1 MOUNT ISA INLIER SYNTHESIS

Compiled by Lesley Wyborn, Irina Bastrakova, Carole Hensley and Anthony Budd.

1.1 Executive Summary - Geology

The Mount Isa Inlier has a long history of mining and exploration, and hosts several major sediment-hosted Pb-Zn deposits (Mount Isa, Hilton, George Fisher, Century, Cannington) and the Mount Isa Cu deposit. Although the relationship between Au and Cu deposits and plutons of the Williams Supersuite was first postulated by Nye and Rayner (1940) in the eastern Mount Isa Inlier, it is only recently that there has been general acceptance that granites may be related to mineralisation in this part of the Inlier (e.g., Wyborn and Heinrich 1993a 1993b) with the discovery of deposits such as Ernest Henry, Osborne, Eloise and Starra.

The regional geology of the Mount Isa Inlier was reviewed by Blake (1987) and Stewart and Blake (1992). The Mount Isa Inlier itself can be subdivided into three broad tectonic divisions: the Western and Eastern Fold Belts separated by the older Kalkadoon-Leichhardt Belt. The Murphy Inlier to the northwest separates the Mount Isa Inlier cover sequences from the McArthur Basin. The oldest sequence in the Mount Isa Inlier, designated by Blake (1987) as basement, consists of a package of predominantly quartzofeldspathic sediments which were deformed and metamorphosed by about 1875 Ma. It was overlain by cover sequences ranging in age from about 1875 Ma to 1580 Ma in the Western and Eastern Fold Belts. The amount of volcanics within these sequences decreases throughout time, and they can be either dominantly felsic, dominantly mafic, or bimodal.

Granites were intruded at various times during the Proterozoic. Most are I-type, with a few S-types. The earliest known granites are dated at ~1860 Ma, and the youngest at ~1490 Ma. The larger granite intrusive events are at 1860 Ma, 1760 Ma, 1740 Ma, 1670 Ma and 1510 Ma. The most mineralised granite event is at ~1510 Ma. Most granites are Sr-depleted, Y-undepleted, indicating a plagioclase-residual source.

1.2 Executive Summary - Metallogenic Potential

This compilation has assessed the metallogenic potential of each granite suite based on the criteria set out in the Project Proposal. The following suites have been identified as having some potential for granite-related mineralisation:

The Williams Supersuite, comprising the post-D_2 (post-1550 Ma) plutons of the Williams and Naraku Batholiths, has the greatest potential for further discoveries of Au and Cu in the surrounding rocks. The magma became more oxidised with increased fractionation, and Cu values decreased with increased SiO_2. The high oxidation state of the late magmatic derivatives means that reduction is the most likely cause for metal precipitation and that suitable host rocks will be either carbonaceous rocks or ironstones. Reduction could also occur by interaction of the magmatically derived fluid with a reduced connate fluid.

The Burstall Suite consists of a series of comparatively small plutons some of which have potential for Cu-Au deposits, and although these are likely to be of low tonnage, they have the potential to be of high grade. With the exception of the Saint Mungo Granite and the Myubee Igneous Complex, members of the Burstall Suite are oxidised, and Cu generally decreases with increasing SiO_2. The Saint Mungo Granite, which is relatively reduced, is the closest pluton, and may be related, to the Tick Hill Au deposit. New geochronological information (Page and Sun 1996; Page *et al.* 1997) indicates that this intrusive suite is coeval with felsic volcanics interbedded with the Ballara Quartzite, Mitakoodi Quartzite and Corella Formation (and may also include volcanics of the Tommy Creek Block). Although speculative, it is possible that epithermal and/or Carlin-style Au deposits may be found within these associated sediments, related to the fractionating magmatism of the Burstall Suite (particularly as some of these sediments are graphitic).

The Sybella Suite has high HFSE contents and is not regarded as having much potential for Au or Cu. It has some potential for Sn, Mo and Be.

The Nicholson Suite is dominated by restite in its more mafic end members. Fractionation has occurred only over a very narrow SiO_2 range at high SiO_2 values. The only metal potential appears to be in areas surrounding these late fractionated derivatives in the central part of the Murphy Inlier, where there is a possibility of small Cu, Sn or even Au deposits.

The Kalkadoon Supersuite, being predominantly a restite suite, is regarded in general as having low economic potential. However, in the north near Dobbyn and also near the Ewen Batholith, minor fractionation appears to have taken place, and the suite may have potential for small Cu deposits.

1.3 Future work

Two areas of further research have been identified.
1) Further sampling of the northern part of the Ewen Granite and the Kalkadoon Granodiorite in the Dobbyn and northern Prospector 1:100000 sheet areas to determine if the granite system has undergone fractionation, and if so, what are the metallogenic implications.
2) A detailed geochemical study of the 1780-1740 Ma intrusive and extrusive felsic igneous rocks of the Eastern Fold Belt and the Wonga region of the Kalkadoon-Leichhardt Belt. The focus of this research should be to determine which parts of the Wonga Suite are comagmatic with the Argylla Suite and which parts are comagmatic with the potentially economic Burstall Suite.

1.4 Methods

Information Sources: 1:250000 maps and explanatory notes, 1:100000 maps and commentaries where available, published ages, AGSO OZCHEM and OZCHRON databases, AGSO MINLOC database, AGSO magnetic and gravity data.

Classification of Granites: In this report the granites have been divided into suites based on the age, geographic location, and geochemistry of each pluton. Using this method, approximately 10 suites are recognised (Table 1.1). However, if it can be proven that the older granites of the Wonga Suite are part of the Argylla Suite and that the Burstall Suite is comagmatic with the Tommy Creek Suite then the number of suites is reduced.

Host Rocks: The country rocks thought to be intruded by each suite have been briefly described and classified according to mineralogical characteristics thought to be important in determining the metallogenic potential of a granite intrusive event.

Relating Mineralisation: As very little direct dating of mineralisation is available in the Mount Isa Inlier, the method used has been to exclude all deposits more than 5 km from a known outcropping granite, then for those remaining, to make an assessment of the likelihood that they may be derived from granite intrusive activity (based on deposit style). The existence of known mineralisation thought to be associated with a granite has been a factor in categorising the metallogenic potential of that granite, however, it is only one criterion of several.

1.5 Acknowledgements

This section has benefited from helpful discussions with David Blake and Shen-Su Sun.

1.6 References

Blake, D.H. 1987. Geology of the Mount Isa Inlier and environs, Queensland and Northern Territory. *Bureau of Mineral Resources, Australia, Bulletin,* 225.

Stewart, A.J. and Blake, D.H. (editors) 1992. Detailed studies of the Mount Isa Inlier , *Bureau of Mineral Resources, Australia, Bulletin,* 243, 374pp.

Nye, P.B. and Rayner, E.O. 1940. The Cloncurry copper deposits, with special reference to the gold-copper ratios of the ores. *Aerial, Geological and Geophysical Survey of Northern Australia,* Report Queensland No. 35, 38 pp.

Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, *EGRU Contribution 55*, 95-98.

Page, R.W., Sun, S.-S. and McCready, T. 1997. New geochronological results in the central and eastern Mount Isa Inlier and implications for mineral exploration. *Abstracts, Geodynamics and Ore Deposits Conference, Australian Geodynamics Cooperative Research Centre, Ballarat, Victoria,* 46-48.

Wyborn, L.A.I. 1998. Youger *ca* 1500 Ma granites of the Williams and Naraku Batholiths, Cloncurry district, eastern Mt Isa Inlier: geochemistry, origin, metallogenic significance and exploration indicators, *Australian Journal of Earth Sciences,* 45, 397-411.

Wyborn, L.A.I. and Heinrich, C.A. 1993a. The relationship between late-tectonic felsic intrusives and Cu-Au mineralisation in the Eastern Fold Belt, Mount Isa Inlier. *Australian Institute of Geoscientists,* Bulletin, 13, 27-30.

Wyborn, L.A.I. and Heinrich, C.A. 1993b. Empirical observations on granite-associated gold + base-metal mineral deposits in the Proterozoic of Australia: delineating exploration criteria. *AGSO Research Newsletter,* 19, 3-4.

1.7 Table 1.1

Chpt #	Grouping (Type)	Age (Ma)	Potential					Confid Level	Pluton
			Cu	Au	Pb/Zn	Sn	Mo/W		
2	Kalkadoon (Kalkadoon)	1860	Low	Low	None	Low	None	322	Kalkadoon Granodiorite
									Wills Creek Granite
									Woonigan Granite
									One Tree Granite
									Hardway Granite
									Leichhardt Volcanics
									Ewen Granite
3	Nicholson (Nicholson)	1850	Mod	Mod	Low	Mod	Low	322	Nicholson Granite
									Cliffdale Volcanics
4	Argylla (Sybella)	1780	None	None	None	None	None	321	Argylla Formation
									Bottletree Formation
									Bowlers Hole Granite
									Mairindi Creek Granite
5	Wonga (Sybella)	1760	None	None	None	None	None	321	Birds Well Granite
									Bushy Park Gneiss
									Mount Maggie Granite
									Natalie Granite
									Playboy Granite
									Scheelite Granite
									Winston Churchill Granite
									Wonga Granite
6	Burstall (Hiltaba)	1740	Mod	Mod	None	Low	Low	322	Burstall Granite
									Mount Godkin Granite
									Overlander Granite
									Mount Erle Igneous Complex
									Revenue Granite
									Saint Mungo Granite
									Myubee Igneous Complex
7	Fiery (Sybella)	1710	None	None	None	None	None	321	Peters Creek Volcanics
									Fiery Creek Volcanics
									Weberra Granite
8	Sybella (Sybella)	1670	None	None	None	Low	Low	321	Annable Granite
									Briar Granite
									Dingo Granite
									Easter Egg Granite
									Garden Creek Porphyry

Chpt #	Grouping (Type)	Age (Ma)	Potential					Confid Level	Pluton
			Cu	Au	Pb/Zn	Sn	Mo/W		
									Gidya Granite
									Guns Knob Granite
									Hay Mill Granite
									Kahko Granodiorite
									Keithys Granite
									Kitty Plain microgranite (in part)
									Queen Elizabeth Granite
									Steeles Granite
									Widgewarra Granite
									Wonomo Granite
									Carters Bore Rhyolite
9	Maramungee (Maramungee)	1545	None	None	None	None	None	321	Maramungee Granite
10	**Williams** (Hiltaba)	**1510**	**High**	**High**	None	None	Low	323	The Mavis Granodiorite
									Malakoff Granite
									Saxby Granite
									Mount Angelay Granite
									Squirrel Hills Granite
									Yellow Waterhole Granite
									Wimberu Granite
									Mount Cobalt Granite
									Mount Dore Granite
11	Tommy Creek (Hiltaba)	1760	Low	Mod	None	None	None	321	Tommy Creek Microgranite
									Lalor beds
									Milo beds(?)
11	Little Toby (Sybella)	?	?	?	?	?	?	210	Little Toby granite
11	Monaghans (Forsayth)	1804	None	None	None	None	None	320	Monaghans granite
11	Yeldham (Forsayth)	1820	None	None	None	None	None	220	Yeldham Granite
11	Cowie (Unclassified)	?	?	?	?	?	?	220	Cowie Granite
									Blackeye Granite
11	Levian (Unclassified)	1746	?	?	?	?	?	321	Levian Granite
11	Mount Maragret (Unclassified)	1530	?	?	?	?	?	100	Mount Margaret Granite

2 KALKADOON SUPERSUITE

2.1 Timing

1860 Ma

2.2 Individual Ages

Primary Ages:

1. Leichhardt Volcanics [1, 2] 1886 ± 32 Ma, U-Pb
2. Leichhardt Volcanics [1, 2] 1866 ± 5 Ma, U-Pb
3. Leichhardt Volcanics [1, 3] 1865 ± 3 Ma, U-Pb
4. Kalkadoon Granodiorite [1, 3] 1862 ± 24 Ma, U-Pb
5. Kalkadoon Granodiorite [1] 1860 ± 32 Ma, U-Pb
6. Leichhardt Volcanics [1] 1857 ± 20 Ma, SHRIMP
7. Kalkadoon Granodiorite [1, 3, 4] 1856 ± 10 Ma, U-Pb
8. Leichhardt Volcanics [1, 2] 1852 ± 26 Ma, U-Pb
9. Leichhardt Volcanics [1, 2] 1852 ± 7 Ma, U-Pb
10. Ewen Granite [1, 3, 4] ~1820 Ma, U-Pb

Sources: [1] OZCHRON, [2] Page (1983), [3] Page (1978), [4] Wyborn and Page (1983). Note: most of these ages are U-Pb conventional zircon ages. As this is a restite-rich supersuite, the wide spread of ages probably reflects an abundance of inherited zircons, particularly in the restite-rich samples. The ages are around 1860 Ma for the Kalkadoon Granodiorite/Leichhardt Volcanics in the central part of the Kalkadoon-Leichardt Belt. However, the ages appear to be younger in the Ewen Block to the northwest and it may be a separate event: this issue will not be resolved until more precise SHRIMP age determinations are carried out in both areas, closely combined with geochemical studies to ensure that restite-rich samples are not selected for age determination.

2.3 Regional Setting

The Kalkadoon Supersuite is predominantly felsic, but some net-veined complexes recorded in the Duchess area (Blake *et al*. 1984) suggest that the event may have been bimodal. The granites intrude Palaeoproterozoic basement rocks and their own volcanic ejecta (the Leichhardt Volcanics) as well as the sedimentary Candover Metamorphics and Orient Beds. The high silica content of this supersuite and the trace element patterns indicate that this supersuite was derived from an intracontinental setting (Wyborn 1988) rather than a continental margin (*c.f.,* Wilson 1978).

2.4 Summary

The Kalkadoon Supersuite is characterised by chemical uniformity over a wide area within both intrusive and extrusive suites. Most trends either increase or decrease in a linear fashion, and the K/Rb ratios do not decrease with increasing SiO_2, implying little or no fractionation throughout most of the magma system.

2.5 Potential

The restite dominance of the Kalkadoon Supersuite combined with the lack of evidence of extensive fractional crystallisation limits its metallogenic potential. It is possible that minor fractionation of the residual liquid took place, after the restite was removed in the Dobbyn area in the northern part of the Kalkadoon Granodiorite and also within the Ewen Granite. If so, these areas may have potential for small Au/Cu deposits, although there are no significant potential hosts.

Cu:	**Low**
Au:	**Low**
Pb/Zn:	**None**
Sn:	**Low**
Mo/W:	**None**
Confidence level:	**322**

2.6 Descriptive Data

Location: Central and southern parts of the Mount Isa Inlier, and forms a significant basement to later sedimentary sequences.

Dimensions and area: Northerly trending belt 300 km long by 30 km wide. Total area is 3500 km^2.

2.7 Intrusives

Component plutons: Kalkadoon Granodiorite, Wills Creek Granite, Woonigan Granite, One Tree Granite, Hardway Granite and Ewen Granite. The so-called ‘Black Angel gneiss complex’ of McDonald *et al.* (1996) has been excluded as it is of an entirely different composition and is possibly older, although the Archaean age assigned to the unit by McDonald *et al.* (1996) has been disputed, and a Palaeoproterozoic age is preferred (Page and Sun 1996). Small S-type granites have also been excluded.

Form: The supersuite occurs as large elongate masses, which for the most part have not been subdivided into individual plutons. The Kalkadoon Granodiorite extends in a northerly direction over five 1:100000 map sheet areas.

Metamorphism and Deformation: Metamorphosed from lower greenschist to upper amphibolite facies and shows significant isotopic disturbances. Textural modification increases with increasing metamorphic grade. Scapolite occurs in amphibolite facies rocks adjacent to the Corella Formation.

Dominant intrusive rock types: Coarse-grained porphyritic granodiorite to monzogranite.

Colour: Grey dominantly, some areas of pink K-feldspar.

Veins, Pegmatites, Aplites, Greisens: Aplite common, minor pegmatite.

Distinctive mineralogical characteristics: Hornblende- and/or biotite-bearing. In the south, the Kalkadoon Granodiorite contains white or grey feldspar phenocrysts in a black and white groundmass. Accessory titanite, allanite, zircon, calcite, epidote, chlorite.

Breccias: None recorded.

Alteration in the granite: Alteration related to primary magmatism may be difficult to recognise due to later metamorphism.

2.8 Extrusives

Leichhardt Volcanics (formerly Leichhardt Metamorphics). These are predominantly crystal-rich ignimbrite with some flow-banded lava.

2.9 Country Rock

Contact metamorphism: None noted.

Reaction with country rock: None noted.

Units the granite intrudes: The supersuite intrudes its comagmatic volcanics (Leichhardt Volcanics), sediments of the Orient Beds (Blake 1992) as well as migmatitic quartzofeldspathic gneisses of the undivided Tewinga Group and the Kurbayia Migmatite (Blake and Page 1988). It also intrudes the so-called ‘Black Angel gneiss complex’ of McDonald *et al.* (1996). The Ewen Granite intrudes the Candover Metamorphics (Derrick and Wilson 1982).

Dominant rock types: Felsic volcanics, quartzofeldspathic gneisses.

Potential hosts: No distinctive hosts are apparent in the country rock.

2.10 Mineralisation

Numerous small Cu deposits occur throughout the Kalkadoon Granodiorite and its comagmatic volcanics. Many occur near the contact with dolerites and amphibolites (Raymond 1992) and are believed to have formed during later metamorphic events (Ellis and Wyborn 1984). Some small Cu deposits in the Dobbyn area may be due to late fractionation of the melt, after the bulk of the restite had separated out. Some Au and U deposits occur within the 5km buffer on the western side of the Kalkadoon Granodiorite in the Mary Kathleen sheet area These are hosted by younger rocks, but it is possible that the U was leached from the rocks of the Kalkadoon Supersuite during metamorphism and deformation at ~1530 Ma.

2.11 Geochemical Data

Data source: The data come from three sources: (1) geochemistry of samples collected by Rod Page for Rb-Sr age determinations; (2) collections made as part of a regional mapping program in the Duchess 1:250 000 sheet area (Blake *et al.* 1984); and (3) specialised collection made by L. Wyborn during 1978 as part of a regional synthesis program on Mount Isa granites. All data are stored in OZCHEM .

Data quality: All samples were analysed in the AGSO laboratories and the quality is good.

Are the data representative? The samples are believed to be representative of the main petrographic types present.

Are the data adequate? More than adequate for all units with the exception of the Ewen Granite. More sampling of this unit is required, particularly as one of the samples shows strong evidence of fractionation.

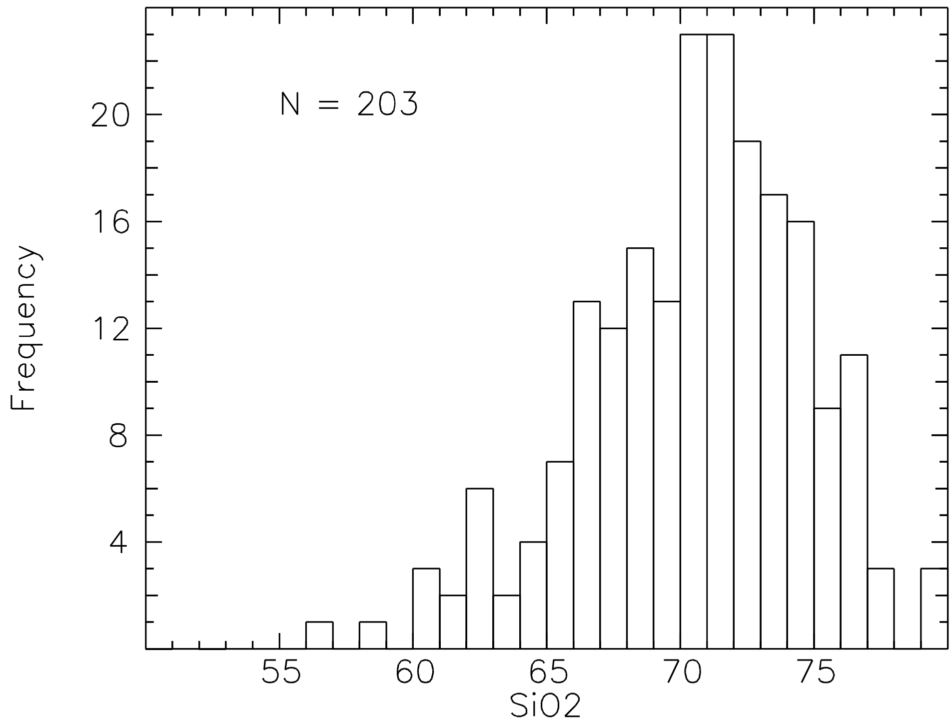


Figure 2.1. Frequency histogram for SiO_2 values for the Kalkadoon Supersuite.

SiO_2 range (Fig. 2.1): The SiO_2 range is wide, from 56 wt.% to 78 wt.% SiO_2, with a peak between 70-72 wt.%.

Alteration (Fig. 2.2):

- ***SiO_2:*** The samples show minor evidence of silicification.
- ***K_2O/Na_2O:*** There are minor amounts of sodic and potassic alteration present, particularly near outcrops of the Corella Formation.
- ***Th/U:*** Many of the Th/U values are somewhat high, and very extreme in some altered samples. This is probably a function of later metamorphism and deformation. Many samples plot below the Proterozoic median for U (Figure 2.7B) suggesting that removal of U has been fairly widespread.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** This plot shows there is some extensive oxidation of the volcanic samples. This may be due to diagenetic alteration of the volcanics, later deformation and metamorphism, weathering or a combination of all these.

Fractionation Plots (Fig. 2.3):

- ***Rb:*** Samples only show slight increases in Rb with increasing SiO_2. Note the one sample of Ewen Granite is relatively high, indicating possible fractionation.

- ***U:*** Samples only show slight increases in U with increasing SiO_2. Note the one sample of Ewen Granite is relatively high, indicating possible fractionation.
- ***Y:*** No trend.
- ***P_2O_5:*** Decreases with increasing SiO_2.
- ***Th:*** Samples only show slight increases in Th with increasing SiO_2.
- ***K/Rb:*** If anything the K/Rb ratio increases with increasing SiO_2. Note again that the sample from the Ewen Granite has the lowest K/Rb value.
- ***Rb-Ba-Sr:*** Only three samples plot in the strongly differentiated field.
- ***Sr:*** Decreases with with increasing SiO_2.
- ***Rb/Sr:*** Very weak increase with increasing SiO_2. The Ewen Granite sample has the highest value.
- ***Ba:*** Somewhat scattered trend with a rapid decrease shown for those intrusives with > 75 wt.% SiO_2.
- ***F:*** Limited data with values up to 2500 ppm, which is just within the range noted by Eby (1990) of 0.07-1.7 wt.% for Palaeozoic A-type granites.

Metals (Fig. 2.4):

- ***Cu:*** Mostly low values, but some high values in the volcanics, probably due to later metamorphism and deformation.
- ***Pb:*** Scattered values.
- ***Zn:*** Broad general decrease with increasing SiO_2.
- ***Sn:*** Generally low values with some high values.

High field strength elements (Fig. 2.5):

- ***Zr:*** Broad general decrease with increasing SiO_2.
- ***Nb:*** Flat trend. For Proterozoic granites of Australia as a whole, these values are very low.
- ***Ce:*** Generally low values, with decreasing values at highest SiO_2 contents.

Classification (Fig. 2.6):

- ***The $CaO/Na_2O/K_2O$ plot of White, quoted in Sheraton and Simons (1992):*** The granites plot in the granodiorite through monzogranite to granite fields reflecting the wide range in SiO_2 values of this supersuite. The rocks that plot in the trondhjemite field are altered.
- ***Zr/Y vs Sr/Sr*:*** All values are <1 reflecting the fact that all spidergrams for this supersuite are Sr-depleted, Y-non depleted (as are most Proterozoic granites).
- ***Spidergram:*** All spidergrams for this supersuite are Sr-depleted, Y-non depleted, with weak depletion of Ba with increasing SiO_2.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most of the intrusive samples are in the reduced to oxidised range, whilst the volcanics are in the oxidised to strongly oxidised fields. This plot is not likely to reflect primary magmatic conditions and has been affected by alteration associated with metamorphism, deformation and even weathering.
- ***ASI:*** The majority of samples have an ASI index up to 1.3 and show almost no change with increasing SiO_2.
- ***A-type plot of Eby (1990):*** The Kalkadoon-Leichhardt supersuite clearly straddles the fields for normal and A-type granites based on Palaeozoic granites. However, this granite is clearly not ‘A-type’ in character.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-granodiorite, restite.

Australian Proterozoic granite type: Type example of the Kalkadoon type.

2.12 Geophysical Signature

Radiometrics (Fig. 2.7): Most samples plot above the median line for K_2O and Th, but many are below the median line for U. Hence the dominant colour would be yellow to white.

Gravity: The measured wet densities of rocks from the Kalkadoon Supersuite ranged from 2.60 to 2.78 kg/m^3 (Hone *et al.* 1987). These densities are higher than normally expected for granites, possibly reflecting the amount of restite within most members of the supersuite. Most of the area covered by the Kalkadoon Supersuite plots as a regional gravity high, which is unusual for a granite body. The higher densities of the units, combined with the large number of dolerite dykes intruding the supersuite may contribute to this gravity high.

Magnetics: The area covered by the Kalkadoon Supersuite is a major magnetic low on the regional aeromagnetic data set. This is in keeping with extremely low measured susceptibilities on hand specimens and outcrops in the field (Wyborn, unpublished data).

2.13 References

Blake, D.H. 1992. Stratigraphy, folding and faulting within the Quilalar Fault System, Mount Isa Inlier. In: Stewart, A.J. and Blake, D.H., (editors), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Australia, Bulletin*, 243, 161-179.

Blake, D.H. and Page, R.W. 1988. Early Proterozoic migmatitic basement in the Kalkadoon-Leichhardt Belt of the Mount Isa Inlier, northwest Queensland. *BMR Journal of Australian Geology and Geophysics*, 10, 323-328.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981a. Definitions of new and revised Precambrian stratigraphic and intrusive rock units in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report*, 233, *(BMR Microform* MF 164*).*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981b. Summary of new and revised Precambrian stratigraphic nomenclature in the Duchess and Urandangi 1:250 000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Queensland Government Mining Journal,* 82, 580-589.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1982, Dajarra, Queensland. *Bureau of Mineral Resources, Geology and Geophysics 1:100,000 Geological map commentary.*

Blake, D.H., Bultitude, R.J., Donchak, P.J.T., Wyborn, L.A.I. and Hone, I.G. 1984, Geology of the Duchess-Urandangi region, Mount Isa Inlier, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 219, 96 pp.

Derrick, G.M. and Wilson, I .H. 1982. Geology of the Alsace 1:100 000 sheet area (6858) Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1982/6.

Ellis, D.J. and Wyborn, L.A.I. 1984. Petrology and geochemistry of Proterozoic dolerites from the Mount Isa Inlier. *BMR Journal of Australian Geology and Geophysics,* 9, 19- 32.

Hone, I.G., Carberry, V.P. and Reith, H.G. 1987. Physical property measurements on rock samples from the Mount Isa Inlier, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report,* 265, 30 pp.

Joplin, G.A. and Walker, K.R. 1961. The Precambrian granites of north-western Queensland. *Proceedings of the Royal Society of Queensland* volume 72, No. 2.

McDonald, G.D., Collerson, K.D. and Wendt, J.I. 1996. New field and Nd-Pb isotopic constraints on the early evolution of the Mount Isa Block. *Geological Society of Australia, Abstracts*, 41, 285.

Raymond, O. 1992. Mount Isa Inlier and Environs Mineral Deposit Database Version 1.0. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1992/66, 27 pp.

Page, R.W. 1978. Response of U-Pb zircon and Rb-Sr total-rock and mineral systems to low-grade regional metamorphism in Proterozoic igneous rocks, Mount Isa, Australia. *Journal of the Geological Society of Australia,* 25, 141-164.

Page, R.W. 1983. Timing of superimposed volcanism in the Proterozoic Mount Isa Inlier. *Precambrian Research,* 21, 223-245.

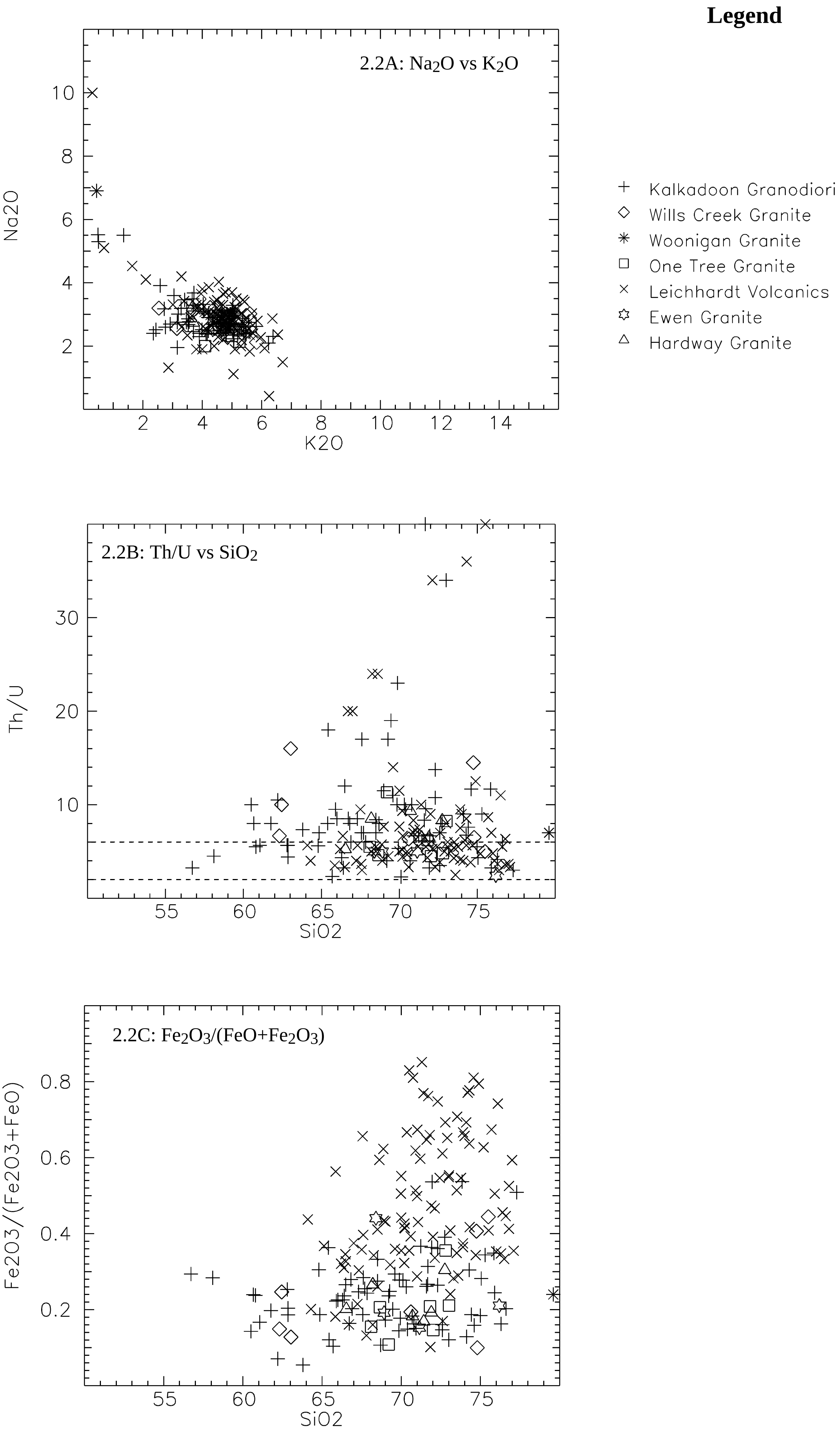
Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. MIC'96: *New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, EGRU Contribution,* 55, 95-98.

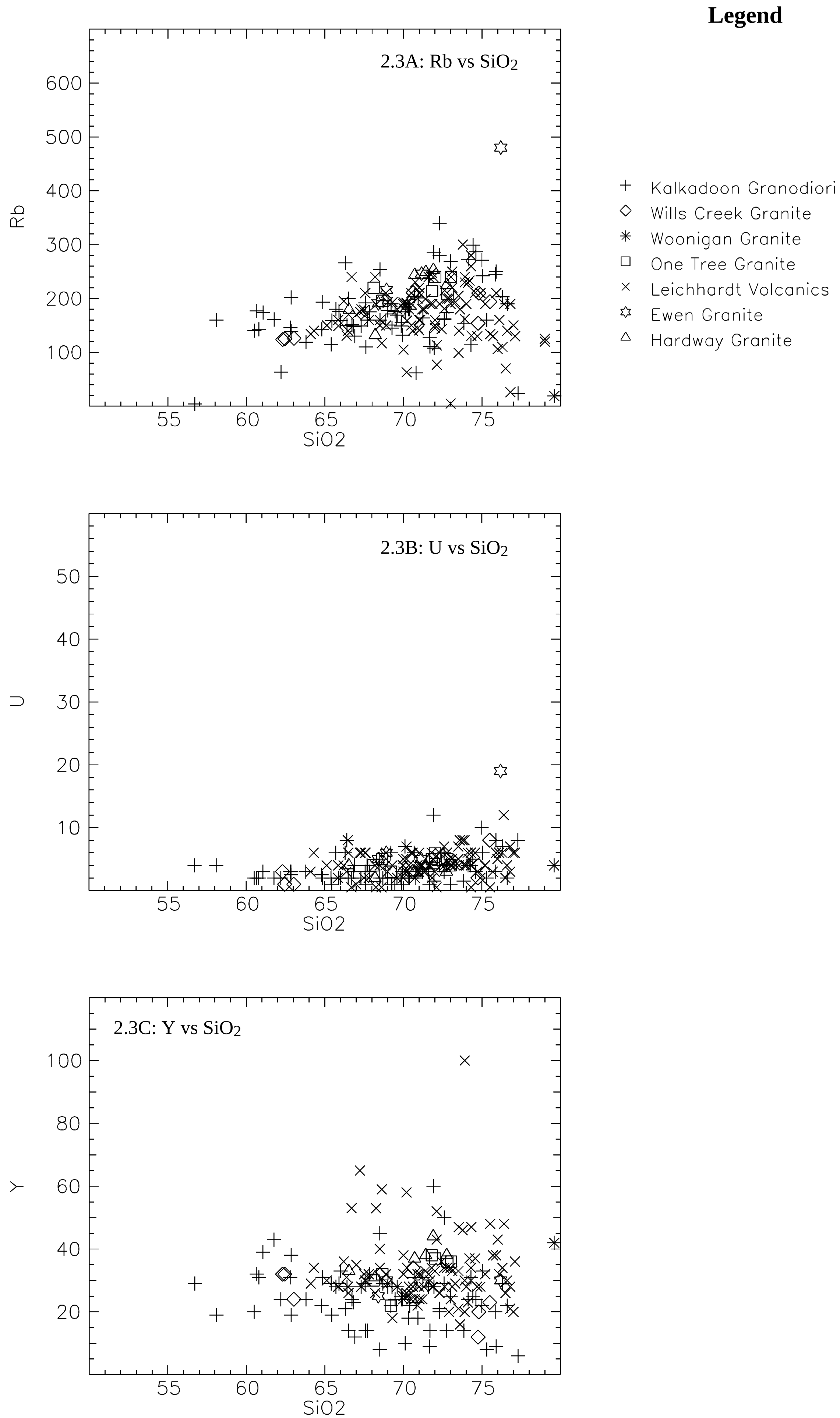
Wilson, I.H. 1978. Volcanism on a Proterozoic continental margin in northwestern Queensland. *Precambrian Research,* 7, 205-235.

Wilson, I.H. 1987. Geochemistry of Proterozoic volcanics, Mount Isa Inlier, Australia. In: Pharoah, T.C., Beckinsale, R.D. and Rickard, D. (editors) 1987, *Geochemistry and Mineralization of Proterozoic Volcanic Suites, Geological Society Special Publication* No. 33, 409-423.

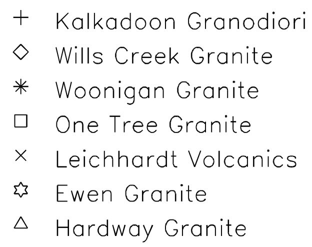
Wyborn, L.A.I. 1988. Petrology, geochemistry, and origin of a major Australian 1840-1880 Ma felsic volcano-plutonic suite: a model for intracontinental felsic magma generation. *Precambrian Research*, 40/41, 37-60.

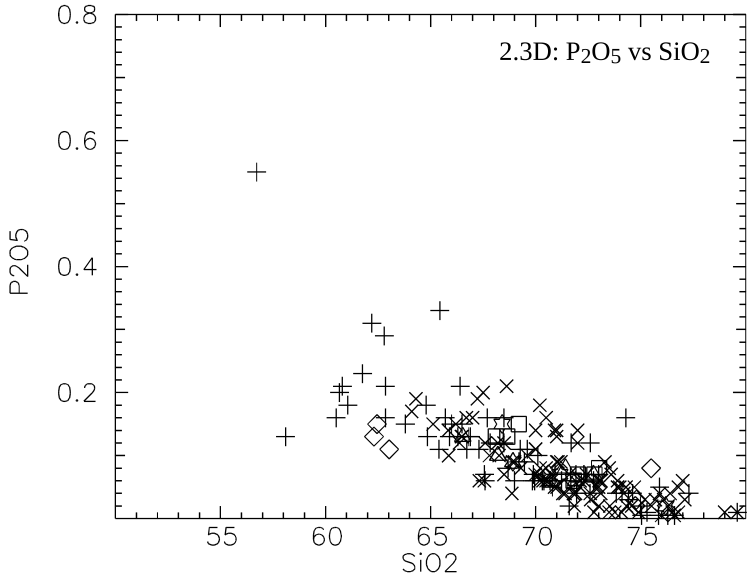
Wyborn, L.A.I. and Page, R.W. 1983. The Proterozoic Kalkadoon and Ewen Batholiths, Mount Isa Inlier, Queensland: source, chemistry, age, and metamorphism. *BMR Journal of Australian Geology and Geophysics*, 8, 53-69.

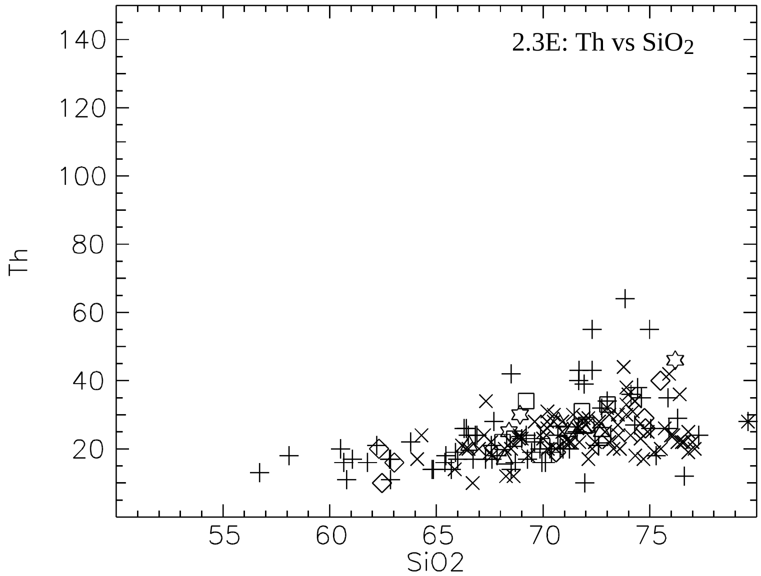

Legend
Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite
2.2A: Na2O vs K2O
Na2O
K2O
2.2B: Th/U vs SiO2
Th/U
SiO2
2.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2

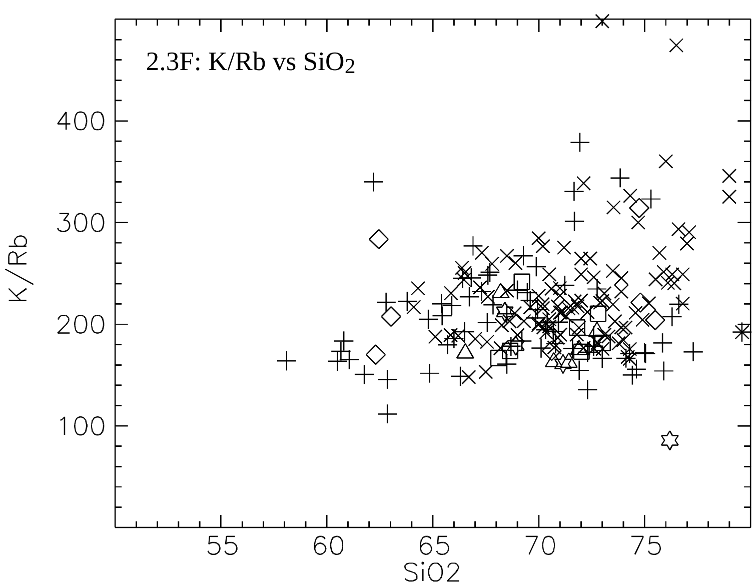

Legend
+ Kalkadoon Granodiori
◇ Wills Creek Granite
✳ Woonigan Granite
□ One Tree Granite
× Leichhardt Volcanics
✡ Ewen Granite
△ Hardway Granite
2.3A: Rb vs SiO2
Rb
600
500
400
300
200
100
55
60
65
70
75
SiO2
2.3B: U vs SiO2
U
50
40
30
20
10
55
60
65
70
75
SiO2
2.3C: Y vs SiO2
Y
100
80
60
40
20
55
60
65
70
75
SiO2

Legend

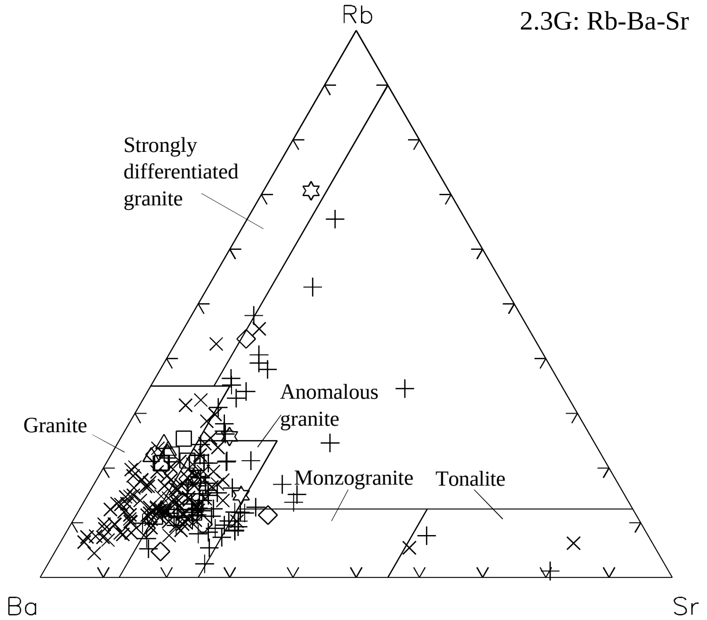

Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite

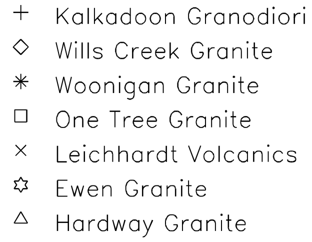

2.3D: P_2O_5 vs SiO_2
0.8
0.6
0.4
0.2
P2O5
55
60
65
70
75
SiO2

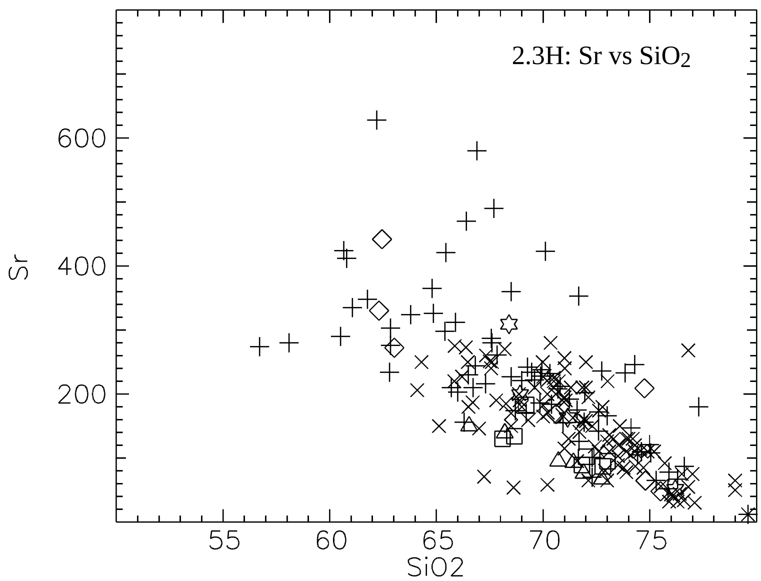

2.3E: Th vs SiO_2
140
120
100
80
60
40
20
Th
55
60
65
70
75
SiO2

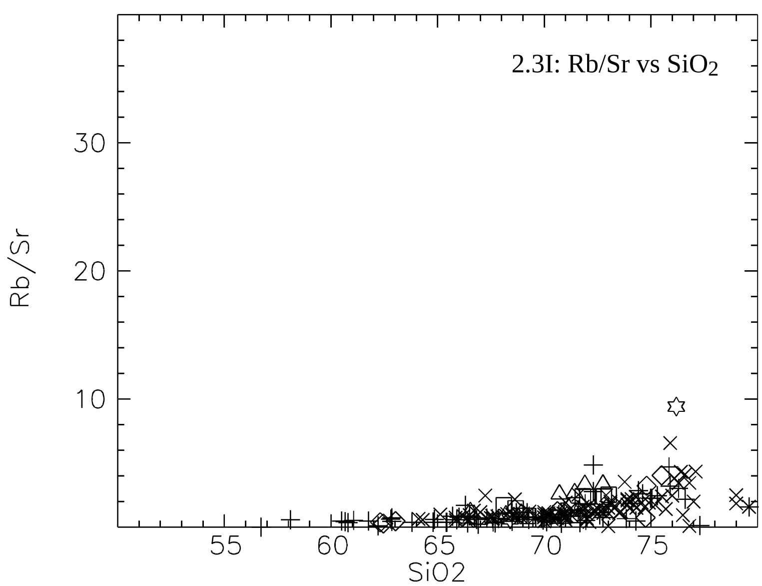

2.3F: K/Rb vs SiO_2
400
300
200
100
K/Rb
55
60
65
70
75
SiO2

Legend

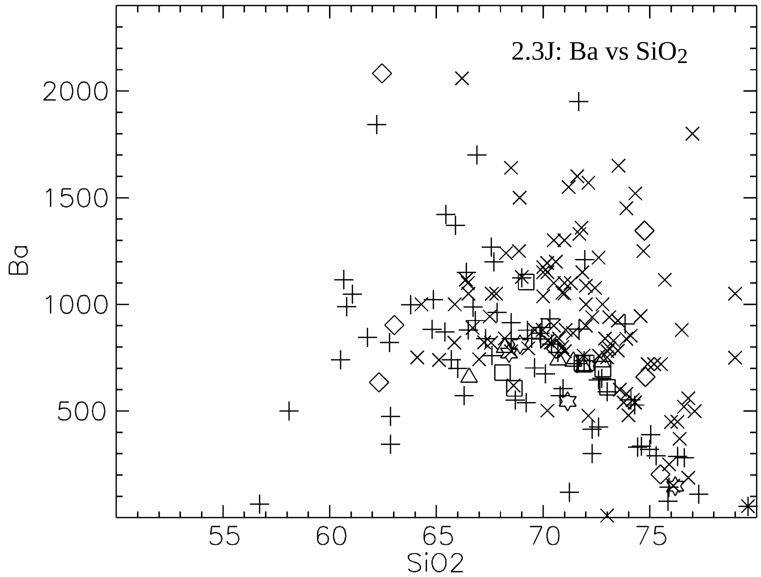

2.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Anomalous granite
Granite
Monzogranite
Tonalite

