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Aller au sommaire du numéro

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Résumé de l'article

Les roches cristallines de la sous-zone du mont Steel, dans la zone de Humber du sud-ouest de Terre-Neuve, ont donni des ages de 1498+9/-8 Ma pour le mltamorphisme de haul grade, similaires a ceux de la boutonniere de Long Range et du nord de l'lle-du-Cap-Breton. Un leucogranite peralcalin s'est mis en place a 608 ± 4 Ma. L'intrusion des complexes a anorthosite-gabbro et le m£tamorphisme au facies amphibolite se sont produits entre ces deux dvenements. La partie sud de la zone de Dunnage (sous-zone de gneiss centrale), en contact avec la sous-zone du mont Steel a la faille de Long Range, ne contient pas de roches cristallines pricambriennes mais a 616 recouped par des plutons charnockitiques et a 616 mdtamorphisee au facies granulite a 460 ± 10 Ma. Cette sous-zone a 6l6 exhumge avant 435 Ma. Dans la sous-zone Mulpaeg de la zone de Gander, qui est mise en contact avec la sous-zone de gneiss centrale par la faille de la riviere Victoria, la phase intrusive la plus ancienne d'un gneiss migmatitique et granoblastique s'est mise en place a 418 ± 4 Ma.

Ces donnles d£montrent que les failles de Long Range et de la riviere Victoria sont des frontieres tectoniques majeures. Les sous-zones semblent avoir subi un chevauchement vers l'ouest au plus tard au Silurien.

Age of high-grade gneisses south of Grand Lake, Newfoundland

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Crystalline rocks of the Steel Mountain Subzone of the Humber Zone in southwest Newfoundland give an age for granulite-grade metamorphism of 1498+9/-8 Ma, similar to ages from the Long Range inlier and northwestern Cape Breton Island. Peralkaline leucogranite was emplaced at 608 ± 4 Ma. The emplacement of anorthosite-gabbro complexes and amphibolite-grade metamorphism took place between these dates. The southern part of the Dunnage Zone (Central Gneiss Subzone), in contact with the Steel Mountain Subzone at the Long Range Fault, lacks Precambrian crystalline rocks, but was intruded by charnockitic plutons and metamorphosed to granulite facies at 460 ± 10 Ma. This subzone was exhumed before 435 Ma. In the Meelpaeg Subzone of the Gander Zone, which is in contact with the Central Gneiss Subzone along the Victoria River Fault, the oldest intrusive component of a granoblastic migmatitic gneiss was emplaced at 418 ± 4 Ma.

These data demonstrate that both the Long Range and Victoria River faults form major tectonic boundaries. Subzones appear to have been thrust westward in Silurian or later time.

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Ces données démontrent que les failles de Long Range et de la rivière Victoria sont des frontières tectoniques majeures. Les sous-zones semblent avoir subi un chevauchement vers l'ouest au plus tard au Silurien.

[Traduit par le journal]

INTRODUCTION

Central and western Newfoundland exhibit the products of subduction of oceanic plate and eventual continent-continent collision (Bird and Dewey, 1971), but timing of subduction and the location of the suture zone(s) between colliding continental blocks remain uncertain. Zonal hypotheses (for example, Williams, 1979; Williams *et al.*, 1988) assume that vestiges of the pre-collision(s) geometry of the orogen persist, although distorted and transported, in the form of subzones or chains of terranes longitudinally spread along the orogen (Fig. 1) and separated from one another by major faults. According to these hypotheses, the Humber Zone represents the North American plate with relicts of deformed and transported shelf and rise prism. The Dunnage Zone consists of relicts of ocean floor and superincumbent volcanic and sedimentary rocks, whereas the Gander Zone comprises a continental rise prism of uncertain source, possibly derived from the Avalon Zone which in Newfoundland consists of late Precambrian and younger supracrustal rocks. The Dunnage Zone is now thought to be entirely allochthonous (Currie *et al.*, 1979; Colman-Sadd and Swinden, 1984; Kean *et al.*, 1986; Marillier *et al.*, 1988) and hence does not necessarily give any information on the tectonic history of underlying subzones.

South of Grand Lake, rocks typical of the Dunnage Zone are absent (Fig. 2) and deeper seated subzones or zones appear to be in contact (van Berkel and Currie, 1988). Geochronology of the southeastern part of this region has been investigated by Dunning *et al.* (1988), but geochronological information on the northwestern part is sparse. In particular, the character and extent of Precambrian basement remain uncertain. We here present results of a search for basement in a recently mapped region south of Grand Lake.

