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New Data on the Age and Geochemical Features of Granites in the Southern Prince Charles Mountains and Prydz Bay Coast

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Abstract - In the southern Prince Charles Mountains (SPCM) apparently undeformed post-tectonic granites are dated by zircon U–Pb (SHRIMP) study at *c.* 525–515 Ma. Early Palaeozoic granites in the SPCM may be correlated with peraluminous leucogranite type. Origination of these rocks as a result of voluminous mafic underplate at the base of the crust during the course of an intraplate orogeny is possible. Granites in some parts of the Ruker Terrane (Mts Dummett, Stinear, and Newton) contain inherited zircon populations with Palaeoproterozoic or Mesoproterozoic ages, which are not known from the Ruker Terrane. Granites in the Prydz Bay coast form two magmatic phases, the earlier one was pre- or syn-tectonic and is dated at *c.* 505 Ma. The later phase has A-type granite features (high HFSE, Ga/Al, biotite with high Fe, and F) and originated in within-plate tectonic setting.

INTRODUCTION

The southern Prince Charles Mountains (SPCM) are mainly underlain by the Archaean to Neoproterozoic Ruker Province (Phillips et al., 2006), termed Ruker Terrane by other authors (Mikhalsky et al., 2006a and references therein; Fig. 1). The northern Prince Charles Mountains (NPCM) are a part of extensive Meso- to Neoproterozoic mobile belt and comprises the Beaver Terrane (1150–940 Ma; Boger et al., 2000, Carson et al., 2000, Mikhalsky et al., 2001), and the Fisher Terrane (1300–1000 Ma; Mikhalsky et al., 2001, and references therein). The Fisher Terrane may represent a specific compositional zone within the Beaver Terrane (Mikhalsky et al., 2006b). Fitzsimons (2000) considered the NPCM as a part of the Rayner Province extending from western Enderby Land to the Lambert Glacier area. An area in the central and northern Mawson Escarpment was distinguished as a separate Palaeoproterozoic Lambert Terrane by Kamenev et al. (1990), Mikhalsky et al. (2006a). The Ruker Terrane comprises Meso- to Neoarchaean felsic orthogneisses, variously deformed granites, and metasediments (collectively termed the Ruker Complex by Kamenev et al. (1993) or Tingey Complex by Phillips et al. (2006)) which form the basement overlain by Proterozoic metamorphosed and deformed cover sequences (Phillips et al., 2005, 2006). Most of the Ruker Terrane, and the Lambert Terrane experienced Cambrian (*c.* 500 Ma, hereafter Early Palaeozoic) granite intrusion. Boger et al. (2001) considered the Lambert Terrane a Cambrian collisional suture and correlated it with a high-grade belt exposed in the Prydz Bay area, while Fitzsimons (2003) supported this model, but noted that c. 550–500 Ma tectonism was reported only from the southern part of Mawson Escarpment. However, Phillips et al. (2006) based on a U–Pb detrital zircon study concluded the collisional model "needs a revision".

Previous granite datings in the SPCM mostly yielded Palaeoproterozoic and Archaean ages: 2589 Ma, 2100 Ma, 1995 Ma, and 1708 Ma (muscovite-bearing pegmatites cutting the metasediments in the Ruker Terrane; Tingey, 1982); c. 2650 (pegmatite crystallization and minimum age of deformation; Boger et al., 2001). Early Palaeozoic ages were obtained for granitic rocks or pegmatites in the SPCM by Halpern & Grikurov (1975): 495 Ma (Rb–Sr muscovite age, Mt McCauley), and Tingey (1991): 551±74 Ma (Rb–Sr whole rock, Harbour Bluff).

The compositional and structural diversity of granites in the SPCM was described by Roland & Mikhalsky (submitted). In this paper we present new geochemical and zircon U–Pb isotopic data (SHRIMP) for essentially post-kinematic (*i.e.* apparently postdated major tectonic and metamorphic events in the area) granitic rocks from both the Lambert and the Ruker Terranes. Mostly the granitoids occur as relatively thin vein and dykes or irregular shaped masses, but in a few localities they form larger bodies (up to some hundred meter wide). In some localities late granitic veins may exhibit some shearing attributive of tectonic activities, but the applied strain was not regional scale and did not produce metamorphic foliation in the host rocks apart from relatively narrow zones. However, in other localities (*e.g.*, Mt Dummett), similar rocks preserve a tectonic foliation (Phillips et al., 2005).

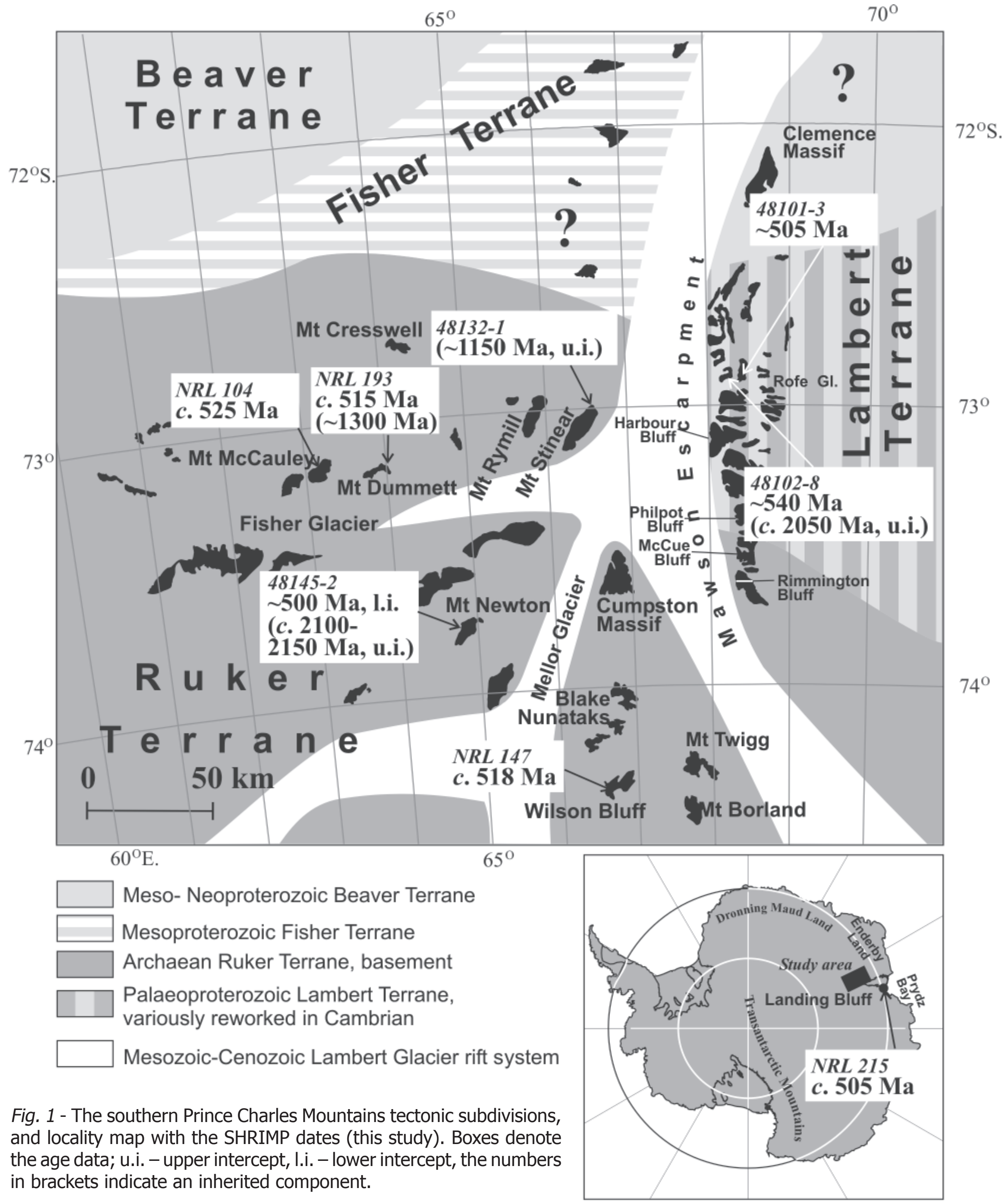


Fig. 1 - The southern Prince Charles Mountains tectonic subdivisions, and locality map with the SHRIMP dates (this study). Boxes denote the age data; u.i. – upper intercept, l.i. – lower intercept, the numbers in brackets indicate an inherited component.

Granitic rocks were also sampled from Landing Bluff in Prydz Bay coast and studied for a comparison. The main goal of this study is to investigate the geochemical features of the granitic rocks in the area of the SPCM, in light of petrological and tectonic constraints. The samples were obtained during the Prince Charles Mountains Expedition of Germany and Australia (PCMEGA 2002/2003).

SHRIMP DATING

Zircon U–Pb isotopic study was conducted on eight samples which represent apparently post-tectonic granite bodies. Samples NRL[1] 104, NRL 147, NRL 193, 48132-1, 48145-2 were collected from the Ruker Terrane, samples 48101-3, and 48102-8 from the Lambert Terrane and sample NRL 215 from Landing Bluff in the Prydz Bay coast. Typical granite outcrops in the SPCM are shown in figure 2. The data are presented in table 1.

The measurements were carried out with a SHRIMP-II ion microprobe at the Centre for Isotopic Research (VSEGEI, St. Petersburg, Russia). Zircon grains were hand selected and mounted in epoxy resin, together with chips of the TEMORA 1 (Middledale Gabbroic Diorite, New South Wales, Australia) and 91500 (Geostandart) reference zircons (Black et al., 2003). Each analysis consisted of 5 scans through the

[1]NRL is part of a sample number and not an abbreviation.

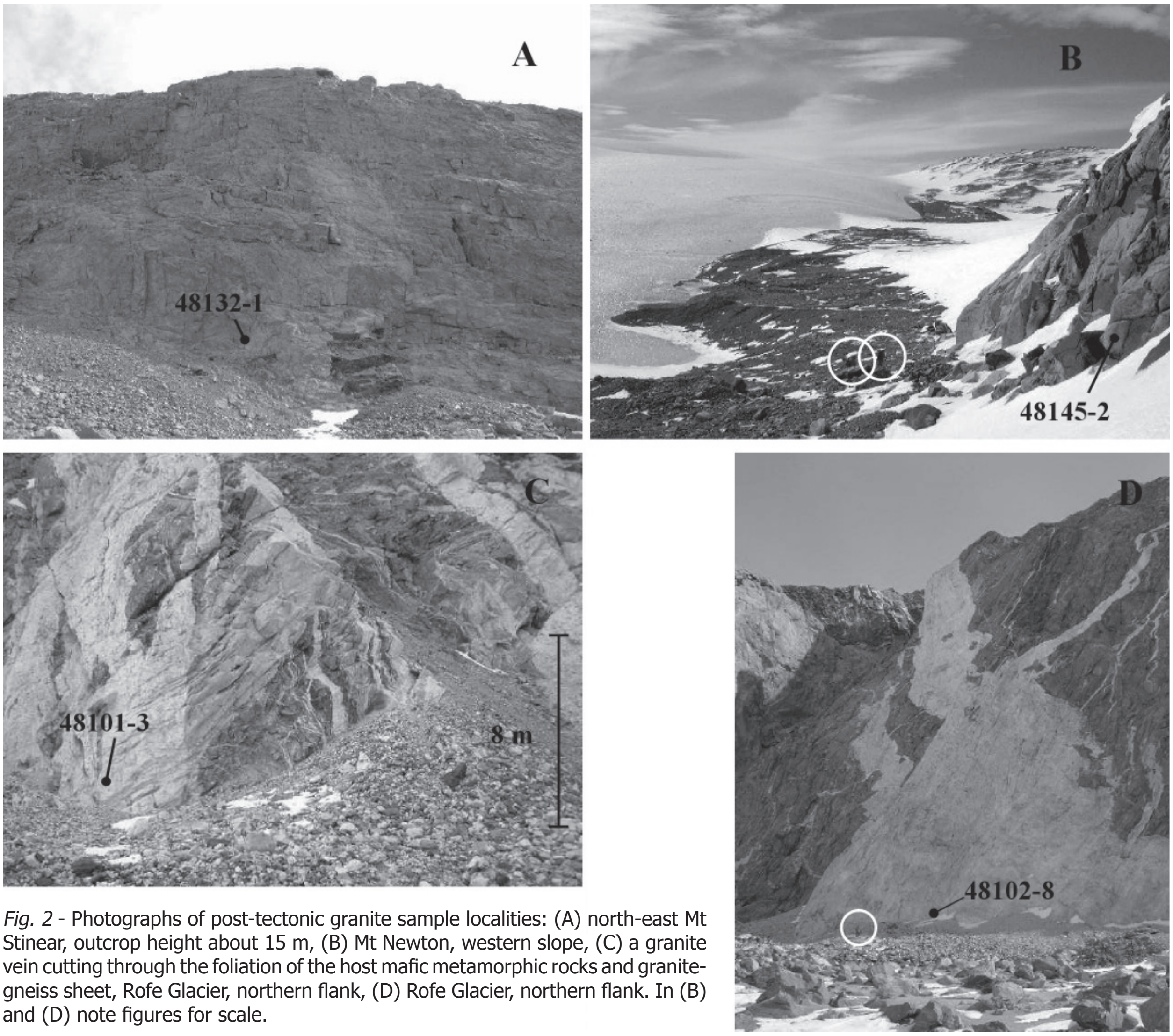


Fig. 2 - Photographs of post-tectonic granite sample localities: (A) north-east Mt Stinear, outcrop height about 15 m, (B) Mt Newton, western slope, (C) a granite vein cutting through the foliation of the host mafic metamorphic rocks and granite-gneiss sheet, Rofe Glacier, northern flank, (D) Rofe Glacier, northern flank. In (B) and (D) note figures for scale.

