UR1985_63

1985/63. Geochemical diagrams of Cambrian volcanic rocks and associated intrusives from western Tasmania

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Abstract

Geochemical diagrams of nine groups of Cambrian igneous rocks from western Tasmania are presented as an aid to discussion of their tectonic setting and correlation. The groups are divided into those with tholeiitic and calc-alkalic character; two tholeiitic groups, the Henty Fault System and Miners Ridge-Diorite Creek rocks occur within the general Mt Read Volcanic Belt. It is concluded that the Smithton Trough, Crimson Creek Formation and Lucas Creek-Birchs Inlet basalts, have tholeiitic character and are very similar. The Mt Read Volcanics and Noddy Creek volcanics are also very similar and have calc-alkalic character. The high-Mg andesite and low-Ti basalt groups have tholeiitic character and form a single group distinct from the other tholeiitic groups. The Henty Fault System group differs from the Crimson Creek Formation basalts and the high-Mg andesite and low-Ti basalt groups. Previous unpublished geochemical data are presented in the appendix.

INTRODUCTION

This report presents a series of standard geochemical diagrams derived from chemical analyses of Cambrian igneous rocks from western Tasmania, in order to determine if the various appreciations are geochemically distinct and what the similarities and differences are between them. Such information is useful in determining the tectonic settings of the rock suites and suggesting possible correlations.

The data were derived from sources within the Department of Mines, and were plotted using a Sinclair QL computer and dot-matrix printer.

ROCK GROUPS AND DATA SOURCES

Nine rock groups have been selected on the basis of their stratigraphic-structural setting as determined by regional mapping. General locations of the major groups (exceping the basalts from the Smithton Trough, located in the north-western corner of the State) are shown on Figure 1. Those analyses not otherwise available in publications or departmental Unpublished Reports are listed in Appendix A, with grid references. A brief description of the rock groups is given below.

1. *Lucas Creek and Birchs Inlet basalts, Sorell Peninsula*

Pillow lavas and massive basalts occur at several localities in a NE-SW trending belt of unfossiliferous sedimentary rocks (greywacke, conglomerate, siltstone, mudstone, carbonate) extending across Sorell Peninsula from Lucas Creek to Birthday Bay (fig. 1). Similar mafic lavas occur in a fault-bounded block on the western shore of Birchs Inlet.

A total of 27 analyses were obtained from this group, ten being from the Lucas Creek area (MH101, MH104, MH105, MH106, 41567, 41569, 41570, 41571, 41572, 41575 - see Appendix A), eight from an area along strike on the south-west side of the peninsula (MH158, MH161, MH163, MH165, MH177, MH178, MH245, MH269 - Appendix A), and nine from the Birchs Inlet area (MH192, MH193, MH194A, MH194B, MH195, MH196, MH200, 41507, 41508 -

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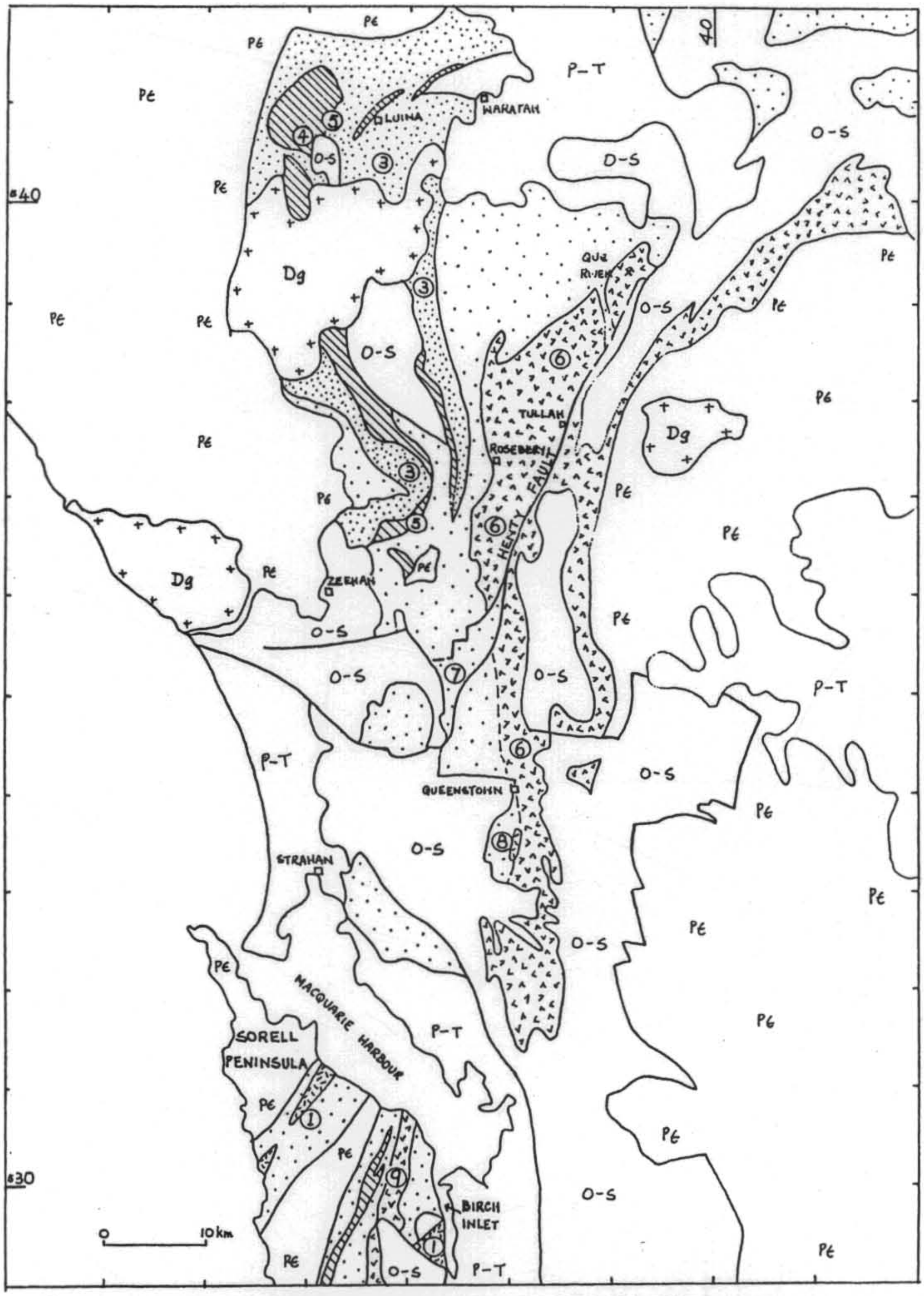


Figure 1. *Simplified geological map of western Tasmania showing locations of sample groups other than Smithton Trough basalts. 1 - Lucas Creek and Birch Inlet basalts; 3 - Crimson Creek Formation basalts; 4 - High-magnesium andesites; 5 - Low-titanium basalts; 6 - Mt Read Volcanics; 7 - Henty Fault system volcanics and intrusives; 8 - Miners Ridge and Diorite Creek basalts; 9 - Noddy Creek volcanics. Diagonal hatching = ultramafic-mafic complexes; fine stipple = Crimson Creek Formation; coarse stipple = other Cambrian sequences; O-S = Ordovician and Siluro-Devonian sequences; P-T = Permian to Tertiary cover rocks; Dg = Devonian granite.*

5 cm

Appendix A). Eight of these samples represent re-assays of White's (1975) samples (41567, 41569, 41570, 41572, 41575, 41507, 41508).

2. *Smithton Trough basalts*

Massive and pillowed basalts, with associated hyaloclastites, occur near the eastern and western margins of the Smithton Trough (Baillie and Crawford, 1984) within an unfossiliferous greywacke-siltstone-mudstone sequence underlying late Middle Cambrian fossiliferous sediments. The basalts have been described as low-K_2O tholeiites, possibly erupted in a back-arc basin (Baillie and Crawford, 1984).

Fourteen analyses of these basalts have been provided by A.V. Brown (in prep.) for use in the present study (813133, 813134, 814087, 814088, 814089, 814090, 841091, 841092, 814093, 814094, 814100, 814101, 814102, 814104).

