Current Research (2002) Newfoundland Department of Mines and Energy
Geological Survey, Report 02-1, pages 67-77

PRELIMINARY REPORT ON U–Pb AGES FOR INTRUSIVE ROCKS FROM THE WESTERN MEALY MOUNTAINS AND WILSON LAKE TERRANES, GRENVILLE PROVINCE, SOUTHERN LABRADOR

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Regional Geology Section

ABSTRACT

The Wilson Lake (WLT), Mealy Mountains (MMT), and Mecatina (MET) terranes of the Grenville Province, southern Labrador, are Grenvillian (ca. 1050 to 1000 Ma) tectonic divisions consisting primarily of late Paleoproterozoic and early Mesoproterozoic crust. Igneous emplacement ages for some MMT and WLT orthogneiss units, and of syenite plutons that punctuate the MMT and MET are unknown, and are the focus of this U–Pb geochronological study.

Field relationships suggest that a composite orthogneiss unit in the MMT includes the oldest rocks in the terrane. A granodiorite orthogneiss from this unit has an igneous emplacement age of 1653 ± 5 Ma, consistent with emplacement ages for variably deformed and gneissic granitoid rocks elsewhere in the western MMT. The emplacement age of the orthogneiss suggests it may be related to the Middle Labradorian Mealy Mountains intrusive suite. A recrystallized and weakly deformed granitic aplite dyke, which cuts the gneissosity in the 1653 Ma orthogneiss, was emplaced at 995 ± 2 Ma. Thus, gneissosity in the host orthogneiss could be a Labradorian or a Grenvillian feature. A WLT granodiorite orthogneiss, which intrudes supracrustal gneiss, has an igneous emplacement age of 1650 ± 4 Ma, and may be related to the Trans-Labrador batholith. Similar protolith ages for MMT and WLT orthogneiss units do not constrain the terranes to be joined at that time.

A weakly recrystallized and non-foliated syenite, informally named the Lac Arvert syenite and dated at 982 ± 2 Ma, intruded the late Paleoproterozoic rocks of the MMT. Field relationships suggest the Lac Arvert syenite, and correlative syenite plutons in the MMT and MET, postdate Grenvillian deformation and metamorphism in the this part of the Grenville Province.

INTRODUCTION

Precise dating of rocks using U–Pb geochronological methods is an essential supplement to reconnaissance-scale bedrock mapping in areas where intrusive and metamorphic ages are inadequately known and unequivocal contact relationships between rock units are unexposed. As part of 1:100 000-scale mapping of the Grenville Province in map areas NTS 13/C and 13/D in the 2000 field season (Figure 1), samples were collected for geochronological studies from intrusive units that make up the western Mealy Mountains and Wilson Lake terranes (*see* James and Nadeau, 2001b, c, d). The purpose of the geochronological studies is to determine emplacement ages of intrusive units and timing of metamorphism. Collected from the western Mealy Mountains terrane are samples of granodiorite orthogneiss, a granitic aplite dyke, and a syenite. A sample of a granodiorite orthogneiss unit, which makes up part of the Wilson Lake terrane, was also collected. The results of the geochronology studies are presented in this report, which is the third in a series of reports containing new age data from the Grenville Province in NTS areas 13D and 13C (James *et al.*, 2000, 2001).

Each sample analysed contained datable zircon, and a total of 15 fractions were analysed at the Jack Satterley Geochronology Laboratory, Royal Ontario Museum, Toronto. The ages reported herein should be considered as pre-

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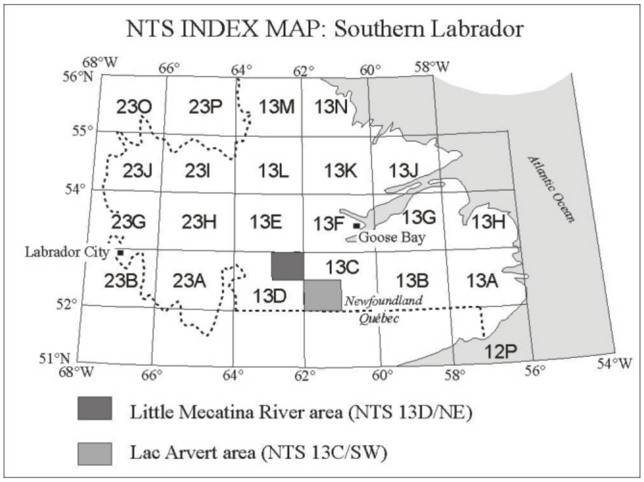

Figure 1. *NTS index map for southern Labrador showing location of the NTS 13C and 13D map areas.*

liminary. It may be necessary in the future to collect additional mineral fractions from the same samples, or to reanalyse certain fractions in order to refine the ages.

REGIONAL GEOLOGY

The Grenville Province in southern Labrador, in NTS map areas 13D and 13C, includes parts of the Wilson Lake, Mealy Mountains, and Mecatina terranes (Figures 2 and 3). These terranes are Grenvillian (ca. 1050 to 1000 Ma) tectonic divisions, although they consist primarily of late Paleoproterozoic and early Mesoproterozoic crust (James and Lawlor, 1999; James and Nadeau, 2000, 2001d; James *et al., this volume*). In the north, the Wilson Lake terrane (WLT) is dominated by high-grade metasedimentary gneiss derived primarily from pelitic and semipelitic sedimentary rocks, although very minor amounts of metasedimentary rocks derived from quartzite and siliceous carbonate rocks occur. The depositional age of the sedimentary precursors is constrained to be older than the onset of Labradorian orogenesis (i.e., >1720 Ma) (*see* discussion in the next paragraph). The northern part of the WLT, in the Red Wine Mountains area, also includes intrusions of late Paleoproterozoic gabbro and gabbronorite, and mafic gneisses possibly derived from supracrustal rocks. Intrusions of foliated granite and porphyritic granite, correlated on the basis of rock type with the ca. 1650 Ma Trans-Labrador batholith, granitoid orthogneisses and meta-igneous rocks of uncertain age make up minor amounts of the terrane. A sample from an orthogneiss unit, Sample 3, that intrudes the metasedimentary gneiss, was collected for dating and is discussed in detail below.