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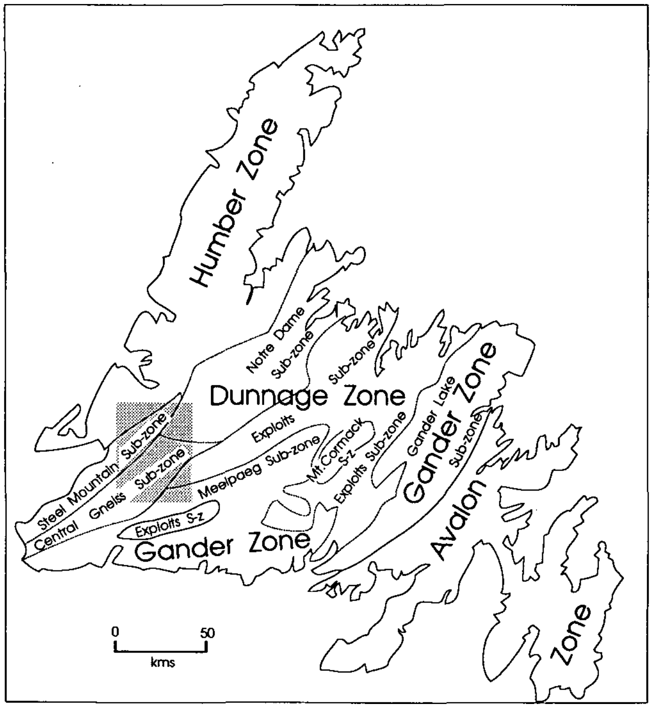

Fig. 1. Tectonostratigraphic zones of Newfoundland [modified after Williams *et al.* (1988)]. Zone boundaries shown by heavy broken lines, subzone boundaries by light broken lines. The Mt. Cormacks Subzone belongs to the Gander Zone. The location of Figure 2 is shown by the shaded box.

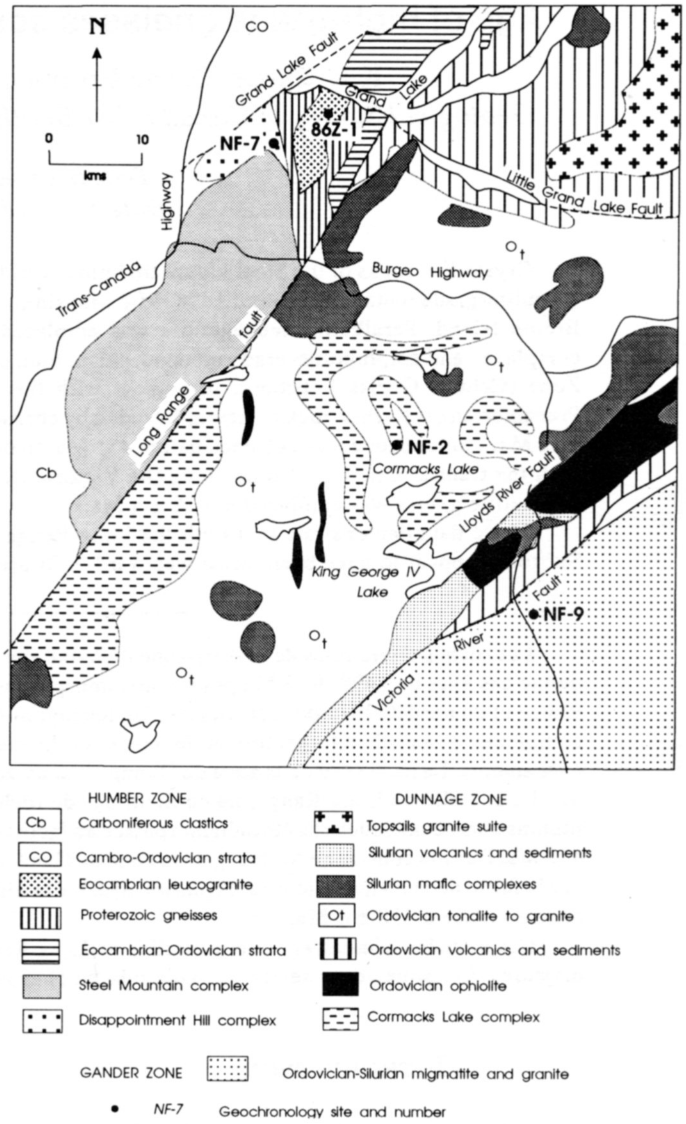

Fig. 2. Geological sketch of southwestern Newfoundland (geology after van Berkel and Currie, 1988) showing location of zircon samples in Table 1.

