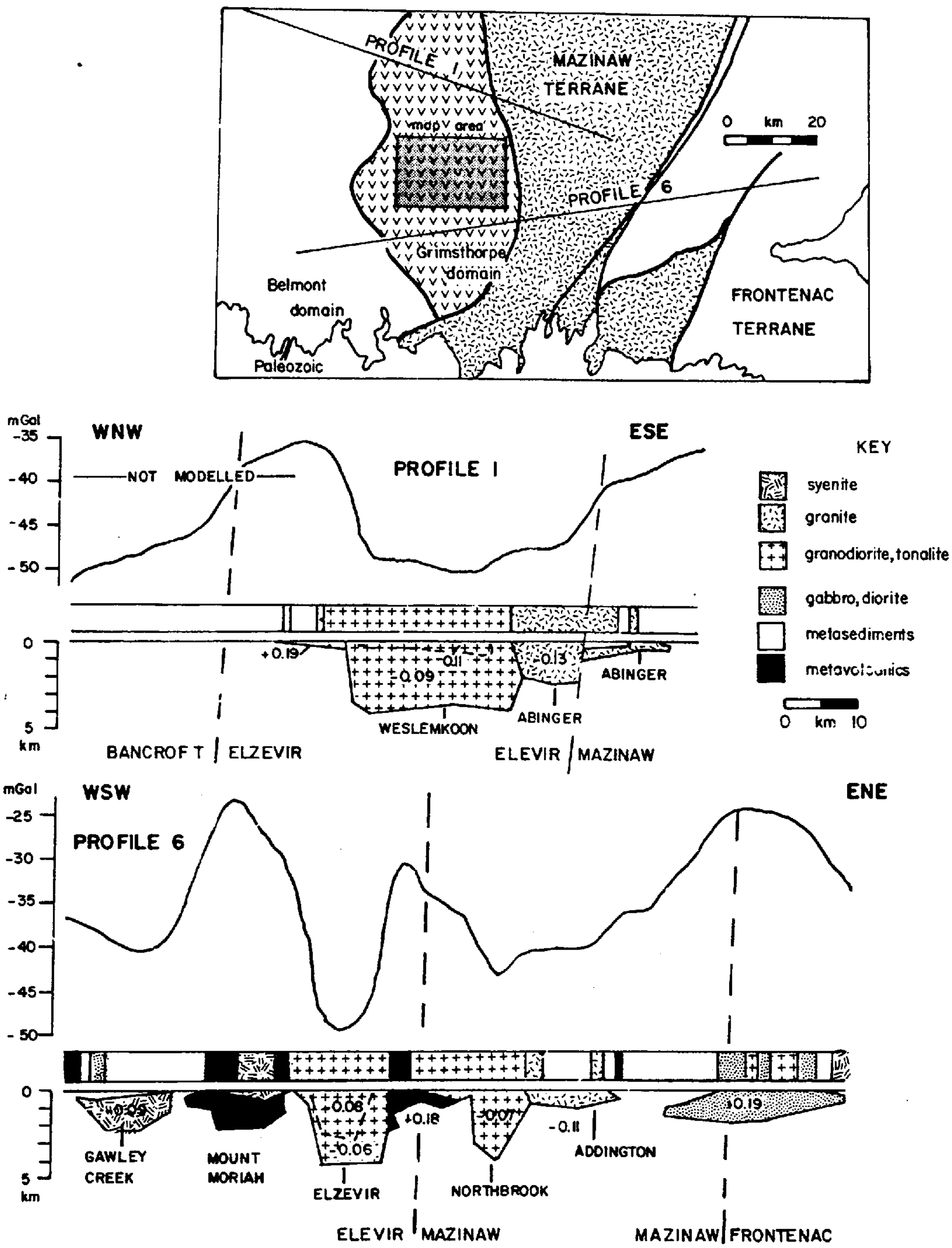
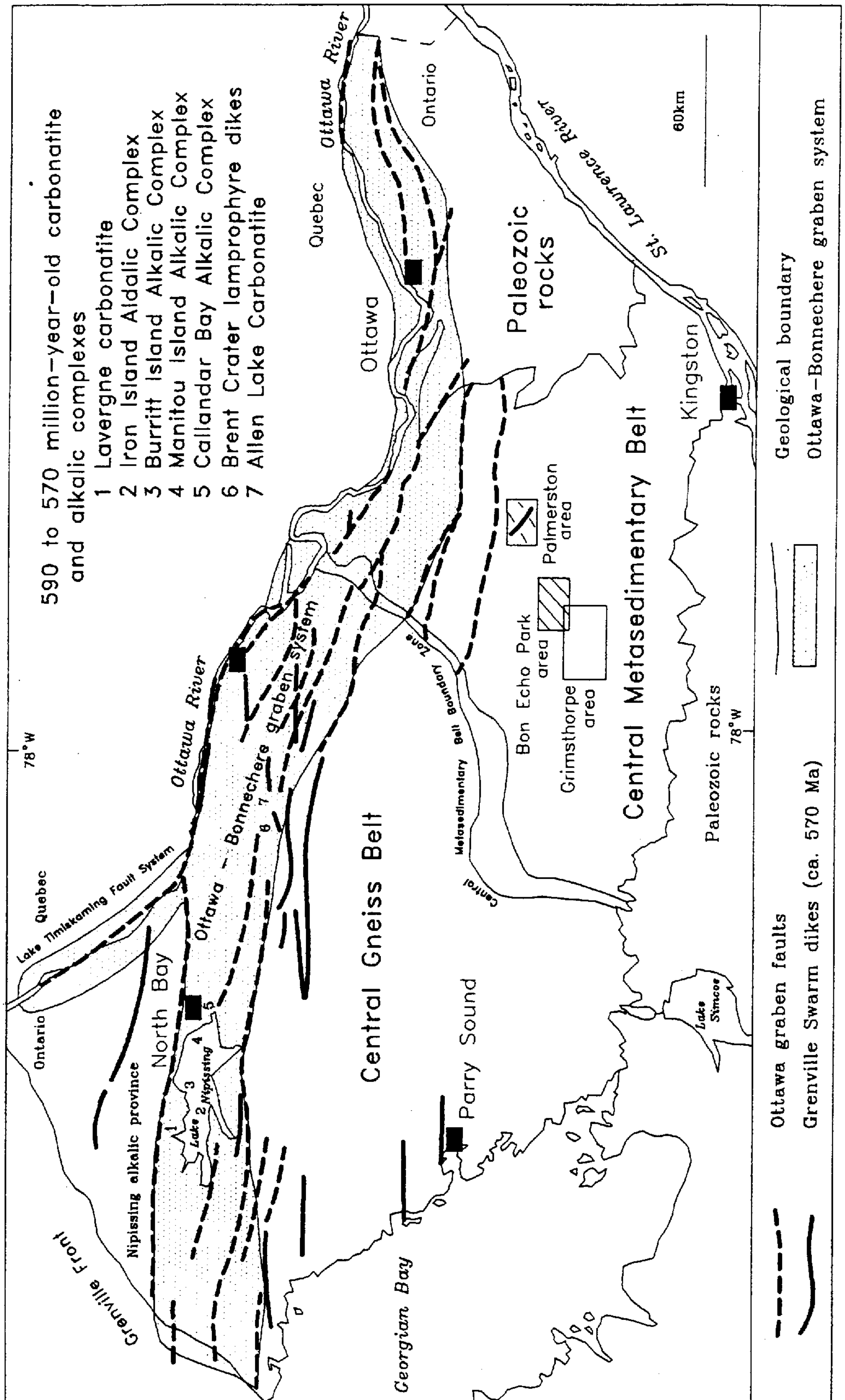