Geochronological studies of monazite contained in sapphrine-bearing diatexite, occurring in the northern part of the WLT and presumed to be derived from anatexis of the metasedimentary gneisses, indicate that high-grade metamorphism and attendant deformation in the WLT are Middle Labradorian (ca. 1640 Ma) (Corrigan *et al.*, 1997). Corrigan *et al.* (*op. cit.*) have also shown, on the basis of U–Pb dating of monazite, that the southeastern part of the WLT has been locally overprinted by Grenvillian (ca. 1000 Ma) metamorphism. Regionally persistent ductile high-strain zones separating the WLT from the Trans-Labrador batholith to the north, and the Mealy Mountains terrane to the south, are ca. 1010 to 990 Ma structures (Corrigan *et al.*, 1997). Along its northern boundary, the WLT is inferred to be thrust over autochthonous Trans-Labrador batholith. The southern boundary is defined by ductile shear zones having mainly northwest- and southeast-dipping segments allowing WLT rocks to structurally overlie and underlie Mealy Mountains terrane rocks (James and Nadeau, 2001d).

The Mealy Mountains terrane (MMT; Gower and Owen, 1984) consists primarily of late Paleoproterozoic, Labradorian-age plutons of the Mealy Mountains intrusive suite (MMIS) (*see* Emslie, 1976; Emslie and Hunt, 1990; Krogh *et al.*, 1996), minor amounts of Paleoproterozoic pre-Labradorian crust, and Pinwarian (1510 to 1450 Ma) intrusions (Gower, 1996). The MMIS consists mainly of an older group of anorthositic, leucogabbroic and leucotroctolitic rocks, and a younger group of pyroxene-bearing monzonite and quartz monzonite intrusions. Emplacement ages for units of MMIS monzodiorite orthogneiss, porphyritic quartz monzodiorite and pyroxene-bearing monzonite, determined by U–Pb geochronology of zircon and occurring in the Kenamu River area, are 1659 ± 5 Ma, 1650 ± 1 Ma and 1643 ± 2 Ma, respectively (James *et al.*, 2000). In addition, pyroxene monzonite and pyroxene granite, inferred to be from the younger group of MMIS rocks and occurring in the northeastern part of the MMIS, have emplacement ages of 1646 ± 2 Ma and 1635 +22/−8 Ma (Emslie and Hunt, 1990), respectively. Unlike the Mesoproterozoic (anorthosite–monzonite–charnockite–granite) AMCG suites in Labrador, such as the Harp Lake Igneous complex, Nain Plutonic Suite and Atikonak River massif, the MMIS is not anorogenic. Emplacement ages of MMIS rocks overlap with regionally significant tectonothermal and magmatic events of the Labradorian Orogeny, which affected northeastern Laurentia in the interval between 1720 Ma and 1600 Ma (*see* Gower, 1996). For this study, a sample of granodiorite orthogneiss, Sample 1 (*discussed below*), was collected for dating. Based on field relationships, the orthogneiss was provisionally interpreted to predate MMIS anorthosite and gabbro intrusions. A recrystallized aplite dyke, Sample 2,