3. *Crimson Creek Formation basalts*

Basalts and basaltic sediments are common throughout the Crimson Creek Formation, a sequence of greywacke, mudstone and chert, with mafic and ultramafic complexes, occupying the western part of the Dundas Trough between Zeehan and Waratah (fig. 1). Twenty-four analyses have been obtained, 18 being from Brown (in press) from the Pieman River-Mt Ramsay area (C302, C313, C314, C447(i), C447(ii), C952, C953, C960, C961, C962, C1007, C1635, C1636, C1637, C1575), and eight from Collins (1983) from the Luina area (48302, 48305, 48306, 48325, 48326, 48333, 781011, 781012 - Appendix A).

4. *High-magnesium andesites*

Sequences of orthopyroxene-phyric lavas which occur in close association with the mafic-ultramafic complex in the Waratah-Heazlewood River area (fig. 1) have been described by Brown (in press) and Brown *et al* (1980) as high-magnesium andesites. Nine analyses of these rocks from Brown (in press) have been used in the present study (MR5R, MM26, ABM2, ABM6, C1461, C1462, C1463, C1464, C1605).

5. *Low-titanium basalts*

Variable sequences of vesicular mafic lavas, breccias and associated intrusives occurring at the margin of the Serpentine Hill ultramafic complex near Dundas and the margin of the Heazlewood River complex have been referred to as low-titanium basalts by Brown (in press) and Brown *et al.* (1980). The latter authors grouped these rocks with the 'high-magnesium andesites' in a general group referred to as the 'low-titania ophiolite association'.

Eighteen analyses of these rocks from Brown (in press) have been included in the present study (Z270, Z277(i), Z277(ii), Z277(iii), C874, WA71, WA77, WA80, 60892, 60894, 60895, 60896, 60897, 60898, 60900, 60901, 60903, 60919).

6. *Mt Read Volcanics*

This extensive belt of dominantly rhyolitic to andesitic volcanics lies at the eastern margin of the Dundas Trough, and extends through Queenstown, Rosebery and Que River (fig. 1). Sixty-three analyses of lavas and intrusives from this belt are included in the present study. Two analyses only were available from the unusual andesite-basalt-dacite sequence at Que River, and these have been highlighted on the diagrams (M116, M117, from Collins *et al.*, 1981).

Published sources are as follows: Corbett, 1979 (C7, C8, C9, C10, C11, C18, C21, C22, C23, C24, C25, C26, C27, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B15); Corbett, 1984 (1, 2, 3, 4, 5, 6, 7, 16, 17, 18, 19, 20, 21, 22, 26, 28, 33); Collins *et al.*, 1981 (M65, M83, M84, M85, M87, M98, M116, M117).

Unpublished analyses are given in Appendix A, and are from the following sources: K.D. Corbett (mainly Rosebery-Stirling Valley area; MR300, MR379, MR385, MR390, MR391, MR396, MR397, MR398, MR401); J.E. Everard (Mainly Queenstown area; Y408, Z96, Z102, Z569, Z627).

7. Henty Fault system mafic-intermediate volcanics and intrusives

The Henty Fault zone is a major structure which cuts obliquely through the Mt Read Volcanics belt from north of Tullah to south of Mt Read (fig. 1). Towards its southern end the structure splits into two faults which enclose a wedge-shaped belt of sedimentary, volcanic and intrusive rocks, including pillowed and massive basalts, andesites, gabbros, and ultramafics. In addition, mafic dykes of basaltic to gabbroic character occur abundantly within the Mt Read Volcanics adjacent to the North Henty Fault and Henty Fault, and up to several kilometres west of the zone around Mt Read (Corbett, 1984). These dykes show a spatial relationship to the fault zone, and have been groupd with the fault sequence rocks for the purposes of the present study. Andesites within the central part of the wedge sequence resemble the Mt Read Volcanics, while those in the south-western part of the sequence are closely associated with basalts, and may be of different derivation.

Eleven analyses from the Henty Fault sequence and associated intrusives are included in the present study. Three of these are extrusive basaltic rocks from the south-western part of the wedge near the Zeehan Highway (9, 11 from Corbett, 1984; HR126 in Appendix A); one is an andesite from the central part of the wedge near Hall Rivulet (8 from Corbett, 1984); and five are intrusive dykes from within the Mt Read Volcanics in the Howards Road-Mt Read area (23, 24, 25, 27 from Corbett, 1984; MR337 from Appendix A).

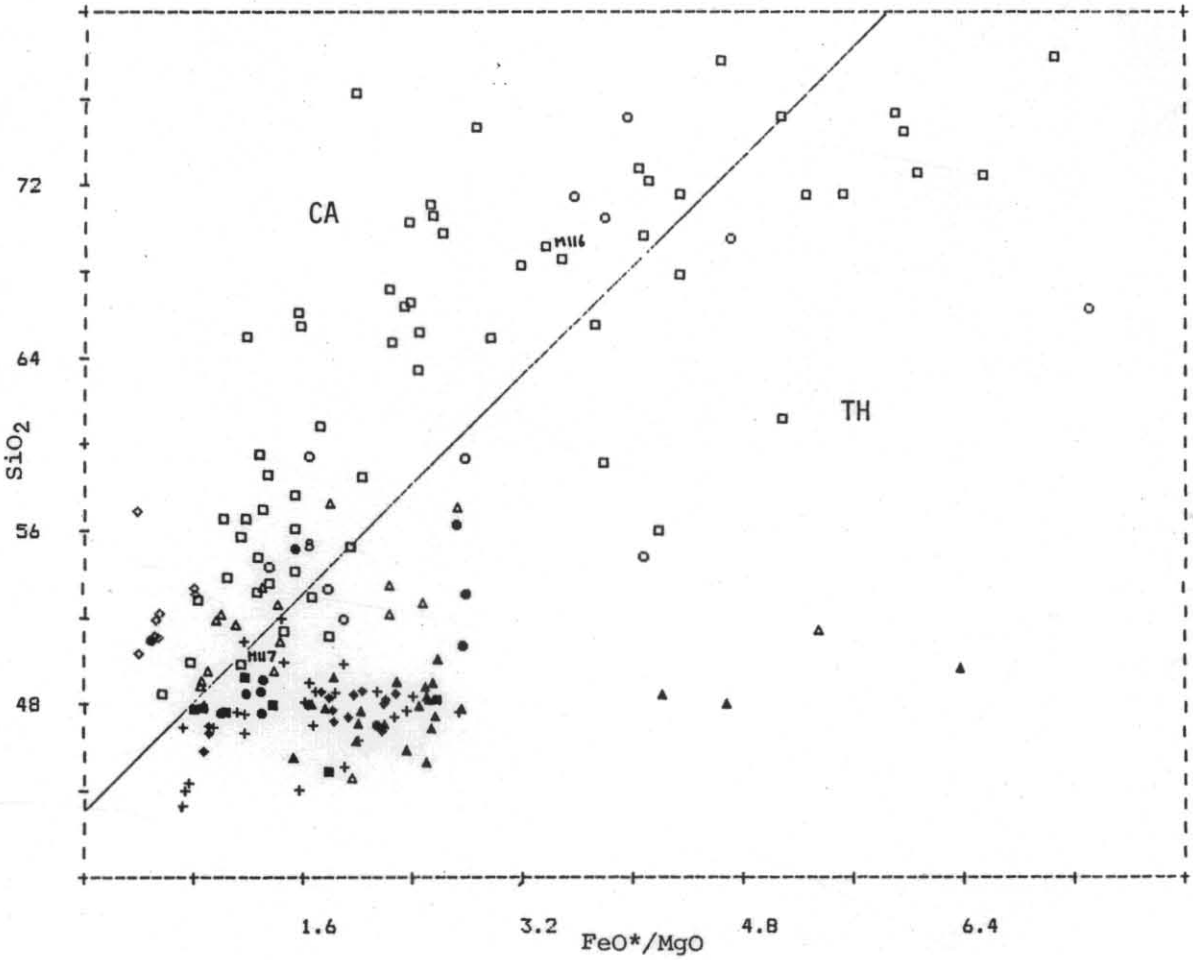
8. Miners Ridge-Diorite Creek basalts, South Queenstown

A distinctive suite of ophitic-textured basaltic lavas and breccias, with related intrusives, occurs within a volcano-sedimentary sequence at the western margin of the central belt of Mt Read Volcanics at Miners Ridge, south of Queenstown (Corbett, 1979). The extrusive rocks occur within the core of an anticline, and appear to represent an early or precursor phase of the Mt Read volcanism.

Seven samples from this suite are included in the present study, comprising four from Corbett, 1979 (C1, C2, C3, C4) and three supplied by J.E. Everard from Diorite Creek, just south of Miners Ridge (D1, D2, D3 in Appendix A).