Figure 16: Map showing the relative location of Bon Echo Provincial Park and the Ottawa-Bonnechere Graben System. After Easton (1992a).



Key differences between the terranes are noted in Table 2. Additional differences between the two terranes are: (i) changes in structural orientation from northerly and northeasterly trends in the Grimsthorpe domain to easterly trends in the Mazinaw Terrane; (ii) the presence of granitic dikes and granitic plutons within the Mazinaw Terrane which are less common in the Grimsthorpe domain; (iii) the development of biotite in mafic metavolcanic and metaplutonic rocks in the Mazinaw Terrane; and (iv) increased deformation and higher metamorphic grade within Mazinaw Terrane rocks.

ECONOMIC GEOLOGY

Assay Results

Field party personnel collected samples for assay from a variety of rock types within the map area. Table 3 presents the results of these assays.

Old Pits

Three old pits occur within the park. The first is located by post 3 along the Canadian Shield trail which follows the Anglesea-Barrie township line using the old Addington Road (UTM 18T 325290E 4973250N). This pit is in till, and exposes a variety of boulder types. Although described as an old prospector's pit in the trail guide, there is no indication that this pit reached bedrock, and in fact, it may have been created as a borrow pit during construction of the now abandoned Addington Road.

The second occurs west of Joeperry Lake (UTM 18T 318335E 4974968N), and is also described in park brochures. It consists of a timbered shaft, now partly filled, roughly 5 m and 5 m in size and 5 m deep. It is hosted in metawacke (unit 3b grading to 4b), and an assay sample collected by field party personnel showed slightly anomalous gold values (Sample 91RME-0225, Table 2). This pit is referred to locally as the Printis Mine, however, no record of this property is present in the assessment files. The pit lies along the trace of the west branch of the Joeperry fault, and the gold mineralization may be related to this fault.

A third pit occurs in metagabbro (unit 7b) due east of Highway 41 near the north boundary of the park (UTM 18T 325050E 4976100N). This pit could have been a small road metal quarry, or an old blasted roadcut related to the abandoned Addington Road.

Magnetite and Chromite in Metagabbroic Rocks

Easton and Ford (1990) reported enrichments in magnetite and chromite in rocks of the Killer Creek Gabbro Suite, particularly the hornblendite and melanocratic gabbro phases. The most significant accumulation is located in the Joeperry Gabbro, which is associated with a significant aeromagnetic high (GSC 1952). Assay sample 91RME-060 (Table 3) is from one of these pods, and shows elevated concentrations of Cr and V. The high Ti contents of the Killer Creek-type gabbros suggests the presence of ilmenite as well. The Joeperry Gabbro has a fine-grained phase of chlorite-hornblende-magnetite around its margins, which may be the product of metamorphic reaction related to fluid interaction with surrounding rocks during M_2. This

TABLE 3: Assay results from samples collected by field party personnel within and adjacent to Bon Echo Provincial Park. All analyses by Geoscience Laboratories, Ontario Geological Survey.