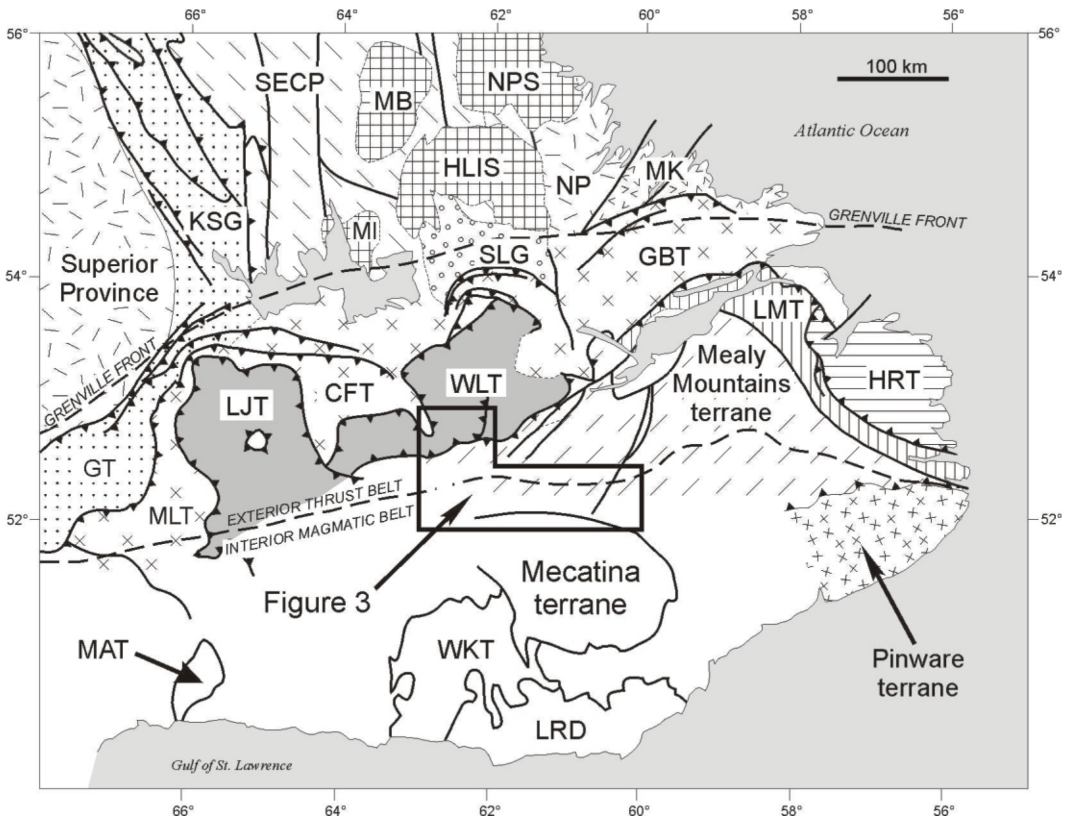

Figure 2. *Tectonic and major lithotectonic units of southern Labrador. Grenville Province: HRT - Hawke River terrane, LMT - Lake Melville terrane, GBT - Groswater Bay terrane, WLT - Wilson Lake terrane, CFT - Churchill Falls terrane, LJT - Lac Joseph terrane, MLT - Molson Lake terrane, GT - Gagnon terrane, MAT - Matamec terrane, WKT - Wakeham terrane, LRD - La Romaine domain. Archean divisions: Superior Province, NP - Nain Province (Hopedale Block). Archean and Paleoproterozoic divisions: MK - Makkovik Province, SECP - Southeastern Churchill Province (core zone), KSG - Kaniapiskau Supergroup (2.25 to 1.86 Ga). Mesoproterozoic units: NPS - Nain Plutonic Suite, HLIS - Harp Lake intrusive suite, MB - Mistastin batholith, MI - Michikamau Intrusion, SLG - Seal Lake Group.*

which is discordant to the gneissosity in the Sample 1 granodiorite orthogneiss, was also sampled.

Rocks in the western MMT are variably foliated and locally gneissic; in general they have northeast- to east–northeast-striking planar fabrics that are inferred to be Labradorian (James and Nadeau, 2000). However, the local occurrence of deformed, Pinwarian (ca. 1514 Ma) granite in the Kenamu River area (James *et al.*, 2000) demonstrates the western MMT has also been affected by Pinwarian and/or Grenvillian deformation.

The location and nature of the boundary between the MMT and the Mecatina terrane is somewhat uncertain. In the Fourmont Lake area (James and Nadeau, 2000, 2001a), rare occurrences of mylonitic rocks having an undetermined kinematic history, suggest the boundary is a south-dipping high-strain zone, at least locally. However, in general, the area inferred to contain the terrane boundary is very poorly exposed and reliable field data for its demarcation are lacking.

The Mecatina terrane (MET) consists of upper amphibolite-facies supracrustal rocks, including quartzite, pelitic gneiss, and amphibolite, as well as granitoid orthogneiss. The terrane also includes bodies of deformed granite, monzonite, gabbro and anorthosite that are provisionally correlated with the Petit Mecatina AMCG suite. The metasedimentary rocks are tentatively correlated with the Wakeham Supergroup on the basis of rock types, and intrusive relationships which constrain depositional ages to be >1500 Ma. Foliated quartz monzonite and K-feldspar porphyritic granite, occurring in the MET in the Fourmont Lake area (James and Nadeau, 2001a), intrude the supracrustal gneisses and have emplacement ages of 1500 ± 4 Ma and 1493 ± 3 Ma, respectively, determined by U–Pb geochronology of zircon (James *et al.*, 2001; Figure 3). Titanite in the 1493 Ma porphyritic granite is dated by U–Pb techniques to be 1043 ± 6 Ma (James *et al.*, 2001), providing evidence that the terrane has been overprinted by Grenvillian metamorphism.

