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SILURIAN COVER, LATE PRECAMBRIAN-EARLY ORDOVICIAN BASEMENT, AND THE CHRONOLOGY OF SILURIAN OROGENESIS IN THE HERMITAGE FLEXURE (NEWFOUNDLAND APPALACHIANS)

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ABSTRACT. Redefining the La Poile Group as an Early-Late Silurian (429 ± 2 Ma to 422 ± 2 Ma) terrestrial volcanosedimentary succession and establishing its external relationships has led to its recognition as a cover sequence developed upon a basement complex. Basal La Poile Group conglomerate rests nonconformably on Late Precambrian basement granite (578 ± 10 Ma), which crosscuts undated high-grade amphibolitic gneiss and low-grade sedimentary and volcanic rocks. This composite sub-La Poile Group basement also contains early Paleozoic plutonic constituents, the youngest of which is Early Ordovician (495 ± 2 Ma) in age, that delimit discrete pre-Silurian tectonothermal events within the complex. Early Silurian granites (429 ± 2 Ma; 430 ± 2 Ma), which are in part synchronous with the accumulation of subaerial cover deposits, are restricted to the sub-La Poile basement and have been affected, in places, by mesozonal synplutonic shear zones. Later Silurian plutons were emplaced syntectonically during regional deformation and dynamothermal metamorphism of the Silurian cover and contemporaneous remobilization of its basement. Thrust imbrication of cover and basement, which was preferentially sited along the fault zones that bound the La Poile Group, occurred shortly after deposition, prior to the emplacement of Late Silurian granite porphyry (418 + 2/ −1.5 Ma). The older Silurian granites and the thrust-imbricated assemblage of basement and cover are crosscut by Late Silurian granite plutons (419 ± 2 Ma); all have been affected by further inhomogeneous ductile deformation that predates the posttectonic intrusion of Early Devonian granite (390 ± 3 Ma).

The Silurian La Poile Group and its underlying Late Precambrian-Early Ordovician basement delimit the southern extent of the medial Ordovician Dunnage Zone in the southwest Hermitage Flexure region of the Newfoundland Appalachians. The sub-La Poile basement and its cover, both of which overthrust Dunnage Zone rocks, were variably deformed and metamorphosed during a climactic Silurian orogeny sited along the exposed northwestern margin of a composite Avalonian crustal block.

INTRODUCTION

In most regional geological syntheses, the Appalachian orogen on the Island of Newfoundland is divided into four major tectonostratigraphic zones each with unique Ordovician history (Williams, 1979). The Humber Zone, the westernmost division, consists of a late Precambrian-Ordovician cover developed on a Grenville crystalline basement and

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records rift- and drift-related deposition on the passive, Laurentian continental margin (Williams and Stevens, 1974). Eastward, the Dunnage and Gander Zones include the vestiges of the Paleozoic Iapetus Ocean (Harland and Gayer, 1972) and, possibly, elements of its eastern margin (Kennedy, 1976). The Dunnage Zone was juxtaposed with the Humber Zone in the west (Williams, 1975) and the Gander Zone in the east (Williams and Piasecki, 1990; Dec and Colman-Sadd, 1990) during the Ordovician, although significant tectonic interaction occurred subsequently (Cawood and Williams, 1988; Colman-Sadd and Swinden, 1984). The Avalon Zone is generally viewed as an exotic terrane of Pan-African affinity (O'Brien, Wardle, and King, 1983), whose Precambrian rocks record events occurring in the Grenvillian-Appalachian time gap. Juxtaposition with inboard Appalachian elements has been considered to be the result of Devonian accretion (Williams and Hatcher, 1983).

The Eastern Crystalline Belt (Brown and Colman-Sadd, 1976), which includes rocks assigned to the Gander Zone in the northeast and the Dunnage Zone in the southwest (compare Colman-Sadd, Hayes, and Knight, 1990), denotes the sinuous tract of complexly deformed magmatic and metamorphic rocks that lies adjacent to the Avalon Zone. Much controversy surrounds the age and nature of the oldest rocks in this belt and whether or not such rocks constitute basement to the Paleozoic vestiges of the Iapetus Ocean. The most widely held view (Hanmer, 1981; Blackwood, 1982, 1985; Chorlton, 1982; Chorlton and Dallmeyer, 1986) is that all the medium- to high-grade metamorphic rocks of the Eastern Crystalline Belt are associated with a regional plexus of granitic intrusions and represent the deepest exposed levels of a prograde metamorphic assemblage, whose protolith was Iapetan arc, ophiolite, and continental margin assemblages, mainly of Ordovician age. This interpretation challenged previously held views that the gneissic rocks of the Eastern Crystalline Belt constitute a Precambrian basement that lies beneath a variably metamorphosed, early- to mid-Paleozic cover succession (Brown, 1973; Brown and Colman-Sadd, 1976; Kennedy, 1975, 1976).

It is further held that conformable and gradational relationships locally exist between Ordovician Iapetan arc-related turbidites (Davidsville Group) of the eastern Dunnage Zone (Exploits Subzone of Williams, Colman-Sadd, and Swinden, 1988) and continental margin successions of the Gander Zone (Gander Group; Blackwood, 1982). Similarly, conformable relationships are reported between these Ordovician arc-related rocks and Silurian marine to terrestrial strata (Botwood Group; Williams, 1962, 1972). The regional metamorphism of all these rocks has been generally considered to be Devonian in age, related to the Acadian Orogeny (Blackwood, 1982; Dallmeyer, Blackwood, and Odom, 1981; Chorlton and Dallmeyer, 1986). This hypothesis implies the existence, at least locally, of stratigraphic, structural, and metamorphic continuity across the Eastern Crystalline Belt.

Extending from northeast to southwest Newfoundland, the Eastern Crystalline Belt follows a curvilinear trend that defines the Hermitage

Flexure (fig. 1; Williams, Kennedy, and Neale, 1970; Brown and Colman-Sadd, 1976). In southwest Newfoundland, Middle Ordovician volcanosedimentary assemblages, which are coextensive with Dunnage Zone rocks in northeast Newfoundland (O'Brien, Dickson, and Blackwood, 1986), are affected by a climactic Silurian orogenic event (Dunning and others, 1988, 1990). The medium- to high-grade regional metamorphism and related nappe-style deformation of the Ordovician strata was synchronous with Silurian magmatism, represented by the generation and emplacement of syntectonic granites and the eruption of thick subaerial volcanic sequences. However, south of the main Ordovician tract (Bay du Nord Group) in the west-central Hermitage Flexure, a unique zone of Late Precambrian and earliest Paleozoic crust is either preserved as enclaves in Silurian granite or is directly juxtaposed with Silurian strata (Dunning and O'Brien, 1989; O'Brien and O'Brien, 1989, 1990b).

This paper presents results of an on-going study of the Silurian and Precambrian rocks in southwest Newfoundland, integrating previously published U-Pb geochronology from the southern Hermitage Flexure area (Dunning and O'Brien, 1989; Dunning and others, 1988,1990). We focus here on the redefinition and reinterpretation of the La Poile Group, previously considered as part of the mid-Ordovician Iapetan arc sequence (Chorlton, 1978, 1980; Chorlton and Dallmeyer, 1986). Redefining this group, establishing its external boundaries, and calibrating its magmatic history, are critical to understanding orogenesis along the Eastern Crystalline Belt.

PREVIOUS DEFINITIONS OF THE LA POILE GROUP

Cooper (1954) first proposed the name "La Poile" for a group of sedimentary and volcanic rocks he mapped northeast of La Poile Bay, on the southwest coast of Newfoundland (fig. 2). It was his view that the group cropped out within a regional synclinorium, underlain to the north and south by metasedimentary and metavolcanic rocks, which he included in the Bay du Nord Group; he assigned the latter a Lower or early Middle Devonian age. Cooper (1954) divided the La Poile Group into basal conglomeratic, intermediate clastic-pyroclastic, and upper volcanic-dominated units, without formally defining the group. He inferred that the La Poile Group unconformably overlay the Bay du Nord Group.