mass range (40–270 a.m.u.); the spot diameter was about 18 µm and the primary beam intensity about 4 nA. The data were reduced in a manner similar to that described by Williams (1998, and references therein), using the SQUID 1.1 Excel Macro of Ludwig (2000). The plotting and regression calculations were supported by ISOPLOT 3.57. The Pb/U ratios were normalised relative to a value of 0.0668 for the $^{206}Pb/^{238}U$ ratio of the TEMORA zircon, equivalent to an age of 416.75 Ma (Black et al., 2003). Uncertainties given for individual analyses (ratios and ages) are at the one σ level, whereas uncertainties in calculated concordia ages are reported at the two σ level.

THE RUKER TERRANE

Sample NRL 104 is a coarse-grained muscovite granite from Mt McCauley. The rock has a coarse-grained, equigranular, subhedral texture and contains large muscovite flakes. Zircon grains are small (generally <200 μm), metamict and are partly rounded, short-prismatic (Fig. 3 A) or rarely pseudooctagon shape.

Six analyses were obtained and all show very low U (200–300 ppm) and Th (50–100 ppm). Th/U ratio is within 0.2–0.5 suggesting magmatic origin of zircon. All the analyses are nearly concordant and yield a weighted mean $^{207}Pb/^{238}U$ age of 525±4 Ma (MSWD = 2.0; Fig. 4 A), which is likely to reflect the granite crystallization/emplacement age.

Sample NRL 147 is a porphyric muscovite-biotite granite from a postkinematic dyke in Wilson Bluff. The rock has a heterogranular, subhedral to anhedral texture. Reddish-brown biotite and colourless muscovite form large tabular crystals. Tourmaline and garnet, apart from zircon, are the rare accessories. Zircon forms mostly short-prismatic crystals (length/width ratio, $l \approx 2$) (Fig. 3 B) and their aggregates; zircon grains are brownish-pink in colour, not transparent and mostly metamict; thin transparent mantle may be observed.

Five analyses were obtained with very similar and high U (2900–3700 ppm) and Th (1700–3600 ppm) and high Th/U ratio (0.7–0.9) suggestive of a magmatic origin of zircon. All the analyses are nearly concordant and yield a weighted mean $^{206}Pb/^{238}U$ age of 518±3 Ma (MSWD = 2.8; Fig. 4 B), which is likely to reflect the granite crystallization/emplacement age.

Sample NRL 193 is a coarse-grained muscovite

Tab. 1 - Zircon U-Pb (SHRIMP) data for granitoid rocks in the SPCM and Landing Bluff.

				Age (Ma)				**Isotopic ratios**				
Grain spot	*ppm U*	*ppm Th*	$^{232}Th/^{238}U$	*(1)* $^{206}Pb/^{238}U$		*(1)* $^{207}Pb/^{206}Pb$		*(1)* $^{207}Pb^{*}/^{235}U$	±%	*(1)* $^{206}Pb^{*}/^{238}U$	±%	*r*
NRL 104												
1.1	260	94	0.37	520.8	±4.6	497	±110	0.663	5.1	0.0841	0.9	0.182
5.1	345	59	0.18	520.9	±3.4	520	±66	0.670	3.1	0.0842	0.7	0.219
3.1	270	52	0.20	526.0	±3.9	603	±67	0.703	3.2	0.0850	0.8	0.239
2.1	285	55	0.20	527.9	±3.7	538	±63	0.685	3.0	0.0853	0.7	0.245
6.1	186	97	0.54	528.0	±5.2	550	±67	0.689	3.2	0.0853	1.0	0.318
4.1	267	50	0.19	528.5	±4.4	599	±45	0.705	2.3	0.0854	0.9	0.384
NRL 147												
2.1	3702	3611	0.90	518.7	±5.5	385	± 91	0.626	4.0	0.08369	1.1	0.273
3.1	2332	1725	0.70	522.2	±5.1	524	± 65	0.672	3.1	0.08433	1.0	0.331
4.1	2499	2091	0.81	523.2	±4.3	456	± 85	0.655	3.9	0.08455	0.9	0.243
5.1	3537	3123	0.83	516.1	±1.9	492	±19.6	0.655	1.0	0.08335	0.4	0.394
6.1	3729	2895	0.73	519.6	±3.1	546	±21.8	0.680	5.0	0.08394	0.6	0.223
NRL 193												
6.1	1208	115	0.10	479.2	±2.1	502	±30	0.609	1.4	0.0772	0.5	0.333
4.1	1223	136	0.11	492.8	±2.1	470	±34	0.618	1.6	0.0794	0.5	0.302
5.1	772	76	0.10	501.5	±2.0	500	±27	0.638	1.3	0.0809	0.5	0.357
2.1	1114	89	0.08	513.9	±1.9	525	±26	0.662	1.3	0.0830	0.5	0.378
3.2	1537	123	0.08	516.1	±2.0	492	±20	0.655	1.0	0.0833	0.4	0.390
3.1	729	90	0.13	519.6	±3.1	560	±108	0.681	5.0	0.0839	0.6	0.123
1.1	849	38	0.05	590.9	±3.0	722	±71	0.840	3.4	0.0960	0.5	0.154
48132-1												
1.1	374	94	0.26	776	±14	852	±51	1.189	3.1	0.1279	1.9	0.605
1.2	1575	673	0.44	861	±14	1023	±17	1.445	2	0.1429	1.8	0.900
1.3	2931	1322	0.47	607	±10	905	±29	0.943	2.3	0.0988	1.8	0.787
1.4	3383	1234	0.38	351.5	± 6.2	590	±78	0.461	4	0.056	1.8	0.447
1.5	931	446	0.49	774	±14	927	±62	1.23	3.6	0.1275	2	0.548
1.6	2230	556	0.26	812	±14	928	±25	1.296	2.2	0.1343	1.8	0.822
48101-3												
1.1	1844	38	0.02	505.9	±4.7	512	± 23	0.648	2.1	0.08164	1.9	0.875
2.1	4677	67	0.01	423.1	±4.4	546	±200	0.546	9.4	0.06784	1.9	0.205
3.1	2139	29	0.01	506.6	±4.8	928	± 14	0.653	2.6	0.0806	1.9	0.712
4.1	5909	91	0.02	423	±3.9	566	± 14	0.5514	2	0.06782	1.9	0.943
5.1	4341	93	0.02	476.9	±4.4	508	± 14	0.608	2	0.07679	1.9	0.949
6.1	2737	32	0.01	450.8	±4.3	524	± 15	0.5777	2	0.07243	1.9	0.940
7.1	3513	63	0.02	488.8	±4.6	513	± 19	0.625	2	0.07877	1.9	0.909
8.1	3783	71	0.02	500.2	±4.7	551	± 51	0.651	3	0.08069	1.9	0.628
9.1	3458	118	0.04	434.8	±4.1	1976	± 57	0.497	12	0.064	2	0.163
10.1	3430	115	0.03	485.3	±4.5	2031	± 74	0.555	13	0.0713	1.9	0.151
48102-8												
6.1	5256	243	0.05	472.9	± 1.3	538	±16	0.6111	0.77	0.07612	0.28	0.361
2.1	1500	57	0.04	1.811.9	± 4.7	1940.3	± 6.8	5.322	0.48	0.32455	0.30	0.618
5.1	2910	89	0.03	1.941.6	± 3.8	1933.3	± 4.5	5.741	0.34	0.35148	0.23	0.670
1.1	1692	74	0.05	1.969.6	± 5.7	2015.1	± 6.0	6.112	0.47	0.3574	0.33	0.704
4.1	3277	185	0.06	1.988	±12	2054.5	± 8.7	6.318	0.88	0.3613	0.73	0.829
3.1	1410	163	0.12	2.008.6	± 5.2	2032.8	± 8.2	6.315	0.55	0.3656	0.30	0.545
48145-2												
2.1	2571	30	0.01	2.054.8	±4.5	2102.2	±6.1	6.745	0.43	0.37541	0.25	0.590
1.1	2444	32	0.01	2.072.8	±5.2	2114.3	±6.2	6.861	0.46	0.3793	0.29	0.633
6.1	2316	52	0.02	2.079.1	±5.4	2101.9	±5.9	6.837	0.45	0.3806	0.30	0.668
3.1	2111	96	0.05	2.090.6	±4.7	2127.9	±5.3	6.984	0.40	0.3831	0.26	0.658
5.1	2453	54	0.02	2.100.0	±7.5	2114.9	±5.4	6.969	0.52	0.3851	0.42	0.804
4.1	7729	114	0.02	2.199.1	±3.9	2127.1	±2.8	7.409	0.26	0.40654	0.21	0.798
NRL 215												
1.1	149	133	0.92	488.1	± 6.8	419	± 85	0.598	4.1	0.0787	1.4	0.353
2.1	153	130	0.87	503.8	± 7.1	346	± 130	0.598	5.8	0.0813	1.5	0.251
3.1	129	85	0.68	464.4	± 7.2	371	± 110	0.556	5.2	0.0747	1.6	0.311
4.1	145	126	0.90	521.3	± 7.2	454	± 70	0.651	3.5	0.0842	1.4	0.412
5.1	147	131	0.92	496.4	± 7.3	565	± 87	0.651	4.3	0.08	1.5	0.358
6.1	542	618	1.18	504.7	± 6	522	± 27	0.649	1.7	0.08143	1.2	0.706
7.1	178	156	0.91	519.7	± 7.1	505	± 76	0.664	3.7	0.084	1.4	0.384
7.2	242	251	1.07	493.2	± 6.3	407	± 67	0.602	3.3	0.0795	1.3	0.406
8.1	482	511	1.15	503.1	± 6	521	± 26	0.639	1.6	0.0812	1.2	0.704

Note: Common Pb corrected using measured ^{204}Pb. Errors are 1-sigma. Error in standard calibration did not exceed 1.16% (not included into above errors). Pb* indicates the radiogenic Pb portion. r - error correlation.