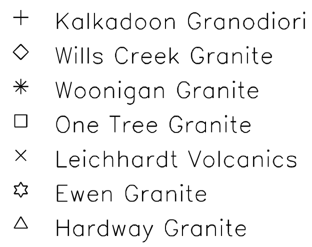

Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite

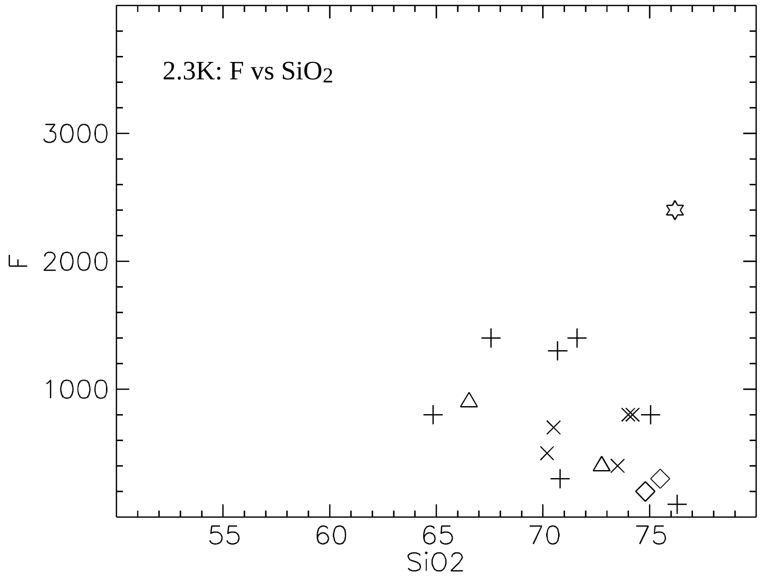

2.3H: Sr vs SiO2
Sr
SiO2
600
400
200
55
60
65
70
75

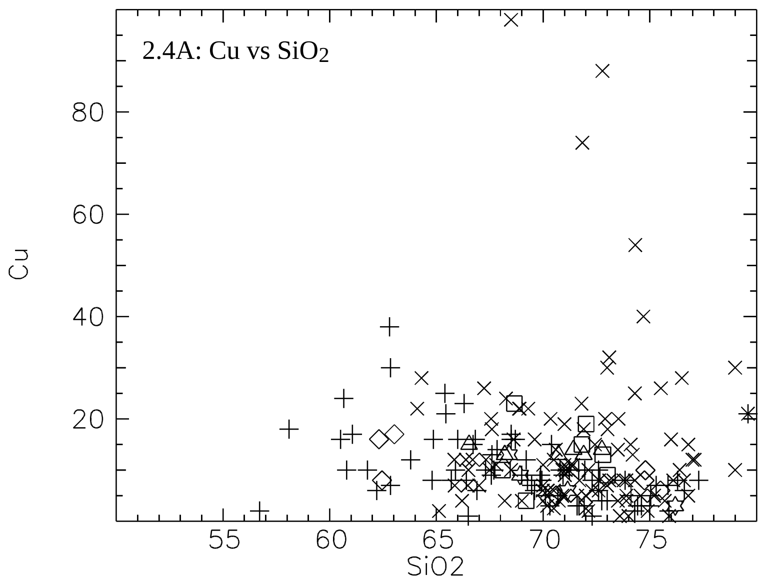

2.3I: Rb/Sr vs SiO2
Rb/Sr
SiO2
30
20
10
55
60
65
70
75

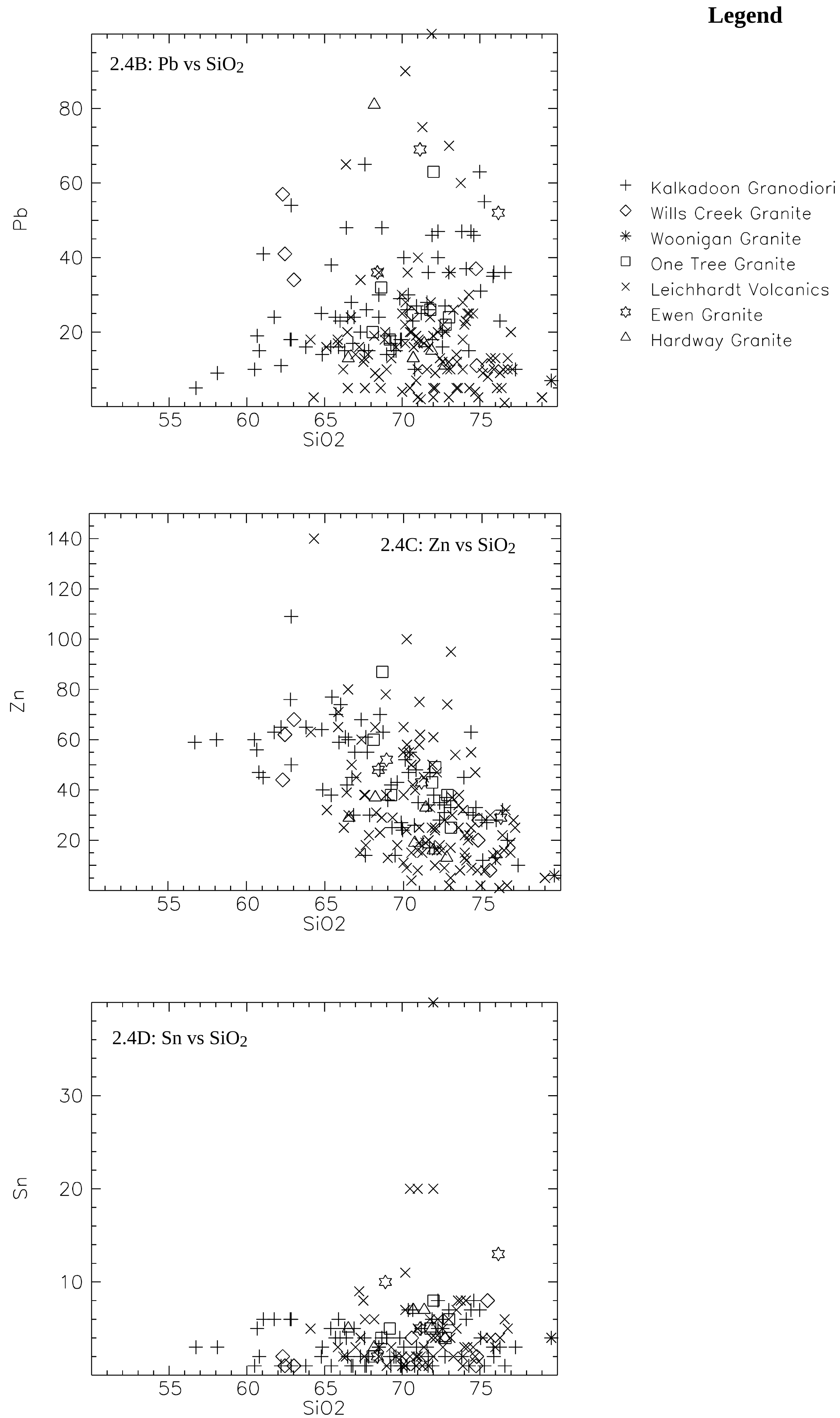
Legend

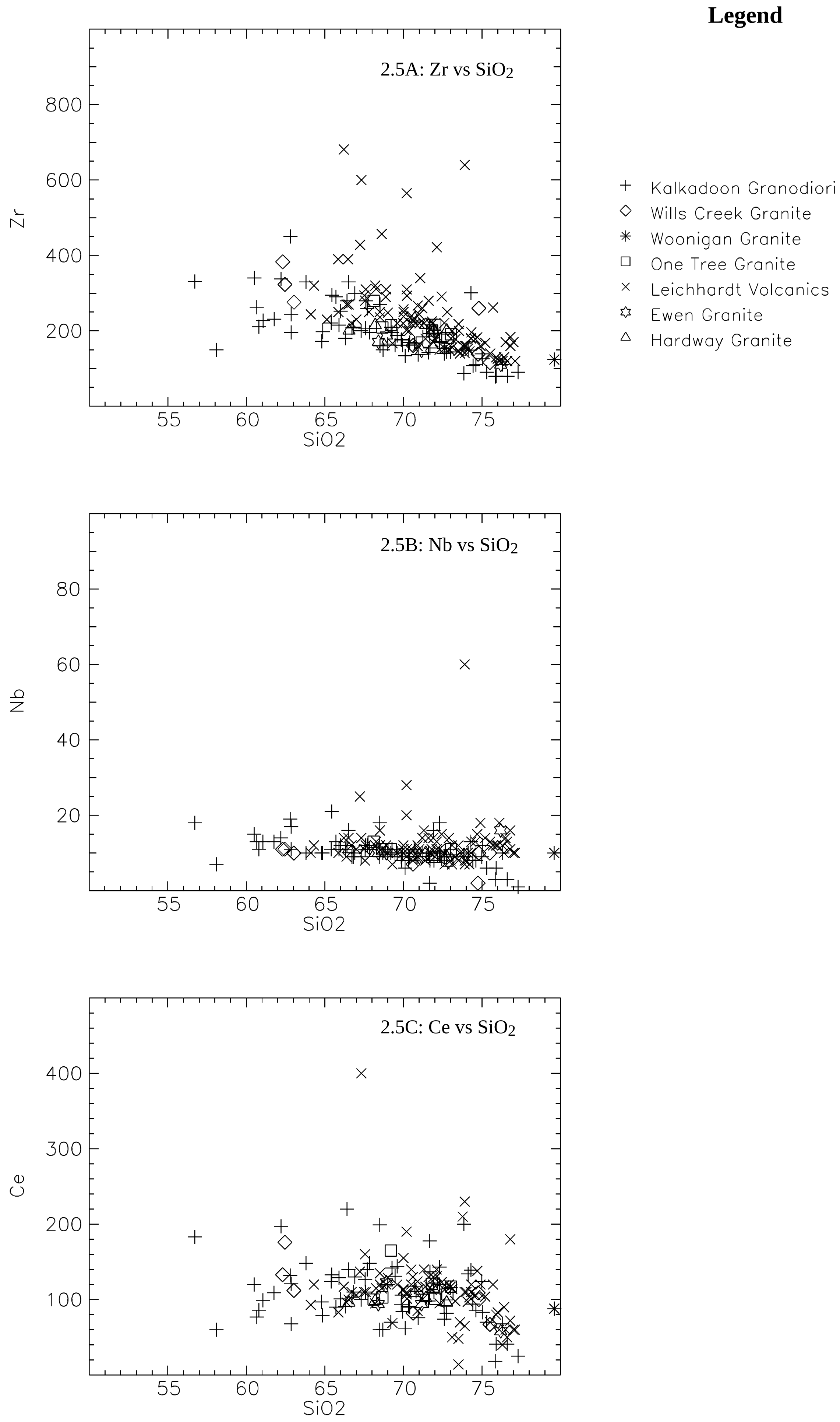

2.3J: Ba vs SiO2
Ba
2000
1500
1000
500
55
60
65
70
75
SiO2

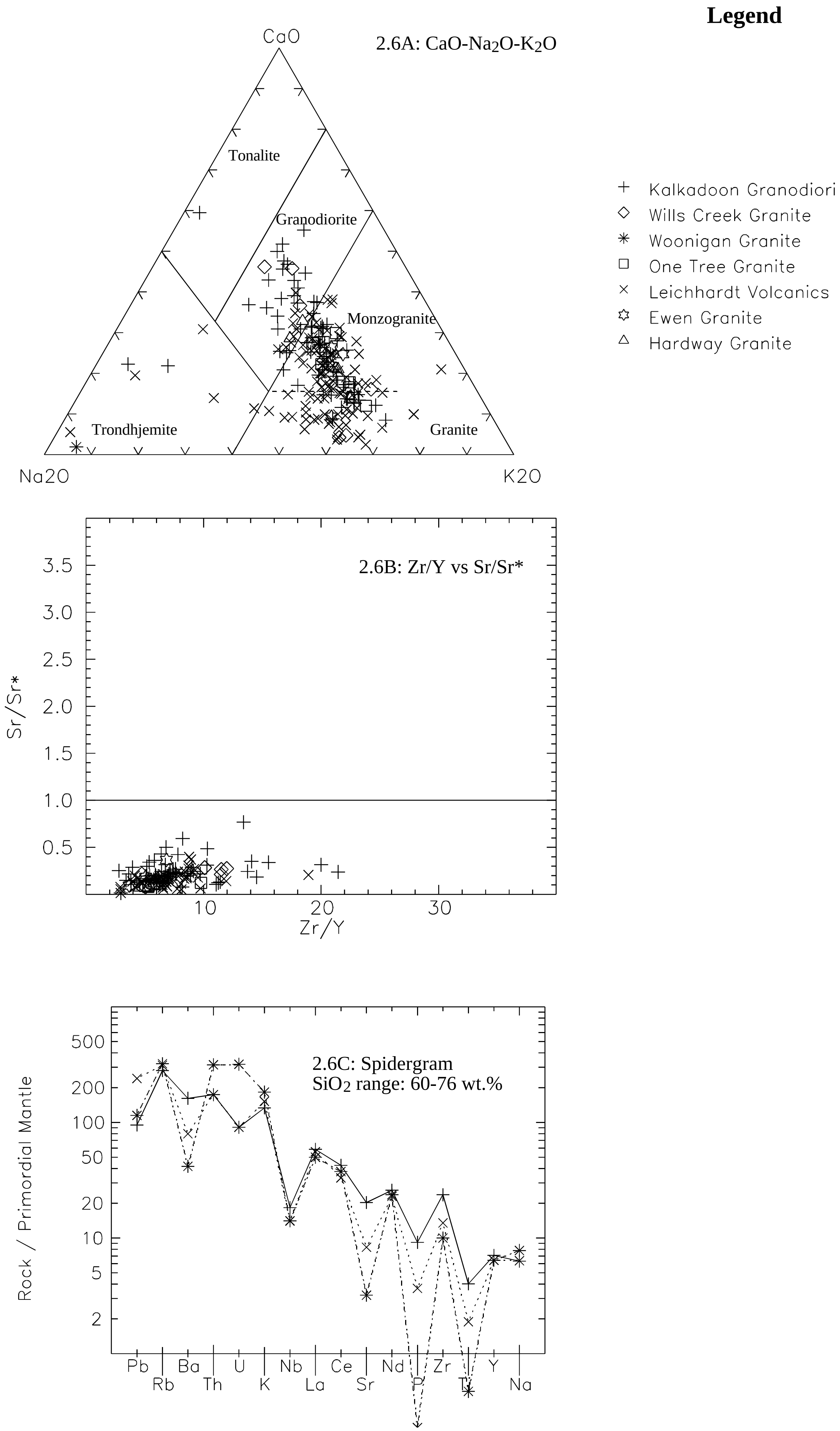

Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite


2.3K: F vs SiO2
F
3000
2000
1000
55
60
65
70
75
SiO2

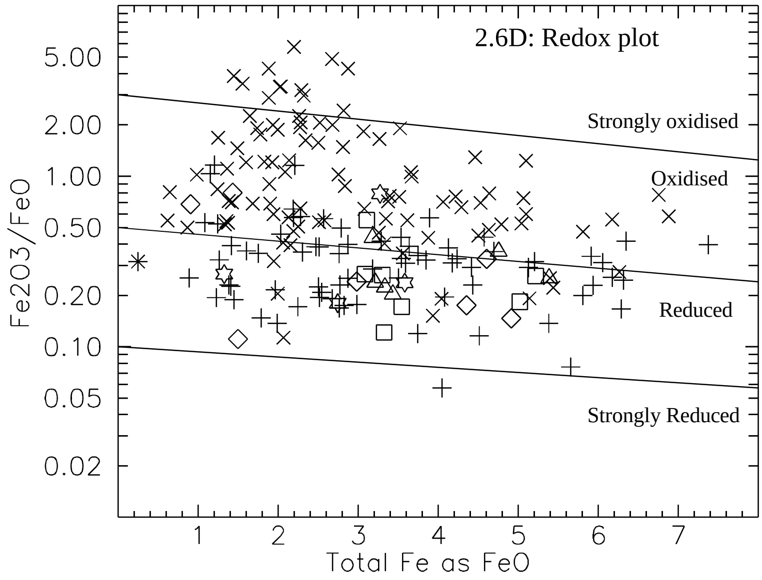

2.4A: Cu vs SiO2
Cu
80
60
40
20
55
60
65
70
75
SiO2


Legend
2.4B: Pb vs SiO2
Pb
SiO2
2.4C: Zn vs SiO2
Zn
SiO2
2.4D: Sn vs SiO2
Sn
SiO2
Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite


Legend
Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite
2.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
2.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
2.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

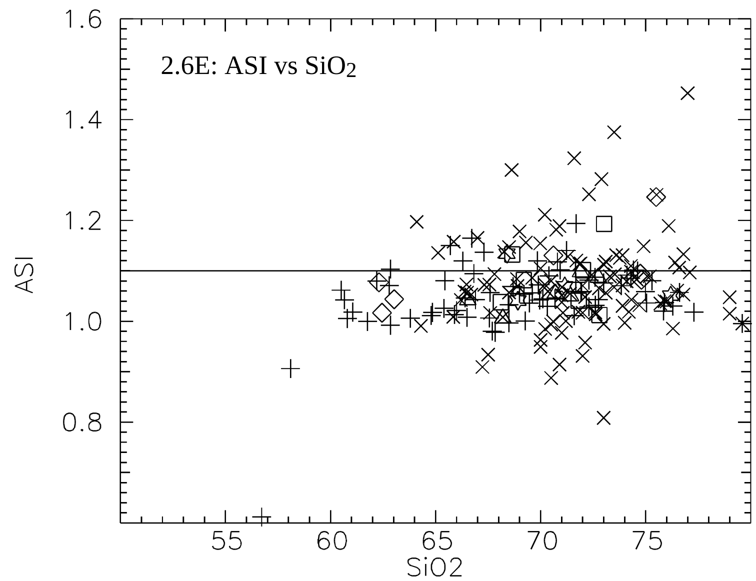


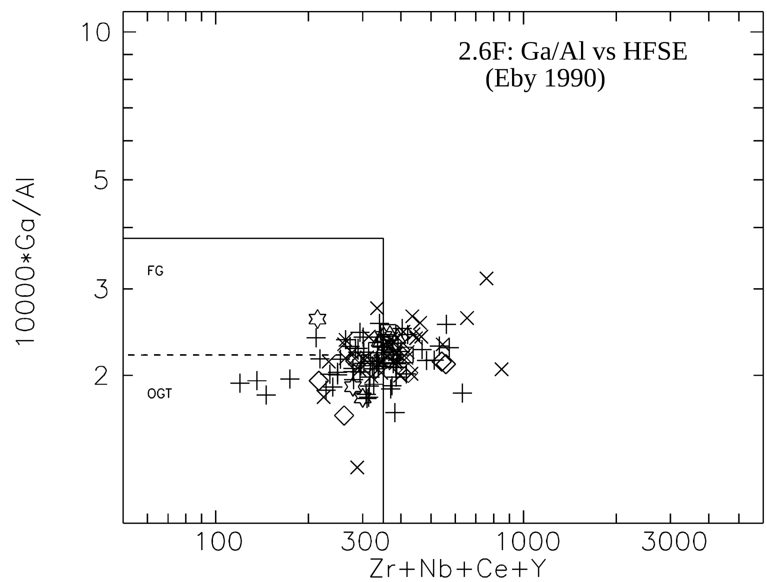
Legend
2.6A: CaO-Na2O-K2O
CaO
Na2O
K2O
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite
2.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
Zr/Y
2.6C: Spidergram
SiO2 range: 60-76 wt.%
Rock / Primordial Mantle
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na

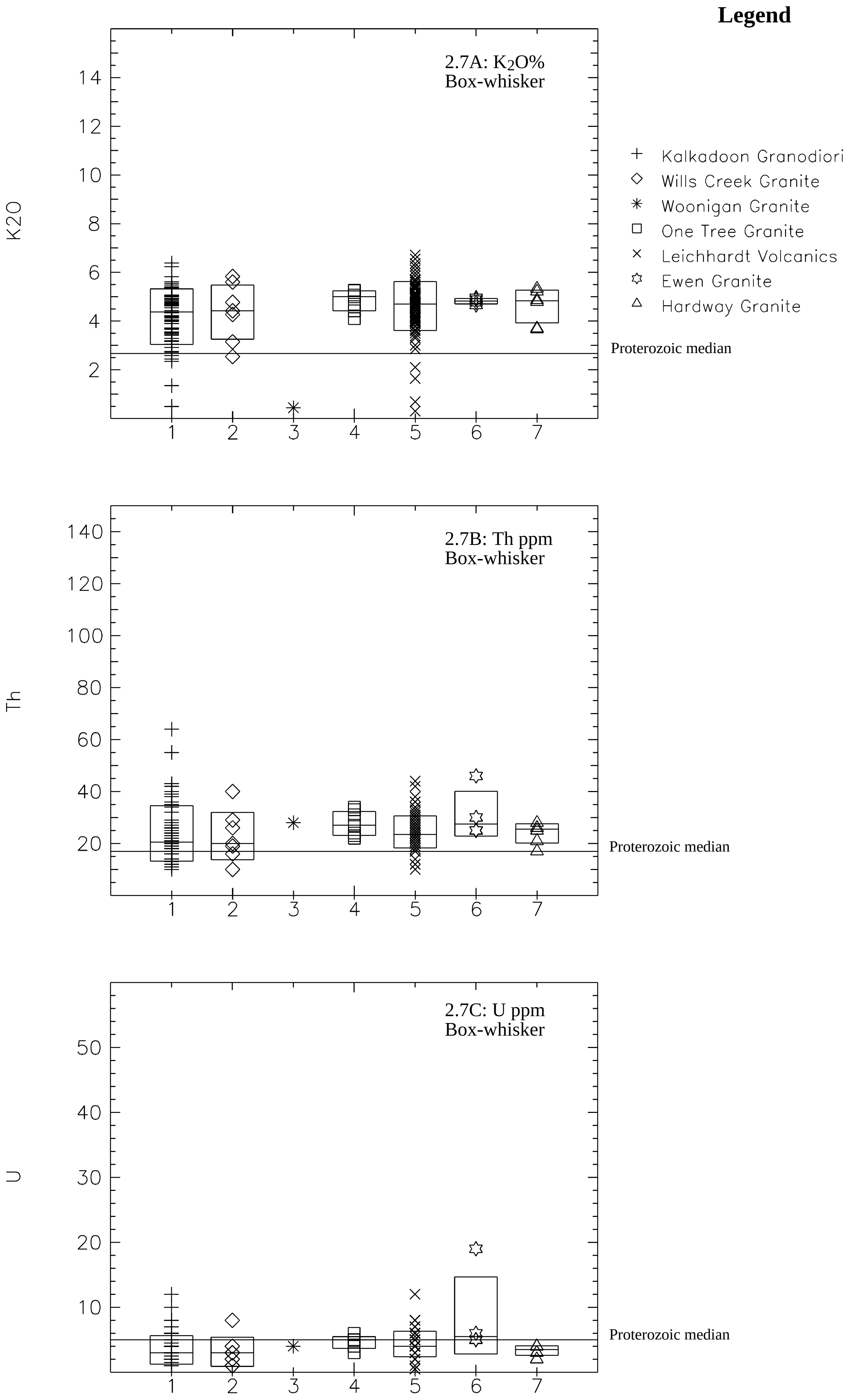


Legend

- + Kalkadoon Granodiori
- ◇ Wills Creek Granite
- ✳ Woonigan Granite
- □ One Tree Granite
- × Leichhardt Volcanics
- ✡ Ewen Granite
- △ Hardway Granite






Legend
Kalkadoon Granodiori
Wills Creek Granite
Woonigan Granite
One Tree Granite
Leichhardt Volcanics
Ewen Granite
Hardway Granite
2.7A: K2O%
Box-whisker
K2O
Proterozoic median
2.7B: Th ppm
Box-whisker
Th
Proterozoic median
2.7C: U ppm
Box-whisker
U
Proterozoic median

Kalkadoon Granodiorite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.88	69.36	4.72	56.72	77.3	72
TiO2	0.42	0.38	0.26	0.05	1.42	72
Al2O3	14.8	14.9	1.41	11.46	18.4	72
Fe2O3	0.76	0.7	0.41	0.18	2.1	72
FeO	2.57	2.35	1.33	0.56	5.4	72
MnO	0.05	0.05	0.02	0.01	0.1	72
MgO	0.97	0.81	0.76	0.13	4.25	72
CaO	2.85	2.56	1.45	0.77	8.82	72
Na2O	2.9	2.74	0.65	1.95	5.52	72
K2O	4.18	4.38	1.15	0.49	6.38	72
P2O5	0.11	0.09	0.09	01	0.55	72
H2O+	0.93	0.95	0.32	0.25	1.73	65
H2O-	0.1	0.08	0.08	01	0.32	65
CO2	0.12	0.1	0.12	05	0.7	65
LOI	1.18	1.24	0.19	0.86	1.4	7
Ba	758.26	767	386.29	64	1951	72
Li	11.46	8	8.95	2	44	59
Rb	175.29	166.5	60.99	4	340	72
Sr	240.18	227.5	116.85	52	628	72
Pb	26.97	24	13.5	5	65	72
Th	23.83	20.5	10.74	10	64	72
U	3.44	3	2.22		12	72
Zr	195.89	182	73.46	79	450	72
Nb	10.49	10	3.66		21	72
Y	24.75	24	9.57	6	60	72
La	60.24	61.5	22.5	10	119	72
Ce	108.75	108	39.69	18	220	72
Pr	11.2	13	3.96	6	15	5
Nd	46.82	46	18	10	130	61
Sc	6.7	6	4.84		27	61
V	34.47	29.5	26.93		130	72
Cr	20.65	11	29.44		217	62
Co	8.19	7	5.76		38	55
Ni	6.03	4	7.4		51	62
Cu	10.01	8	6.9		38	72
Zn	43.33	42	19.22	10	109	72
Sn	3.36	3	2.11		8	72
W	2.7	3	0.97		4	5
Mo	2.25	1.5	1.34		5	10
Ga	16.41	16	2.35	12	22	61
As	0.98	0.5	0.92		5	61
S	38	38	1.41	37	39	2
F	871.43	800	528.25	100	1400	7
Cl	120.5	120.5	48.79	86	155	2
Be	3.14	3	1.07	2	5	7
B	35	35	-	35	35	1
Ag	1	1	-	1	1	2
Bi	0.94	.50	0.5		2	8
Hf	5.5	5.5	0.71	5	6	2
Ta	1.5	1.5	0.71		2	2
Cs	10.67	10	4.04	7	15	3
Ge	1.5	1.5	-	1.5	1.5	2
Se	0.83	0.5	0.29		1	3

Wills Creek Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.06	70.61	6.26	62.31	75.5	7
TiO2	0.36	0.34	0.21	0.09	0.59	7
Al2O3	15.08	14.13	2.34	12.6	17.93	7
Fe2O3	0.59	0.63	0.3	0.15	1.14	7
FeO	2.37	2.41	1.5	0.54	4.29	7
MnO	0.04	0.05	0.02	0.01	0.07	7
MgO	0.96	0.88	0.49	0.36	1.76	7
CaO	2.62	2.02	2.03	0.33	4.92	7
Na2O	2.78	2.76	0.4	2.12	3.22	7
K2O	4.37	4.42	1.2	2.54	5.83	7
P2O5	0.08	0.08	0.05	0.02	0.15	7
H2O+	1.03	0.96	0.44	0.52	1.58	7
H2O-	0.08	0.03	0.08	01	0.22	7
CO2	0.1	0.04	0.12	05	0.35	7
LOI	-	-	-	-	-	-
Ba	945.86	792	606.84	203	2083	7
Li	12.67	15.5	6.15	3	18	6
Rb	163.43	154	40.59	124	211	7
Sr	219.29	209	141.67	48	442	7
Pb	30.86	34	16.62	11	57	7
Th	22.86	20	9.81	10	40	7
U	3.14	3	2.41	1	8	7
Zr	236.71	260	100.81	116	383	7
Nb	8.71	10	3.25	2	11	7
Y	25.29	24	7.93	12	34	7
La	64.71	62	22.59	36	105	7
Ce	111.29	109	35.62	67	176	7
Pr	-	-	-	-	-	-
Nd	48.17	47.5	14.26	28	70	6
Sc	6.5	8	4.59		11	6
V	27.71	23	19.47		60	7
Cr	14.33	11.5	10.11	3	32	6
Co	9.6	10	3.85	4	14	5
Ni	4.5	3.5	3.39	2	11	6
Cu	10	8	4.73	5	17	7
Zn	40.29	44	22.34	8	68	7
Sn	2.71	2	2.56		8	7
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	16.5	17	3.45	12	20	6
As	1.08	0.75	0.97		3	6
S	-	-	-	-	-	-
F	250	250	70.71	200	300	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
B	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Woonigan Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	79.6	79.6	-	79.6	79.6	1
TiO2	0.07	0.07	-	0.07	0.07	1
Al2O3	12	12	-	12	12	1
Fe2O3	0.06	0.06	-	0.06	0.06	1
FeO	0.19	0.19	-	0.19	0.19	1
MnO	-	01	-	01	01	1
MgO	0.05	0.05	-	0.05	0.05	1
CaO	0.14	0.14	-	0.14	0.14	1
Na2O	6.9	6.9	-	6.9	6.9	1
K2O	0.44	0.44	-	0.44	0.44	1
P2O5	0.01	0.01	-	0.01	0.01	1
H2O+	0.3	0.3	-	0.3	0.3	1
H2O-	0.09	0.09	-	0.09	0.09	1
CO2	0.1	0.1	-	0.1	0.1	1
LOI	-	-	-	-	-	-
Ba	54	54	-	54	54	1
Li	1	1	-	1	1	1
Rb	19	19	-	19	19	1
Sr	12	12	-	12	12	1
Pb	7	7	-	7	7	1
Th	28	28	-	28	28	1
U	4	4	-	4	4	1
Zr	124	124	-	124	124	1
Nb	10	10	-	10	10	1
Y	42	42	-	42	42	1
La	45	45	-	45	45	1
Ce	88	88	-	88	88	1
Pr	-	-	-	-	-	-
Nd	45	45	-	45	45	1
Sc	1		-			1
V	1		-			1
Cr	4	4	-	4	4	1
Co	2.5		-			1
Ni	1	1	-	1	1	1
Cu	21	21	-	21	21	1
Zn	6	6	-	6	6	1
Sn	4	4	-	4	4	1
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	15	15	-	15	15	1
As	1	1	-	1	1	1
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
B	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

One Tree Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.8	71.81	2.08	68.1	73.02	7
TiO2	0.48	0.43	0.12	0.36	0.66	7
Al2O3	13.45	13.14	0.72	12.6	14.6	7
Fe2O3	0.74	0.69	0.28	0.36	1.11	7
FeO	3.07	2.97	0.85	2.01	4.25	7
MnO	0.05	0.04	0.02	0.04	0.08	7
MgO	0.81	0.76	0.23	0.53	1.16	7
CaO	1.89	1.66	0.61	1.01	2.68	7
Na2O	2.43	2.5	0.31	2	2.93	7
K2O	4.83	5	0.44	4.1	5.27	7
P2O5	0.1	0.08	0.04	0.06	0.15	7
H2O+	0.84	0.83	0.18	0.6	1.12	7
H2O-	0.07	0.02	0.08	01	0.21	7
CO2	0.06	0.05	0.03	05	0.11	7
LOI	-	-	-	-	-	-
Ba	735.43	697	170.1	606	1105	7
Li	13.17	12.5	5.71	8	24	6
Rb	211.29	214	27.4	161	240	7
Sr	117.14	102	34.66	87	183	7
Pb	29.29	24	15.54	18	63	7
Th	27.71	27	4.96	22	34	7
U	4.57	5	0.98	3	6	7
Zr	213.29	209	32.07	181	280	7
Nb	10.29	11	1.7	8	13	7
Y	33	36	5.63	22	38	7
La	63.43	58	15.51	50	96	7
Ce	116.29	107	22.94	100	165	7
Pr	-	-	-	-	-	-
Nd	51.5	48.5	9.4	44	69	6
Sc	5.83	5	2.93	3	11	6
V	31.86	23	17.66	18	60	7
Cr	13.83	10.5	6.85	8	24	6
Co	8.6	8	3.29	5	14	5
Ni	5.83	4.5	2.79	4	11	6
Cu	13.29	13	6.4	4	23	7
Zn	48.57	43	20.07	25	87	7
Sn	4.86	5	1.86	2	8	7
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	16.17	16	0.75	15	17	6
As	0.92	1	0.2		1	6
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
B	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Leichhardt Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.6	71.75	3.28	64.1	79	106
TiO2	0.29	0.25	0.17	0.08	0.89	106
Al2O3	13.81	13.7	1.09	11	15.92	106
Fe2O3	1.39	1.29	0.79	0.21	5.28	106
FeO	1.65	1.24	1.17	0.3	4.93	99
MnO	0.03	0.03	0.02	02	0.13	106
MgO	0.56	0.41	0.45	0.02	2.7	106
CaO	1.8	1.74	0.91	0.23	3.9	106
Na2O	2.92	2.89	0.96	0.42	10	106
K2O	4.62	4.7	1.01	0.3	6.71	106
P2O5	0.07	0.06	0.05	02	0.21	106
H2O+	0.74	0.7	0.29	0.25	1.77	102
H2O-	0.13	0.11	0.08	01	0.48	84
CO2	0.2	0.15	0.16	05	0.61	49
LOI	1.3	1.05	0.66	0.83	2.26	4
Ba	955.15	885	438.47	10	3650	106
Li	7.85	6	5.42	2	32	41
Rb	173.54	180	48.93	5	300	106
Sr	153.52	156.5	68.59	30	280	106
Pb	19.65	14	22.82		173	106
Th	24.43	23.5	6.19	10	44	86
U	4.34	4	1.99		12	98
Zr	237.14	220	106.97	120	681	98
Nb	12.33	11	6.33	7	60	84
Y	32.92	30	11.29	16	100	98
La	62.15	61	21.17	20	190	78
Ce	112.45	113	46.72	14	400	84
Pr	10.33	10	2.52	8	13	3
Nd	42.9	43	8.29	24	66	50
Sc	6.41	6	3.77		17	41
V	17.37	14	13.22		68	63
Cr	26.09	12	32.4		170	91
Co	6.05	5	4.74		35	71
Ni	4.72	3	3.97		17	59
Cu	17.44	10	29.89		260	106
Zn	32.25	25	24.09		140	106
Sn	5.11	3	6.06		40	64
W	4.46	4.5	1.42		7	14
Mo	1.98		0.93		5	21
Ga	16.49	17	2.13	9	21	41
As	2.24	1	4.09		24	44
S	-	-	-	-	-	-
F	640	700	181.66	400	800	5
Cl	-	-	-	-	-	-
Be	3.25	3	1.26	2	5	4
B	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	0.88	0.75	0.25		1	4
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	8.33	9	1.15	7	9	3
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Ewen Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.17	70.04	3.56	68.4	76.19	4
TiO2	0.35	0.39	0.15	0.14	0.47	4
Al2O3	13.79	14.06	1.02	12.34	14.7	4
Fe2O3	0.71	0.56	0.52	0.28	1.45	4
FeO	2.03	2.09	0.78	1.05	2.9	4
MnO	0.05	0.05	0.01	0.05	0.06	4
MgO	0.88	0.95	0.53	0.18	1.44	4
CaO	1.95	2.2	0.78	0.82	2.57	4
Na2O	2.6	2.56	0.3	2.29	3	4
K2O	4.82	4.82	0.13	4.66	4.96	4
P2O5	0.08	0.08	0.05	0.02	0.15	4
H2O+	1.04	1.07	0.31	0.66	1.37	4
H2O-	0.07	0.05	0.08	0.01	0.19	4
CO2	0.05	0.05	0.01	0.04	0.06	4
LOI	-	-	-	-	-	-
Ba	569.5	659	304.43	148	812	4
Li	26	17	23.64	9	61	4
Rb	283.25	231	133.08	191	480	4
Sr	180.5	181	106.35	51	309	4
Pb	238.5	60.5	372.58	36	797	4
Th	31.5	27.5	9.95	25	46	4
U	8.75	5.5	6.85	5	19	4
Zr	154	159	33.81	110	188	4
Nb	11.25	10	3.2	9	16	4
Y	28.5	29.5	2.38	25	30	4
La	48.5	51	15.97	27	65	4
Ce	92.25	94	26.61	58	123	4
Pr	-	-	-	-	-	-
Nd	40	40.5	10.3	27	52	4
Sc	5.25	6	3.1		8	4
V	30.75	35	20.4	3	50	4
Cr	22.25	18	17.61	6	47	4
Co	6.67	8	4.16	2	10	3
Ni	8.25	6	7.46	2	19	4
Cu	7.75	7.5	4.27	3	13	4
Zn	43	45.5	10.03	29	52	4
Sn	7.5	7.5	4.93	2	13	4
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	15.75	15.5	2.06	14	18	4
As	0.5		-			4
S	-	-	-	-	-	-
F	2400	2400	-	2400	2400	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
B	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Hardway Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.25	71.07	2.39	66.53	72.75	6
TiO2	0.51	0.47	0.1	0.42	0.68	6
Al2O3	13.64	13.47	0.58	12.94	14.51	6
Fe2O3	0.86	0.8	0.29	0.58	1.27	6
FeO	3.04	2.8	0.75	2.22	4.31	6
MnO	0.04	0.04	0.01	0.03	0.05	6
MgO	0.75	0.52	0.37	0.5	1.23	6
CaO	2.07	1.97	0.77	1.26	3.15	6
Na2O	2.68	2.55	0.28	2.48	3.22	6
K2O	4.6	4.83	0.74	3.67	5.33	6
P2O5	0.08	0.08	0.03	0.06	0.13	6
H2O+	0.85	0.83	0.14	0.67	1.1	6
H2O-	0.07	0.07	0.03	0.03	0.11	6
CO2	0.06	0.05	0.02	0.04	0.08	6
LOI	-	-	-	-	-	-
Ba	726.67	730.5	45.28	658	797	6
Li	5.67	6	1.97	3	8	6
Rb	213.67	234.5	48.41	132	253	6
Sr	103.33	94	33.74	67	150	6
Pb	25	14	27.51	11	81	6
Th	23.83	25.5	4.07	17	28	6
U	3.33	3.5	0.82	2	4	6
Zr	211.17	208	12.84	201	233	6
Nb	9.83	10	0.75	9	11	6
Y	36.83	37.5	4.54	31	44	6
La	56.33	56	4.76	51	63	6
Ce	102.5	100	7.48	96	114	6
Pr	-	-	-	-	-	-
Nd	46.17	45	3.06	43	50	6
Sc	7.33	6.5	2.16	5	10	6
V	31.17	24.5	13.82	21	56	6
Cr	13.67	10.5	6.25	9	25	6
Co	9.83	8	2.99	8	15	6
Ni	6.83	6	2.32	5	11	6
Cu	13.67	13.5	0.82	13	15	6
Zn	24.5	24	9.83	13	37	6
Sn	5.17	5	1.6	3	7	6
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	16.83	17	0.75	16	18	6
As	0.75	0.75	0.27		1	6
S	-	-	-	-	-	-
F	650	650	353.55	400	900	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
B	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

3 NICHOLSON SUITE

3.1 Timing

1850 Ma

3.2 Individual Ages

Primary Ages:

1. Nicholson Granite [1]	~1850 Ma, SHRIMP
2. Cliffdale Volcanics [1]	~1850 Ma, SHRIMP
3. Nicholson Granite [2]	1804 ± 83, initial 0.7069 ±0.0040, Rb-Sr
4. Norris Granite [2]	1735 ±24, initial 0.7178 ± 0.0038, Rb-Sr
5. Cliffdale Volcanics [2]	1732 ± 20, initial 0.7078 ± 0.0017, Rb-Sr

Sources: [1] Scott *et al.* 1997, [2] AMDEL unpublished report: Note these ages are believed to have been reset by later metamorphism up to amphibolite grade; the high initial ratios are indicative of resetting. Although the 'Norris Granite' age is younger, this is a more fractionated sample with a higher Rb content, and hence has reset to a much younger age than the other 'Nicholson Granite' age, which is more mafic and has a lower Rb content).

3.3 Regional Setting

The Nicholson Suite of the Murphy Inlier is predominantly felsic and comprises the I-(granodiorite) type Nicholson Granite and its comagmatic volcanics, the Cliffdale Volcanics (which include the Billicumidji Rhyolite Member). There are coeval basic dykes intruded at the same time as these felsic rocks, but they are not extensive. Many samples have a regional metamorphic overprint, some up to amphibolite facies. The suite has distinct mappable phases (Gardner 1978; Ahmad and Wygralak 1989) and previous workers had defined the Norris Granite as a separate phase (Roberts *et al.* 1963), but this distinction was later dropped (e.g., Sweet *et al*. 1981; Ahmad and Wygralak 1989). AGSO stream sediment surveys in this area highlight a significant Sn anomaly over the area originally defined as Norris Granite (AGSO unpublished data). The tectonic setting of the Murphy Inlier is unknown.

3.4 Summary

The Nicholson Suite shows evidence of fractional crystallisation only in the high SiO_2 end members when some trends increase/decrease exponentially from >72 wt.% SiO_2. In the more mafic end members, the volcanics and granites plot very closely together, suggesting that the early stages of this suite were dominated by restite-unmixing, and that fractionation started to occur only after the restite crystals were lost from the magma. The fact that the Cliffdale Volcanics become more phenocryst-poor up section supports this view.

3.5 Potential

As fractionation begins only at relatively high SiO_2 levels, the potential for forming large tonnage deposits is restricted, and any ore deposits associated with this suite are likely to be of low tonnage, although they could be of high grade. In the vicinity of the granites there are no significant potential host rocks documented, although graphitic rocks are likely to have been present. Potential exists for small Sn and W deposits within the granite and for smaller Cu and Au deposits outside the granite.

Cu:	**Moderate**
Au:	**Moderate**
Pb/Zn:	**Low**
Sn:	**Moderate**
Mo/W:	**Low**
Confidence level:	**322**

3.6 Descriptive Data

Location: Murphy Inlier on the Northern Territory/Queensland border. The Murphy Inlier is traditionally taken as the boundary between the Mount Isa Inlier and the McArthur Basin.

Dimensions and area: The Nicholson Suite extends for 150 km east-northeast and is ~27 km wide. Total outcrop area is 1200 km^2.

3.7 Intrusives

Component plutons: Nicholson Granite.

Form: Consists of an elongate belt of granite which intrudes its own comagmatic felsic volcanics.

Metamorphism and Deformation: The granite has been regionally metamorphosed to varying degrees up to amphibolite facies; in places the granite is foliated.

Dominant intrusive rock types: Biotite ± muscovite monzogranite, hornblende-biotite monzogranite to granodiorite. Some samples are strongly porphyritic with exceptionally large K-feldspar phenocrysts up to 8 cm wide.

Colour: White to pink.

Veins, Pegmatites, Aplites, Greisens: All are common in later fractionated phases; cassiterite and wolframite-bearing greisens are recorded. The more felsic phases have been fractured and impregnated by quartz veins and stringers.

Distinctive mineralogical characteristics: Hornblende and magnetite in the more mafic phases, accessory zircon, apatite, fluorite and topaz.

Breccias: No major breccia systems recorded.

Alteration in the granite: Some sericitisation recorded, although this may be related to later metamorphism.

3.8 Extrusives

The comagmatic Cliffdale Volcanics contain over 4000 m of volcanics, more than half of which consist of crystal-rich ignimbrites with phenocrysts of quartz and feldspar. The remainder are rhyolite lavas, some of which are flow banded. The ignimbrites are more common in the lower part of the sequence, with the Billicumidjii Rhyolite Member occurring towards the top.

3.9 Country Rock

Contact metamorphism: Lit-par-lit injection is recorded at the contact with the Murphy Metamorphics, but the width and mineralogy of the aureole are not noted. Where the granite intruded the Cliffdale Volcanics, recrystallisation of the volcanics has been noted and a chilled margin observed (Sweet *et al.* 1981).

Reaction with country rock: None recorded.

Units the granite intrudes: Murphy Metamorphics, Cliffdale Volcanics.

Dominant rock types: The unit is dominated by quartzofeldspathic rocks including pelites, shales, meta-arenites and greywackes.

Potential hosts: No significant potential hosts are noted; there are also no significant reductants in the units adjacent to the granite. In view of the turbiditic nature of some units of the Murphy Metamorphics, some graphitic units may be present, although none have been specifically documented.

3.10 Mineralisation

There are minor Sn and W occurrences in greisens within the granite, and Cu-bearing veins occur in and near the granite (Ahmad and Wygralak 1989). There are no known Au deposits that can be directly related to granite intrusion. Au deposits in the area are possibly related to the unconformity -tyle U-deposits in the overlying Westmoreland Conglomerate. An alternative hypothesis proposed by Ahmad *et al*. (1984) is that Au occurrences in the Westmoreland Conglomerate are palaeoplacer deposits. If this is the case, then the source of this palaeoplacer Au becomes intriguing and the question needs to be asked if there may have been Au introduced into the region during the emplacement of the Nicholson Suite.

3.11 Geochemical Data

Data source: The samples were collected as part of 1:100 000 scale regional mapping in the Seigal and Hedleys Creek 1:100 000 sheet areas (Gardner 1978; Mitchell 1976). All data are in OZCHEM .

Data quality: All samples were analysed in the AGSO laboratory. They were upgraded to produce more comprehensive trace element sets in 1992.

Are the data representative? Although few in number, the samples seem to be representative of most of the granite types described.

Are the data adequate? The broad picture can be ascertained from the data. Some further sampling of the more fractionated phases is warranted.

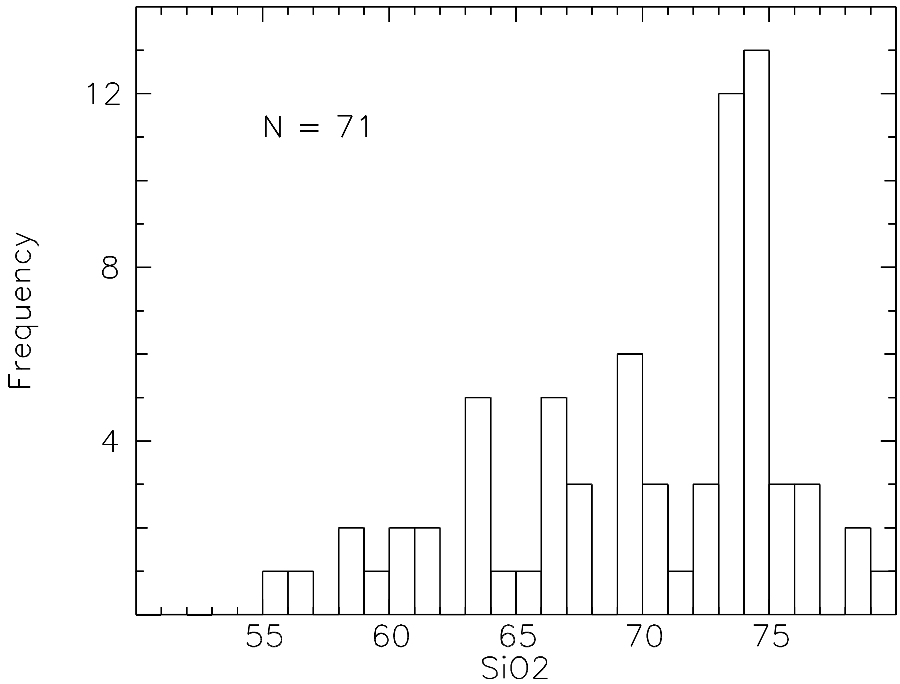


Figure 3.1. Frequency histogram of SiO_2 values for the Nicholson Suite.

SiO_2 range (Fig. 3.1): The SiO_2 content varies from 56 to 78 wt.% SiO_2 with a peak at 74 wt.%.

Alteration (Fig. 3.2):

- ***SiO_2:*** No evidence of extensive silicification.
- ***K_2O/Na_2O:*** There is no evidence of sodic alteration. Some samples have high K_2O and little Na_2O.
- ***Th/U:*** The Th/U values are within the normal igneous range for most samples.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** This plot shows that some samples are oxidised. These more oxidised samples are all at the high SiO_2 range and are mostly Cliffdale Volcanics.

Fractionation Plots (Fig. 3.3):

- ***Rb:*** Samples show exponentially increasing Rb with increasing SiO_2 at values above 72 wt.% SiO_2.
- ***U:*** Samples show exponentially increasing U with increasing SiO_2 at values above 72 wt.% SiO_2.
- ***Y:*** Samples show exponentially increasing Y with increasing SiO_2 at values above 72 wt.% SiO_2.
- ***P_2O_5:*** Samples show decreasing P_2O_5 with increasing SiO_2.
- ***Th:*** Samples show exponentially increasing Th with increasing SiO_2 at values above 72 wt.% SiO_2.
- ***K/Rb:*** Samples show exponentially decreasing K/Rb with increasing SiO_2 at values above 72 wt.% SiO_2.
- ***Rb-Ba-Sr:*** Some samples plot in the strongly differentiated granite field.
- ***Sr:*** Samples show decreasing Sr with increasing SiO_2.
- ***Rb/Sr:*** Samples show exponentially increasing Rb/Sr with increasing SiO_2 at values above 72 wt.% SiO_2.
- ***Ba:*** Samples are scattered but show exponentially decreasing Rb/Sr with increasing SiO_2 at values above 72 wt.% SiO_2.

- ***F:*** F values are moderate and range up to 0.12 wt.%, which is within the range noted by Eby (1990) of 0.07-1.7 wt.% for Palaeozoic A-type granites.

Metals (Fig. 3.4):

- ***Cu:*** Scattered values, weakly decreasing with increasing SiO_2.
- ***Pb:*** The Nicholson Granite shows generally increasing values with increasing SiO_2, presumably reflecting the large K-feldspar megacrysts. In contrast the values for the Cliffdale Volcanics are much lower above 74 wt.% SiO_2, which may reflect alteration.
- ***Zn:*** Values decrease with increasing SiO_2.
- ***Sn:*** Samples show exponentially increasing values with increasing SiO_2 at values above 72 wt.% SiO_2.

High field strength elements (Fig. 3.5):

- ***Zr:*** The trend is remarkably flat and relatively low for Proterozoic granites.
- ***Nb:*** Values show a slight increase with increasing SiO_2. Absolute values are still relatively low for Proterozoic granites.
- ***Ce:*** Values show a slight increase with increasing SiO_2. Absolute values are still relatively low for Proterozoic granites.

Classification (Fig. 3.6):

- ***The CaO/Na_2O/K_2O plot of White, quoted in Sheraton and Simons (1992):*** The granites plot in the granodiorite through monzogranite to granite field reflecting the wide SiO_2 range of this suite.
- ***Zr/Y vs Sr/Sr*:*** All granites plot below 1 as all samples are Sr-depleted, Y-non depleted, a feature typical of Australian Proterozoic granites.
- ***Spidergram:*** All spidergrams for this suite are Sr-depleted, Y-non depleted with noticeable depletion of Ba with increasing SiO2.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples plot in the oxidised field, with some volcanic samples being strongly oxidised. This may be an effect of later weathering or alteration, rather than being a magmatic feature, as the more fractionated granite samples do not plot in the strongly oxidised field.
- ***ASI:*** The majority of samples have an ASI index ranging from 0.8 to 1.4 and are initially metaluminous, fractionating through to strongly peraluminous.
- ***A-type plot of Eby (1990):*** The Nicholson Suite samples straddle the A-type/normal granite fields for Palaeozoic granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-granodiorite, changing from restite to non-restite with increasing SiO_2.

Australian Proterozoic granite type: Type example of the Nicholson type.

3.12 Geophysical Signature

Radiometrics (Fig. 3.7): All samples would appear white in an RGB image with the more felsic fractionated samples having the highest values.

Gravity: The regional gravity database is too coarse to make any meaningful interpretations.

Magnetics: The Nicholson Suite forms a regional magnetic low.

3.13 References

Ahmad, M., Hallenstein, C.P. and Wygralak, A.S. 1984. Paleoplacer potential of the Mid Proterozoic of the Northern Territory — a study of the Westmoreland Conglomerate. *Australasian Institute of Mining and Metallurgy, Darwin Conference,* 357-366.

Ahmad, M. and Wygralak, A.S. 1989. Calvert Hills SE53-8 explanatory notes and mineral deposit data sheets. *Northern Territory Geological Survey 1:250 000 Metallogenic Map Series.*

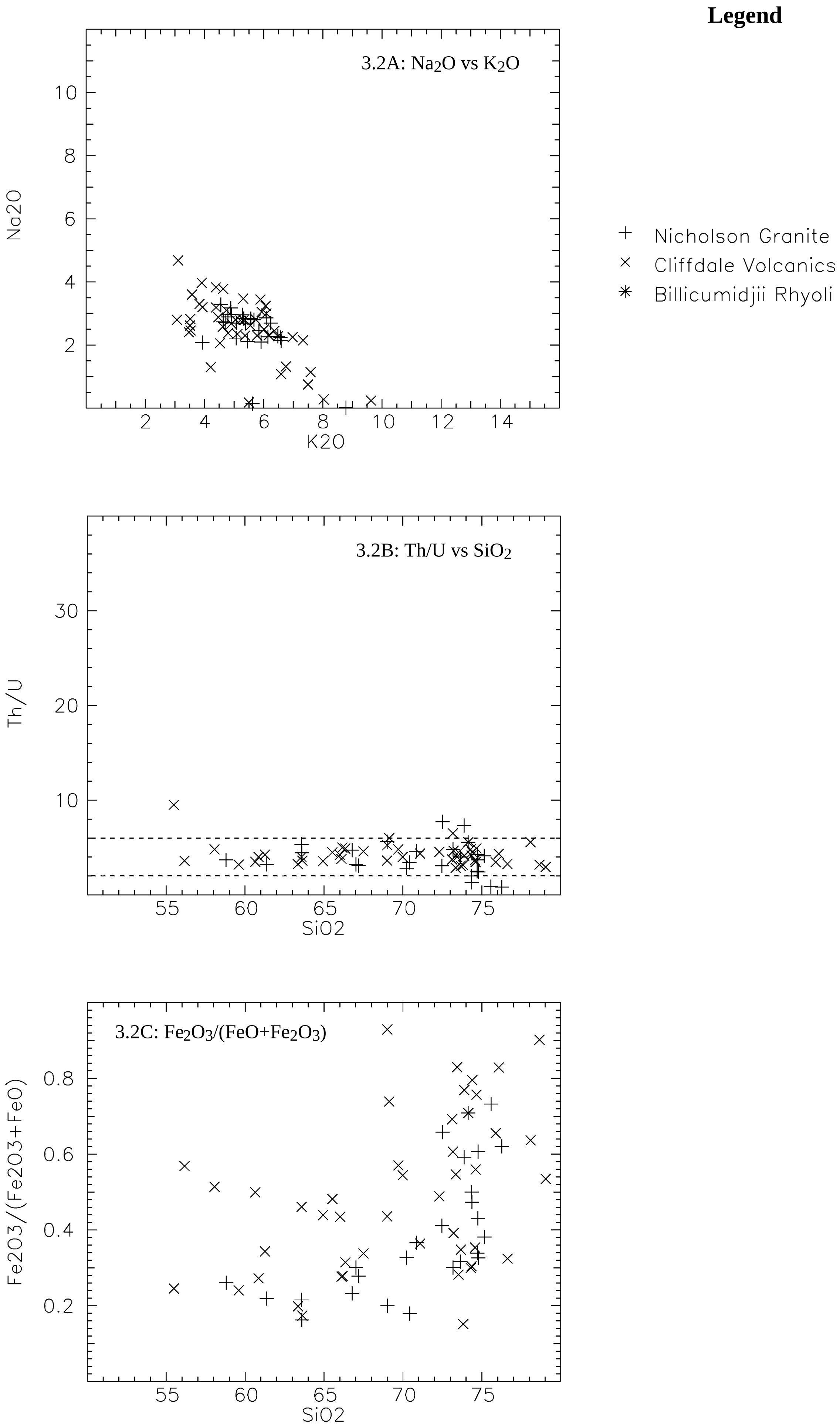
Gardner, C.M. 1978. Precambrian Geology of the Westmoreland region. Part lll the Nicholson Granite Complex and Murphy Metamorphics. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record*, 1978/32.

Mitchell, J. 1976. Precambrian geology of the Westmoreland region, northern Australia. Part II: Cliffdale Volcanics. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record*, 1976/34.

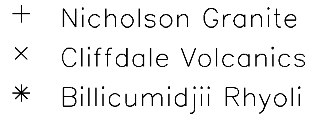
Roberts, H.G., Rhodes, J.M. and Yates, K.R. 1963. Calvert Hills, Northern Territory, 1:250 000 Geological Series, *Bureau of Mineral Resources, Geology and Geophysics, Australia, Explanatory Notes,* 23 pp.

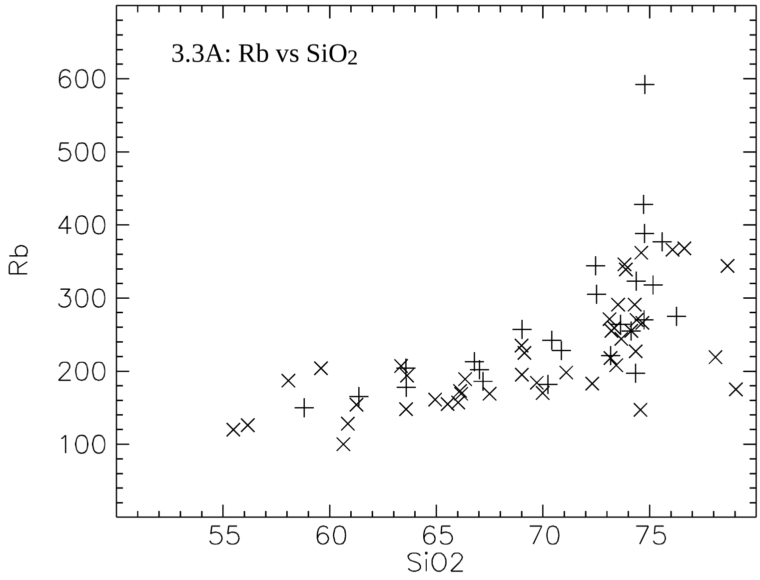
Scott, D., Jackson, J., Page, R., Tarlowski, C. and Leven, J. 1997. Basement Studies: current status of models and dataset integration. *Australian Geological Survey Organisation, Record*, 1997/12.