Chorlton (1978, 1980) expanded the La Poile Group to include clastic and metabasic rocks that Cooper had interpreted as equivalents of the Bay du Nord Group, as well as granite and quartz-feldspar porphyry that Cooper stated to be younger than both groups. Chorlton (1978, 1980) established a stratigraphic discontinuity between Devonian strata, subsequently renamed Billiard's Brook Formation, and the Bay du Nord Group. Her redefined Bay du Nord Group excluded these fossiliferous rocks, which were the basis of Cooper's Devonian age assignment. Chorlton (1980) reported Ordovician Rb/Sr ages for the La Poile Group

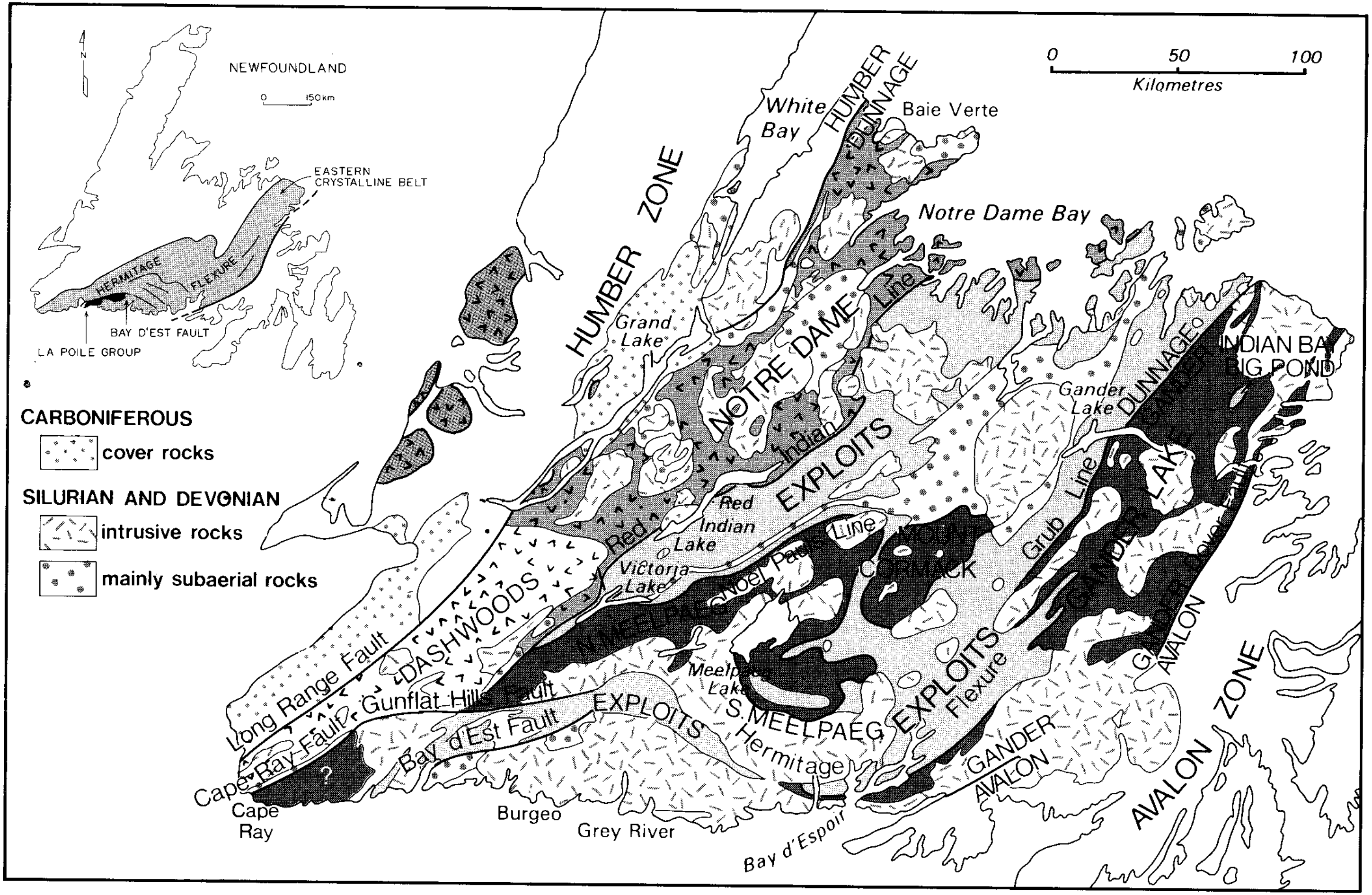
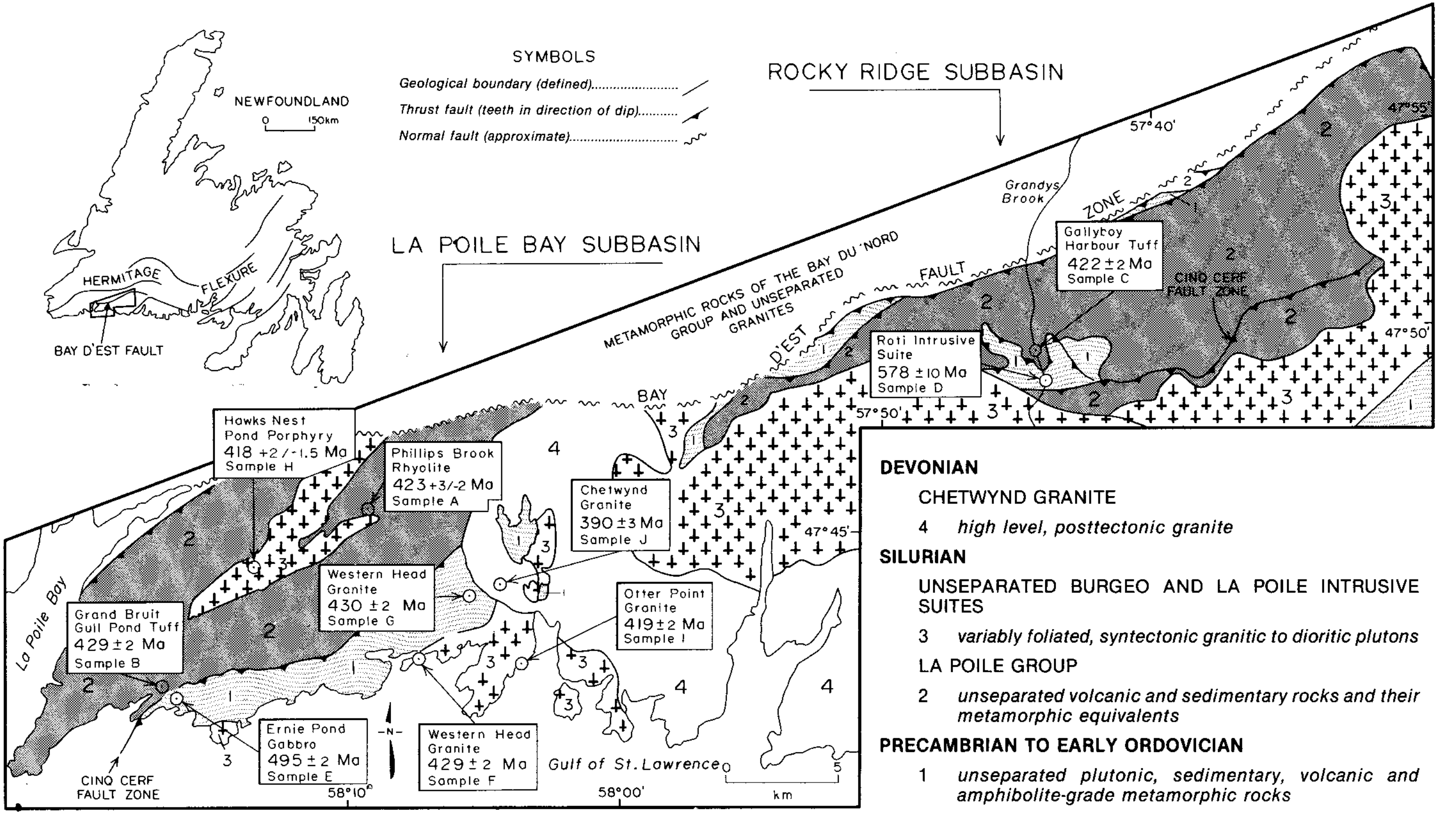


Fig. 1. Tectonostratigraphic divisions of Newfoundland, highlighting subdivisions of the Gander and Dunnage zones (from Williams and Piasecki, 1990). Inset shows distribution of the Eastern Crystalline Belt of Brown and Colman-Sadd (1976).