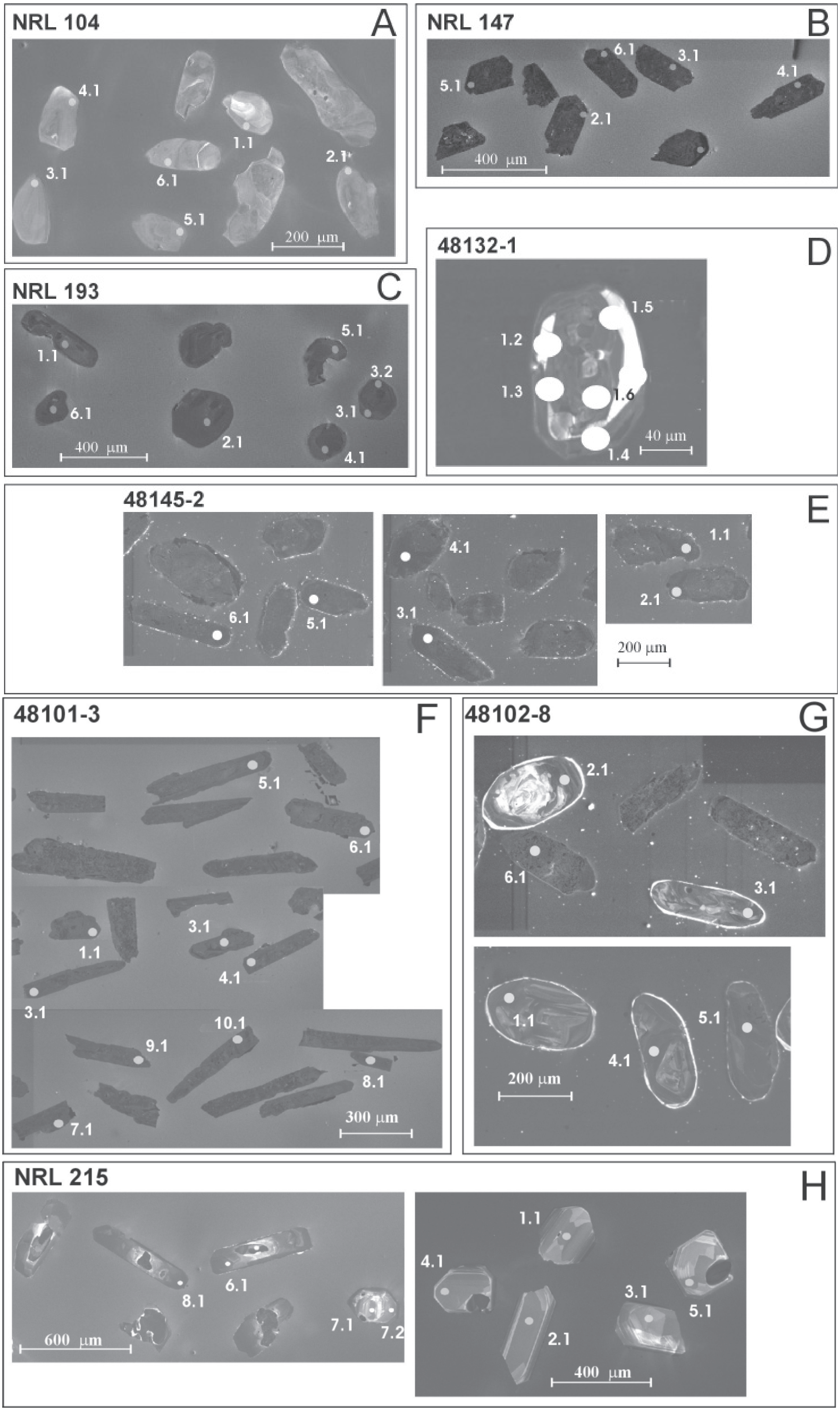
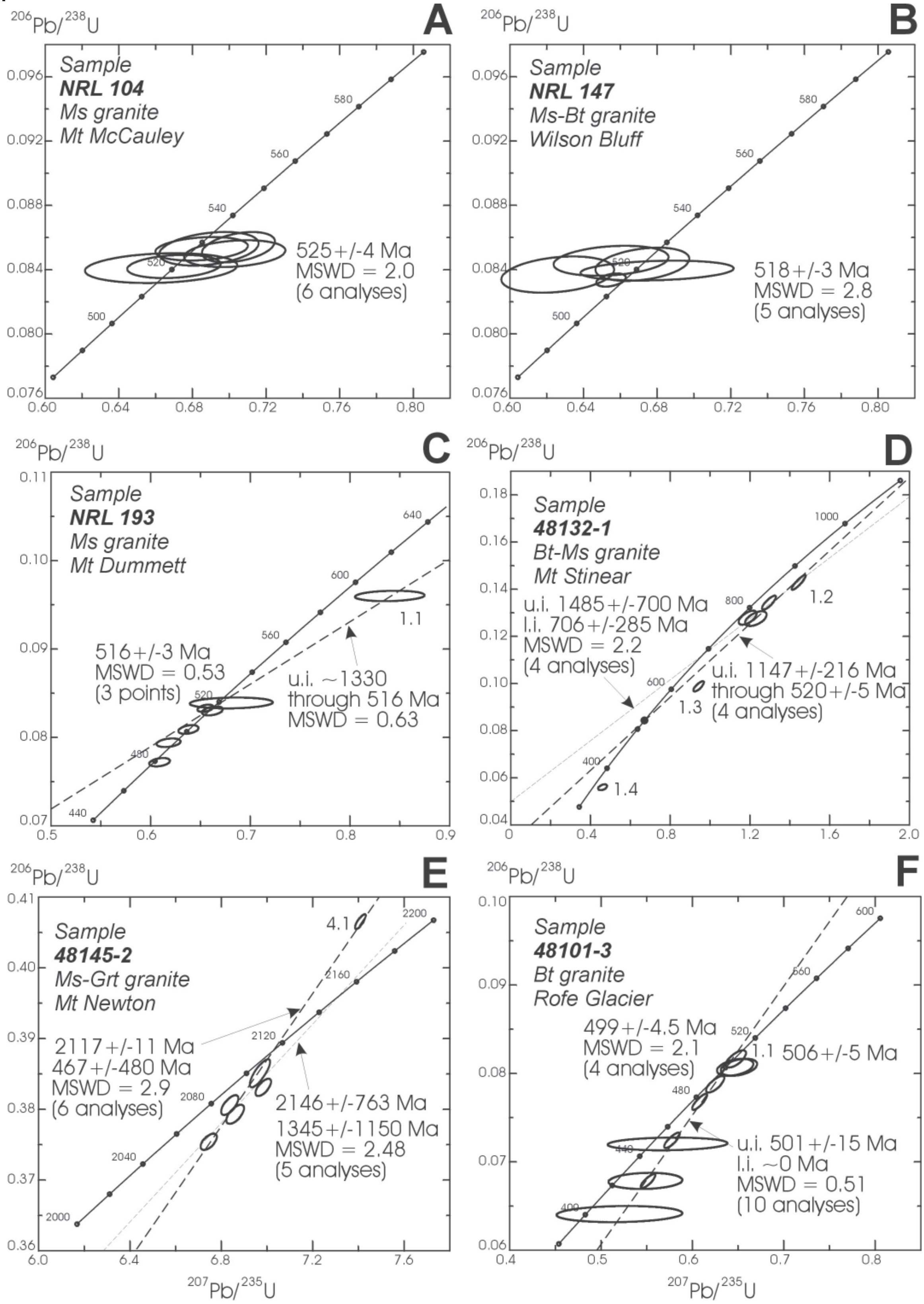


Fig. 3 - The cathodoluminescence images of zircons from the southern PCM (A–G) and Landing Bluff (H).

granite from Mt Dummett. The rock has a coarse-grained, nearly isogranular, euhedral texture and contains large muscovite flakes (5%). Biotite forms scarce fibrous grains, replaced by ferrous minerals. Zircon grains are rounded isometric (Fig. 3 C), but some are prismatic to long-prismatic (l = 4) in shape, pinkish grey in colour, not transparent; some grains exhibit a thin transparent mantle. Morphologically zircon from this sample is very similar to sample NRL 147.

Seven analyses were obtained and all have high U (700–1500 ppm) and low Th (40–130 ppm). Th/U ratio is within 0.05–0.13, which is basically below the typical magmatic values. Six analyses are nearly concordant, but do not form a coherent cluster (Fig. 4 C). Instead, they show a considerable scatter of $^{206}Pb/^{238}U$ ages in the range 480–520 Ma. Three analyses at the older limit of this range yield a weighted mean $^{207}Pb/^{206}Pb$ age of 516±3 Ma (MSWD = 0.53),



which is likely to reflect the granite emplacement age. The other three analyses reflect some Pb loss. The seventh analysis (1.1) is discordant and reflects an inherited component. A model $^{207}Pb/^{206}Pb$ age of this analysis is c. 720 Ma. A regression line drawn through this analysis and the point of 516 Ma has an upper intercept at c. 1330 Ma. Hence the inherited component may be of Meso- to Neoproterozoic age. This is the first indication of a zircon growth event at those times within the Ruker Terrane.

Sample 48132-1 is a medium-grained pink garnet, muscovite and biotite-bearing granite from a small bluff (Fig. 2 A) in otherwise flat north-eastern tip of Mt Stinear with scattered granite outcrops partly covered by moraine and scree. This granite probably comprises a small pluton at least 500 m wide. No mylonitic structures or shear fabrics were observed. The granite contains rare xenoliths of mafic schist with folded felsic veins. The rock has heterogranular euhedral texture and reveals no secondary alteration. Mafic minerals form small and scarce grains. Only one zircon grain was recovered from this sample (Fig. 3 D). The grain is 80x120 μm large and has a rounded shape with subtle crystal facets developed.

Six analyses on one grain were obtained, and all of them are to some extent discordant. U and Th concentrations vary widely (370–3400, and 90–1300 ppm, respectively); Th/U ratio is within 0.26–0.49, retaining typical magmatic values. Two analyses show higher U, Th concentrations, and have younger $^{206}Pb/^{238}U$ ages (c. 600 and 350 Ma). A regression line drawn through all six analyses give an upper intercept at 990±120 Ma, and a lower intercept at 250±220 Ma with high MSWD = 3.1 (Fig. 4 D). The lower intercept does not correspond to the age of any known geological event in the region, thus this date my be meaningless. The four lower-U, Th analyses give a reference line with an upper intercept at 1485±700 Ma, and a lower intercept at 706±285 Ma (MSWD = 2.1). The lower intercept may reflect an Early Palaeozoic age of granite crystallization. Assuming major Pb loss occurred at the time of granite intrusion in other localities in this area (better constrained at c. 525–515 Ma), a regression line drawn through this

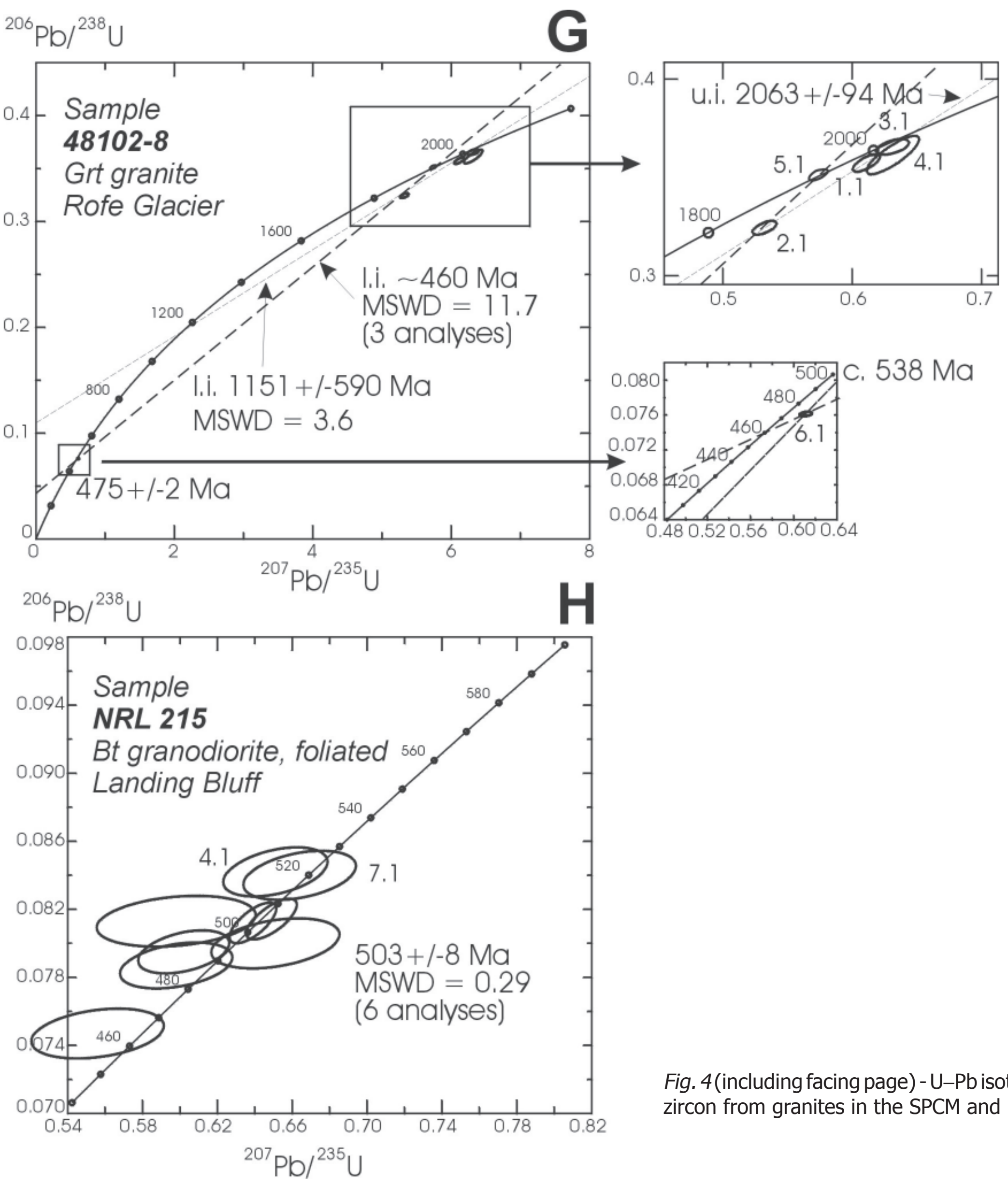


Fig. 4 (including facing page) - U–Pb isotope diagrams for zircon from granites in the SPCM and Landing Bluff.

point and these four analyses gives an upper intercept at c. 1150 Ma. This age may correspond to the age of an inherited component in the source region. It indicates some tectonothermal activity in the SPCM in the Mesoproterozoic.