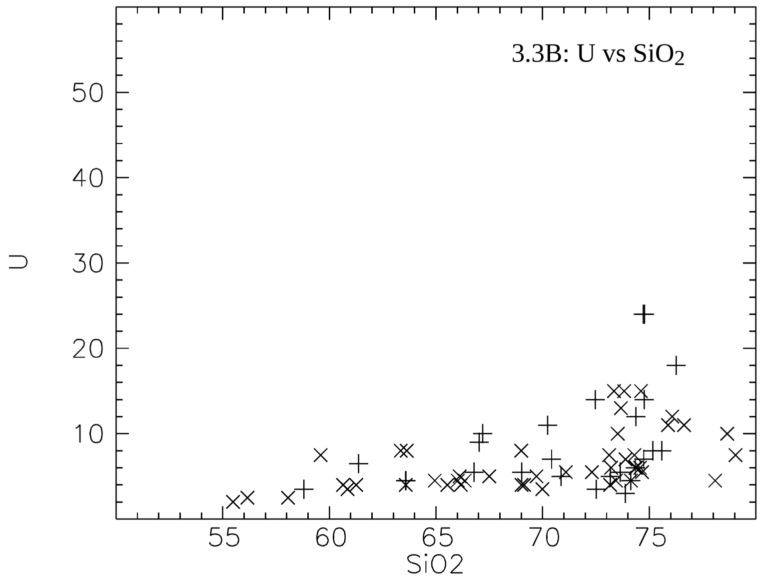
Sweet, I.P., Mock, C.M. and Mitchell, J.E. 1981. Seigal and Hedleys Creek, Queensland, 1:100 000 Geological Map Commentary, *Bureau of Mineral Resources, Geology and Geophysics, Australia*, 32 pp.

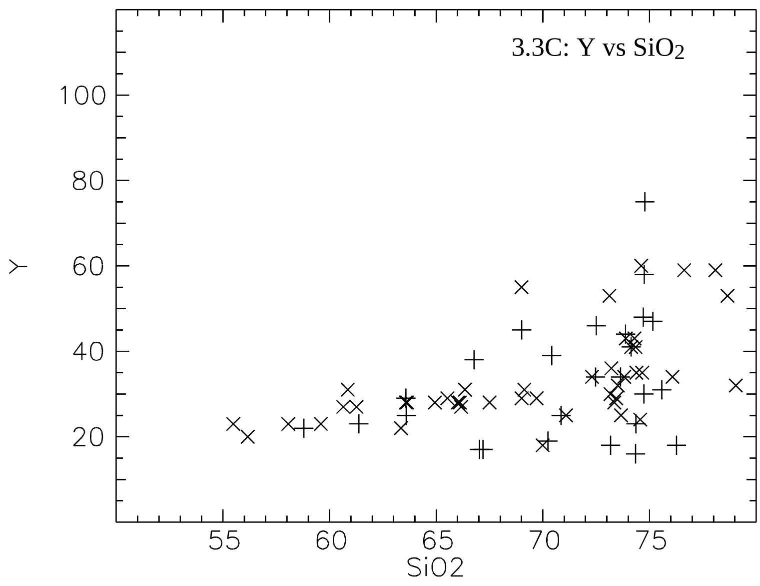

Legend
3.2A: Na2O vs K2O
Na2O
K2O
3.2B: Th/U vs SiO2
Th/U
SiO2
3.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2
Nicholson Granite
Cliffdale Volcanics
Billicumidjii Rhyoli

Legend

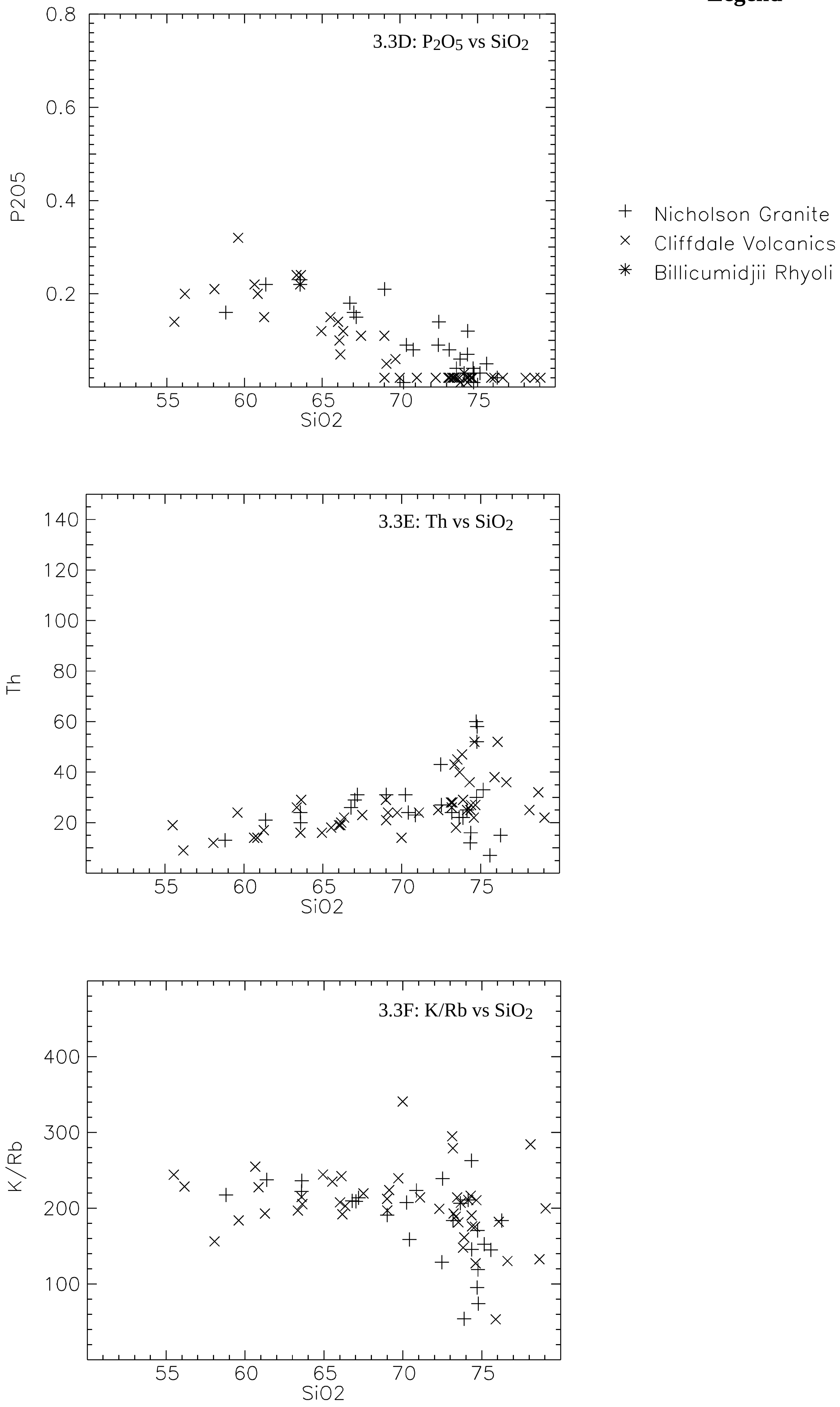

Nicholson Granite
Cliffdale Volcanics
Billicumidjii Rhyoli


3.3A: Rb vs SiO_2
Rb
SiO2
600
500
400
300
200
100
55
60
65
70
75

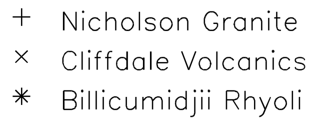

3.3B: U vs SiO_2
U
SiO2
50
40
30
20
10
55
60
65
70
75

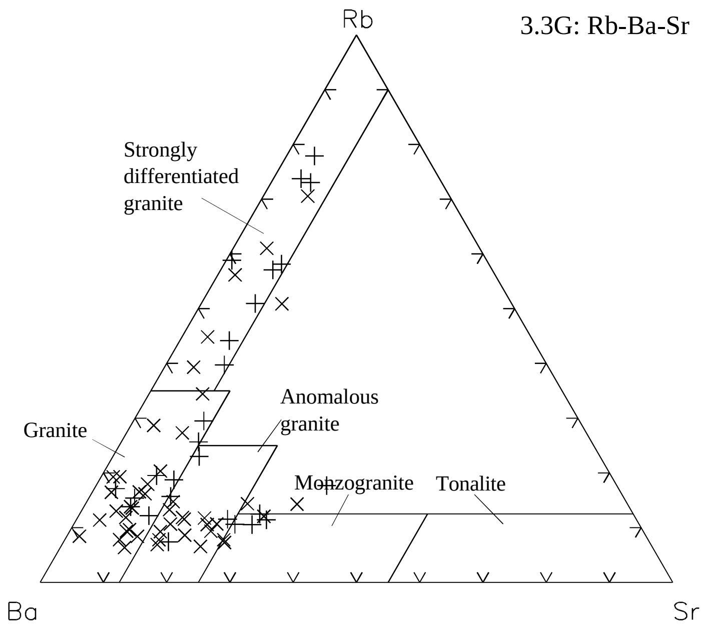

3.3C: Y vs SiO_2
Y
SiO2
100
80
60
40
20
55
60
65
70
75

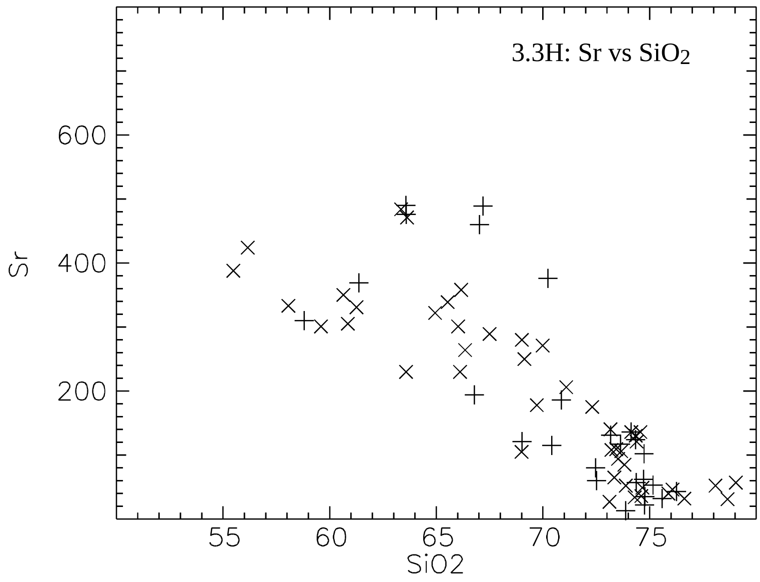
Legend

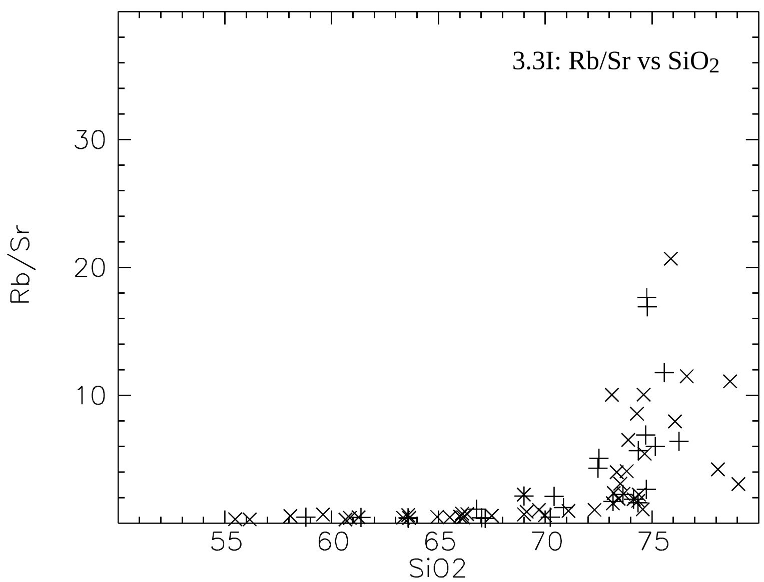

3.3D: P2O5 vs SiO2
P2O5
SiO2
0.8
0.6
0.4
0.2
55
60
65
70
75
3.3E: Th vs SiO2
Th
SiO2
140
120
100
80
60
40
20
3.3F: K/Rb vs SiO2
K/Rb
400
300
200
100
Nicholson Granite
Cliffdale Volcanics
Billicumidjii Rhyoli

Legend

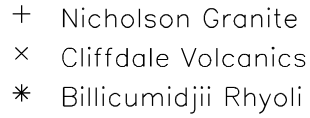

Nicholson Granite
Cliffdale Volcanics
Billicumidjii Rhyoli

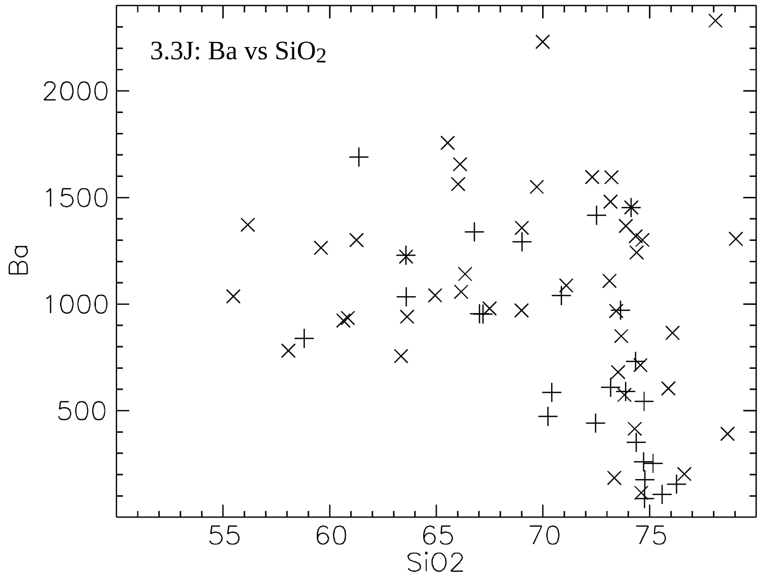

3.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Anomalous granite
Granite
Monzogranite
Tonalite

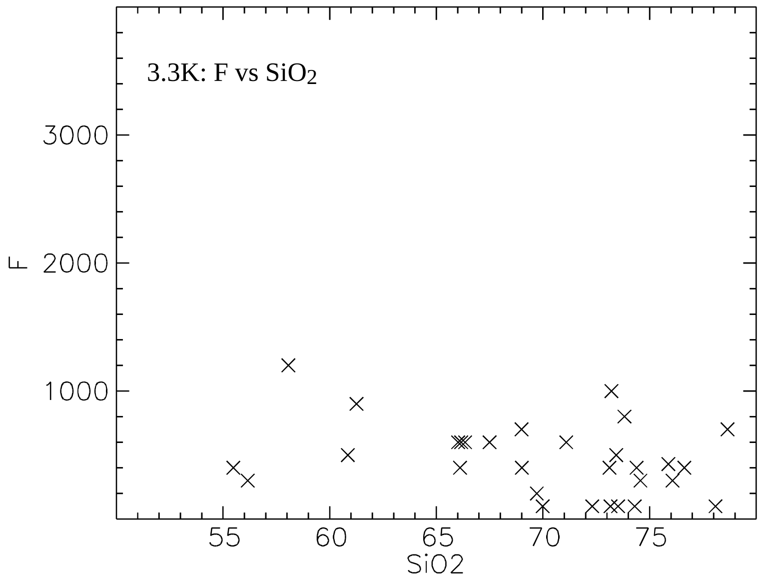

3.3H: Sr vs SiO2
Sr
SiO2
200
400
600
55
60
65
70
75

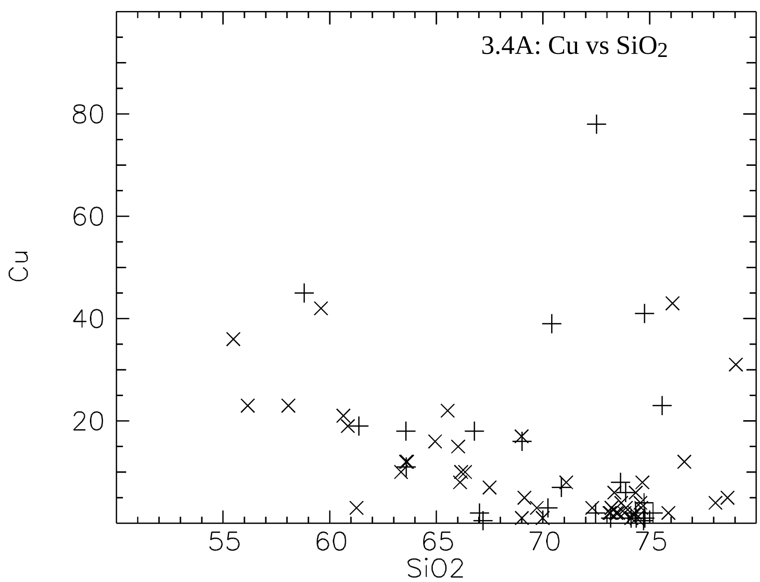

3.3I: Rb/Sr vs SiO2
Rb/Sr
SiO2
10
20
30
55
60
65
70
75

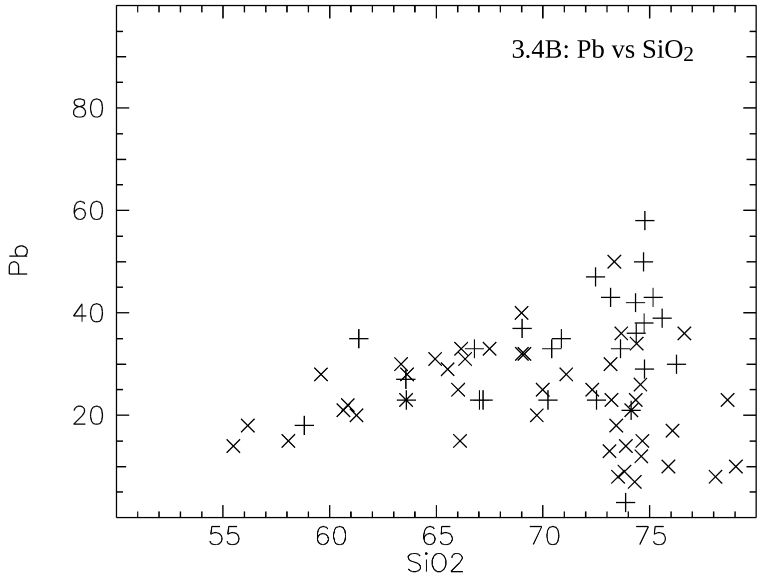
Legend


Nicholson Granite
Cliffdale Volcanics
Billicumidjii Rhyoli


3.3J: Ba vs SiO2
Ba
2000
1500
1000
500
55
60
65
70
75
SiO2

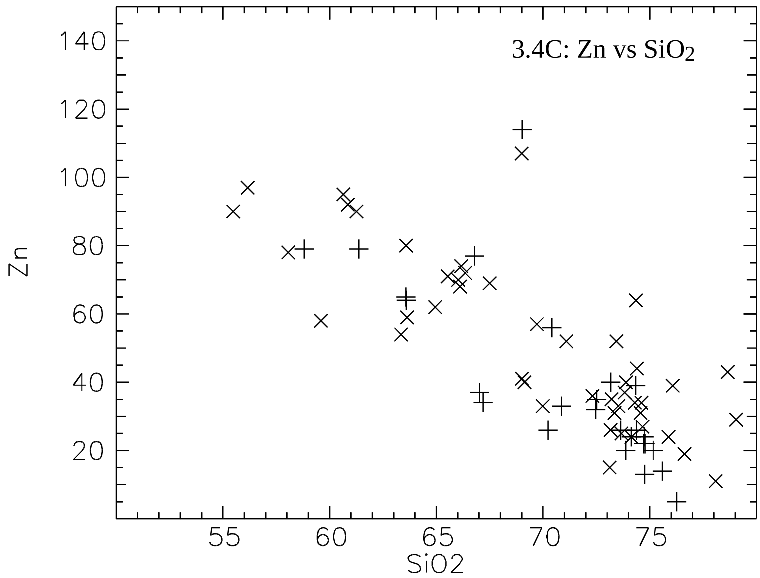

3.3K: F vs SiO2
F
3000
2000
1000
55
60
65
70
75
SiO2

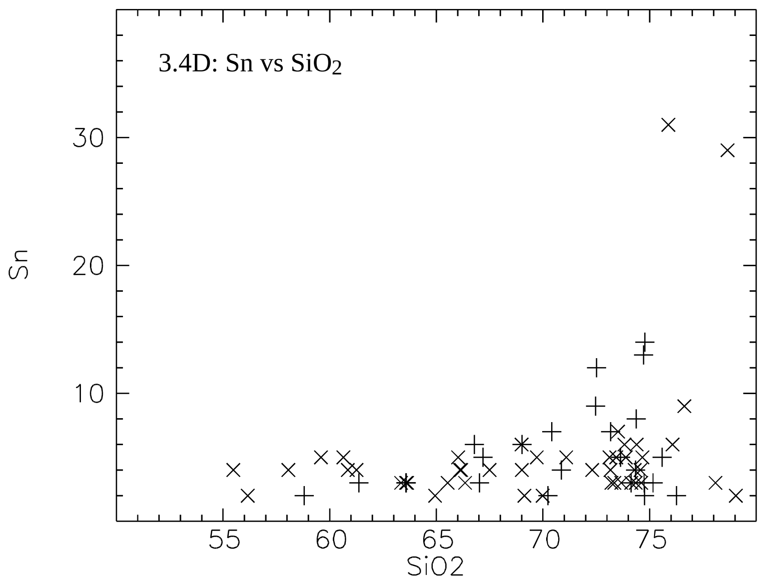

3.4A: Cu vs SiO2
Cu
80
60
40
20
55
60
65
70
75
SiO2

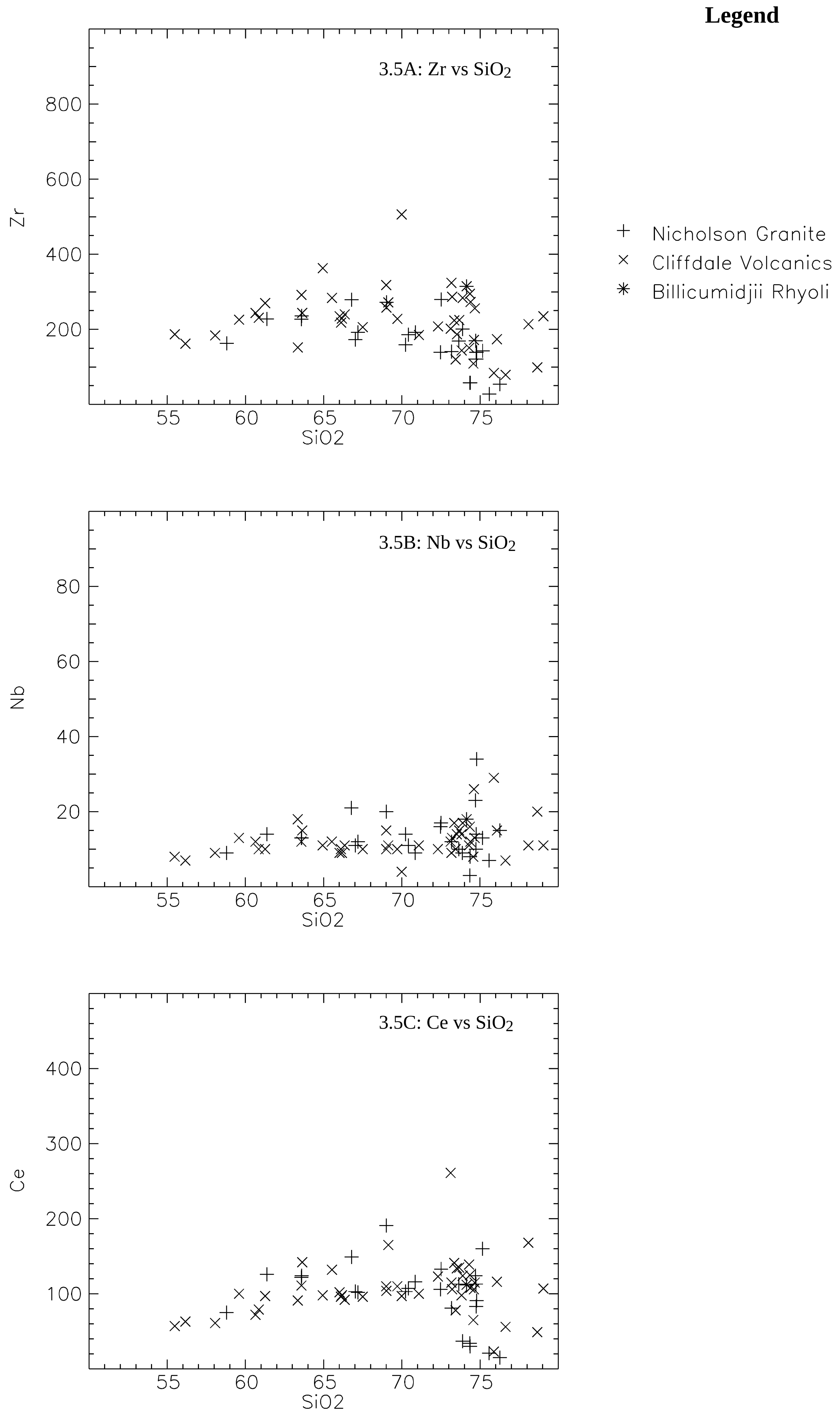


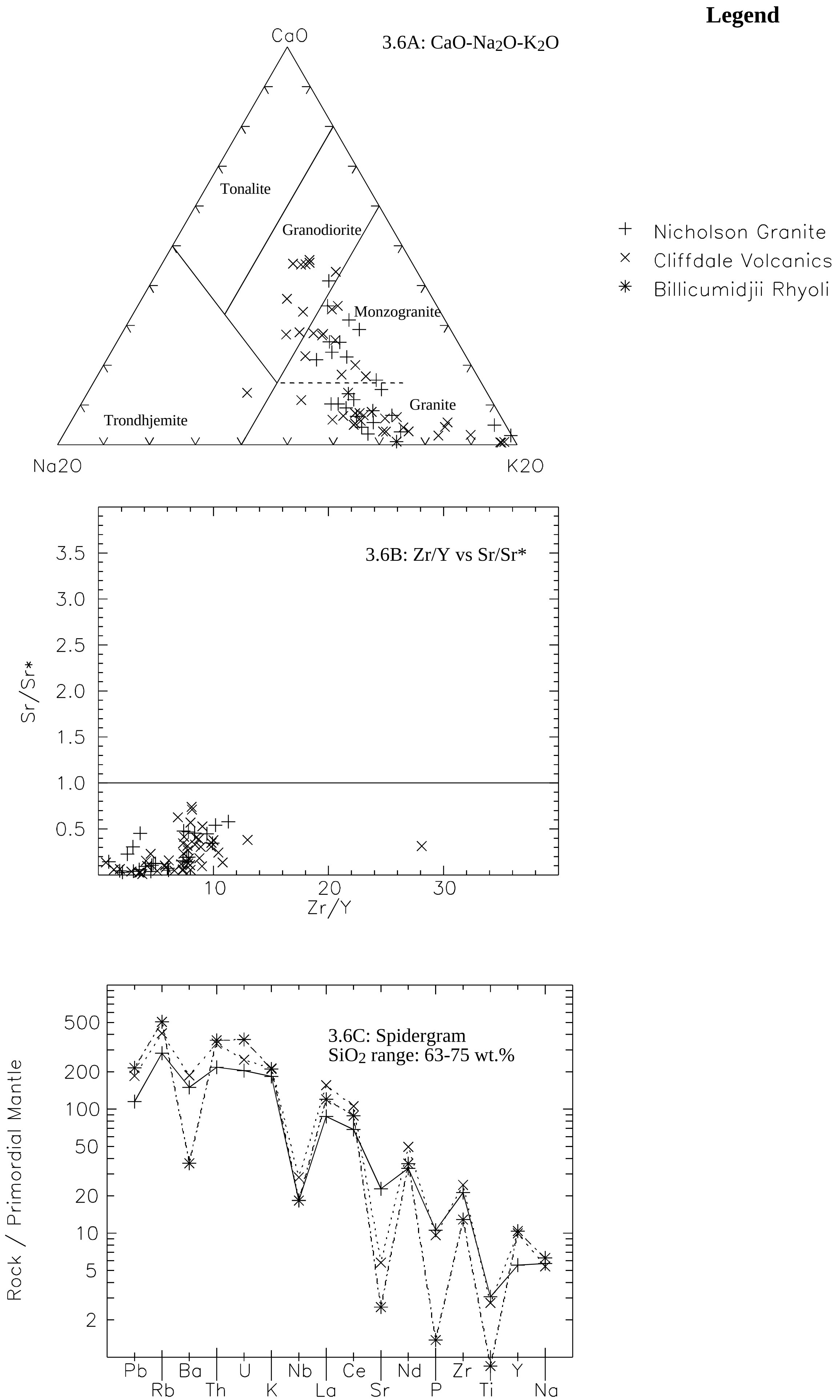
Legend

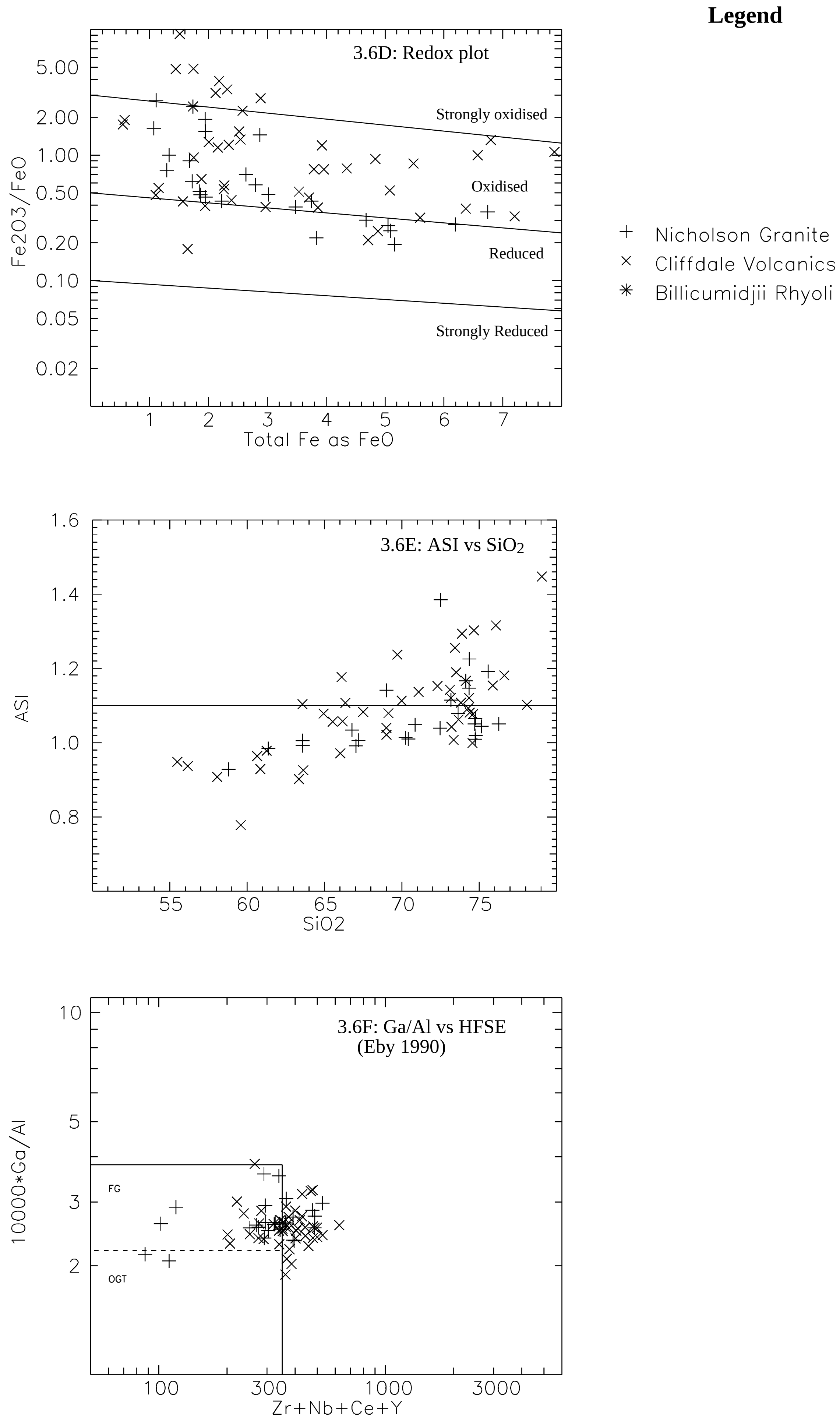
+ Nicholson Granite
× Cliffdale Volcanics
✳ Billicumidjii Rhyoli

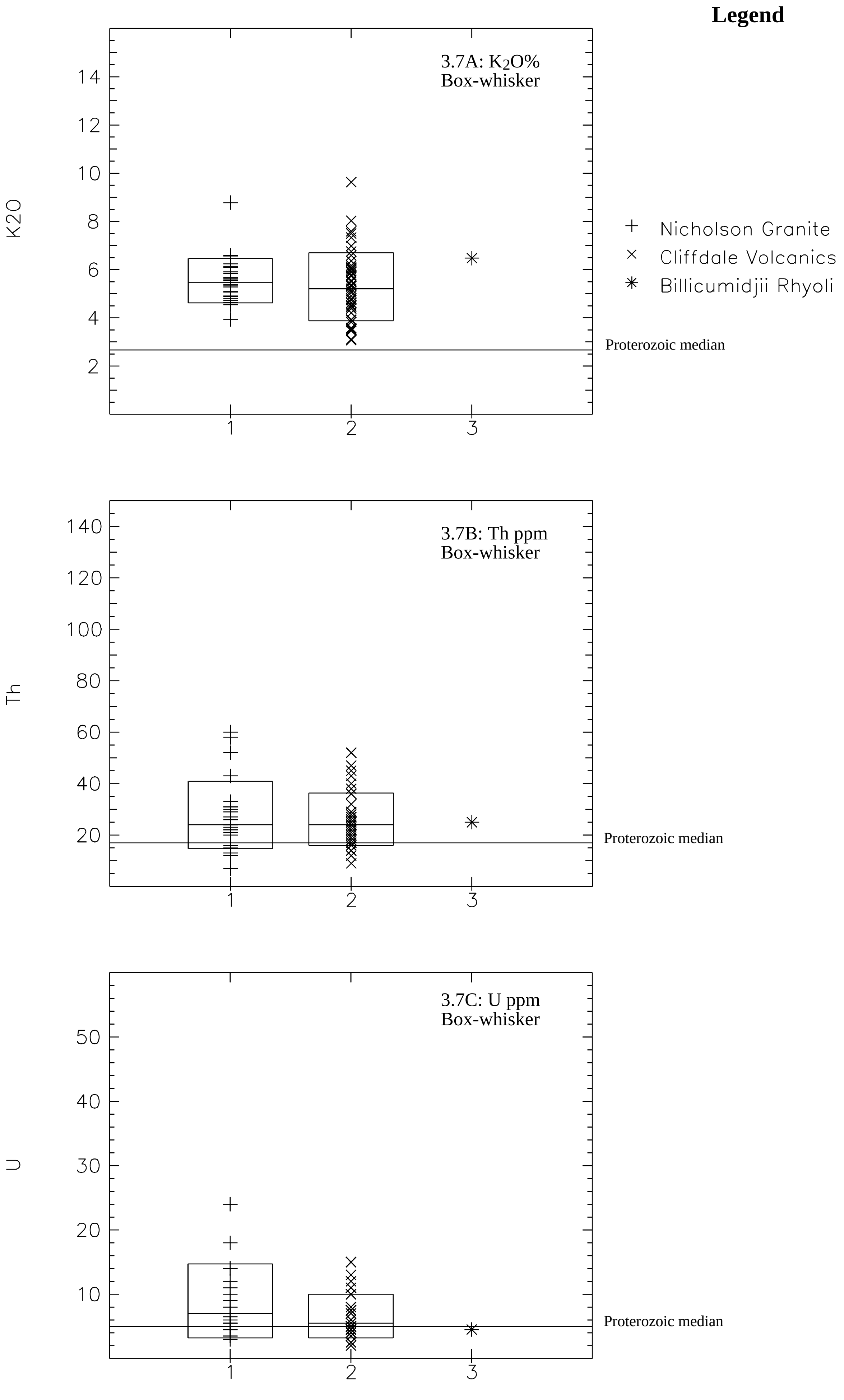





Legend
3.5A: Zr vs SiO2
800
600
400
200
Zr
55
60
65
70
75
SiO2
3.5B: Nb vs SiO2
80
60
40
20
Nb
55
60
65
70
75
SiO2
3.5C: Ce vs SiO2
400
300
200
100
Ce
55
60
65
70
75
SiO2
Nicholson Granite
Cliffdale Volcanics
Billicumidjii Rhyoli


Legend
+ Nicholson Granite
× Cliffdale Volcanics
✳ Billicumidjii Rhyoli
3.6A: CaO-Na2O-K2O
CaO
Na2O
K2O
Tonalite
Granodiorite
Monzogranite
Granite
Trondhjemite
3.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
Zr/Y
3.6C: Spidergram
SiO2 range: 63-75 wt.%
Rock / Primordial Mantle
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na


Legend
Nicholson Granite
Cliffdale Volcanics
Billicumidjii Rhyoli
3.6D: Redox plot
Strongly oxidised
Oxidised
Reduced
Strongly Reduced
Fe2O3/FeO
Total Fe as FeO
3.6E: ASI vs SiO2
ASI
SiO2
3.6F: Ga/Al vs HFSE
(Eby 1990)
FG
OGT
10000*Ga/Al
Zr+Nb+Ce+Y


Legend
+ Nicholson Granite
× Cliffdale Volcanics
✳ Billicumidjii Rhyoli
3.7A: K₂O%
Box-whisker
K2O
Proterozoic median
3.7B: Th ppm
Box-whisker
Th
Proterozoic median
3.7C: U ppm
Box-whisker
U
Proterozoic median

Nicholson Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.77	72.51	4.88	58.8	76.27	25
TiO2	0.34	0.32	0.2	0.07	0.71	25
Al2O3	13.54	13.54	0.93	12.23	16.05	25
Fe2O3	0.96	0.97	0.33	0.56	1.76	25
FeO	2.06	1.56	1.47	0.3	5	25
MnO	0.05	0.05	0.02	0.02	0.09	25
MgO	1.13	0.46	1.54	0.07	6.7	25
CaO	1.54	1.07	1.21	0.21	4.21	25
Na2O	2.43	2.7	0.79	0.02	3.28	25
K2O	5.54	5.46	0.94	3.93	8.78	25
P2O5	0.1	0.08	0.07	0.01	0.23	25
H2O+	0.99	0.97	0.39	0.4	1.88	22
H2O-	0.06	0.04	0.04	0.01	0.17	22
CO2	-	-	-	-	-	-
LOI	0.96	0.81	0.38	0.67	1.39	3
Ba	725.04	609	454.45	88	1690	25
Li	33.74	31	32.33		164	25
Rb	294.84	257	154.42	150	862	25
Sr	180.68	117	165.36	13	490	25
Pb	32.96	33	11.49	3	58	25
Th	27.76	24	13.35	7	60	25
U	8.96	7	5.87	3	24	25
Zr	165.88	169	68.57	28	280	25
Nb	13.52	13	6.18	3	34	25
Y	32.84	30	14.76	16	75	25
La	53.08	59	23.37	6	109	25
Ce	98.36	106	43.95	15	191	25
Pr	10	11	3.61	6	13	3
Nd	34.12	33	14.89	7	67	25
Sc	9.48	7	7.22		27	25
V	31.84	17	37.55		144	25
Cr	15.67	3	22.81	2	42	3
Mn	276	268	140.17	140	420	3
Co	10.32	8	8.94		43	22
Ni	11.28	4	19.72		85	25
Cu	18.76	7	28.33		121	25
Zn	40.08	33	26.18	5	114	25
Sn	11.92	5	32.49	2	167	25
W	3.23		4.03		20	22
Mo	2.48		1.25		5	25
Ga	19.16	19	2.44	15	26	25
As	1.44	1	1.27	50	5.5	22
S	62.44	38	99.53	6	450	25
F	-	-	-	-	-	-
Cl	142.64	128.5	70.21	41	315	22
Be	4.27	3	2.65	1	9	11
Ag	1	1	-	1	1	3
Bi	1.36		0.86		4	25
Hf	4.33	4	0.58	4	5	3
Ta	2	2	1		3	3
Cs	8.33	7	6.11	3	15	3
Ge	4.67	5	0.58	4	5	3
Se	0.5		-			3

Cliffdale Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.51	71.09	6.22	55.48	79.05	45
TiO2	0.35	0.22	0.26	0.03	1.05	45
Al2O3	14.03	13.87	1.64	10.28	17.01	45
Fe2O3	1.45	1.35	0.87	0.25	4.07	45
FeO	1.8	1.4	1.36	0.15	5.45	45
MnO	0.05	0.04	0.03	0.01	0.12	45
MgO	1.18	0.47	1.43	0.18	6.07	45
CaO	1.87	1.04	1.73	0.03	5.25	45
Na2O	2.52	2.62	0.99	0.18	4.68	45
K2O	5.29	5.21	1.42	3.07	9.63	45
P2O5	0.08	04	0.08	04	0.32	45
H2O+	1.14	0.98	0.59	0.4	2.77	42
H2O-	0.07	0.06	0.05	0.01	0.22	42
CO2	-	-	-	-	-	-
LOI	1.47	1.74	0.5	0.89	1.78	3
Ba	1123.29	1088	514.3	115	2414	45
Li	19.71	17	13.87	2	55	45
Rb	231.64	204	114.74	100	827	45
Sr	194.11	175	133.87	27	484	45
Pb	23.11	23	9.68	7	50	45
Th	26.13	24	10.3	9	52	45
U	6.6	5.5	3.42	2	15	45
Zr	224	226	77.2	79	506	45
Nb	12.38	11	4.55	4	29	45
Y	35.24	29	17.86	18	129	45
La	61.24	54	37.08	19	242	45
Ce	105.89	104	37.81	23	261	45
Pr	12.36	11	6.31	5	36	33
Nd	44.47	41	20.91	21	143	45
Sc	10.69	9	6.43	2	26	45
V	29.64	7	38.93		126	45
Cr	34.56	6	78.96		409	33
Mn	474.33	443	294.25	197	783	3
Co	15.23	14	11.57	2	37	13
Ni	8.99	2	21.32		121	45
Cu	10.53	6	10.89	1	43	45
Zn	51.96	44	24.56	11	107	45
Sn	5.24	4	5.59	2	31	45
W	23.54		77.06		280	13
Mo	2.8	3	1.03		5	45
Ga	18.93	20	3.49	5	26	45
As	3.15	2	3.71	50	23	45
S	83.58	33	177.38	9	1030	45
F	461	400	282.19	Â	1200	30
Cl	112.6	80.5	82.77	26	372	42
Be	2.52	3	0.95		5	41
Ag	1.33	1	0.58	1	2	3
Bi	0.83		0.3		2	45
Hf	6.06	6	2.03	3	13	33
Ta	1.58		1.25		7	33
Cs	10.48	10	3.61	3	19	33
Ge	1.51	1.5	1.01	50	5	32
Se	0.32	50	0.11		0.5	33

Billicumidji Rhyolite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.14	74.14	-	74.14	74.14	1
TiO2	0.23	0.23	-	0.23	0.23	1
Al2O3	12.62	12.62	-	12.62	12.62	1
Fe2O3	1.24	1.24	-	1.24	1.24	1
FeO	0.51	0.51	-	0.51	0.51	1
MnO	0.02	0.02	-	0.02	0.02	1
MgO	0.23	0.23	-	0.23	0.23	1
CaO	0.07	0.07	-	0.07	0.07	1
Na2O	2.28	2.28	-	2.28	2.28	1
K2O	6.48	6.48	-	6.48	6.48	1
P2O5	0.03	0.03	-	0.03	0.03	1
H2O+	0.26	0.26	-	0.26	0.26	1
H2O-	-	-	-	-	-	-
CO2	0.03	0.03	-	0.03	0.03	1
LOI	0.87	0.87	-	0.87	0.87	1
Ba	1453	1453	-	1453	1453	1
Li	7	7	-	7	7	1
Rb	255	255	-	255	255	1
Sr	136	136	-	136	136	1
Pb	21	21	-	21	21	1
Th	25	25	-	25	25	1
U	4.5	4.5	-	4.5	4.5	1
Zr	315	315	-	315	315	1
Nb	18	18	-	18	18	1
Y	41	41	-	41	41	1
La	56	56	-	56	56	1
Ce	112	112	-	112	112	1
Pr	11	11	-	11	11	1
Nd	40	40	-	40	40	1
Sc	9	9	-	9	9	1
V	1		-			1
Cr	2	2	-	2	2	1
Mn	162	162	-	162	162	1
Co	-	-	-	-	-	-
Ni	1	1	-	1	1	1
Cu	1	1	-	1	1	1
Zn	24	24	-	24	24	1
Sn	3	3	-	3	3	1
W	-	-	-	-	-	-
Mo	1		-			1
Ga	17	17	-	17	17	1
As	0.25	50	-	50	50	1
S	40	40	-	40	40	1
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	2	2	-	2	2	1
Ag	2	2	-	2	2	1
Bi	1		-			1
Hf	11	11	-	11	11	1
Ta	1		-			1
Cs	4	4	-	4	4	1
Ge	2	2	-	2	2	1
Se	0.5		-			1

4 ARGYLLA SUITE

4.1 Timing

1780 Ma

4.2 Individual Ages

Primary Ages:

1. Bottletree Formation [1, 2]	1808 ± 19 Ma, U-Pb
2. Bottletree Formation [1, 2]	1790 ± 9 Ma, U-Pb
3. Argylla Formation [1, 3]	1777 ± 7 Ma, U-Pb
4. Argylla Formation [1, 3]	1771 ± 17 Ma, U-Pb
5. Argylla Formation [1, 2]	1766 ± 21 Ma, U-Pb
6. Argylla Formation [1, 2]	~1746 Ma, U-Pb

Other chronologically similar units in the Mt. Isa Inlier (within error)

1. Unnamed Volcanics, Boorama Horst [4]	1774 ± 4 Ma, SHRIMP
2. Unnamed Volcanics, Boorama Horst [4]	1775 ± 4 Ma, SHRIMP

Sources: [1] OZCHRON, [2] Page (1983), [3] Page (1978), [4] Page *et al.* (1997). Note: All ages of the named outcrops of this unit are by the U-Pb method. The Argylla Suite is defined in this project as including all felsic volcanics in the Mount Isa Inlier prior to the deposition of the Ballara Quartzite, Mitakoodi Quartzite and the Corella Formation. It is considered possible, but not yet proven that some plutons of the Wonga Suite may be comagmatic, particularly those that intrude the Argylla Formation and are part of the 'Lower Plate' group of granites of the Wonga area as defined by Pearson *et al.* (1992). Until proper geochemical studies are carried out on these volcanic suites and on the granites of the Wonga Suite, the issue will remain enigmatic.

4.3 Regional Setting

This suite is mainly extrusive and was emplaced in the Western Fold Belt, Kalkadoon-Leichhardt Belt and Eastern Fold Belt between 1810 to 1746 Ma. To date, only two intrusions are considered to be part of the suite: the Bowlers Hole Granite and Mairindi Creek Granite. Although the ages generally become younger to the east, very few dated samples have been properly assessed for their geochemical affinities, and so there is a possibility that some of the younger samples may be part of the Burstall Suite. Ages of other units that are within error have been listed in section 4.2 above.

The suite is the felsic end member of a major bimodal event, the mafic part of which is represented by the Magna Lynn Metabasalt, Oroopo Metabasalt, Jayah Creek Metabasalt, Kamarga Volcanics and basalt in the Bottletree Formation. The suite forms the basal part of Cover Sequence 2 of Blake (1987) and is presumed to be related to a major extensional event.

4.4 Summary

This suite is predominantly extrusive and has anomalously high concentrations of High Field Strength Elements such as Zr, Nb, Y and F.

4.5 Potential

The Argylla Suite is probably a genuine A-type suite, it is predominantly volcanic and as such is not considered to have significant potential.

Cu:	**None**
Au:	**None**
Pb/Zn:	**None**
Sn:	**None**
Mo/W:	**None**
Confidence level:	**321**

4.6 Descriptive Data

Location: Central part of the Mount Isa Inlier in the Western Fold Belt, the Kalkadoon-Leichhardt Belt, and extends across the whole width of the Eastern Fold Belt. However, some of the outcrops marked as Argylla Formation in the eastern part of the Eastern Fold Belt may belong to felsic volcanics of the Burstall Suite.

Dimensions and area: 270 km from north to south and 90 km east to west. Total outcrop area covered is 1820 km^2.

4.7 Intrusives

Component plutons: Mairindi Creek Granite and Bowlers Hole Granite. Some plutons of the Wonga Suite may also be comagmatic with this suite.

Form: Small intrusions. *Specifically:* Bowlers Hole Granite - an elliptical intrusion 11 km long from north to south and 3.5 km wide; Mairindi Creek Granite - a small near-circular intrusion 5 km wide.

Metamorphism and Deformation: Both plutons strongly foliated. *Specifically:* Mairindi Creek Granite - the foliation is in places crenulated.

Dominant intrusive rock types: Granite.*Specifically:* Bowlers Hole Granite - Gneissic to slightly porphyritic, medium-grained granite; Mairindi Creek Granite - medium to coarse-grained granite, commonly porphyritic.

Colour: Pink to grey.

Veins, Pegmatites, Aplites, Greisens: Aplite and some pegmatites present. *Specifically:* Bowlers Hole Granite - minor aplite and pegmatite; Mairindi Creek Granite - minor aplite.

Distinctive mineralogical characteristics: The dominant mineralogies are quartz, K-feldspar, plagioclase, biotite ± hornblende. *Specifically:* Bowlers Hole Granite - quartz, plagioclase, K-feldspar, biotite, dark blue-green hornblende, with accessory allanite, opaque minerals, titanite and zircon; Mairindi Creek Granite - scattered phenocrysts of microcline, quartz, and rare plagioclase in a groundmass of quartz, plagioclase, microcline, biotite with accessory muscovite, blue-green hornblende, opaque minerals, allanite and fluorite.

Breccias: None recorded.

Alteration in the granite: Most alteration appears due to later deformation and metamorphic events. *Specifically:* Bowlers Hole Granite - calcite, chlorite, epidote.

4.8 Extrusives

The suite is dominantly extrusive. The Bottletree Formation comprises interlayered pink to grey rhyolitic to dacitic metavolcanics (pyroclastics and lava flows), metabasalt lavas and metamorphosed greywacke and greywacke conglomerate. The volcanics are commonly magnetic and show contorted flow banding, quartz-filled vesicles and recrystallised spherulites. Phenocrysts vary from sparse to abundant. Mineralogically the volcanic rocks contain quartz ± biotite ± hornblende in a recrystallised groundmass of feldspar ± biotite and magnetite. The Argylla Formation comprises massive to intensely foliated felsic volcanics, clastic sedimentary rocks and minor metabasalt. The felsic volcanics are generally magnetic, pinkish brown to grey ignimbrite, tuff, and flow banded lavas. They contain phenocrysts of quartz, plagioclase and K-feldspar with minor biotite, blue-green hornblende ± opaque minerals (mainly magnetite) in a quartzofeldspathic groundmass.

4.9 Country Rock

Contact metamorphism: None recorded; chilled margins occur around the Bowlers Hole Granite.

Reaction with country rock: None noted.

Units the granite intrudes: Magna Lynn Metabasalt and Argylla Formation.

Dominant rock types: Basalt and felsic volcanics.

Potential hosts: Basalt and felsic volcanics.

4.10 Mineralisation

Numerous small Cu deposits are associated with this suite. All are believed to be related to later defomation and metamorphism (*e.g.*, Ellis and Wyborn 1984).

4.11 Geochemical Data

Data source: AGSO's OZCHEM database.

Data quality: Good.