9. Noddy Creek volcanics, Sorell Peninsula

A SSW-trending zone of andesites, dacites and rhyolites, with associated intrusives, extends from Asbestos Point on Macquarie Harbour to the Timbertops area (fig. 1). The volcanics are in fault contact with



KEY
- □ Mt.Read Volcanics (63) Samples M116, M117 from Que River indicated
- ○ Noddy Creek volcanics (12)
- ● Henty Fault System volcanics and intrusives (11)
- ■ Miners Ridge - Diorite Creek basalts (7)
- ▲ Crimson Creek Formation basalts (23)
- + Lucas Creek and Birchs Inlet basalts (27)
- ◇ High-Mg andesites (9)
- △ Low-Ti basalts (18)
- ◆ Smithton Trough basalts (14)

Figure 2. *Plot of FeO*/MgO against* SiO_2*, with key to plot symbols used in Figures 2-9.*

5 cm

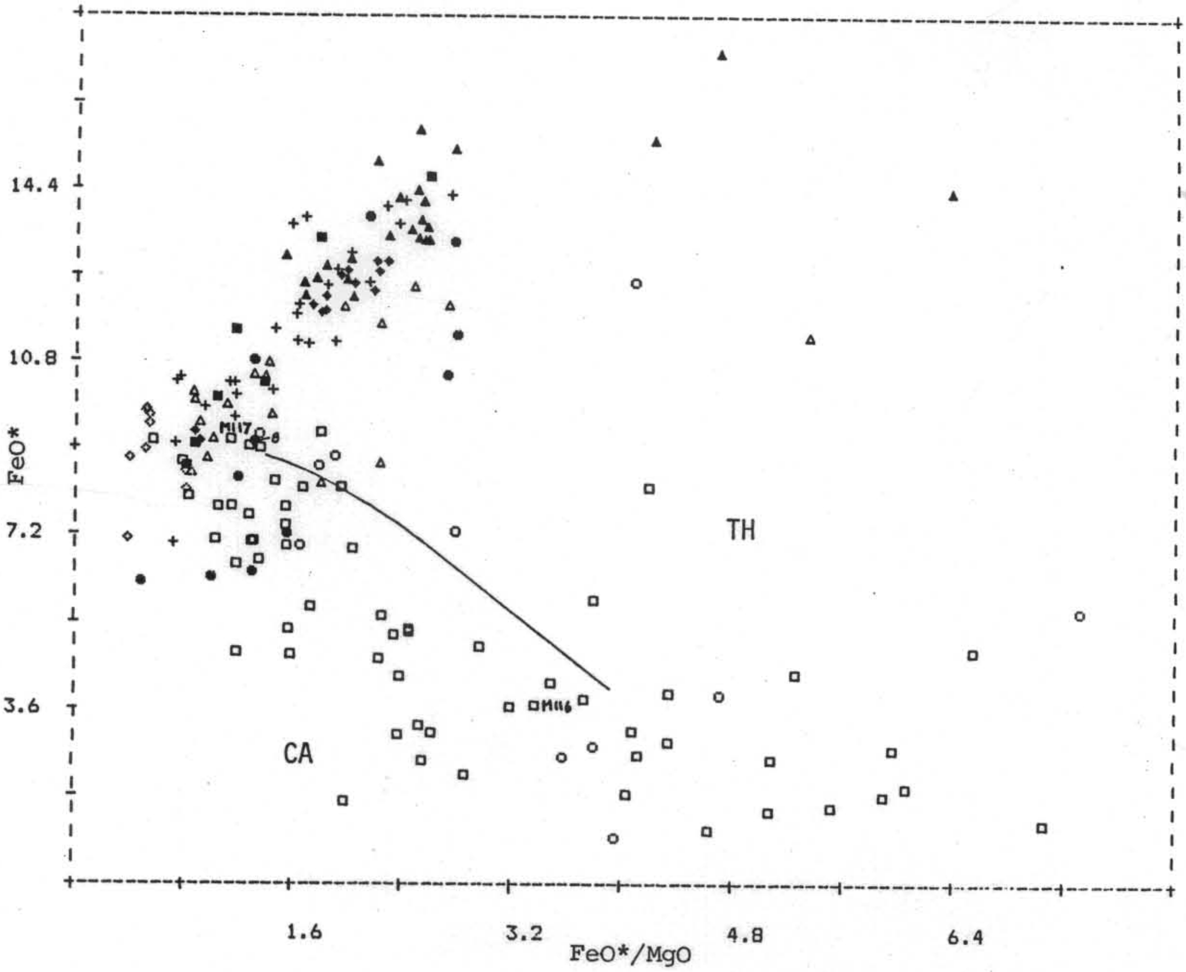


Figure 3. *Plot of FeO*/MgO against FeO*.*

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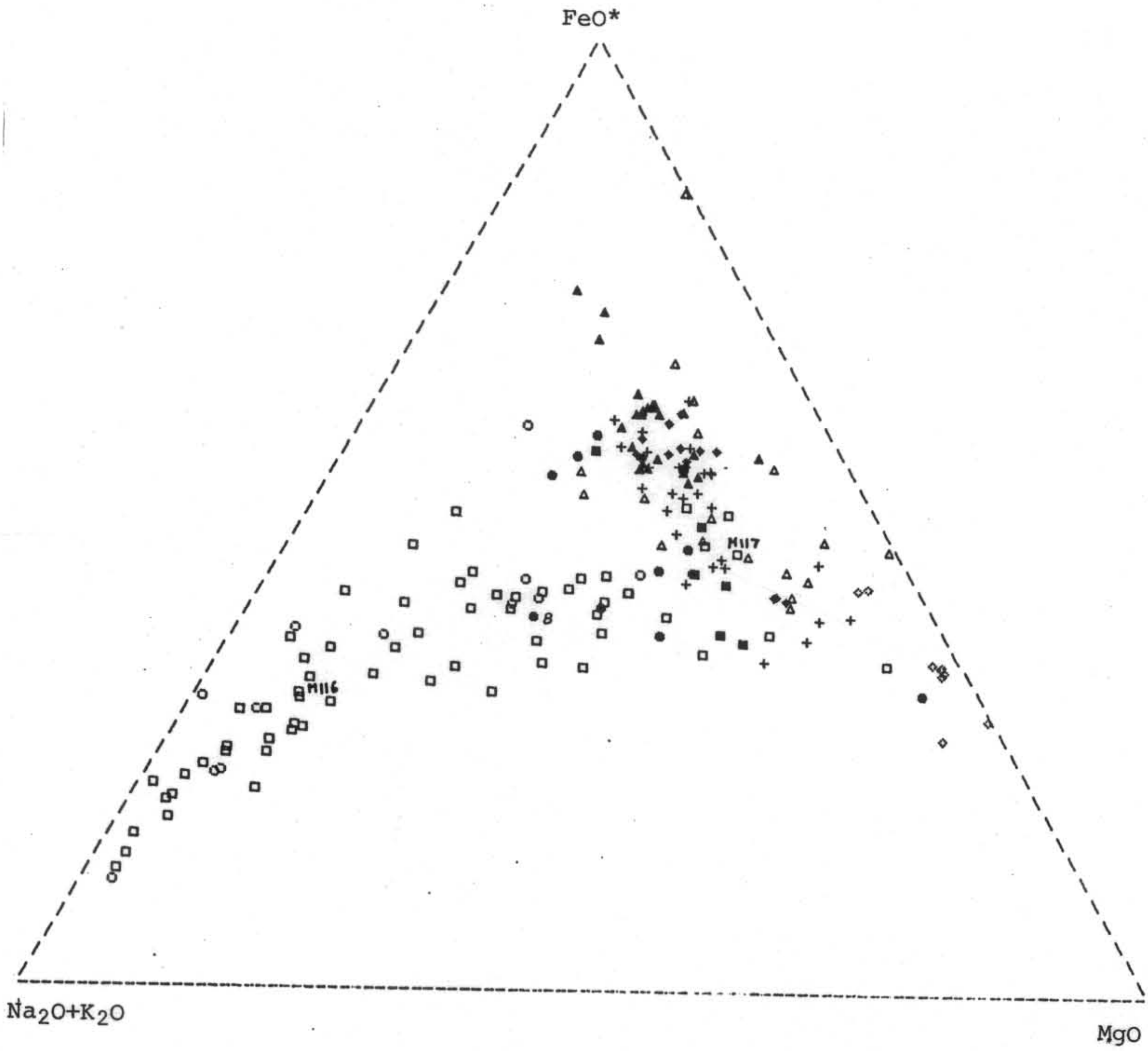