Sample Number	UTM Coordinates	Au (ppb)	Cu (ppm)	Zn (ppm)	Other (ppm)	Comment
Gossan Zones in Metaplutonic Rocks						
91RME-0200A	327700E 4972800N	14	9	<10	--	
yellow-white gossan, Abinger Granite						
91RME-0200B	327700E 4972800N	107	7	26	--	
black-white gossan, Abinger Granite						
91RME-0200C	327700E 4972800N	13	<5	<10	--	
sulphides in quartz vein, gossan zone in Abinger Granite						
Samples from Older Shear Zones						
91RME-0031	325550E 4973120N	<2	10	14	--	Hematite-pyrite, Hwy 41
91RME-0032	325440E 4973450N	<2	7	9	--	Highway 41
Gabbroic and Ultramafic Rocks						
91RME-0060	318980E 4976480N	<2	32	175	Cr=970, Ni=240, V=725,	
hornblendite, Bon Echo Provincial Park					Pt,Pd= <1 ppb	
91RME-0138	315199E 4973605N	39	26	92	--	
metagabbro, diss. sulphide, SW Rainy Lake, Grimsthorpe domain						
91RME-1141	318800E 4976340N	49	12	155	Pd=125ppb,Pt=67ppb,Cr=1550,	
fine-grained, mt-rich altered hornblendite, Bon Echo Provincial Park					V=327, 14.8% Fe	
Miscellaneous Samples						
91RME-0225	318335E 4974968N	55	7	24	--	
adit, Printis mine, west shore, Joeperry Lake						

Detection limit for Au is 2 ppb, <5 ppm for Cu, Ni and Cr, and <10 ppm for Zn and Pb. Background levels in area are generally close to detection limits. All samples analyzed for Pb and Ni, only significant values reported. ND = not determined

magnetite-rich rim may be responsible for the intense aeromagnetic signature of this body which is atypical of the suite elsewhere in the Grimsthorpe domain or the Mazinaw Terrane.

Hematite

The occurrence of hematite in the area of the park has been of interest because the Algonkian Indians used hematite-based pigments for the some 260-odd petrogylphs present along the 3 km of cliff exposed on the east shore of Mazinaw Lake by Old Walt Rock. Although no major hematite occurrences are present in the park, hematite encrusted fracture surfaces occur in the felsite-mylonite outcrop located just south of the entrance to Park Headquarters. Hematite lenses have also been found along east-trending faults in the Grimsthorpe area about 10 km from the park (Easton and Ford 1990, 1993). Several hematite occurrences are found near Kaladar, some 40 km south of the park, associated with the Precambrian-Paleozoic unconformity. Thus, a variety of local hematite sources exist in the vicinity of the park and may have been used to produce pigments.

UNIQUE FEATURES OF BON ECHO PROVINCIAL PARK

This study illustrates, more clearly than previously recognized, that Bon Echo Provincial Park is a geologically unique area within eastern Ontario. Northwest-trending faults, best exemplified by fault scarp at Old Walt Rock are more abundant in this area than to the west, and were critical in creating the landscape of the park. In addition, the park straddles the boundary between two geologic terranes, and although this boundary is exposed elsewhere outside the park, the northwest-trending faults make the boundary relationships preserved in the park unique compared respect to those preserved outside of the park. Further, the geology of the park preserves several key contact relationships between different plutonic suites present within eastern Ontario. All of these specific geologic conditions contribute to the unique aspects of the geology of Bon Echo Provincial Park. In retrospect, the park is well chosen in terms of preserving some unique aspects of the geology of eastern Ontario.

Recognition of the unique aspects of the park geology, and the geologic evolution of the park, should make it much easier to develop a public education program for park visitors that focuses on the many geologic features that are preserved within Bon Echo Provincial Park.

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Appendix A: Chemical analyses of rocks within Bon Echo Provincial Park.

wt%.	1 basalt	2 unit 3h	3 unit 5	4 unit 5	5 unit 7	6 unit 7	7 unit 7
SiO_2	51.7	63.1	51.1	49.5	48.6	51.9	52.6
TiO_2	1.43	1.26	1.22	1.07	0.8	0.91	0.61
Al_2O_3	14.60	13.3	16.2	16.2	7.59	15.5	18.6
Fe_2O_3	ND	ND	ND	ND	ND	ND	ND
FeO	12.2	9.7	8.81	10.2	11.2	8.94	6.82
MgO	6.25	1.71	7.21	7.83	23.6	7.97	6.44
MnO	0.23	0.26	0.15	0.16	0.22	0.13	0.11
CaO	9.65	3.79	10.9	11.0	7.13	10.3	10.3
Na_2O	3.09	3.82	3.39	2.09	0.25	3.18	3.32
K_2O	0.67	2.39	0.55	1.08	0.03	0.80	0.76
P_2O_5	0.14	0.40	0.19	0.17	0.16	0.13	0.12
CO_2	ND	ND	ND	ND	ND	ND	ND
S							
H_2O^+							
H_2O^-							
LOI							
Total	99.96	99.73	99.72	99.3	99.61	99.76	99.68

1 - JA-40, metabasalt, Ayer (1979)
2 - JA-3, unit 3h, "andesite", Ayer (1979)
3 - JA-37, metagabbro, unit 5, Ayer (1979)
4 - JA-38, metagabbro, unit 5, Ayer (1979)
5 - JA-35, hornblendite, unit 7, Killer Creek suite, Ayer (1979)
6 - JA-10, metagabbro, unit 7, Killer Creek suite, Ayer (1979)
7 - JA-12, metagabbro, unit 7, Killer Creek suite, Ayer (1979)

ND = not determined

Appendix A: Chemical analyses of rocks within Bon Echo Provincial Park (continued).

wt%.	8 felsite	9 unit A	10 unit A	11 unit A	12 unit A?	13 unit 8	14 unit 8
SiO_2	73.4	74.9	74.1	76.12	79.4	69.1	68.7
TiO_2	0.37	0.25	0.27	0.19	0.12	0.61	0.72
Al_2O_3	12.9	14.2	14.1	12.15	11.5	17.0	15.5
Fe_2O_3	ND	ND	ND	1.73	ND	ND	ND
FeO	3.39	1.61	1.79	ND	1.74	2.19	3.71
MgO	0.10	0.40	0.36	0.79	0.47	0.86	1.23
MnO	0.06	0.02	0.02	0.02	0.01	0.03	0.04
CaO	1.25	0.70	0.83	0.60	0.33	3.58	1.85
Na_2O	4.31	3.97	4.83	4.39	6.14	5.13	6.36
K_2O	3.99	3.78	3.50	3.66	0.21	1.07	1.59
P_2O_5	0.02	0.08	0.07	0.02	0.05	0.12	0.17
CO_2	ND	ND	ND	ND	ND	ND	ND
S							
H_2O^+							
H_2O^-							
LOI				0.56			
Total	99.79	99.91	99.87	100.23	99.97	99.69	99.87