Sample 48145-2 is a coarse-grained muscovite-garnet granite from Mt Newton (collected in the central part of its western slope) (Fig. 2 B). Garnet forms large ovoid megacrysts abundant in some localities. The rock has a heterogranular subhedral texture, and reveals no secondary alteration. In that area garnet granite occurs in a chain of outcrops separated by scree. The granite makes up a relatively large (at least 500 m wide) body. No deformation structures were observed within the granite. The zircon grains are large (mostly 200–300 μm), short-prismatic (l = 1.2–1.5) or rarely long-prismatic in shape (l up to 5.0) (Fig. 3 E). Many grains are somewhat corroded and original facets rounded. No clear oscillatory zoning patterns were observed optically, but cathodoluminescence images (CL) of some grains show inner zoning.

Six analyses on six grains were obtained and all show consistently high U (2000–2500 ppm, and analysis 4.1 yields 7700 ppm), and low Th (30–114 ppm). Thus Th/U ratio is very low, in the range 0.01–0.05, suggestive of a metamorphic origin of these grains. None of the analyses are concordant, but the discordance is not very strong (Fig. 4 E). Five analyses form a stretched cluster, and the sixth one (high-U, Th analysis 4.1) is reversely discordant. All six analyses form a poorly constrained regression line with an upper intercept at 2117±11 Ma, and a lower intercept at 467±480 Ma (Fig. 3 E). If the reversely discordant analysis 4.1 is excluded, a regression line would give an upper intercept at 2146±763, and a lower intercept at 1345±1150 Ma. These data are indicative of two thermal events, the first one in the Palaeoproterozoic (at c. 2100–2150 Ma), and the second one in the Meso- to Neoproterozoic or Early Palaeozoic (at c. 1300 Ma or 500 Ma, respectively). Taken at face value, these data are suggestive of a Palaeoproterozoic emplacement age of this granite, with subsequent Pb lost at some later stage; but that would contradict the apparent metamorphic nature of the zircon. Moreover, the lack of any alteration in the rock-forming minerals precludes a suggestion of strong Pb loss during post-crystallization history. This rock contains very low Zr (30 ppm) and it may be alternatively suggested that the emplacement age of the granite is young (Early Palaeozoic) and the lack of c. 500 Ma grains may be due to insufficient sampling. In this case the zircon grains are inherited from the source, and the c. 2100 Ma date reflects some metamorphic event in the source region. This argues for either the Ruker Terrane experienced some Palaeoproterozoic tectonothermal activity (not yet recognized), or otherwise Mt Newton, which is a separate and relatively large nunatak, is not composed of the Ruker (or Tingey) Complex.

THE LAMBERT TERRANE

Sample 48101-3 is a medium- to coarse-grained leucocratic, pegmatitic white granite with euhedral texture, containing rare small biotite flakes and garnet crystals. The sample was collected from a subvertical granitic dyke 1–2 m thick (Fig. 2 C), cutting through an earlier syn-tectonic granite sheet (dated by SHRIMP at c. 920 Ma, unpublished data of the authors) and mafic granulite invaded by felsic veins (dated by SHRIMP at c. 1750 Ma, unpublished data of the authors). Zircon forms highly elongated to acicular (l up to 10) (Fig. 3 F) cloudy crystals of grayish-pink colour, and aggregates of such crystals. Few grains have short-prismatic or pseudo-octagonal shape.

Ten analyses were obtained. All analyses show high U (2100–6000 ppm) and low Th (30–120 ppm) concentrations. The Th/U ratio is basically low (0.01–0.04), but that was likely due to low-Th parent melt character; a metamorphic origin of zircon would be inconsistent with the observed crystal shape. Most analyses are to some extent discordant. Four nearly concordant analyses give a weighted mean $^{207}Pb/^{206}Pb$ age of 499±4.5 Ma. A regression line drawn through eight points gives an upper intercept at 501±15 Ma, and a lower intercept at recent time (MSWD = 0.51; Fig. 4 F). The upper intercept nearly coincides with analysis 1.1 which has a $^{206}Pb/^{238}U$ age of 506±5 Ma. This age probably dates the granite crystallization/emplacement event.

Sample 48102-8 is a garnet-bearing coarse-grained granite from a relatively thick (at least 10 m) dyke-like body in the Rofe Glacier area (Fig. 2 D). In the sample locality the granite body does not reveal any deformation pattern. The rock-forming minerals are not altered. The zircon grains recovered from this sample are generally small (150–200 μm), moderately elongated (l = 1.8–3.5), and strongly rounded (Fig. 3G). No original crystal facets are preserved. The cathodoluminescence images reveal irregular grain structure, but no clear zonation or rim overgrowth may be discerned. In the CL images there seem to be another population of dull, and more prismatic grains, but whether it represents another zircon generation with different lattice structure or not, cannot be defined by the CL alone.

Six analyses on six grains were obtained and show considerable diversity. Five analyses were obtained on the highly rounded grains, and one on a more prismatic-shaped grain (6.1). Most analyses (except 6.1) show moderately high concentrations of U (1400–3300 ppm), and Th (60–180 ppm), which result in generally low Th/U ratio in the range (0.03–0.12). The analysis 6.1 has much higher U, and Th, although the Th/U ratio (0.05) does not differ from the others. Among the analyses of the rounded grains four are concordant or nearly concordant; one of them has a $^{206}Pb/^{238}U$ age of c. 1940 Ma, the others cluster around $^{206}Pb/^{238}U$ age of c. 2000 Ma (Fig. 4G). Analysis 2.1 is more discordant with a $^{206}Pb/^{238}U$ age of *c*. 1800 Ma. Analysis 6.1 is slightly discordant at *c.* 475 Ma. A regression line drawn through four discordant analyses of highly rounded grains (1.1, 2.1, 3.1, 4.1) define an upper intercept at 2063±94 Ma, and a lower intercept at 1151±590 Ma (MSWD = 3.6). These data may be interpreted in terms of three geological events: a metamorphic event at *c.* 2050 Ma, a metamorphic event at c. 1150 Ma (maybe better define the age as late Mesoproterozoic, due to the high uncertainty of this dating), and a magmatic event (granite emplacement) at *c.* 480–470 Ma. It is noteworthy that this rock contains low Zr (83 ppm), which may explain the scarcity of crystallization-age zircon grains. Another Palaeoproterozoic event may be reflected by the analysis 5.1 (*c.* 1940 Ma). A regression line drawn through this analysis, discordant analysis 2.1 and nearly concordant (at the younger concordia section) analysis 6.1 gives the interceptions at *c.* 1940 Ma, and 460 Ma, but the MSWD = 11.7 is very large. Thus, it is reasonable to suggest that the analysis 2.1 reflect Pb loss in Mesoproterozoic (*c.* 1150 Ma) rather than in Early Palaeozoic (*c.* 460 Ma). As the analysis 6.1 is slightly discordant, the real age of the zircon crystallization may be somewhat older if the grain experienced Pb loss at a subsequent event. Thus, assuming Pb lost at present time, the age of crystallization would be 538±30 Ma. It should be noted that the isotopic ratios measured in the zircon grains from this sample (collected from the Lambert Terrane) are not dissimilar to the zircon features of sample 48145-2 from Mt Newton (collected from the Ruker Terrane).

PRYDZ BAY COAST

Sample NRL 215 is a gneissose biotite granodiorite collected from a small xenolith within an Early Palaeozoic granite pluton in Landing Bluff. The rock has a heterogranular, fine- to medium-grained, anhedral texture. Reddish-brown biotite forms coarse-grained irregular crystals. A few tiny fluorite grains occur in the interstitials or as inclusions in feldspars. Zircon grains are short- to long-prismatic (l = 1–5), have well developed dipyramid facets (Fig. 3 H) and are transparent or semitransparent. The zircon crystals contain cloudy or transparent zonal cores.

Nine analyses were obtained and all show low U (130–540 ppm) and high Th (85–620 ppm) resulted in high Th/U ratio in the range 0.7–1.15, suggestive of a magmatic origin. All the analyses are concordant (Fig. 4 H), and six of them form a coherent cluster, which yields a weighted mean $^{206}Pb/^{238}U$ age of 503±8 Ma (MSWD = 0.29). Two analyses gave somewhat older $^{206}Pb/^{238}U$ ages at about 520 Ma, which may indicate the presence of an inherited component, as one of these analyses (7.1) was taken from an inner core. However, the other one (4.1) represents a common zircon domain, and is noteworthy reversely discordant.

GEOCHEMICAL DATA

MAJOR AND TRACE ELEMENTS

Twenty eight samples of granitoids collected in the southern Prince Charles Mountains and Landing Bluff in Prydz Bay Coast were analysed for major and trace elements at BGR (Hannover) by X-ray fluorescence. The data are presented in table 2.

In a classification by LeMaitre (1989) most samples studied fall within the monzogranite field, while a few are of granodioritic to tonalitic composition (Fig. 5 A). In a classification by Barker (1979) most rocks also fall within granite field, while some of them fall within tonalite and trondhjemite fields (Fig. 5 B). It is noteworthy that the rocks from the Ruker Terrane form a more sodium trend in figure 5 B, while the rocks from the Lambert Tettane form somewhat more calcareous trend, although a few rocks from the

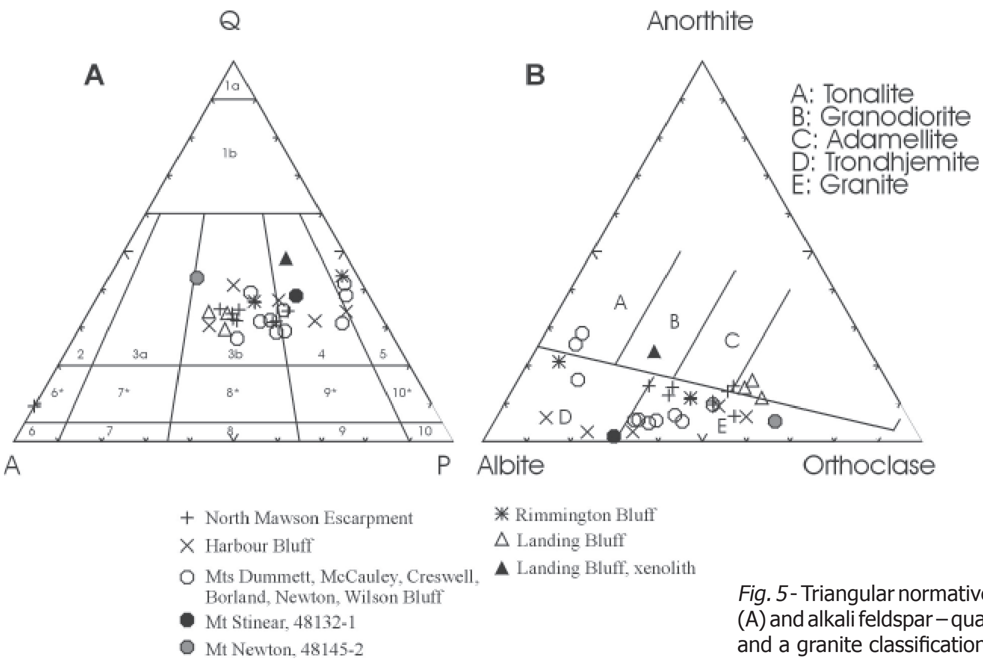


Fig. 5 - Triangular normative albite–anorthite–orthoclase (A) and alkali feldspar – quartz – plagioclase (B) diagrams and a granite classification by LeMaitre (1989).

Tab. 2 - Major and trace element data for the granitic rocks from the SPCM and Landing Bluff.