REGIONAL GEOLOGY

The region south and southeast of Grand Lake (Fig. 2) falls into subzones bounded by major faults. West of the Grand Lake Fault, Cambro-Ordovician sedimentary rocks represent the ancient passive margin shelf of North America (Humber Zone of Williams, 1979) imbricated westward in Arenig to Llandeilo time (Williams and Stevens, 1974). Williams and Cawood (1986) noted that deformation and metamorphism increase toward the Grand Lake Fault, a vertically dipping zone 150 to 500 m in width in which a complex early ductile history has been almost totally obliterated by late brittle deformation (Currie, 1987). Between the Grand Lake and Long Range faults, crystalline rocks of the Steel Mountain Subzone appear in a sequence of westerly transported thrust slices. The oldest recognizable unit comprises felsic to intermediate two-pyroxene granulite-facies gneisses of the Disappointment Hill complex (Currie, 1987) variously retrogressed and reworked on ductile shear zones. The Steel Mountain complex, a massif of anorthositic to gabbroic rocks more than 50 km in length, cuts and includes granulite-facies gneisses of the Disappointment Hill complex. A gabbroic margin of the Steel Mountain complex exhibits strong gneissic foliation and becomes amphibolitic near the Long Range Fault. Gneisses younger than the Steel Mountain complex contain minor quartzite and crystalline limestone horizons in a granitic and amphibolitic matrix. This gneissic sequence is in turn unconformably overlain by a sequence of staurolite-kyanite grade metasedimentary schists of the Late Precambrian-Early Paleozoic Fleur de Lys Supergroup (Knapp *et al.*, 1979; Hibbard, 1983; Currie, 1987). Leucocratic alkaline to peralkaline granites intruded the metasedimentary rocks. All units of the Steel Mountain Subzone have been affected by late penetrative deformation associated with low-angle north-northwest-directed thrusting associated with a low-grade overprint in the gneisses (Currie, 1987).

No correlatives of the Steel Mountain Subzone have been positively identified east of the Long Range Fault in the Central Gneiss Subzone. The Central Gneiss Subzone comprises highly metamorphosed supracrustal rocks (Cormacks Lake complex) invaded by voluminous, generally foliated tonalitic to granitic plutons of Ordovician (~460 Ma) age (Stevens *et al.*, 1982; Dunning *et al.*, 1988) and cut post-tectonically by mafic plutons of Silurian age (431 Ma, Dunning *et al.*, 1988). Felsic and mafic gneisses of the Cormacks Lake complex preserve small areas of granulite-facies metamorphism and larger areas of retrograded gneisses (Herd and Dunning, 1979). Metasedimentary rocks just east of the Long Range Fault have recrystallised to coarse (>2 mm) granoblastic fabrics difficult to distinguish from granitoid plutons (van Berkel and Currie, 1988) and may also have reached granulite facies. The Central Gneiss Subzone contains thin (<500 m) strips of ophiolite bounded by high strain zones (Fox and van Berkel, 1988), as well as larger sheets of ophiolite (Brown, 1977) intruded by the tonalite-granite complex (Dunning and Chorlton, 1985). All rocks exhibit a late, greenschist or lower grade metamorphic overprint.

To the north, the Central Gneiss Subzone contacts the Notre Dame Subzone of the Dunnage Zone (Williams *et al.*, 1988) along the Little Grand Lake Fault (Fig. 2, van Berkel and Currie, 1988). The Notre Dame Subzone exhibits low-grade mafic and felsic volcanics of lower to mid-Ordovician age and locally ophiolitic affinities (Glover and Buchans Groups, Nowlan and Thurlow, 1987), unfoliated mid-Ordovician tonalitic to granitic plutons (~460 Ma, Whalen *et al.*, 1987), and a highly distinctive suite of Silurian A-type granites (Whalen *et al.*, 1987; Whalen and Currie, 1990). To the east, the Lloyds River Fault truncates the Central Gneiss Subzone against the Exploits Subzone of the Dunnage Zone (Fig. 2, Williams *et al.*, 1988), which consists of the lower Ordovician Annieopsquotch ophiolite complex, mid-Ordovician Victoria Lake Group of mafic to felsic volcanic rocks, and outliers of Silurian redbeds and rhyolitic volcanic rocks (Dunning, 1987). South of Annieopsquotch complex the Victoria River Fault juxtaposes the Central Gneiss Subzone against the Meelpaeg Subzone of the Gander Zone which consists of psammitic sedimentary rocks which were deformed, migmatised and intruded by S-type granites in Silurian time (Williams *et al.*, 1988; Dunning *et al.*, 1988).

Sample Selection and Description

Steel Mountain Subzone

Previous compilations have generally suggested that rocks of the Steel Mountain Subzone are of Precambrian age (Williams, 1978; Knapp *et al.*, 1979), but relative ages of the units were poorly known [compare the relative age of the Hare Hill granite in Knapp *et al.* (1979) and Currie (1987)], and some evidence suggested that the Steel Mountain massif could be of Paleozoic age (Riley, 1962; Leech *et al.*, 1963; Murthy and Rao, 1976). No comparisons between this subzone and nearby Precambrian crystalline terranes such as the Indian Head complex (Heyl and Ronan, 1954; Lowdon *et al.*, 1963), the northern Long Range (Baadsgaard *et al.*, in press) or northern Cape Breton Island (Barr *et al.*, 1987) could be attempted because of lack of chronological data.

We have attempted to determine the age of the oldest plutons in the Steel Mountain Subzone and the age of the youngest granitoid rocks in this region (Hare Hill granite). To attack these problems we selected samples from the Disappointment Hill complex and the Hare Hill granite. Locations are given in Figure 2 and petrographic descriptions follow.