Are the data representative? Very representative of the volcanics: no samples of the Mairindi Creek Granite and only four of the Bowlers Hole Granite.

Are the data adequate? No.

SiO_2 range (Fig. 4.1): The SiO_2 range is from 62 to 77 wt.% with a peak at 69 wt.%.

Alteration (Fig. 4.2):

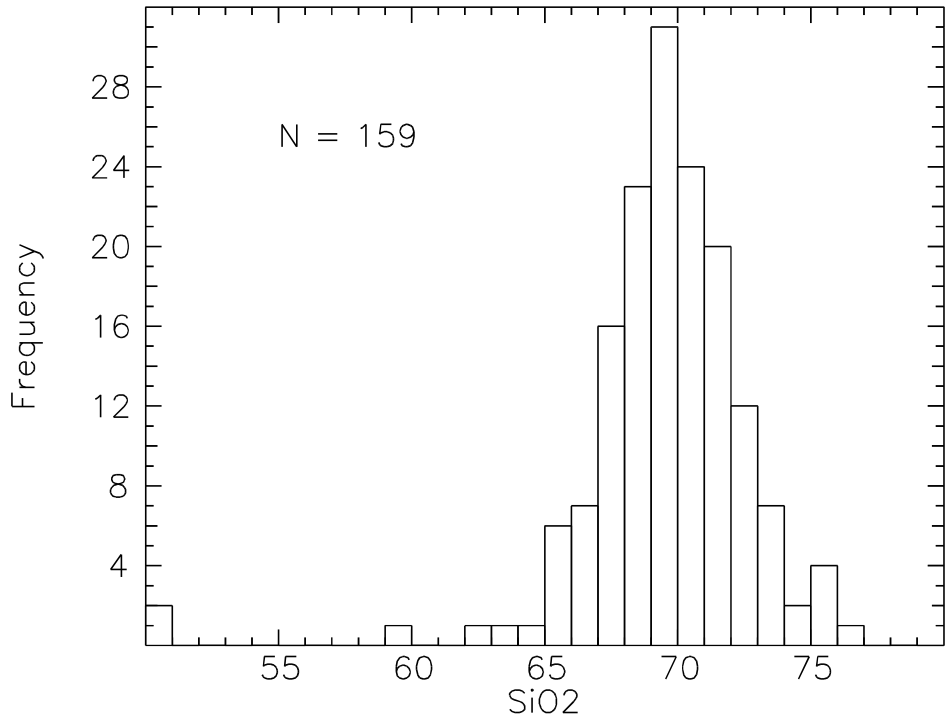


Figure 4.1. Frequency histogram for SiO_2 values for the Argylla Suite.

- ***SiO_2:*** No significant silicification recorded in the volcanics.
- ***K_2O/Na_2O:*** Some sodic alteration is noted in samples of the volcanics.
- ***Th/U:*** Some samples have lost U presumably during later metamorphism.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** Overall, the Argylla Formation is more oxidised than the Bottletree Formation. This is also an alteration overprint.

Fractionation Plots (Fig. 4.3):

- ***Rb:*** A weak increase is shown with increasing SiO_2.
- ***U:*** No increase with increasing SiO_2.
- ***Y:*** No increase with increasing SiO_2: some values for the Argylla Formation are exceptionally high.
- ***P_2O_5:*** Decreases with increasing SiO_2.
- ***Th:*** No increase with increasing SiO_2.
- ***K/Rb:*** No consistent pattern with increasing SiO_2.
- ***Rb-Ba-Sr:*** No samples are strongly differentiated.
- ***Sr:*** Values are low, and exceptionally low for the Argylla Formation samples.
- ***Rb/Sr:*** No consistent pattern with increasing SiO_2.
- ***Ba:*** Values are moderate to high, no consistent pattern with increasing SiO_2.
- ***F:*** Values are quite high and are within the range noted by Eby (1990) for Palaeozoic A-type granites.

Metals (Fig. 4.4):

- ***Cu:*** Some values are quite high: this may relate to later deformation and alteration.
- ***Pb:*** Most values are low to moderate. Some values are quite high: this may relate to later deformation and alteration.
- ***Zn:*** Some values are quite high, particularly for the Bottletree Formation.
- ***Sn:*** Some values appear to be increasing with increasing SiO_2.

High field strength elements (Fig. 4.5):

- ***Zr:*** Values are quite high for Australian Proterozoic felsic igneous rocks.
- ***Nb:*** Values are moderate.
- ***Ce:*** Values are low to moderate.

Classification (Fig. 4.6):

- ***The $CaO/Na_2O/K_2O$ plot of White, quoted in Sheraton and Simons (1992):*** Most samples plot in the granite to monzogranite field.
- ***Zr/Y vs Sr/Sr*:*** All samples plot below 1 reflecting the Sr-depleted, Y-undepleted nature of this suite.
- ***Spidergram:*** The samples plotted are all Sr-depleted, Y-undepleted.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples are in the oxidised field; some samples of the Argylla Formation are strongly oxidised and may be altered.
- ***ASI:*** Most samples are metaluminous to weakly peraluminous.
- ***A-type plot of Eby (1990):*** Members of this suite clearly plot in the A-type field as defined by Eby (1990) for Palaeozoic A-type granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-(granodiorite) type.

Australian Proterozoic granite type: Sybella type.

4.12 Geophysical Signature

Radiometrics (Fig. 4.7): Most samples would appear white in an RGB image.

Gravity: The measured wet densities of samples of the Argylla Suite range from 2.62 to 2.68 gm/cm^3. The regional gravity data are too coarse to make any predictive interpretations.

Magnetics: The Argylla Suite is a regional magnetic high reflecting the high measured susceptibilities on hand specimens and outcrop in the field (Wyborn, unpublished data).

4.13 References

Blake, D.H. 1987, Geology of the Mount Isa Inlier and environs, Queensland and Northern Territory. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin*, 225, 83 pp.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981a. Definitions of new and revised Precambrian stratigraphic and intrusive rock units in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report,* 233, *(BMR Microform* MF 164*).*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981b. Summary of new and revised Precambrian stratigraphic nomenclature in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Queensland Government Mining Journal,* 82, 580-589.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1982, Dajarra, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Blake, D.H., Bultitude, R.J. Donchak, P.J.T., Wyborn, L.A.I. and Hone, I.G. 1984, Geology of the Duchess-Urandangi region, Mount Isa Inlier, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 219, 96 pp.

Bultitude, R.J., Blake, D.H., Donchak, P.J.T. and Mock, C.M. 1982, Duchess Region, Queensland, 1:100 000 Geological Map Mommentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Bultitude, R.J. and Wyborn, L.A.I. 1982. Distribution and geochemistry of volcanic rocks in the Duchess-Urandangi region, Queensland. *BMR Journal of Australian Geology and Geophysics*, 7, 99-112.

Derrick, G.M. and Wilson, I .H. 1982. Geology of the Alsace 1:100 000 sheet area (6858) Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1982/6.

Derrick, G.M., Wilson, I.H., Hill, R.M. and Mitchell, J.E. 1971. Geology of the Marraba 1:100000 Sheet area, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record*, 1971/56.

Derrick, G.M., Wilson, I.H., Hill, R.M., Glikson, A.Y. and Mitchell, J.E. 1977. Geology of the Mary Kathleen 1:100 000 Sheet area, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin*, 193.

Ellis, D.J. and Wyborn, L.A.I. 1984. Petrology and geochemistry of Proterozoic dolerites from the Mount Isa Inlier. *BMR Journal of Australian Geology and Geophysics*, 9, 19- 32.

Hone, I.G., Carberry, V.P. and Reith, H.G. 1987. Physical property measurements on rock samples from the Mount Isa Inlier, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report*, 265, 30 pp.

Page, R.W. 1978. Response of U-Pb zircon and Rb-Sr total-rock and mineral systems to low-grade regional metamorphism in Proterozoic igneous rocks, Mount Isa, Australia. *Journal of the Geological Society of Australia*, 25, 141-164.

Page, R.W. 1983. Timing of superimposed volcanism in the Proterozoic Mount Isa Inlier. *Precambrian Research*, 21, 223-245.

Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. *MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, EGRU Contribution,* 55, 95-98.

Page, R.W., Sun, S.-S. and McCready, T. 1997. New geochronological results in the central and eastern Mount Isa Inlier and implications for mineral exploration. *Abstracts, Geodynamics and Ore Deposits Conference, Australian Geodynamics Cooperative Research Centre, Ballarat, Victoria,* 46-48.

Pearson, P.J., Holcombe, R.J. and Page, R.W. 1992. Synkinematic emplacement of the Middle Proterozoic Wonga Batholith into a mid-crustal extensional shear zone, Mount Isa Inlier, Queensland, Australia, In Stewart, A.J. and Blake, D.H. (editors), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 243, 289-328.

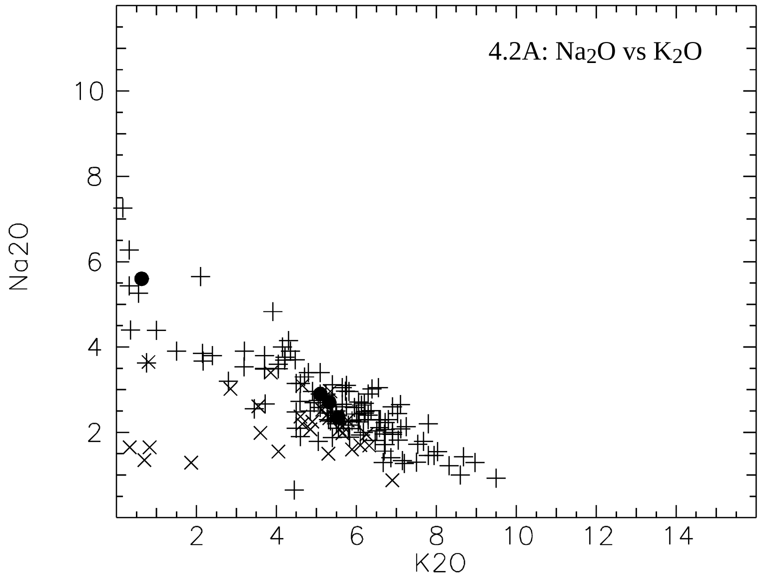
Wilson, I.H. 1978. Volcanism on a Proterozoic continental margin in northwestern Queensland. *Precambrian Research,* 7, 205-235.

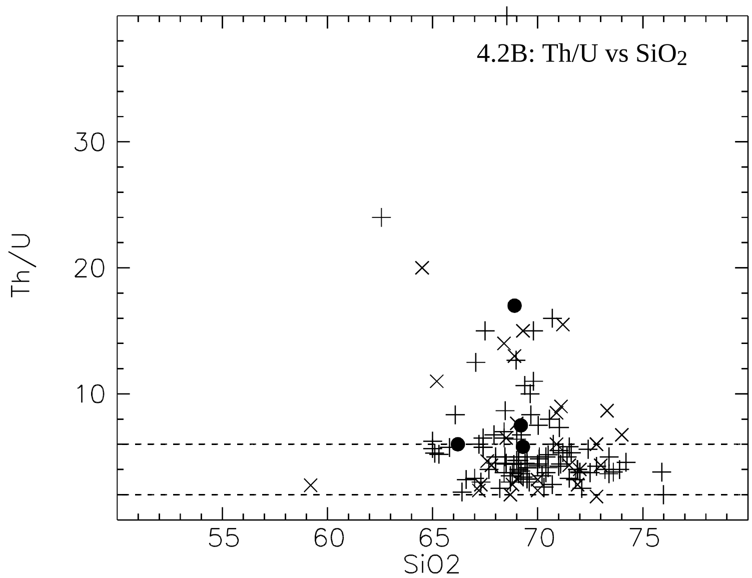
Wilson, I.H. 1987. Geochemistry of Proterozoic volcanics, Mount Isa Inlier, Australia. In: Pharaoh, T.C., Beckinsale, R.D. and Rickard, D.(editors) 1987, *Geochemistry and Mineralization of Proterozoic Volcanic Suites*, *Geological Society Special Publication* No. 33, 409-423.

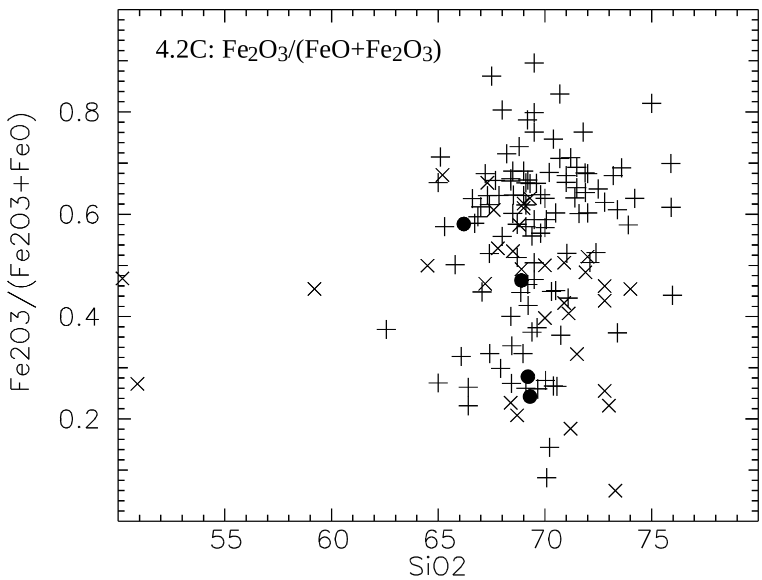
Wyborn, L.A.I. 1988. Petrology, geochemistry, and origin of a major Australian 1840-1880 Ma felsic volcano-plutonic suite: a model for intracontinental felsic magma generation. *Precambrian Research,* 40/41, 37-60.

Legend

+ Argylla Formation
× Bottletree Formation
● Bowlers Hole Granite

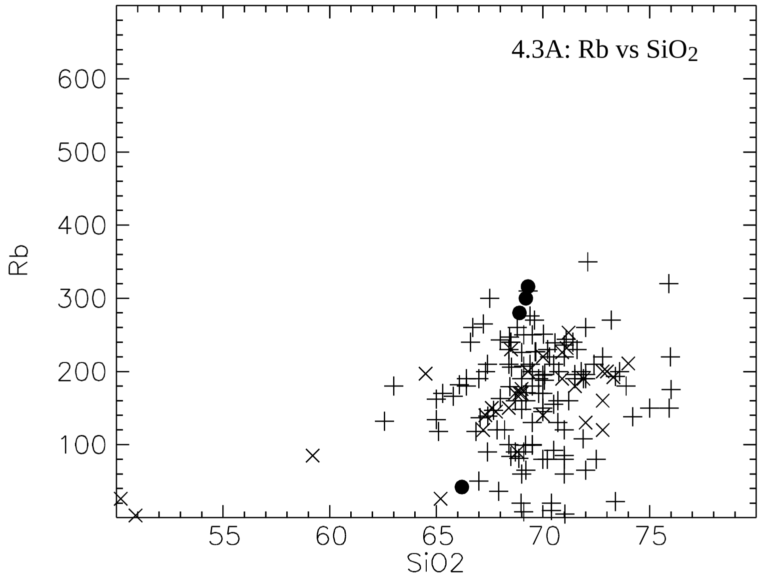


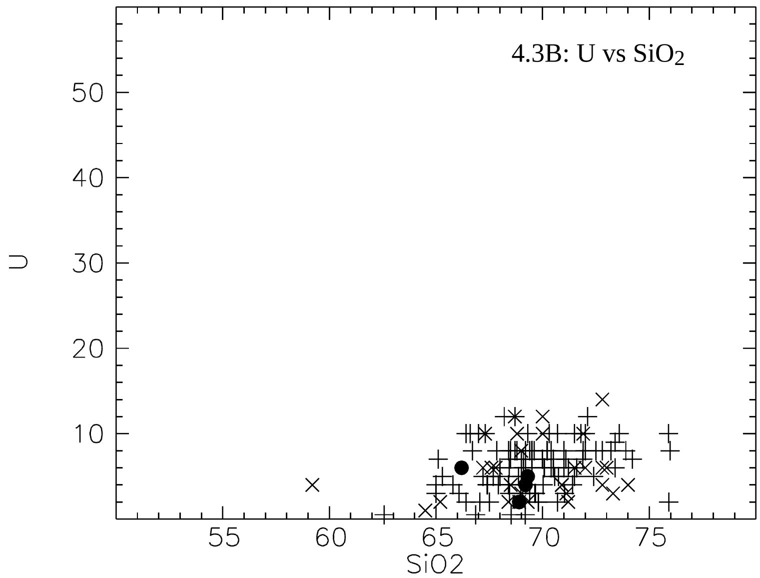


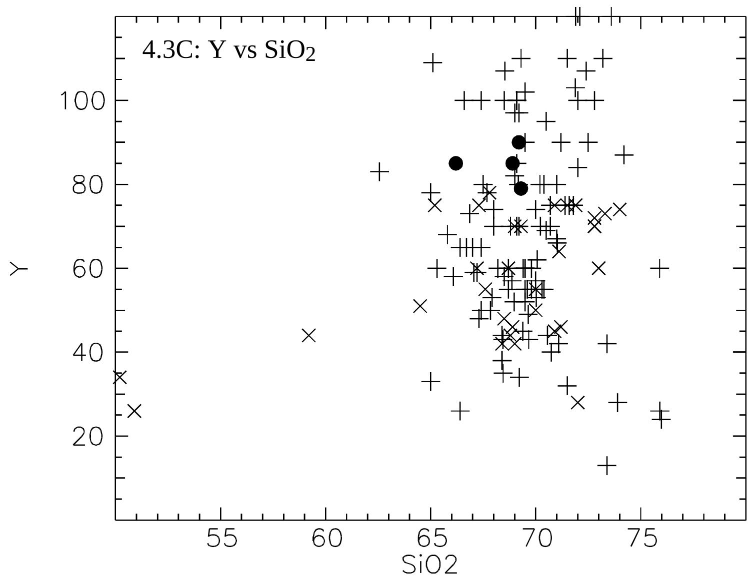


Legend

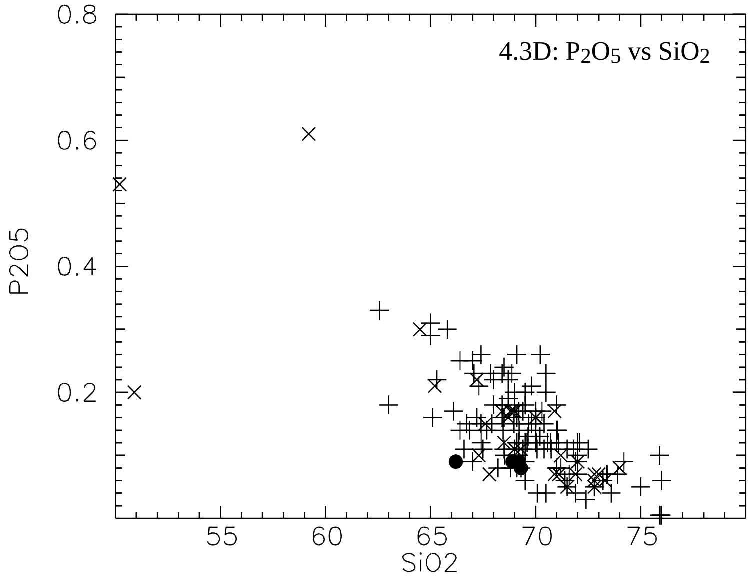

Argylla Formation
Bottletree Formation
Bowlers Hole Granite


4.3A: Rb vs SiO2
Rb
600
500
400
300
200
100
55
60
65
70
75
SiO2

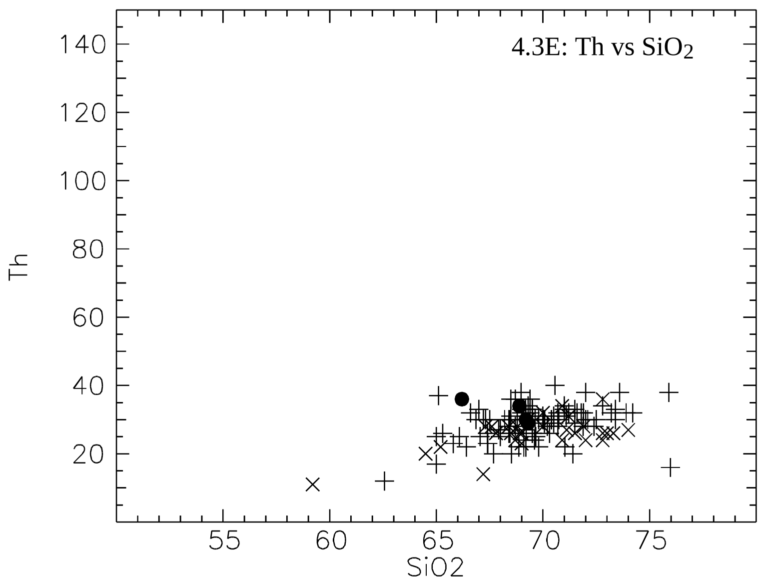

4.3B: U vs SiO2
U
50
40
30
20
10
55
60
65
70
75
SiO2

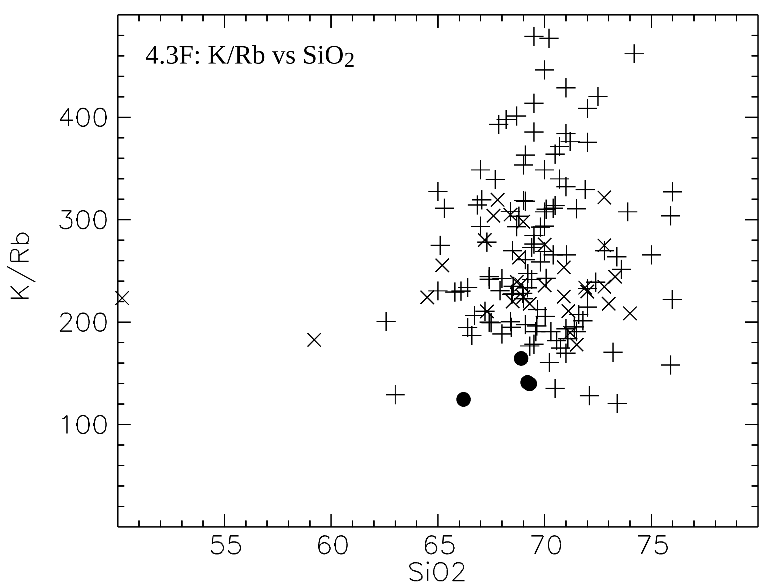

4.3C: Y vs SiO2
Y
100
80
60
40
20
55
60
65
70
75
SiO2

Legend


4.3D: P2O5 vs SiO2
P2O5
SiO2
0.8
0.6
0.4
0.2
55
60
65
70
75

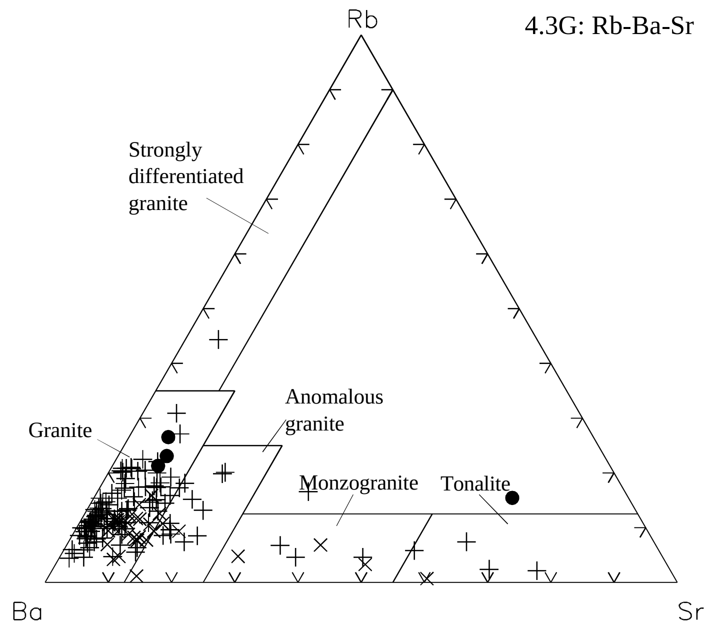

Argylla Formation
Bottletree Formation
Bowlers Hole Granite

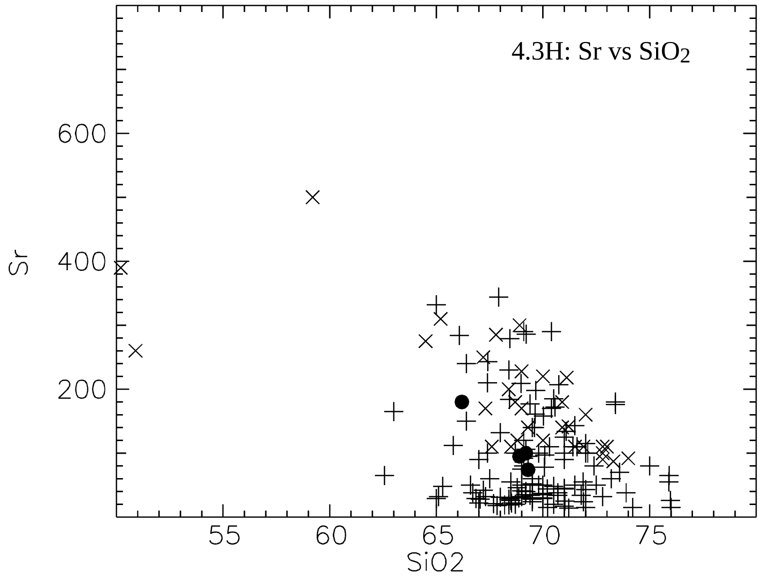

4.3E: Th vs SiO2
Th
SiO2
140
120
100
80
60
40
20
55
60
65
70
75

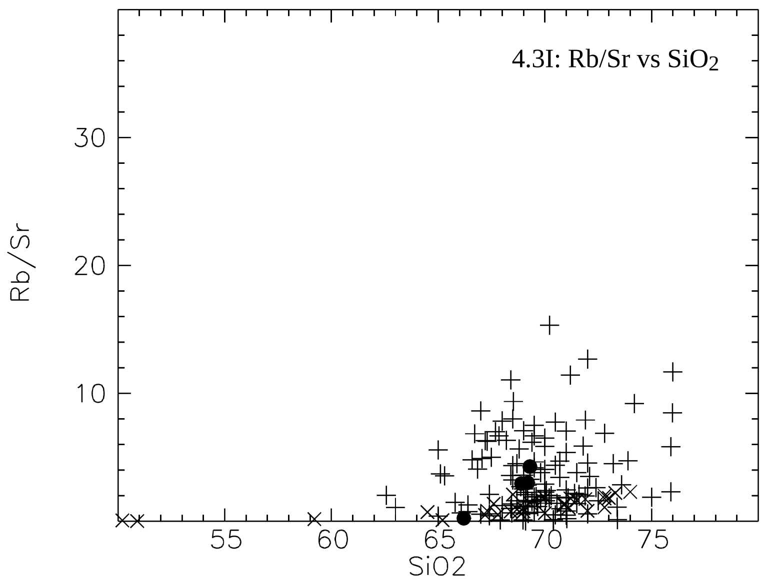

4.3F: K/Rb vs SiO2
K/Rb
SiO2
400
300
200
100
55
60
65
70
75

Legend

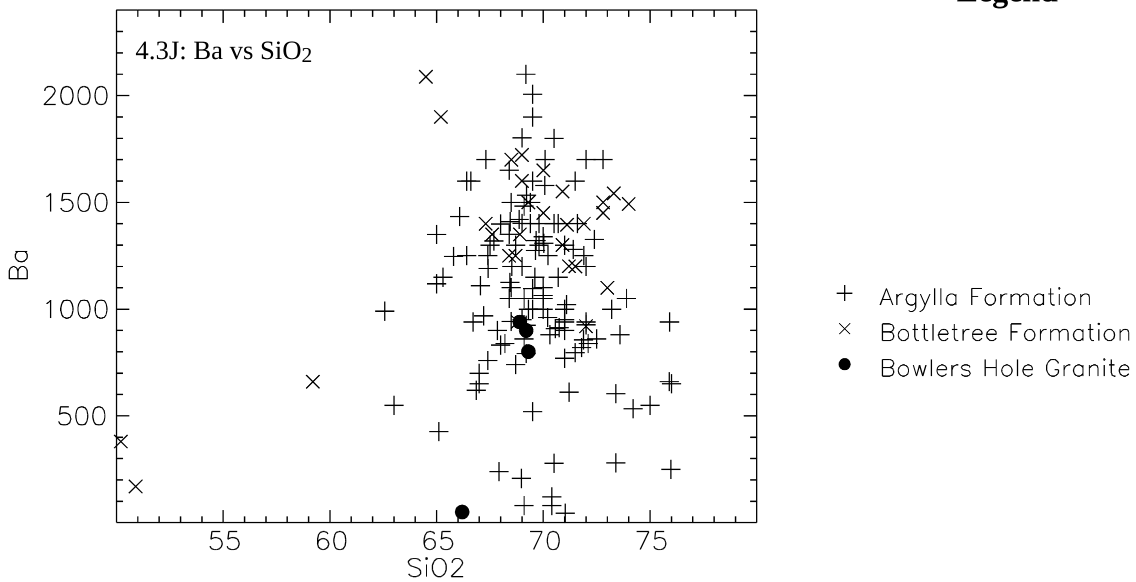
- \+ Argylla Formation
- × Bottletree Formation
- ● Bowlers Hole Granite

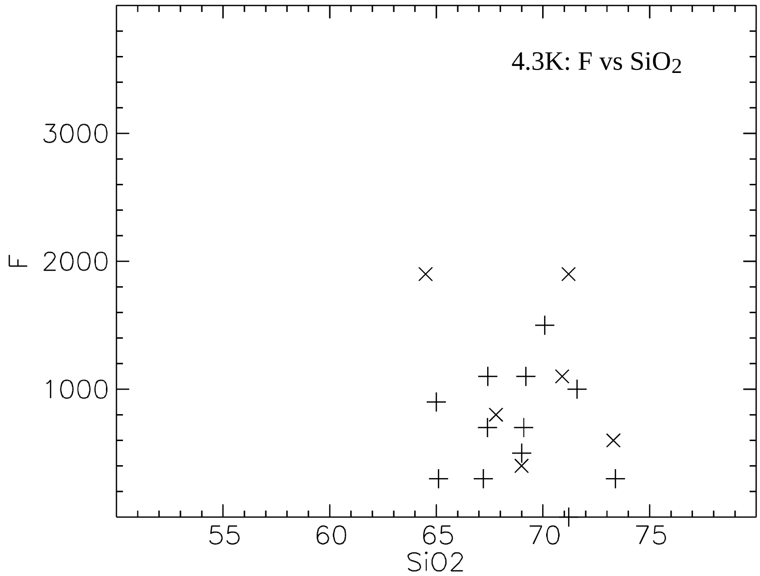


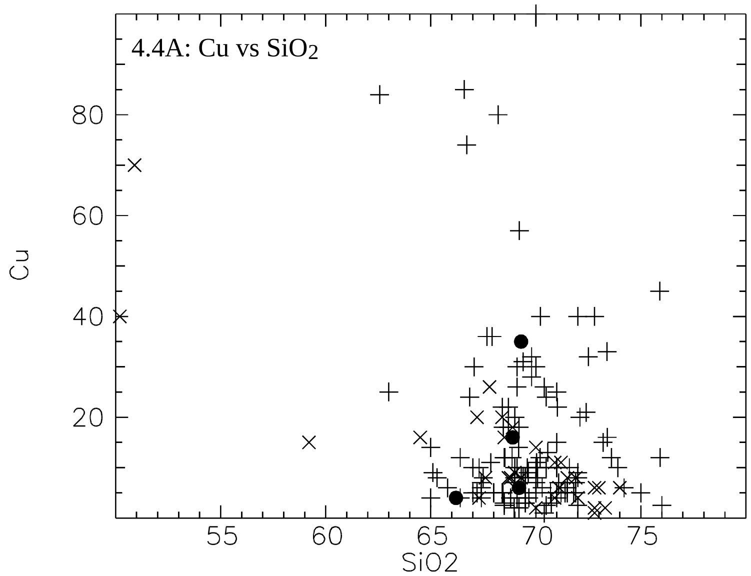


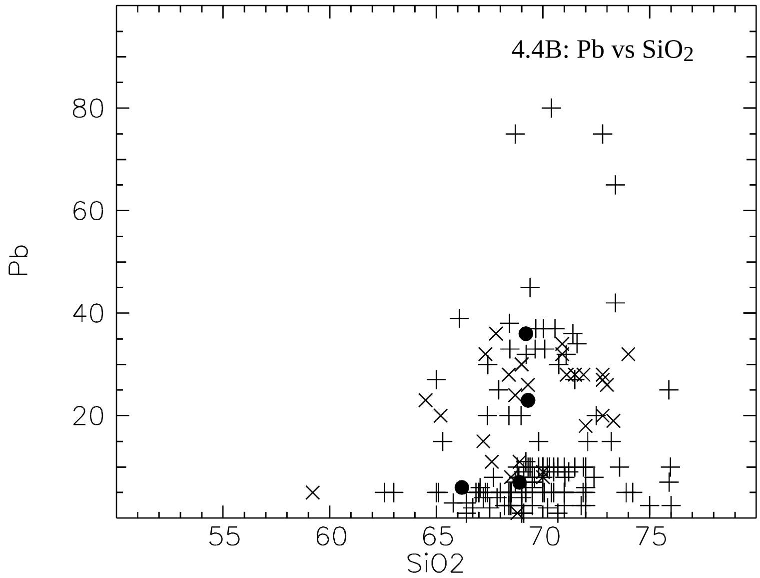


Legend


4.3J: Ba vs SiO2
Ba
SiO2
2000
1500
1000
500
55
60
65
70
75
Argylla Formation
Bottletree Formation
Bowlers Hole Granite

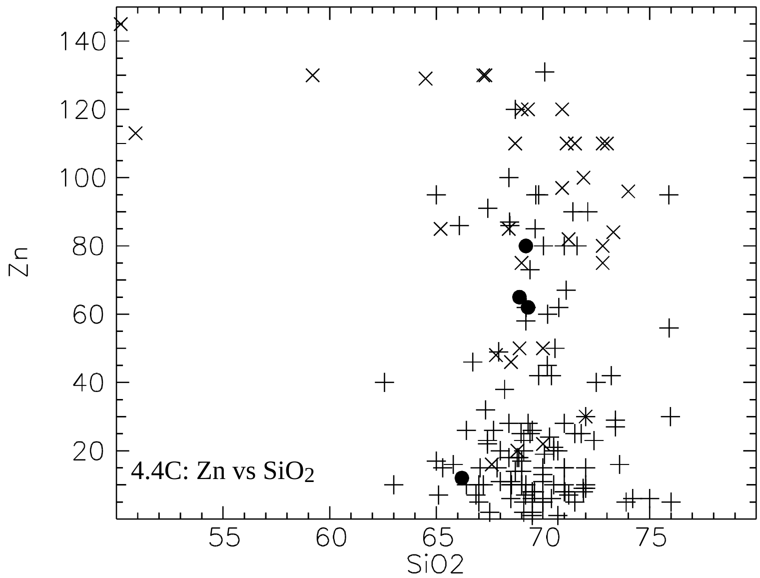

4.3K: F vs SiO2
F
SiO2
3000
2000
1000
55
60
65
70
75

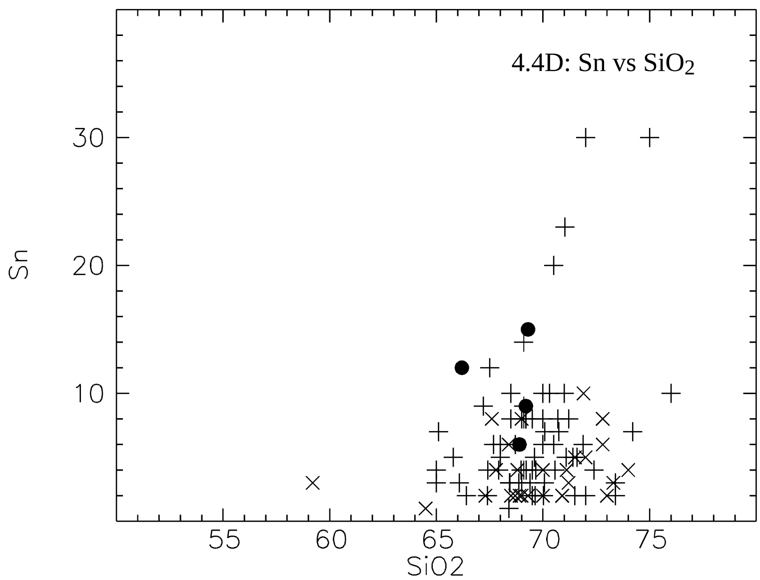

4.4A: Cu vs SiO2
Cu
SiO2
80
60
40
20
55
60
65
70
75


4.4B: Pb vs SiO_2
Pb
80
60
40
20
55
60
65
70
75
SiO2

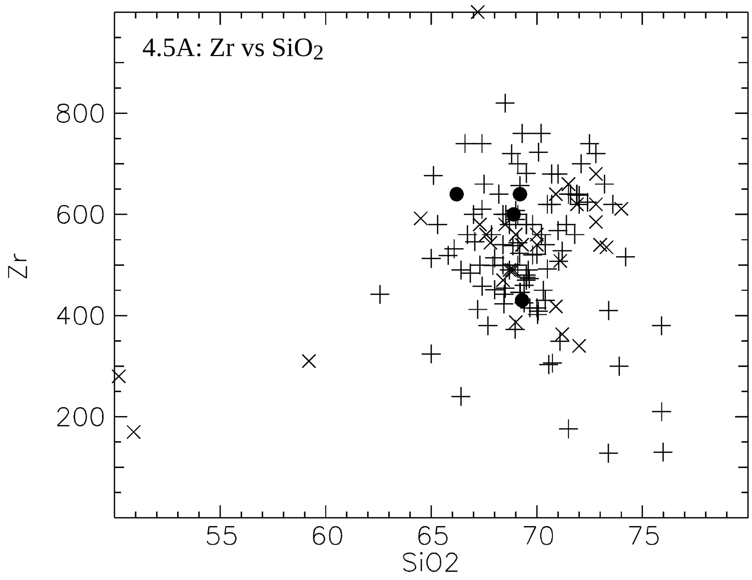
Legend


Argylla Formation
Bottletree Formation
Bowlers Hole Granite

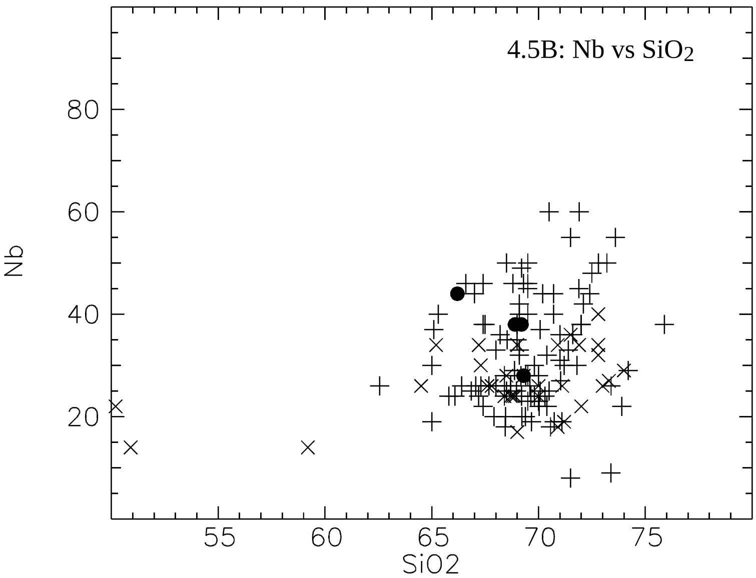

4.4C: Zn vs SiO_2
Zn
140
120
100
80
60
40
20
55
60
65
70
75
SiO2

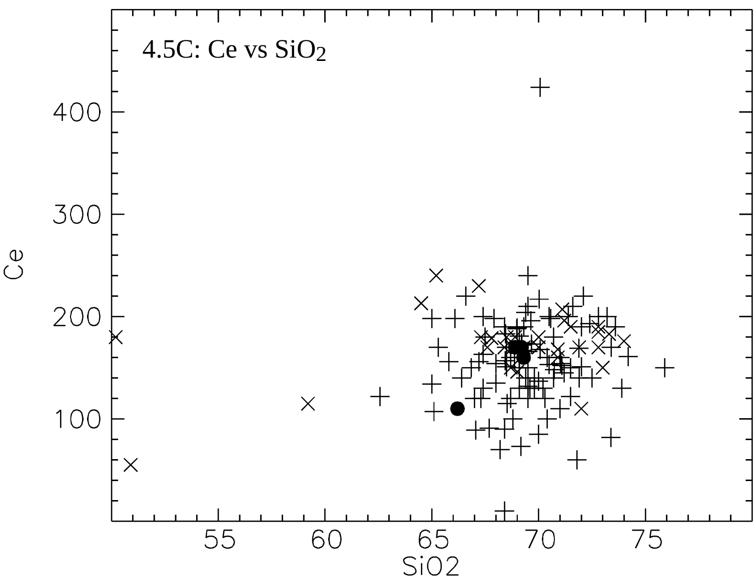

4.4D: Sn vs SiO_2
Sn
30
20
10
55
60
65
70
75
SiO2

Legend


4.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2

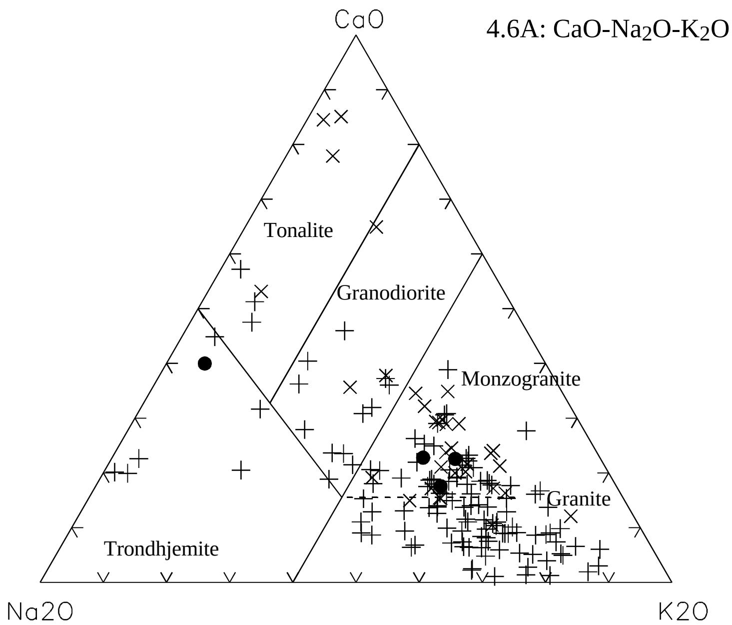

Argylla Formation
Bottletree Formation
Bowlers Hole Granite

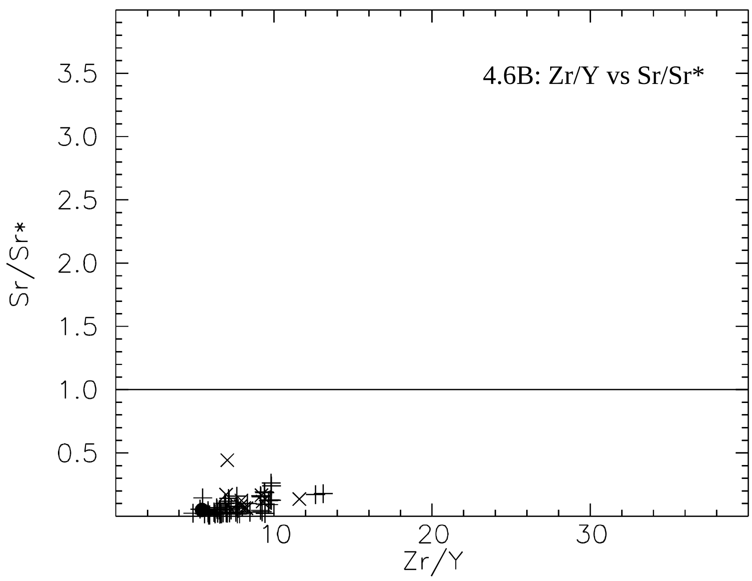

4.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2

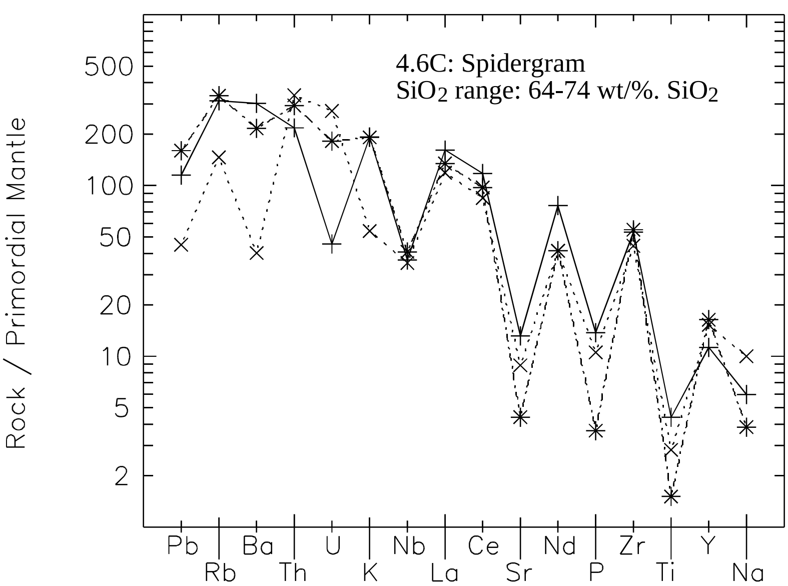

4.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

Legend

+ Argylla Formation
× Bottletree Formation
● Bowlers Hole Granite

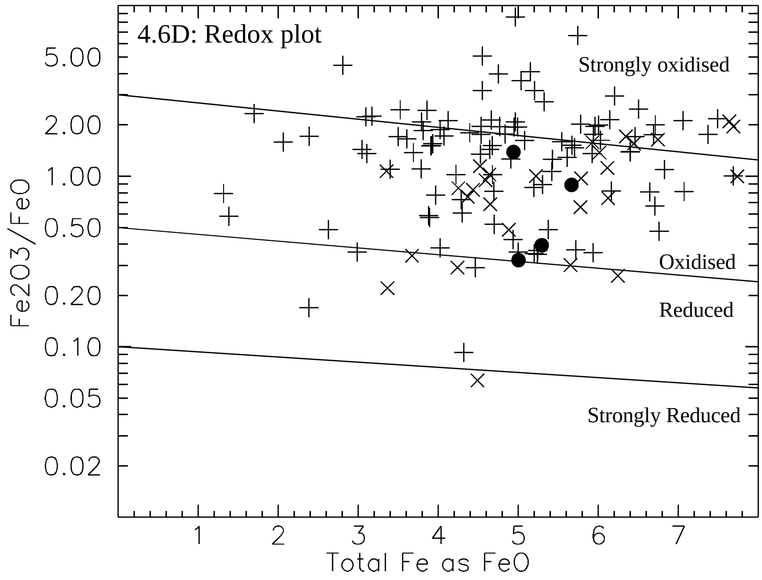


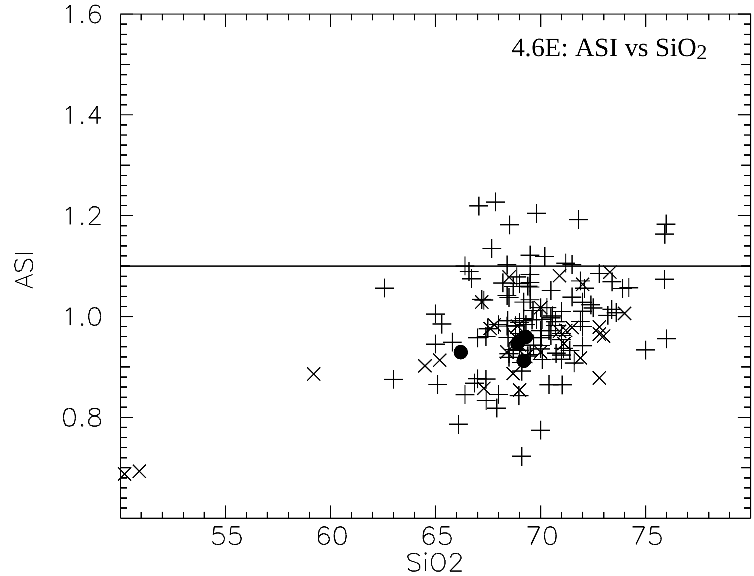


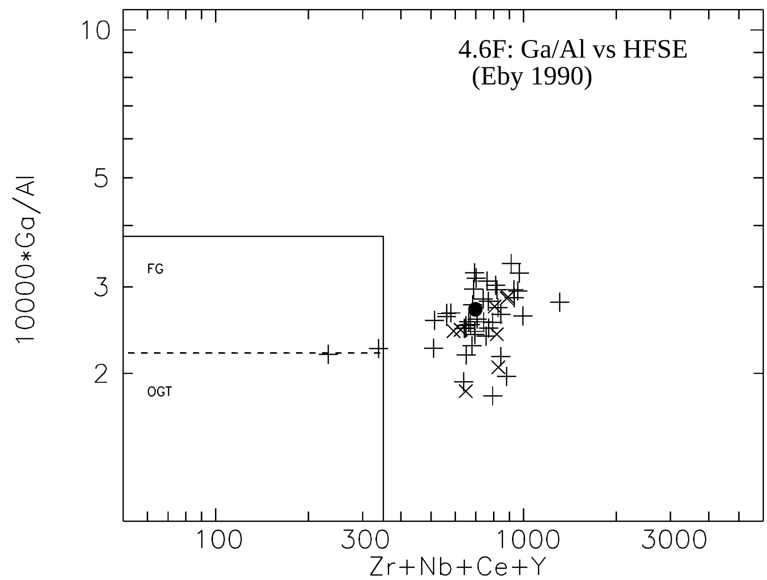


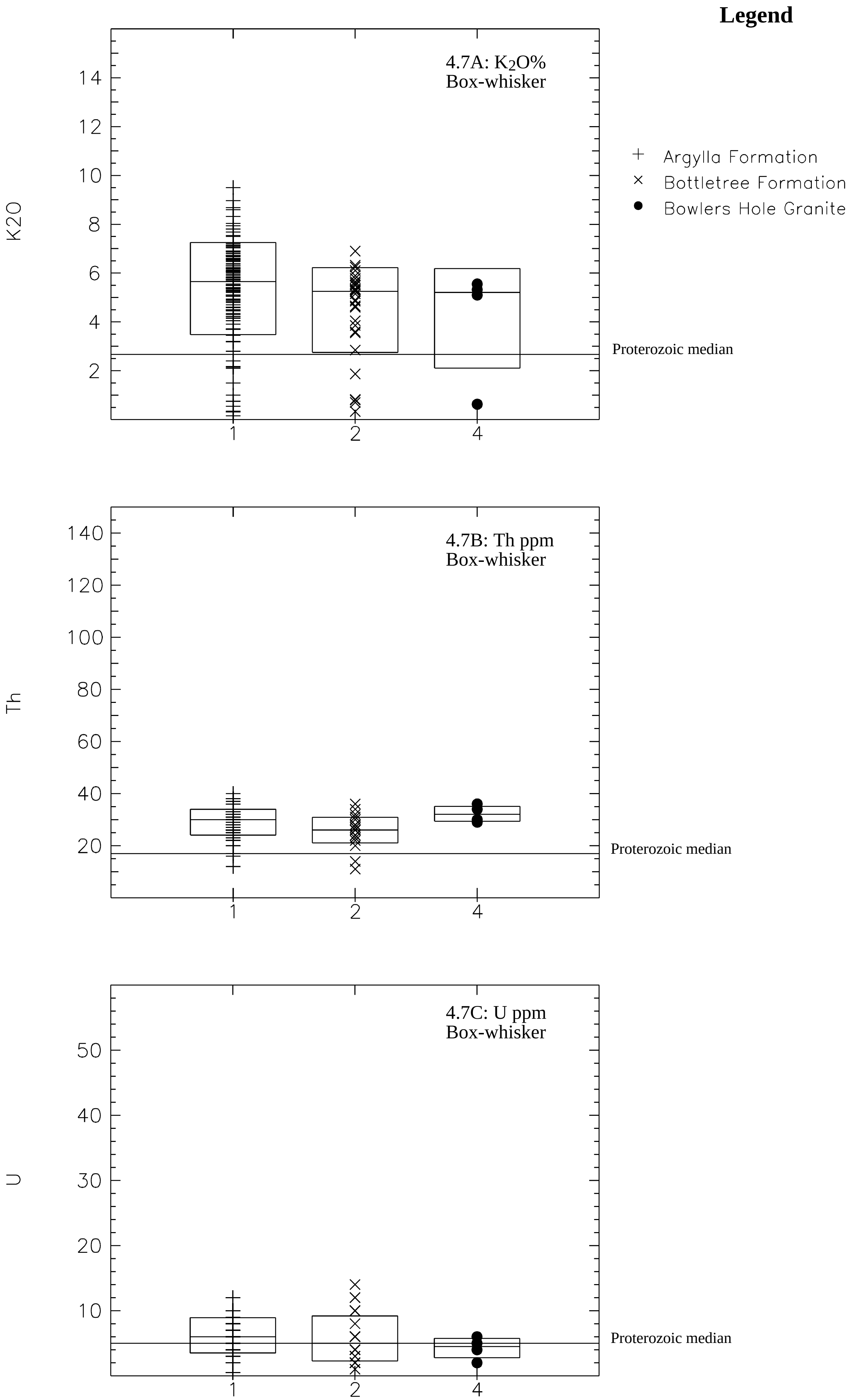
Legend

+ Argylla Formation
× Bottletree Formation
● Bowlers Hole Granite








Legend
Argylla Formation
Bottletree Formation
Bowlers Hole Granite
4.7A: K2O%
Box-whisker
K2O
Proterozoic median
4.7B: Th ppm
Box-whisker
Th
Proterozoic median
4.7C: U ppm
Box-whisker
U
Proterozoic median