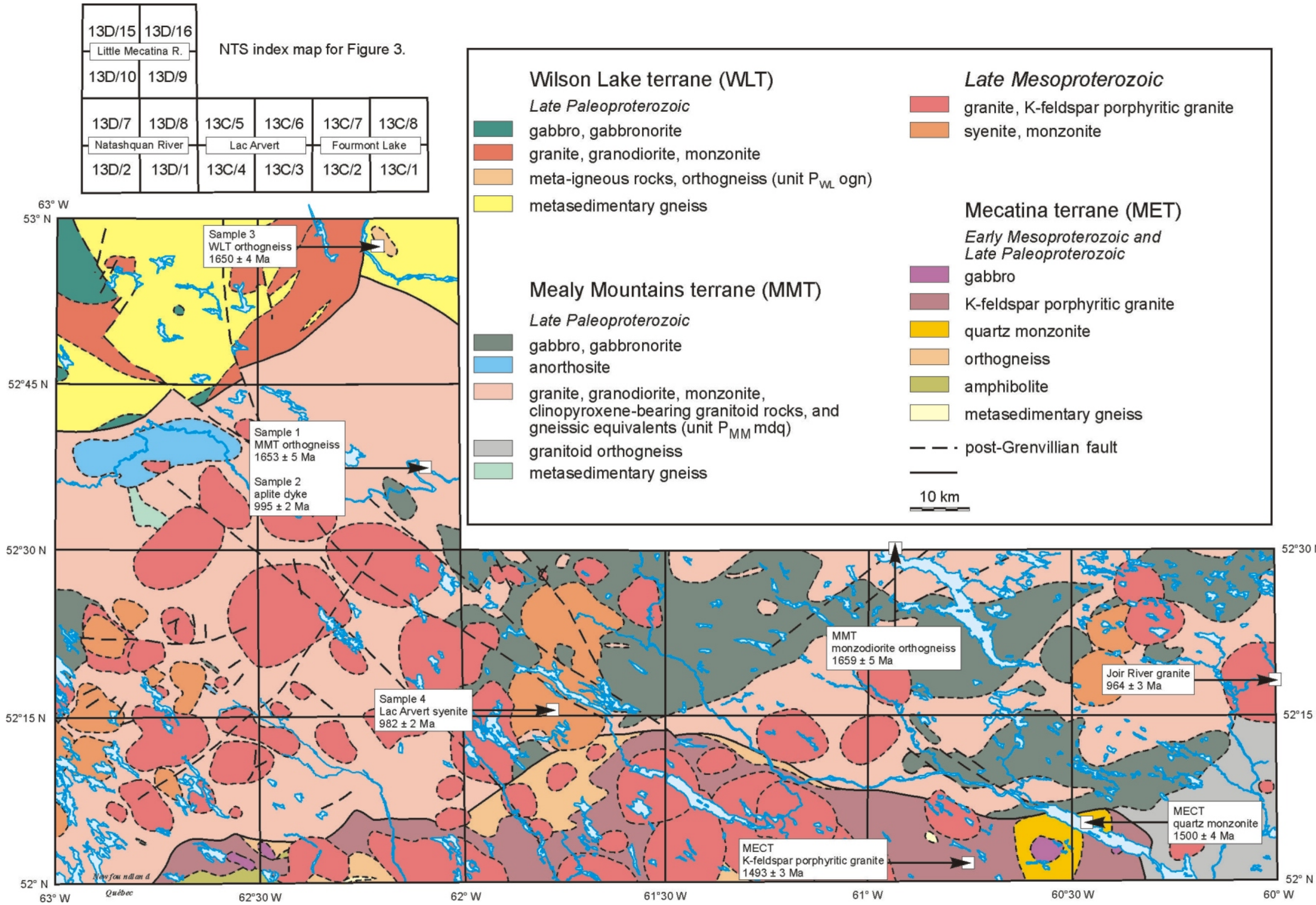

Figure 3. *General geology of the Grenville Province in parts of NTS map areas 13C and 13D (modified from James and Nadeau, 2001a, b, c, d; James* et al., this volume). *Also shown are geochronological results (discussed in the text) for samples in the MMT and MET (*see *James* et al., *2000, 2001).*

The MET and the MMT are intruded by plutons of unmetamorphosed, massive to weakly foliated biotite granite, monzonite and clinopyroxene-bearing syenite. The field relationships demonstrate these plutons slightly overlap and postdate, temporally, the late stages of Grenvillian orogenesis. A biotite granite occurring in the southwestern part of the MMT is determined to have an emplacement age of 964 ± 3 Ma based on U–Pb techniques on zircon (James *et al.*, 2001; Figure 3). This age is consistent with 966 to 956 Ma ages for widespread granitoid plutons in the Pinware terrane and, locally, in the southeastern MMT reported by Gower (1996). Sample 4, discussed below, was collected from a clinopyroxene-bearing syenite pluton interpreted to postdate Grenvillian deformation on the basis of field relationships.

ANALYTICAL PROCEDURES

Zircon was separated from rock samples using standard heavy liquid and magnetic separation techniques. All zircon fractions had an air abrasion treatment (Krogh, 1982). Mineral dissolution and isolation of U and Pb from zircon follow the procedure of Krogh (1973), modified by using small anion exchange columns (0.05 ml of resin) that permit the use of reduced acid reagent volumes. However, if the weight of the grain, or grains, was 5 micrograms or less, no chemical separation procedure was followed, and the bulk dissolved sample was analyzed.

Lead and U were loaded together with silica gel onto outgassed rhenium filaments. The isotopic compositions of Pb and U were measured using a single collector with a Daly pulse counting detector in a solid source VG354 mass spectrometer. Data are corrected for a mass discrimination of 0.14% per AMU and a deadtime of 21.0 nsec. The thermal source mass discrimination correction is 0.1% per AMU. The laboratory blanks for Pb and U are usually less than 2 and 0.2 pg, respectively. In this study, the total common Pb for each analysis, with the exception of Fraction 14 (Table 1),

Table 1. U–Pb isotopic data

Fraction	Number of grains	Weight (mg)	U (ppm)	Th/U	PbCom (pg)	$^{207}Pb/^{204}Pb$	$^{206}Pb/^{238}U$	2 sigma	$^{207}Pb/^{206}Pb$	2 sigma	$^{207}Pb/^{206}Pb$	2 sigma	$^{206}Pb/^{238}U$ Age (Ma)	2 sigma	$^{207}Pb/^{235}U$ Age (Ma)	2 sigma	$^{207}Pb/^{206}Pb$ Age (Ma)	2 sigma	% Disc.
Sample 1: MMT granodiorite orthogneiss; field number: DJ-00-9006A																			
Fraction 8	1	0.007	118.6	0.53	5.3	284.8	0.27264	0.00080	3.7057	0.0148	0.098578	0.00023	1554.2	4.1	1572.6	3.2	1597.4	4.5	3.0
Fraction 9	1	0.008	68.3	0.68	1.3	737.7	0.27243	0.00113	3.7119	0.0165	0.098819	0.00016	1553.1	5.7	1573.9	3.6	1602.0	2.9	3.4
Fraction 10		0.005	201.8	0.69	5.2	352.6	0.27052	0.00106	3.6975	0.0164	0.099131	0.00021	1543.4	5.4	1570.8	3.5	1607.8	4.0	4.5
Fraction 1	3	0.007	493.6	0.65	1.9	2767.0	0.24749	0.00073	3.2317	0.0090	0.094705	0.00017	1425.5	3.8	1464.8	2.2	1522.2	3.5	7.1
Sample 2: MMT aplite dyke; field number: DJ-00-9006B																			
Fraction 1	1	0.005	221.1	1.85	1.3	689.7	0.16674	0.00063	1.6631	0.0068	0.072342	0.00010	994.1	3.5	994.6	2.6	995.6	2.9	0.2
Fraction 1	1	0.009	60.3	1.89	1.1	403.1	0.16673	0.00077	1.6654	0.0080	0.072445	0.00021	994.1	4.3	995.4	3.0	998.5	6.0	0.5
Fraction 1	1	0.005	212.2	1.36	11.9	84.3	0.16668	0.00067	1.6602	0.0167	0.072240	0.00061	993.8	3.7	993.4	6.4	992.7	17.1	-0.1
Fraction 1	1	0.003	238.2	1.27	0.6	979.6	0.16641	0.00043	1.6613	0.0047	0.072405	0.00012	992.3	2.4	993.9	1.8	997.3	3.3	0.5
Sample 3: WLT granodiorite orthogneiss; field number: NK-00-8020																			
Fraction 4	3	0.005	255.0	0.72	1.4	1707.6	0.28798	0.00104	4.0074	0.0143	0.100924	0.00017	1631.4	5.2	1635.7	2.9	1641.2	3.2	0.7
Fraction 5	3	0.007	237.2	0.90	1.4	2225.8	0.28706	0.00156	3.9855	0.0220	0.100694	0.00013	1626.8	7.8	1631.2	4.5	1636.9	2.3	0.7
Fraction 6	1	0.003	193.5	0.72	0.5	2346.4	0.28563	0.00106	3.9581	0.0148	0.100503	0.00015	1619.7	5.3	1625.6	3.0	1633.4	2.7	1.0
Fraction 7	1	0.005	234.1	0.72	0.7	3273.2	0.28554	0.00080	3.9584	0.0120	0.100545	0.00010	1619.2	4.0	1625.7	2.5	1634.2	1.9	1.0
Sample 4: Lac Arvert syenite; field number: DJ-00-7049																			
Fraction 1	1	0.003	15.8	1.60	0.6	74.9	0.16501	0.00084	1.6275	0.0223	0.071535	0.00085	984.5	4.6	980.9	8.6	972.7	24.3	-1.3
Fraction 2	1	0.010	34.0	1.52	5.7	61.2	0.16472	0.00043	1.6297	0.0228	0.071756	0.00091	983.0	2.4	981.7	8.8	979.0	25.8	-0.4
Fraction 3	2	0.013	29.1	1.63	4.5	79.1	0.16438	0.00055	1.6240	0.0168	0.071656	0.00066	981.0	3.1	976.6	6.5	976.2	18.9	-0.5