The Disappointment Hill complex comprises felsic to mafic or intermediate two-pyroxene granulite-facies gneisses layered on a meter scale. The dated sample, from a leucocratic band some 50 m wide, has a homogeneous, weakly foliated granoblastic texture, and consists of mosaic quartz, fine string mesoperthite (An_{25}), augite, hypersthene, and minor biotite and garnet. There is no evidence of retrogression in the sample, although other specimens exhibit development of amphibole haloes on pyroxene, coarse patch perthite, and gradation to foliated porphyroblastic hornblende-biotite granite along high strain zones. The granulite-facies gneisses are cut by dykes of salmon pink to pale orange aplite or pegmatite related to the nearby Hare Hill granite.

The sample of Hare Hill granite was collected from an outcrop tens of meters across near a survey marker at the summit of the hill. The rock is massive, homogeneous coarse-grained leucogranite varying from pink to pale red in colour, and consists largely of subhedral string perthite grains, many showing relict Carlsbad twins, with interstitial quartz and minor acmitic pyroxene and relics of arfvedsonite replaced by riebeckite. Quartz and feldspar have been locally recrystallised along cracks or at the margins of grains ("mortar texture").

Central Gneiss Subzone

There is no consensus about the age of the oldest rocks in the Central Gneiss Subzone. Herd and Dunning (1979) assigned a Precambrian age to granulite-grade metamorphism of the Cormacks Lake complex. van Berkel and Currie (1988) argued that units could be correlated across the Long Range Fault and that much of the protolith could be Precambrian, although strongly reworked during the Paleozoic. Dunning and Chorlton (1985) suggested that the oldest rocks were lower Ordovician ophiolites.

Dunning (1987) demonstrated that the pervasive tonalite to granite suite is of mid-Ordovician age (456 Ma), but the age of the granulite-facies metamorphism could be older. To investigate this question, we collected fresh, homogeneous, leucocratic charnockite from the Cormacks Lake complex (Herd and Dunning, 1979). This specimen consists mainly of subhedral large grains of string perthite, extensively recrystallised around their margin, with local conversion to microcline. Mafic minerals consist of augite, hypersthene, and hornblende developed at the expense of hypersthene. This rock forms a pluton with a granulite-facies mineral assemblage within a generally amphibolite-grade complex containing local quartzite and gedrite-cordierite enclaves.

Meelpaeg Subzone

Precambrian rocks have been found in the Meelpaeg Subzone on the south coast of Newfoundland (Dunning *et al.*, 1988), but their extent remains uncertain. Complex migmatites south of Peter Strides Pond consist of granoblastic mesocratic biotite gneiss with small potash feldspar porphyroblasts, and numerous nebulous foliated granitoid lenticles, cross-cut by massive coarse leucogranite sills and dykes. The grade of metamorphism resembles that in the Central Gneiss Subzone (van Berkel, 1987). We have sampled the older foliated rocks in a quarry just off the Burgeo highway near Peter Strides Pond. We interpret this material to represent the oldest metamorphic event in this part of the Meelpaeg Subzone, which here affected high-grade psammitic sedimentary rocks.

GEOCHRONOLOGY - ANALYTICAL RESULTS

The locations of samples from which zircons were separated are plotted in Figure 2, and zircons are described in Appendix 1. General techniques of zircon concentration, preparation, chemical dissolution and isotopic analysis have been described by Parrish *et al.* (1987). All zircon fractions were strongly abraded before analysis (Krogh, 1982). The two sigma uncertainties in the isotopic ratios are 0.5% for ^{206}Pb/^{238}U and ^{207}Pb/^{235}U and 0.1% for ^{207}Pb/^{206}Pb. Results are presented in Table 1 and displayed in concordia plots in Figures 4 to 6.

Disappointment Hill complex

The dated sample, a felsic granulite-facies gneiss collected from the northeast side of Disappointment Hill, is considered to represent a pluton metamorphosed with the intermediate to mafic gneisses of the complex. Data points corresponding to five zircon fractions are linearly aligned with the highest point corresponding to the coarsest abraded fraction (Fig. 3). This pattern would be consistent with older cores to the zircons, but no cores are evident on either etched or unetched grain mounts. A regression line to the data points according to the procedures of York (1969) yields upper and lower intercept ages of 1498+9/-8 Ma and 840 ± 25 Ma with a mean square of weighted deviates (MSWD) of 8.6. The latter value indicates a significant component of scatter beyond analytical uncertainty. This scatter could be due to recent lead loss, but such an effect may not be very great because the U concentrations are low and because there is no

Table 1. U-Pb zircon analytical data.