Figure 4. *Ternary diagram for FeO*, MgO and Na_2O+K_2O.*

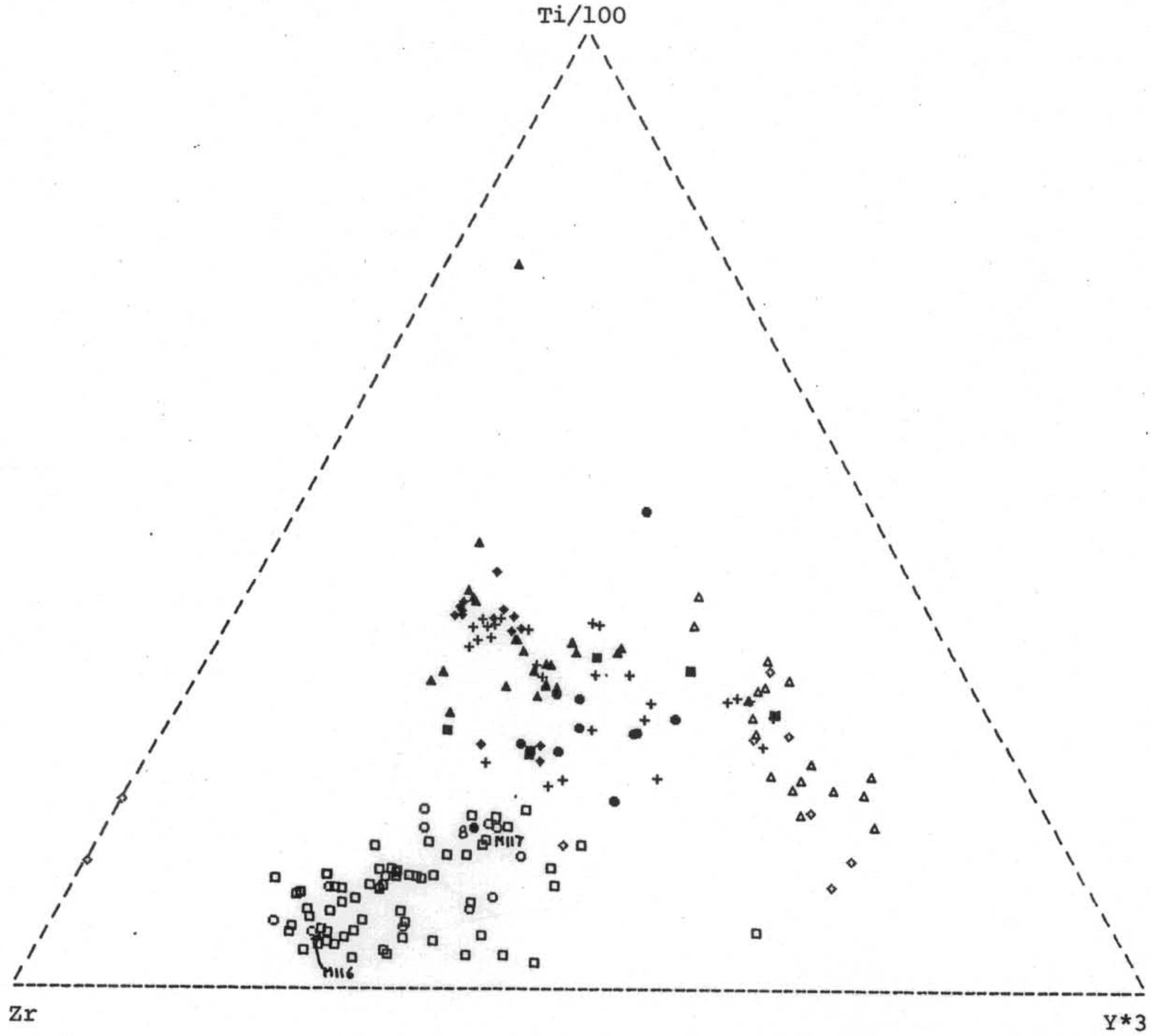
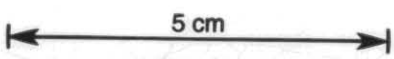


Figure 5. *Ternary diagram for Ti/100, Yx3 and Zr.*



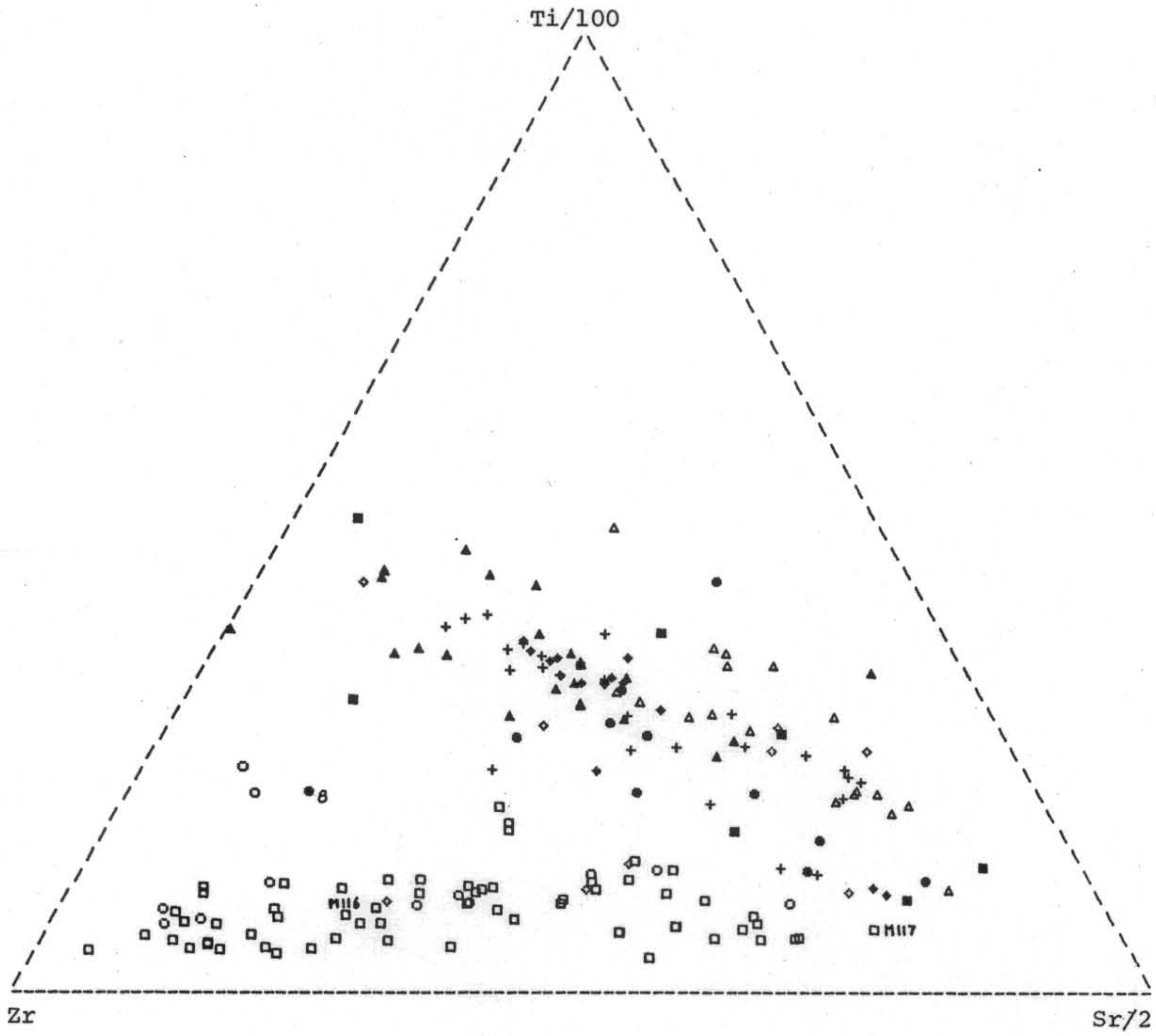
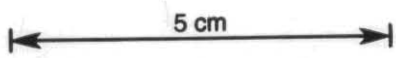