Model Th/U ratio estimated from $^{208}Pb/^{206}Pb$ ratio and age of the sample.
PbCom is total common Pb in analysis, includes initial and blank.
$^{207}Pb/^{204}Pb$ corrected for spike and fractionation.
All other isotopic ratios corrected for spike, fractionation, blank and initial common Pb, which is estimated using Stacey and Kramer's (1975) model.
2 sigma uncertainty calculated by error propagation procedure that takes into account internal measurement statistics and external reproducibility as well as uncertainities in the blank and comm.

Plate 1. *Sample 1 hornblende + biotite granodiorite orthogneiss dated in this study.*

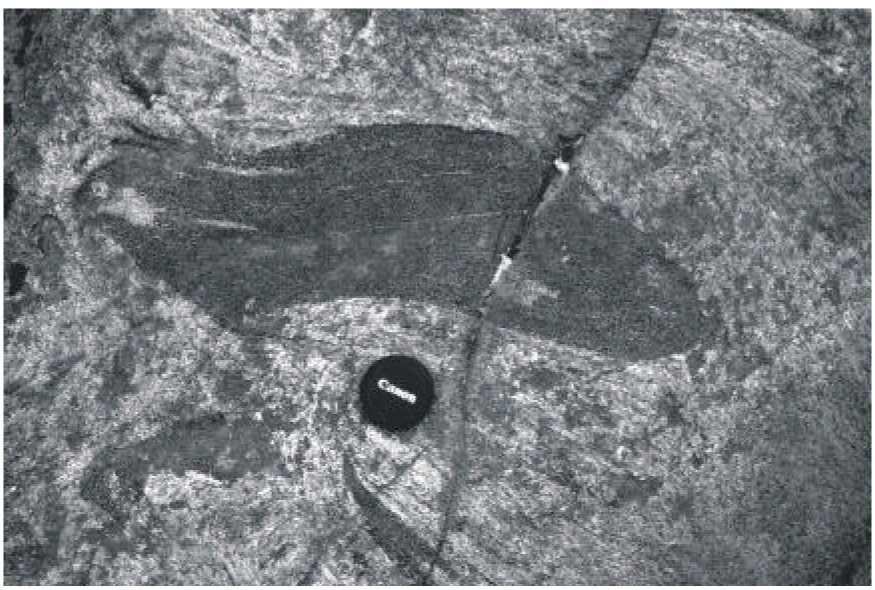

Plate 2. *Deformed mafic xenolith contained in Sample 1 granodiorite orthogneiss.*

varied from 0.5 to 5.7 pg, and was attributed to laboratory Pb. Thus, no correction for initial common Pb was made, except for Fraction 14 for the amount above 10 pg. Error estimates were calculated by propagating known sources of analytical uncertainty for each analysis including ratio variability (within run), uncertainty in the fractionation correction, 0.015% and 0.038% (1 sigma) for Pb and U, respectively, based on long-term replicate measurements of the standards NBS981 and U-500, uncertainties in the isotopic composition, and amount of laboratory blank and initial Pb. Decay constants are those of Jaffey *et al.* (1971). All age errors quoted in the text and error ellipses in the concordia diagrams are given at the 95% confidence interval. Errors in Table 1 are 2 sigma. The discordia lines and intercept ages shown in the concordia diagrams are calculated using the regression program of Davis (1982).

U–Pb ISOTOPIC RESULTS

Sample 1: Granodiorite orthogneiss, Mealy Mountains terrane (DJ-00-9006A)

Gneissic and foliated, amphibolite-facies granitoid rocks, mainly including biotite ± hornblende ± clinopyroxene granite, granodiorite, quartz monzonite, and local diorite, are widespread in the western MMT (Figure 3). Generally, these rocks are poorly exposed, and because they could not be reasonably subdivided in the field at the scale of mapping, they are collectively assigned to a single unit, defined as $\mathrm{P_{MM}}$ mdq. Unit $\mathrm{P_{MM}}$ mdq rocks may be equivalent to Lower Brook metamorphic suite orthogneisses defined by Wardle *et al.* (1990). Clinopyroxene-bearing $\mathrm{P_{MM}}$ mdq monzodiorite gneiss, occurring at Minipi Lake, has an emplacement age of 1659 ± 5 Ma based on U–Pb dating of zircon (James *et al.*, 2000). However, it is possible the unit may also contain rocks having pre-Labradorian emplacement ages. Discovering pre-Labradorian rocks in the MMT is one of the goals of this project.

To determine the igneous emplacement age of one component of the $\mathrm{P_{MM}}$ mdq orthogneiss unit, a sample, Sample 1, was collected from a composite outcrop including granodiorite orthogneiss, a 1-m-wide granitic aplite dyke (Sample 2), and an undeformed, 30-cm-wide granitic pegmatite dyke (Plates 1 to 3; Figure 3). The Sample 1 orthogneiss is grey-weathering, foliated and variably gneissic. It contains biotite, hornblende, and accessory zircon and titanite. Gneissosity is defined by quartzofeldspathic layers. The orthogneiss contains common inclusions of gneissic meta-diorite.