NEWFOUNDLAND
0 150km
HERMITAGE
FLEXURE
BAY D'EST FAULT
SYMBOLS
Geological boundary (defined)
Thrust fault (teeth in direction of dip)
Normal fault (approximate)
ROCKY RIDGE SUBBASIN
LA POILE BAY SUBBASIN
METAMORPHIC ROCKS OF THE BAY DU NORD GROUP AND UNSEPARATED GRANITES
BAY D'EST FAULT ZONE
Grandys Brook
CINQ CERF FAULT ZONE
Gallyboy Harbour Tuff 422 ±2 Ma Sample C
Roti Intrusive Suite 578 ±10 Ma Sample D
Hawks Nest Pond Porphyry 418 +2/-1.5 Ma Sample H
Phillips Brook Rhyolite 423 +3/-2 Ma Sample A
Chetwynd Granite 390 ±3 Ma Sample J
Western Head Granite 430 ±2 Ma Sample G
Otter Point Granite 419 ±2 Ma Sample I
Grand Bruit Gull Pond Tuff 429 ±2 Ma Sample B
Ernie Pond Gabbro 495 ±2 Ma Sample E
Western Head Granite 429 ±2 Ma Sample F
La Poile Bay
Gulf of St. Lawrence
CINQ CERF FAULT ZONE
57°40'
47°55'
47°50'
57°50'
47°45'
58°00'
58°10'
N
0 5 km
DEVONIAN
CHETWYND GRANITE
4 high level, posttectonic granite
SILURIAN
UNSEPARATED BURGEO AND LA POILE INTRUSIVE SUITES
3 variably foliated, syntectonic granitic to dioritic plutons
LA POILE GROUP
2 unseparated volcanic and sedimentary rocks and their metamorphic equivalents
PRECAMBRIAN TO EARLY ORDOVICIAN
1 unseparated plutonic, sedimentary, volcanic and amphibolite-grade metamorphic rocks

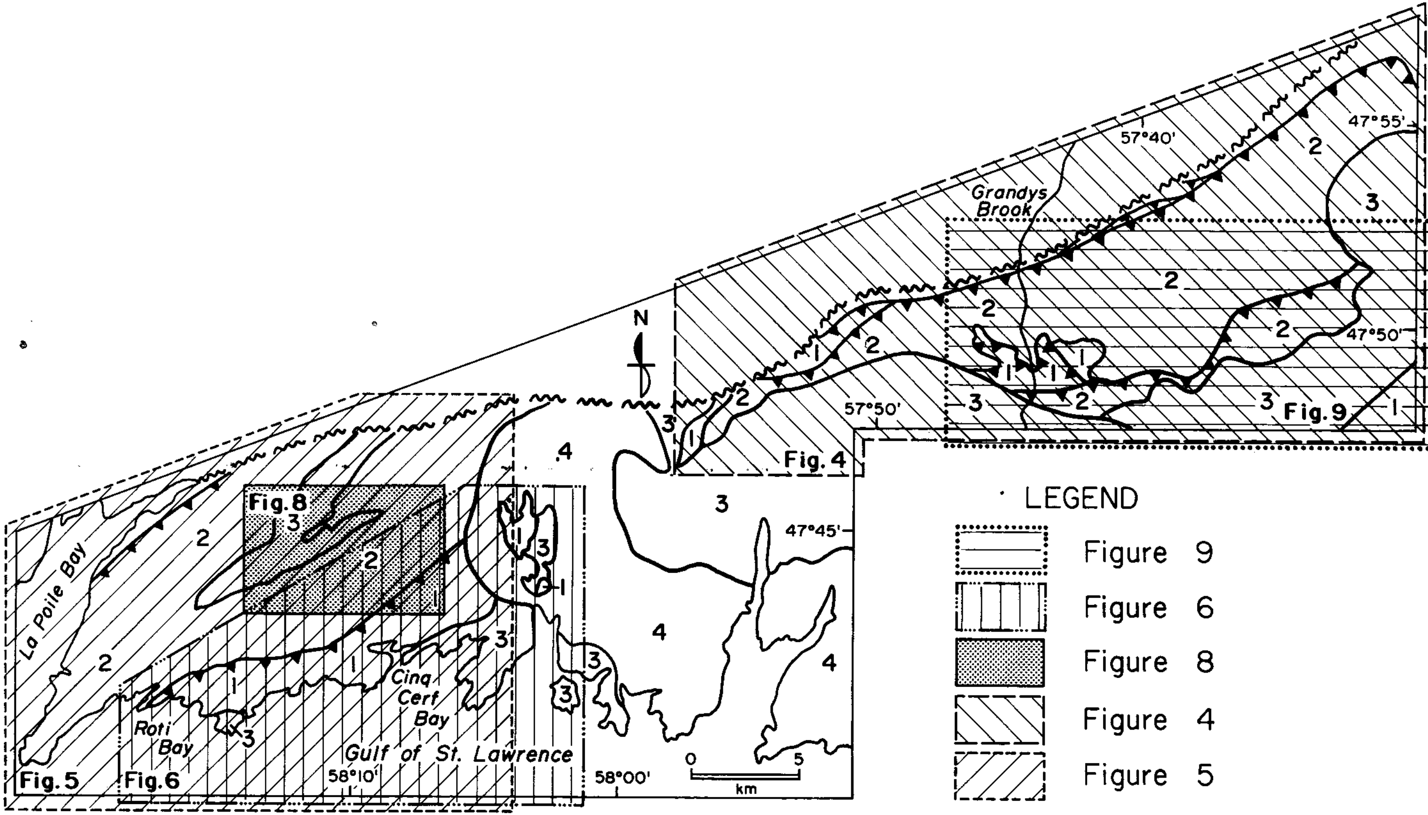


Fig. 2. Simplified geological map of the region south of the Bay d'Est Fault Zone showing the disposition of the Silurian La Poile Group and other major rock units (modified after O'Brien and O'Brien, 1989). The locations, names, and ages of rocks dated in this study are also indicated.

and the adjacent Bay du Nord Group, and, on this basis, she correlated both groups.

Intrusive contacts between the Roti Granite of Cooper (1954) and low-grade stratified rocks were described by Chorlton (1978, 1980), who also documented the presence of clasts of Roti Granite in what she inferred to be equivalent strata. On the basis of these relationships, she chose to include this distinctive blue-quartz-phyric granitoid and the intruded strata within her Ordovician La Poile Group, invoking a model of hypabyssal intrusion and unroofing into an evolving comagmatic volcanic carapace. Chorlton (1978) also included within the group porphyritic microgranite intrusions of the Hawks Nest Pond Porphyry that she originally interpreted as subvolcanic intrusions, comagmatic with La Poile Group volcanism. However, she considered other intrusions into the group (Otter Point Granite; Ernie Pond Gabbro) to be significantly younger than La Poile volcanism and sedimentation. Amphibolitic gneiss, schist, and granodiorite (Cinq Cerf Complex of Chorlton, 1978) adjacent to and south of Chorlton's La Poile Group had been previously interpreted by Cooper (1954) as products of high grade tectonism of the Bay du Nord Group, which occurred prior to La Poile deposition. In contrast, Chorlton (1978) interpreted the Cinq Cerf Complex to be younger than her La Poile Group and speculated that some of the Cinq Cerf metamorphic rocks were of La Poile protolith. She stated that formation of the complex occurred between intrusion of the Ernie Pond Gabbro and the Otter Point Granite (Chorlton, 1978).

More recently, Dunning and others (1988, 1990) reported U-Pb isotopic ages on the upper volcanic unit of the La Poile Group as defined by Cooper (1954), which demonstrate that at least part of the group is Silurian. Cooper's (1954) Roti Granite was subsequently discovered to contain two cross-cutting, lithologically distinct plutons, dated as Late Precambrian and Early Ordovician, which were assigned to the Roti Intrusive Suite (Dunning and O'Brien, 1989). This data challenged previously published interpretations of the Roti Granite (Cooper, 1954; Chorlton, 1978) and its relationships with La Poile Group strata, thus highlighting the need to reinterpret and redefine the group and reassess the nature of its boundaries. Some of the principal results of the authors' work to this end are presented below.

U-Pb GEOCHRONOLOGY RESULTS

Analytical procedures used in this study are as described in Dunning and others (1990). Lines were calculated using the program of Davis (1982), and uncertainties on the ages are reported at the 95 percent confidence interval.

Stratified rocks.—Samples were collected from two stratigraphic units in the informal type area of the La Poile Group east of La Poile Bay (fig. 2); namely, the Phillips Brook Rhyolite and the Grand Bruit Gull Pond Tuff (O'Brien, 1988). A third sample was collected from equivalents of the Gallyboy Harbour Tuff (O'Brien, 1988; O'Brien and O'Brien, 1989, 1990b) in the northeastern outcrop area of the La Poile Group, near Grandy's Brook (fig. 2).

Phillips Brook Rhyolite: A sample (A) of finely banded rhyolite yielded two fractions of abraded clear stubby euhedral zircon and two fractions of clear prism fragments (table 1). They define a discordia line with a 25 percent probability of fit (fig. 3A), which yields an upper intercept age of crystallization of 423 +3/−2 Ma.

Grand Bruit Gull Pond Tuff: One fraction each of abraded prism fragments and clear euhedral prisms were separated from a sample (B) of quartz-phyric lithic tuff. Analyses are concordant with ^{207}PB/^{206}Pb ages of 429 and 431 Ma respectively (fig. 3B). The ^{206}Pb/^{238}U age of 427.4 Ma for the fragments is a younger age limit for the rock, and an age of crystallization of 429 ± 2 Ma is determined from these data.