Figure 6. *Ternary diagram for Ti/100, Sr/2 and Zr.*



M 1681

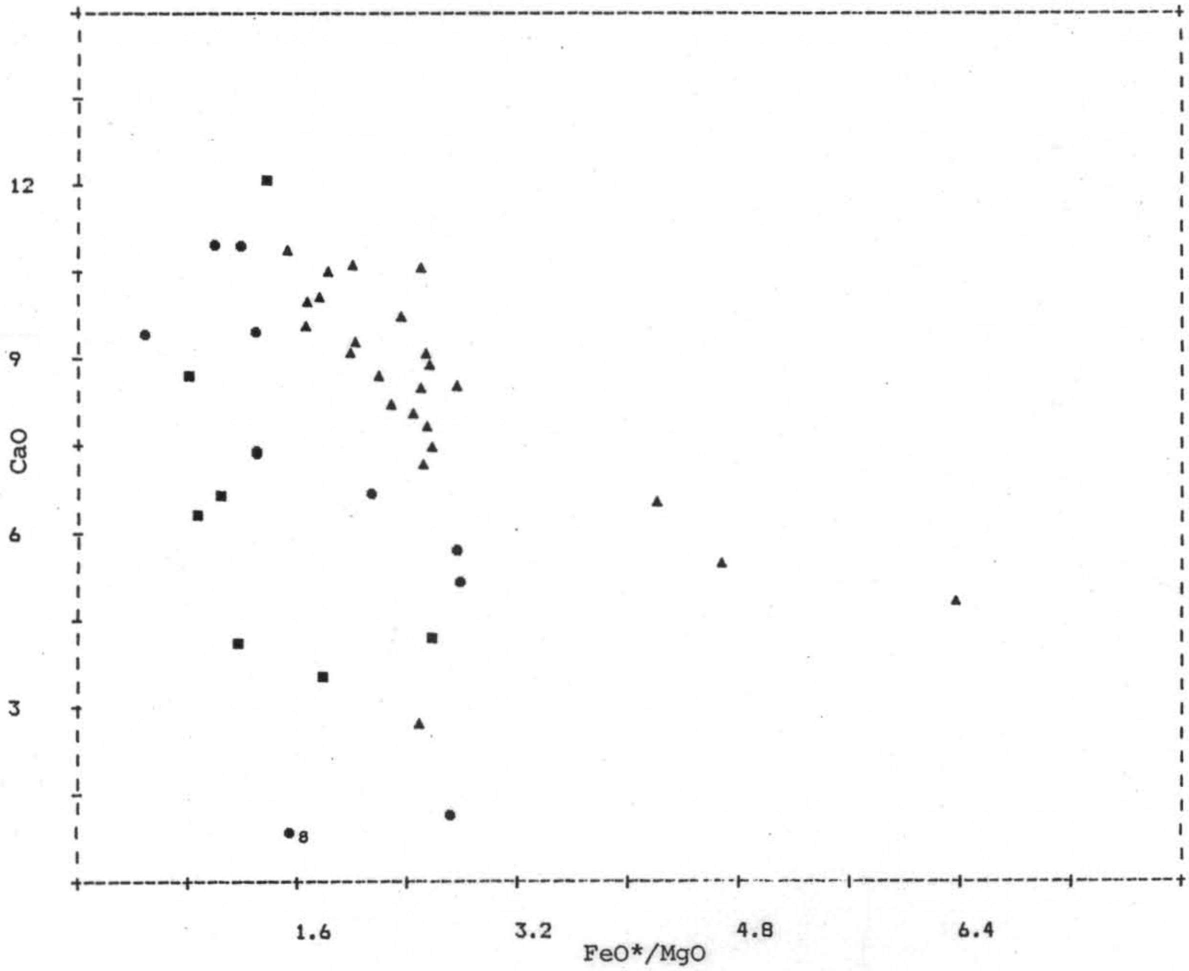
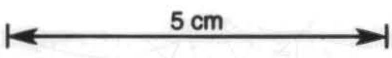