Plate 3. *Sample 2 outcrop. To the right of the lens cap is the recrystallized granitic aplite dyke (Sample 2), which cuts gneissosity in host granodiorite orthogneiss (Sample 1). Sample 1 was collected approximately 5 m from the Sample 2 site.*

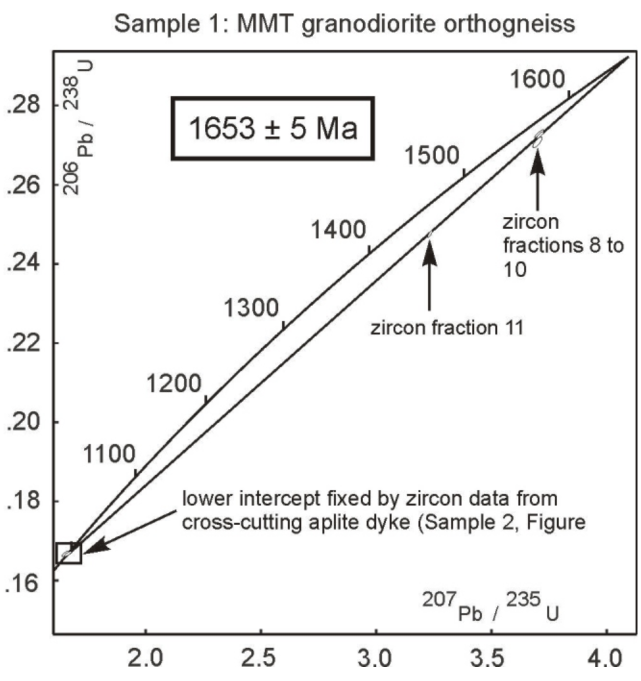

Figure 4. *U–Pb concordia diagram for Sample 1. Sample 1: field number - DJ-00-9006A, UTM - 560136 E, 5827039 N, Grid Zone 20, NAD 1927.*

Sample 1 contains abundant, equant to 2:1 prismatic, somewhat rounded "gem quality" zircon. Zircon fractions 8 to 11, including two single grain fractions and two fractions consisting of 3 grains each, gave varying degrees of discordant, colinear data (Table 1 and Figure 4). The $^{207}Pb/^{206}Pb$ ages for fractions 8 to 11 are 1597.5 ± 4.4, 3.1% discordant, 1602.0 ± 3.0, 3.4% discordant, 1607.9 ± 4.0, 4.5% discordant, and 1522.3 ± 3.4, 7.1% discordant. A regression line drawn through points defined by fractions 8, 9, and 11, gives upper- and lower-intercept ages of 1646 ± 110 and 958 ± 520 Ma, MSWD of 2.6 and probability of fit of 0.1. The point defined by fraction 10, which appears to drop slightly below the cluster of data points defined by the other fractions, possibly due to recent Pb loss, is omitted from this interpretation. Abundant titanite was recovered from Sample 1, but was not analyzed.

A better estimate for the timing of Pb loss in zircon and igneous emplacement for Sample 1 orthogneiss is obtained by using the zircon data from the Sample 2 aplite dyke (*discussed below*), and Sample 1 zircon fractions 8, 9 and 11. The age of emplacement for the aplite dyke is ca. 995 Ma (*discussed below*). A line drawn through fractions 8, 9, 11, and the four data points defined by data from the aplite zircons, gives upper- and lower-intercept ages of 1652.8 ± 5 Ma and 990 ± 4 Ma (34 percent probability of fit). The age of 1653 ± 5 Ma is considered the best estimate for time of granodiorite crystallization. Clearly, this rock is not pre-Labradorian, and the search for > 1720 Ma crust in the western MMT continues.

Sample 2: Aplite dyke, Mealy Mountains terrane (DJ-00-9006B)

Gneissosity in the granodiorite orthogneiss described above is cut by a 1-m-wide granitic aplite dyke. Thus, high-grade metamorphism and formation of the gneissosity in Sample 1 must predate emplacement of the dyke. The dyke is pink-weathering, fine to medium grained, and weakly foliated (Plate 3). The dyke is recrystallized.

Sample 2 contained a population of euhedral, pale brown, high-quality zircon grains. Four, concordant and overlapping data points are defined by zircon fractions 12 to 15 (Table 1 and Figure 5). The weighted mean $^{207}Pb/^{206}Pb$, $^{206}Pb/^{238}U$, and $^{207}Pb/^{235}U$ ages are 997 ± 2, 993.2 ± 1.6, and 994.3 ± 1.3 Ma, respectively. The data suggests that the best estimate for time of dyke emplacement is 995 ± 2 Ma, which is within the error limits of the three weighted mean ages. A small quantity of titanite was recovered from Sample 2, but was not analysed.

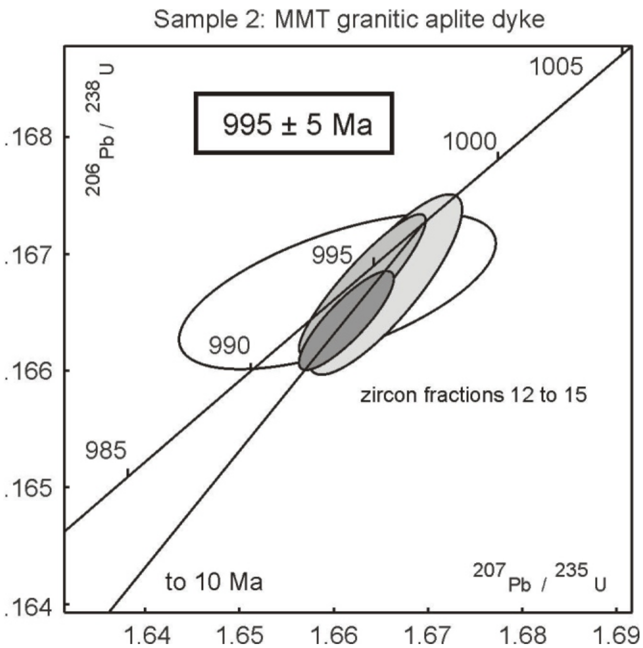

Figure 5. *U–Pb concordia diagram for Sample 2. Sample 2: field number - DJ-00-9006B, UTM - 560136 E, 5827039 N, Grid Zone 20, NAD 1927.*