Gallyboy Harbour Tuff: A sample (C) of recrystallized biotite schist, the protolith of which was a quartz-feldspar crystal tuff, yielded an unequivocal igneous population of euhedral zircons and abundant titanite. Two abraded fractions of euhedral zircon are concordant and yield an age of 422 ± 2 Ma (fig. 3C). The titanite has a high common Pb content, but the ^{206}Pb/^{238}U age, which is least affected by uncertainty in the common Pb correction, is 419 ± 3 Ma. 422 ± 2 Ma is interpreted as the age of igneous crystallization of the protolith of the schist.

Intrusive rocks.—Samples for U-Pb dating were collected from six plutons, five of which are ductilely deformed syntectonic intrusions (fig. 2). One of these, the Hawks Nest Pond Porphyry, crosscuts folds of the Phillips Brook Rhyolite of the La Poile Group. Three other variably foliated and metamorphosed plutons (Ernie Pond Gabbro, Otter Point Granite, and Western Head Granite) intrude various Precambrian rocks that occur immediately south of the La Poile Group. The fifth pluton, a granodiorite of the Roti Intrusive Suite, was sampled near its contact with the La Poile Group in the latter's northeastern outcrop area. The sixth dated pluton, the posttectonic Chetwynd Granite, was sampled approx 1 km from its contact with Precambrian rocks.

Roti Intrusive Suite: A sample of foliated granodiorite (D) yielded clear euhedral zircon and high quality titanite. Three fractions of euhedral abraded zircon are clustered opposite ^{206}Pb/^{238}U ages of 534 to 548 Ma (fig. 3D). They appear to represent an igneous population but are not co-linear, and it is interpreted that analysis 10 (table 1) contains inherited older zircon. Two abraded titanite fractions yield ^{207}Pb/^{206}Pb ages of 423 and 421 Ma with corresponding ^{206}Pb/^{238}U ages of 417 and 418 Ma. Analysis 13 is concordant, and an age of 421 ± 3 Ma is indicated for this metamorphic event.

Assuming that Pb-loss from the zircons occurred at the time of this metamorphism, a line projected from 421 Ma through the zircon fractions 11 and 12 yields an upper intercept age of crystallization of the igneous protolith of 578 ± 10 Ma.

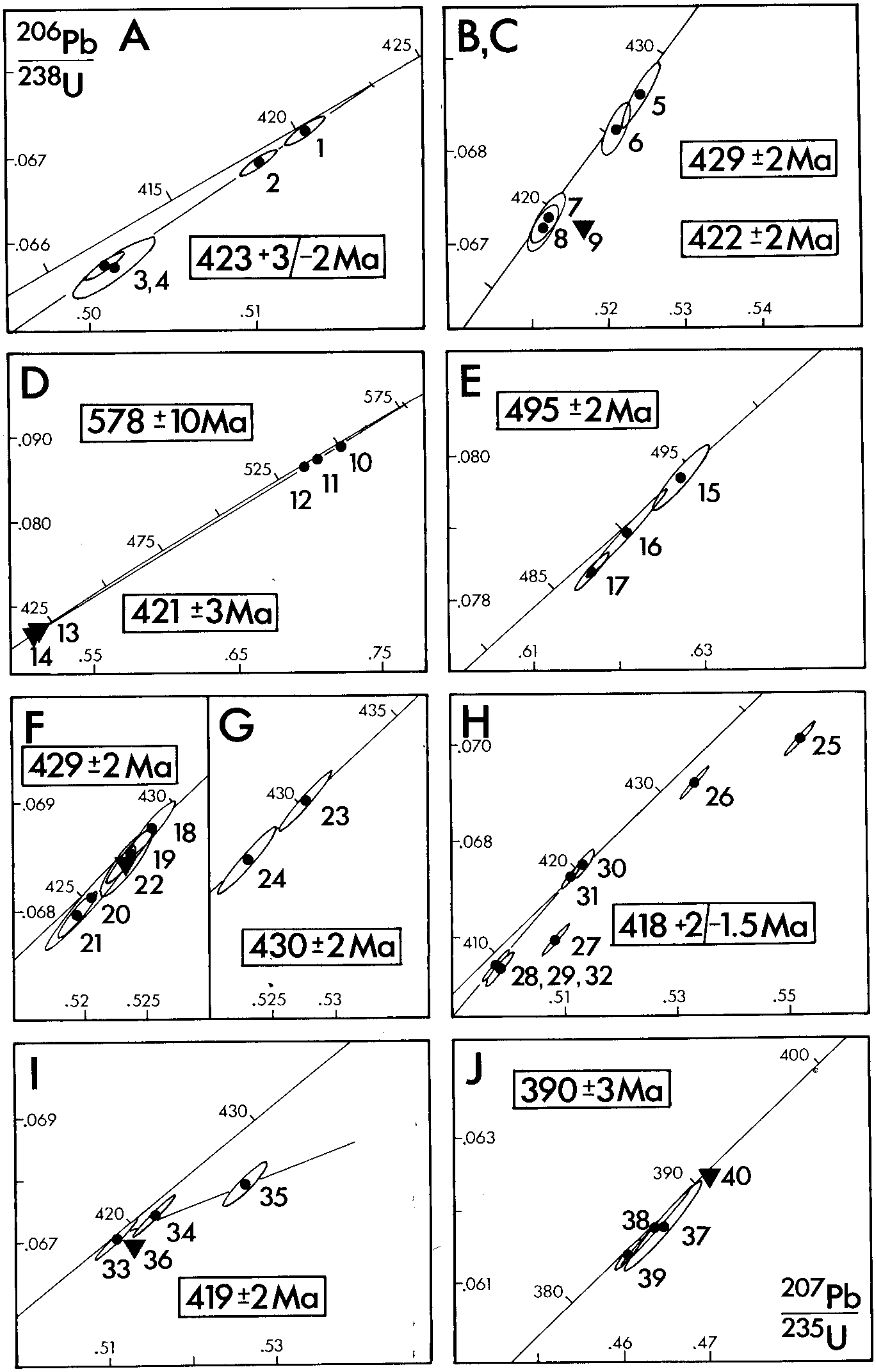


Fig. 3. Concordia diagrams with data from the La Poile Group (A–C), the sub-La Poile Group basement (D–E), the La Poile Intrusive Suite (F–I), and the Chetwynd Granite (J). A–Phillips Brook Rhyolite, B–Grand Bruit Gull Pond Tuff, C–Gallyboy Harbour Tuff, D–Roti Intrusive Suite, E–Ernie Pond Gabbro, F and G–Western Head Granite, H–Hawks Nest Pond Porphyry, I–Otter Point Granite.

Ernie Pond Gabbro: A sample (E) of medium grained hornblende gabbro yielded coarse angular fragments of zircon and euhedral zircon prisms. Two abraded and one unabraded fraction of zircon fragments are 0.25 to 1.6 percent discordant and yield $^{207}Pb/^{206}Pb$ ages of 495 or 494 Ma (fig. 3E). These indicate an age of 495 ± 2 Ma for crystallization of this intrusion.

Western Head Granite: A sample (F) of biotite-hornblende granodiorite from the main body of this pluton yielded four fractions of high quality euhedral zircon. Three fractions were abraded, and these are concordant to 1.3 percent discordant and yield $^{207}Pb/^{206}Pb$ ages of 428.5 to 429.3 Ma (table 1). One abraded titanite fraction yields an age of 430 Ma. The age of crystallization of this pluton is 429 ± 2 Ma (fig. 3F).

Zircons were also separated from a sample (G) of quartz-feldspar porphyry that forms a small apophysis that crosscuts Precambrian gneissic rocks. Two fractions of clear euhedral zircon from the sample were analyzed, and both are concordant at 430 and 428 Ma, respectively (fig. 3G). An age of crystallization of 430 ± 2 Ma is indicated for this satellite body, with the uncertainty covering both data points.

Hawks Nest Pond Porphyry: A sample of biotite-bearing quartz-feldspar porphyry (H) yielded a large amount of clear to cracked euhedral zircon. Eight fractions were analyzed of which numbers 25 to 29 display varying proportions of inherited Proterozoic zircon (table 1). Inheritance was encountered, despite selecting flat prisms or needles for analysis to avoid grains with cores. Fractions 30 and 31 of long euhedral needles, which were abraded, are concordant with $^{207}Pb/^{206}Pb$ ages of 418 and 419 Ma (table 1). A line with a 60 percent probability of fit, through three fractions (30–32) of needle-like zircon, yields an upper intercept age of crystallization of 418 +2/−1.5 Ma (fig. 3H).