Sample ID	*Locality*	*SiO_2*	*TiO_2*	*Al_2O_3*	*Fe_2O_3**	*MnO*	*MgO*	*CaO*	*Na_2O*	*K_2O*	*P_2O_5*	*LOI*	*Cr*	*Ni*	*Pb*	*Zn*	*Rb*	*Ba*	*Sr*	*Ga*	*Nb*	*Hf*	*Zr*	*Y*	*Th*	*U*	*La*	*Ce*	*Nd*
NRL5	north ME	74.38	0.01	14.66	0.17	0.01	0.02	1.36	3.27	5.56	0.02	0.24	11	0	136	8	127	98	65	25	3	bdl	50	26	24.0	22.0	20	42	0
NRL6	north ME	73.63	0.03	14.11	2.34	0.09	0.12	1.40	3.28	4.40	0.01	0.23	13	5	107	14	106	49	53	23	10	bdl	83	34	15.0	8.0	20	54	0
NRL18	north ME	74.02	0.09	14.43	1.23	0.01	0.16	1.94	4.05	3.43	0.02	0.28	14	5	42	18	74	647	174	19	3	bdl	82	3	27.0	0.0	40	72	0
NRL19	north ME	73.66	0.09	14.76	0.74	0.01	0.15	1.67	4.00	4.27	0.01	0.32	0	8	42	12	87	666	161	23	2	bdl	59	3	35.0	3.0	42	77	0
NRL45	north ME	74.40	0.11	14.03	0.78	0.01	0.14	1.40	3.09	5.22	0.04	0.49	3	5	51	17	132	625	150	16	5	bdl	44	3	9.0	0.0	20	20	0
NRL47	north ME	74.31	0.14	13.78	0.93	0.01	0.26	0.89	2.84	5.91	0.04	0.53	13	8	53	18	151	902	161	16	6	bdl	132	3	33.0	0.0	49	55	0
NRL61	north ME	73.37	0.06	14.55	0.81	0.01	0.18	1.81	2.85	5.67	0.04	0.33	9	0	56	20	144	1001	124	19	4	bdl	58	3	14.0	3.0	20	20	0
NRL63	north ME	72.14	0.16	14.49	1.66	0.01	0.38	1.93	2.61	5.54	0.08	0.36	26	18	42	27	123	2204	194	15	6	5	281	3		8.0	250	409	106
NRL64	north ME	71.10	0.19	14.83	2.48	0.02	0.51	1.99	3.73	4.10	0.06	0.44	10	13	62	35	220	491	83	21	14	bdl	181	3		14.0	279	429	141
48101-3	north ME	74.00	0.01	15.10	0.37	0.02	0.01	1.91	3.42	4.67	0.02	0.34	7	4	nd	nd	nd	194	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
NRL67	Harbour Bluff	74.95	0.32	11.73	3.12	0.05	0.09	1.10	2.67	4.78	0.04	0.67	8	5	28	56	220	756	50	16	50	8	533	73	21.0	6.0	90	165	69
NRL69	Harbour Bluff	74.29	0.03	14.22	0.27	0.01	0.01	0.89	2.88	6.72	0.01	0.37	11	6	59	8	273	978	183	14	5	bdl	19	3	5.0	4.0	20	20	bdl
NRL71	Harbour Bluff	75.43	0.01	14.39	0.86	0.18	0.01	0.38	4.49	3.45	0.04	0.51	8	11	38	10	545	5	4	34	97	bdl	27	18	7.0	6.0	26	20	bdl
NRL72b	Harbour Bluff	75.66	0.00	14.06	0.63	0.28	0.04	1.00	6.18	1.27	0.11	0.47	13	12	7	47	271	13	48	46	94	bdl	29	3	8.0	3.0	33	20	bdl
NRL73b	Harbour Bluff	75.31	0.01	14.16	0.70	0.29	0.01	0.39	5.81	2.63	0.03	0.32	10	9	15	12	625	5	6	44	83	bdl	30	26	11.0	4.0	20	20	bdl
NRL104	Mt McCauley	74.01	0.03	14.83	0.85	0.01	0.01	0.88	4.37	4.22	0.09	0.47	13	0	71	47	246	26	36	29	27	bdl	36	9	9.0	16.0	20	20	bdl
NRL106	Mt McCauley	74.08	0.11	14.11	1.20	0.02	0.09	0.97	4.05	4.68	0.02	0.32	10	0	82	47	200	511	143	25	23	bdl	76	13	11.0	9.0	22	42	bdl
NRL136	Mt Newton	73.63	0.01	15.58	1.07	0.02	0.07	3.57	4.37	0.89	0.03	0.46	16	4	27	5	19	268	424	16	2	bdl	30	5	5.0	0.0	22	20	bdl
48132-1	Mt Stinear	74.22	0.17	14.46	1.19	0.03	0.60	1.04	4.73	3.02	0.66	0.40	51	31	nd	nd	nd	57	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
48145-2	Mt Newton	74.89	0.10	14.34	1.08	0.02	0.18	0.91	1.88	6.02	0.30	0.36	21	16	nd	nd	nd	2180	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
NRL142	Mt Borland	73.88	0.00	15.54	0.09	0.01	0.01	2.30	5.54	1.63	0.03	0.60	12	3	93	3	32	551	568	13	2	bdl	19	3	5.0	0.0	20	20	bdl
NRL146	Wilson Bluff	73.95	0.03	14.88	0.58	0.08	0.04	0.73	4.80	4.31	0.02	0.31	10	4	89	8	184	167	58	24	10	bdl	77	79	12.0	8.0	20	26	bdl
NRL147	Wilson Bluff	74.25	0.01	14.77	0.58	0.11	0.01	0.86	4.95	3.97	0.02	0.22	7	3	85	3	155	166	61	25	3	bdl	64	83	18.0	5.0	20	44	bdl
NRL191	Mt Dummett	73.97	0.08	15.04	0.91	0.02	0.12	0.84	3.41	4.25	0.17	0.90	12	6	51	20	215	223	63	33	23	bdl	42	3	16.0	7.0	20	20	bdl
NRL193	Mt Dummett	75.12	0.04	14.56	0.53	0.01	0.05	0.80	4.59	3.52	0.04	0.51	10	6	53	14	184	83	52	26	20	bdl	54	3	11.0	12.0	20	20	bdl
NRL209	Mt Cresswell	71.80	0.01	16.08	0.53	0.02	0.05	1.39	3.47	5.86	0.03	0.35	7	7	118	3	111	1680	198	13	2	bdl	56	3	7.0	0.0	20	27	bdl
NRL210	Mt Cresswell	74.77	0.14	14.35	1.33	0.01	0.45	3.05	4.36	0.84	0.01	0.43	14	13	26	26	36	190	213	18	3	bdl	84	3	0.0	6.0	20	20	bdl
NRL214	Landing Bluff	71.70	0.30	13.60	3.13	0.04	0.14	1.58	2.19	6.23	0.12	0.45	8	7	49	69	249	1100	158	28	27	bdl	324	45	54.0	0.0	159	252	108
NRL215**	Landing Bluff	77.14	0.24	11.75	1.92	0.02	0.24	2.57	2.83	2.38	0.06	0.55	14	6	37	43	132	294	112	19	8	bdl	171	7	55.0	7.0	40	65	bdl
NRL216	Landing Bluff	67.77	0.73	14.29	4.43	0.06	0.69	2.41	2.29	6.04	0.20	0.50	15	6	61	88	300	903	178	27	21	8	405	26		6.0	168	278	123
NRL217	Landing Bluff	68.40	0.76	13.85	4.36	0.06	0.62	2.24	2.32	5.53	0.39	0.96	21	10	60	79	316	912	162	25	24	11	476	35	88.0	0.0	115	194	102

Lambert Terrane also exhibit albite "enrichment". In a classification by Frost et al. (2001) most rocks are ferroan or marginally magnesian and calc-alkalic to alkali-calcic (Fig. 6), although mostly samples from both the Ruker Terrane, and the Lambert Terrane scatter widely. An exception of that is a group of biotite and garnet-biotite granites from the northern part of Mawson Escarpment (the Lambert Terrane), which form a more or less consistent trend in figure 6. Garnet–muscovite-bearing granitoids from the Harbour Bluff, as well as granites from the Landing Bluff are ferroan and more alkali-calcic, than the north Mawson Escarpment rocks. The muscovite granitoids and pegmatites in the Ruker Terrane form a rather heterogeneous clusters in figure 5 and span wide range of the MALI index, although none is alkalic, and most rocks are highly ferroan (Fe* > 0.85).

Most granitoids are marginally peraluminous (1.00<ASI<1.12), and rocks from the north-western part of the terrain (Mts Cresswell, McCauley, Dummett) have somewhat elevated ASI (1.05–1.30). In normative CIPW composition, apart from usual quartz and feldspars, corundum may be present. However, corundum content only rarely exceeds 1%. Most corundum-enriched rocks occur in the Ruker Terrane.

In a triangular Ba–Rb–Sr diagram after El Bouseily & El Sokkari (1975) most samples plot along the normal granitoid differentiation trend (Fig. 7), and some samples (NRL 71, 73b, 72b, 104, 193) plot within a highly evolved aplite field. Rb/Sr and Ba/Rb ratios vary very widely, but when only less fractionated samples (those with higher Ba/Rb > 3.0) are considered, the Rb/Sr ratio show more consistent values: 0.5–2.0 for north Mawson Escarpment rocks, 1.5–4.4 for Harbour Bluff rocks (the Lambert Terrane), 0.05–1.4 for the western and southern parts of the SPCM (the Ruker Terrane), and 1.2–2.0 for the Landing Bluff rocks (the latter actually have consistently high Ba/Rb suggestive of relatively less fractionated nature of these rocks). K/Rb ratio also varies in a very wide range in the Ruker Terrane (mostly 150–600), and to a lesser extent in other areas: 250–480 in northern Mawson Escarpment, 100–330 in Harbour Bluff and 150–400 in Landing Bluff.

The spiderdiagram patterns of rocks from various areas also show considerable scatter (Fig. 8). Most scatter is displayed by Ba, which may be due to highly fractionated nature of many samples. In this respect, the granites from Landing Bluff have much less scatter of Ba content.

Granitic rocks in the northern Mawson Escarpment (the Lambert Terrane; Fig. 8 A), apart from two samples (NRL 63, NRL 64) collected within a mafic to ultramafic tectonic slab in the northern Rofe Glacier area, show more or less consistent patterns with moderate LILE enrichment, they generally have no Ba anomaly, and have prominent negative Nb anomaly. The exception is provided by two granitoid samples collected within a mafic–ultramafic slab. These rocks are biotite-bearing monzogranites petrographically similar to the other granitic rocks from the same area, except for containing notable amounts of accessory monazite and zircon. They are strikingly enriched in many LILE, and LREE in particular and also by the HFSE.

Granitic rocks from Harbour Bluff show the largest scatter of most trace elements, especially

Tab. 2 - Continued.