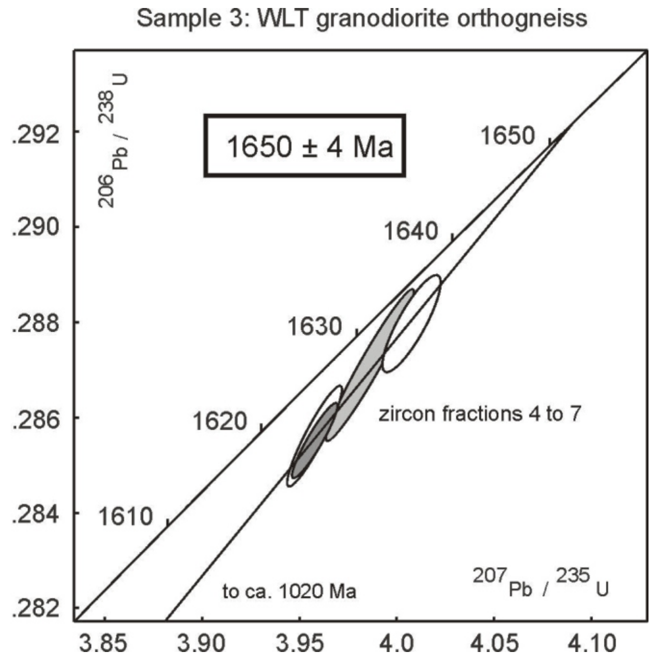

Figure 6. *U–Pb concordia diagram for Sample 3. Sample 3: field number - NK-00-8020, UTM - 553454 E, 5868200 N, Grid Zone 20, NAD 1927.*

Sample 3: Granodiorite orthogneiss, Wilson Lake terrane (NK-00-8020)

High-grade metasedimentary gneiss, which dominates the WLT (Figure 3), is locally intruded by meta-igneous rocks derived from granodiorite, diorite, and defined as unit P_{WL} ogn (James and Nadeau, 2001d). Generally, the meta-igneous rocks are grey-, white- and pink-weathering rocks, that are foliated and locally gneissic. Locally, rocks are migmatitic having <5-cm-thick layers of neosome and grey-weathering layers of paleosome containing biotite, hornblende, and possible clinopyroxene. The rocks locally contain K-feldspar augen presumed to be relicts of K-feldspar phenocrysts.

The emplacement age of P_{WL} ogn meta-igneous rocks is constrained by field relationships to be younger than the host metasedimentary gneisses and older than the upper amphibolite-facies event that overprints the rocks. The metamorphism is undated but presumed to be Labradorian on the basis of U–Pb dating by Corrigan *et al.* (1997).

A sample of granodiorite orthogneiss, Sample 3, from the P_{WL} ogn unit is a fine- to medium-grained rock containing K-feldspar augen, biotite and hornblende (Figure 3). The rock is foliated and gneissic. Sample 3 contained an abundance of clear, euhedral, and colourless zircons. Four zircon fractions, fractions 4 to 7 (Table 1 and Figure 6), gave $^{207}Pb/^{206}Pb$ ages of 1641.3 ± 3.2, 1637.0 ± 2.4, 1633.5 ± 2.8, and 1634.1 ± 1.6 Ma. These ages are 0.7%, 0.7%, 1.0%, and 1.0% discordant, respectively. A regression line calculated through the four data points gives upper- and lower-intercept ages of 1652 ± 27 Ma and 1086 ± 570 Ma, with a probability of fit of 1 and an MSWD of 0.2. The approximate lower intercept of 1086 Ma is an indication of Grenvillian-aged Pb loss, rather than recent Pb loss. If the time of Pb loss is anchored at ca. 1040 and ca. 990 Ma, the upper-intercept ages are 1651 ± 4 Ma and 1649 ± 3 Ma, respectively. A regression line having upper- and lower-intercept ages of 1650 ± 4 Ma and ca. 1020 Ma (Figure 6) straddles all of the possibilities. The upper-intercept age is interpreted to be the best age estimate for igneous emplacement of the granodiorite orthogneiss. The lower-intercept age is interpreted to represent the approximate age of Grenvillian metamorphism.

Sample 4: Lac Arvert syenite (DJ-00-7049)

The western MMT contains plutons of syenite defined as Unit M_{LG} sye (Figure 3). Locally, the plutons underlie prominent, rounded hills that rise up to 200 m above the surrounding peneplain. In some cases, plutons are associated with a pronounced magnetic anomaly. Outcrops are commonly marked by conspicuous horizontal jointing.

Plate 4. *Sample 4 outcrop. Typical field aspects of massive, coarse-grained Lac Arvert syenite at the Sample 4 location.*

Unit M_{LG} sye plutons consist of medium pink-weathering syenite to monzonite (Plate 4). Rocks are mainly coarse grained, massive, and have fresh, igneous textures, although weakly recrystallized rocks, and rocks having a weak foliation occur locally. In some rocks, the foliation may be a relict igneous fabric related to pluton emplacement. Rocks may contain up to 10 percent, medium-grained clinopyroxene, which is variably replaced by hornblende and minor biotite. Nepheline is suspected to occur in several outcrops in M_{LG} sye in the Senécal Lake map area (James *et al., this volume*). Magnetite is an ubiquitous accessory mineral.

A sample of syenite, herein named the Lac Arvert syenite, was collected for this study. The sample, designated as Sample 4, is a mainly coarse-grained, weakly recrystallized rock consisting of >85 percent coarse-grained microcline surrounded by finer grained, recrystallized microcline. The microcline is perthitic. The sample also contains minor amounts of fine-grained plagioclase, quartz, blue-green amphibole, biotite, accessory titanite and zircon. The sample is not foliated.