Otter Point Granite: This sample (I) of K-feldspar porphyritic, biotite granite yielded clear euhedral zircon and titanite. Two fractions of euhedral abraded zircon are discordant while a third fraction (analysis 33), composed of abraded tips of prisms, overlaps concordia with a $^{207}Pb/^{206}Pb$ age of 422 Ma and a $^{206}Pb/^{238}U$ age of 419 Ma. A line, with a 36 percent probability of fit, through these fractions indicates a lower intercept age of crystallization of 419 ± 2 Ma (fig. 3I). The upper intercept age of 1952 Ma is the average age of inherited Proterozoic zircon occurring as cores in some of the grains. One fraction of abraded titanite is discordant due to uncertainty in the isotopic composition of common Pb with which to correct for initial common Pb in the grains, but the more reliable $^{206}Pb/^{238}U$ age of 418 ± 2 Ma is the same as the zircon intercept age.

Chetwynd Granite: A sample (J) of medium grained, equigranular, biotite granite (fig. 3J) yielded abundant, clear euhedral prismatic

TABLE 1

U-Pb data

FRACTIONS			CONCENTRATIONS		MEASURED		ATOMIC RATIOS***							AGE [Ma]
No.	Properties	Wt. [mg]*	U [ppm]	Pb rad [ppm]	total common Pb (pg)	$^{206}Pb/^{204}Pb$**	$^{208}Pb/^{206}Pb$	$^{206}Pb/^{238}U$	+/-	$^{207}Pb/^{235}U$	+/-	$^{207}Pb/^{206}Pb$	+/-	$^{207}Pb/^{206}Pb$
A.	**PHILLIPS BROOK RHYOLITE** (E414070 N528994)													
1	N3 clr euhed prisms Abr	0.149	166	14.6	9	11505	.4580	.06730	13	.5129	12	.05527	6	423
2	N3 clr euhed prisms Abr	0.151	189	16.9	9	12593	.4906	.06693	15	.5101	12	.05528	5	423
3	M3 -200 clr frags	0.474	191	16.7	164	2212	.4809	.06574	15	.5009	12	.05526	5	423
4	M3 clr euhed prisms	0.379	200	17.6	100	3205	.5031	.06571	32	.5015	25	.05535	13	426
B.	**GRAND BRUIT GULL POND TUFF** (E404800 N5281800)													
5	M1 -100 frags Abr	0.093	151	13.1	41	1482	.4101	.06854	32	.5242	26	.05547	10	431
6	M1 M3 -100 clr prisms Abr	0.091	146	12.5	18	3195	.4040	.06819	24	.5210	18	.05542	13	429
C.	**GALLYBOY HARBOUR TUFF** (E444800 N5295850)													
7	N0 -100 clr euhed Abr	0.133	211	16.4	33	3605	.2872	.06726	27	.5123	21	.05524	9	422
8	N0 -100 clr needles Abr	0.129	236	18.8	38	3393	.3238	.06715	23	.5116	18	.05525	10	422
9	M1.7A lt brn titanite Abr	0.589	114	8.3	2488	132	.1966	.06714	23	.5169	49	.05584	44	446
D.	**ROTI INTRUSIVE SUITE** (E444750 N5295450)													
10	M0 clr euhed Abr	0.101	203	19.6	5	22620	.2041	.08874	28	.7220	25	.05902	6	568
11	M0 clr euhed prisms Abr	0.101	244	22.9	12	11032	.1912	.08736	46	.7051	38	.05854	8	550
12	M0 clr euhed Abr	0.089	280	25.7	9	14805	.1735	.08640	44	.6957	35	.05840	10	545
13	M1.7A brn titan Abr	0.362	343	25.6	307	1714	.2406	.06706	28	.5106	23	.05522	8	421
14	M1.7A brn titan Abr	0.717	368	27.6	677	1647	.2482	.06685	29	.5095	23	.05527	10	423
E.	**ERNIE POND GABBRO** (E405250 N5281600)													
15	M0 clr euhed frags Abr	0.163	124	11.9	10	10484	.3442	.07968	43	.6273	34	.05710	11	495
16	M0 clr chips + euhed Abr	0.220	157	14.9	26	6486	.3371	.07892	60	.6209	48	.05706	6	494
17	M0 clr prism frags + tips	0.374	161	15.0	16	18928	.3227	.07839	23	.6168	20	.05706	6	494
F.	**WESTERN HEAD GRANITE** (E415100 N5282900)													
18	M0 -100 clr euhed Abr	0.199	267	19.1	101	2286	.1515	.06876	21	.5253	18	.05540	7	429
19	M0 -100 stubby euhed Abr	0.244	248	17.8	14	19079	.1584	.06853	25	.5237	20	.05542	6	429
20	M0 -100 long prisms Abr	0.107	279	20.1	10	12710	.1757	.06813	48	.5205	37	.05541	9	429
21	M0 -200 euhed 2:1 prisms	0.114	333	23.4	9	17997	.1471	.06797	19	.5194	16	.05542	6	429
22	M1.7A brn titan Abr	0.178	403	34.0	544	583	.3754	.06845	23	.5233	23	.05545	12	430

G.	**WESTERN HEAD QUARTZ-FELDSPAR PORPHYRY** (E418850 N5285050)													
23	clr euhed Abr	0.260	700	50.9	34	22904	.1690	.06903	26	.5276	21	.05543	5	430
24	clr euhed Abr	0.104	611	43.0	10	26236	.1387	.06848	30	.5230	23	.05538	7	428
H.	**HAWKS NEST POND PORPHYRY** (E408580 N528710)													
25	M1 -100 clr euhed Abr	0.355	159	10.6	30	8004	.0533	.07005	30	.5523	28	.05718	9	499
26	M1 -100 prism tips Abr	0.187	180	13.8	23	6162	.2367	.06916	28	.5334	26	.05593	10	450
27	M1 -100 flat + prism tips	0.340	195	14.3	78	3410	.2299	.06593	29	.5084	30	.05593	11	449
28	M1 -100 cracked needles	0.390	267	19.2	330	1260	.2208	.06534	26	.4984	28	.05533	10	425
29	M1 -100 clr needles + frags	0.250	219	16.0	61	3517	.2476	.06536	31	.4986	26	.05532	12	425
30	N0 -100 clr needles Abr	0.021	282	20.9	9	2767	.2204	.06749	26	.5134	23	.05518	13	419
31	N0 -100 euhed needles Abr	0.092	204	15.4	20	3886	.2500	.06724	22	.5112	19	.05514	8	418
32	M1 -100 cracked needles	0.317	328	23.4	125	3281	.2109	.06542	31	.4978	30	.05519	11	420
I.	**OTTER POINT GRANITE** (E420910 N528252)													
33	M1 -100 clr prism tips Abr	0.186	279	20.6	16	13034	.2233	.06707	27	.5108	29	.05524	10	422
34	M1 -100 clr euhed Abr	0.531	257	19.2	46	11947	.2312	.06744	26	.5153	30	.05542	9	429
35	M1 -100 clr euhed Abr	0.126	280	21.0	135	1086	.2268	.06794	28	.5262	26	.05617	14	459
36	M1.0A brn titan Abr	0.668	74	15.9	1238	179	2.6587	.06695	25	.5130	60	.05557	55	435
J.	**CHETWYND GRANITE** (E420000 N5286100)													
37	N1 -100 tips + crack frags	0.269	419	28.3	53	8291	.2156	.06178	62	.4646	46	.05455	12	394
38	N1 -100 clr euhed Abr	0.431	336	23.1	20	28532	.2381	.06177	57	.4637	43	.05445	5	390
39	M1 -70 clr euhed Abr	0.476	287	19.5	31	17055	.2284	.06139	19	.4604	16	.05439	6	387
40	M1.0A titan. clr brown Abr	0.366	75	11.0	1022	124	1.6370	.06247	20	.4702	51	.05459	51	395

Notes: N, M = non-magnetic, magnetic fractions; 0,1 indicate degrees of tilt on a Frantz isodynamic separator; -100 = grain size between 100 and 200 mesh; Abr= abraded sample (cf. Krogh 1982). Sample UTM coordinates are reported in brackets.

* Uncertainty in weight +/- 0.003 mg (1 sigma).

** Corrected for fractionation and common Pb in the spike

*** Corrected for fractionation and spike, 5- 10 pg Pb laboratory blank and initial common lead calculated from the model of Stacey and Kramers (1975) and 2 pg U blank. 2 sigma uncertainties on the isotopic ratios calculated with the procedure of Ludwig (1980) are reported after the ratios and refer to the final digits.

zircon with a high proportion of cracked grains. Three fractions (table 1, analyses 37–39) overlap (fig. 3J) and yield $^{207}Pb/^{206}Pb$ ages from 387 to 394 Ma. An abraded titanite fraction (analysis 40) is concordant with a $^{206}Pb/^{238}U$ age of 391 Ma. The crystallization age of this intrusion is 390 ± 3 Ma, significantly older than the $^{40}Ar/^{39}Ar$ (biotite) age of 372 ± 5 Ma of Chorlton and Dallmeyer (1986).