Sample ID	*ASI*	*K/Rb*	*Rb/Sr*	*Ga/Al*	*K/Na*	*La/Y*	*Ba/Rb*	*mg*	*normative corundum*
NRL5	1.06	363	1.95	3.22	1.70	0.77	0.77	21.52	0.82
NRL6	1.11	345	2.00	3.08	1.34	0.59	0.46	10.68	1.42
NRL18	1.04	385	0.43	2.49	0.85	13.33	8.74	23.26	0.50
NRL19	1.04	407	0.54	2.94	1.07	14.00	7.66	32.08	0.47
NRL45	1.06	328	0.88	2.16	1.69	6.67	4.73	29.49	0.78
NRL47	1.09	325	0.94	2.19	2.08	16.33	5.97	39.45	1.09
NRL61	1.03	327	1.16	2.47	1.99	6.67	6.95	34.12	0.43
NRL63	1.06	374	0.63	1.96	2.12	83.33	17.92	34.79	0.69
NRL64	1.05	155	2.65	2.68	1.10	93.00	2.23	32.40	0.72
48101-3	1.07				1.37			9.67	0.00
NRL67	1.02	180	4.40	2.58	1.79	1.23	3.44	6.30	0.19
NRL69	1.04	204	1.49	1.86	2.33	6.67	3.58	0.00	0.50
NRL71	1.22	53	136.25	4.47	0.77	1.44	0.01	0.00	2.64
NRL72b	1.06	39	5.65	6.18	0.21	11.00	0.05	12.89	0.94
NRL73b	1.08	35	104.17	5.87	0.45	0.77	0.01	0.00	1.08
NRL104	1.12	142	6.83	3.70	0.97	2.22	0.11	12.06	1.67
NRL106	1.05	194	1.40	3.35	1.16	1.69	2.56	14.88	0.60
NRL136	1.07	389	0.04	1.94	0.20	4.40	14.11	13.23	0.94
48132-1	1.19				0.64			47.64	3.10
48145-2	1.32				3.20			22.90	3.63
NRL142	1.03	423	0.06	1.58	0.29	6.67	17.22	0.00	0.45
NRL146	1.07	194	3.17	3.05	0.90	0.25	0.91	13.85	1.01
NRL147	1.06	213	2.54	3.20	0.80	0.24	1.07	0.00	0.79
NRL191	1.30	164	3.41	4.15	1.25	6.67	1.04	23.51	3.67
NRL193	1.14	159	3.54	3.37	0.77	6.67	0.45	18.02	1.82
NRL209	1.11	438	0.56	1.53	1.69	6.67	15.14	18.02	1.42
NRL210	1.05	194	0.17	2.37	0.19	6.67	5.28	44.09	0.71
NRL214	1.04	208	1.58	3.89	2.84	3.53	4.42	9.44	0.55
NRL215	0.99	150	1.18	3.06	0.84	5.71	2.23	22.56	0.00
NRL216	0.99	167	1.69	3.57	2.64	6.46	3.01	26.63	0.00
NRL217	1.03	145	1.95	3.41	2.38	3.29	2.89	24.89	0.80

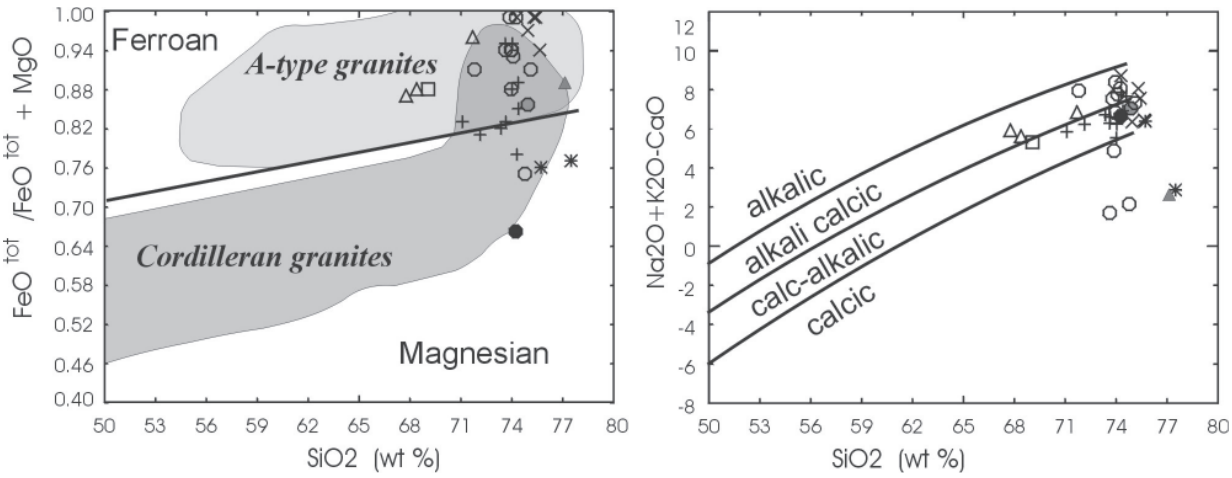


Fig. 6 - SiO_2 vs Fe* index and SiO_2 *vs* Na_2O+K_2O-CaO (modified alkali-lime index, MALI) diagrams (Frost et al., 2001). Fields of the Cordilleran, and the A-type granites from Frost et al. (2001). Symbols as in figure 5.

due to the lack of Ba, Ti, and Sr in some samples and have noticeably high Nb contents. One of the rocks from Harbour Bluff (NRL 67) exhibits elevated concentrations of LREE, Zr, and Y, similar to the two samples from the mafic–ultramafic slab in the Rofe Glacier area, and may have a similar origin.

Granitic rocks from the Ruker Terrane (Fig. 8 B) have basically similar compositions to the granitoids in the Lambert Terrane. The muscovite granites from Mts McCauley and Dummett have consistent patterns, and considerable LILE enrichment (except for Ba) but low LREE, which results in the lack of negative Nb anomalies, and overall low HFSE abundances. Petrographically similar granites from Mts Newton, Borland, Cresswell and Wilson Bluff have generally similar spiderdiagram patterns, but display prominent negative Nb anomalies, and three out of six rocks do not have Ba anomalies.

The granitic rocks from Landing Bluff have much higher than the rocks from both Ruker Terrane, and Lambert Terrane, concentrations of Th, LREE, and most HFSE (except Y) (Fig. 8 C). These rocks exhibit

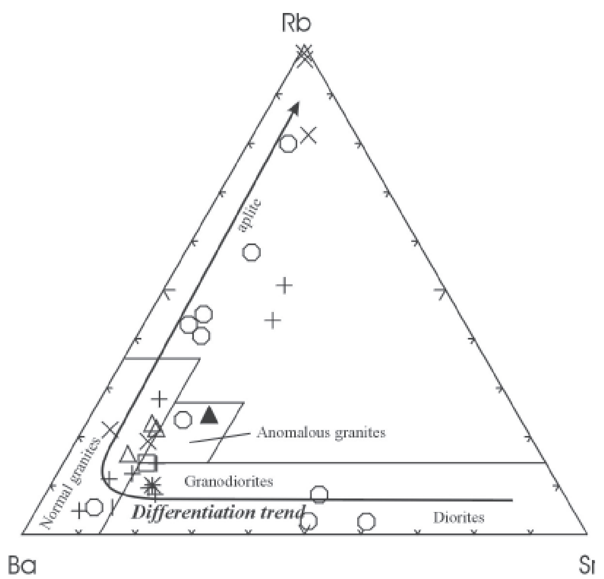


Fig. 7 - Triangular Ba – Rb – Sr diagram after El Bouseily & El Sokkary (1975). Symbols as in figure 5.

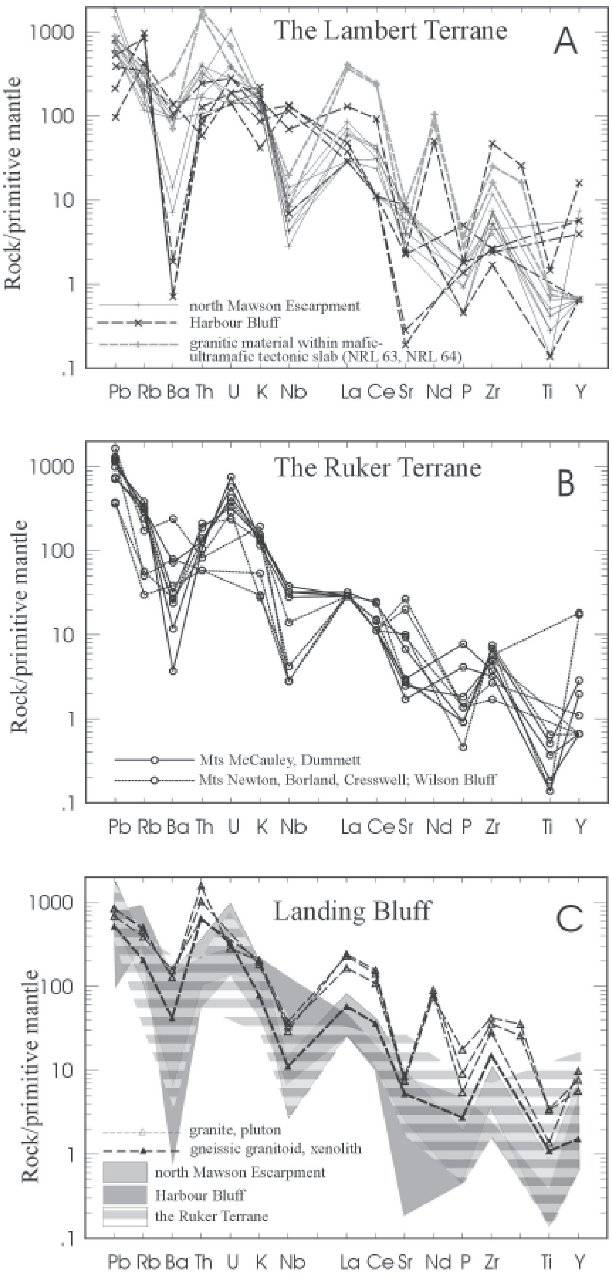


Fig. 8 - Primitive-mantle normalized trace element abundance diagrams (spiderdiagrams) for the dated presumably Early Palaeozoic granites in the SPCM and Landing Bluff. Normalization factors from Sun & McDonough (1989).

prominent negative Nb, Sr, P anomalies, and positive Th anomalies.

THE RARE EARTH ELEMENTS

Four samples were analyses for the REE abundances by INAA at the Geological Institute (VSEGEI, St Petersburg). Two of them represent granitic dykes in the Rofe Glacier area (northern Mawson Escarpment, the Lambert Terrane), the other two represent granitic bodies in Mts Newton and Stinear. The data are presented in table 3.

The REE data show considerable scatter (Fig. 9). All rocks show quite unfractionated REE patterns (La/Yb_N < 8) with generally minor LREE fractionation (La/Sm_N = 3–10) and especially minor HREE fractionation ($Sm/Yb_N \leq 1.5$). The Rofe Glacier granitoids reveal concave REE distribution patterns with very low REE concentrations (about 2 to 15 times chondritic), low total fractionation (La/Yb_N < 8) and small positive Eu anomaly. Mt Newton sample shows quite similar REE distribution pattern to these samples, differing from them with strong positive Eu anomaly and more pronounced LREE enrichment. The Mt Stinear granite shows high HREE abundances, small negative Eu anomaly and no light REE enrichment (La/Sm_N = 1.0), which is actually out of range of the REE variation in common granitoid types.

MINERAL COMPOSITIONS

Wavelength-dispersive electron microprobe analyses were carried out using a CAMECA SX 100 instrument, equipped with a PGT energy-dispersive spectrometer, at the Federal Institute for Geosciences and Natural Resources (BGR) in Hannover, Germany. Silicates and oxides were analyzed at 15 kV acceleration voltage and a sample current of 20 nA. The X-ray lines were calibrated against natural mineral and pure element standards. Counting times ranged from 10 to 20 seconds. Fluorine was analyzed for 30 seconds using the PC1 multi-layer crystal. The representative analyses of biotite, and amphibole and muscovite are presented in tables 4 and 5, respectively.

Biotite in the Lambert Terrane granites have different compositions with mg varying from 12–20 to 35–37 and TiO_2 from 0.03 to 2.7%. Sample NRL 63 (representing an undeformed felsic material within a mafic–ultramafic slab) have the most magnesian and TiO_2-rich biotite. Biotite in the granites from the Ruker Terrane has more consistent composition with mg = 26–30 and TiO_2 mostly in the range 2.0–2.4%. Biotite from both the Lambert Terrane and the Ruker Terrane has low F concentration only rarely up to 1%. Biotite in the Landing Bluff granitoid (of an early magmatic phase) has mg = 23–25, with TiO_2 in the range 2.7-3.2%, which is somewhat higher, than in the SPCM granites. F concentration is also elevated in these rocks: mostly 1.4–1.5%. Amphibole was detected in sample NRL 67 from Harbour Bluff (the Lambert Terrane). Amphibole is low-magnesium (mg = 10.5–11) and contains 0.8–0.9% TiO_2. Muscovite composition was only measured in the Ruker Terrane granites. It showed uniform composition in two potassium feldspar–quartz–biotite–muscovite samples in terms of SiO_2 (45.5–46.4%), and Al_2O_3 (31–33%), while mg is higher (37–38) in sample NRL 147 and lower (25–28) in sample NRL 193. Atomic Si is within 3.15–3.19 f.u. (calculated on 11 oxygen basis).

DISCUSSION AND CONCLUSIONS

In the Ruker Terrane three out of five granite samples in our study yielded the Cambrian ages in the range 515–525 Ma, while the other two fail to recover directly Early Palaeozoic ages, but their crystallization at this time may not be excluded by our data. Zircon from these two samples contains Palaeo- or Mesoproterozoic component, which we interpret as the inheritance from the source regions, rather than as a magmatic signature. The detected U–Pb zircon age of a granite in Mt McCauley (c. 525 Ma) is about 30 Ma older than a Rb–Sr muscovite age (Halpern & Grikurov, 1975) from a granite from the same locality. Assuming crystallization of the granite at temperature below c. 700–750°C and the closure temperature for the Rb–Sr system in white mica of about 500±50 °C, it may be concluded that the granite cooled for about 200–250 °C during 30 Ma. That gives a cooling rate within c. 5–10 °C/Ma. As the apparent thermal effect of the granite on the country rocks was reported (*e.g.*, Lopatin & Semenov, 1982), it is clear that the host rocks experienced an even lower cooling rate. This indicates that the Ruker Terrane experienced slow rather than fast cooling during the early Palaeozoic event.