Fraction size[1]	Wt. (mg)	U (ppm)	Pb (ppm)	^{206}Pb/^{204}Pb[2]	Pb$_c$ (pg)[3]	^{208}Pb (%)[4]	^{206}Pb/^{238}U	^{207}Pb/^{235}U	R	^{207}Pb/^{206}Pb	^{207}Pb/^{206}Pb Age (Ma)
1. Disappointment Hill complex (NF-7)											
a, +74 N1	0.021	117	30	1193	31	10.4	0.24258 ± .09	3.0484 ± .12	0.87	0.09114 ± .06	1449.5 ± 2.4
b, +74 N1	0.076	167	42	10348	18	9.6	0.24260 ± .08	3.0507 ± .10	0.95	0.09120 ± .03	1450.8 ± 1.1
c, -74 N1	0.342	215	46	46841	20	7.5	0.21095 ± .09	2.5078 ± .10	0.96	0.08622 ± .03	1343.1 ± 1.1
d, +62 M1	0.324	179	39	44328	17	8.5	0.21423 ± .09	2.5690 ± .10	0.96	0.08697 ± .03	1359.9 ± 1.1
e, -62 M1	0.160	141	34	13261	24	9.5	0.23427 ± .08	2.9041 ± .10	0.96	0.08991 ± .03	1423.6 ± 1.1
2. Hare Hill granite (86-Z-1)											
a, +149 N0	0.172	290	29	1286	243	10.2	0.09798 ± .10	0.8124 ± .13	0.87	0.06013 ± .07	608.4 ± 2.9
b, +105 N0	0.213	266	26	1547	232	10.0	0.09768 ± .10	0.8095 ± .13	0.85	0.06010 ± .07	607.3 ± 3.0
c. +105 N0	0.173	358	36	3134	122	11.3	0.09792 ± .10	0.8118 ± .12	0.91	0.06012 ± .05	608.0 ± 2.2
d, +105 M0	0.146	278	27	1208	206	10.0	0.09633 ± .11	0.7947 ± .14	0.85	0.05983 ± .07	597.5 ± 3.2
e, -105 M0	0.127	264	26	1039	201	10.2	0.09734 ± .10	0.8054 ± .14	0.85	0.06001 ± .08	603.9 ± 3.3
f, -105 N0	0.015	350	35	2966	11	10.2	0.09840 ± .09	0.8156 ± .10	0.93	0.06011 ± .04	607.6 ± 1.7
g, -105 N0	0.004	323	32	519	14	10.5	0.09835 ± .14	0.8124 ± .19	0.80	0.05991 ± .11	600.2 ± 5.0
3. Cormacks Lake complex (NF-2)											
a, +149	0.109	766	58	16860	23	12.8	0.07245 ± .10	0.5600 ± .11	0.97	0.05606 ± .03	454.9 ± 1.3
b, +105 NM1	0.072	354	27	6443	18	13.2	0.07236 ± .10	0.5592 ± .11	0.96	0.05605 ± .03	454.5 ± 1.5
c, +100 M1	0.041	462	32	1635	50	11.8	0.06729 ± .09	0.5136 ± .13	0.81	0.05536 ± .08	426.8 ± 3.6
d, -105 M1	0.003	256	19	341	13	12.1	0.07348 ± .29	0.5701 ± .36	0.84	0.05627 ± .19	463.1 ± 8.6
e, -105 NM1	0.079	413	31	8806	17	11.8	0.07339 ± .09	0.5688 ± .10	0.94	0.05621 ± .04	460.8 ± 1.6
4. Peter Strides migmatite (NF-9)											
a, +105 M2	0.131	232	17	2518	51	18.2	0.06729 ± .09	0.5129 ± .12	0.88	0.05528 ± .06	423.4 ± 2.6
b, +74 N2	0.067	263	19	4451	17	14.8	0.06718 ± .09	0.5117 ± .10	0.94	0.05524 ± .04	422.0 ± 1.6
c, -74 M2	0.041	244	18	3384	12	17.5	0.06706 ± .09	0.5100 ± .11	0.91	0.05515 ± .04	418.3 ± 2.0

Uncertainties are 1 standard error of mean in % except ^{207}Pb/^{206}Pb age errors which are 2 standard errors in Ma.

Pb = radiogenic; Pb$_c$ = common Pb; R = correlation of errors in isotope ratios.

[1] mineral is zircon unless indicated otherwise; sizes before abrasion (either -74+62, indicating less than or greater than respective sieve sizes in microns; M and N refer to magnetic and non-magnetic at side slope indicated in degrees.

[2] measured ratio, corrected for spike and fractionation.

[3] total common Pb in analysis corrected for fractionation.

[4] radiogenic ^{208}Pb, expressed as % of total radiogenic Pb.

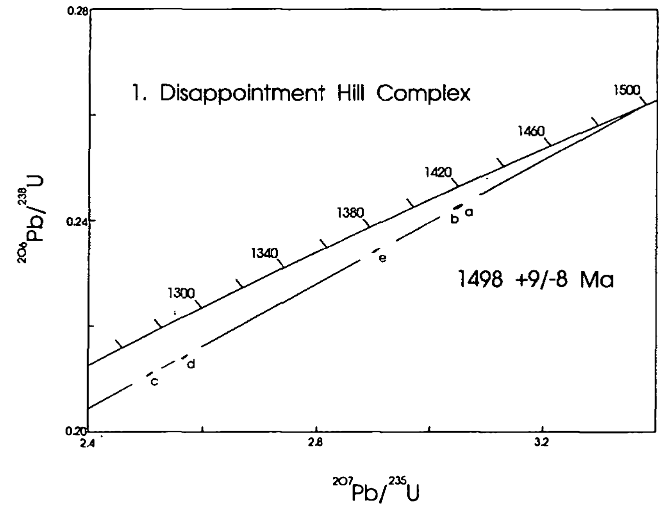

Fig. 3. Concordia plot showing zircon fractions for the Disappointment Hill complex.