LA POILE GROUP: THE COVER

The La Poile Group redefined.—The data presented in this paper demonstrate that inconsistencies exist between previously reported contact relationships and age assignments among the wide spectrum of rocks historically assigned to the La Poile Group. These highlight three fundamental errors in previous attempts to define the group. The first error is the inclusion, within a single lithostratigraphic unit, of rocks of significantly different absolute ages and tectonothermal histories; for example, the assignment of late Precambrian granite and low-grade country rocks to the La Poile Group (Chorlton, 1978). The second is the deduction of incorrect external stratigraphic relationships; for example, the relationship of the Devonian or younger La Poile Group of Cooper (1954) to his Bay du Nord Group. The third is the assignment of an incorrect absolute age to the La Poile Group, either on the basis of incorrect regional correlations (Devonian by Cooper, 1954) or erroneous geochronological data (Ordovician by Loveridge and Chorlton, 1985; Chorlton and Dallmeyer, 1986).

The name La Poile is retained for that group of low-grade volcanic and sedimentary rocks of Silurian age and their higher-grade metamorphic equivalents that occur south of the Bay d'Est Fault Zone, in the west-central portion of the Hermitage Flexure (figs. 1 and 2). As informally redefined, the La Poile Group is a conformable lithostratigraphic sequence of subaerial felsic volcanic and associated epiclastic rocks and crossbedded quartz-rich clastic sedimentary rocks of fluvial and alluvial origin (O'Brien, 1983, 1988, 1989; O'Brien and O'Brien, 1990b). Most of the succession consists of chlorite-grade phyllitic rocks with well preserved primary features. Because of lateral pinch-outs, lithostratigraphic units display primary split and wedge shapes. Thus, internal stratigraphic order and stratigraphic thickness of individual component units, as well as the group as a whole, are variable along its strike length. Total thickness may range between 3.5 and 5 km. The stratigraphical base of the La Poile Group is drawn at the nonconformity of basal boulder conglomerate on Late Precambrian granite. The stratigraphical top of the group is not observed.

The La Poile Group is composed of two, elongate, non-contiguous, regionally northeast-trending outcrop belts separated by granitoids and high-grade metamorphic rocks (fig. 2). The dominantly volcanic southwestern outcrop area, referred to as the La Poile Bay subbasin (O'Brien and O'Brien, 1990b), embodies the total extent of Cooper's (1954) La

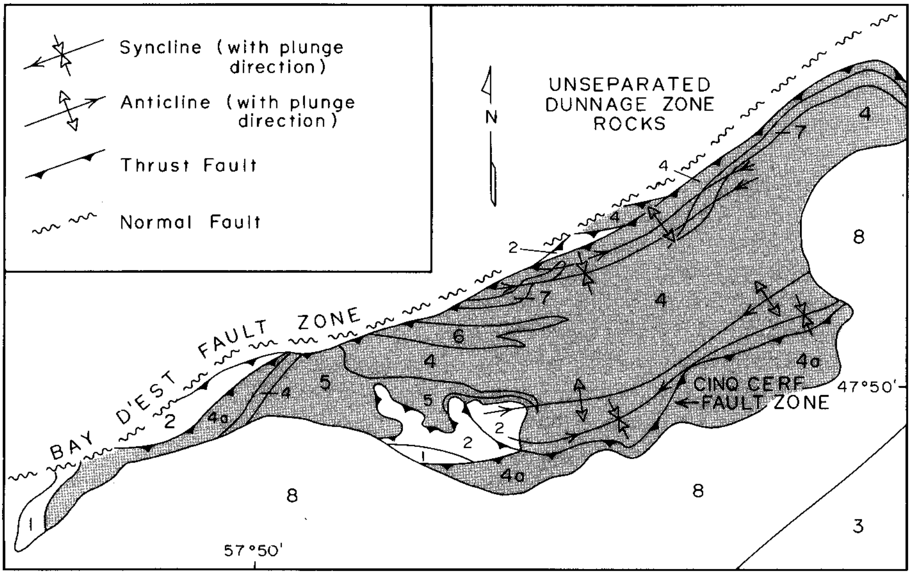
Poile Group. The mainly clastic northeastern outcrop belt, the Rocky Ridge subbasin (O'Brien and O'Brien, 1990b), lies approx 10 km northeast of the La Poile Bay subbasin and has dimensions similar to the latter. Inclusion of rocks in this northeast subbasin within the La Poile Group, therefore, significantly increases the original extent of the group as defined by Cooper (1954).

Although a depositional contact with granitic basement is locally preserved (O'Brien, 1982, unpublished data; O'Brien and O'Brien, 1989), the external boundaries of the La Poile Group are, in almost all areas, either thrust and normal fault contacts with older rocks or intrusive contacts with several generations of granite (fig. 2). Along much of its northern boundary, the La Poile Group is separated from adjacent rocks of the Middle Ordovician Bay du Nord Group by the Bay d'Est Fault Zone. To the south, where younger granites do not intervene, the La Poile Group is juxtaposed with a pre-Silurian basement complex along the Cinq Cerf Fault Zone (fig. 2).

Stratigraphy and lithology.—Both subbasins contain approximately equal thicknesses of La Poile Group strata; however, each has a unique stratigraphy. The oldest strata are confined to the La Poile Bay subbasin. Rocks near the base of the Rocky Ridge subbasin are significantly younger than the lower part of the succession in the La Poile Bay subbasin.

Each subbasin is distinctive in terms of the nature and relative proportions of its component lithofacies (O'Brien and O'Brien, 1989, 1990b). In the La Poile Bay subbasin, welded ash flows and rhyolite flows are widespread; however, in the Rocky Ridge subbasin, these lithofacies are absent or volumetrically insignificant, and fluviatile clastic rocks are predominant. Shale-argillite and wacke-olistostrome sequences are important constituents of the La Poile Bay subbasin, but such lithofacies are not found in the Rocky Ridge subbasin. A variety of bedded tuffs, agglomerates, and quartz-feldspar crystal tuffs are found in varying proportions in both subbasins, intercalated with sedimentary rocks. In general, internal lithological diversity of volcanic units, particularly in the middle parts of the group, is most pronounced where such lithostratigraphic divisions are laterally extensive.

Near the southeast margin of the Rocky Ridge subbasin, a basal boulder conglomerate unit containing plutonic, gneissic, sedimentary and volcanic clasts unconformably overlies basement, represented by late Precambrian granite of the Roti Intrusive Suite (fig. 4). There, the conglomerate is succeeded by a 3.5 km succession composed almost entirely of gray, quartz-rich feldspathic sandstone, characterized by large-scale cross-stratification. Quartz granule to pebble conglomerate and matrix- and clast-supported polymictic conglomerate are locally interbedded with the sandstones in the lower half of the group. The sandstones persist to near the top of the total exposed succession. The stratigraphically lowest volcanic rocks in the Rocky Ridge subbasin, mainly rhyolitic and rhyodacitic, quartz-feldspar tuffs of airfall and related epiclastic origin, comprise a eastward-thinning unit that wedges



SILURIAN

8 Burgeo Intrusive Suite

LA POILE GROUP

7 *quartz-feldspar tuff*

6 *bedded lithic tuff and agglomerate*

5 *quartz-feldspar tuff and metamorphic equivalents*

4 *sandstone and conglomerate;* 4a: *schistose to hornfelsic equivalents*

ORDOVICIAN OR EARLIER

3 *unseparated sub-La Poile basement*

PRECAMBRIAN

2 Roti Intrusive Suite

1 Cinq Cerf Gneiss

Fig. 4. Geological map of the Rocky Ridge subbasin of the La Poile Group showing the distribution of lithostratigraphic units and some of the major structures.

into the sandstone succession near the local base of the group. Lithic tuff and agglomerate in the middle part of the La Poile succession thin dramatically toward the east to interdigitate with sandstone. Quartz-feldspar tuff units occur near the top of the succession, and these are locally more laterally persistent than stratigraphically lower tuff units.

Near the northwest margin of the Rocky Ridge subbasin, a basal fanglomerate unit is preserved, uncomformably overlying granitic basement. Significantly, the 3.5 km thick sandstone-dominated sequence developed above basal strata on the southeast margin is not developed on this margin. This clearly demonstrates the existence of abrupt facies changes near the northwest margin of the subbasin.