8 - JA-2, felsic dike cutting unit 3h, same outcrop as sample #2, Ayer (1979)
9 - JA-11, granite, unit A, Ayer (1979)
10 - JA-14, granite, unit A, Ayer (1979)
11 - average of 17 Abinger Granite samples, unit A, Lumbers *et al.* (1990)
12 - JA-16, albite granite or albite trondhjemite, unit A?, Ayer (1979)
13 - JA-13, tonalite, unit 8, Ayer (1979)
14 - JA-15, tonalite, unit 8, Ayer (1979)

ND = not determined

Appendix A: Chemical analyses of rocks within Bon Echo Provincial Park (continued).

wt%.	15 unit 8	16 unit 8	17 unit 8	18 unit 3h	19 unit 3h
SiO_2	71.8	70.1	69.85	63.69	63.1
TiO_2	0.41	0.52	0.35	1.33	1.26
Al_2O_3	15.3	15.0	15.28	13.60	13.3
Fe_2O_3	ND	ND	2.45	ND	ND
FeO	1.35	2.75	ND	8.43	9.7
MgO	1.20	1.03	1.21	1.45	1.71
MnO	0.07	0.05	0.04	0.20	0.26
CaO	1.81	2.46	2.37	3.10	3.79
Na_2O	6.43	6.52	4.62	4.63	3.82
K_2O	1.47	1.35	2.94	2.13	2.39
P_2O_5	0.10	0.12	0.09	0.46	0.40
CO_2	ND	ND	ND	0.22	ND
S				0.03	
H_2O^+				0.66	
H_2O^-				0.09	
LOI			0.71	0.64	
Total	99.94	99.90	99.91	99.66	99.73

15 - JA-17, tonalite, unit 8, Ayer (1979)
16 - JA-56, tonalite, unit 8, Ayer (1979)
17 - average of 26 samples from Elzevir, Weslemkoon and White Lake tonalites, unit 8, Lumbers *et al.* (1990)
18 - 91RME-0021, unit 3h, same outcrop as sample JA-3, Easton and Ford (in press)
19 - JA-3, repeated

ND = not determined

Photo 1: Siliceous veins forming intrusion breccias within unit 5 gabbros south of Rainy Lake 0.5 km west of the western park boundary. Compare with textures shown in Figure 8. A) UTM 18T 316387E 4972513N; B) UTM 18T 315423E 4975370N.

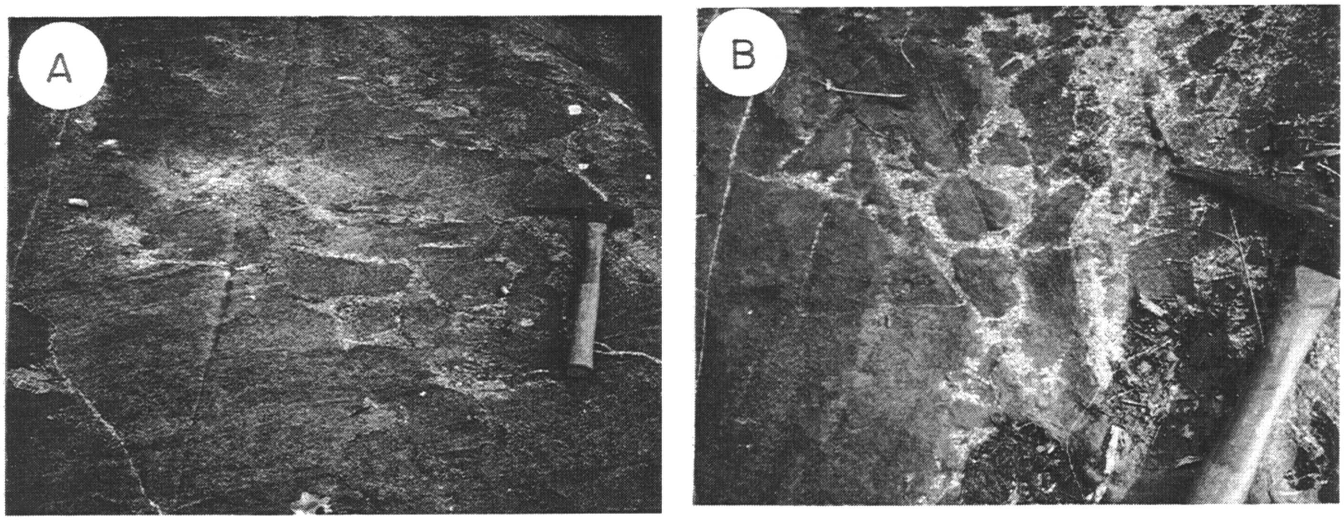
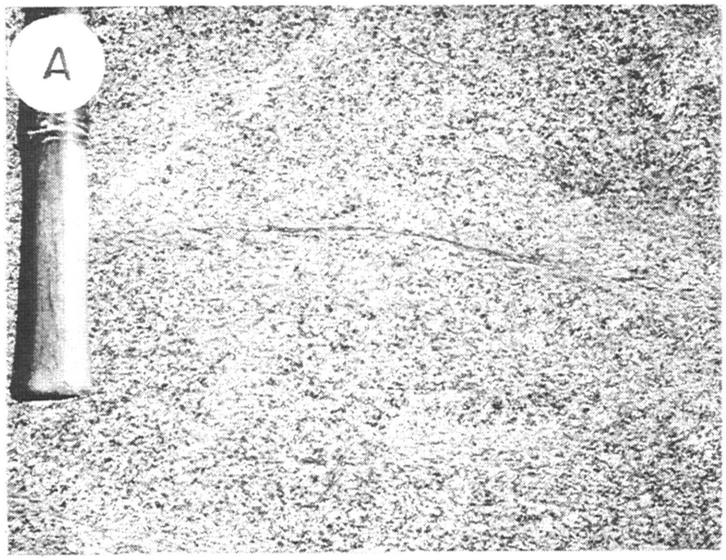