Argylla Formation

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.69	69.5	2.45	62.57	76	123
TiO2	0.57	0.55	0.19	0.09	1.47	123
Al2O3	12.7	12.6	0.78	10.5	15.6	123
Fe2O3	3.32	3.11	1.59	0.35	8.2	123
FeO	2.28	2.15	1.05	0.55	6.3	107
MnO	0.04	0.03	0.03	02	0.13	123
MgO	0.59	0.54	0.36	01	2.02	123
CaO	1.63	1.42	1.14	0.09	6.35	123
Na2O	2.69	2.5	1.06	0.65	7.26	123
K2O	5.37	5.65	1.89	0.16	9.5	123
P2O5	0.14	0.12	0.07	01	0.33	123
H2O+	0.67	0.58	0.35	0.18	2.65	120
H2O-	0.15	0.15	0.07	0.04	0.35	92
CO2	0.21	0.1	0.3	01	1.41	53
LOI	1.05	1.23	0.39	0.6	1.32	3
Ba	1083.58	1064	436.53	44	2500	123
Li	6.69	6	4.46	2	19	42
Rb	168.91	180	71.7	5	350	123
Sr	89.93	55	77.84	14	344	123
Pb	14.68	8	20.99		170	123
Th	29.02	30	4.98	12	40	101
U	6.21	6	2.71		12	106
Zr	527.25	530	135.67	128	820	106
Nb	32.32	29.5	10.89	8	60	100
Y	69.3	66.5	24.56	13	124	106
La	83	80	23.42	30	196	94
Ce	155.95	155	47.98		424	100
Pr	19	19	-	19	19	1
Nd	67.83	66	21.59	31	165	53
Sc	7.33	8	3.46		15	43
V	18.4	14	16.28		113	60
Cr	26.96	9	35.37		180	108
Co	7.43	7	4.65		30	97
Ni	3.99	2	3.25		14	68
Cu	17.45	10	21.73		120	123
Zn	42.11	19	105.77		1100	123
Sn	6.77	5	5.71		30	66
W	6.15	5	4.53		26	30
Mo	2.3		1.16		6	38
Ga	17.77	18	2.26	12	23	43
As	1.6	1	1.66		10	48
S	64	64	-	64	64	1
F	700	700	436.93	01	1500	12
Cl	94	94	-	94	94	1
Be	4.33	4	1.53	3	6	3
Ag	1	1	-	1	1	1
Bi	1		-		1	3
Hf	17	17	-	17	17	1
Ta	1		-			1
Ge	1.5	1.5	-	1.5	1.5	1
Se	0.25	50	-	50	50	1

Bottletree Formation

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	67.83	69	6.36	49.7	74	33
TiO2	0.72	0.65	0.41	0.32	1.97	33
Al2O3	12.83	12.6	0.98	11.3	15.8	33
Fe2O3	2.99	2.73	1.6	0.27	6.65	33
FeO	3.71	2.81	1.97	1.71	10.3	33
MnO	0.09	0.07	0.05	0.04	0.24	33
MgO	0.77	0.35	1.39	0.1	5.92	33
CaO	3.21	2.38	2.56	0.89	11.7	33
Na2O	2.19	2.2	0.63	0.88	3.65	33
K2O	4.49	5.25	1.76	0.33	6.9	33
P2O5	0.15	0.12	0.12	0.05	0.61	33
H2O+	0.65	0.56	0.4	0.19	1.87	32
H2O-	0.15	0.13	0.06	0.06	0.28	31
CO2	0.11	0.06	0.15	01	0.59	29
LOI	0.96	0.96	-	0.96	0.96	1
Ba	1372.91	1400	523.51	170	2635	33
Li	9.25	11	3.92	4	13	8
Rb	154.97	170	64.68	3	253	33
Sr	185.36	160	95.06	87	500	33
Pb	42.67	27	71.86		380	33
Th	25.97	26	4.96	11	36	30
U	5.73	5	3.51		14	30
Zr	530.39	540	188.22	140	1100	33
Nb	26.36	26	6.67	14	40	33
Y	56.97	60	15.91	26	78	33
La	87.45	90	23.53	15	130	33
Ce	167.67	170	41.44	30	240	33
Pr	-	-	-	-	-	-
Nd	76.5	78	13.51	56	103	10
Sc	8.13	8	4.82	3	16	8
V	12.83	10.5	8.19		30	12
Cr	23.07	7	38.64		144	15
Co	9.75	7	9.01		25	6
Ni	14.59	2	23.12		62	11
Cu	23.3	8	50.59		280	33
Zn	89.39	97	36.22	16	145	33
Sn	4.07	3.5	2.45		10	28
W	6	6	1.41	5	7	2
Mo	3.5	3.5	0.71	3	4	2
Ga	16.38	16.5	2.67	11	20	8
As	0.63		0.23		1	8
S	-	-	-	-	-	-
F	1116.67	950	649.36	400	1900	6
Cl	-	-	-	-	-	-
Be	4	4	-	4	4	1
Ag	-	-	-	-	-	-
Bi	1		-			1
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Bowlers Hole Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.4	69.05	1.48	66.2	69.3	4
TiO2	0.52	0.52	0.04	0.48	0.56	4
Al2O3	13.7	13.1	1.55	12.6	16	4
Fe2O3	2.16	2.17	0.9	1.25	3.05	4
FeO	3.28	3.52	0.8	2.2	3.91	4
MnO	0.08	0.09	0.03	0.04	0.1	4
MgO	0.31	0.3	0.11	0.21	0.44	4
CaO	2.63	2.33	1.05	1.71	4.15	4
Na2O	3.39	2.81	1.49	2.35	5.6	4
K2O	4.15	5.21	2.35	0.63	5.55	4
P2O5	0.09	0.09	0.01	0.08	0.09	4
H2O+	0.47	0.51	0.08	0.35	0.53	4
H2O-	0.18	0.19	0.1	0.05	0.29	4
CO2	0.16	0.13	0.18	01	0.4	4
LOI	-	-	-	-	-	-
Ba	672.75	850.5	419.26	50	940	4
Li	14	14	-	14	14	1
Rb	234.5	290	129.18	42	316	4
Sr	112.25	97.5	46.55	74	180	4
Pb	18	15	14.31	6	36	4
Th	32.25	32	3.3	29	36	4
U	4.25	4.5	1.71		6	4
Zr	577.5	620	100.12	430	640	4
Nb	37	38	6.63	28	44	4
Y	84.75	85	4.5	79	90	4
La	80.75	81.5	8.3	70	90	4
Ce	152.5	165	28.72	110	170	4
Pr	-	-	-	-	-	-
Nd	75	75	-	75	75	1
Sc	6	6	-	6	6	1
V	19.25	20	9.43	7	30	4
Cr	6	6	-	6	6	1
Co	2.5		-			1
Ni	2	2	-	2	2	1
Cu	15.25	11	14.17	4	35	4
Zn	54.75	63.5	29.57	12	80	4
Sn	10.5	10.5	3.87	6	15	4
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	18	18	-	18	18	1
As	1	1	-	1	1	1
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

5 WONGA SUITE

5.1 Timing

1760 Ma

5.2 Individual Ages

Primary Ages:

1. Granite (Natalie Granite, low-U population)	1778 ± 15 Ma, SHRIMP
2. Granite (Natalie Granite)	1758 ± 8 Ma, SHRIMP
3. Coarse grained augen gneiss (Playboy Granite)	1742 ± 13 Ma, U-Pb
4. Granite (Natalie Granite, high-U population)	1729 ± 5 Ma, SHRIMP

Sources: OZCHRON, Pearson *et al.* (1992). Note that samples 1 and 4 are two zircon populations from the one sample (sample 72-253), whilst 2 is from sample 85205001. Pearson *et al.* (1992) selected sample 75-253 as it was the oldest in the deformation sequence, and yet it apparently has the youngest age. It is worth noting that both samples are from the one belt of granite (Natalie Granite) and are compositionally similar. Both had a low-U population of zircons, which in sample 85205001 was interpreted by Pearson *et al*. (1992) as a magmatic population at 1758 ± 8 Ma, whilst in sample 72-253, the low-U population at 1778 ± 15 Ma was interpreted to be 'inherited'. Both these populations are within error, and if the low U-population was interpreted to be magmatic in both samples then the ages would be equivalent and more compatible with the observed field relationships (see discussion in Pearson *et al.* 1992, p 319). These older ages would put these intrusions within error of the main Argylla Suite ages and would suggest that much of the Wonga Suite is comagmatic with the Argylla Suite. It is worth noting that zircons from these granites and those of the Argylla Formation are all low in U.

The third sample is from an elliptical intrusion near Wonga Waterhole (informally called the Playboy Granite). It appears to intrude rocks higher in the sequence and may be part of the Burstall Suite, particularly as it shows some chemical affinities to it (Zr, Nb, Ce in particular).

5.3 Regional Setting

The Wonga Suite is a collection of granites and volcanics emplaced into the Kalkadoon-Leichhardt Belt and the Eastern Fold Belt (Blake 1987) during a major early extensional event between 1760 Ma and 1720 Ma (Holcombe *et al.* 1992; Passchier 1986; Passchier and Williams 1989). Holcombe *et al.* (1992) and Pearson *et al.* (1992) divided the granitic intrusives in the Mary Kathleen Fold Belt into two types: lower plate and upper plate intrusives. Holcombe *et al.* (1992) and Pearson *et al*. (1992) proposed that the lower plate intrusives were emplaced as elongate sills in the lower plate of a major midcrustal extensional zone, which were then progressively streaked out by the ongoing D^W deformation. In contrast, the upper plate intrusives which were emplaced as sills, apophyses and dykes in the heterogeneously sheared and stretched upper plate were much less deformed by the ongoing D^W deformation.

In this project, the lower plate intrusives are equivalent to the Wonga Suite whilst the upper plate intrusives are equivalent to the Burstall Suite. The Wonga Suite can also be shown to intrude mainly Argylla Formation, although to the south and north, it does intrude higher into the Corella Formation. For this study, we have treated the Burstall Suite as a separate entity (Chapter 6) as it does show a clear spatial relationship to some Cu and Au mineralisation.

Although the extrusives whose age is within error of the Wonga and Burstall suite granites can be found over a considerable areal extent of the Eastern Fold Belt, no systematic geochemical study has been carried out of these volcanics. The samples that have been dated (and analysed) are extremely altered and have not been incorporated in this study as it is unclear whether the volcanics are part of the Wonga Suite or the Burstall Suite. As noted in Chapter 11, new age determinations suggest that there is a possibility that most of the felsic volcanics of the Tommy Creek Block are part of the Wonga/Burstall Suites. If it can be shown that these volcanics as well as some of those currently assigned to the Argylla Formation (Chapter 4) are part of this Suite, then based on the areal extent, these two magmatic events could become one of the more significant extensional events in the Mount Isa Inlier. For this project, as the volcanics are mainly located in the younger Ballara and Mitakoodi Quartzites and the Corella Formation, they have been included in the Burstall Suite.

5.4 Summary

Plutons of the Wonga Suite are elongate, heterogeneous and high in F. They are possibly in part comagmatic with the volcanics of the Argylla Formation.

5.5 Potential

The high-F content of these granites combined with the small size of the intrusions and the lack of suitable host rocks downgrades the potential of this suite. Further, if the model of Holcombe *et al.* (1992) and Pearson *et al*. (1992) that the intrusives of the Wonga Suite have been emplaced at mid-crustal levels is correct, then there is little potential for granite-related mineralisation with these units, as they have been emplaced too deeply for a major fluid phase to exsolve. Unlike the intrusives of the Burstall suite, the Wonga Suite plutons show little evidence of alteration.

Cu:	**None**
Au:	**None**
Pb/Zn:	**None**
Sn:	**None**
Mo/W:	**None**
Confidence level:	**321**

5.6 Descriptive Data

Location: Eastern part of the Kalkadoon-Leichhardt Belt, and western part of the Eastern Fold Belt (Mary Kathleen Zone), Mount Isa Inlier.

Dimensions and area: A narrow northerly trending belt 190 km long by 10 km wide. Total area covered by the intrusives of this suite is 315 km^2.

5.7 Intrusives

Component plutons: Playboy Granite, Wonga Granite, Birds Well Granite, Bushy Park Gneiss and as yet informally named units of the Wonga Batholith on the Mary Kathleen, Marraba, Prospector and Quamby 1:100000 map sheet area (Mount Maggie granite, Natalie granite, Scheelite granite, Winston Churchill granite). Some of the fine-grained xenolith-rich mapped intrusives are not likely to be cogenetic with the coarser grained intrusives and they are possibly S-type (Wyborn *et al.*1988).

Form: Extremely elongate, almost dyke-like plutons. Bushy Park Gneiss - forms a series of intrusive pods and elongate lenses.

Metamorphism and Deformation: All intrusions are weakly to strongly deformed and most are metamorphosed to upper amphibolite facies. Birds Well Granite - weakly foliated to gneissic, extensively recrystallised, Bushy Park Gneiss - strongly foliated and gneissic; extensively recrystallised.

Dominant intrusive rock types: The individual granite intrusions are all heterogeneous, implying that the melts never homogenised. The dominant intrusive type is a coarse-grained strongly porphyritic granite. In the Mary Kathleen 1:100 000 sheet area, Pearson *et al*. (1992) have identified 14 granite types ranging from pale to dark, fine to-coarse grained, porphyritic to even-grained granite, to leucocratic alkali granite. *Specifically*: Birds Well Granite - medium to coarse-grained, slightly to markedly porphyritic granite, leucogranite, augen gneiss; Bushy Park Gneiss - coarse-grained orthogneiss and augen gneiss: slightly foliated to gneissic porphyritic granite, medium to coarse-grained leucocratic gneiss.

Colour: Pink to grey. *Specifically*: Birds Well Granite - pink.

Veins, Pegmatites, Aplites, Greisens: Pegmatites are common and contain quartz, feldspar ± tourmaline. *Specifically*: Birds Well Granite - aplite and pegmatite present, mainly as thin veins; Bushy Park Gneiss - tourmaline-bearing pegmatite present.

Distinctive mineralogical characteristics: Quartz, K-feldspar, plagioclase, biotite ± hornblende. Where present the amphibole is a deep blue-green ferrohastingsite and is rich in Cl.

Accessory minerals include titanite, apatite, zircon, fluorite, allanite and tourmaline (Pearson *et al.* 1992). *Specifically*: Birds Well Granite - K-feldspar, quartz, plagioclase, biotite is the main mafic mineral, but hornblende predominates locally; Bushy Park Gneiss - K-feldspar, quartz, plagioclase: biotite, hornblende.

Breccias: Some breccias occur, but these are probably related to the deformation.

Alteration in the granite: Metasomatic alteration products include muscovite, scapolite, chlorite and some opaques (Pearson *et al.* 1992). These alteration minerals are likely to have formed as a result of metamorphic and deformation processes rather than magmatic effects.

5.8 Extrusives

There is a possibility that felsic volcanics of the Argylla Formation (Chapter 4) are part of this suite.

5.9 Country Rock

Contact metamorphism: Due to the later metamorphic overprint it is unlikely that any original contact aureoles are preserved.

Reaction with country rock: Due to the later widespread metasomatic overprint any primary interaction with the country rock would be difficult to distinguish.

Units the granite intrudes:Leichhardt Volcanics, Kalkadoon Granodiorite, Argylla Formation, Magna Lynn Metabasalt, Corella Formation, unnamed dolerite.

Dominant rock types: Predominantly felsic volcanics, with minor mafic volcanics, basalt, carbonates.

Potential hosts: Mafic volcanics and basalt.

5.10 Mineralisation

The suite is poorly mineralised. There are a number of small Cu prospects and shows in the vicinity of the plutons of the Wonga Suite, but these are believed to have formed as a result of the later metamorphism and deformation. The suite itself is not considered to be all that prospective as it is a high-F suite and a genuine A-type. Further, the plutons are all small and unlikely to concentrate sufficient quantities of metal and the most abundant host rocks are unreactive felsic volcanics.

5.11 Geochemical Data

Data source: AGSO's OZCHEM database.

Data quality: Good.

Are the data representative? For the plutons on the sheet areas to the north of the Duchess 1:250000 map sheet area it is not known whether the samples collected reflect dominant or minority types, as the plutons have not been systematically mapped throughout the area. However, given the heterogeneity of the 'lower plate' Wonga Suite intrusives, the mapping would have to be at a scale of 1:5000 in order to fully resolve the granite systematics.

Are the data adequate? For such a heterogeneous granite system the data cannot be regarded as adequate. More sampling is definitely required.

SiO_2 range (Fig. 5.1): The SiO_2 range is from 62 to 77 wt.%, peak at 72 wt.%.

Alteration (Fig. 5.2):

- ***SiO_2:*** No significant silicification noted.
- ***K_2O/Na_2O:*** Some Na-alteration only in samples of the Playboy Granite. Given the degree of deformation and metamorphism of the samples analysed, this plot is somewhat surprising. It can only be reconciled by suggesting that the regional alteration that has been extensively documented for the Mary Kathleen Belt (*e.g.*, Oliver 1995, Oliver *et al.* 1994), only affected granites intrusive into the upper plate (Pearson *et al.* 1992; Holcombe *et al*. 1992). Another suggestion is that many of the Burstall Suite plutons intrude the reactive Corella Formation, whilst most of the plutons of the Wonga Suite intrude the unreactive Argylla Formation. The Playboy Granite, located at Wonga Waterhole is the most altered and appears to intrude highest into the sequence. Further, the comagmatic alteration documented within the Revenue Granite of the Burstall Suite by Aslund (1994) and Aslund *et al*. (1995), has not been located within the Wonga Suite plutons, suggesting that Wonga Suite plutons have not derived a late magmatic fluid.
- ***Th/U:*** There has been some loss of U in some samples, presumably due to the deformation.

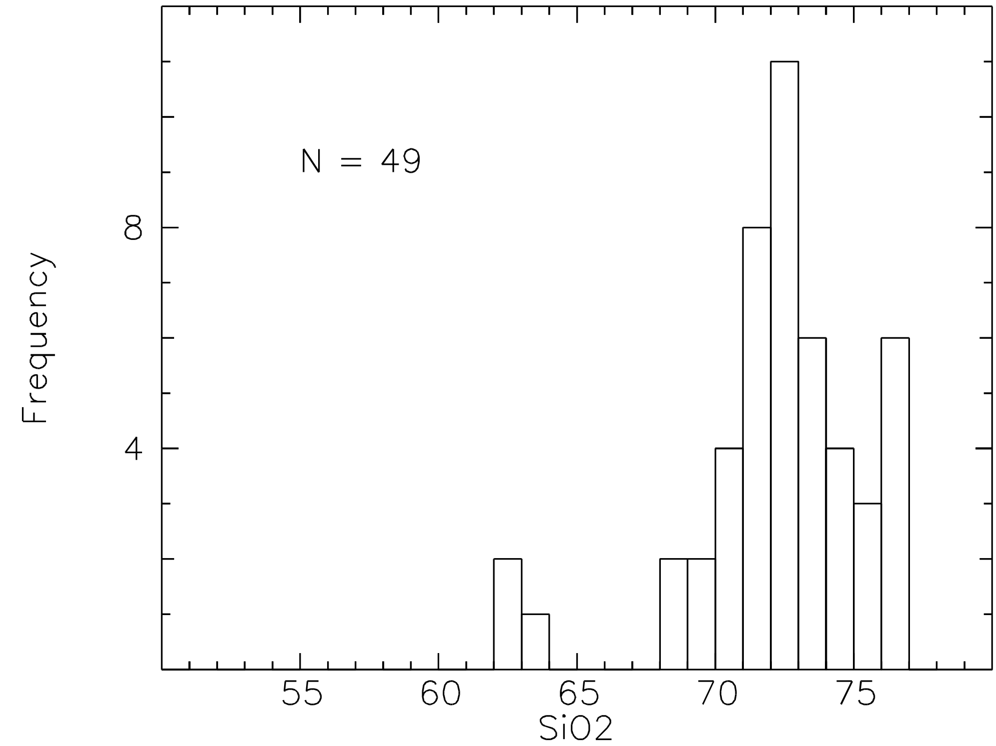


Figure 5.1. Frequency histogram of SiO_2 values for the Wonga Suite.

- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** Samples appear to become more oxidised with increasing SiO_2 although this may be an artifact of the metamorphism and alteration.

Fractionation Plots (Fig. 5.3):

- ***Rb:*** No change in Rb with increasing SiO_2.
- ***U:*** Samples show exponential increase with increasing SiO_2.
- ***Y:*** Some plutons show a weak increase with increasing SiO_2.
- ***P_2O_5:*** All samples show a decrease in P_2O_5 with increasing SiO_2.
- ***Th:*** Samples show a weak increase with increasing SiO_2.
- ***K/Rb:*** Samples show a weak decrease with increasing SiO_2.
- ***Rb-Ba-Sr:*** Most samples plot in the strongly differentiated field.
- ***Sr:*** Values are extremely low for Australian Proterozoic felsic igneous rocks.
- ***Rb/Sr:*** Samples show a weak exponential increase with increasing SiO_2.
- ***Ba:*** Samples show a decrease with increasing SiO_2.
- ***F:*** Values are very high and are within the range of A-types defined by Eby (1990) for Palaeozoic A-type granites.

Metals (Fig. 5.4):

- ***Cu:*** Values are mostly low.
- ***Pb:*** Values are moderate to low.
- ***Zn:*** Values are moderate to low.
- ***Sn:*** Values are moderate to low.

High field strength elements (Fig. 5.5):

- ***Zr:*** Samples show a decrease with increasing SiO_2: overall values are moderate to low.
- ***Nb:*** Values are moderate to low. For the Playboy Granite, these values are remarkably similar to trends of the Burstall Suite plutons.
- ***Ce:*** Values are moderate to low. For the Playboy Granite, these values are remarkably similar to trends of the Burstall Suite plutons.

Classification (Fig. 5.6):

- ***The CaO/Na_2O/K_2O plot of White, quoted in Sheraton and Simons (1992):*** Most samples plot in the granite and monzogranite field due to the high SiO_2 contents of the suite.
- ***Zr/Y vs Sr/Sr*:*** All values are below 1 indicating that the suite is Sr-depleted, Y-undepleted.
- ***Spidergram:*** The spidergrams are Sr-depleted, Y-undepleted and show strong fractionation of Sr, P and TiO_2.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples plot in the oxidised field, with five out of eight samples of the Mount Maggie Granite being reduced. There are some black shales of the Corella Formation in the vicinity, but the pluton does not directly intrude them.
- ***ASI:*** All samples are metaluminous to weakly peraluminous.
- ***A-type plot of Eby (1990):*** The samples straddle the boundary between the normal granites and A-type granites as defined for Palaeozoic igneous suites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-(granodiorite) type.

Australian Proterozoic Granite type: Sybella.

5.12 Geophysical Signature

Radiometrics (Fig. 5.7): All samples plot well above the Proterozoic median values for K_2O, and Th and most plot above it for U. It is predicted that the colour of this suite would be white for most plutons, with those that have lost U appearing yellow.

Gravity: The measured wet densities range from 2.56 to 2.77 gm/cm^3(Hone *et al.* 1987), with the highest densities being recorded in the more mafic, deformed and metamorphosed samples (Wyborn, unpublished data). The regional gravity data are too coarse relative to the size of the plutons for meaningful correlations to be made.

Magnetics: Only the regional magnetics are available, and these are coarse relative to the elongate outline of the plutons.

5.13 References

Aslund, T. 1994. Deformation and fluid flow within a syn-tectonic granite hydrothermal system, Revenue Granite, Duchess: regional implications. *Mount Isa Inlier, One Day Seminar, AMF Workshop Course No. 902/94,* p29.

Aslund, T., Oliver, N.H.S. and Cartwright, I. 1995. Metasomatism of the Revenue Granite and aureole rocks, Mt Isa Inlier, Queensland. *Australian Journal of Earth Sciences,* 42, 291-299.

Blake, D.H. 1981. Intrusive felsic-mafic net-veined complexes in north Queensland. *BMR Journal of Australian Geology and Geophysics*, 5, 243-256.

Blake, D.H. 1987. Geology of the Mount Isa Inlier and environs, Queensland and Northern Territory. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 225.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981a. Definitions of new and revised Precambrian stratigraphic and intrusive rock units in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report*, 233, *(BMR Microfilm* MF 164*).*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981b. Summary of new and revised Precambrian stratigraphic nomenclature in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Queensland Government Mining Journal,* 82, 580-589.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1982, Dajarra, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1984, Geology of the Duchess-Urandangi region, Mount Isa Inlier, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 219.

Derrick, G.M., Wilson, I.H., Hill, R.M., Glikson, A.Y. and Mitchell, J.E. 1977. Geology of the Mary Kathleen 1:100000 Sheet area, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin*, 193, 114 pp.

Derrick, G.M., Wilson, I.H., Hill, R.M. and Mitchell, J.E. 1971. Geology of the Marraba 1:100000 Sheet area, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1971/56, 142 pp.

Holcombe, R.J., Pearson, P.J. and Oliver, N.H.S. 1992. Structure of the Mary Kathleen Fold Belt. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 243, 257-287.

Hone, I.G., Carberry, V.P. and Reith, H.G. 1987. Physical property measurements on rock samples from the Mount Isa Inlier, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report*, 265, 30 pp.

Oliver, N.H.S. 1995. Hydrothermal history of the Mary Kathleen Fold Belt, Mt Isa Block, Queensland. *Australian Journal of Earth Sciences,* 42, 267-279.

Oliver, N.H.S., Rawling, T.J., Cartwright, I. and Pearson, P.J. 1994. High-temperature fluid-rock interaction and scapolitization in an extensional-related hydrothermal system, Mary Kathleen, Australia. *Journal of Petrology,* 35, 1455-1491.

Passchier, C.W. 1986. Evidence for early extensional tectonics in the Proterozoic Mount Isa Inlier, Australia. *Geology*, *14,* 1008-1011.

Passchier, C.W. and Williams, P.R. 1989. Proterozoic extensional deformation in the Mount Isa Inlier, Queensland, Australia. *Geological Magazine*, 126, 43-53.

Page, R.W. 1978. Response of U-Pb zircon and Rb-Sr total-rock and mineral systems to low-grade regional metamorphism in Proterozoic igneous rocks, Mount Isa, Australia. *Journal of the Geological Society of Australia*, 25, 141-164.

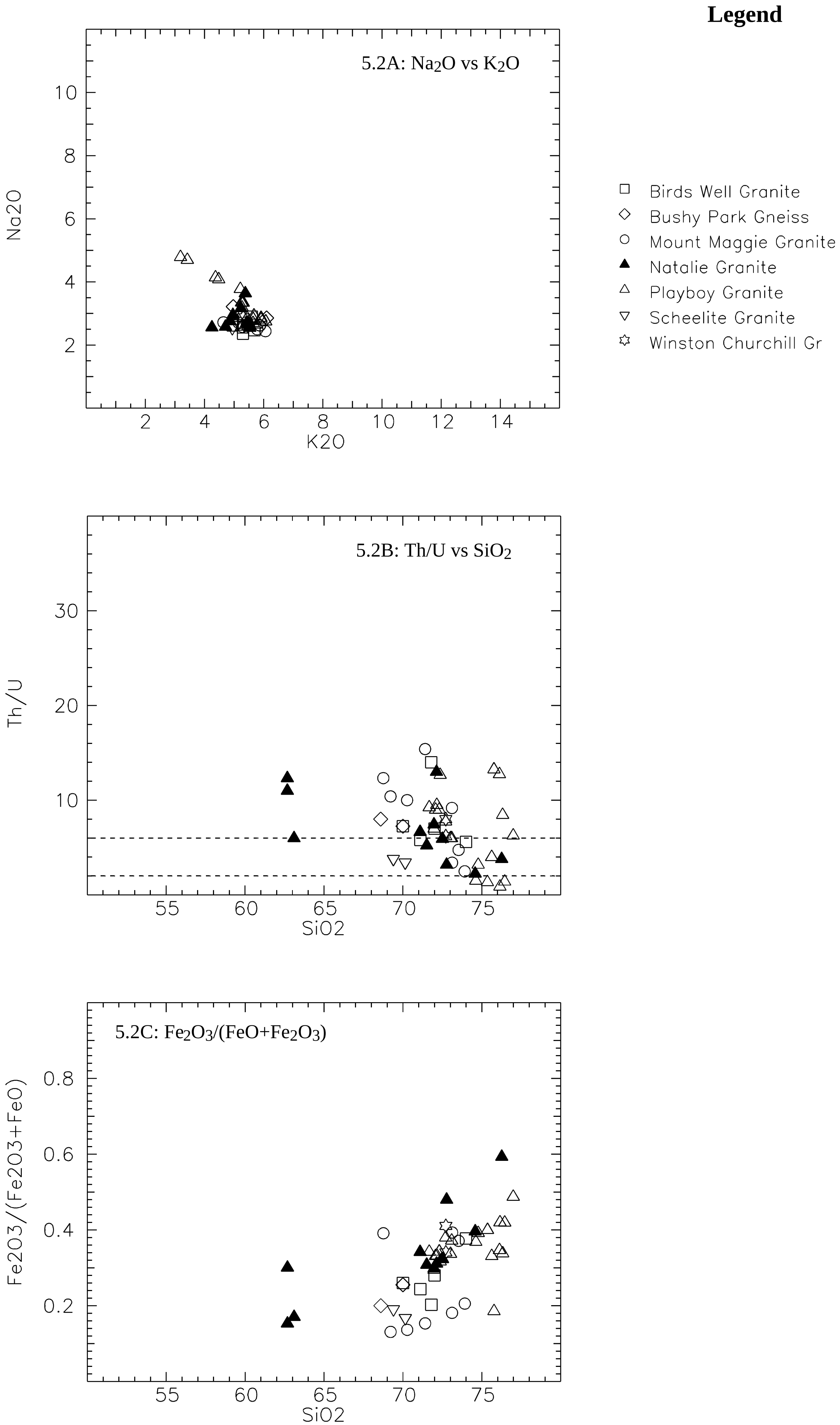
Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, *EGRU Contribution 55*, 95-98.

Page, R.W. and Sun, S.-S. 1998. Aspects of geochronology and crustal evolution in the Eastern Fold Belt, Mount Isa Inlier. *Australian Journal of Earth Sciences,* 45, 343-361.

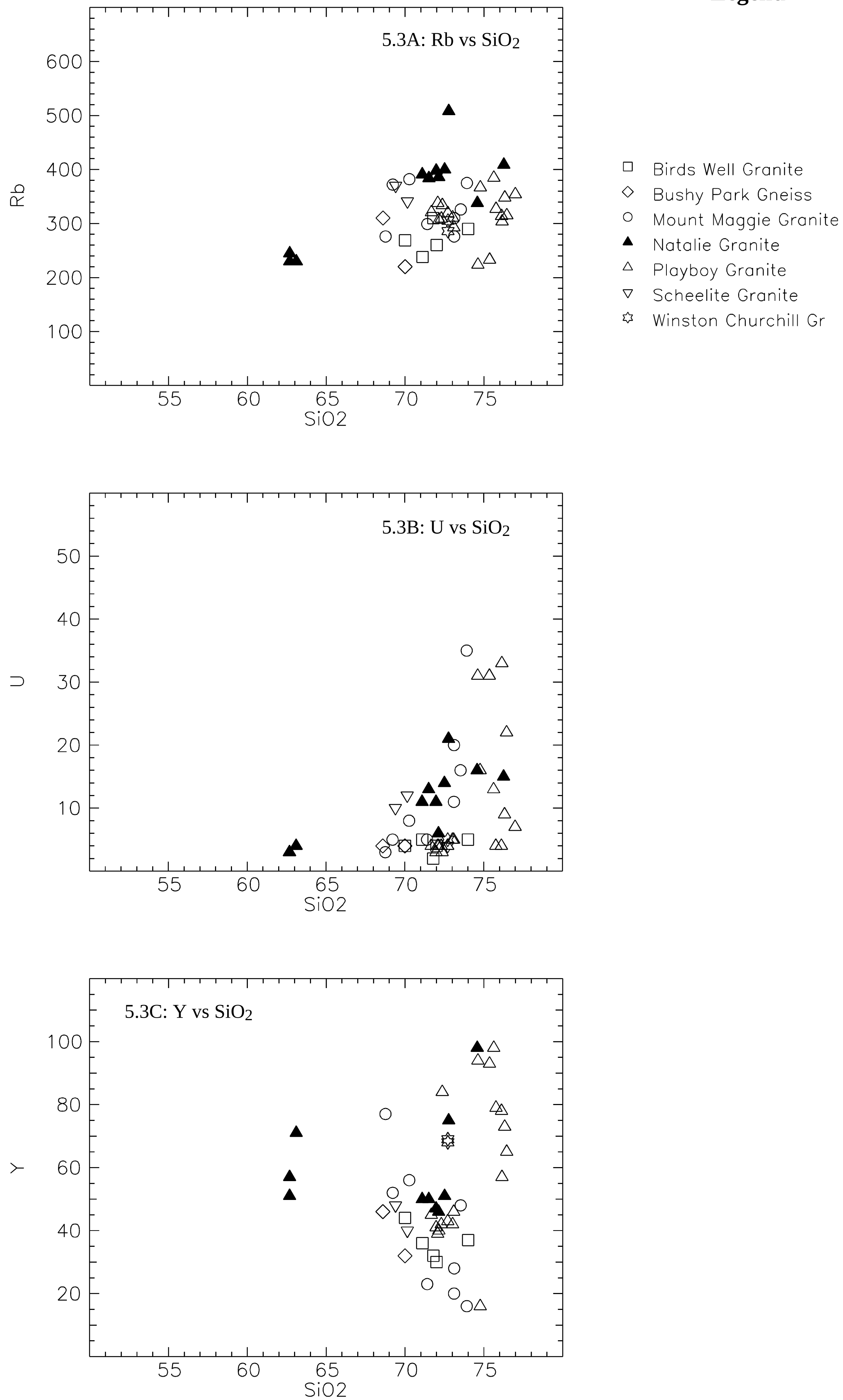
Page, R.W., Sun, S.-S. and McCready, T. 1997. New geochronological results in the central and eastern Mount Isa Inlier and implications for mineral exploration. *Abstracts, Geodynamics and Ore Deposits Conference, Australian Geodynamics Cooperative Research Centre, Ballarat, Victoria,* 46-48.

Pearson, P.J., Holcombe, R.J. and Page, R.W. 1992. Synkinematic emplacement of the Middle Proterozoic Wonga Batholith into a mid-crustal extensional shear zone, Mount Isa Inlier, Queensland, Australia, In Stewart, A.J. and Blake, D.H. (editors), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 243, 289-328.

Wyborn, L.A.I., Page, R.W. and McCulloch, M.T. 1988, Petrology, geochronology and isotope geochemistry of the post-1820 Ma Granites of the Mount Isa Inlier: Mechanisms for the generation of Proterozoic anorogenic granites. *Precambrian Research*, 40/41, 509-541.

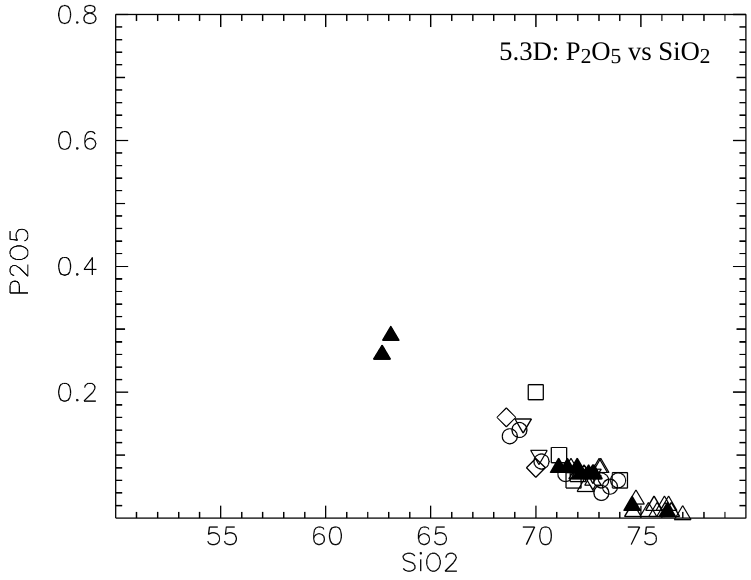

Legend
Birds Well Granite
Bushy Park Gneiss
Mount Maggie Granite
Natalie Granite
Playboy Granite
Scheelite Granite
Winston Churchill Gr
5.2A: Na2O vs K2O
Na2O
K2O
5.2B: Th/U vs SiO2
Th/U
SiO2
5.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2

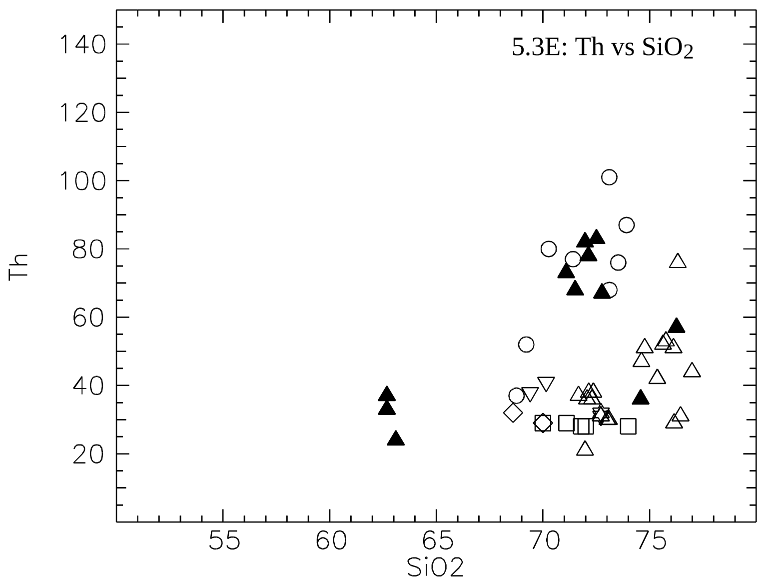
Legend

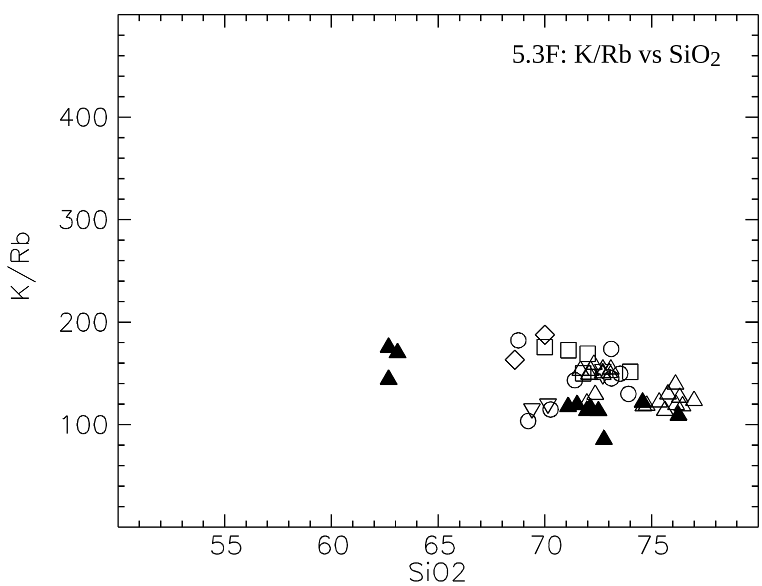

5.3A: Rb vs SiO2
Rb
600
500
400
300
200
100
55
60
65
70
75
SiO2
Birds Well Granite
Bushy Park Gneiss
Mount Maggie Granite
Natalie Granite
Playboy Granite
Scheelite Granite
Winston Churchill Gr
5.3B: U vs SiO2
U
50
40
30
20
10
55
60
65
70
75
SiO2
5.3C: Y vs SiO2
Y
100
80
60
40
20
55
60
65
70
75
SiO2

Legend

- □ Birds Well Granite
- ◇ Bushy Park Gneiss
- ○ Mount Maggie Granite
- ▲ Natalie Granite
- △ Playboy Granite
- ▽ Scheelite Granite
- ✡ Winston Churchill Gr

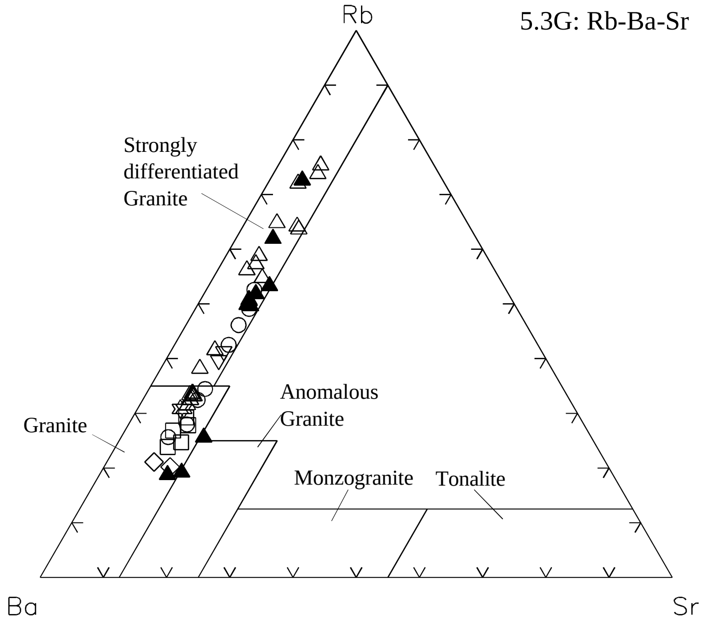


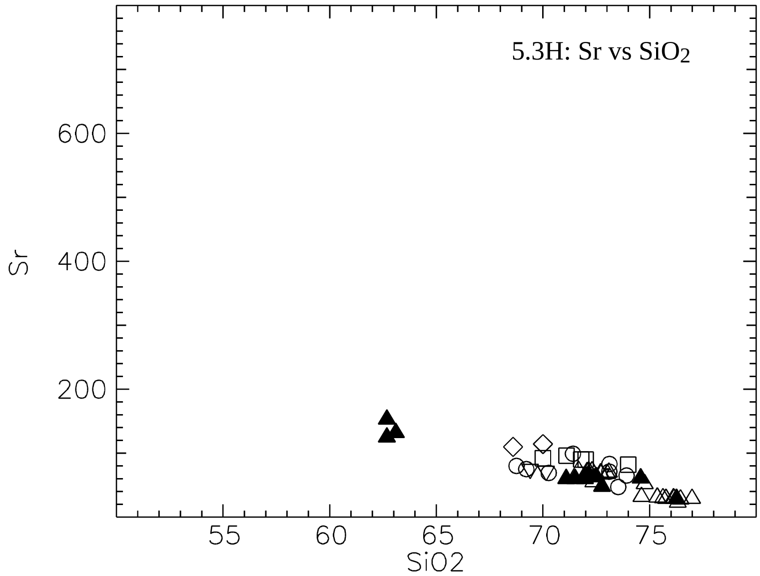


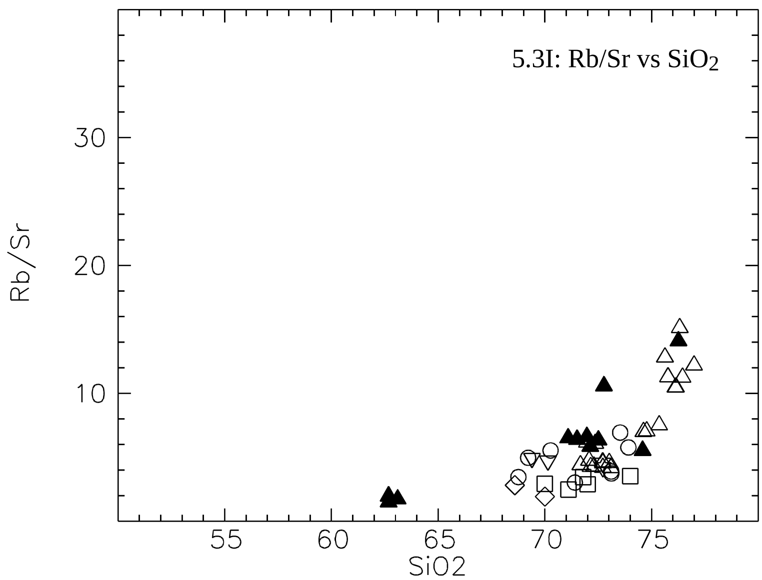


Legend

- □ Birds Well Granite
- ◇ Bushy Park Gneiss
- ○ Mount Maggie Granite
- ▲ Natalie Granite
- △ Playboy Granite
- ▽ Scheelite Granite
- ✡ Winston Churchill Gr

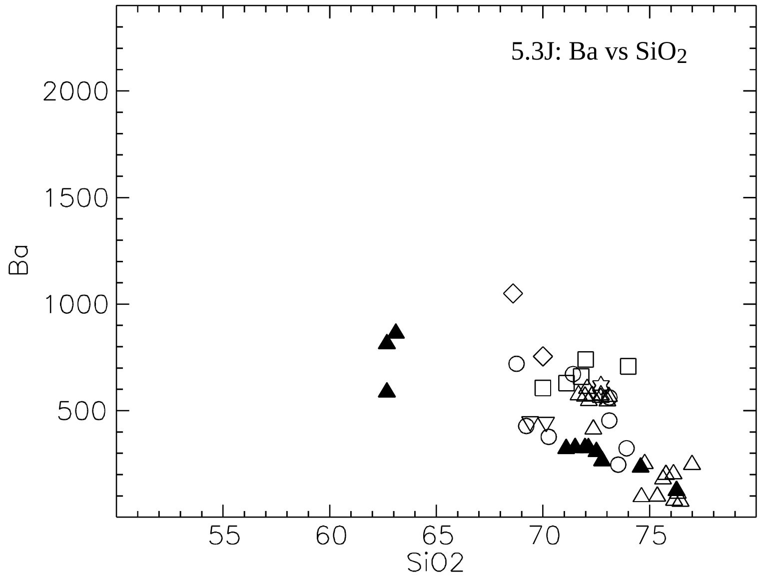


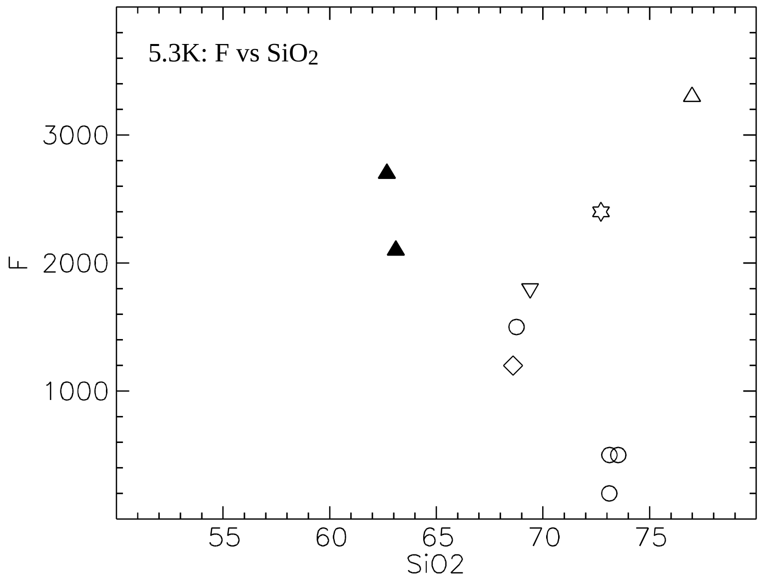


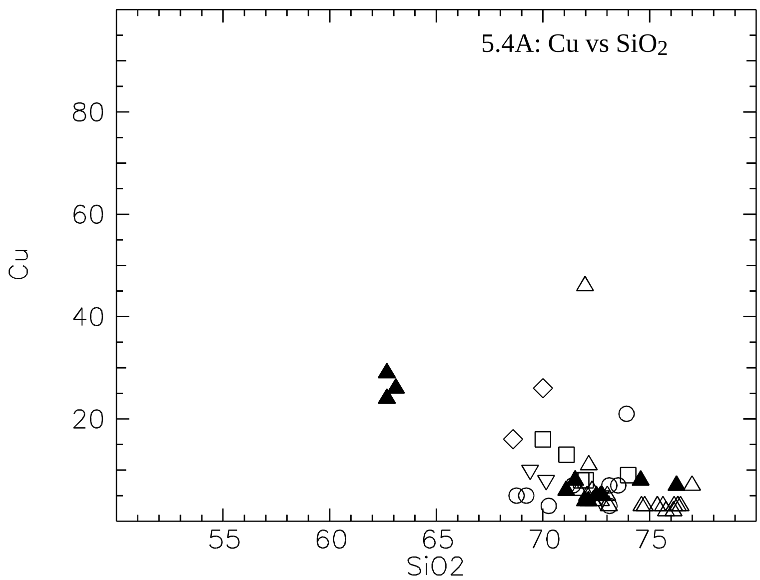


Legend

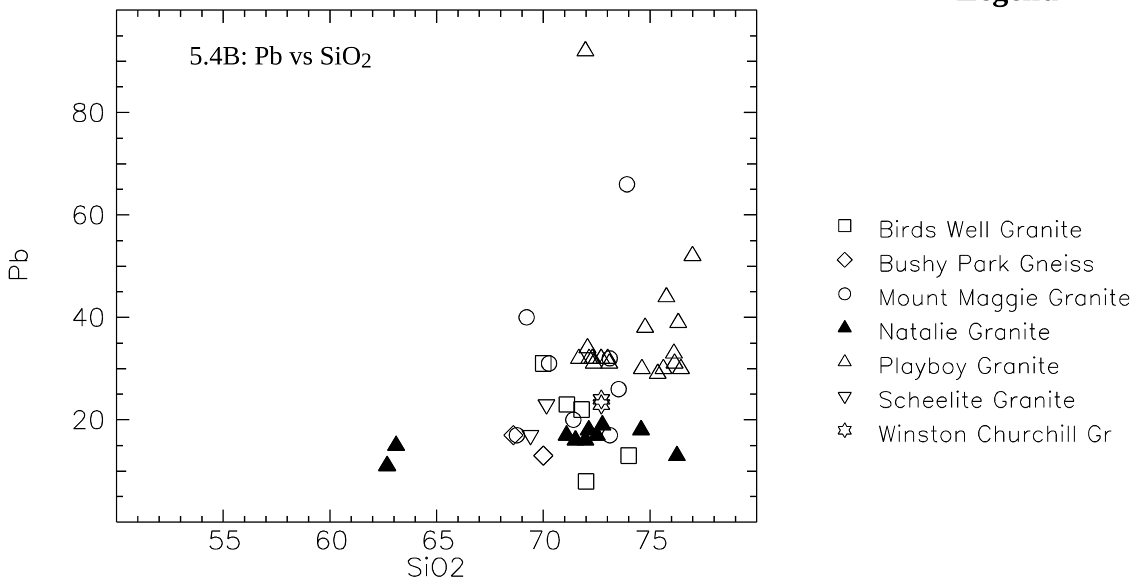

Birds Well Granite
Bushy Park Gneiss
Mount Maggie Granite
Natalie Granite
Playboy Granite
Scheelite Granite
Winston Churchill Gr