The various lithostratigraphic units of the La Poile Bay subbasin are given in figure 5. The lower part of the succession contains the thinnest and most laterally continuous stratigraphic units, which are dominantly composed of polymictic boulder and monolithic, quartz pebble conglomerate and distinctive, purple-red lithic tuff. Three massive to flow banded rhyolite bodies occur in laterally distinct and stratigraphically unique positions in the middle part of the succession. Units that had accumulated before, during, and after each rhyolitic eruption terminate by pinch-out and become increasingly abundant stratigraphically upward. Each rhyolite is underlain by poorly sorted, immature volcanogenic wackes, polymictic conglomerate and gray sandstone; each is succeeded by lithic tuffs that are capped, above two of the three lava flows, by thin-bedded, discontinuous units of gray shale and parallel- to cross-laminated argillite. The wackes are massive to crudely bedded, show abundant evidence of soft sediment deformation, and locally contain tilted blocks, up to 300 m in maximum dimension, of shale, argillite, and rhyolite. They pass laterally into chaotic olistostromes that occur locally at the margins of major rhyolite bodies. The upper part of the succession in the La Poile Bay subbasin is composed almost exclusively of pyroclastic rocks. A laterally continuous, 1.5 to 2 km thick, markedly homogeneous, quartz-feldspar tuff unit comprises most of the upper part of the group. Smaller tongues of this tuff occur in the middle part of the succession, where they locally separate and stratigraphically isolate some of the major rhyolite bodies.

Provenance.—Fanglomerates at the northwest margin of the La Poile Group lie directly on regolith developed on a fractured paleosurface of late Precambrian granite of the Roti Intrusive Suite. Polymict conglomerates on the southeast margin of the group contain boulders and cobbles of extrabasinal sedimentary, plutonic, and metamorphic rocks, together with intrabasinal volcanic detritus. Their detrital assemblage, which includes blue-quartz-phyric granitic rocks, vein quartz, quartz pebble conglomerate, schist, granodiorite injected by diabase, highly altered net-veined rocks, and banded amphibolite, are recognizable components of the pre-Silurian basement complex in the Hermitage Flexure region (O'Brien and O'Brien, 1990a). Monolithic conglomerates, which are composed chiefly of hydrothermal, metamorphic, and plutonic quartz clasts, may also be linked to this basement.

The macroscopic detritus of the wackes and other sandstones is like that of the coarser grained rocks and includes angular and rounded grains of blue quartz, feldspars, magnetic heavy minerals, metabasite, vein quartz, and a variety of igneous, sedimentary, and metamorphic rock fragments. Paleocurrent directions obtained from the sandstones are from the northeast and southeast (T. Dec, personal communication, 1989), consistent with erosion of the presently exposed sub-La Poile basement throughout the accumulation of the basin-fill.

THE SUB-LA POILE BASEMENT

Precambrian constituents.—The most characteristic elements of the sub-La Poile basement are Late Precambrian granodiorite, tonalite, and associated porphyry plutons, components of the Roti Intrusive Suite of Dunning and O'Brien (1989). A 499 +3/−2 Ma pluton (Wild Cove Granite), previously included in this suite, is now known to be synchronous with and related to a magmatic episode in the pre-Silurian basement that is significantly younger than the Precambrian event. This younger granodiorite is therefore excluded from the suite. The term Roti Intrusive Suite is herein retained to denote only the characteristic granodiorite, tonalite, and porphyry plutons of Late Precambrian (about 590-560 Ma) age within the sub-La Poile basement.

Basal boulder conglomerate of the Silurian La Poile Group unconformably overlies granodiorite of the Roti Intrusive Suite dated at 578 ± 10 Ma. The unconformity of Silurian strata with the Roti Intrusive Suite demonstrates that rocks intruded by the suite also constitute part of the sub-La Poile Precambrian basement. Although basement rocks are most extensive south of the La Poile Group, the occurrence of the unconformity between Silurian cover and Precambrian basement at or near both margins of the subbasin implies that the basement is continuous at depth beneath the La Poile Group. Relatively narrow, noncontiguous tracts of

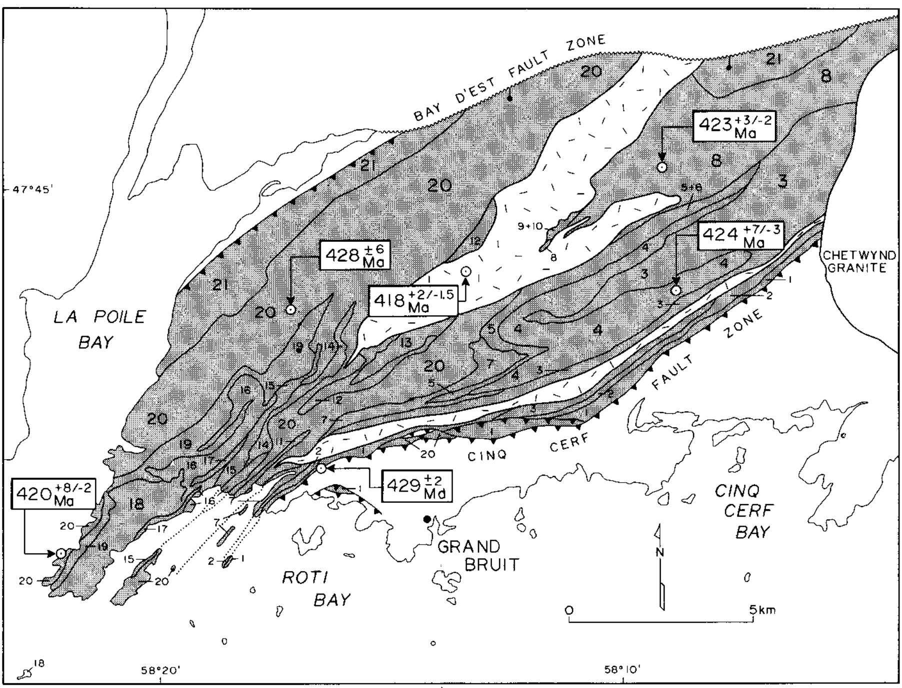


Fig. 5. Geological map of the La Poile Bay subbasin of the La Poile Group showing the distribution of lithostratigraphic units and some of the major structures (modified from O'Brien, 1990). The locations of rocks dated by Dunning and others (1990) are indicated. Symbols as for figure 2; hatched unit is the Hawks Nest Pond Porphyry.

LA POILE GROUP

CROSS GULCH TUFF

21	*lithic tuff composed of multicolored, polylithic, felsic volcanic fragments; minor argillite and tuffaceous sandstone*

GALLYBOY HARBOUR TUFF

20	*pink, medium- to coarse-grained, locally layered and stratified, quartz-feldspar crystal tuff; rare blocks of felsic volcanic and siliciclastic sedimentary rocks*

FLINT CLIFF POND TUFF

19	*buff, medium grained lithic tuff; coarse agglomerate composed of pink, massive rhyolite blocks; minor thin-bedded quartz sandstone; rare lava flows of limited extent*

EASTERN POINT RHYOLITE

18	*pink, massive aphanitic lava; locally welded*

FRENCH COVE TUFF

17	*well-bedded lithic tuff; breccia containing siliciclastic sedimentary and felsic volcanic fragments; minor lithic-crystal tuff*

GUIDERS POND GRIT

16	*gray-brown, poorly sorted, locally stratified, quartz-feldspar grit and tuffaceous wacke; minor boulder conglomerate and olistostrome; rare gray slate*

BLACK DUCK BROOK CONGLOMERATE

15	*polylithic, cobble and boulder conglomerate; thin-bedded quartz sandstone interstratified with laminated argillite; minor gray slate*

OLD MAN HILL TUFF

14	*fine grained lithic tuff composed of pink rhyolite fragments*

WITHY GULCH HILL AGGLOMERATE

13	*agglomerate and breccia composed of massive, flow-banded and flow-folded rhyolite; minor pink and cream rhyolite*

OLD MAN POND SLATE

12	*gray slate and laminated argillite; rare, interstratified, thin-bedded quartz sandstone*

LITTLE ROTI BAY AGGLOMERATE

11	*crudely stratified, coarse agglomerate and breccia containing polylithic, felsic volcanic blocks; purple lithic tuff*

BUTTERFLY POND GRIT

10	*gray-brown, poorly sorted, quartz-feldspar grit and tuffaceous wacke; gray slate*

GEORGES POND SLATE

9	*gray slate and laminated argillite*

PHILLIPS BROOK RHYOLITE

8	*cream and pink, massive to finely laminated lava;* **14a:** *uppermost breccia unit composed of flow-banded rhyolite fragments*

OUTSIDE GULL POND SLATE

7	*gray slate and laminated argillite; minor, interstratified, thin-bedded quartz sandstone*