Figure 7. *Plot of FeO*/MgO against CaO.*



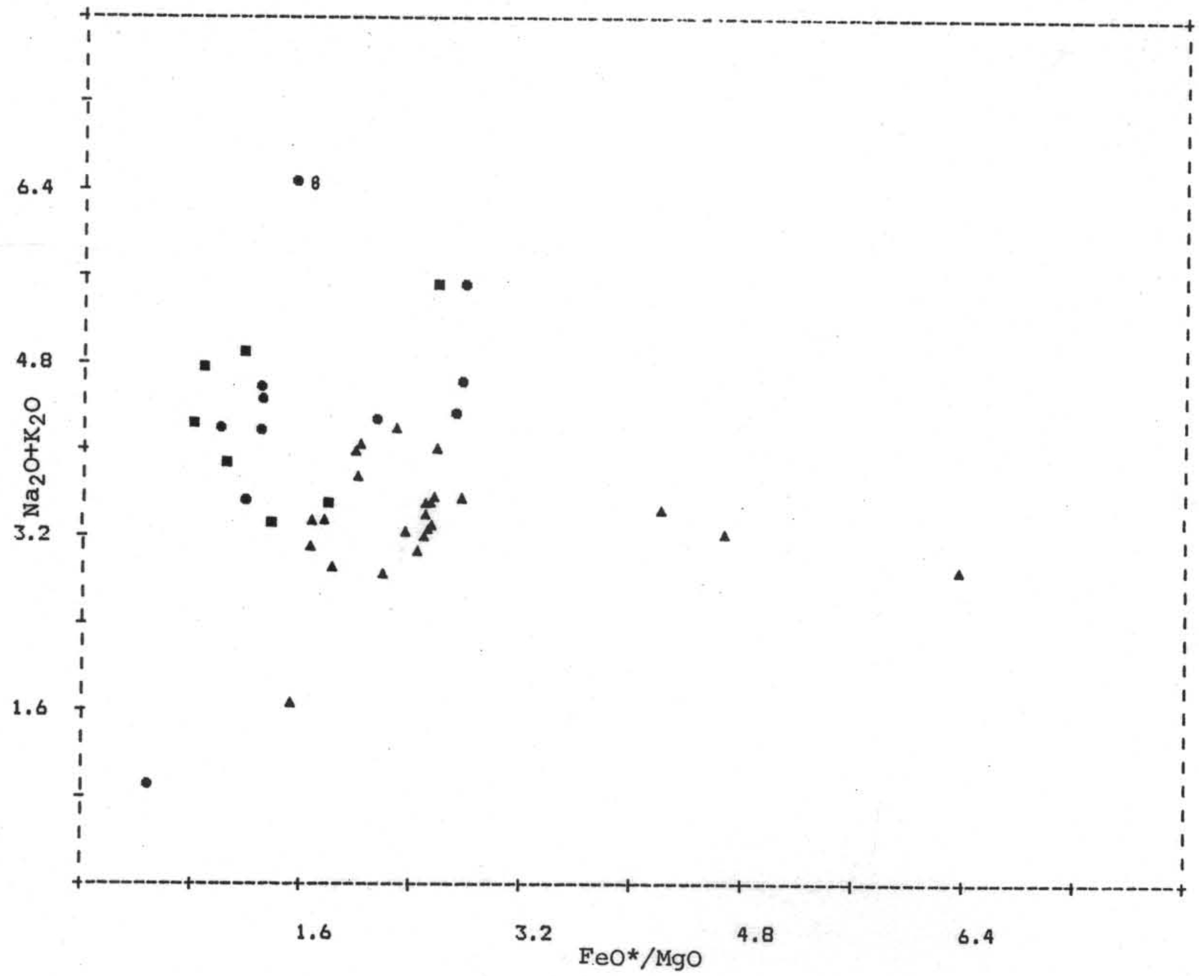


Figure 8. *Plot of FeO*/MgO against Na_2O+K_2O.*

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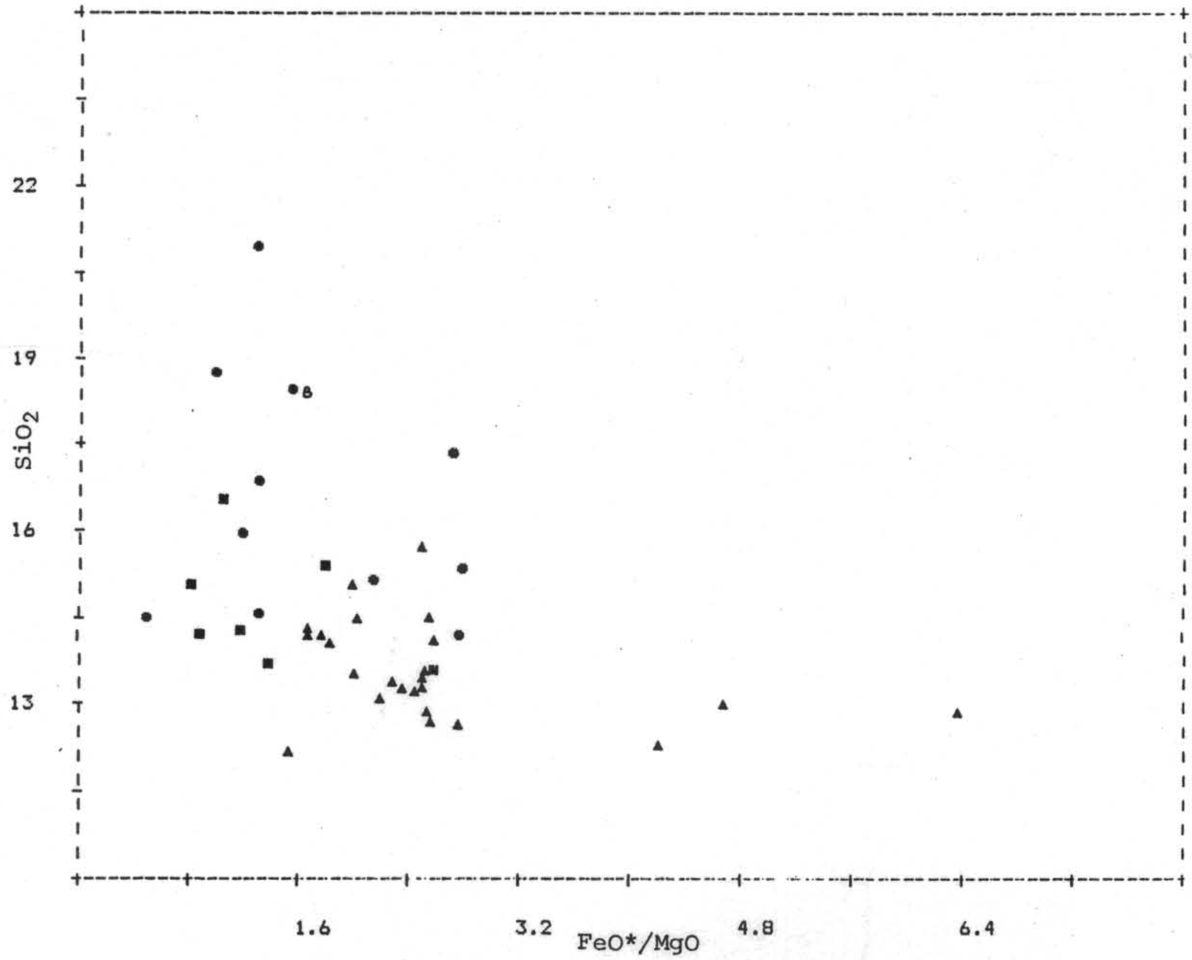
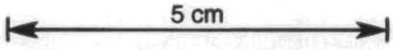


Figure 9. *Plot of FeO*/MgO against* SiO_2.



the surrounding sedimentary sequence (conglomerate, sandstone, siltstone, mudstone), but the presence of sedimentary intercalations of similar type within the volcanics, and of thin volcanic horizons within the sediments, suggests that the two sequences were partly contemporaneous. One of the fault-bounded sediment blocks contains Late Cambrian fossils (Jago, 1972).

Twelve samples of these rocks are included in the present study (MH209, 41524, 41525, 41527, 41530, 41531, 41536, 41509, 41513, 41514, 41516, 41517 - Appendix A). All except MH209 represent re-assays of samples analysed by White (1975).

DISCUSSION

The nine groups of igneous rocks have been plotted on SiO_2 *v* FeO*/MgO, FeO* *v* FeO*/MgO, and Na_2O+K_2O *v* FeO* *v* MgO diagrams (fig. 2-4) in order to distinguish tholeiitic and calc-alkalic trends (see Miyashiro, 1974). It is clear that the Mt Read Volcanics and Noddy Creek volcanics show calc-alkalic trends, while the remaining groups all show tholeiitic trends.

The following observations may also be made about these plots:

(1) The basalts from the Crimson Creek Formation, Smithton Trough, Lucas Creek-Birchs Inlet area and Miners Ridge-Diorite Creek area all lie on very similar trends.

(2) Rocks from the Henty Fault system overlap slightly with the above four groups, but appear to be on a slightly different, although sub-parallel, trend with higher SiO_2, lower FeO* and lesser iron enrichment.

(3) The high-Mg andesites and low-Ti basalts appear to form a single trend which is slightly different from that of the other tholeiitic groups.

(4) The Mt Read and Noddy Creek rocks overlap extensively and have identical trends.

Plots on Zr *v* Ti/100 *v* Yx3 and Zr *v* Ti/100 *v* Sr/2 diagrams (fig. 5, 6) give clear distinctions between some of the groups. The Zr-Ti/100-Yx3 diagram (Pearce and Cann, 1973) is particularly useful, and indicates the following:

(1) There is a clear distinction between the calc-alkalic rocks (Mt Read and Noddy Creek volcanics) and the tholeiitic groups.

(2) The two calc-alkalic groups are again very similar.

(3) The Crimson Creek, Smithton Trough and Lucas Creek-Birchs Inlet basalts form a single group which also includes the Miners Ridge-Diorite Creek rocks and most of the Henty Fault system rocks.

(4) The high-Mg andesites and low-Ti basalts form a single group which has very little overlap with the other tholeiitic groups (the three samples falling outside the main group may be inaccurately positioned as their Y values are at or below the detection limit), and has a distinctly different trend.

(5) There is only slight overlap between the Crimson Creek Formation samples and those from the Miners Ridge-Diorite Creek area and Henty Fault System.

Plots on CaO *v* FeO*/MgO and Na_2O+K_2O *v* FeO*/MgO diagrams (fig. 7,8) show a fairly clear separation between Crimson Creek Formation samples and those from Miners Ridge-Diorite Creek and Henty Fault System. For similar FeO*/MgO values the Miners Ridge and Henty Fault System rocks have less CaO and extend to higher Na_2O+K_2O than the Crimson Creek Formation basalts.

On the Al_2O_3 *v* FeO*/MgO diagram (fig. 9), the Miners Ridge-Diorite Creek and Crimson Creek Formation samples, form a continuous trend, with the Henty Fault System samples overlapping to some extent but extending to higher Al_2O_3 values.

CONCLUSIONS

(1) The Mt Read Volcanics and Noddy Creek volcanics show clear calc-alkalic trends, and overlap to form a single group on most diagrams. The two samples (M116, M117) from the Que River area plot with the calc-alkaline rocks on the Ti/100 *v* Zr *v* Yx3 diagram (fig. 5).

(2) The Crimson Creek Formation, Lucas Creek-Birchs Inlet, and Smithton Trough basalts show clear tholeiitic trends and tend to form overlapping groups on most diagrams.

(3) The high-Mg andesites and low-Ti basalts also show tholeiitic trends, but plot as a distinct group with a distinct trend on the best of the discriminatory diagrams (Ti/100 *v* Zr *v* Yx3, fig. 5). This suggests that the two groups are related, but distinct from the other tholeiites.

(4) The Miners Ridge-Diorite Creek basalts plot with the other tholeiitic groups on most diagrams. They have generally lower CaO values than the Crimson Creek Formation basalts (fig. 7), but the significance of this is not clear.

(5) The Henty Fault System samples plot generally with the tholeiitic groups, but have a trend which is slightly offset from those of the other groups, particularly the Crimson Creek Formation, on several diagrams. They are lower in FeO* and CaO (fig. 3, 7) and higher in SiO_2 and Al_2O_3 (fig. 2, 9) than the Crimson Creek Formation samples, suggesting there may be a significant difference. They are clearly distinct from the high-Mg andesites and low-Ti basalts (fig. 5).

(6) One sample from the Henty Fault System plots in the calc-alkaline field on Figures 2-6. This sample (8 on the diagrams) is from a large lens of andesites in the central part of the fault wedge (Hall Rivulet area, Corbett, 1984), and demonstrate that both calc-alkaline and tholeiitic rocks are present within the wedge.