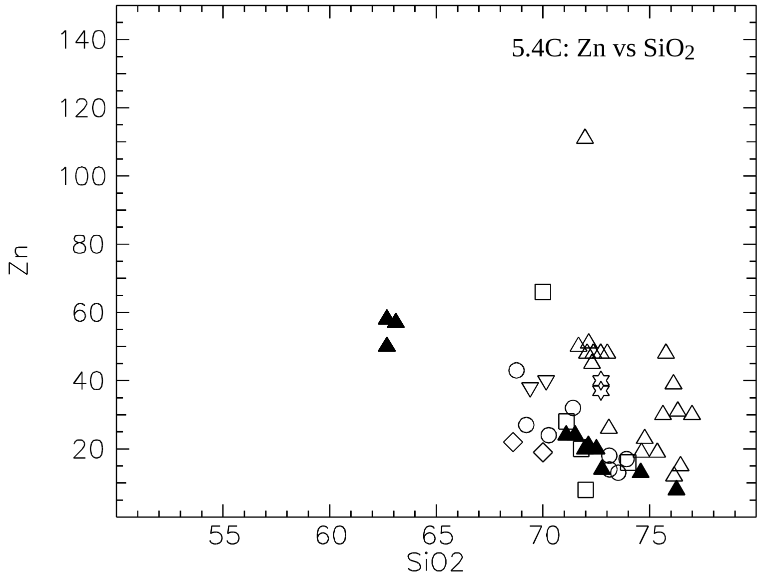

5.3J: Ba vs SiO2
Ba
2000
1500
1000
500
55
60
65
70
75
SiO2

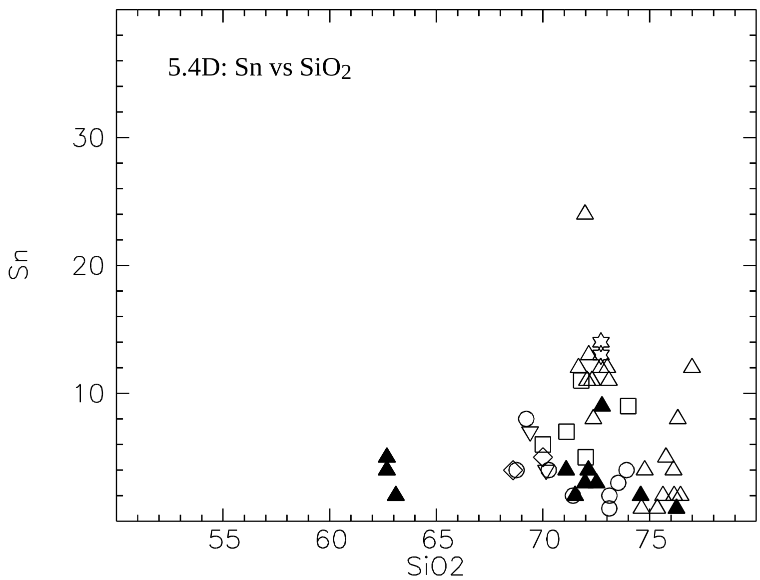

5.3K: F vs SiO2
F
3000
2000
1000
55
60
65
70
75
SiO2

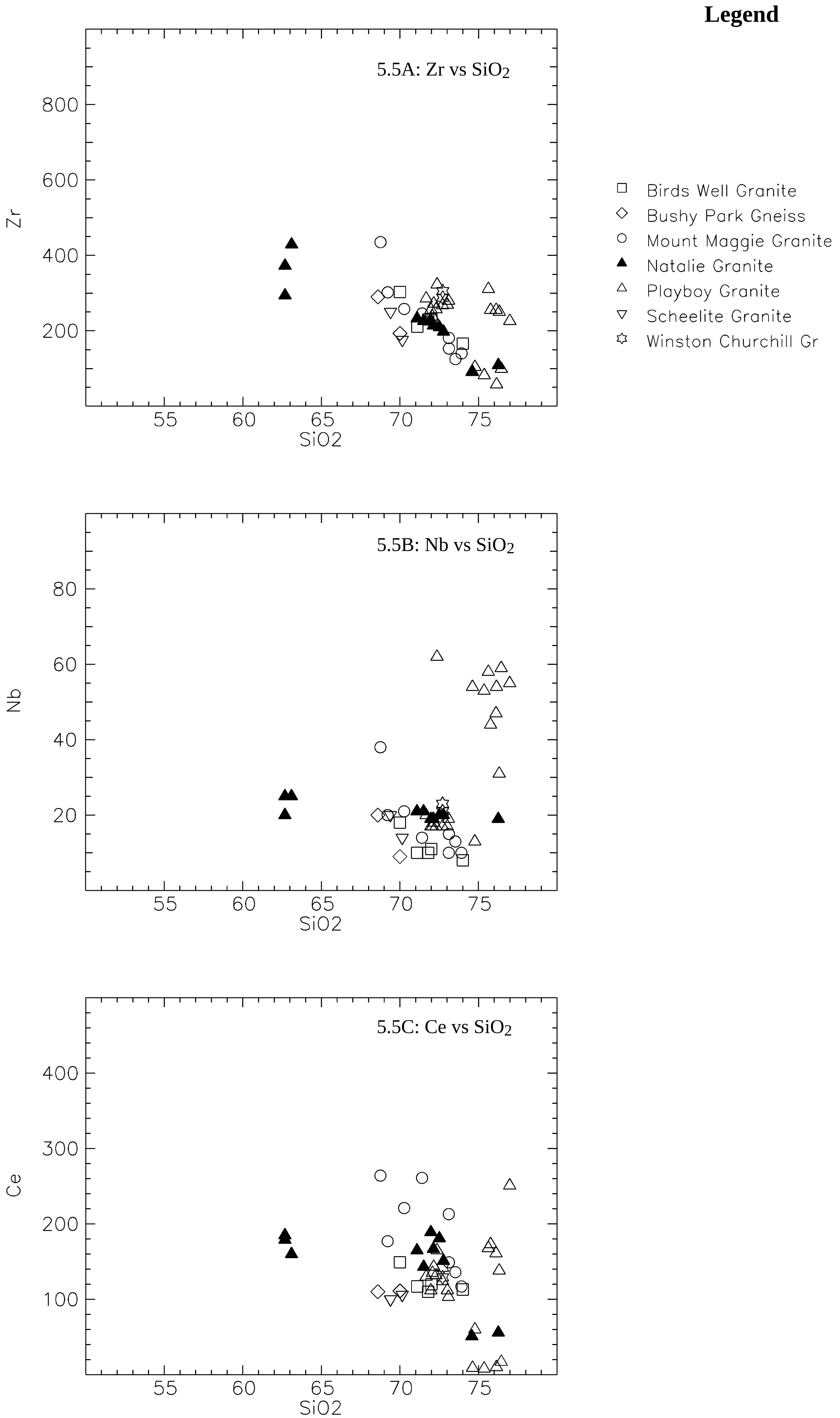

5.4A: Cu vs SiO2
Cu
80
60
40
20
55
60
65
70
75
SiO2

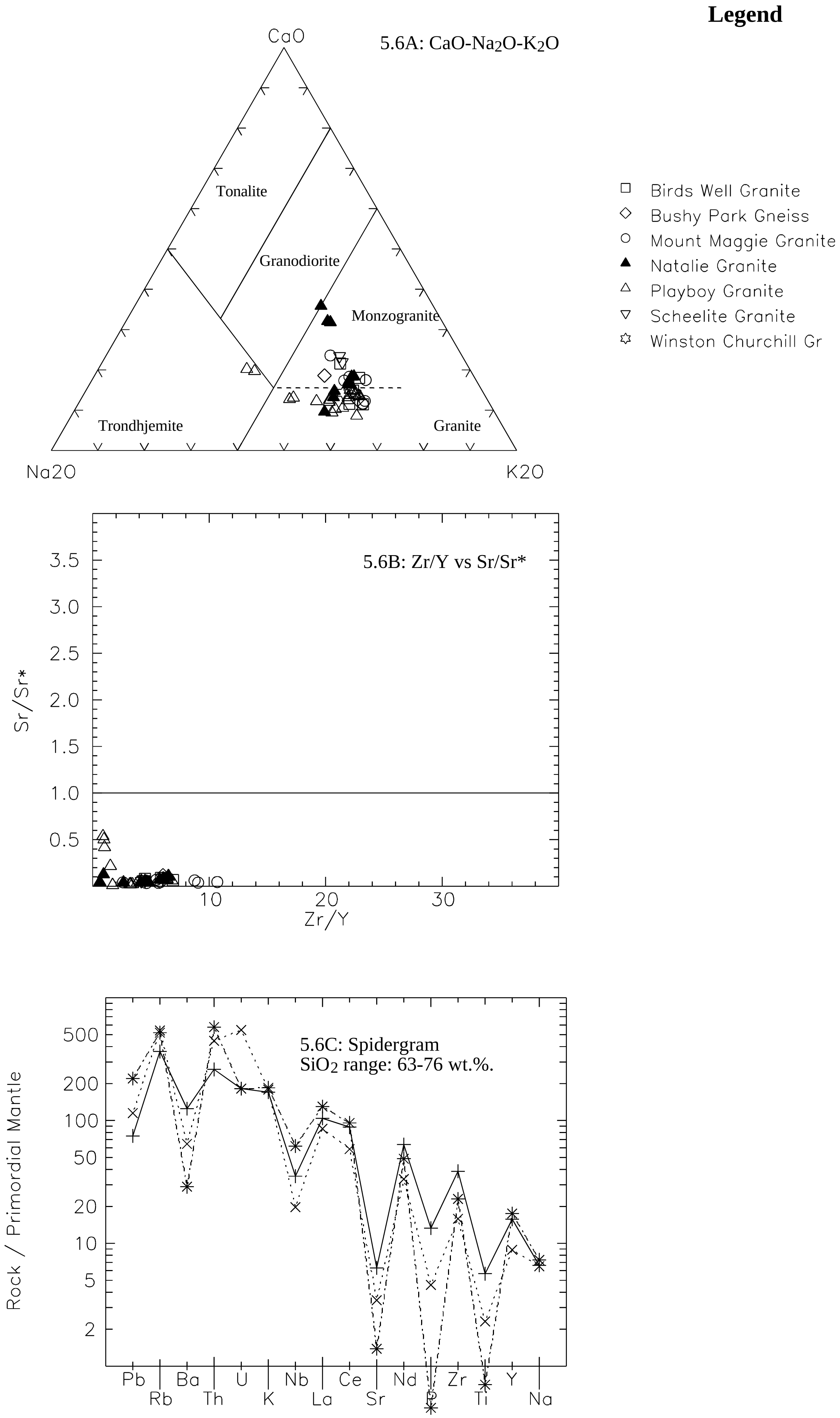
Legend


5.4B: Pb vs SiO2
Pb
SiO2
80
60
40
20
55
60
65
70
75
Birds Well Granite
Bushy Park Gneiss
Mount Maggie Granite
Natalie Granite
Playboy Granite
Scheelite Granite
Winston Churchill Gr


5.4C: Zn vs SiO2
Zn
SiO2
140
120
100
80
60
40
20
55
60
65
70
75

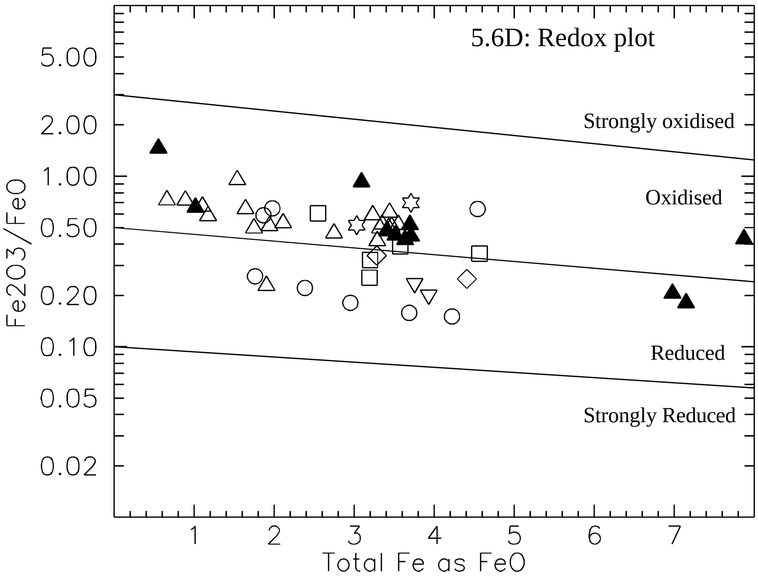

5.4D: Sn vs SiO2
Sn
SiO2
30
20
10
55
60
65
70
75

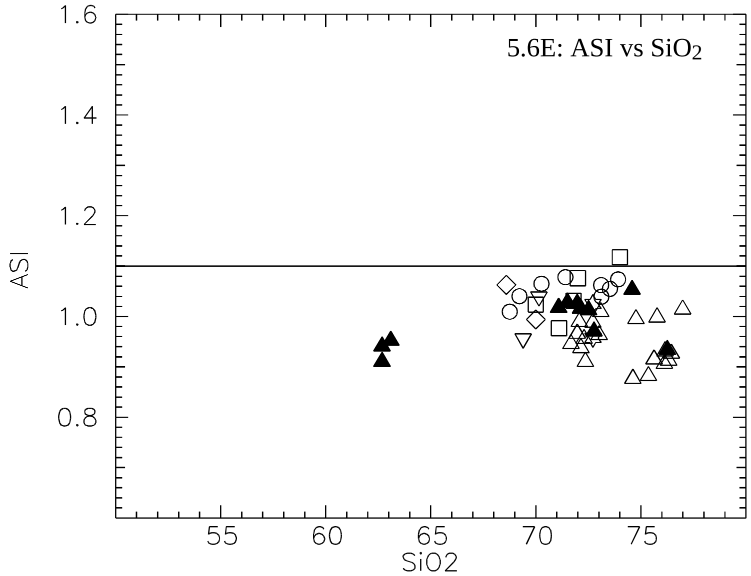

Legend
Birds Well Granite
Bushy Park Gneiss
Mount Maggie Granite
Natalie Granite
Playboy Granite
Scheelite Granite
Winston Churchill Gr
5.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
5.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
5.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

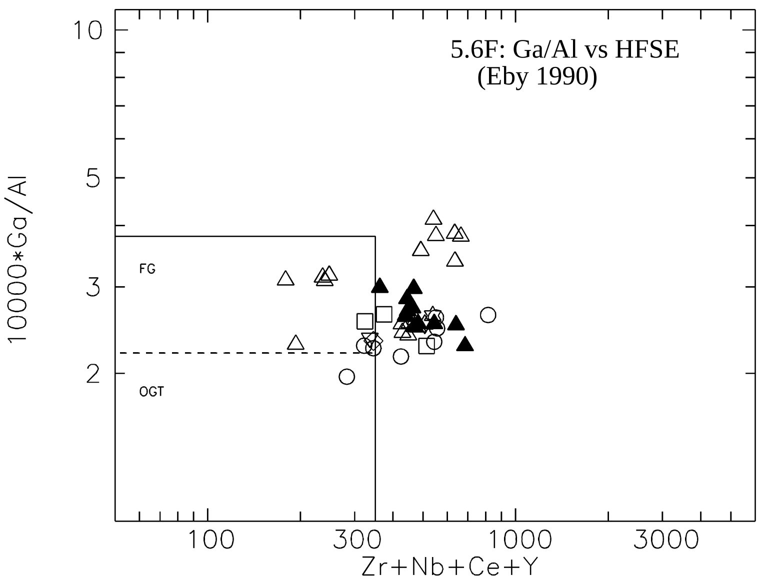

Legend
CaO
5.6A: CaO-Na2O-K2O
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
Na2O
K2O
Birds Well Granite
Bushy Park Gneiss
Mount Maggie Granite
Natalie Granite
Playboy Granite
Scheelite Granite
Winston Churchill Gr
5.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
3.5
3.0
2.5
2.0
1.5
1.0
0.5
10
20
30
Zr/Y
5.6C: Spidergram
SiO2 range: 63-76 wt.%.
Rock / Primordial Mantle
500
200
100
50
20
10
5
2
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na

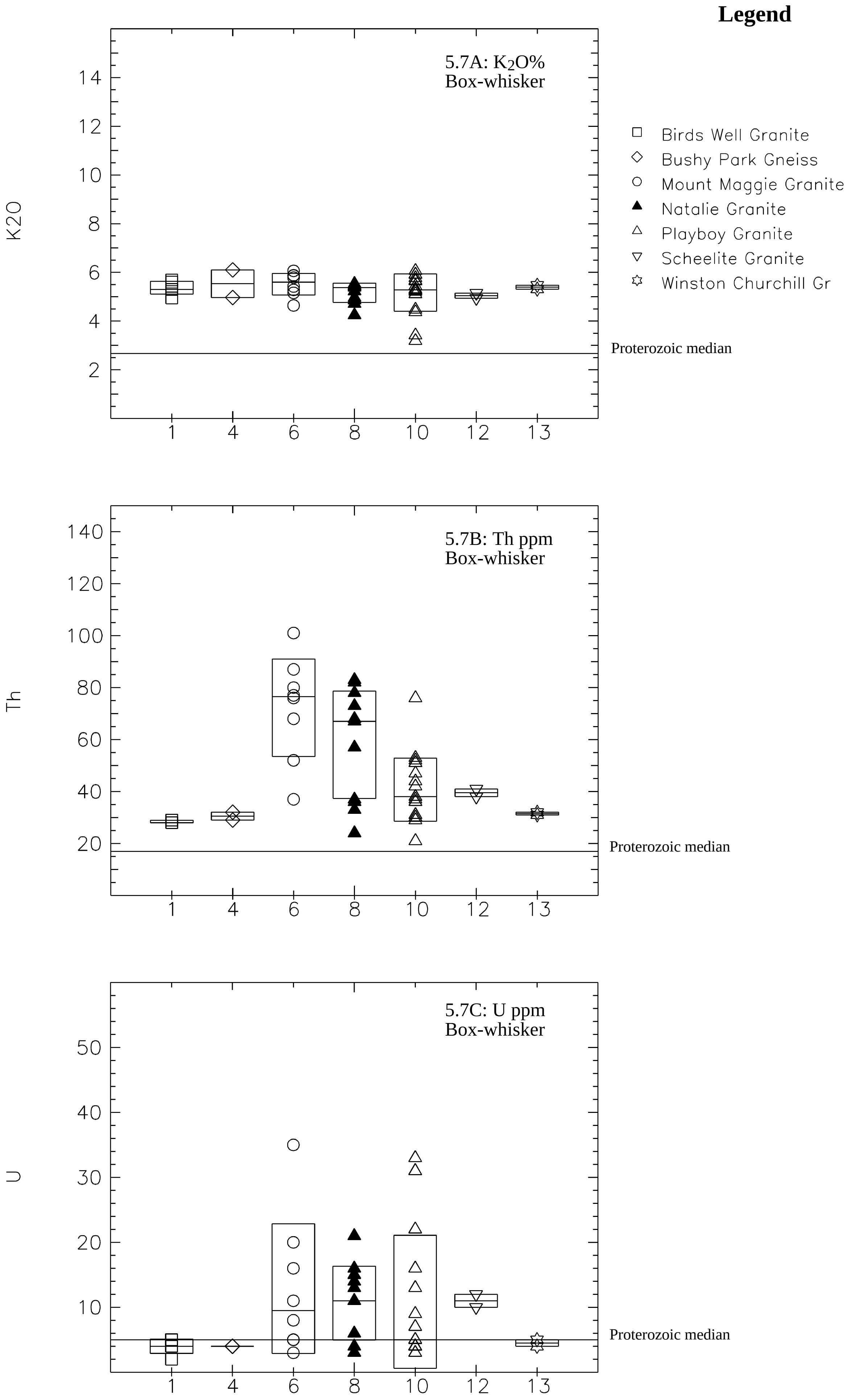
Legend

- Birds Well Granite
- Bushy Park Gneiss
- Mount Maggie Granite
- Natalie Granite
- Playboy Granite
- Scheelite Granite
- Winston Churchill Gr








Legend
5.7A: K$_2$O%
Box-whisker
K2O
14
12
10
8
6
4
2
Proterozoic median
1
4
6
8
10
12
13
Birds Well Granite
Bushy Park Gneiss
Mount Maggie Granite
Natalie Granite
Playboy Granite
Scheelite Granite
Winston Churchill Gr
5.7B: Th ppm
Box-whisker
Th
140
120
100
80
60
40
20
Proterozoic median
1
4
6
8
10
12
13
5.7C: U ppm
Box-whisker
U
50
40
30
20
10
Proterozoic median
1
4
6
8
10
12
13

Birds Well Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.78	71.8	1.47	70	74	5
TiO2	0.42	0.39	0.11	0.28	0.58	5
Al2O3	13.02	13.1	0.28	12.6	13.3	5
Fe2O3	0.94	1	0.22	0.66	1.22	5
FeO	2.57	2.6	0.65	1.65	3.47	5
MnO	0.04	0.04	0.02	0.02	0.06	5
MgO	0.56	0.6	0.09	0.4	0.62	5
CaO	1.47	1.37	0.46	0.99	2.08	5
Na2O	2.58	2.56	0.2	2.36	2.9	5
K2O	5.37	5.3	0.29	4.95	5.69	5
P2O5	0.1	0.07	0.06	0.06	0.2	5
H2O+	0.6	0.59	0.16	0.45	0.84	5
H2O-	0.17	0.17	0.03	0.13	0.2	5
CO2	0.09	0.05	0.08	05	0.2	5
LOI	-	-	-	-	-	-
Ba	668.8	660	55.07	606	740	5
Li	23	22	13.53	10	37	3
Rb	273.4	269	27.69	238	310	5
Sr	90	90	5.1	82	96	5
Pb	19.4	22	9.02	8	31	5
Th	28.4	28	0.55	28	29	5
U	4	4	1.22		5	5
Zr	228	230	49.41	166	303	5
Nb	11.4	10	3.85	8	18	5
Y	35.8	36	5.4	30	44	5
La	63	63	14.73	40	80	5
Ce	121.8	117	15.67	110	149	5
Pr	-	-	-	-	-	-
Nd	58	52	11.27	51	71	3
Sc	5.67	7	2.31	3	7	3
V	25.8	24	10.26	12	40	5
Cr	13	12	2.65	11	16	3
Mn	-	-	-	-	-	-
Co	4.17	5	1.44		5	3
Ni	4.33	4	0.58	4	5	3
Cu	10.8	9	3.56	8	16	5
Zn	27.6	20	22.65	8	66	5
Sn	7.6	7	2.41	5	11	5
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	17	17	1	16	18	3
As	1.5	1	1.32		3	3
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Bushy Park Gneiss

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.3	69.3	0.99	68.6	70	2
TiO2	0.44	0.44	0.08	0.38	0.5	2
Al2O3	13.95	13.95	0.21	13.8	14.1	2
Fe2O3	0.88	0.88	0.03	0.86	0.9	2
FeO	3.05	3.05	0.77	2.51	3.6	2
MnO	0.04	0.04	0.01	0.03	0.05	2
MgO	0.63	0.63	0.04	0.6	0.65	2
CaO	1.58	1.58	0.41	1.29	1.87	2
Na2O	3.04	3.04	0.25	2.86	3.22	2
K2O	5.53	5.53	0.8	4.97	6.1	2
P2O5	0.12	0.12	0.06	0.08	0.16	2
H2O+	0.71	0.71	0.29	0.5	0.91	2
H2O-	0.09	0.09	0.08	0.04	0.15	2
CO2	0.03	0.03	0.03	01	0.05	2
LOI	-	-	-	-	-	-
Ba	902.5	902.5	208.6	755	1050	2
Li	13	13	-	13	13	1
Rb	265	265	63.64	220	310	2
Sr	112	112	2.83	110	114	2
Pb	15	15	2.83	13	17	2
Th	30.5	30.5	2.12	29	32	2
U	4	4	-	4	4	2
Zr	241.5	241.5	68.59	193	290	2
Nb	14.5	14.5	7.78	9	20	2
Y	39	39	9.9	32	46	2
La	64	64	8.49	58	70	2
Ce	110.5	110.5	0.71	110	111	2
Pr	-	-	-	-	-	-
Nd	44	44	-	44	44	1
Sc	5	5	-	5	5	1
V	35	35	21.21	20	50	2
Cr	10	10	-	10	10	1
Mn	-	-	-	-	-	-
Co	5	5	-	5	5	1
Ni	4	4	-	4	4	1
Cu	21	21	7.07	16	26	2
Zn	20.5	20.5	2.12	19	22	2
Sn	4.5	4.5	0.71	4	5	2
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	17	17	-	17	17	1
As	1	1	-	1	1	1
S	-	-	-	-	-	-
F	1200	1200	-	1200	1200	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Mount Maggie Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.67	72.26	2.04	68.76	73.92	8
TiO2	0.31	0.28	0.16	0.14	0.59	8
Al2O3	13.55	13.55	0.28	13.1	13.86	8
Fe2O3	0.72	0.53	0.48	0.37	1.85	8
FeO	2.28	2.26	0.96	1.22	3.72	8
MnO	0.03	0.03	0.02	0.01	0.05	8
MgO	0.45	0.42	0.23	0.2	0.92	8
CaO	1.54	1.57	0.41	1.1	2.27	8
Na2O	2.61	2.62	0.1	2.44	2.72	8
K2O	5.51	5.6	0.48	4.64	6.06	8
P2O5	0.08	0.06	0.04	0.04	0.14	8
H2O+	0.74	0.73	0.15	0.53	0.96	8
H2O-	0.08	0.06	0.06	0.03	0.22	8
CO2	0.11	0.09	0.08	0.04	0.26	8
LOI	-	-	-	-	-	-
Ba	473	441	166.22	247	720	8
Li	21.13	21.5	6.94	10	33	8
Rb	327	318	44.13	276	382	8
Sr	73.63	73	15.05	47	99	8
Pb	31.13	28.5	16.23	17	66	8
Th	72.25	76.5	20.04	37	101	8
U	12.88	9.5	10.68	3	35	8
Zr	230	213.5	103.99	125	435	8
Nb	17.63	14.5	9.18	10	38	8
Y	40	38	21.52	16	77	8
La	103.75	99	31.54	65	153	8
Ce	192.25	195	56.14	117	264	8
Pr	-	-	-	-	-	-
Nd	72.13	81.5	23.84	41	100	8
Sc	5.13	5	2.7		10	8
V	15.75	10.5	13.24	4	43	8
Cr	4.38	3	4.44		14	8
Mn	-	-	-	-	-	-
Co	8.88	8.5	2.1	5	11	8
Ni	3	2.5	2.45		8	8
Cu	7.25	6	5.8	3	21	8
Zn	23.5	21	10.27	13	43	8
Sn	3.5	3.5	2.14		8	8
W	3.67	3	1.15	3	5	3
Mo	2		0.87		3	3
Ga	16.75	16.5	1.83	14	19	8
As	0.53		0.21		1	8
S	26.33	16	21.46	12	51	3
F	675	500	567.89	200	1500	4
Cl	633.33	347	597.4	233	1320	3
Be	4	4	1	3	5	3
Ag	-	-	-	-	-	-
Bi	1		-			3
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Natalie Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.12	71.97	4.91	62.68	76.26	11
TiO2	0.49	0.29	0.44	0.02	1.2	11
Al2O3	13.52	13.47	0.57	12.64	14.31	11
Fe2O3	1.18	1.14	0.55	0.35	2.44	11
FeO	3	2.52	2.04	0.24	6.15	11
MnO	0.04	0.03	0.03	0.01	0.09	11
MgO	0.76	0.58	0.5	0.19	1.61	11
CaO	2.09	1.67	1.01	0.96	3.81	11
Na2O	2.81	2.7	0.33	2.55	3.64	11
K2O	5.16	5.38	0.42	4.25	5.53	11
P2O5	0.12	0.08	0.1	0.01	0.29	11
H2O+	0.69	0.55	0.3	0.44	1.27	10
H2O-	0.03	0.03	0.03	01	0.05	2
CO2	0.08	0.08	0.04	0.05	0.11	2
LOI	0.79	0.79	-	0.79	0.79	1
Ba	408.73	326	239.21	125	863	11
Li	23.45	20	12.59	1	40	11
Rb	356.27	386	87.7	230	508	11
Sr	77.91	61	39.6	29	153	11
Pb	15.55	16	2.77	11	19	11
Th	58	67	21.71	24	83	11
U	10.64	11	5.95	3	21	11
Zr	236.73	226	99.66	91	429	11
Nb	39.64	20	62.18	19	227	11
Y	70.36	51	39.07	46	178	11
La	76.64	84	21.03	29	98	11
Ce	147.91	165	48.79	51	189	11
Pr	5	5	-	5	5	1
Nd	53.82	51	17.75	24	86	11
Sc	5.55	4	4.25		13	11
V	30.05	18	29.51		94	11
Cr	13	14	11.53		24	3
Mn	-	-	-	-	-	-
Co	10.11	8	4.91	5	19	9
Ni	7.36	7	3.07	4	15	11
Cu	11.45	7	9.72	4	29	11
Zn	28.09	21	18.04	8	58	11
Sn	3.55	3	2.16		9	11
W	8.38	8	2.45	5	13	8
Mo	1.72		0.87		4	9
Ga	18.91	19	1.04	17	21	11
As	0.86	1	0.45		2	11
S	18	18	-	18	18	1
F	2400	2400	424.26	2100	2700	2
Cl	253	253	-	253	253	1
Be	8	8	-	8	8	1
Ag	-	-	-	-	-	-
Bi	1		-			1
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	0.5		-			1

Playboy Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.19	74.62	1.87	71.67	76.99	19
TiO2	0.24	0.15	0.16	0.03	0.43	19
Al2O3	12.57	12.74	0.58	11.43	13.27	19
Fe2O3	0.84	0.79	0.35	0.29	1.36	19
FeO	1.59	1.58	0.72	0.4	2.42	19
MnO	0.03	0.03	0.01	0.01	0.04	19
MgO	0.37	0.33	0.14	0.18	0.61	19
CaO	1.31	1.29	0.32	0.74	2.02	19
Na2O	3.29	2.94	0.69	2.58	4.79	19
K2O	5.17	5.28	0.79	3.19	6.07	19
P2O5	0.04	0.03	0.03	01	0.08	19
H2O+	0.51	0.51	0.09	0.33	0.66	19
H2O-	0.01	0.01	-	0.01	0.01	2
CO2	0.05	0.05	0.01	0.04	0.05	2
LOI	-	-	-	-	-	-
Ba	341.68	251	211.94	75	604	19
Li	14	15	9.29	2	30	19
Rb	320.63	319	42.1	224	389	19
Sr	48.74	52	20.02	23	73	19
Pb	37.05	32	14.48	29	92	19
Th	40.68	38	12.48	21	76	19
U	10.84	5	10.53	3	33	19
Zr	220	255	85.2	58	323	19
Nb	35.37	31	18.85	13	62	19
Y	63.53	57	28.48	16	132	19
La	59.63	70	35.96	3	138	19
Ce	113.21	130	65.84	8	251	19
Pr	-	-	-	-	-	-
Nd	35.87	36	25.32		106	19
Sc	1.95		1.27		5	19
V	6.66	4	5.77		14	19
Cr	2	2	1.41		3	2
Mn	-	-	-	-	-	-
Co	4.74	4	1.91	2	8	19
Ni	4.63	4	1.5	2	7	19
Cu	6.47	3	9.81	2	46	19
Zn	39	39	21.92	12	111	19
Sn	8.16	8	5.86		24	19
W	8.29	8	1.96	4	13	17
Mo	1.5		-			17
Ga	20	21	3.28	16	26	19
As	0.82		0.56		2	19
S	-	-	-	-	-	-
F	3850	3850	777.82	3300	4400	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Scheelite Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.78	69.78	0.53	69.4	70.15	2
TiO2	0.53	0.53	0.06	0.49	0.57	2
Al2O3	13.51	13.51	0.16	13.4	13.62	2
Fe2O3	0.7	0.7	0.04	0.67	0.73	2
FeO	3.21	3.21	0.16	3.1	3.33	2
MnO	0.05	0.05	0.01	0.05	0.06	2
MgO	0.81	0.81	0.11	0.74	0.89	2
CaO	2.25	2.25	0.21	2.1	2.4	2
Na2O	2.62	2.62	0.11	2.54	2.7	2
K2O	5.05	5.05	0.15	4.94	5.15	2
P2O5	0.13	0.13	0.04	0.1	0.15	2
H2O+	0.76	0.76	0.1	0.69	0.83	2
H2O-	0.11	0.11	0.11	0.03	0.18	2
CO2	0.04	0.04	-	0.04	0.04	2
LOI	-	-	-	-	-	-
Ba	448	448	2.83	446	450	2
Li	15	15	-	15	15	1
Rb	355.5	355.5	20.51	341	370	2
Sr	73.5	73.5	2.12	72	75	2
Pb	20	20	4.24	17	23	2
Th	39.5	39.5	2.12	38	41	2
U	11	11	1.41	10	12	2
Zr	213	213	52.33	176	250	2
Nb	17	17	4.24	14	20	2
Y	44	44	5.66	40	48	2
La	60	60	-	60	60	2
Ce	103	103	4.24	100	106	2
Pr	-	-	-	-	-	-
Nd	45	45	-	45	45	1
Sc	6	6	-	6	6	1
V	37.5	37.5	3.54	35	40	2
Cr	11	11	-	11	11	1
Mn	-	-	-	-	-	-
Co	9	9	-	9	9	1
Ni	5	5	-	5	5	1
Cu	9	9	1.41	8	10	2
Zn	39	39	1.41	38	40	2
Sn	5.5	5.5	2.12	4	7	2
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	17	17	-	17	17	1
As	0.5		-			1
S	-	-	-	-	-	-
F	1800	1800	-	1800	1800	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Winston Churchill Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.72	72.72	0.02	72.72	72.72	2
TiO2	0.39	0.39	0.01	0.38	0.4	2
Al2O3	12.51	12.51	0.35	12.26	12.76	2
Fe2O3	1.33	1.33	0.37	1.07	1.59	2
FeO	2.17	2.17	0.15	2.07	2.28	2
MnO	0.04	0.04	-	0.04	0.04	2
MgO	0.39	0.39	0.13	0.3	0.48	2
CaO	1.35	1.35	0.04	1.32	1.37	2
Na2O	2.74	2.74	0.2	2.6	2.88	2
K2O	5.39	5.39	0.11	5.31	5.47	2
P2O5	0.06	0.06	0.01	0.06	0.07	2
H2O+	0.62	0.62	0.06	0.58	0.66	2
H2O-	0.08	0.08	-	0.08	0.08	1
CO2	0.04	0.04	-	0.04	0.04	1
LOI	-	-	-	-	-	-
Ba	596	596	31.11	574	618	2
Li	10	10	1.41	9	11	2
Rb	295.5	295.5	13.44	286	305	2
Sr	67.5	67.5	0.71	67	68	2
Pb	23.5	23.5	0.71	23	24	2
Th	31.5	31.5	0.71	31	32	2
U	4.5	4.5	0.71	4	5	2
Zr	296.5	296.5	12.02	288	305	2
Nb	22	22	1.41	21	23	2
Y	68.5	68.5	0.71	68	69	2
La	68.5	68.5	0.71	68	69	2
Ce	135.5	135.5	9.19	129	142	2
Pr	-	-	-	-	-	-
Nd	54	54	9.9	47	61	2
Sc	3.5	3.5	0.71	3	4	2
V	10.5	10.5	2.12	9	12	2
Cr	1		-			1
Mn	-	-	-	-	-	-
Co	6.5	6.5	0.71	6	7	2
Ni	4.5	4.5	3.54	2	7	2
Cu	4.5	4.5	0.71	4	5	2
Zn	38.5	38.5	2.12	37	40	2
Sn	13.5	13.5	0.71	13	14	2
W	8	8	-	8	8	1
Mo	1.5		-			1
Ga	17	17	-	17	17	2
As	0.75	0.75	0.35		1	2
S	-	-	-	-	-	-
F	2400	2400	-	2400	2400	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

6 BURSTALL SUITE

6.1 Timing

1740 Ma

6.2 Individual Ages

Primary Ages:

1. Burstall Granite[1,2]	1745 ± 16 Ma, U-Pb
2. Lunch Creek Gabbro [1,2]	1740 ± 24 Ma, U-Pb
3. Burstall Rhyolite dykes [1,2]	1737 ± 15 Ma, U-Pb
4. Burstall Granite [1,2]	1726 ± 8 Ma, U-Pb

Other chronologically similar volcanics that are stratigraphically post-Argylla Formation:

1. Unnamed Volcanics, Tommy Creek Block [3]	1762 ± 5 Ma, SHRIMP
2. Unnamed Volcanics, Tommy Creek Block [3]	1758 ± 4 Ma, SHRIMP
3. Mitakoodi Quartzite [3]	1756 ± 3 Ma, SHRIMP
4. Ballara Quartzite [3]	1755 ± 3 Ma, SHRIMP
5. Corella Volcanics at Mount Roseby [1,4,5]	1750 ± 7 Ma, SHRIMP
6. Corella Volcanics at Mount Fort Constantine [1,4,5]	1742 ± 6 Ma, SHRIMP
7. Corella Volcanics at Mount Fort Constantine [1,4,5]	1746 ± 9 Ma, SHRIMP
8. Double Crossing Metamorphics [1,4,5]	1740 ±6 Ma, SHRIMP
9. Doherty Formation [1,4,5]	1725 ± 3 Ma, SHRIMP
10. Doherty Formation [1,4,5,6]	1720 ± 7 Ma, U-Pb

Sources: [1] OZCHRON, [2] Page (1983a), [3] Page *et al*. (1997), [4] Page and Sun (1996), [5] Page and Sun (*in press*), [6] Page (1983b). Note: all of the ages of the intrusives are based on conventional U-Pb analyses.

6.3 Regional Setting

This linear north-trending suite was emplaced as small circular to elliptical intrusions into the Eastern Fold Belt at around 1740 Ma. The suite is characterised by a common association with coeval gabbros (Blake 1981). On the basis of structural data, Pearson *et al.* (1992) contend that the granites of the Burstall Suite were emplaced into the upper plate during an extensional episode. The whole suite has been affected by regional metamorphism and some units have been metamorphosed to upper amphibolite facies. Primary magmatic alteration has been documented (Aslund 1994; Aslund *et al.* 1995) but this is difficult to distinguish from syn-intrusion alteration and later alteration associated with the regional metamorphism and deformation at ~1500 Ma and 1100 Ma (Oliver 1995, Oliver *et al.* 1994). The Burstall Suite has a progression from more mafic plutons in the northern and southernmost parts of the Mary Kathleen Zone to more felsic, fractionated plutons in the central part (Overlander and Burstall Granites). The granites of this suite intrude the Corella Formation, and felsic volcanics which are in the Corella Formation are more likely to be comagmatic with this suite than with the Wonga Suite.

6.4 Summary

The Burstall Suite is classified as an Hiltaba type as it shows evidence of fractionation and concentration of elements during crystallisation. Fluorite is more common in the more fractionated components. It has a noted spatial association with small but rich Cu-Au-Ag deposits, although many authors would argue for a much younger, post-intrusive origin for some of these deposits (*e.g.,* Oliver 1995). If the deposits do have a magmatic origin, one limitation is that as plutons of the Burstall Suite are relatively small, any associated deposits are likely to have a low tonnage, although they could have high grades. The oxidation plots of this granite are interesting. Most of the felsic plutons are oxidised and most of the associated deposits are Cu-rich. In contrast, all of the unaltered samples of the Saint Mungo Granite are reduced. This granite is the closest granite to the Au-dominated Tick Hill deposit and may thus have unrecognised metallogenic significance.

6.5 Potential

The Burstall Suite has potential for further Cu-Au deposits, and although these are likely to be of low tonnage, they have the potential to be of high grade. New geochronological information (Page and Sun 1996, *in press;* Page *et al.* 1997) suggest that coeval with this intrusive suite is a series of felsic volcanics which are interbedded with the Ballara Quartzite, Mitakoodi Quartzite and Corella Formation (and may also include volcanics of the Tommy Creek Block). Although speculative, it is possible that epithermal and/or Carlin-style Au deposits may be found within these sediments, related to the fractionating magmatism of the Burstall Suite (particularly as some of these sediments contain graphitic schist).

Cu:	**Moderate**
Au:	**Moderate**
Pb/Zn:	**None**
Sn:	**Low**
Mo/W:	**Low**
Confidence level:	**322**

6.6 Descriptive Data

Location: Along the eastern margin of the Mary Kathleen Zone in the central part of the Mount Isa Inlier.

Dimensions and area: A series of narrow plutons in a northerly trending belt 150 km long and 6 km wide. Total area covered by the suite is 160 km^2.

6.7 Intrusives

Component plutons: Mount Godkin Granite, Burstall Granite, Overlander Granite, Mount Erle Igneous Complex, Revenue Granite, Saint Mungo Granite and possibly the Myubee Igneous Complex.

Form: Most plutons form elongate elliptical or circular bodies that are no more than 30 km^2.

Metamorphism and Deformation: All members of the suite have been metamorphosed and deformed to some extent. *Specifically*: Burstall Granite - foliated; Mount Erle Igneous Complex - generally foliated and recrystallised, regionally metamorphosed to amphibolite facies: some prehnite also recorded; Myubee Igneous Complex - regionally metamorphosed to amphibolite facies; Overlander Granite - massive to foliated; Revenue Granite - crenulated gneissic granite in places. Aslund (1994) and Aslund *et al.* (1995) argued that the it was affected by two phases of deformation prior to the Isan Orogeny; Saint Mungo Granite - slightly to intensely foliated and recrystallised.

Dominant intrusive rock types: Leucogranite, porphyritic hornblende-biotite granite, minor tonalite, microgranite. *Specifically*: Burstall Granite - fine to medium-grained, leucocratic, even-grained to porphyritic hornblende-biotite granite; minor tonalite and diorite (in net-veined complexes); aplite, pegmatite, microgranite, porphyritic rhyolite dykes; Mount Erle Igneous Complex - leucocratic medium to fine-grained granite which is locally porphyritic, metadolerite, gabbro, diorite, and a net-veined complex of granite, dolerite, and dioritic hybridised rocks; Myubee Igneous Complex - leucocratic granite (contains inclusions of coarse granite), gabbro, minor diorite; Overlander Granite, Revenue Granite - massive to foliated, leucocratic medium to coarse-grained, even-grained to slightly porphyritic granite; Saint Mungo Granite - medium to coarse-grained granite with microcline phenocrysts up to 3 cm across, minor foliated porphyritic granite; Burstall Granite - fairly homogenous leucocratic, coarse even-grained to porphyritic granite; Mount Godkin Granite - microgranite, fine to medium-grained granite.

Colour: Pink to grey. *Specifically:* Burstall Granite - pink to grey; Overlander Granite, Revenue Granite - pink.

Veins, Pegmatites, Aplites, Greisens: Aplite and pegmatite are common. *Specifically:* Burstall Granite - numerous late-stage rhyolite dykes emanate from the intrusion, aplite and microgranite dykes common, as well as some fluorite veins which are subeconomic; Mount Erle Igneous Complex - minor aplite, feldspar porphyry and pegmatite; Myubee Igneous

Complex - aplite and pegmatite recorded; Overlander Granite - swarms of tourmaline-bearing pegmatite dykes and veins, as well as being cut by veins of fluorite, tourmaline, amethyst; Saint Mungo Granite - aplite, pegmatite.

Distinctive mineralogical characteristics: Hornblende, biotite, titanite, apatite, zircon, allanite, fluorite. *Specifically:* Burstall Granite - K-feldspar, plagioclase, quartz, hornblende, biotite, chlorite, with accessory fluorite (abundant), zircon and apatite: titanite rims opaques or occurs as aggregates; Mount Erle Igneous Complex - K-feldspar, hornblende, biotite, plagioclase with accessory allanite, apatite, opaque minerals, titanite and zircon; Myubee Igneous Complex - hornblende biotite granite; Overlander Granite, Revenue Granite - hornblende, biotite; Saint Mungo Granite - quartz, microcline, plagioclase, biotite, hornblende, accessory apatite, fluorite, calcite, chlorite, scapolite, titanite, allanite; Mount Godkin Granite - quartz, K-feldspar, albite, biotite, zircon and opaques.

Breccias: None noted.

Alteration in the granite: Some alteration recorded - it is difficult to discern whether alteration is related to magmatism or metamorphism. Aslund (1994) and Aslund *et al.* (1995) argued that the fluids altering the Revenue Granite were high temperature (~700° C), highly saline (up to 50 wt.% NaCl) and that the metasomatic fluids had an igneous stable isotope signature. *Specifically:* Mount Godkin Granite - highly altered and albitised; Mount Erle Igneous Complex - scapolite, calcite, epidote, sericite/muscovite, chlorite, prehnite recorded: these are more likely to be related to later metamorphism; Revenue Granite - intensely scapolitised and albitised (Aslund 1994).

6.8 Extrusives

Felsic volcanics outcrop in the vicinity of the granites, but the chemistry and age relationships are yet to be determined. Many of the felsic volcanics within the Ballara and Mitakoodi Quartzites and the Corella Formation are likely to be comagmatic with the Burstall Suite.

6.9 Country Rock

Contact metamorphism: Narrow hornfelses have been recorded adjacent to some intrusions. It is generally difficult to discern the exact extent due to overprinting by the later regional metamorphism. *Specifically*: Mount Erle Igneous Complex - intrudes Corella Formation and thermal effects are restricted to within one metre of the contact; and Overlander Granite - converts Corella Formation to skarn adjacent to intrusion.

Reaction with country rock: Some endoskarn assemblages are developed where granites intrude calc-silicate rocks. Net-veined complexes are commonly recorded adjacent to coeval gabbros. Extensive alteration is associated with the intrusion of some of the granites of the Burstall Suite and garnet and pyroxene exoskarns are extensive in their contact aureoles (Aslund 1994; Aslund *et al.* 1995; Derrick 1977; Cruickshank *et al.* 1977; Oliver 1995; Oliver *et al.* 1986). *Specifically:* Mount Erle Igneous Complex - net-veined complexes formed with coeval dolerite

Units the granite intrudes: Corella Formation, Mary Kathleen Group, Plum Mountain Gneiss. Net-veined complexes have been recorded.

Dominant rock types: Calc-silicate rocks, hornblende and biotite schists, dolerites.

Potential hosts: Due to metamorphic overprinting it is difficult to identify potential hosts.

6.10 Mineralisation

There is a clear spatial association of members of the Bustall Suite with a series of small but rich Cu/Au deposits, including Duchess (Cu-Au-Ag), Trekelano (Cu-Au-Ag) and Revenue (Cu-Au). All three are hosted by hornblende-biotite schist, biotite schist and calc-silicate granofels, and at Duchess, the mine is also hosted by granite. The Mary Kathleen uranium deposit is among rhyolite dykes emanating from the Burstall Granite.

Despite the clear spatial association, a direct genetic relationship between any of these deposits and intrusives of the Burstall Suite is unproven. The Mary Kathleen U deposit has been considered to be related to the Burstall Granite (*e.g.,* Derrick 1977, 1978; Abeysinghe *et al.* 1984a, 1984b; Abeysinghe 1985; Cruickshank *et al.* 1977) but it is more probable that U in this deposit was remobilised during later metamorphism (e.g., Oliver 1995; Oliver *et al.* 1986, Maas *et al.* 1988, Page 1983a). Oliver (1995) also attributes the calcite-hosted Cu deposits in the vicinity of the Burstall Suite (including Trekelano) to his Phase 2 Hydrothermal Activity at ~1550 Ma, but does argue for some Au mobilisation during his Phase 1 hydrothermal activity at 1750-1730 Ma. The Tick Hill Gold deposit lies within 5 km of the Saint Mungo Granite, although very few theories for its genesis ever invoke a granite (e.g., Crookes 1993).

This project argues that the plutons of the Burstall Suite were capable of concentrating economic amounts of Cu, Au and possibly U during fractionation, although some remobilisation could have occurred during the major D_2 activity at ~1550 Ma. The source of the Au which preferentially partitions along the upper plate/lower plate boundary during the 1750-1730 Ma episode (Oliver 1995), could well be plutons of the Burstall Suite. Due to the small size of the individual plutons, any deposits formed as a result of fractionation processes in the Burstall Suite are likely to be small, but have the potential to be of high grade.

6.11 Geochemical Data

Data source: The data come from five sources: (1) Geoff Derrick's Ph.D (Derrick 1978); (2) regional mapping programs carried out by AGSO and GSQ (Bultitude *et al*. 1982; Blake *et al*. 1982; Derrick *et al.* 1971, 1977; Wilson *et al.* 1979); (3) specialised granite sampling by Wyborn in 1978 as part of a survey of Mount Isa granites; (4) samples collected by Page for age determinations using Rb-Sr and U-Pb zircon techniques (Page 1983a); (5) samples collected as part of a regional study of the Mary Kathleen U-deposit (Cruickshank *et al.* 1977).

Data quality: Good. All samples were analysed within the one laboratory at AGSO.

Are the data representative? The collections are not biased towards any particular granite type.

Are the data adequate? Barely, more specialised sampling needs to be done.

SiO_2 range (Fig. 6.1): The silica range of the felsic magmas of the Burstall suite is relatively limited and very high, being predominantly > 68 wt.% SiO_2. Rocks above 68 wt.% SiO_2 have a

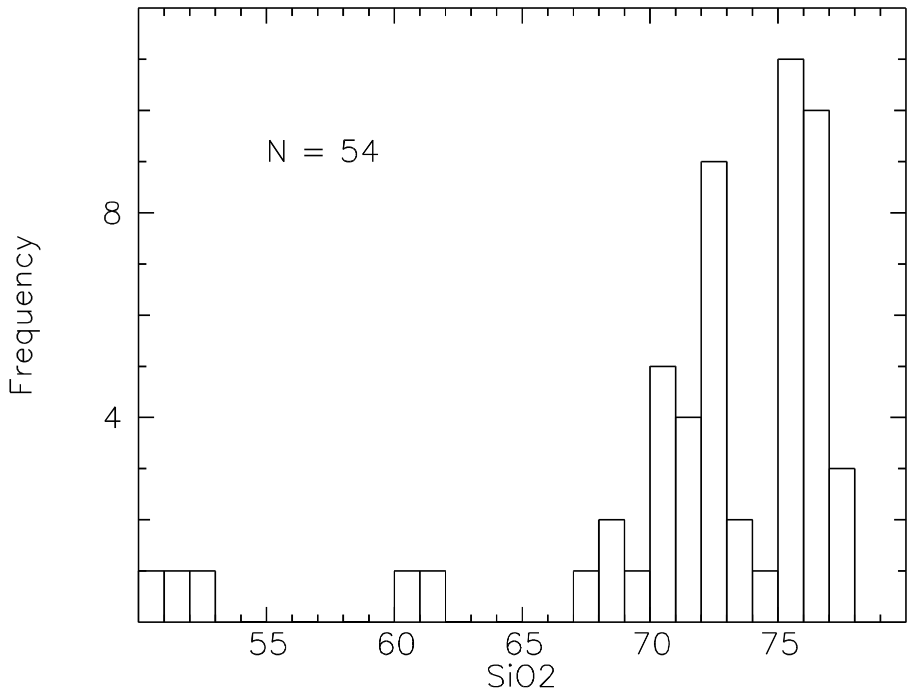


Figure 6.1. Frequency histogram for SiO_2 values for the Burstall Suite

bimodal distribution reflecting the contrast between the normal granites and late-stage aplites and rhyolite/micogranite dykes. There are coeval gabbros intimately associated with at least four of the plutons (Myubee and Mount Erle Igneous Complexes, and the Revenue and Burstall Granites) whilst the rocks that plot at around 60 wt.% SiO_2 are likely to be hybrids.

Alteration (Fig. 6.2):

- ***SiO_2:*** One sample with > 80 wt.% is an aplite; silicification is absent.
- ***K_2O/Na_2O:*** Both potassic and sodic alteration occur in this suite. There is a gradual change in compositions to more K-rich alteration, whereas the sodic samples are distinctly separate and probably formed due to contamination with the local Corella Formation. The evidence of alteration in this suite contrasts with that of the Wonga Suite, which intrudes unreactive felsic volcanics of the Argylla Formation. Studies by Aslund (1994) suggest that this alteration is related to magmatic processes.
- ***Th/U:*** The Th/U values are somewhat high, and extreme in some altered samples, particularly those of the Burstall Granite.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** This plot shows oxidation of some samples (in particular the Overlander and Burstall Granites), whilst the more mafic samples are relatively reduced.

Fractionation Plots (Fig. 6.3):

- ***Rb:*** Rb appears to first increase and then decrease with increasing SiO_2.
- ***U:*** Samples show increasing U with increasing SiO_2.
- ***Y:*** Samples show strongly increasing Y with increasing SiO_2.
- ***P_2O_5:*** Samples show decreasing P_2O_5 with increasing SiO_2.
- ***Th:*** Samples show increasing Th with increasing SiO_2 (except the Burstall Granite).
- ***K/Rb:*** Plot too scattered to determine a consistent trend.
- ***Rb-Ba-Sr:*** Some samples (particularly those of the Overlander Granite) plot in the strongly differentiated granite field.
- ***Sr:*** Values of Sr are very low (below 150 ppm).
- ***Rb/Sr:*** Samples show a strongly exponentially increasing trend in Rb/Sr with increasing SiO_2.
- ***Ba:*** Values of Ba are moderate (up to 1500 ppm).
- ***F:*** Insufficient data to determine. Six of the seven samples have low values, and lower than those for the Wonga and Argylla Suites.