TWIN POND ARGILLITE

6	*laminated argillite; minor cobble and boulder, polymictic conglomerate; minor tuffaceous sandstone and wacke*

INSIDE GULL POND TUFF

5	*buff, fine grained lithic tuff; local breccia composed of pink rhyolite fragments; welded lithic-crystal tuff*

DINNER BOX HILL RHYOLITE

4	*pink, flow-banded and massive, locally phenocrystic lava; rare rhyolite breccia*

NORTHWEST POND BROOK GRIT

3	*gray-brown, poorly sorted, massive and stratified, locally graded and cross-bedded, quartz-feldspar grit and tuffaceous wacke; rip-up clasts and large blocks of laminated argillite; clasts of quartzofeldspathic schist, foliated granitoid and diabase*

CINQ CERF BROOK CONGLOMERATE

2	*thick-bedded, polymictic, boulder and cobble conglomerate interstratified with thin-bedded tuffaceous sandstone and tuff; clasts of blue-quartz-bearing granodiorite (containing pre-incorporation foliation), diabase, quartz pebble conglomerate, amphibolitic gneiss, jasper, vein quartz and felsic tuff*

GRAND BRUIT GULL POND TUFF

1	*light green, fine grained, felsic lithic tuff; red and purple lithic tuff, tuffaceous sandstone and slate; quartz pebble conglomerate*

Fig. 5. (continued)

basement that crop out along the northern margin of the group, separate the Silurian strata from Middle Ordovician rocks of the Bay du Nord Group (fig. 2).

Correctly establishing the age and contact relationships of the Roti Intrusive Suite is critical to redefining the La Poile Group and separating the Silurian cover from its basement. A tonalitic pluton of the Roti Intrusive Suite crosscuts amphibolite facies metamorphic banding in the Cinq Cerf Gneiss (O'Brien, 1987, 1988), also intrudes a conformable succession of greenschist facies sedimentary and volcanic rocks (Whittle Hill Sandstone and Third Pond Tuff of O'Brien, 1990; fig. 6), and is thus viewed as a Late Precambrian stitching pluton. The intrusive relationship with the Cinq Cerf Gneiss refutes previously held views that these high-grade rocks formed part of a complex that was younger than the La Poile Group (Cinq Cerf Complex of Chorlton, 1978) and precludes the possibility that these rocks have either the Silurian La Poile or Ordovician Bay du Nord groups as their protolith. The intrusive relationship with the Whittle Hill-Third Pond succession also demonstrates that these undated, low-grade sedimentary and tuffaceous volcanic rocks cannot be included within the La Poile Group as previously defined. Instead, these rocks, together with dated granite and undated gneiss, must be reassigned to the Precambrian part of the sub-La Poile basement block. If the Cinq Cerf Gneiss is coeval with the lithologically similar Grey River Gneiss to the east (Dunning and O'Brien, 1989; O'Brien and O'Brien, 1990a,b), then the three known Precambrian constituents of this basement block have ages between 686 $+33/-15$ Ma (protolith age of Grey River Gneiss) and 563 $\pm$ 4 Ma (crystallization age of the youngest known constituent of the Roti Intrusive Suite).

Paleozoic constituents.—The sub-La Poile basement is intruded by Precambrian, Ordovician, and Silurian mafic and felsic plutons and dikes (fig. 6). Paleozoic intrusive rocks that predate deposition of the La Poile Group facilitate separation of deformational and metamorphic events in the basement that postdate the formation of the Cinq Cerf Gneiss and the accumulation of the Whittle Hill-Third Pond succession. An older event is bracketed by the emplacement of the Roti Intrusive Suite (dated between 578 $\pm$ 10 Ma and 563 $\pm$ 4 Ma) and its subsequent intrusion by the Wild Cove Granite (499 $+3/-2$ Ma), while a younger event is constrained between the emplacement of the Ernie Pond Gabbro (495 $\pm$ 2 Ma) and the deposition of the oldest known strata in the La Poile Group (Grand Bruit Gull Pond Tuff, 429 $\pm$ 2 Ma).

The timing of initial regional deformation and dynamothermal metamorphism of the Whittle Hill-Third Pond succession relative to the emplacement of the Roti Intrusive Suite is equivocal. To date, the oldest known rocks that provide a younger limit for these events are the early Ordovician Ernie Pond Gabbro and Wild Cove Granite, both of which crosscut major folds of this succession (fig. 6). The Ernie Pond Gabbro intrudes the Wild Cove Granite; this relationship is corroborated by the U-Pb data, which also indicate that the mafic and felsic plutonism may be coeval (2 sigma uncertainties meet at 497 Ma). Amphibolite facies, contact

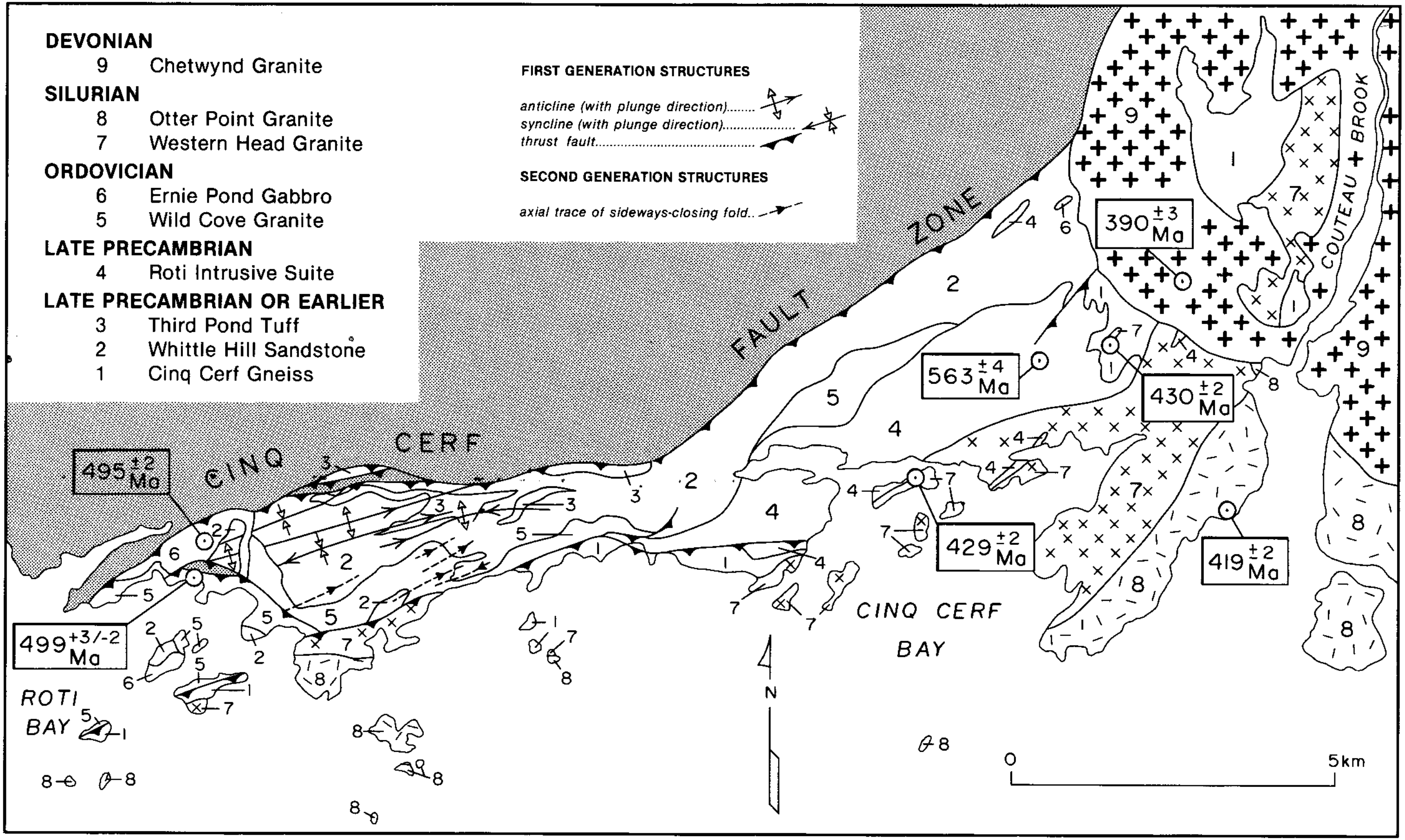


Fig. 6. Geological map of the sub-La Poile Group basement southeast of the Cinq Cerf Fault Zone in the Roti Bay-Cinq Cerf Bay area (modified from O'Brien, 1990). Locations of rocks dated by Dunning and O'Brien (1989) are indicated.