Photo 2: Euhedral magnetite porphyroblasts (noted by arrows) in intermediate composition metawacke (unit 3h), highway 41, 1.5 km south of Bon Echo Provincial Park. UTM 18T 326500E 4971400N.

Photo 3: Gabbros of the Killer Creek Suite. Both photos from UTM 18T 320600E 4975260N.
A) Typical medium grained gabbro (unit 7b) of the Killer Creek Suite, Joeperry Gabbro, northeast of Joeperry Lake.
B) Fine-grained mafic dike (unit 7f) cross-cutting unit 7b gabbro, Joeperry Gabbro. These fine-grained dikes are common within the Killer Creek Suite, and may be cogenetic with the suite.



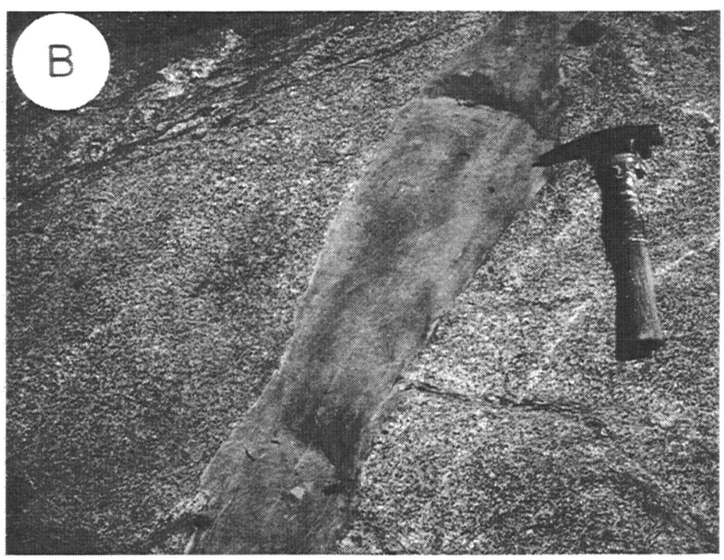
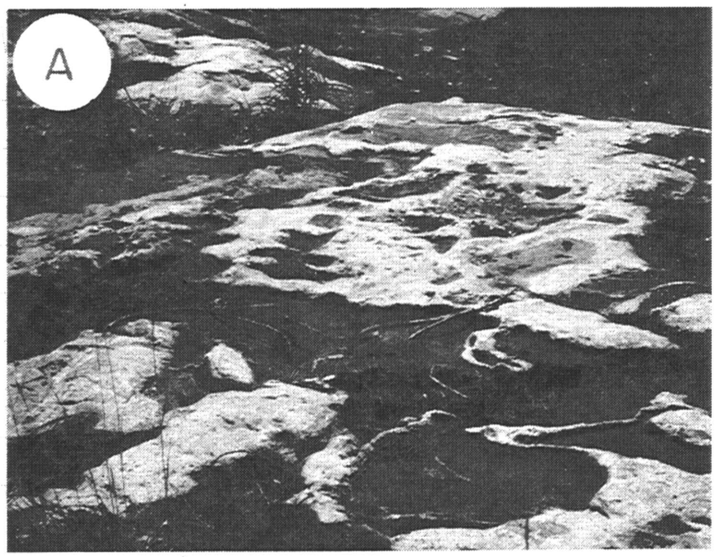


Photo 4: Tonalite intrusion breccias from throughout Bon Echo Provincial Park. All samples from Highway 41, UTM 18T 325830E 4972490N.
A) Large dark masses of volcaniclastic metasediment and recrystallized amphibolite cut by tonalite of the Elzevir Suite.
B) Elongate angular blocks of volcaniclastic metasediment and gabbro showing varying degrees of assimilation.