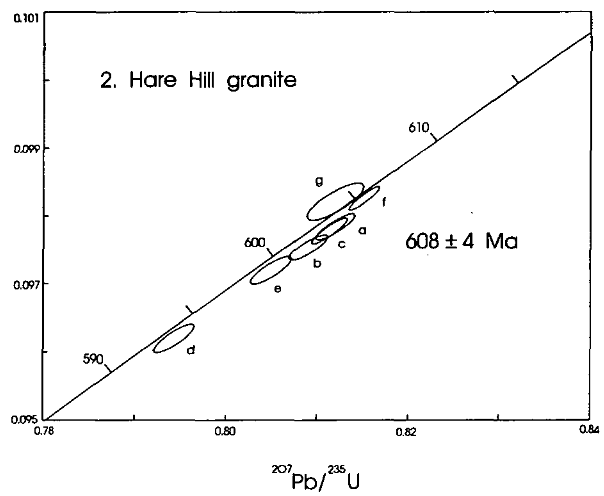

Fig. 4. Concordia plot showing zircon fractions for the Hare Hill granite.

evidence for a downward shift in the finest fraction. We interpret the upper intercept to be close to age of emplacement. The lower intercept age may represent a geological event (see below), but it may be composite effect of Grenville and later metamorphism, possibly including a minor component of zircon growth as well as Pb loss during Paleozoic metamorphic events.

Hare Hill granite

Data points for five fractions correspond to a linear array which lies close, and almost parallel, to concordia and spans about 10 Ma (Fig. 4). Fractions f and g represent strongly abraded zircon populations in which length dimensions have been reduced by 50%. As corresponding data points are concordant, the remaining slightly discordant data points are interpreted in terms of slight recent Pb loss. The explanation for the linear array is not obvious from the zircons which have a euhedral morphology and do not have visible cores. Extensive memory is not expected in any case in alkaline granites as zircon is more soluble in magmas with high (Na+K+2Ca)/(Al+Si) ratios (Watson and Harrison, 1983). The data array is, therefore, more likely to be the result of marginal crystal Pb loss effects which may have been aided by reactive fluids passing through this alkaline rock during later Palaeozoic events. Two fractions of sphene have yielded imprecise U-Pb ages in the 500 Ma to 440 Ma range, suggestive of Paleozoic events.

Four out of the eight data points (a,b,c,f) $^{207}Pb/^{206}Pb$ model ages cluster within analytical uncertainty at 608.2 Ma (607.6-609.1 Ma). Given the lack of metamorphic overgrowth, the extremely strong abrasion of fraction f, and the large size of fraction a, the igneous age is assigned at 608 ± 4 Ma.

Cormacks Lake complex

The four zircon data points for this granulite-facies rock are concordant to slightly discordant with a range of $^{207}Pb/^{206}Pb$ model ages ranging from 463.1 Ma to 426.8 Ma (Fig. 5). The youngest model age for fraction c is surprising, as K-Ar biotite ages of 447 ± 8 Ma and 449 ± 8 Ma and a K-Ar hornblende age of 455 ± 14 Ma have been reported from this area (Stevens *et al.*, 1982). The low age for this slightly more magnetic and weakly abraded zircon fraction is interpreted in terms of radiogenic lead loss due to later, low-temperature tectonic events.

The two oldest fractions are in close agreement, yielding $^{207}Pb/^{208}Pb$ ages of 461 Ma and 463 Ma and $^{206}Pb/^{238}U$ ages of 457 Ma. It is unlikely that these fractions represent mixtures of igneous and metamorphic zircon as etched sections of the zircons show that low U rims were very thin and were likely to have been removed by abrasion prior to analysis. Textures seen in thin section are consistent with slightly recrystallized primary igneous texture (Fig. 6). We therefore interpret this intrusion to have been emplaced at 460 ± 10 Ma under granulite-facies metamorphic conditions which were followed by rapid cooling.

Peter Strides migmatite

Data points corresponding to four zircon fractions for the oldest granitoid component of this migmatite give almost concordant results (Fig. 7). The finest fraction gave a concordant result of 418.3 Ma. The other three fractions plot slightly below concordia indicating the presence of a small amount of significantly older inheritance. The age for igneous crystallization of this unit is placed at 418 ± 4 Ma.