Metals (Fig. 6.4):

- ***Cu:*** With the exception of the Overlander Granite and Mount Erle Igneous Complex, Cu decreases with increasing SiO_2.
- ***Pb:*** Values are low.
- ***Zn:*** Values are low and decrease with increasing SiO_2.
- ***Sn:*** Values increase weakly with increasing SiO_2, particularly for the Saint Mungo Granite.

High field strength elements (Fig. 6.5):

- ***Zr:*** Samples showmoderate values for Zr, with two samples of the Mount Erle Igneous Complex being anomalously high.
- ***Nb:*** Samples show moderate values for Nb which increases up to 60 ppm with increasing SiO_2.
- ***Ce:*** Samples show moderate values for Ce, and individual plutons show decreases with increasing SiO_2.

Classification (Fig. 6.6):

- ***The $CaO/Na_2O/K_2O$ plot of White, quoted in Sheraton and Simons (1992):*** The granites plot in the monzogranite to granite field reflecting the high SiO_2 range of this suite. Some samples plot in the trondhjemite field reflecting albitisation.
- ***Zr/Y vs Sr/Sr*:*** All samples plot below 1 reflecting the Sr-depleted, Y-non-depleted nature of this suite.
- ***Spidergram:*** The spidergrams for this suite are Sr-depleted, Y-non-depleted and show strong fractionation of B, Sr and Ti with increasing SiO_2.
- ***Oxidation plot of Champion and Heinemann (1994):*** The felsic samples are oxidised, with four of the Overlander Granite samples being strongly oxidised. In contrast, most samples of the Myubee Igneous Complex and the Saint Mungo Granite, from the southern part of the area, are reduced.
- ***ASI:*** The majority of samples have an ASI index of <1.1 and are metaluminous to weakly peraluminous.
- ***A-type plot of Eby (1990):*** The Wonga suite straddles the A-type/normal granite fields for Palaeozoic granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-(granodiorite) type, non-restite.

Australian Proterozoic granite type: Hiltaba type.

6.12 Geophysical Signature

Radiometrics (Fig. 6.7): Most samples plot well above the Proterozoic median values for K_2O, Th and U and hence would appear white in an RGB image.

Gravity: The AGSO regional gravity data are too coarse and the plutons too small for a meaningful assessment to be made.

Magnetics: The magnetics appear extremely variable and are probably dependent on the degree of alteration and the SiO_2 content of the individual granite phases. No systematic measurements are available.

6.13 References

Abeysinghe, P.B., Kwak, T.A.P. and White, A.J.R. 1984a. The evolution and concentration of U and REE in the Mary Kathleen Skarn, Queensland. *Geological Society of Australia, Abstracts,* 12, 29.

Abeysinghe, P.B., White, A.J.R., Kwak, T.A.P. and Price, R.C. 1984b. Fractionation of the Burstall Granite and the source of uranium in the Mary Kathleen Deposit. *Geological Society of Australia, Abstracts,* 12, 30.

Abeysinghe, P.B. 1985. A fluid inclusion, petrological, mineralogical and thermodynamic study of the Mary Kathleen Skarn and its genesis. *La Trobe University, Ph.D. Thesis (unpublished),* 383 pp.

Aslund, T. 1994. Deformation and fluid flow within a syn-tectonic granite hydrothermal system, Revenue Granite, Duchess: regional implications. *Mount Isa Inlier, One day seminar, AMF Workshop Course No. 902/94,* p29.

Aslund, T., Oliver, N.H.S. and Cartwright, I. 1995. Metasomatism of the Revenue Granite and aureole rocks, Mt Isa Inlier, Queensland. *Australian Journal of Earth Sciences,* 42, 291-299.

Blake, D.H. 1981. Intrusive felsic-mafic net-veined complexes in north Queensland. *BMR Journal of Australian Geology and Geophysics*, 5, 243-256.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1982, Dajarra, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1984, Geology of the Duchess-Urandangi region, Mount Isa Inlier, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 219.

Crookes, R.A. 1993. The geology of the host lithologies to the enigmatic gold mineralisation at the Tick Hill Deposit, NW Queensland. *Australian Institute of Geoscientists, Bulletin*, 13, 43-45.

Cruickshank, B.I., Ferguson, J. and Derrick, G.M. 1977. The association of uranium and skarn development in the Mary Kathleen area, Queensland. Proceedings of the International Symposium on the Pine Creek Geosyncline, Sydney. *International Atomic Energy Agency, Vienna,* 693-706.

Derrick, G.M. 1977. Metasomatic history and origin of uranium mineralisation at Mary Kathleen, northwest Queensland. *BMR Journal of Australian Geology and Geophysics*, 2, 123-130.

Derrick, G.M. 1978. Proterozoic igneous and sedimentary rocks and associated metamorphism at Mary Kathleen, northwest Queensland. *Ph.D Thesis, University of Queensland* (unpublished).

Derrick, G.M., Wilson, I.H., Hill, R.M., Glikson, A.Y. and Mitchell, J.E. 1977. Geology of the Mary Kathleen 1:100 000 Sheet area, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin*, 193, 114 pp..

Derrick, G.M., Wilson, I.H., Hill, R.M. and Mitchell, J.E. 1971. Geology of the Marraba 1:100 000 Sheet area, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1971/56, 142 pp.

Holcombe, R.J., Pearson, P.J. and Oliver, N.H.S. 1992. Structure of the Mary Kathleen Fold Belt, In Stewart, A.J. and Blake. D.H. (editors), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 243, 257-287.

Maas, R., McCulloch, M.T. and Campbell, I.H. 1988. Sm-Nd isotope systematics in uranium rare-earth element mineralization at Mary Kathleen Uranium Mine, Queensland. *Economic Geology,* 82, 1805-1826.

Oliver, N.H.S. 1995. Hydrothermal history of the Mary Kathleen Fold Belt, Mt Isa Block Queensland. *Australian Journal of Earth Sciences,* 42, 267-279.

Oliver, N.H.S., Rawling, T.J, Cartwright, I. and Pearson, P.J. 1994. High-temperature fluid-rock interaction and scapolitization in an extension-related hydrothermal system, Mary Kathleen, Australia. *Journal of Petrology*, 35, 1455-1492.

Oliver, N.H.S., Wall, V.J. and Pearson, P.J. 1986. The Mary Kathleen uranium-REE deposit: a product of regional metamorphism. *Geological Society of Australia, Abstracts,* 15, 149-150.

Page, R.W. 1983a. Chronology of magmatism, skarn formation and uranium mineralisation, Mary Kathleen, Queensland, Australia. *Economic Geology*, 78, 838-853.

Page, R.W. 1983b. Timing of superimposed volcanism in the Proterozoic Mount Isa Inlier. *Precambrian Research*, 21, 223-245.

Page, R.W. 1993. Mount Isa Geochronology. *AGSO 93*, 60.

Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, *EGRU Contribution 55*, 95-98.

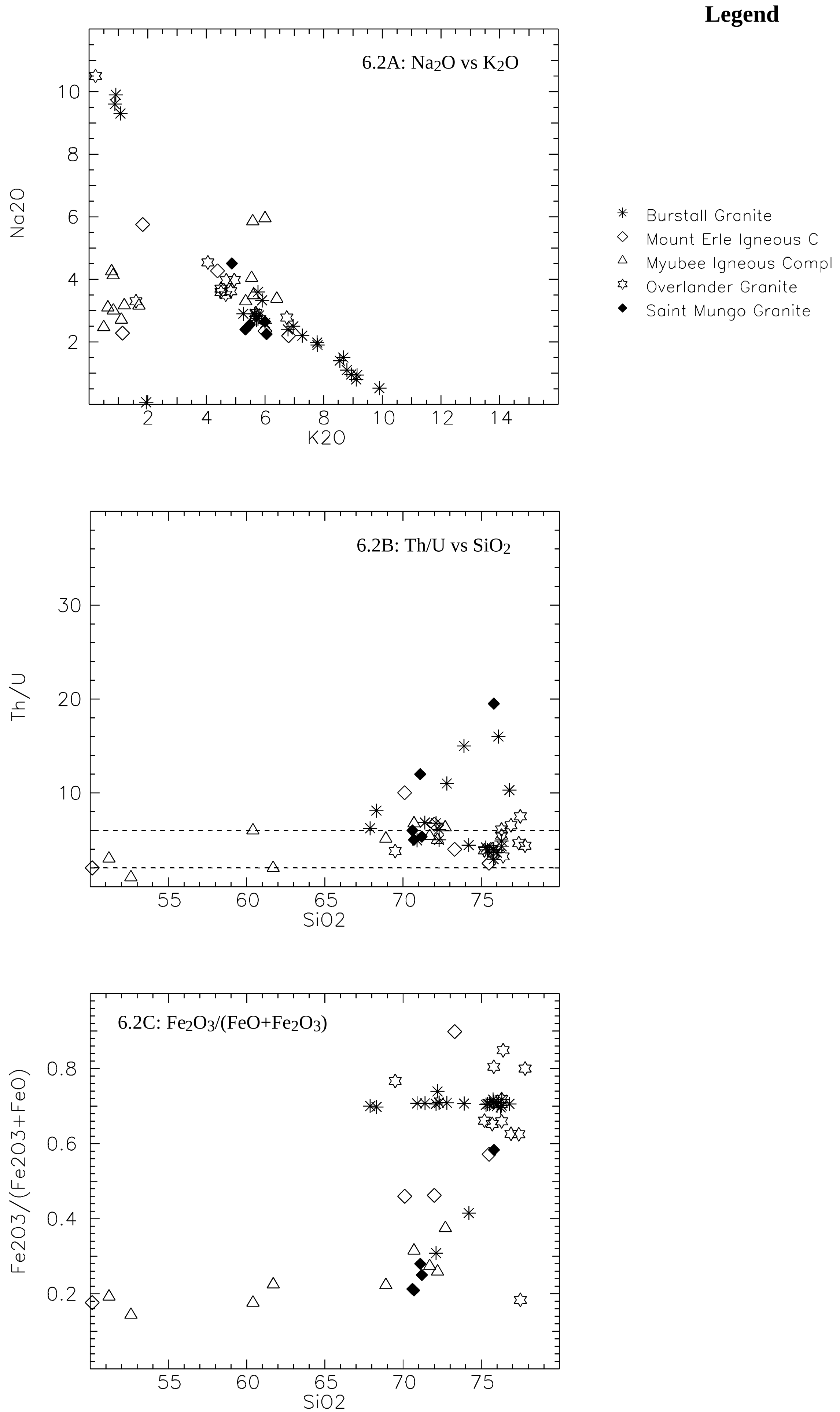
Page, R.W. and Sun, S.-S. 1998. Aspects of geochronology and crustal evolution in the Eastern Fold Belt, Mount Isa Inlier. *Australian Journal of Earth Sciences,* 45, 343-361.

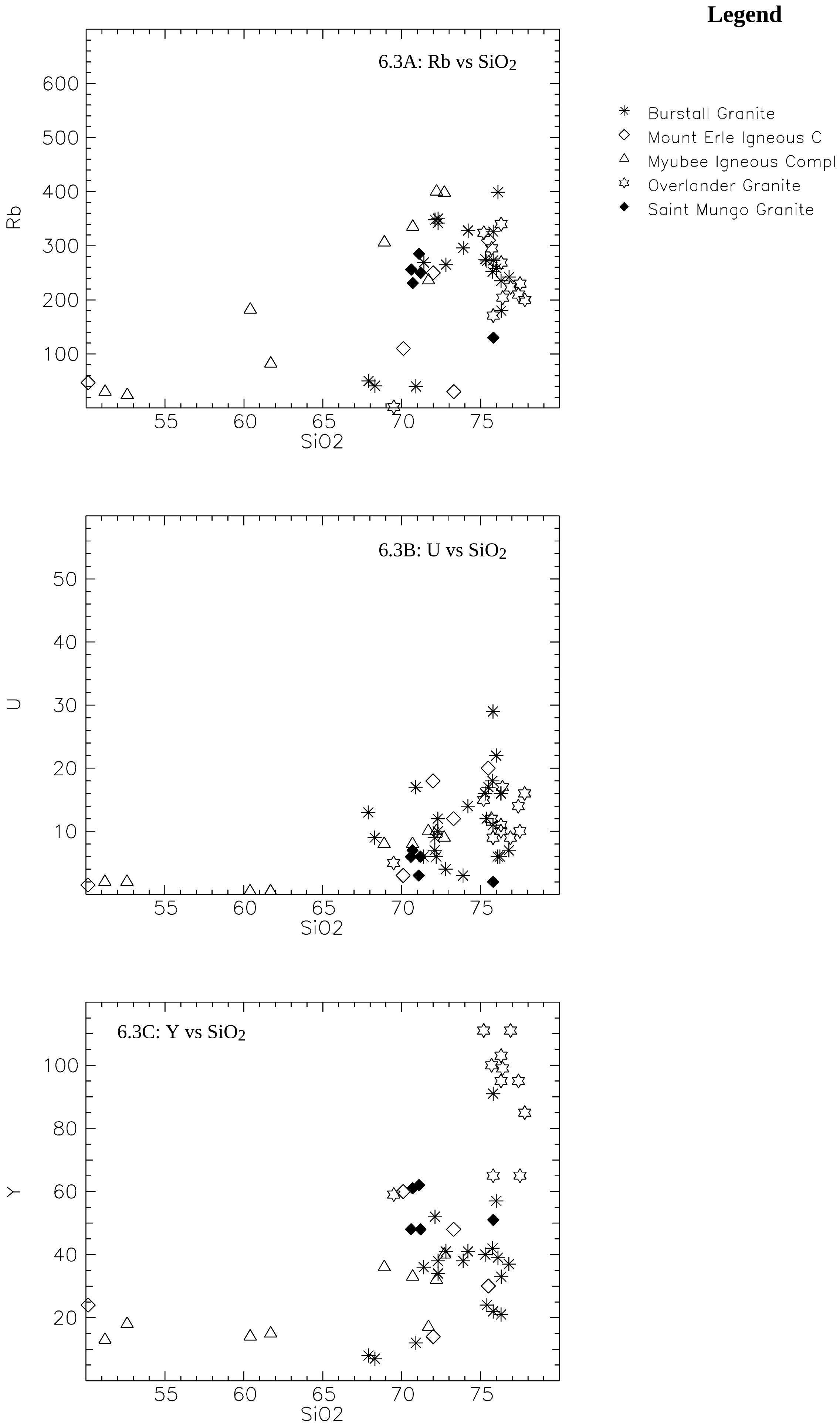
Page, R.W., Sun, S.-S. and McCready, T. 1997. New geochronological results in the central and eastern Mount Isa Inlier and implications for mineral exploration. *Abstracts, Geodynamics and Ore Deposits Conference, Australian Geodynamics Cooperative Research Centre, Ballarat, Victoria,* 46-48.

Pearson, P.J., Holcombe, R.J. and Page, R.W. 1992. Synkinematic emplacement of the Middle Proterozoic Wonga Batholith into a mid-crustal extensional shear zone, Mount Isa Inlier, Queensland, Australia, In Stewart, A.J. and Blake, D.H. (editors), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 243, 289-328.

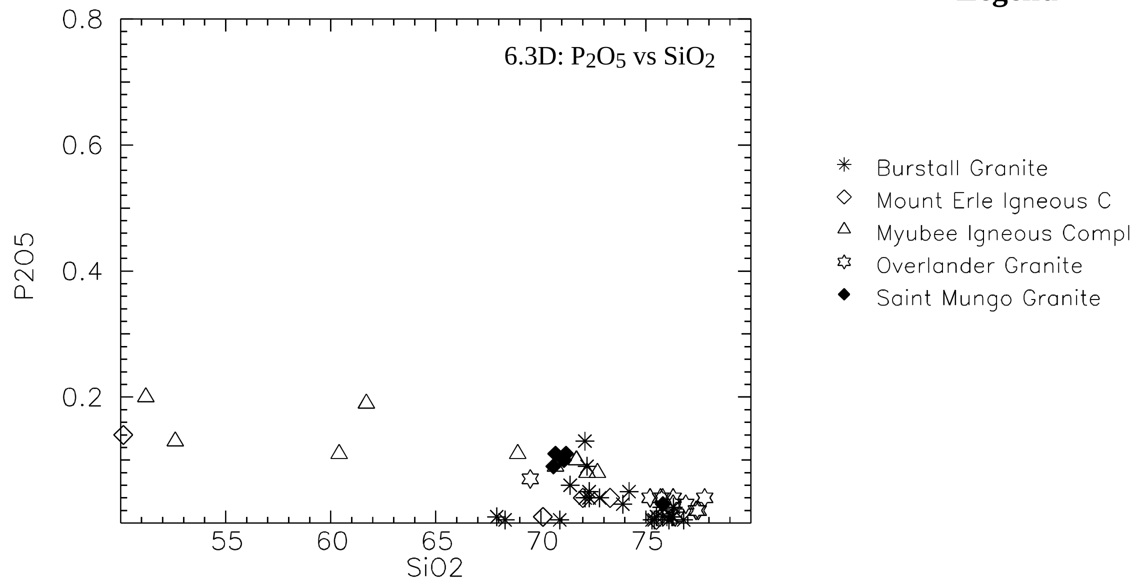
Wilson, I.H., Noon, T.A., Hill, R.M. and Duff, B.A. 1979. Geology of the Quamby 1:100 000 sheet area (6957), Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1979/56.

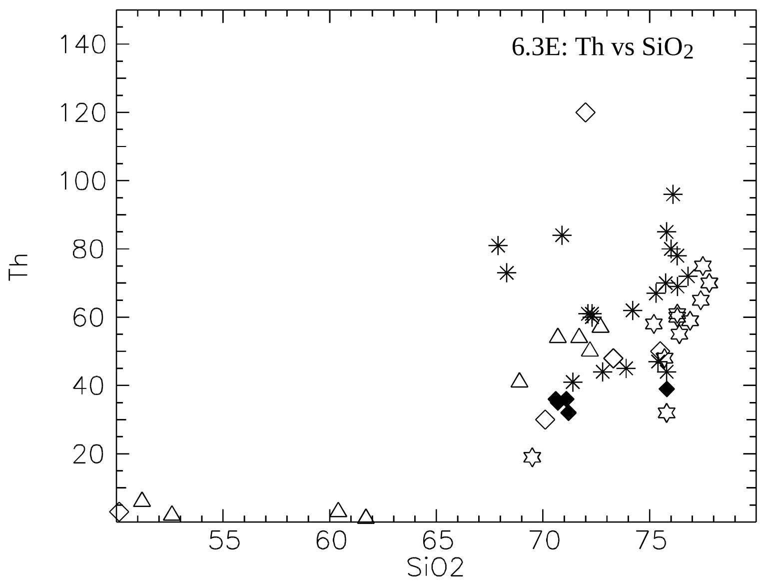
Wyborn, L.A.I., Page, R.W. and McCulloch, M.T. 1988, Petrology, geochronology and isotope geochemistry of the post-1820 Ma granites of the Mount Isa Inlier: Mechanisms for the generation of Proterozoic anorogenic granites. *Precambrian Research,* 40/41, 509-541.

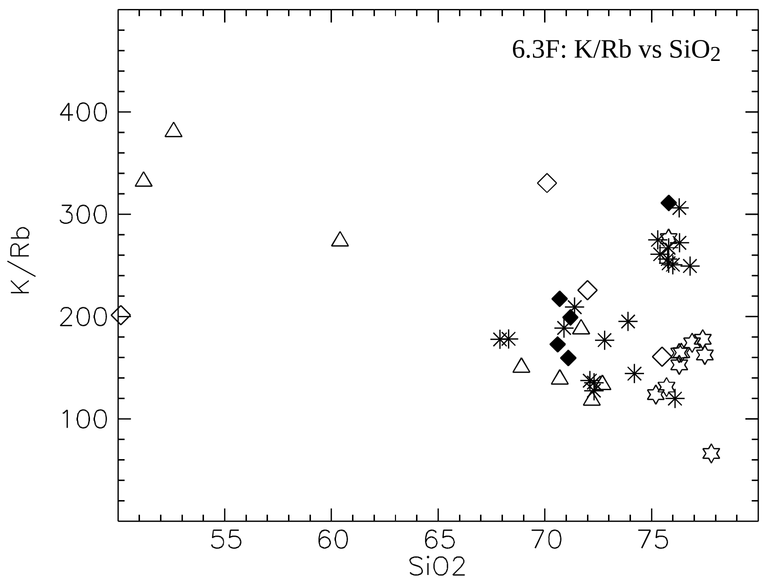

Legend
6.2A: Na2O vs K2O
Na2O
K2O
6.2B: Th/U vs SiO2
Th/U
SiO2
6.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2
Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite

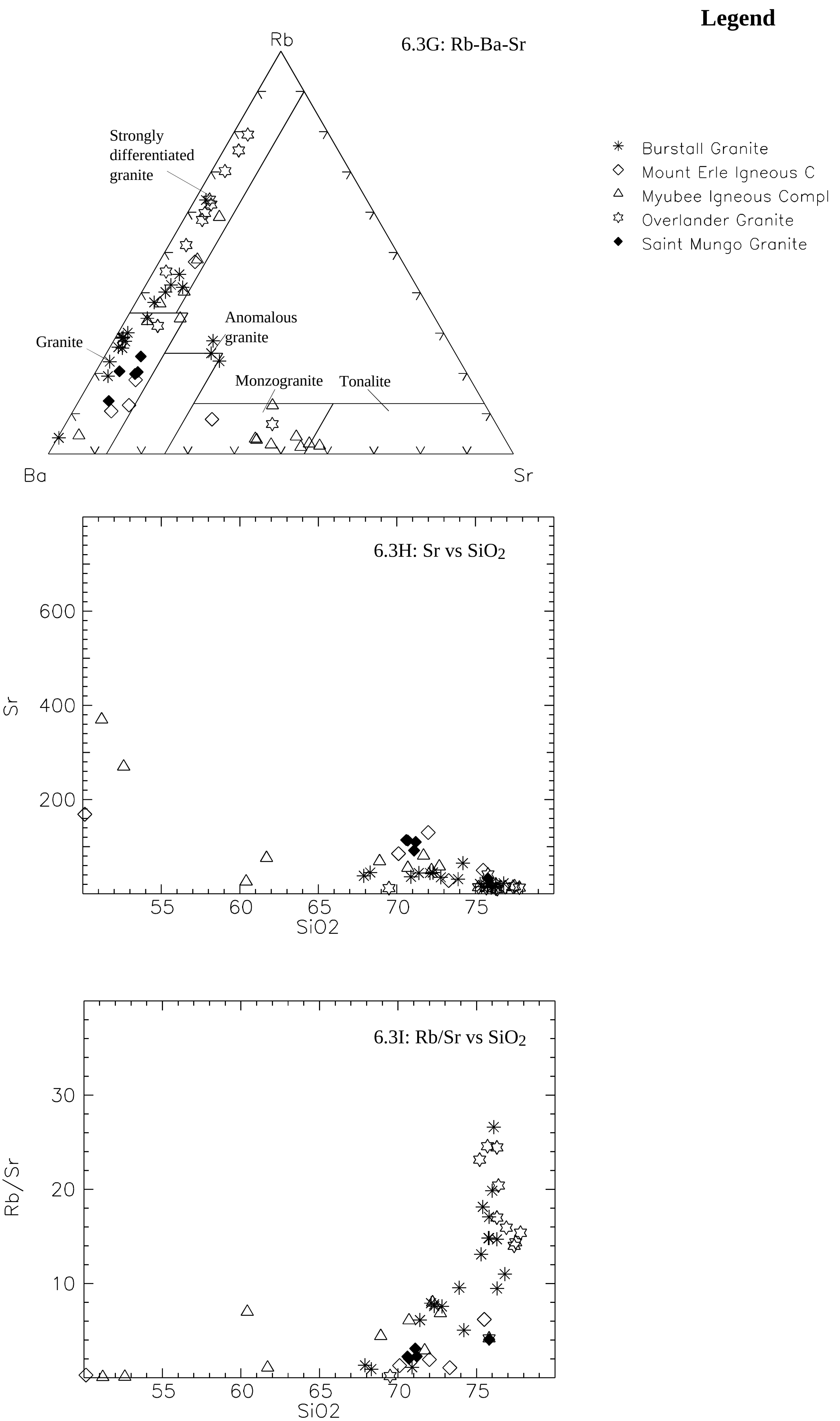

Legend
Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite
6.3A: Rb vs SiO2
Rb
100
200
300
400
500
600
SiO2
55
60
65
70
75
6.3B: U vs SiO2
U
10
20
30
40
50
SiO2
55
60
65
70
75
6.3C: Y vs SiO2
Y
20
40
60
80
100
SiO2
55
60
65
70
75

Legend


6.3D: P_2O_5 vs SiO_2
P2O5
0.8
0.6
0.4
0.2
55
60
65
70
75
SiO2
Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite

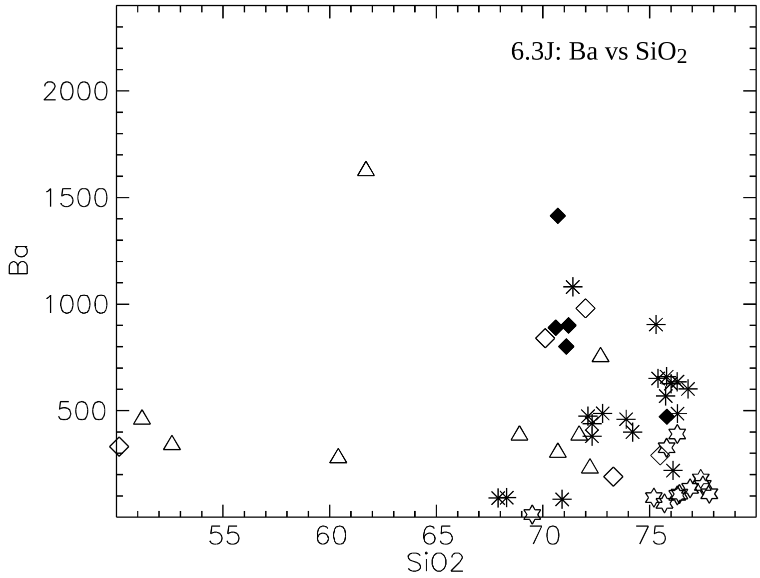

6.3E: Th vs SiO_2
Th
140
120
100
80
60
40
20
55
60
65
70
75
SiO2

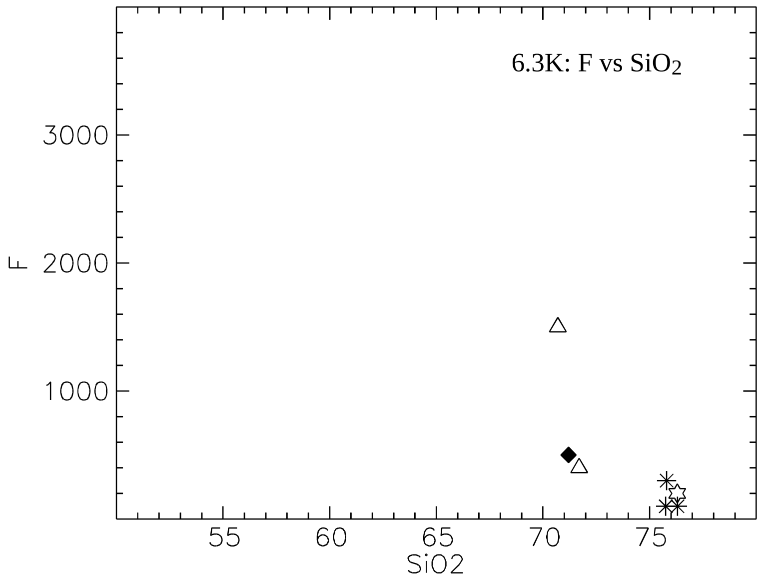

6.3F: K/Rb vs SiO_2
K/Rb
400
300
200
100
55
60
65
70
75
SiO2

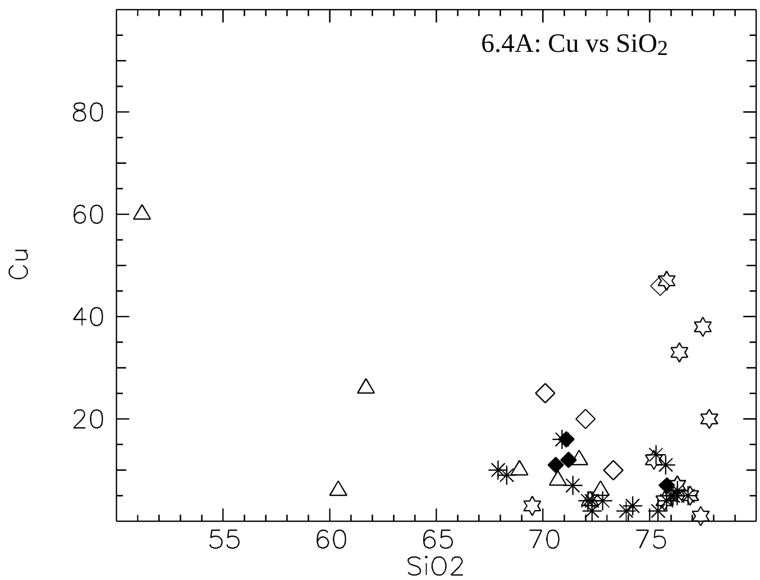

Legend
Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite
6.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Granite
Anomalous granite
Monzogranite
Tonalite
6.3H: Sr vs SiO2
Sr
600
400
200
55
60
65
70
75
SiO2
6.3I: Rb/Sr vs SiO2
Rb/Sr
30
20
10
55
60
65
70
75
SiO2

Legend

- Burstall Granite
- Mount Erle Igneous C
- Myubee Igneous Compl
- Overlander Granite
- Saint Mungo Granite

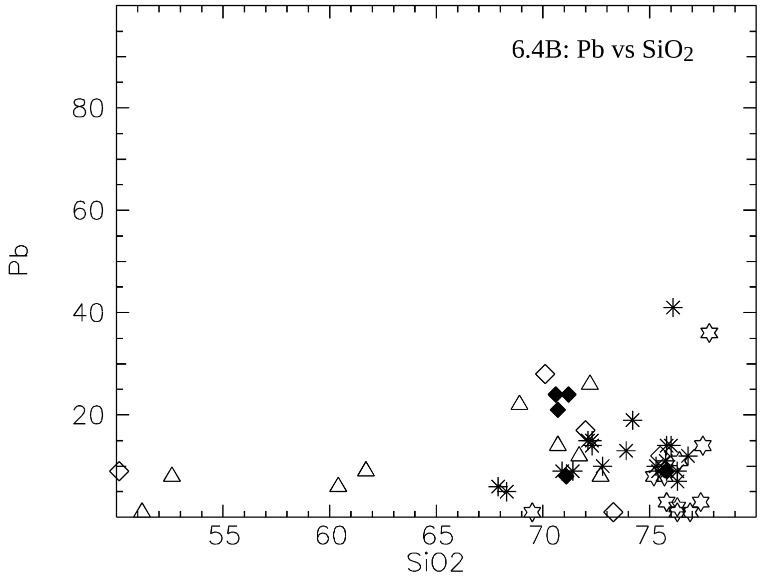


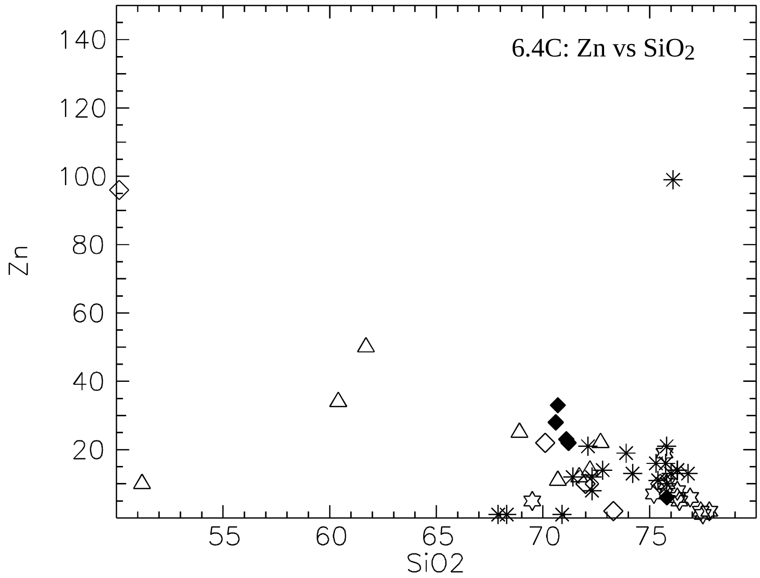


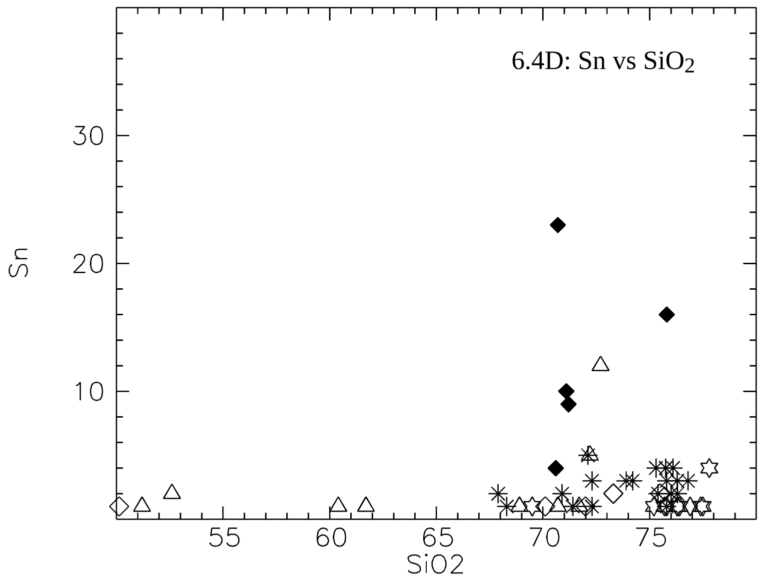


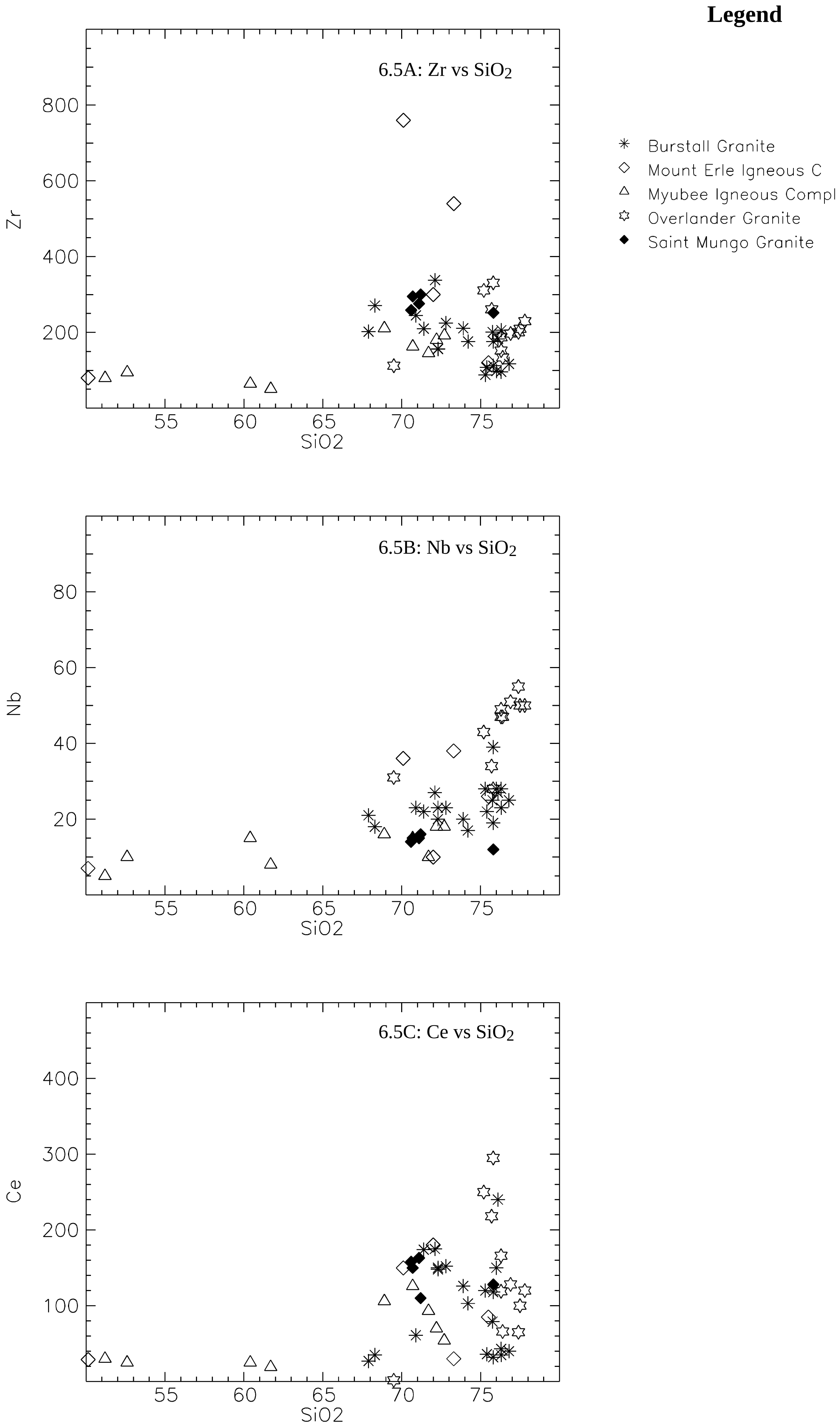
Legend

- Burstall Granite
- Mount Erle Igneous C
- Myubee Igneous Compl
- Overlander Granite
- Saint Mungo Granite

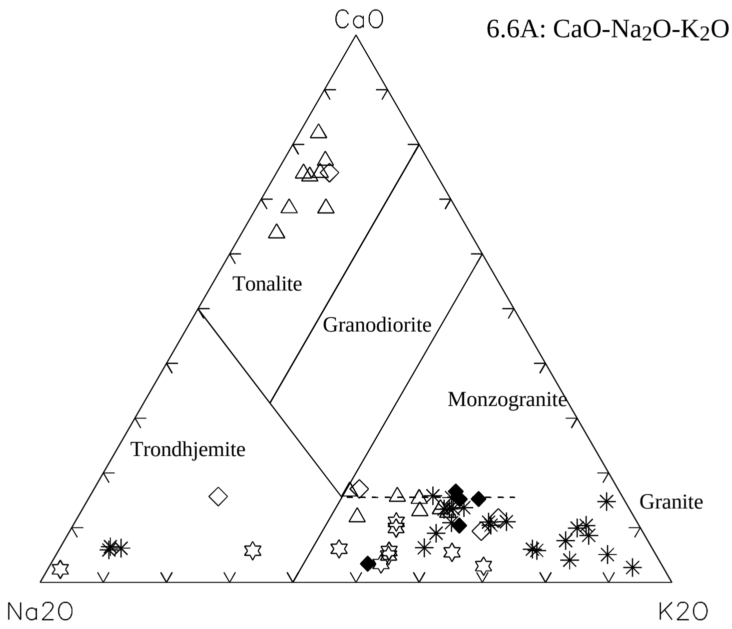


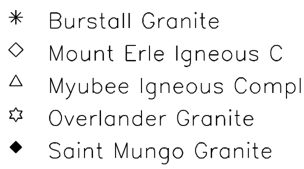


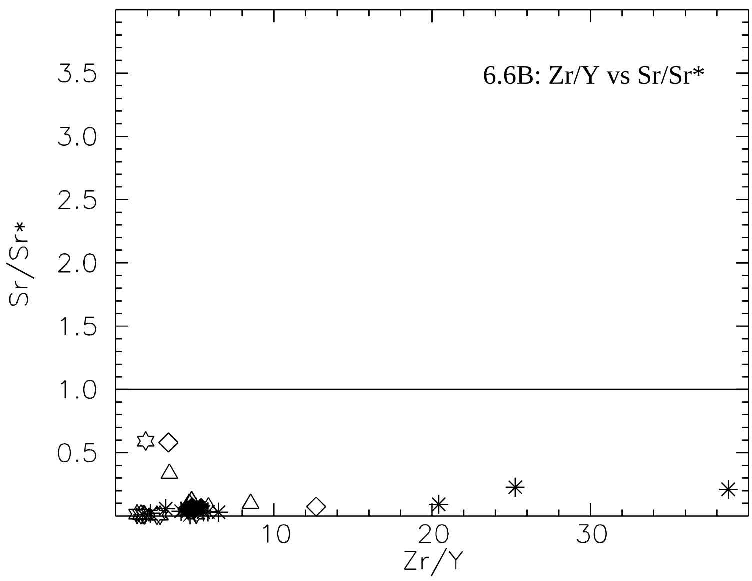


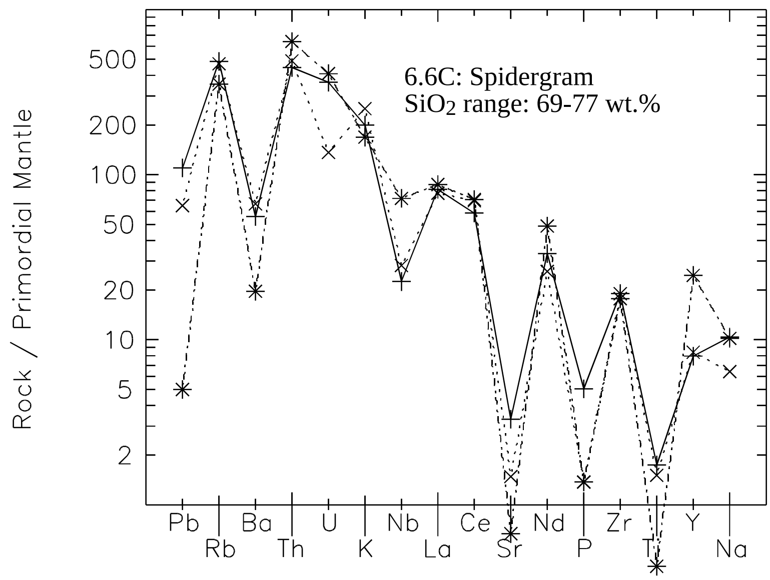

Legend
Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite
6.5A: Zr vs SiO2
Zr
SiO2
800
600
400
200
55
60
65
70
75
6.5B: Nb vs SiO2
Nb
SiO2
80
60
40
20
55
60
65
70
75
6.5C: Ce vs SiO2
Ce
SiO2
400
300
200
100
55
60
65
70
75

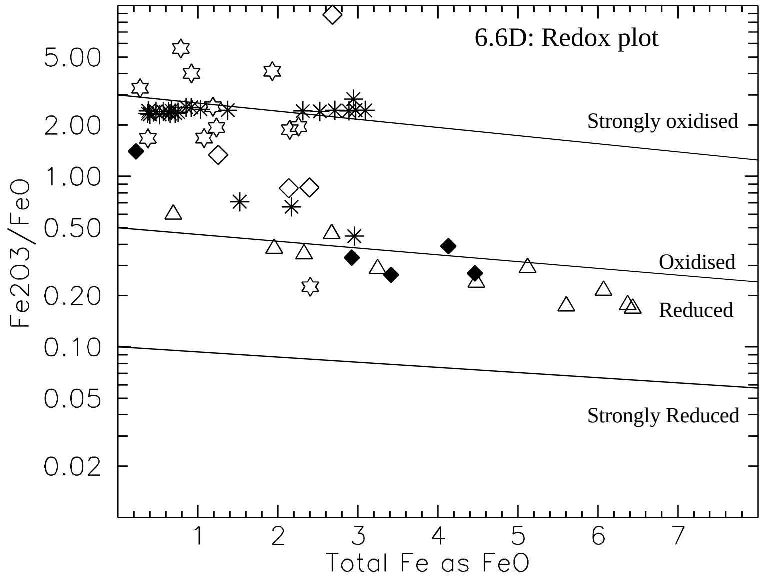
Legend


6.6A: CaO-Na2O-K2O
CaO
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
Na2O
K2O

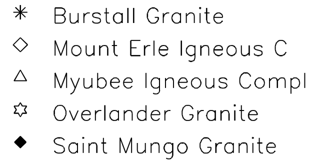

Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite

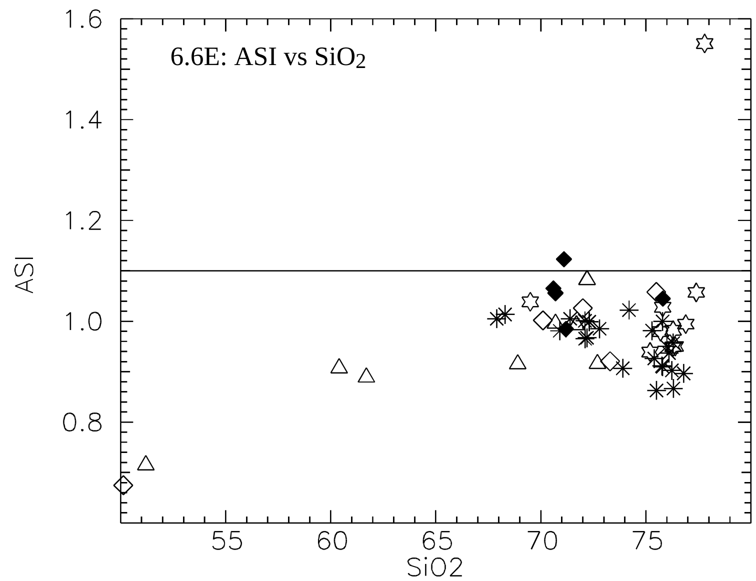

6.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
Zr/Y
3.5
3.0
2.5
2.0
1.5
1.0
0.5
10
20
30

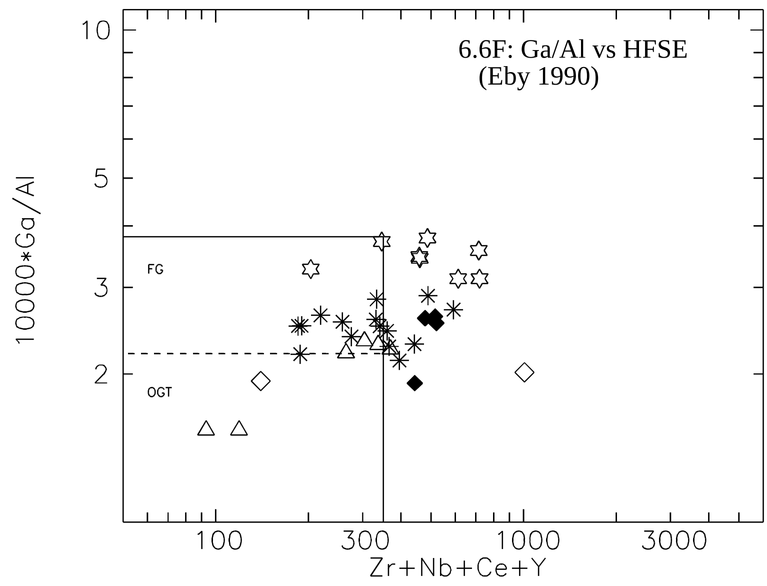

6.6C: Spidergram
SiO2 range: 69-77 wt.%
Rock / Primordial Mantle
500
200
100
50
20
10
5
2
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na

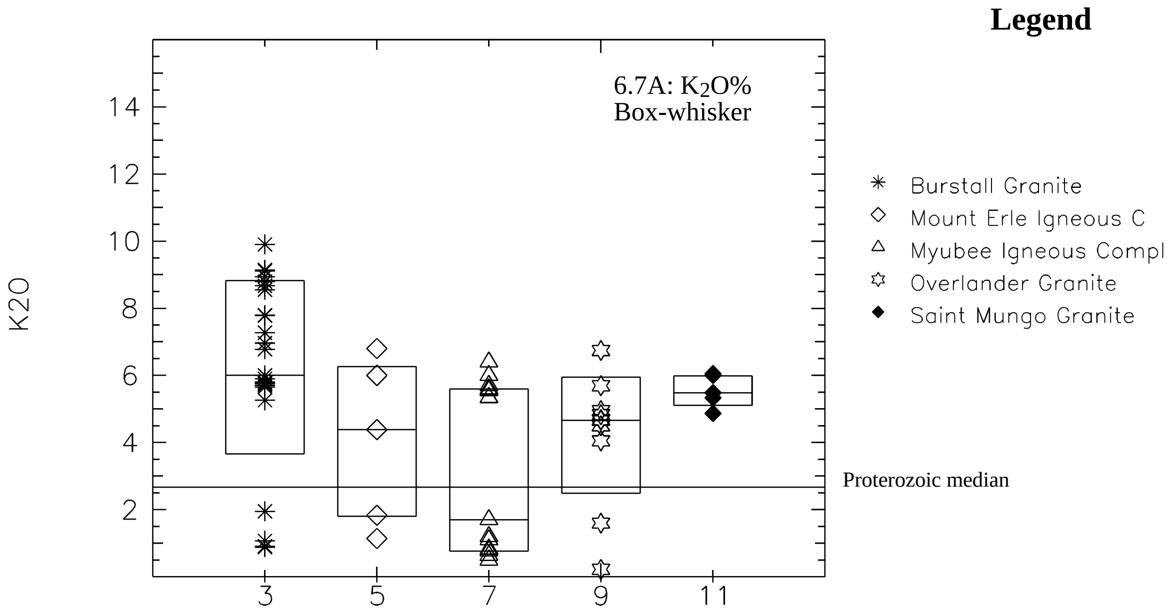

6.6D: Redox plot
Strongly oxidised
Oxidised
Reduced
Strongly Reduced
Fe2O3/FeO
5.00
2.00
1.00
0.50
0.20
0.10
0.05
0.02
1
2
3
4
5
6
7
Total Fe as FeO

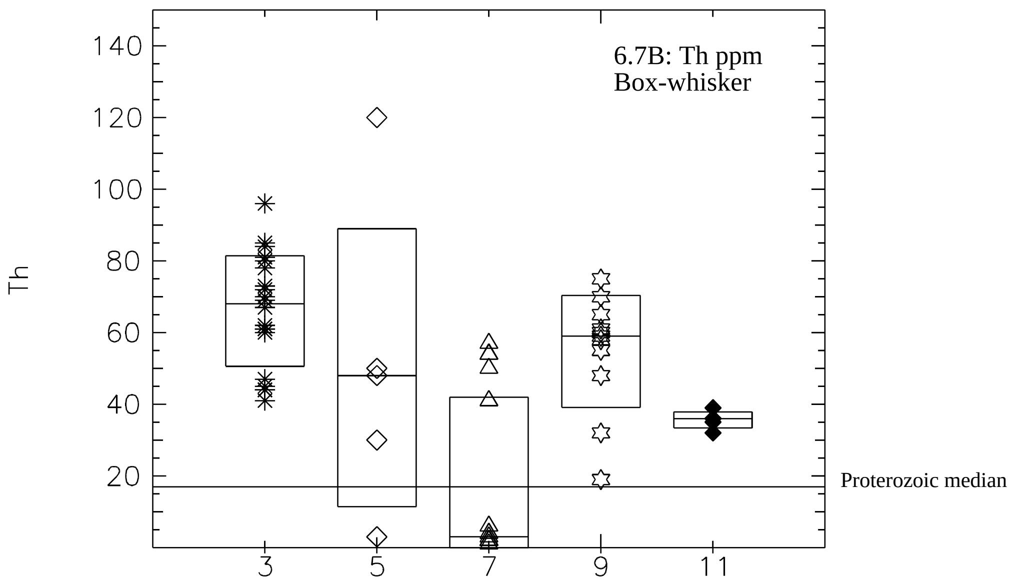
Legend

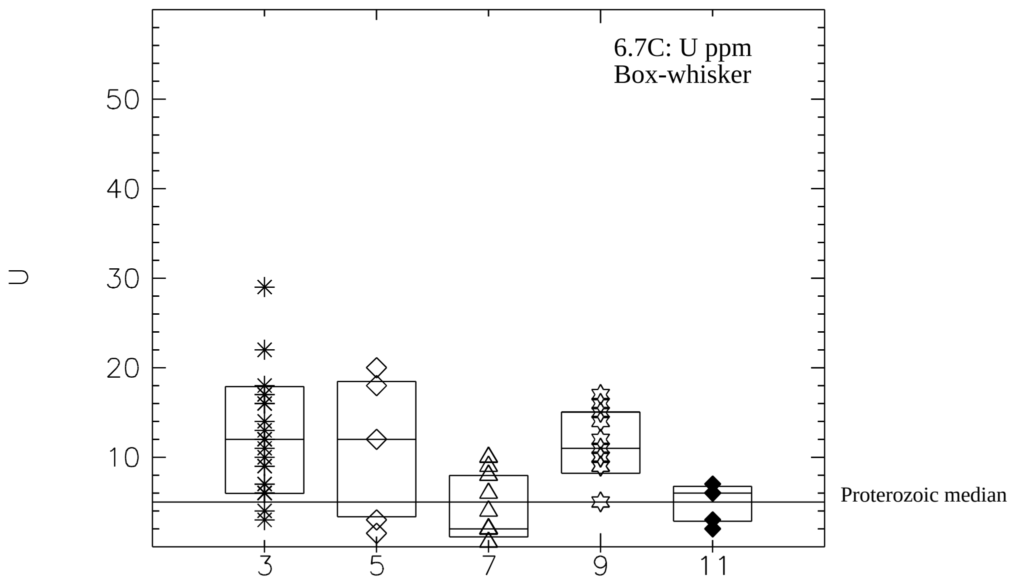

Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite


6.6E: ASI vs SiO2
ASI
1.6
1.4
1.2
1.0
0.8
55
60
65
70
75
SiO2


6.6F: Ga/Al vs HFSE
(Eby 1990)
FG
OGT
10000*Ga/Al
10
5
3
2
100
300
1000
3000
Zr+Nb+Ce+Y