The two dated granites from the Lambert Terrane also yielded the Cambrian ages, but these ages are not well constrained being based on single slightly discordant analyses. The age of a sample collected from Landing Bluff in the Prydz Bay coast is much better constrained at c. 503 Ma. This sample represent an older magmatic phase gneissic granitoid xenolith enclosed in a hornblende–biotite granite body. The host granite has given a Rb–Sr whole-rock isochron age of 492±17 Ma (Tingey, 1991) and a U–Pb zircon age of about 500 Ma (Sheraton & Black, 1988). The xenolith rock experienced pronounced deformation reflected in the rock texture, which demonstrates that the two different magmatic phases were separated by a deformation event, or otherwise that the first phase was syn-tectonic. The initial magmatic phase intruded earlier or during some tectonic activities, while the second one post-dated it.

The post-tectonic granitic rocks of Early Palaeozoic age in the SPCM have noticeably varying mineral compositions in different areas: in the Ruker Terrane they are syenogranitic muscovite±biotite±garnet bearing with accessory allanite, and monazite, in the Lambert Terrane they are monzo- to syenogranitic biotite±garnet bearing (north Mawson Escarpment)

Tab. 3 - REE contents in granitoids from the SPCM.

Sample	48101-3	48102-8	48132-1	48145-2
Rock	granite	granite	granite	granite
Age	Cambrian	Cambrian	Cambrian(?)	Cambrian(?)
Locality	Rofe Glacier	Rofe Glacier	Mt Stinear	Mt Newton
La	3.31	4.08	4.27	19.60
Ce	5.54	6.69	7.99	29.50
Pr	0.57	0.71	1.00	2.80
Nd	1.94	2.25	4.46	8.38
Sm	0.54	0.46	2.29	1.10
Eu	0.47	0.33	0.42	3.00
Gd	0.52	0.48	4.03	0.96
Tb	0.09	0.08	1.04	0.16
Dy	0.81	0.54	8.20	1.33
Ho	0.25	0.11	1.87	0.39
Er	0.90	0.34	5.78	1.37
Tm	0.15	0.05	1.06	0.30
Yb	1.37	0.34	7.43	2.16
Lu	0.19	0.06	1.16	0.37
$(La/Yb)_N$	1.5	7.5	0.4	5.7
$(La/Sm)_N$	3.4	5.0	1.0	10.0
$(Sm/Yb)_N$	0.4	1.5	0.3	0.6

or garnet±muscovite±biotite bearing in Harbour Bluff with minor or accessory amphibole, allanite, apatite, monazite. Occurrence of garnet, and elevated ASI index (1.0–1.3) may imply the rocks are S-type granites. However, as no cordierite has been detected, the ASI only rarely exceeds 1.1, and normative corundum only rarely exceeds 1.0%, the rocks are thus only marginally peraluminous. It may be suggested that at least some of these rocks have been derived from (meta)igneous, rather than (meta)sedimentary precursors, that is they may not be S-type, but rather I-type granitoids. White et al. (1986) showed that local peraluminous granites may result from contamination of metaluminous I-type, or even could be derived by partial melting of igneous sources with fractionation enhancing the peraluminous nature of such magmas. However, many granitoids have relatively high Ba/Rb (>2.0), and mg values (mostly in the range 10-30), thus pointing out to their unfractionated nature. At the same time, other granites, indeed, have low Ba/Rb, and mg accompanied by high MnO content (up to 0.10%) which stabilizes garnet (Clemence & Wall, 1981). That indicates that these magmas have undergone extensive crystal fractionation. A negative correlation between Ba/Rb and Fe^{tot}/Mg ratios may be observed at lower Ba/Rb (the plot not presented), which suggests that a Fe–Mg mineral phase (hornblende?) was involved.

In spite of apparent mineralogical differences between the Ruker Terrane and the Lambert Terrane granites, these rocks have basically similar chemical compositions, as shown by the spiderdiagram patterns (Fig. 8). The wide occurrence of muscovite in the Ruker Terrane may indicate that these granitoids crystallized at higher depths (P>3 kbar), than generally biotite-bearing granites in the northern Mawson Escarpment (Clemence & Wall, 1981 and references therein). The crystallization pressure of a biotite–white mica-bearing granite may be accessed from the Si content in white mica (Massonne & Schreyer, 1987). According to this calibration the Ruker Terrane granites crystallized at pressure <6 kbar.

An important feature of the granites in the Lambert Terrane (*e.g.*, northern Mawson Escarpment) is their close spatial association, unlike the granites in the Ruker Terrane (apart from Mt Dummett), with variously deformed granite sheets and veins which occur concordant or obliquely cutting the country rock structure. Field observations also provide evidence for syn- to late-tectonic emplacement of many granitic veins and dykes in Rofe Glacier area. Some of these veins and dykes are of early Neoproterozoic or older age (unpublished data of the authors).

Granitic rocks in the SPCM display low REE fractionation patterns, in a way similar to mantle-derived Mesoproterozoic rocks from the northern and central PCM (Fig. 9). However, the SPCM granites differ significantly from the Mesoproterozoic rocks, which implies their derivation from different sources. Higher level of the heavy REE indicates garnet played an important role in the source region composition, and in the granitoid petrogenesis. Anyway, a mantle component may also have been involved, at least in generation of the Rofe Glacier granitoid (48102-8). The absence of prominent negative Eu anomalies and less fractionated REE distribution are characteristics of some late-orogenic granites (Rogers & Greenberg 1990). Thus, it may be suggested that the Early Palaeozoic granitoids in the Lambert Terrane may

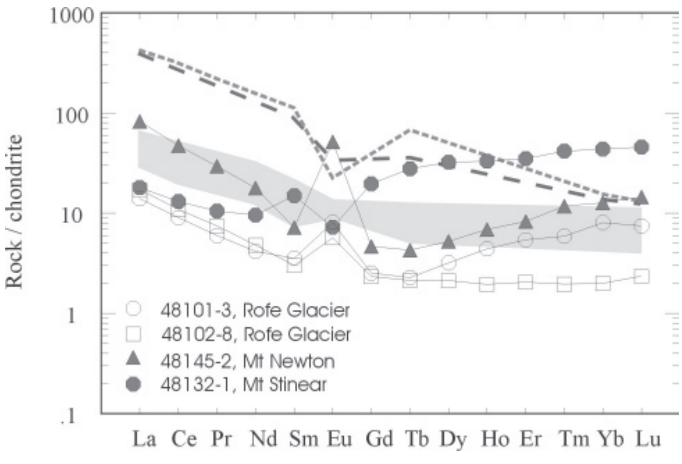


Fig. 9 - Chondrite-normalized REE abundance plot for the southern Prince Charles Mountains granitoids. Shaded field – the Mesoproterozoic Beaver Terrane orthogneisses and the Fisher Terrane granitoids (Mikhalsky et al., 1996, J.W. Sheraton, unpublished data). Thicker long dashed line – Opx syenite from Mt Collins (northern PCM), thicker short dashed line – an A-type granite from the Prydz Bay coast (Sheraton et al., 1996). Normalization factors from Sun & MacDonough (1989).

Tab. 4 - Representative compositions of biotite and hornblende in granites from the SPCM and Landing Bluff.

	NRL 63	*NRL 67*	*NRL 67*	*NRL 67*	*NRL 71*	*NRL 146*	*NRL 146*	*NRL 147*	*NRL 147*	*NRL 193*	*NRL 193*	*NRL 215*	*NRL 215*	*NRL 215*
	Bt	*Hbl*	*Hbl*	*Bt*	*Bt*	*Bt*	*Bt*	*Bt*	*Bt*	*Bt*	*Bt*	*Bt*	*Bt*	*Bt*
SiO_2	35.14	38.75	38.48	30.08	45.32	35.17	34.64	34.65	35.01	34.69	34.90	35.28	35.16	35.42
TiO2	2.97	0.90	0.93	1.92	0.05	0.27	0.28	1.98	2.38	2.02	2.00	3.15	3.10	3.00
Al_2O_3	15.35	11.00	11.11	15.84	34.07	18.74	18.82	17.36	18.23	16.88	17.10	13.61	13.51	14.32
Cr_2O_3				0.00	0.00	0.00		0.00		0.00	0.00	0.04		0.01
FeO	24.09	28.14	27.77	33.61	1.69	24.02	24.33	24.04	23.54	23.22	23.68	27.60	27.27	26.70
MnO	0.16	0.88	0.92	0.85	0.03	0.42	0.41	0.38	0.36	1.17	1.24	0.34	0.40	0.32
NiO		0.00	0.03	0.04	0.00	0.02		0.00	0.03	0.00	0.02	0.01	-0.05	0.01
MgO	7.53	1.85	1.84	2.45	0.22	5.25	5.10	4.98	4.80	5.52	5.55	4.97	4.82	4.85
CaO	0.00	11.15	11.12	0.15				0.05	0.00	0.12	0.01	0.00	0.00	
Na_2O	0.04	1.54	1.36	0.05	0.58	0.05	0.05	0.06	0.06	0.05	0.10	0.07	0.07	0.05
K2O	9.65	1.71	1.69	4.97	10.50	9.52	9.28	9.36	9.63	9.30	9.52	9.28	9.32	9.47
Cl	0.42	0.22	0.21	0.08	0.01	0.11	0.10	0.05	0.05	0.01	0.02	0.35	0.34	0.35
F	0.28						0.95	1.02	0.93	0.89	0.87	1.51	1.40	1.14
Total	95.64	96.14	95.45	90.05	92.47	93.57	93.96	93.92	95.01	93.87	95.01	96.21	95.39	95.65

have orogenic, rather than anorogenic origin. Highly varying Eu concentration probably reflects varying solubility of Eu in fluid-enriched magmatic system, and varying crystallization conditions. A depleted character of LREE distribution in sample 48132-1 may be attributed for by fractionation of accessories (i.e., monazite, zircon). The REE patterns of the SPCM rocks are strikingly different from the A-type granites in the Prydz Bay coast and alkaline granitoid in the central PCM (Fig. 9). This suggests that derivation of these rock groups are from different source regions, and maybe in varying tectonic environments.

Early Palaeozoic granites (independently muscovite-, garnet- or biotite-bearing) of the Ruker Terrane also plot mostly within the orogenic granite to fractionated granite fields in discrimination diagrams by Whalen and co-workers (1987) (Fig. 10), within volcanic arc – syn-collisional granite field (Pearce et al., 1984; Fig. 11 A) or within post-orogenic epeirogenetic and post-orogenic fields in the discrimination diagram of Maniar & Piccoli (1989; Fig. 11 B). Taken altogether, these diagrams provide some indirect evidence for orogenic or syn-collisional origin (as opposed to anorogenic setting) of these rocks. It should be noted, that the Early Palaeozoic granites in the SPCM have a restricted range of relatively high SiO_2 content, span the wide range of compositions from magnesian to ferroan and from calcic to alkali-calcic, form small intrusive bodies and are not associated with mafic rocks. These features suggest that this magmatic suite may be correlated with peraluminous leucogranite type. However, the latter generally comprises rocks which were derived by partial melting of sedimentary rocks (S-type granites), which is not likely the case in the SPCM, as these rocks are only marginally peraluminous and do not contain sedimentary source (restite) xenoliths. Nonetheless, we believe that peraluminous leucogranite granite type most closely corresponds with the observed granite features, unlike A-type or calc-alkaline granite suite which is mostly known as I-type. Thus we suggest that metaigneous, rather than metasedimentary component was mainly involved in partial melting within the source region, but the tectonic setting was probably similar to those

Tab. 5 - The composition of muscovite in granites of the Ruker Terrane.