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[16 December 1985]

APPENDIX A

Tables of unpublished geochemical data

	HR126	MR300	MR379	MR385	MR390	MR391	MR396	MR397	MR398	MR401
SIO2	49.23	65.52	63.43	56.06	65.19	57.67	59.16	64.91	64.76	67.88
TIO2	1.34	.52	.7	1.25	.68	.71	.68	.7	.7	.51
AL2O3	14.62	14.29	14.8	18.09	14.27	11.17	16.78	15.21	14.84	14.46
FE2O3	2.78	1.72	2.34	4.51	2.37	.5	3.89	2.47	1.37	1.97
FEO	8.37	2.29	3.18	4.13	3.09	7.34	2.38	2.7	4.32	2.19
MNO	.17	.1	.1	.14	.09	.14	.12	.1	.13	.08
MGO	8.27	1.03	2.16	1.96	2.13	5.06	1.55	1.66	2.47	.91
CAO	7.45	4.31	6.57	4.33	5.42	6.42	9.44	4.75	3.39	3.65
NA2O	3.13	3.35	2.55	7.31	1.88	1.4	3.47	3.25	5.46	3.78
K2O	1.07	2.58	2.08	.14	3.02	1.08	.84	2.33	1.46	2.9
P2O5	.11	.13	.11	.38	.11	.36	.15	.12	.1	.11
CO2	.14	3.12	.56	.05	.09	4.77	.33	.04	0	.68
H2O+	3.7	1.73	1.89	2.15	2.17	3.56	1.65	2.23	1.58	1.29
H2O-	0	0	0	0	0	0	0	0	0	0
LOI	0	0	0	0	0	0	0	0	0	0
TOTAL	100.38	100.69	100.47	100.5	100.51	100.18	100.44	100.47	100.58	100.41
BA	410	620	440	140	890	320	200	530	490	730
CO	40	9	13	15	10	37	13	8	12	7
CR	250	30	88	29	105	640	145	65	100	98
NB	3	12	12	7	12	7	11	12	12	12
NI	92	0	5	0	8	190	10	3	7	0
RB	34	93	66	4	77	50	27	65	68	97
SC	30	7	12	14	12	29	13	13	14	8
SR	220	190	270	260	280	140	390	220	200	240
V	350	56	115	200	105	190	145	96	110	51
Y	28	27	35	49	35	22	33	30	33	27
ZN	140	34	42	89	45	100	38	48	57	28
ZR	95	180	210	185	204	266	210	210	220	185

GRID REFERENCES
HR126 CP748509 MR300 CP794712 MR379 CP826723 MR385 CP830724
MR390 CP820725 MR391 CP734668 MR396 CP821715 MR397 CP819716
MR398 CP817722 MR401 CP825720

	MR337	48302	48305	48306	48325	48326	48333	781011	781012	MH101
SIO2	47.14	45.35	47.09	49.05	47.17	49.28	47.81	47.7	46.3	44.48
TIO2	1.8	2.56	2.49	1.59	1.57	1.67	3.76	1.7	1.8	.73
AL2O3	15.22	13.29	13.1	13.4	13.53	14.07	12.64	14.5	15.1	14.36
FE2O3	4.73	4.83	2.64	2.23	3.35	2.74	2.84	5.2	4.6	2.11
FEO	9.62	11.3	12.61	11.43	9.95	10.35	12.7	7.5	8.4	8.62
MNO	.3	.25	.38	.29	.23	.23	.28	.17	.23	.19
MGO	6.49	6.25	6.81	5.88	6.45	6.99	5.53	6	6.3	13.61
CAO	6.73	10.58	8.7	8.22	10.63	10.51	8.54	9.3	9.1	8.1
NA2O	2.8	3.31	2.63	3.92	3.15	2.44	3.1	3.9	3.7	1.18
K2O	1.5	.2	.23	.28	.61	.48	.46	.15	.3	1.51
P2O5	.09	.3	.31	.17	.17	.17	.78	.31	.29	.16
CO2	.03	0	0	0	0	0	0	0	0	.14
H2O+	3.64	0	0	0	0	0	0	0	0	3.95
H2O-	0	0	0	0	0	0	0	0	0	.13
LOI	0	2.3	2.67	4.05	2.35	1.82	2.42	3.2	3.5	0
TOTAL	100.09	100.52	99.66	100.51	99.16	100.75	100.86	99.63	99.62	99.27
BA	640	121	35	108	147	141	89	62	90	420
CO	55	0	0	0	0	0	0	47	57	61
CR	75	92	92	48	50	48	50	116	109	1400
NB	0	15	14	7	8	8	21	0	13	0
NI	10	65	65	56	61	55	28	103	93	480
RB	47	7	11	38	28	42	48	4	8	47
SC	55	0	0	0	0	0	0	0	0	34
SR	200	620	311	141	362	230	209	284	380	95
V	840	415	317	473	395	467	449	388	408	230
Y	22	46	44	29	27	29	76	30	3	20
ZN	155	110	136	80	123	93	126	110	146	79
ZR	42	162	159	89	85	90	187	115	26	42

GRID REFERENCES
MR337 CP810677 48302 CQ650065 48305 CQ650065 48306 CQ650065
48325 CQ650065 48326 CQ650065 48333 CQ650065 781011 CQ664072
781012 CQ664072 MH101 CP616123

	MH104	MH105	MH106	MH158	MH161	MH163	MH165	MH177	MH178	MH192
SIO2	48.7	48.69	47.77	45.21	44.16	47.08	47.05	48.08	47.51	48.22
TIO2	1.66	1.85	3.44	.9	.84	1.14	.48	1.35	3.45	2.11
AL2O3	13.68	14.45	12.73	17.31	16.67	13.85	14.19	14.48	12.73	14.24
FE2O3	3.14	2.55	7.01	3.88	3.29	2.58	1.89	2.77	3.09	4.91
FEO	9.68	8.92	8.01	9.3	10.75	7.56	7.43	9.56	11.31	7.42
MNO	.22	.2	.21	.24	.26	.16	.16	.21	.22	.15
MGO	5.84	6.61	5.22	6.7	8.67	10.41	12.49	7.36	6.22	7.35
CAO	9.8	10.25	8.39	7.87	4.86	10.42	7.67	9.81	8.68	7.36
NA2O	3.35	1.93	3.24	2.53	1.45	1.18	1.12	2.46	1.88	3.05
K2O	.29	1.59	1.03	.31	2.28	.41	1.87	.22	.49	1.13
P2O5	.32	.29	.47	.57	.53	.21	.22	.23	.46	.24
CO2	.24	.18	.1	.17	.17	.1	.21	.14	.1	.04
H2O+	3.44	2.92	2.69	4.65	5.76	4.83	5.09	3.57	4.18	3.03
H2O-	.18	.04	.17	.18	.05	.05	.06	.04	.03	.39
LOI	0	0	0	0	0	0	0	0	0	0
TOTAL	100.54	100.47	100.48	99.82	99.74	99.98	99.93	100.28	100.35	99.64
BA	150	550	210	320	320	310	1150	81	125	89
CO	43	38	40	54	37	34	53	43	43	37
CR	67	190	83	33	32	420	1300	165	96	190
NB	9	0	13	52	52	12	11	3	9	6
NI	63	105	76	70	68	130	390	105	77	104
RB	12	36	19	9	31	12	45	8	15	22
SC	37	35	38	30	23	36	49	40	35	34
SR	220	210	360	560	470	180	150	270	340	180
V	400	330	460	145	150	240	210	340	450	360
Y	35	26	39	31	29	29	20	23	39	27
ZN	97	99	93	99	120	78	95	88	130	190
ZR	97	105	220	100	100	135	42	62	210	135

GRID REFERENCES
MH104 CP620122 MH105 CP623118 MH106 CP623116 MH158 CP555008
MH161 CP554007 MH163 CP554005 MH165 CP554004 MH177 CP548021
MH178 CP548027 MH192 CN730955