An abundant yield of high-quality zircons was recovered from Sample 4. Euhedral, equant to 2:1 prismatic grains containing melt inclusions were selected from the least magnetic fraction to be analysed for U and Pb. Clear, brown titanite was also recovered from the initial Franz fraction at 1.0° forward tilt, but was not analysed.

Three analyses (Fractions 1 to 3; Figure 7 and Table 1) including two single-grain fractions and one fraction of two grains, gave overlapping and concordant data with weighted mean ages of 982.5 ± 1.8 Ma ($^{206}Pb/^{238}U$ age), 980.5 ± 4.4 Ma ($^{207}Pb/^{235}U$ age), and 976 ± 13 Ma ($^{207}Pb/^{206}Pb$ age). Each data point is slightly reversely discordant, -1.3%, −0.4%, and −0.5%, respectively, and may give too young a Pb/Pb age if the discordance is due to an over-correction in the $^{207}Pb/^{204}Pb$ ratio. Thus, the Pb/U ratios, which are consistent and precise, give the best age estimate. Therefore, the best estimate for the time of zircon crystallization and emplacement of the Lac Arvert syenite is 982 ± 2 Ma.

DISCUSSION

The igneous emplacement age of a MMT granodiorite orthogneiss (Sample 1) of 1653 ± 5 Ma suggests the igneous protolith of this gneiss is related to the middle Labradorian MMIS. The age of the Sample 1 orthogneiss is identical, within error, to the 1659 ± 5 Ma igneous emplacement age of a MMIS monzodiorite orthogneiss at Minipi Lake, and to the 1650 ± 1 Ma age of a foliated, MMIS quartz monzodiorite from the Kenamu River map area (James *et al.*, 2000). Sample 1 orthogneiss is only slightly older than an undeformed, 1643 ± 2 Ma pyroxene-bearing, MMIS monzonite, also from the Kenamu River area (James *et al.*, 2000). The

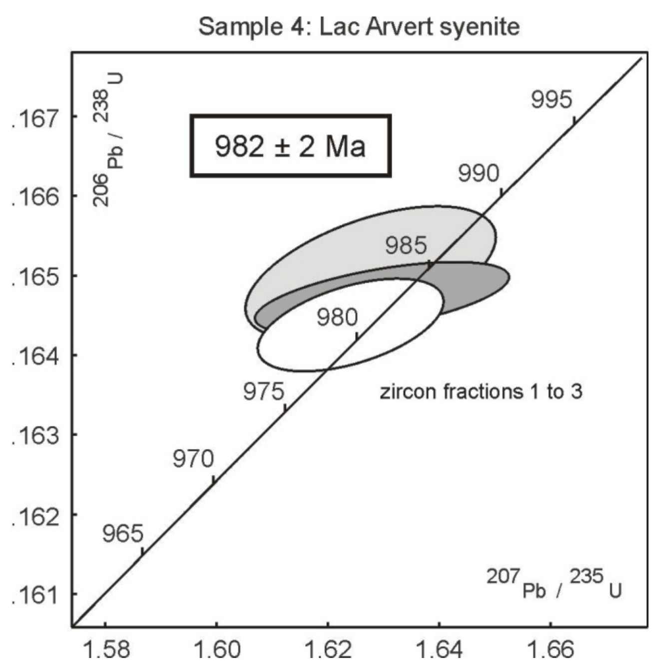

Figure 7. *U–Pb concordia diagram for Sample 4. Sample 4: field number - DJ-00-7049, UTM - 583279 E, 5790026 N, Grid Zone 20, NAD 1927.*

gneissosity in Sample 1 orthogneiss is constrained by field relationships to be older than a weakly deformed and recrystallized aplite dyke that cuts it and has an emplacement age of 995 ± 2 Ma. Thus, gneissosity in the host orthogneiss could be a late to middle Labradorian (1650 to 1600 Ma) or Grenvillian (1050 to 995 Ma) feature. More work is required to better understand the effects of Labradorian and Grenvillian metamorphism on rocks in the western MMT.

An augen-textured, granodiorite orthogneiss, Sample 3, from the WLT has an igneous emplacement age of 1650 ± 4 Ma. This age is identical, within error, to the age of the Sample 1, MMT granodiorite orthogneiss, although the similarity of ages does not constrain the WLT and MMT to be linked at that time. The two orthogneisses, represented by Samples 1 and 3, were intruded into different Labradorian settings; Sample 1 orthogneiss may form part of the MMIS, whereas the igneous protolith of the WLT orthogneiss intruded pre-Labradorian supracrustal rocks, which dominate the WLT. The igneous protolith of the WLT orthogneiss may correlate with the ca. 1650 Ma Trans-Labrador batholith.

The lower-intercept age defined by zircon data from the WLT orthogneiss is poorly constrained, although it suggests that this part of the WLT was overprinted by Grenvillian metamorphism sometime between 1080 and 1000 Ma. This is in agreement with U–Pb monazite data from the southeastern WLT demonstrating Grenvillian (ca. 1000 Ma) metamorphism (Corrigan *et al.*, 1997). The southeastern WLT is interpreted to be the structural footwall below the Hamilton River Shear Zone, which forms the southeastern tectonic contact with the overlying MMT (Wardle *et al.*, 1990; James and Nadeau, 2001d).

The 982 ± 2 Ma Lac Arvert syenite is weakly recrystallized but does not contain a tectonic foliation. The field data demonstrate that emplacement of the Lac Arvert syenite, and other M_{LG} sye plutons into the western MMT, largely postdates Grenvillian metamorphism and deformation in this region. Based on composition, age and evidence of recrystallization, the Lac Arvert syenite correlates with intrusions of an early posttectonic AMCG - mafic magmatic event defined by Gower *et al.* (2001). Some of the early posttectonic AMCG magmatic rocks, like the 974 ± 6 Ma fayalite-bearing Lower Pinware River alkali-feldspar syenite, are strongly foliated (Gower *et al.*, 2001), whereas other units, such as the Lac Arvert syenite are essentially undeformed. These contrasting relationships may indicate that the end of the Grenvillian deformation occurred at different times in the northeastern Grenville Province, although other interpretations, such as local differences in strain, could also be considered.

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