	NRL 147	*NRL 147*	*NRL 147*	*NRL 193*	*NRL 193*	*NRL 193*	*NRL 193*	*NRL 193*	*NRL 193*	*NRL 193*
SiO_2	46.06	46.38	46.02	45.82	46.17	46.00	45.93	46.08	45.59	45.50
TiO_2	0.45	0.41	0.41	0.30	0.33	0.36	0.35	0.34	0.31	0.39
Al_2O_3	32.31	33.09	32.83	31.01	30.78	31.07	31.33	30.86	31.60	31.41
Cr_2O_3		0.00	0.03	0.00	0.01	0.02	0.00	0.00		0.01
FeO	2.16	2.15	2.27	4.13	4.15	4.16	4.38	4.01	4.12	3.94
MnO	0.03	0.01	0.04	0.08	0.06	0.07	0.06	0.06	0.07	0.04
NiO			0.00	0.00	0.02	0.02			0.03	
MgO	0.68	0.74	0.77	0.90	0.86	0.77	0.85	0.86	0.79	0.76
CaO			0.01							
Na_2O	0.47	0.50	0.49	0.44	0.28	0.33	0.43	0.32	0.36	0.37
K_2O	10.93	10.92	10.82	10.74	11.05	10.94	10.77	10.90	10.77	10.92
Cl	0.01									0.01
F		0.42	0.42				0.42	0.45	0.42	0.37
Total	93.11	94.61	94.11	93.42	93.71	93.76	94.52	93.87	94.05	93.71

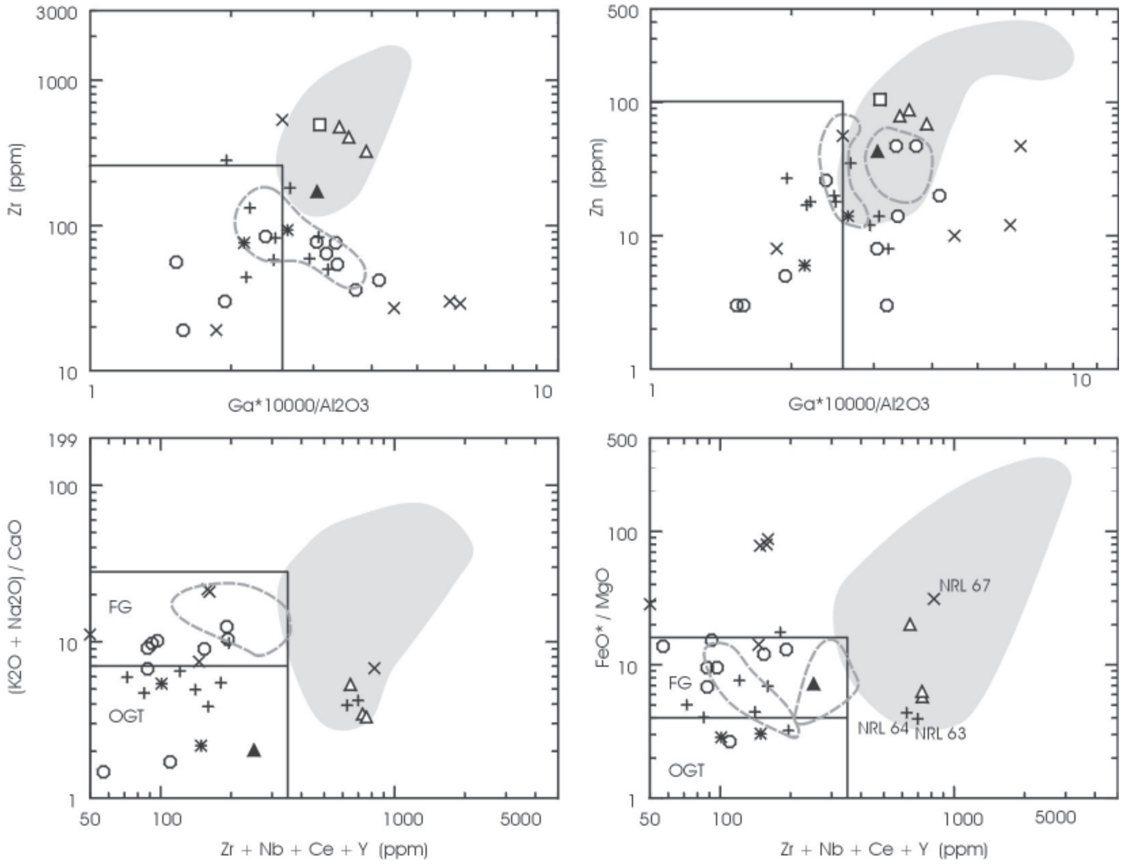


Fig. 10 - Granite discrimination diagrams after Whalen et al. (1987). Symbols as in figure 5.

responsible for the generation of the peraluminous leucogranites. A common tectonic environment for this granite type is within overthickened crust in a collision zone (*e.g.*, Le Fort, 1987). However, there may be another factor capable of inducing the high heat input, that is mafic underplate at the base of the crust.

A remarkable exclusion is represented by Cambrian granitoids of the eastern Amery Ice shelf (including Landing Bluff area). These rocks have much strongly fractionated REE patterns with $(La/Yb)_N$ ratio ranging between 32 and 50, and with moderate to large negative Eu anomalies (Sheraton et al., 1996). Therefore, these rocks can not be correlated with the SPCM granitoids, yet given a wide variation range of the latter in terms of both mineralogical and chemical composition. The Cambrian granites in the eastern Amery Ice Shelf area plot basically in different fields on all the discrimination diagrams, which points to within-plate nature of these rocks (Figs. 10 & 11). As detected by previous authors, these rocks have many compositional features in common with the A-type granites (Collins et al., 1982, Whalen et al., 1987). Elevated content of F, characteristic of A-type granites, is determined only in biotite from Landing Bluff granite. According to a chemical subdivision of the A-type granitoids (Eby, 1992), the granites from Landing Bluff correspond to the A_2 subtype for their relatively high Ce/Nb, and Rb/Nb ratios (8–13 and 9–14, respectively), while the Y/Nb ratio has marginal values between the A_1 and A_2 subtypes (1.2–1.7). Hence, these rocks probably originated from the sources (continental crust or underplated crust) which experienced continent collision or island-arc

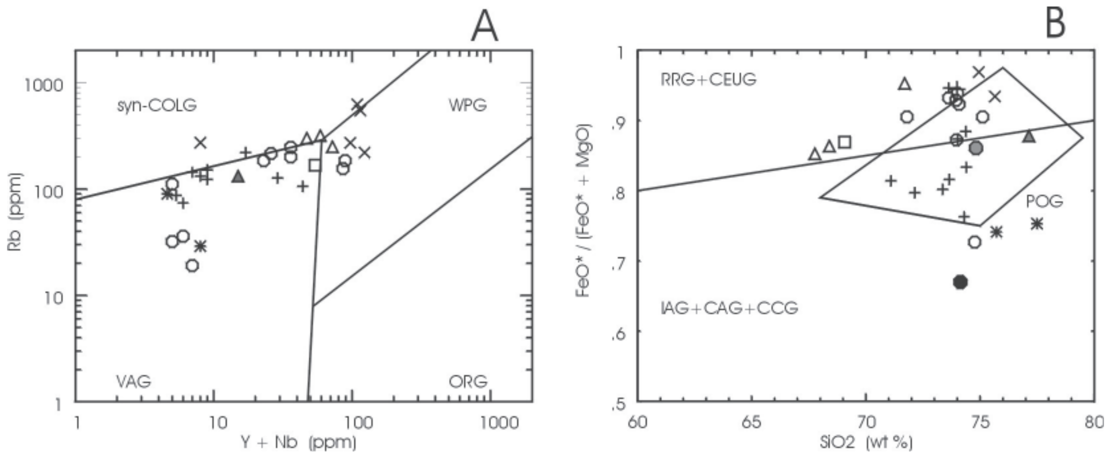


Fig. 11 - Granite discrimination diagrams after Pearce et al. (1984) (A) and Maniar & Piccoli (1989) (B). Symbols as in figure 5.

magmatism. However, the presence of A-type granites in this area point out to different tectonic evolution experienced by the Prydz Bay region and the SPCM in the early Palaeozoic, which resulted in development of distinct granite suites. The composition of a granitic xenolith enclosed in the Landing Bluff granite suite, has many features in common with the SPCM granites (*e.g.*, Figs 8, 10, 11). It should be noted, that the granitic xenolith enclosed in the Landing Bluff granite does not exhibit A-type features, but nevertheless has similar Y/Nb, Ce/Nb, and Rb/Nb ratios, which point to derivation of this rocks from roughly similar source regions. The granites from the SPCM generally have much lower Y/Nb (0.3–1.5 in less fractionated samples). That suggests a magmatic history of the Landing Bluff area, which included a calc-alkaline magmatic event prior to the A-type magmatism.

It should be noted, that some granitic rocks from Harbour Bluff, and Rofe Glacier area differ from the rest of the SPCM in being essentially HFSE-enriched, and these rocks plot in the within-plate granite field (Fig. 11 A). However, most of these rocks are highly fractionated, falling within or in a continuation of the fractionated granite field in a classification diagram by Whalen et al. (1984; Fig. 10), and their composition may not be indicative of their tectonic setting. Only two analyses of granitic rocks sampled within a mafic–ultramafic slab in the Rofe Glacier area have relatively unfractionated compositions, and are considerably enriched in some particular elements (*e.g.*, Fe, Mg, U, Th, LREE) and have distinct spiderdiagram patterns. That implies their derivation from different sources (as compared to other SPCM granites) and most likely in an orogenic tectonic environment, in spite of the fact that these rocks plot within an A-type granite fields in the discrimination diagrams after Whalen et al. (1987; Fig. 10). The latter is due to the anomalously high LREE, and Zr in these rocks, which may be the cause of elevated accessory phases concentration. Biotite in these rocks has specific composition which plot in calc-alkaline field in a discrimination diagram by Abdel-Rahman (1994; Fig. 12). These rocks occur within a mafic–ultramafic slab which was most likely derived in orogenic (collisional?) environments, but the time of this orogeny is unknown, and is not likely to be Early Palaeozoic. In this diagram biotite analyses from the Ruker Terrane plot within the peraluminous suites and biotite analyses from Landing Bluff plot within anorogenic alkaline suites. Two analysed (mineralogically different: NRL 67 amphibole–biotite-bearing, NRL 71 garnet–biotite-bearing) samples from Harbour Bluff plot within different fields, which reflect a complex petrogenesis of granites in that area.

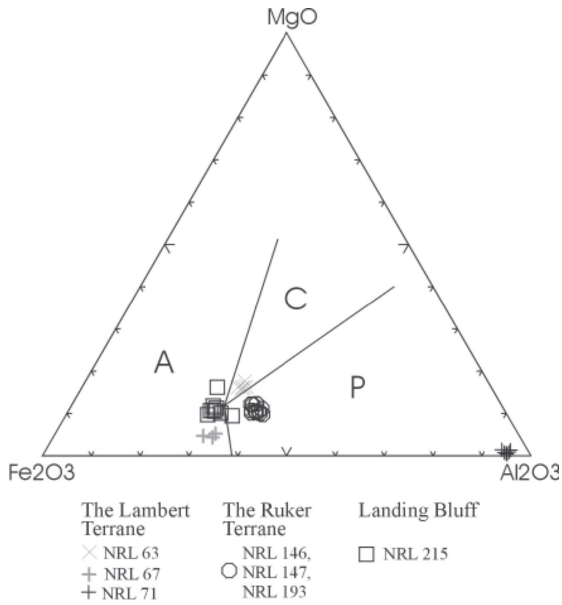


Fig. 12 - Biotite composition in a classification diagram by Abdel-Rahman (1994).

Our data enable the following conclusions:

1. Early Palaeozoic granites in the Ruker Terrane are c. 525–515 Ma, which is about 20 Ma older than granites in Prydz Bay coast; granites at Mt McCauley crystallized at pressure between 4 and 6 kbar and cooled down to c. 500 °C within 30 Ma.
2. Early Palaeozoic granites in the SPCM (both the Ruker Terrane, and the Lambert Terrane) may be correlated with peraluminous leucogranite type although typical S-type compositions are rare; the formation of these rocks as a result of voluminous mafic underplate at the base of the crust is possible during the course of an intraplate orogeny is most likely.
3. Granites in the Ruker Terrane (Mts Dummett, Stinear, and Newton) contain inherited zircon populations with Palaeoproterozoic or Mesoproterozoic ages, which are not known elsewhere from the Ruker Terrane, but have been found in the Lambert, Beaver and Fisher Terranes; we suggest that some blocks in the SPCM may not belong to the Ruker Terrane, or that the Ruker Terrane experienced some post-Archaean tectonothermal activities.
4. A-type Early Palaeozoic granites seem to be lacking from the SPCM; such rocks are known and maybe are restricted to Prydz Bay coast.

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[2]Available from EVM on request.