	MH193	MH194A	MH194B	MH195	MH196	MH200	MH209	MH245	MH269	41507
SIO2	47.17	47.67	47.74	48.46	48.64	49.12	71.55	52.1	51.03	46.44
TIO2	2.34	.76	.76	2.56	2.29	1.27	.32	.96	.58	2.02
AL2O3	14.18	14.41	14.36	12.85	14.19	13.99	14.32	15.86	14.3	13.13
FE2O3	9.57	4.63	5.45	10.3	5	2	.65	.76	3.31	5.97
FEO	5.26	5.97	5.5	4.94	7.95	10.26	2.09	9.55	6.7	7.77
MNO	.08	.15	.15	.15	.24	.2	.08	.21	.14	.2
MGO	8.27	8.7	9.18	5.93	6.75	7.29	.75	7.1	8.32	6.54
CAO	5.28	10.49	9.64	6.33	8.82	10.3	.43	3.13	8.66	8.82
NA2O	2.61	2.62	2.65	3.57	2.41	2.49	5.49	2.67	3.76	3
K2O	.6	1.15	.99	1.08	.88	.15	2.86	1.21	.71	1.11
P2O5	.25	.09	.08	.24	.24	.14	.06	.08	.05	.27
CO2	.1	.09	.07	.1	.07	.04	.11	1.1	.11	.17
H2O+	3.68	3.03	3.11	2.61	2.53	3.03	1.23	5.01	2.65	3.19
H2O-	.56	.23	.28	.62	.41	.08	.05	.08	.2	.36
LOI	0	0	0	0	0	0	0	0	0	0
TOTAL	99.95	99.99	99.96	99.74	100.42	100.36	99.99	99.82	100.52	98.99
BA	125	43	61	120	78	44	590	210	45	120
CO	42	44	44	48	39	45	0	54	75	44
CR	200	280	290	140	100	130	0	100	195	200
NB	8	0	0	6	6	0	10	0	0	6
NI	86	130	130	80	76	96	3	72	77	92
RB	12	17	15	10	12	10	93	40	16	12
SC	37	44	43	33	31	39	0	56	53	32
SR	145	250	210	170	200	135	130	230	200	120
V	420	280	300	410	400	320	45	320	280	390
Y	28	24	24	31	28	21	25	22	19	25
ZN	110	77	75	145	105	92	60	89	81	100
ZR	145	31	33	149	138	59	105	51	23	135

GRID REFERENCES
MH193 CN729955 MH194A CN726927 MH194B CN726927 MH195 CN735960
MH196 CN735959 MH200 CN736936 MH209 CP685018 MH245 CP546038
MH269 CP558035 41507 CN735958

M 1681

	41508	41524	41525	41527	41530	41531	41536	41567	41569	41570
SIO2	46.77	54.95	75.25	66.83	53.44	59.52	70.59	49.98	47.8	48.16
TIO2	.62	.87	.22	.59	.49	.53	.28	1.41	3.14	1.52
AL2O3	14.29	17.2	13.65	15.42	16.93	14.3	14.28	14.26	12.67	14.51
FE2O3	4.46	4.95	.72	4.38	3	3.57	.9	1.52	4.04	.96
FEO	6.4	8.07	.34	.45	5.98	3.83	2.08	9.9	10.09	10.43
MNO	.16	.16	.08	.04	.23	.13	.06	.15	.22	.16
MGO	8.87	3.07	.25	.1	4.87	4.26	.76	5.93	5.82	6.97
CAO	10.62	.27	.02	.26	3.25	5.11	.33	8.28	8.01	9.38
NA2O	2.43	5.4	3.89	3.88	3.51	3.07	4.56	3.55	3.23	2.41
K2O	1.11	.09	3.75	6.05	4.26	2.68	4.65	.47	.54	1.03
P2O5	.12	.17	.03	.2	.19	.13	.07	.21	.38	.21
CO2	.13	.08	.09	.12	.15	.19	.07	.15	.11	.12
H2O+	3.38	3.6	1.46	.91	2.63	2.4	1.13	2.85	3.04	3.05
H2O-	.28	.34	.24	.15	.11	.09	.08	.17	.2	.12
LOI	0	0	0	0	0	0	0	0	0	0
TOTAL	99.64	99.22	99.99	99.38	99.04	99.81	99.84	98.83	99.29	99.03
BA	57	15	720	2600	1500	650	890	210	195	410
CO	42	14	0	6	39	26	4	48	40	48
CR	300	0	0	0	5	105	0	115	82	195
NB	0	8	8	13	0	5	10	4	11	3
NI	135	0	0	0	24	39	0	83	76	105
RB	18	7	128	140	125	125	160	15	17	23
SC	43	13	0	0	21	23	0	40	34	37
SR	230	38	44	105	230	240	115	300	300	250
V	300	195	16	110	240	155	43	380	460	330
Y	26	25	12	25	19	27	24	26	39	26
ZN	72	77	15	18	69	61	100	8	130	110
ZR	31	150	135	220	84	185	110	95	220	99

GRID REFERENCES
41508 CN726926 41524 CN673962 41525 CN678974 41527 CN683984
41530 CP692000 41531 CP686002 41536 CP694038 41567 CP625113
41569 CP624118 41570 CP624119

	41571	41572	41575	D1	D2	D3	Y408	Z569	Z96	Z102
SIO2	50.07	43.38	44.11	47.83	47.66	44.94	49.98	53.86	55.76	52.84
TIO2	.91	.38	.58	.63	.69	2.32	.4	.65	.46	.37
AL2O3	13.34	12.38	13.21	14.23	16.56	15.42	12.09	15.37	13.46	11.71
FE2O3	1.52	1.94	.51	.76	2	3.33	1	2	2.05	2.06
FEO	10.17	5.33	9.97	8.42	8.25	10.41	7.82	5.99	5.96	6.13
MNO	.22	.12	.16	.19	.14	.31	.18	.15	.17	.14
MGO	7.93	9.8	14.06	10.39	9.58	7.5	10.99	7.41	6.79	9.58
CAO	7.6	11.92	9.49	6.32	6.65	3.53	9.15	6.2	6.44	8.96
NA2O	2.74	2.76	1.06	2.65	2.71	2.63	1.95	2.24	3.17	2.84
K2O	.37	.7	.79	2.11	1.17	.88	1.6	2.41	3.06	2.15
P2O5	.14	.1	.12	.09	.13	.34	.48	.17	.23	.27
CO2	.19	5.94	.17	1.2	.1	2.17	.45	.22	.34	.15
H2O+	3.85	4.15	5.13	4.49	4.25	5.27	3.48	3.8	2.17	2.51
H2O-	.31	.13	.07	.15	.07	.05	.09	.06	.02	.14
LOI	0	0	0	0	0	0	0	0	0	0
TOTAL	99.36	99.03	99.43	99.46	99.96	99.1	99.66	100.53	100.08	99.85
BA	110	330	300	910	640	340	1300	760	1150	1750
CO	48	45	64	42	45	48	40	28	29	41
CR	300	1000	1350	300	290	350	580	280	280	640
NB	4	0	0	0	0	4	4	4	0	0
NI	135	330	430	120	115	170	130	72	67	115
RB	12	14	23	71	31	38	41	63	72	45
SC	41	37	37	37	38	44	39	24	31	42
SR	180	120	66	250	640	135	420	320	220	185
V	300	150	210	450	480	500	240	175	195	240
Y	25	14	17	17	19	43	32	23	22	17
ZN	86	48	81	96	115	740	90	62	62	72
ZR	71	15	37	64	72	250	105	110	105	76

GRID REFERENCES
41571 CP622121 41572 CP619122 41575 CP616123 D1 CP816338
D2 CP815337 D3 CP813334 Y408 CP790469 Z569 CP757489
Z96 CP791424 Z102 CP790423

	Z627	41509	41513	41514	41516	41517
SIO2	48.49	66.42	52.08	69.66	54.47	59.41
TIO2	.33	.39	.66	.26	.46	.69
AL2O3	8.3	14.58	17.18	14.6	14.55	16.07
FE2O3	1.89	3.27	3.22	2.25	1.4	4.67
FEO	7.46	2.76	5.99	1.93	8.07	3.13
MNO	.2	.16	.16	.07	.16	.08
MGO	15.8	.78	4.67	.84	6.9	2.64
CAO	11.99	.51	4.43	.3	3.87	1.4
NA2O	1.12	4.14	4.16	4.46	3.69	7.26
K2O	.59	4.43	2.8	4.29	1.31	2.46
P2O5	.21	.14	.28	.1	.17	.14
CO2	.29	.04	.17	.13	.46	.07
H2O+	3.62	1.65	3.02	1.4	2.73	1.35
H2O-	.11	.19	.18	.14	.34	.28
LOI	0	0	0	0	0	0
TOTAL	100.4	99.46	99	100.43	98.58	99.65
BA	400	920	750	750	970	155
CO	58	0	30	9	24	17
CR	810	0	0	0	155	0
NB	3	10	4	11	3	4
NI	250	3	4	3	63	7
RB	15	200	39	175	46	24
SC	45	0	22	0	29	15
SR	140	49	540	44	200	44
V	320	60	210	42	185	190
Y	19	37	27	20	25	23
ZN	150	83	85	59	36	53
ZR	56	220	115	180	95	135

GRID REFERENCES
Z627 CP781423 41509 CN688961 41513 CN683961 41514 CN676964
41516 CN672964 41517 CN670960