DISCUSSION

Our results demonstrate a complex Precambrian history west of the Long Range Fault. The oldest rocks, the Disappointment Hill complex, appear essentially identical in age and petrography with granulite-facies gneisses of the northern Long Range (Baadsgaard *et al.*, in press), and similar lithologies have been reported from the Indian Head Range (Colman-Sadd, 1969). Basement of this character may be

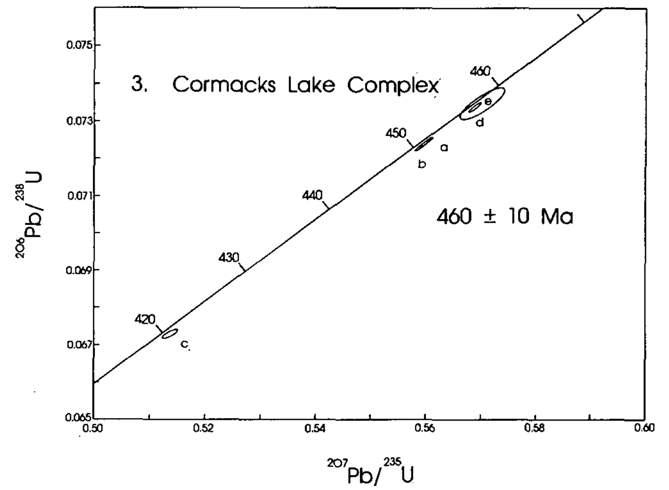

Fig. 5. Concordia plot showing zircon fractions for the Cormacks Lake complex.

present throughout western Newfoundland. The 840 Ma lower intercept age resembles Ar-Ar ages obtained by Dallmeyer (1978) from rocks of the Indian Head Range. Such ages are distinctly younger than known Grenville events. Similar ages from Virginia have been interpreted by Rankin (1975) as dating rifting of Grenvillian basement prior to opening of the Iapetus Ocean.

Metasedimentary rocks of the Fleur de Lys Supergroup and latest Precambrian granitoid plutons like Hare Hill (see also Williams *et al.*, 1985) complete a complex continental margin sequence. Williams *et al.* (1985) interpreted these latest Precambrian leucogranites in terms of a passive margin rifted in late Precambrian time. Similar ages for peralkaline leucogranites have been reported from the western Avalon Zone of Newfoundland (O'Brien *et al.*, 1988), suggesting that the latest Precambrian rifting event split apart these regions (Williams *et al.*, 1989).

The geometry of the thrust duplexes south of Grand Lake demonstrates that the metasedimentary rocks and their underlying gneissic basement originated east of the Long Range Fault which now truncates the duplexes. Therefore Precambrian rocks once occurred east of the Long Range Fault. No such rocks have been recognized in a form appropriate for sampling for geochronology. Large scale movements on the Long Range Fault must have removed the missing portions of thrust duplexes. We do not know the depositional ages of metasedimentary rocks in the Central Gneiss Subzone, but our results on the Cormacks Lake charnockite combined with earlier work on the tonalitic suite (Dunning, 1987; Stevens *et al.*, 1982) clearly establish a mid-Ordovician age for plutonism and metamorphism and suggest rapid uplift so that K-Ar and U-Pb methods give similar results. These observations suggest that very high-grade metamorphic rocks southeast of the Long Range Fault cannot be directly correlated to those of the Steel Mountain Subzone, as argued by van Berkel and Currie (1988). The protolith of the metamorphic rocks of the Central Gneiss Subzone could be lower Ordovician or older in age. The occurrence of quartzite and carbonate, the paucity of mafic metavolcanic rocks, and the K-rich character of parts of the plutonic suite suggest they cannot be correlated to contemporary low-grade, mafic volcanic and ophiolite-dominated rocks of the Dunnage Zone, as suggested by Dunning and Chorlton (1985). According to seismic evidence, the Central Gneiss Subzone may rest on Grenvillian basement (Kean *et al.*, 1986; Marillier *et al.*, 1988). The Notre Dame Subzone clearly overlies the Central Gneiss Subzone along its northern margin (van Berkel and Currie, 1988). The Central Gneiss Subzone could have formed lower continental slope deposits facies equivalent to the Fleur de Lys Supergroup west of the Long Range Fault. On this model, Ordovician metamorphism and plutonism accompanied thickening of the crust by collapse and imbrication to the west of a continental rise prism during eastward subduction.

Fig. 6. Photomicrograph of charnockitic syenite from the Cormacks Lake complex. Note the large string mesoperthite grains, interpreted as original igneous grains, surrounded by finer-grained mosaic feldspar and quartz. Minor ortho-pyroxene, augite and hornblende also occur in the slide. Size of field 3.1 x 4.5 mm.