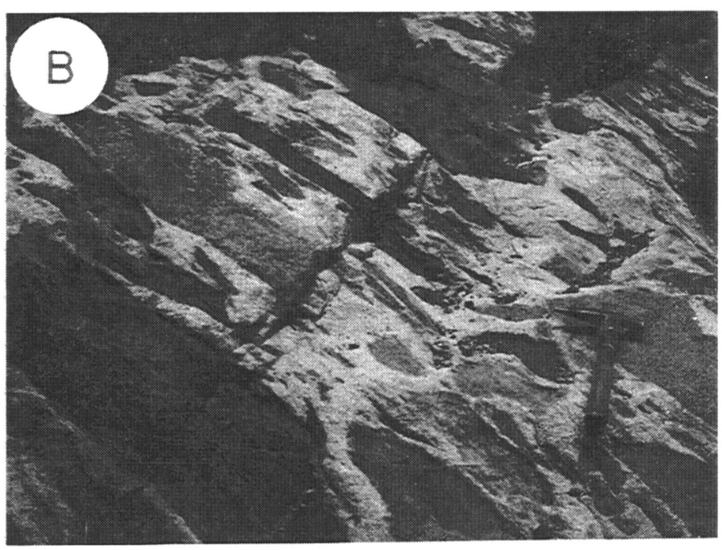
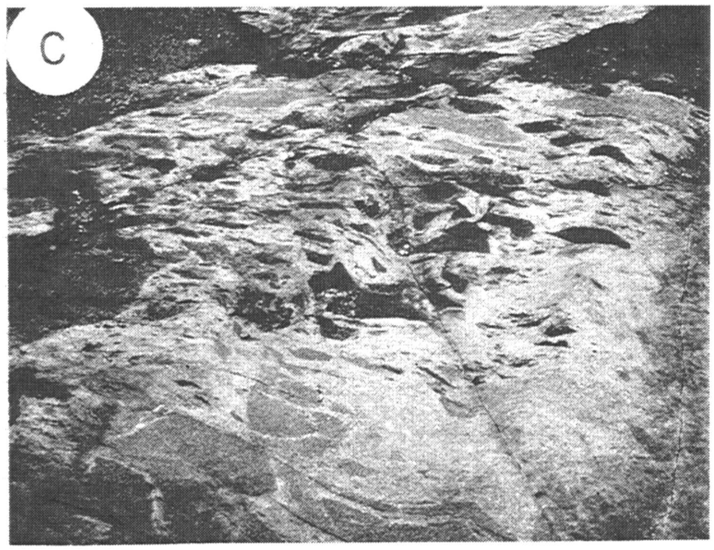


Photo 4 (continued):
C) Schiliren and angular fragments within tonalite intrusion breccia.
D) Isoclinal folds developed within volcaniclastic metasediments defined by folded tonalite veins within a large country rock block within the tonalite intrusion breccia zone on Highway 41. Both rock types are cut by the Abinger Granite outside the field of view.



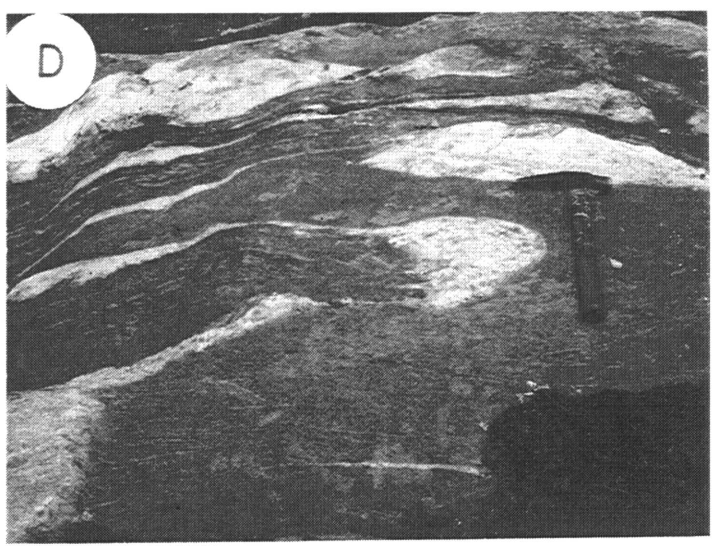
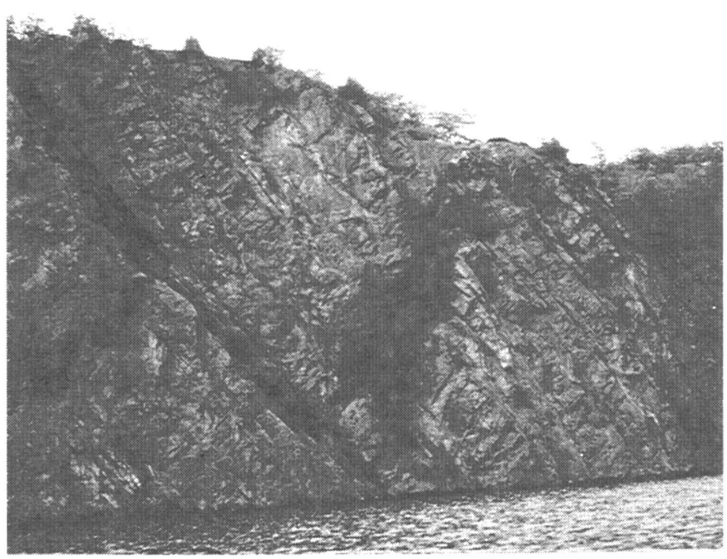


Photo 5: (A) Close-up of cliff-face along Mazinaw Lake south of Old Walt Rock showing spaced granite sills within amphibolitic host rock. UTM 18T 327280E 4973880N. Field of view is 50 m across.
(B) Cliff-face along Mazinaw Lake south of Old Walt Rock showing closely spaced to continuous granite sills within amphibolitic/metasediment host rock. A younger dike crosses the left-side of the outcrop roughly parallel to the regional foliation. UTM 18T 327280E 4973880N. Compare with Photo 5. Field of view is 150 m across.



CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm@	0.155 0	square inches	1 square inch	**6.451 6**	cm@
1 m@	10.763 9	square feet	1 square foot	**0.092 903 04**	m@
1 km@	0.386 10	square miles	1 square mile	2.589 988	km@
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm#	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm#
1 m#	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m#
1 m#	1.308 0	cubic yards	1 cubic yard	0.764 555	m#
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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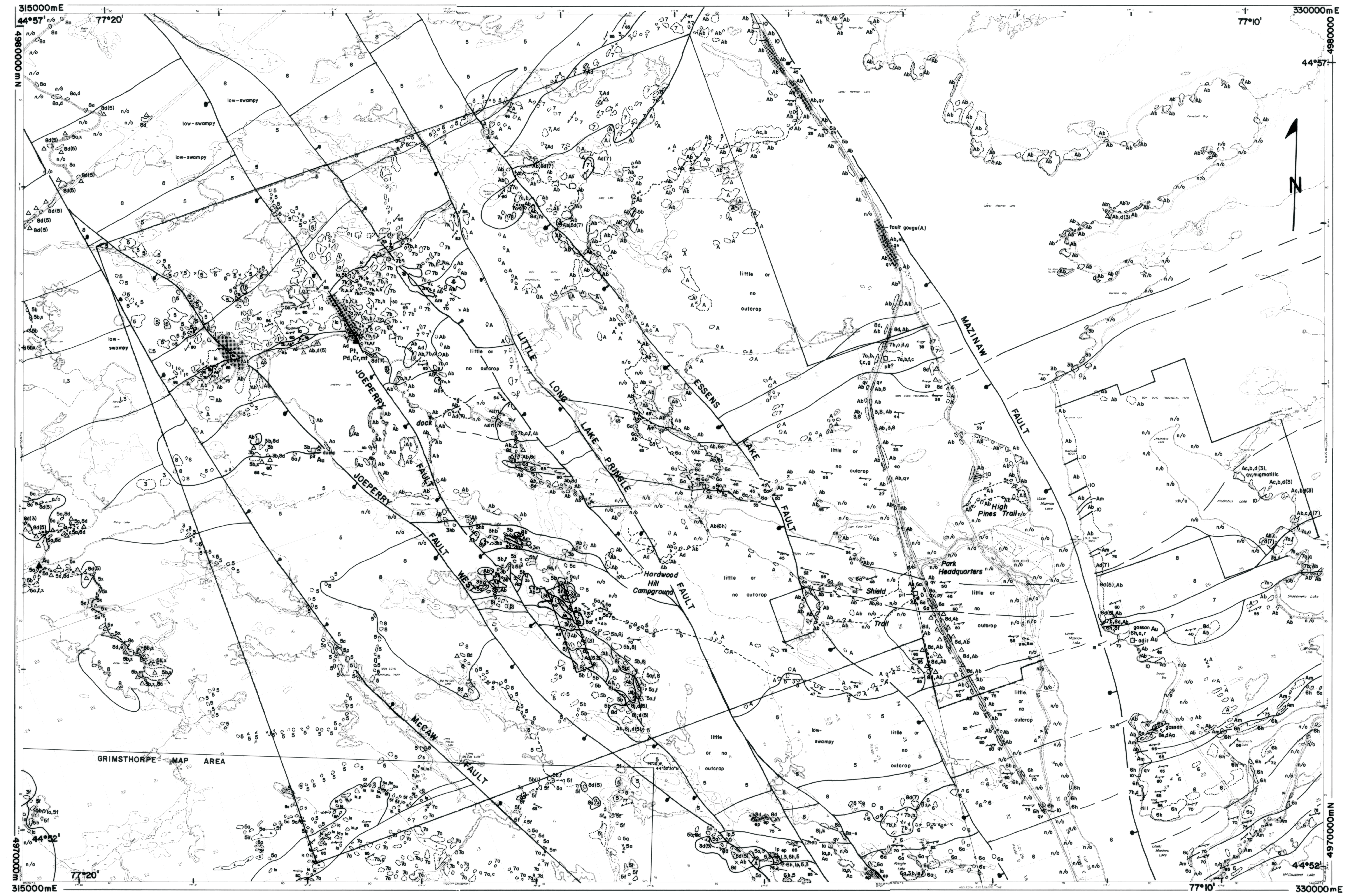

Ministry of Northern Development and Mines
Ontario

Mines and Minerals Division
Ontario Geological Survey

Map P.3270

PRECAMBRIAN GEOLOGY

BON ECHO PROVINCIAL PARK, FRONTENAC AND LENNOX AND ADDINGTON COUNTIES

GRENVILLE PROVINCE

NTS Reference: 31C/14
ODM-GSC Aeromagnetic Map 97G
OGS Geological Compilation Maps: 2544 and 2578

Scale 1:20 000

500 m 0 0.5 1 km

LEGEND[a,b]

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

Sand, gravel, till, ground moraines, and organic deposits

UNCONFORMITY

PRECAMBRIAN[c]

LATE PROTEROZOIC[d]

Late Tectonic to Posttectonic Intrusive Rocks

10 Mafic Intrusive Rocks
- 10 Fine-grained, weakly metamorphosed, diabase dikes (ca. 900 Ma)

INTRUSIVE CONTACT

MIDDLE TO LATE PROTEROZOIC

ELZEVIR TERRANE

Alkalic Intrusive Rocks (ca. 1085 Ma)

9 Syenite, unsubdivided
- 9a Medium-grained biotite syenite

INTRUSIVE CONTACT

A Felsic Intrusive Rocks (min. 1170 Ma, max. 1245 Ma), Methuen Suite?, Abinger Granite
- Aa Fine- to medium-grained, monzongranite to syenogranite gneiss
- Ab Fine-grained, monzogranite to granodiorite gneiss
- Ad Intrusion breccia, () indicates major fragment-type
- Am Mylonitic granite

INTRUSIVE CONTACT

8 Intermediate to Felsic Intrusive Rocks (*ca.* 1270 Ma), Elzevir Suite
- 8a Tonalite to trondhjemite
- 8b Granodiorite
- 8c Migmatite formed by tonalite veins and screens of country rock
- 8d Intrusion breccia, () indicates major fragment-type
- 8f Fine-grained, foliated, sugary-textured tonalite dikes
- 8h Hematite-stained tonalite to granodiorite
- 8j Quartz Diorite
- 8k Aplite
- 8m Mylonitic granite
- 8t Tonalite to granodiorite dikes

Mafic Intrusive Rocks (*ca.* 1270-1280 Ma)

7 Dioritic to Gabbroic Rocks (Killer Creek Gabbro Suite)
- 7a Medium-grained gabbro
- 7b Melanocratic, medium-grained gabbro
- 7c Anorthosite, anorthositic gabbro, gabbroic anorthosite
- 7d Coarse-grained gabbro
- 7f Fine-grained gabbro, commonly feldspar porphyritic, commonly as dikes
- 7h Hornblendite, commonly magnetite-bearing
- 7k Chlorite schist, fine-grained, with magnetite porphyroblasts
- 7m Mylonitic gabbro

FAULTED CONTACT?

Felsites and Mylonites

6 Felsic to Intermediate Gneisses
- 6a Finely-laminated, pink, buff, or grey weathering, quartzofeldspathic gneisses (felsites), locally containing garnet, plagioclase or magnetite porphyroblasts
- 6b Finely-laminated, green to dark green, biotite-hornblende-plagioclase mafic gneisses
- 6c 6a and 6b, finely intercalated
- 6h Grey to dark grey, massive, biotite-hornblende-quartz-plagioclase gneiss, commonly with magnetite porphyroblasts (possible metawacke)

FAULTED CONTACT?

Mafic Intrusive Rocks (*ca.* 1270-1290 Ma)

5 Dioritic to Gabbroic Rocks
- 5a Medium-grained gabbro
- 5b Melanocratic, medium-grained gabbro
- 5f Fine-grained gabbro, commonly feldspar porphyritic
- 5h Hornblendite, commonly magnetite-bearing
- 5m Mylonitic gabbro
- 5x Gabbroic intrusion breccia

INTRUSIVE CONTACT

GRENVILLE SUPERGROUP

Metasedimentary Rocks

4 Siliceous Clastic Metasedimentary Rocks
- 4b Metawacke

3 Siliceous Clastic Metasedimentary Rocks, may include Felsic and Intermediate Metatuffs and Metasedimentary Rocks of Mainly Volcanic Provenance
- 3b Biotite-hornblende-quartz-plagioclase gneiss, black to dark grey weathering (mafic meta-arenite, mafic metawacke)
- 3f Polymictic, matrix-supported conglomerate, with mafic matrix (similar to 3b)
- 3r Rusty schist derived from unit 3 rocks

UNCONFORMITY?

Mafic Intrusive Rocks (*ca.* 1290 Ma)

2 Gabbroic and Talcose Rocks(*NOT PRESENT IN PARK AREA)*

INTRUSIVE CONTACT

Metavolcanic Rocks

Felsic to Intermediate Metavolcanic Rocks

1 Mafic Metavolcanic Rocks
- 1a Massive, fine-grained, dark green to black weathering amphibolite (massive flow?)
- 1b Pillowed, fine-grained, dark green to black weathering amphibolite (pillowed flow)
- 1m Mylonitic amphibolite
- 1p Massive, fine-grained, dark green to black weathering amphibolite, feldspar porphyritic
- 1r Gossan zones, rusty schist horizons

[a] *This is a field legend and may be changed as the result of subsequent laboratory investigations.*

[b] *Unsubdivided outcrops include small outcrops where subdivision was not possible and outcrops plotted from other sources and which were not visited by field party personnel.*

[c] *The Precambrian legend is a lithologic one, and stratigraphic order is only in part implied by numerical order.*

[d] *All Precambrian rocks have been subjected to regional metamorphism; many non-metamorphic terms are used for the sake of brevity and where the protolith is established.*

ABBREVIATIONS

Au	gold	py	pyrite
ep	epidote	qv	quartz vein
mt	magnetite		

SYMBOLS

- Bedding, top known (inclined, overturned).
- Bedding, top unknown (inclined, vertical)
- Pillow top, (inclined, overturned)
- S_1 Foliation (horizontal, inclined, vertical)
- S_2 Foliation (horizontal, inclined, vertical)
- Gneissosity (horizontal, inclined, vertical)
- Lineation, with plunge
- Geological boundary, observed
- Geological boundary, position interpreted
- Fault (observed, assumed). Dot indicates downthrown side
- Mineral occurrence, former mine, stone quarry
- Alteration along NW-trending faults (chloritization, epidotization, hematization)

SOURCES OF INFORMATION

Base map derived from Ontario Basic Mapping Maps, Survey and Mapping Branch, Ontario Ministry of Natural Resources.

Geology of the Grimsthorpe-Barrie area; Ontario Department of Mines, Annual Report, v. 51 (1942), pt. 4., p. 1-50, by V.B. Meen, 1944.

Mazinaw Lake Metavolcanic Complex, Grenville Province, unpublished M.Sc. thesis (100p.) and 1:15 840 scale map, Carleton University, Ottawa, by J.A. Ayer, 1979.

Geology of Bon Echo Provincial Park, unpublished 1:15 840 scale map, Ontario Ministry of Natural Resources, Tweed, by S. van Haaften and J.A. Smedley, 1979.

Geology not tied to survey lines.

Magnetic declination approximately 11°14'W in 1993.

Metric conversion factor: 1 foot = 0.3048 m.

CREDITS

Geology by R.M. Easton and F.D. Ford, 1990, 1991; S. van Haaften and J.A. Smedley, 1979.

To enable the rapid dissemination of information, this map is unedited. Discrepancies may occur for which the Ontario Geological Survey does not assume liability. Users should verify critical information.

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Information from this publication may be quoted if credit is given. It is recommended that reference to the map be made in the following form:

Easton, R.M., Ford, F.D., van Haaften, S. and Smedley, J.A. 1994. Geology of Bon Echo Provincial Park, Frontenac and Lennox and Addington counties, Grenville Province; Ontario Geological Survey, Preliminary Map P.3270, scale 1:20 000.