Migmatites at Peter Strides Pond (418 ± 4 Ma) are younger than the contiguous, essentially unmetamorphosed ophiolitic Annieopsquotch complex (485 Ma, Dunning, 1987) and related slivers of Silurian rocks (429 Ma, Chandler and Dunning, 1983), which form the southern tip of Dunnage Zone rocks, and are also younger than both plutonism-metamorphism (~465 Ma) and younger mafic plutons (~430 Ma)

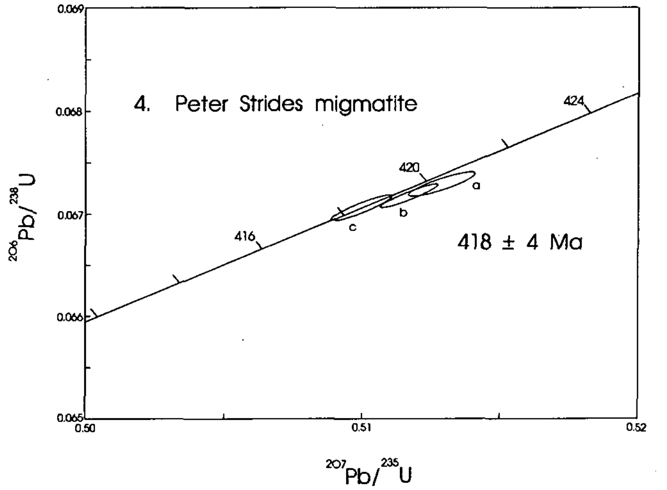

Fig. 7. Concordia plot showing zircon fractions for the Peter Strides migmatite.

in the Central Gneiss Subzone. Therefore the Victoria River Fault must exhibit large-scale motion younger than 418 Ma. We draw attention to the Long Range and Victoria River faults as major separators of radiometric ages. In the Steel Mountain Subzone and Central Gneiss Subzone, Precambrian ages occur only northwest of the Long Range Fault, and Ordovician ages occur only between the Long Range and Victoria River faults.

CONCLUSIONS

Crystalline rocks between the Grand Lake and southern Long Range faults appear to be entirely of Precambrian age. Felsic granulite-facies gneisses have ages of 1.5 Ga, like the northern Long Range, and massif anorthosites were emplaced in the 1.5 to 0.6 Ga interval, like the Indian Head Range and northwestern Cape Breton Island. No plutons of ca. 1 Ga age have been recognized, but metamorphism of this age may be significant. Late Precambrian plutons (610-600 Ma) occur only in transported slices originating east of the Long Range Fault. They are hosted by metasedimentary rocks thought to have formed part of the passive continental margin of North America. In the Central Gneiss Subzone, Precambrian plutons are absent or unrecognizable. The oldest recognizable plutons were emplaced under granulite-facies metamorphic conditions at ~465 Ma into a high-grade metamorphic host derived from mainly clastic sedimentary rocks. The depositional age and provenance of this host remain doubtful, but it was not derived from oceanic material of the Dunnage Zone. It could have been derived from continental slope deposits facies-equivalent to those in the Steel Mountain Subzone. Southeast of the Victoria River Fault, the oldest igneous ages are ca. 420 Ma, developed during pervasive migmatisation of psammitic metasedimentary rocks of uncertain, but probably Paleozoic age. These rocks are separated from the Central Gneiss Subzone and Exploits Subzone of the Dunnage Zone by the Victoria River Fault which appears to be the most profound lithological separator in southwestern Newfoundland. The age distribution and structure of the Steel Mountain Subzone, Central Gneiss Subzone and Meelpaeg Subzone are compatible with westward thrusting of subzones in post-early Silurian time.

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APPENDIX 1: Description of zircon samples

(1) Disappointment Hill complex (NF-7)

The zircon concentrate was abundant but mostly less than 100 microns in size. The crystals formed doubly terminated euhedral prisms with length to breadth ratios about 3:1, and no evidence of cores or overgrowths. Etching with HF did not reveal zoning, but the U content of the zircons is so low (150 ppm) that little differential etching could be expected. The zircons are of igneous morphology, and metamorphic zircon growth seems likely to be negligible or minor.

(2) Hare Hill granite (86-Z1)

This specimen yielded an abundant crop of large zircons (>150 microns) consisting of stubby, doubly terminated prisms with length to breadth ratios of 2:3. About 5% of zircons exhibit geniculate or penetrative twinning. Most have rust-stained surfaces, but they exhibit no evident cores or metamorphic overgrowths, even after etching with HF, and appear entirely of igneous derivation. Sphene in this rock forms euhedral colourless grains similar in size to zircon and locally associated with it.

(3) Cormacks Lake complex (NF-2)

The zircon crop from this homogeneous leucocratic charnockite was abundant, including crystals up to 1 mm long. Large crystals approach 1:1 length to breadth ratios, while smaller crystals are more prismatic, up to 4:1. All form doubly terminated euhedral prisms without visible cores or overgrowths. However, etching with HF showed that the zircons contain euhedral, somewhat patchy, U-rich cores and very thin U-poor rims which do not truncate or cross-cut the cores. The zircon appears to be entirely of igneous origin. The zircon concentrate from this locality contained a significant amount of molybdenite.

(4) Peter Strides Pond migmatite (NF-9)

Granitoid lenticles from the migmatite yielded a moderately abundant crop of small zircons (<100 microns) consisting of doubly terminated prisms with length to breadth ratios of 3:1 to 4:1. They exhibit no evident cores or metamorphic overgrowths, even after etching with HF.