Legend
6.7A: K2O%
Box-whisker
K2O
14
12
10
8
6
4
2
3
5
7
9
11
Proterozoic median
Burstall Granite
Mount Erle Igneous C
Myubee Igneous Compl
Overlander Granite
Saint Mungo Granite


6.7B: Th ppm
Box-whisker
Th
140
120
100
80
60
40
20
3
5
7
9
11
Proterozoic median


6.7C: U ppm
Box-whisker
U
50
40
30
20
10
3
5
7
9
11
Proterozoic median

Burstall Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.23	75.3	3.21	67.9	83.9	25
TiO2	0.23	0.21	0.11	0.08	0.41	25
Al2O3	12.81	12.42	2.35	6.55	18.3	25
Fe2O3	1.01	0.66	0.75	0.28	2.36	25
FeO	0.55	0.28	0.49	0.12	2.11	25
MnO	0.05	0.04	0.05	0.01	0.23	25
MgO	0.28	0.16	0.43	01	2.15	25
CaO	0.93	0.93	0.37	0.29	1.54	25
Na2O	2.94	2.5	2.67	0.07	9.9	25
K2O	6.24	6	2.64	0.88	9.9	25
P2O5	0.03	0.01	0.04	05	0.17	25
H2O+	0.45	0.37	0.31	0.18	1.61	24
H2O-	0.12	0.08	0.13	0.03	0.39	7
CO2	0.11	0.13	0.06	05	0.15	4
LOI	1.14	1.14	-	1.14	1.14	1
Ba	857.95	486.5	1658.07	84	7820	20
Li	16.5	16.5	14.85	6	27	2
Rb	252.05	270.5	102.45	40	399	20
Sr	30.2	26.5	14.59	13	65	20
Pb	12.55	10.5	7.54	5	41	20
Th	66	68	15.82	41	96	20
U	11.92	12	6.09	3	29	25
Zr	178.8	179.5	64.93	88	338	20
Nb	23.9	23	4.9	17	39	20
Y	35.65	37.5	18.66	7	91	20
La	38.33	38	30.91		91	20
Ce	102.2	110.5	62.13	27	240	20
Pr	15	15	-	15	15	1
Nd	25.73	35	18.87		60	15
Sc	1.8		1.26		5	15
V	7.2	5	5.83		18	20
Cr	41.38		79.75		161	4
Mn	297	297	-	297	297	1
Co	4.87	4	3.38		10	15
Ni	3.65	4	1.58		6	17
Cu	37.25	5	139.1	2	628	20
Zn	16.45	13	20.28		99	20
Sn	2.58	3	1.17		5	19
W	5.5	4	3.08	3	13	14
Mo	2.86		5.54		25	18
Ga	17.93	17	3.59	14	25	15
As	2.94	3	2.23		8	18
S	995	65	1870.23	d	3800	4
F	166.67	100	115.47	100	300	3
Cl	266.67	200	115.47	200	400	3
Be	5	5	-	5	5	1
Ag	1	1	-	1	1	1
Bi	1		-			1
Hf	7	7	-	7	7	1
Ta	1		-			1
Cs	1.5		-			1
Ge	5	5	-	5	5	1
Se	0.5		-			1

Mount Erle Igneous Complex

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.21	72	10.29	50.13	75.5	5
TiO2	0.41	0.31	0.26	0.13	0.83	5
Al2O3	13.88	13.4	1.35	12.6	15.62	5
Fe2O3	1.48	1.16	0.76	0.76	2.65	5
FeO	2.36	1.21	3.38	0.3	8.36	5
MnO	0.07	0.05	0.06	0.02	0.17	5
MgO	1.82	0.44	3.21	0.1	7.55	5
CaO	3.09	1.41	3.98	0.86	10.18	5
Na2O	3.37	2.35	1.59	2.2	5.75	5
K2O	4.03	4.38	2.49	1.14	6.8	5
P2O5	0.05	0.04	0.05	01	0.14	5
H2O+	0.42	0.48	0.19	0.15	0.56	4
H2O-	0.14	0.15	0.05	0.08	0.19	4
CO2	0.29	0.09	0.42	0.04	0.92	4
LOI	1.12	1.12	-	1.12	1.12	1
Ba	526.2	331	357.54	190	980	5
Li	18	18	-	18	18	1
Rb	149.4	110	124.71	30	310	5
Sr	92.4	85	57.62	28	169	5
Pb	13.4	12	10.01		28	5
Th	50.2	48	43.34	3	120	5
U	10.9	12	8.44	1.5	20	5
Zr	360	300	288.1	80	760	5
Nb	23.4	26	14.38	7	38	5
Y	35.2	30	18.58	14	60	5
La	55.2	30	50.05	16	140	5
Ce	94.8	85	68.79	29	180	5
Pr	1.5		-			1
Nd	26	26	14.14	16	36	2
Sc	19	19	24.04	2	36	2
V	64	20	95.4		232	5
Cr	81	81	104.65	7	155	2
Mn	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	83	83	111.72	4	162	2
Cu	46.8	25	49.95	10	133	5
Zn	28	10	38.68	2	96	5
Sn	1.4		0.55		2	5
W	-	-	-	-	-	-
Mo	3.25	3.25	2.47		5	2
Ga	16	16	-	16	16	2
As	0.75	0.75	0.35	0.5	1	2
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	0.5		-			1
Ag	-	-	-	-	-	-
Bi	0.5		-			1
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	6	6	-	6	6	1
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Myubee Igneous Complex

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	58.23	52.6	10.42	46.3	72.7	15
TiO2	0.66	0.47	0.55	0.22	2.12	15
Al2O3	16.86	17.2	2.57	13.7	21.2	15
Fe2O3	1.09	0.94	0.71	0.27	3.38	15
FeO	4.83	4.85	3.04	0.45	10.69	15
MnO	0.09	0.1	0.05	0.02	0.17	15
MgO	3.11	3.77	2.77	0.35	8.28	15
CaO	6.86	8.86	5.19	1.25	13.6	15
Na2O	3.66	3.3	1.04	2.47	5.95	15
K2O	3.18	1.7	2.5	0.5	6.4	15
P2O5	0.19	0.12	0.24	0.08	1.03	15
H2O+	0.86	0.66	0.62	0.31	2.57	14
H2O-	0.12	0.11	0.05	0.07	0.24	14
CO2	0.21	0.25	0.15	0.04	0.47	14
LOI	0.73	0.73	-	0.73	0.73	1
Ba	454	380	349.7	220	1625	15
Li	9	9.5	5.73	2	18	6
Rb	145.67	82	149.96	11	400	15
Sr	221.67	270	166.33	26	500	15
Pb	14.4	8	23.49		95	15
Th	18.8	3	23.97		57	15
U	4.53		3.56		10	15
Zr	94.73	75	65.68	22	211	15
Nb	9.27	8	5.73		18	15
Y	18.4	15	11.27	5	40	15
La	25	13	22.6		70	15
Ce	48.2	35	35.67	10	126	15
Pr	-	-	-	-	-	-
Nd	30.5	29.5	14.96	15	49	6
Sc	3.4	4	1.52		5	5
V	19.5	17	12.35		40	8
Cr	5	4.5	3.16		9	6
Mn	-	-	-	-	-	-
Co	2	2	-	2	2	1
Ni	3.67	3.5	0.82	3	5	6
Cu	16.5	9	18.88	4	60	8
Zn	22.25	18	13.97	10	50	8
Sn	2.47		2.83		12	15
W	5	5	-	5	5	1
Mo	4	4	-	4	4	1
Ga	15.83	16.5	1.47	14	17	6
As	1	1	0.32		1.5	6
S	-	-	-	-	-	-
F	950	950	777.82	400	1500	2
Cl	-	-	-	-	-	-
Be	5	5	-	5	5	1
Ag	-	-	-	-	-	-
Bi	1		-			1
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Overlander Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	75.89	76.3	2.27	69.5	77.8	11
TiO2	0.1	0.08	0.05	0.06	0.19	11
Al2O3	12.66	12.1	1.94	11.8	18.5	11
Fe2O3	0.89	0.8	0.51	0.23	1.69	11
FeO	0.53	0.41	0.55	0.07	2	11
MnO	0.39	0.02	1.2	0.01	4	11
MgO	0.45	0.12	1.18	0.02	4	11
CaO	0.51	0.48	0.27	0.26	1.05	10
Na2O	4.22	3.62	2.14	2.78	10.5	11
K2O	4.22	4.66	1.81	0.22	6.74	11
P2O5	0.03	0.04	0.02	02	0.07	11
H2O+	0.26	0.27	0.11	0.1	0.45	11
H2O-	0.13	0.11	0.05	0.06	0.2	11
CO2	0.09	0.06	0.09	05	0.3	11
LOI	-	-	-	-	-	-
Ba	152.27	110	111.78	13	391	11
Li	1.5	1.5	0.53	1	2	8
Rb	224.36	223	91.55	2	340	11
Sr	16.18	14	8.67	10	41	11
Pb	8	3	10.31		36	11
Th	54.73	59	16.38	19	75	11
U	11.64	11	3.59	5	17	11
Zr	211.36	200	68.82	112	331	11
Nb	44.09	47	9.01	28	55	11
Y	89.82	95	18.76	59	111	11
La	81	61	50.37		180	11
Ce	138.95	120	87.03		295	11
Pr	-	-	-	-	-	-
Nd	72.56	74	40		123	8
Sc	1		-			8
V	4.73		6.21		20	11
Cr	18.88	9	24.66	7	79	8
Mn	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	3.69	1.5	5.93		18	8
Cu	16.09	7	16.08		47	11
Zn	6.45	6	4.97		19	11
Sn	1.27		0.9		4	11
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	23.38	22.5	3.81	20	32	8
As	0.75	0.75	0.27		1	8
S	-	-	-	-	-	-
F	200	200	-	200	200	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Saint Mungo Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.88	71.1	2.21	70.6	75.81	5
TiO2	0.43	0.43	0.03	0.38	0.46	5
Al2O3	13.3	13.2	0.32	13	13.81	5
Fe2O3	0.76	0.75	0.39	0.14	1.19	5
FeO	2.35	2.76	1.35	0.1	3.59	5
MnO	0.03	0.03	0.01	0.02	0.04	5
MgO	0.45	0.54	0.22	0.06	0.56	5
CaO	1.17	1.49	0.54	0.33	1.55	5
Na2O	2.87	2.55	0.93	2.25	4.51	5
K2O	5.55	5.48	0.49	4.87	6.05	5
P2O5	0.09	0.1	0.03	0.03	0.11	5
H2O+	0.62	0.68	0.32	0.12	0.89	5
H2O-	0.25	0.24	0.12	0.11	0.38	5
CO2	0.07	0.07	0.04	01	0.11	5
LOI	-	-	-	-	-	-
Ba	895.2	889	338.08	472	1414	5
Li	18.5	22	11.36	2	28	4
Rb	230.4	250	59.37	130	285	5
Sr	92.2	110	34.82	32	114	5
Pb	17.2	21	8.04	8	24	5
Th	35.6	36	2.51	32	39	5
U	4.8	6	2.17	2	7	5
Zr	276.4	276	21.22	252	300	5
Nb	14.4	15	1.52	12	16	5
Y	54	51	6.96	48	62	5
La	72.8	85	29.14	21	90	5
Ce	141.8	150	22.25	110	163	5
Pr	-	-	-	-	-	-
Nd	57.5	68.5	24.47	21	72	4
Sc	7.25	6.5	2.87	5	11	4
V	13.8	13	3.56	11	20	5
Cr	8.75	9	2.87	5	12	4
Mn	-	-	-	-	-	-
Co	6	5	2.71	4	10	4
Ni	3	3	1.63		5	4
Cu	31.4	12	44.61	7	111	5
Zn	22.4	23	10.16	6	33	5
Sn	12.4	10	7.3	4	23	5
W	6	6	-	6	6	1
Mo	1.5		-			1
Ga	17	18	2	14	18	4
As	2.75	3	0.5	2	3	4
S	-	-	-	-	-	-
F	500	500	-	500	500	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

7 FIERY SUPERSUITE

7.1 Timing

1710 Ma

7.2 Individual Ages

Primary Ages:

1. Peters Creek Volcanics	1724 ± 2 Ma, SHRIMP
2. Peters Creek Volcanics	1726 ± 2 Ma, SHRIMP
3. Fiery Creek Volcanics	1709 ± 3 Ma, SHRIMP
4. Weberra Granite	1698 ± 24 Ma, U-Pb

Source: OZCHRON

7.3 Regional Setting

Note: In this project we have chosen to separate the Carters Bore Rhyolite from the Fiery Creek Volcanics due to the similarity of the former with the ~1670 Ma Sybella Suite intrusions and the latter with the 1678 Ma Weberra Granite. Although the Peters Creek Volcanics probably represent a separate, older event, due to the general similarity in both composition and alteration overprint we are including both these volcanic units, along with the Weberra Granite, in the Fiery Supersuite. This is predominantly an extrusive suite, with the only significant intrusive, the Weberra Granite, being relatively small and emplaced at fairly shallow crustal levels.

The Supersuite is bimodal, with both mafic and felsic rock types represented, suggesting that the tectonic setting operating at the time was extensional. An alteration overprint is very pervasive throughout this supersuite, and the primary igneous geochemistry is difficult to ascertain with confidence.

7.4 Summary

Even allowing for the extensive alteration, the members of this supersuite do not appear to have undergone any significant magmatic fractionation which would allow for the concentration of significant amounts of Au or base metals. The significance of this supersuite to metallogenesis is the ubiquitous hematitic alteration overprint. McGoldrick *et al.* (1996) have suggested that because of the low Au tenor of the HYC, Mount Isa and Lady Loretta deposits, the mineralising fluids associated with these deposits are likely to have been oxidising and near-neutral to alkaline. The alteration assemblages within the units of the Fiery Supersuite suggest that these units may possibly have seen a fluid similar to that which carried the Pb and Zn associated with these giant sediment-hosted base metal deposits. Hence mapping the extent of these alteration assemblages may provide clues to fluid pathways associated with these Zn-Pb-Ag deposits.

7.5 Potential

The supersuite is not considered to have any potential for granite-related hydrothermal mineralisation. It is of limited spatial extent.

Cu:	**None**
Au:	**None**
Pb/Zn:	**None**
Sn:	**None**
Mo/W:	**None**
Confidence level:	**321**

7.6 Descriptive Data

Location: Northern Mount Isa Inlier, mainly on the Lawn Hill Platform between the Murphy Inlier and the Mount Gordon Fault.

Dimensions and area: Members of the Fiery Creek Supersuite crop out sporadically over a region 315 km by 120 km. Total area of outcrop is about 200 km^2.

7.7 Intrusives

Component plutons: Weberra Granite and several rhyolite, trachyte, granophyre and dolerite dykes.

Form: A approximately circular intrusion with several major dyke systems emanating from it.

Metamorphism and Deformation: None.

Dominant intrusive rock types: Even-grained medium to coarse-grained syenogranite to alkali-feldspar granite, slightly more biotite towards the perimeter, minor granophyre.

Colour: Grey to pink.

Veins, Pegmatites, Aplites, Greisens: Some aplite and minor pegmatite noted.

Distinctive mineralogical characteristics: Quartz, K-feldspar, plagioclase, interstitial biotite, accessory zircon, titanite and hematite. Rare garnet has been noted.

Breccias: None recorded.

Alteration in the granite: Albitised in places but generally potassically altered although a high primary K_2O content is probable. Chlorite and calcite noted as alteration products.

7.8 Extrusives

Flow-banded rhyolite, rhyolitic agglomerate, rhyolitic ignimbrite interbedded with altered reddish vesicular basalt and trachybasalt, red arkosic sandstone, and conglomerate; quartz-feldspar porphyry in domes and dykes. Mafic volcanics are much more widespread than the felsic volcanics. The Fiery Creek Volcanics contain altered basalt with secondary K-feldspar and hematite, possibly produced by saline fluids under oxidizing conditions. Felsic volcanics of the Peters Creek Volcanics comprise quartz-feldspar porphyry, ashstone, rhyolite, rhyodacite: some are highly altered with assemblages of hematite and K-feldspar.

7.9 Country Rock

Contact metamorphism: The country rocks are contact metamorphosed up to hornblende hornfels facies in a contact aureole up to 4 km from the outcropping edge of the pluton (although the granite may occur at shallow depths beneath this area).

Reaction with country rock: None noted.

Units the granite intrudes: Intrudes a dome of Myally Subgroup and Quilalar Formation.

Dominant rock types: Quartzite, red mudstone, siltstone, dolomite.

Potential hosts: Reactions could occur with the dolomites.

7.10 Mineralisation

There are several small Cu mines in the vicinity of some of the outcrops of the Fiery Creek Volcanics: these are mainly hosted by Whitworth Quartzite, and primary magmatic activity is not considered to have played a role in their formation. The extremely oxidised nature of these volcanics and the dominance of hematite and K-feldspar is of metallogenic significance as it implies that the volcanics have re-equilibrated with an oxidised neutral to alkaline fluid. Such a fluid has been invoked as being the mineralising fluid associated with the formation of major Zn-Pb-Ag deposits such as Mount Isa, HYC and Lady Loretta (McGoldrick *et al.* 1996). There are noticeable differences in the composition of the Peters Creek and Fiery Creek Volcanics in that the Peters Creek Volcanics are higher in Ba and U. These changes probably reflect subtle differences in the physicochemical properties of the alteration fluid.

7.11 Geochemical Data

Data source: AGSO's OZCHEM data base.

Data quality: The data quality is good.

Are the data representative? There is insufficient sampling of the various rock types.

Are the data adequate? No way.

SiO_2 range (Fig. 7.1): The SiO_2 range is from 50 to 77 wt.% reflecting the bimodal character of this suite. There is a gap at around 60 wt.%.

Alteration (Fig. 7.2):

- ***SiO_2:*** There is some evidence of silicification in the altered samples.

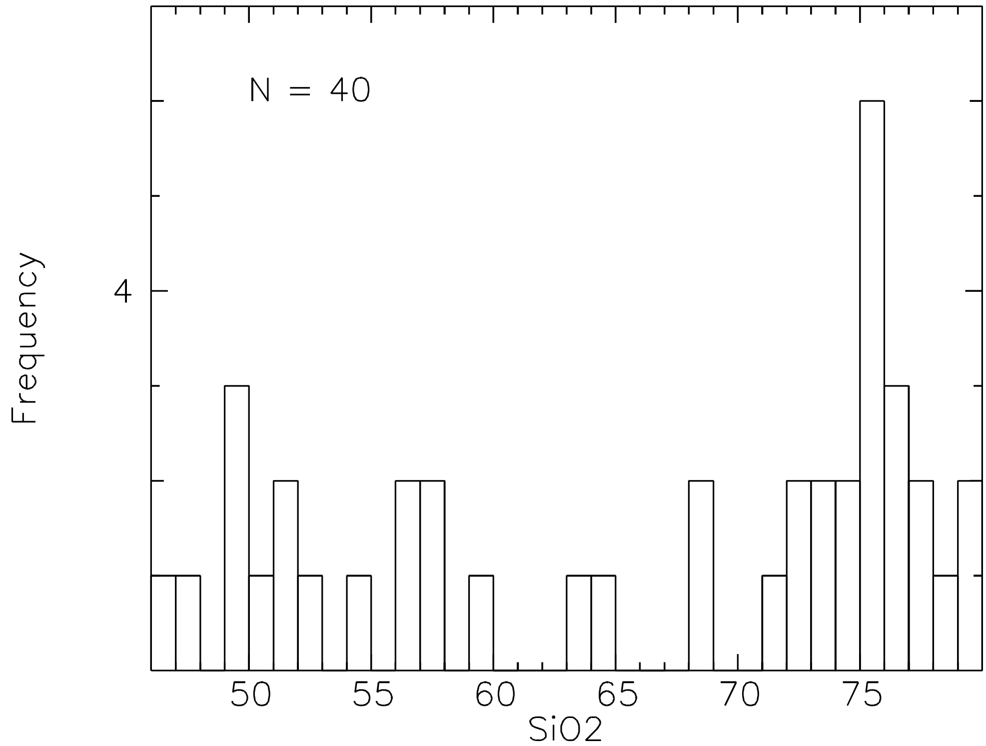


Figure 7.1. Histogram of values for the Fiery Creek Supersuite.

- ***K_2O/Na_2O:*** All samples are extremely altered with unrealistically high values of K_2O and low values for Na_2O for a primary igneous rock.
- ***Th/U:*** During alteration there has been loss of U in most of the Weberra Granite and Fiery Creek samples with > 70 wt.% SiO_2.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** Both suites of volcanics have been extensively oxidised during alteration.

Fractionation Plots (Fig. 7.3):

- ***Rb:*** There is no increase in Rb with increasing SiO_2.
- ***U:*** There is no increase in U with increasing SiO_2.
- ***Y:*** Some samples show a very weak increase in Y with increasing SiO_2.
- ***P_2O_5:*** There is no increase or decrease in P_2O_5 with increasing SiO_2.
- ***Th:*** There is a weak increase in Th with increasing SiO_2.
- ***K/Rb:*** The K/Rb ratios have been drastically affected by alteration and are unrealistically high for primary igneous rocks.
- ***Rb-Ba-Sr:*** These samples are too altered for this plot to be meaningful.
- ***Sr:*** All values are extremely low for primary igneous rocks.
- ***Rb/Sr:*** Very weak increase with increasing SiO_2: this plot is likely to have been affected by the ubiquitous alteration.
- ***Ba:*** Ba values are higher for the Peters Creek Volcanics than the Fiery Creek Volcanics, suggesting that the alteration fluid in this area may have been of different composition.
- ***F:*** Values are within the range noted by Eby (1990) for Palaeozoic A-type granites.

Metals (Fig. 7.4):

- ***Cu:*** Some moderate values, which may reflect alteration.
- ***Pb:*** Values are mostly low, presumably because of the destruction of primary K-Feldspar.
- ***Zn:*** Values are low, no change with increasing SiO_2.
- ***Sn:*** Values are low, no change with increasing SiO_2.

High field strength elements (Fig.7.5):

- ***Zr:*** Values are moderate, no change with increasing SiO_2.
- ***Nb:*** Values are low to moderate, no change with increasing SiO_2.
- ***Ce:*** Values are generally low, no change with increasing SiO_2.

Classification (Fig. 7.6):

- ***The CaO/Na_2O/K_2O plot of White, quoted in Sheraton and Simons (1992):*** Most samples plot in the granite field (including the mafic samples) because of the high K_2O.
- ***Zr/Y vs Sr/Sr*:*** All samples plot below 1 indicating that the primary magma was Sr-depleted, Y-undepleted.
- ***Spidergram:*** The samples plotted have a typical Sr-depleted, Y-undepleted pattern with strong fractionation of Sr, P and Ti.
- ***Oxidation plot of Champion and Heinemann (1994):*** Due to the alteration, most samples plot in the strongly oxidised to oxidised field.
- ***ASI:*** All samples are peraluminous, but this could be because of the removal of Na_2O and CaO during alteration.
- ***A-type plot of Eby (1990):*** Most samples plot within the A-type field defined for Palaeozoic A-type granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-(granodiorite) type.

Australian Proterozoic granite type: Sybella.

7.12 Geophysical Signature

Radiometrics (Fig. 7.7): All samples plot well above the Proterozoic median for K_2O; are close to the median values for Th and U for the Peters Creek Volcanics; and close to median for Th in the Fiery Creek Volcanics. In a RGB plot, most would plot as white, with a tendency to red for the Fiery Creek Volcanics.

Gravity: Density measurements have been carried out on the Weberra Granite and the Fiery Creek Volcanics by Hone *et al.* (1987). The wet densities ranged from 2.53 to 2.59 gm/cm^3 and were the lowest values recorded for any felsic igneous rocks in the Mount Isa Inlier. Given the narrow size of the outcrops, the AGSO regional data are too coarse for any significant correlations to be made.

Magnetics: The Peters Creek Volcanics have a distinctive high magnetic signature (Martin *et al.* 1997) which suggests that a high proportion of the subsurface members of this unit are mafic volcanics. The felsic volcanics and the Weberra Granite have low measured susceptibilities (Wyborn, unpublished data; Hone *et al.* 1987).

7.13 References

Blake, D.H. 1987, Geology of the Mount Isa Inlier and environs, Queensland and Northern Territory. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 225.

Derrick, G.M. and Wilson, I.H. 1982. Geology of the Alsace 1:100000 sheet area (6858) Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1982/6, 88 pp.

Hone, I.G., Carberry, V.P. and Reith, H.G. 1987. Physical property measurements on rock samples from the Mount Isa Inlier, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report,* 265, 30 pp.

Hutton, L.J. and Wilson, I.H. 1984, Mount Oxide Region, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Hutton, L.J. and Wilson, I.H. 1985, Mammoth Mines Region, Queensland, 1:100000 Geological Map Commentary, *Bureau of Mineral Resources, Geology and Geophysics.*

Martin, S., Retter, A. and Scott, D. 1997. Regional applications of GIS. NABRE workshop, March 1997. *Australian Geological Survey Organisation, Record,* 1997/12.

McGoldrick, P., Keays, R., Smith, R., McOrist, G. and Fardy, J. 1996. Gold in Australian Late Palaeoproterozoic stratiform sediment-hosted zinc-lead-silver deposits. G*eological Society of Australia, Abstracts, No*. 41, 287.

Scott, D., Tarlowski, C., Leven, J., Martin, S., Jackson, J. and Page, R. 1997. Basement Studies: current status of models and data set integration. NABRE workshop, March 1997. *Australian Geological Survey Organisation, Record,* 1997/12.

Sweet, I.P. and Hutton, L.J. 1980. The geology of the Lawn Hill/Riversleigh Region, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1980/43, 73 pp.

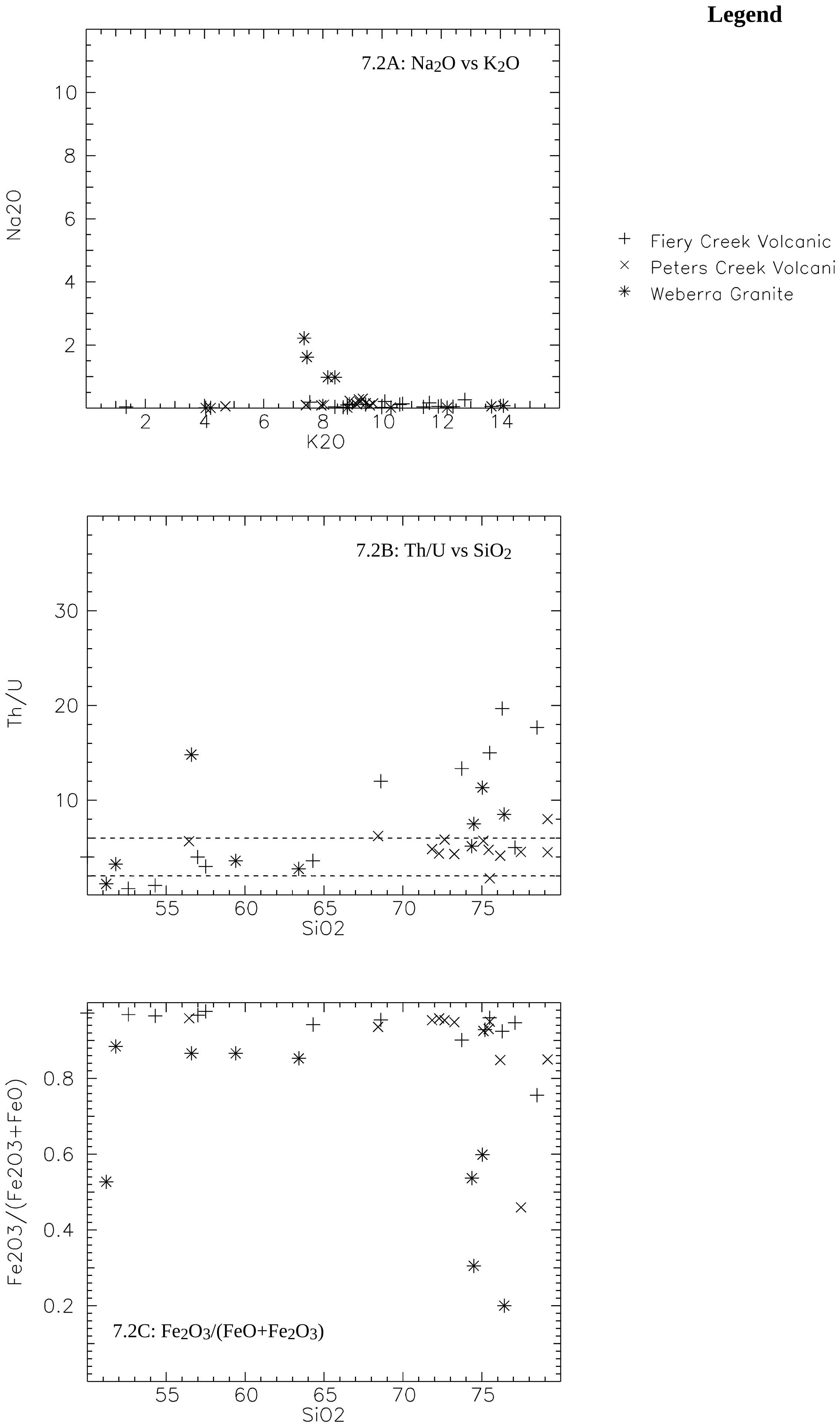
Sweet, I.P. and Hutton, L.J. 1982. Lawn Hill Region, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Sweet, I.P. and Slater, P.J. 1975. Precambrian geology of the Westmoreland Region, Northern Australia. Part I: regional setting and cover rocks. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1975/88, 90 pp.

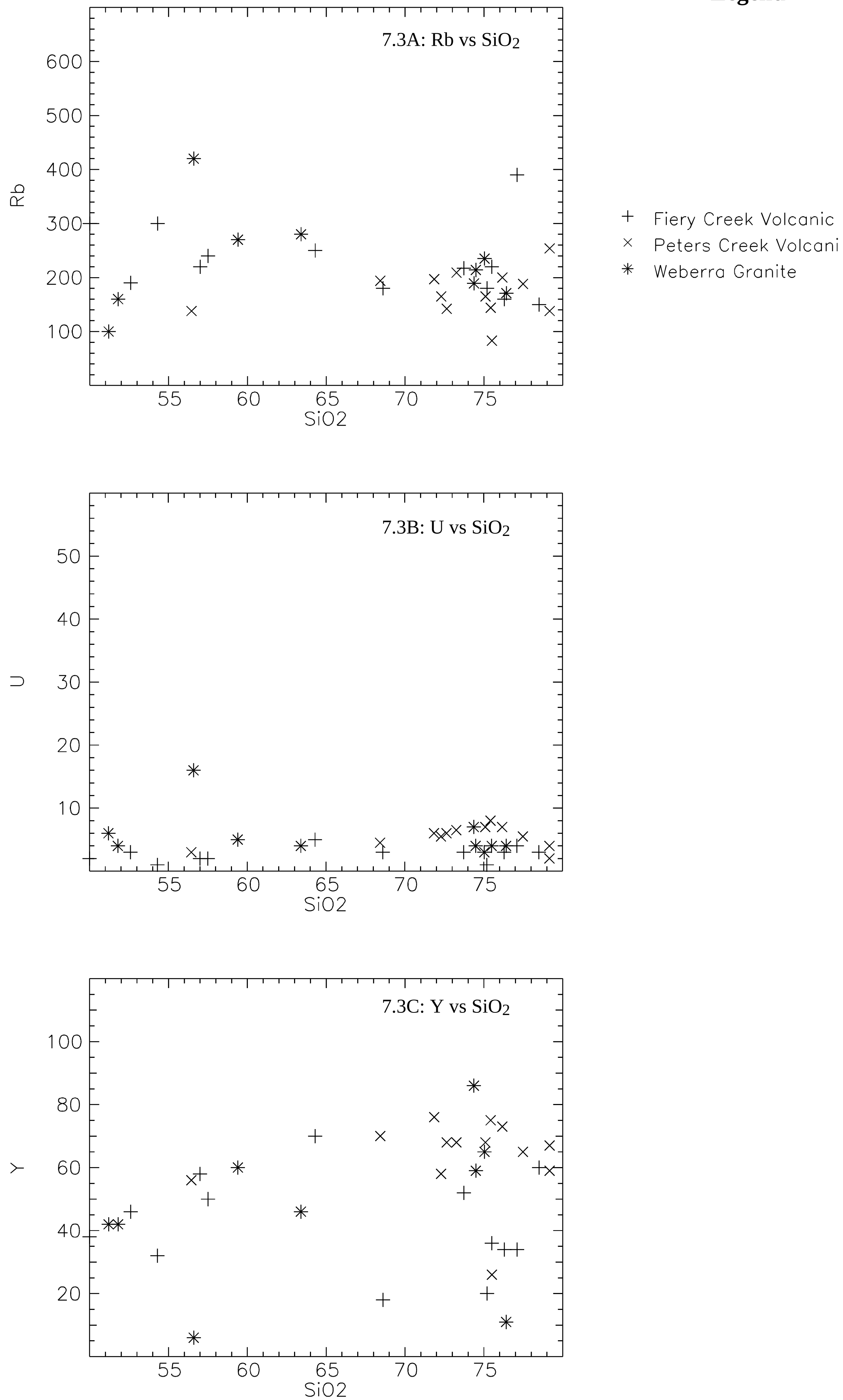
Sweet, I.P., Mock, C.M. and Mitchell, J.E. 1981. Seigal, Northern Territory and Hedleys Creek, Queesland, 1:100000 Geological Map Commentary, *Bureau of Mineral Resources, Geology and Geophysics,* 32 pp.

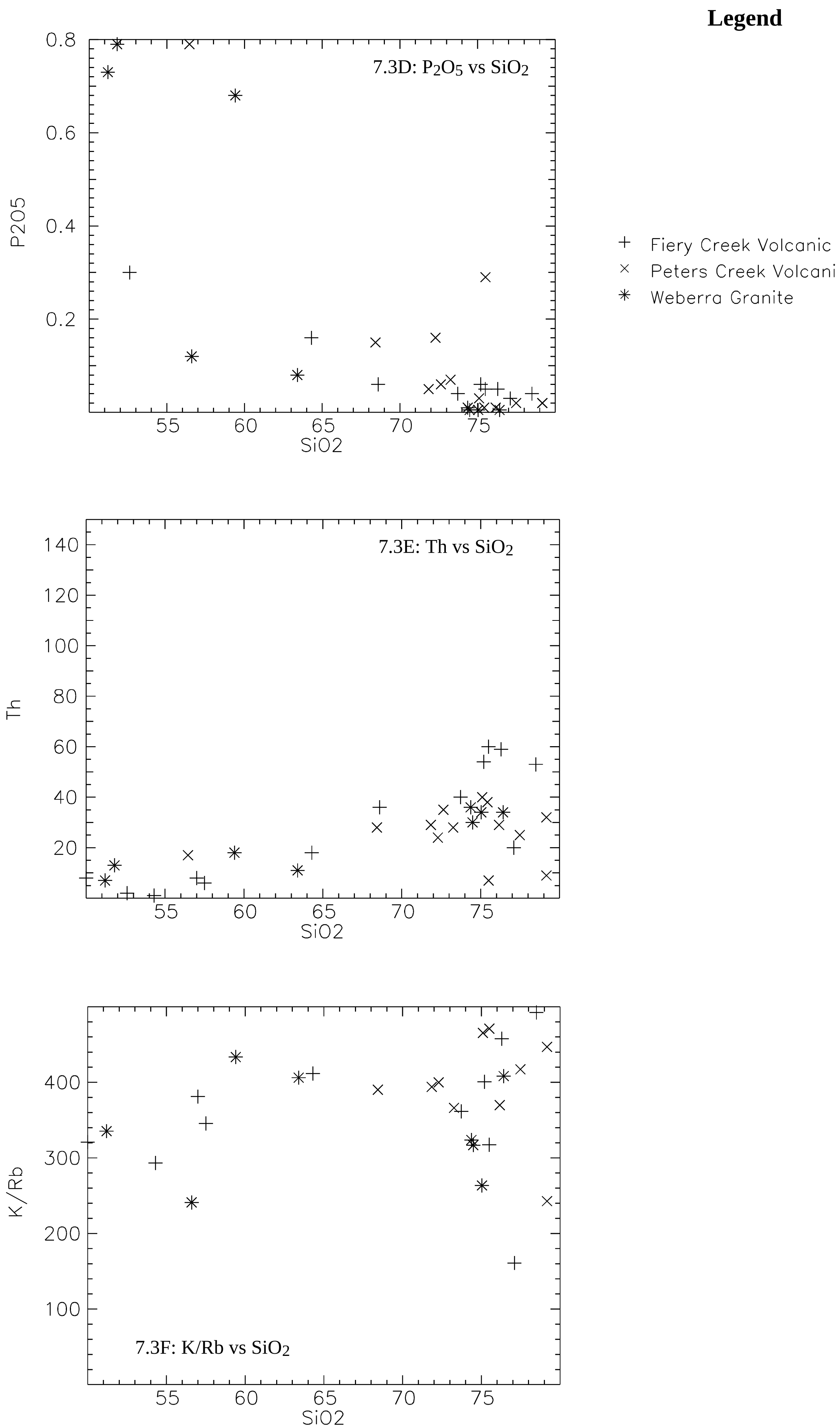
Wilson, I.H. 1987. Geochemistry of Proterozoic volcanics, Mount Isa Inlier, Australia. In: Pharaoh, T.C., Beckinsale, R.D. and Rickard, D., (editors), Geochemistry and Mineralization of Proterozoic Volcanic Suites. *Geological Society Australia Special Publication,* 33, 409-423.

Wyborn, L.A.I., Page, R.W. and McCulloch, M.T. 1988, Petrology, geochronology and isotope geochemistry of the post-1820 Ma granites of the Mount Isa Inlier: Mechanisms for the generation of Proterozoic anorogenic granites. *Precambrian Research,* 40/41, 509-541.

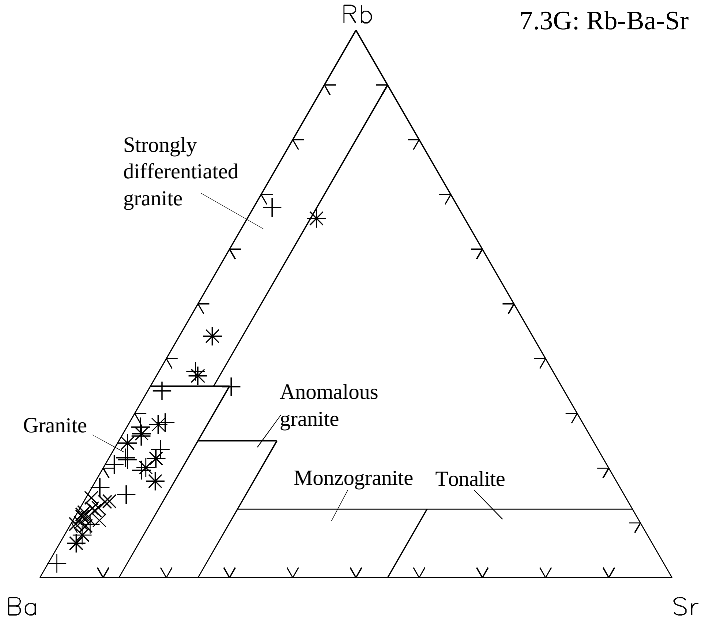

Legend
7.2A: Na2O vs K2O
Na2O
K2O
+ Fiery Creek Volcanic
× Peters Creek Volcani
* Weberra Granite
7.2B: Th/U vs SiO2
Th/U
SiO2
7.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2

Legend

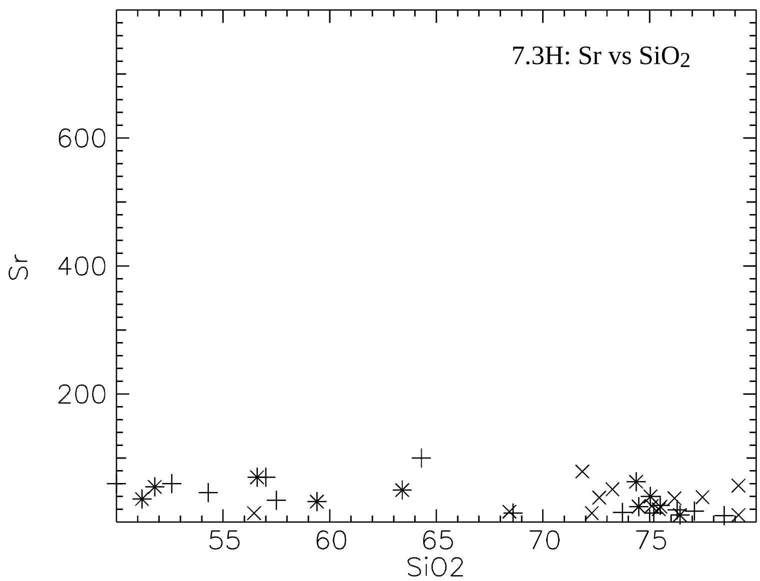

7.3A: Rb vs SiO2
Rb
600
500
400
300
200
100
55
60
65
70
75
SiO2
Fiery Creek Volcanic
Peters Creek Volcani
Weberra Granite
7.3B: U vs SiO2
U
50
40
30
20
10
55
60
65
70
75
SiO2
7.3C: Y vs SiO2
Y
100
80
60
40
20
55
60
65
70
75
SiO2

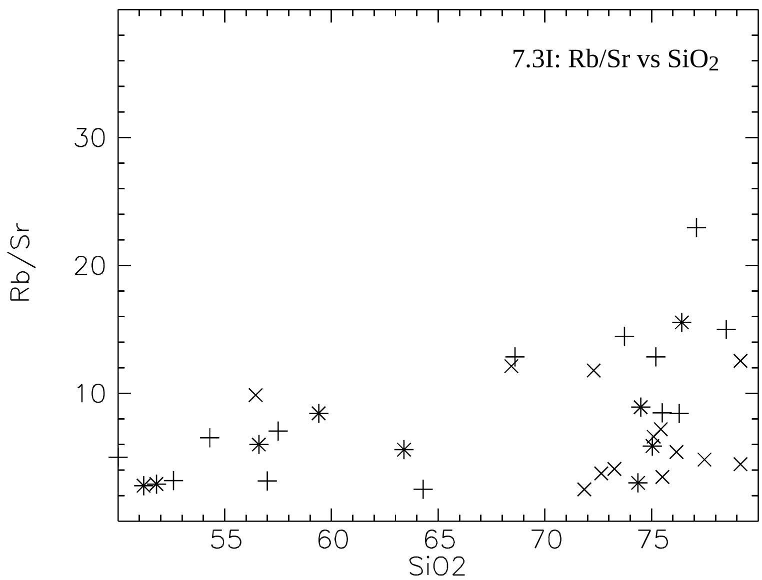

Legend
+ Fiery Creek Volcanic
× Peters Creek Volcani
✳ Weberra Granite
7.3D: P2O5 vs SiO2
P2O5
SiO2
7.3E: Th vs SiO2
Th
SiO2
7.3F: K/Rb vs SiO2
K/Rb
SiO2

Legend

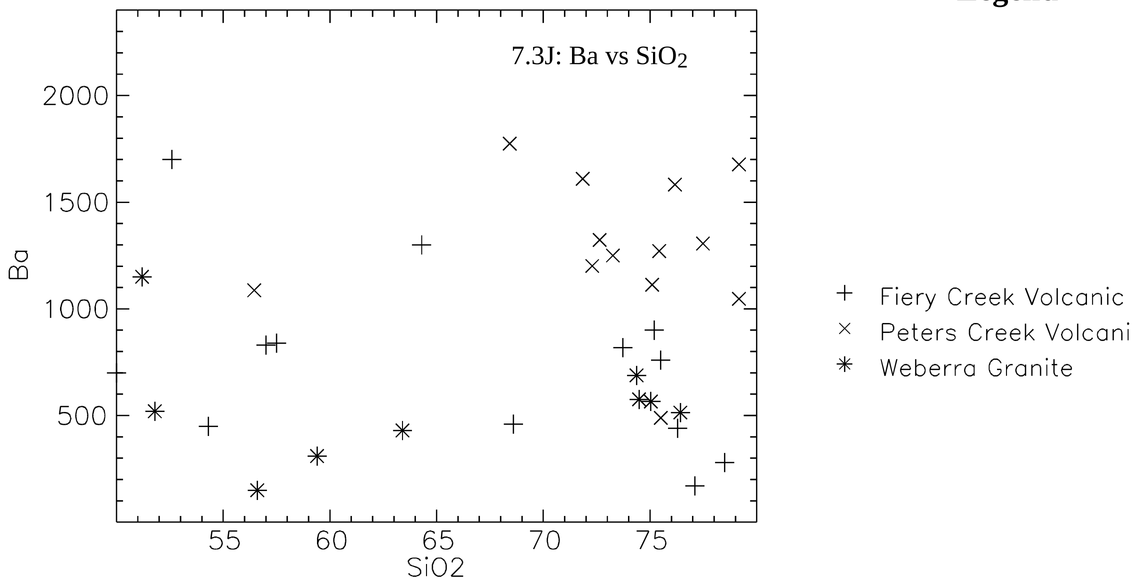


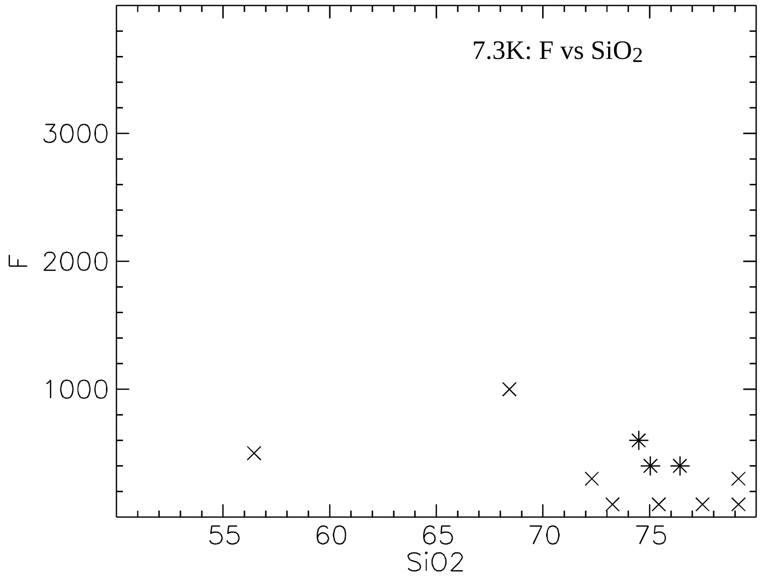
+ Fiery Creek Volcanic
× Peters Creek Volcani
* Weberra Granite

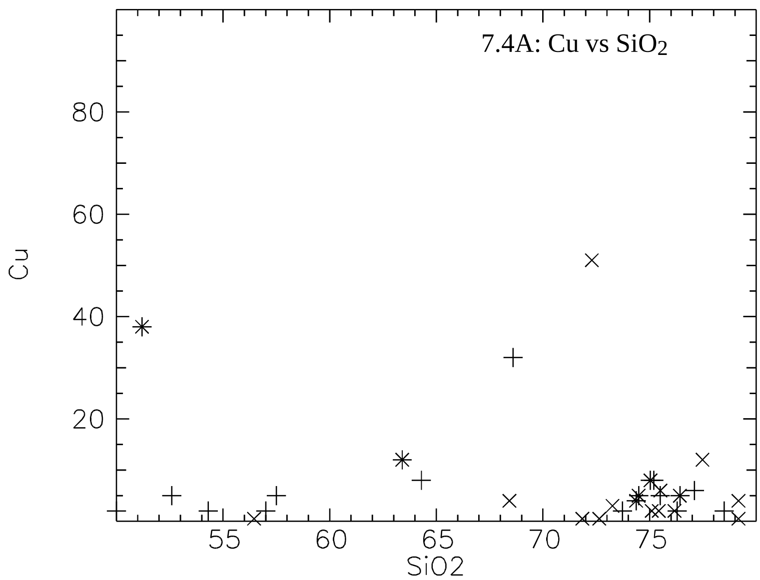


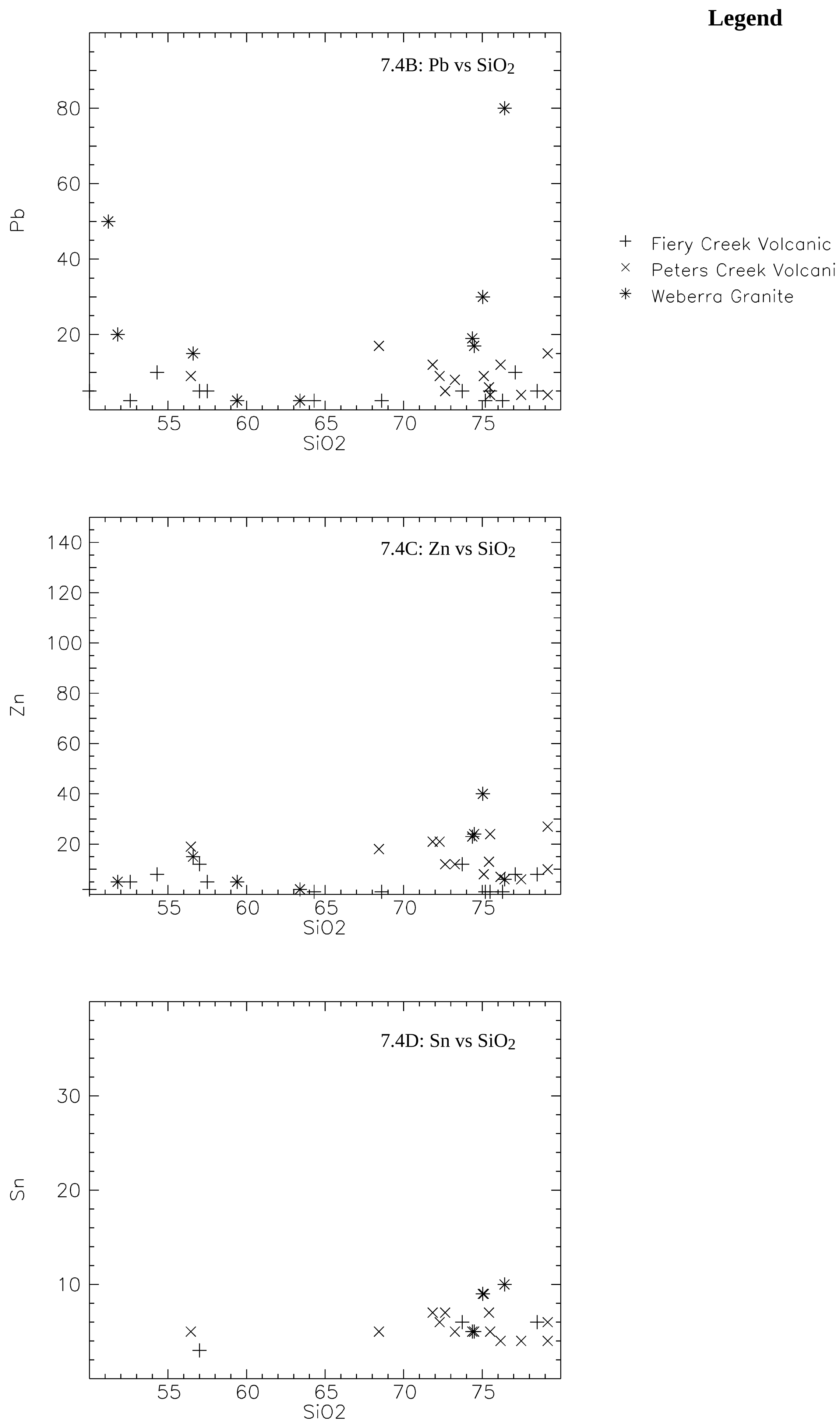


Legend

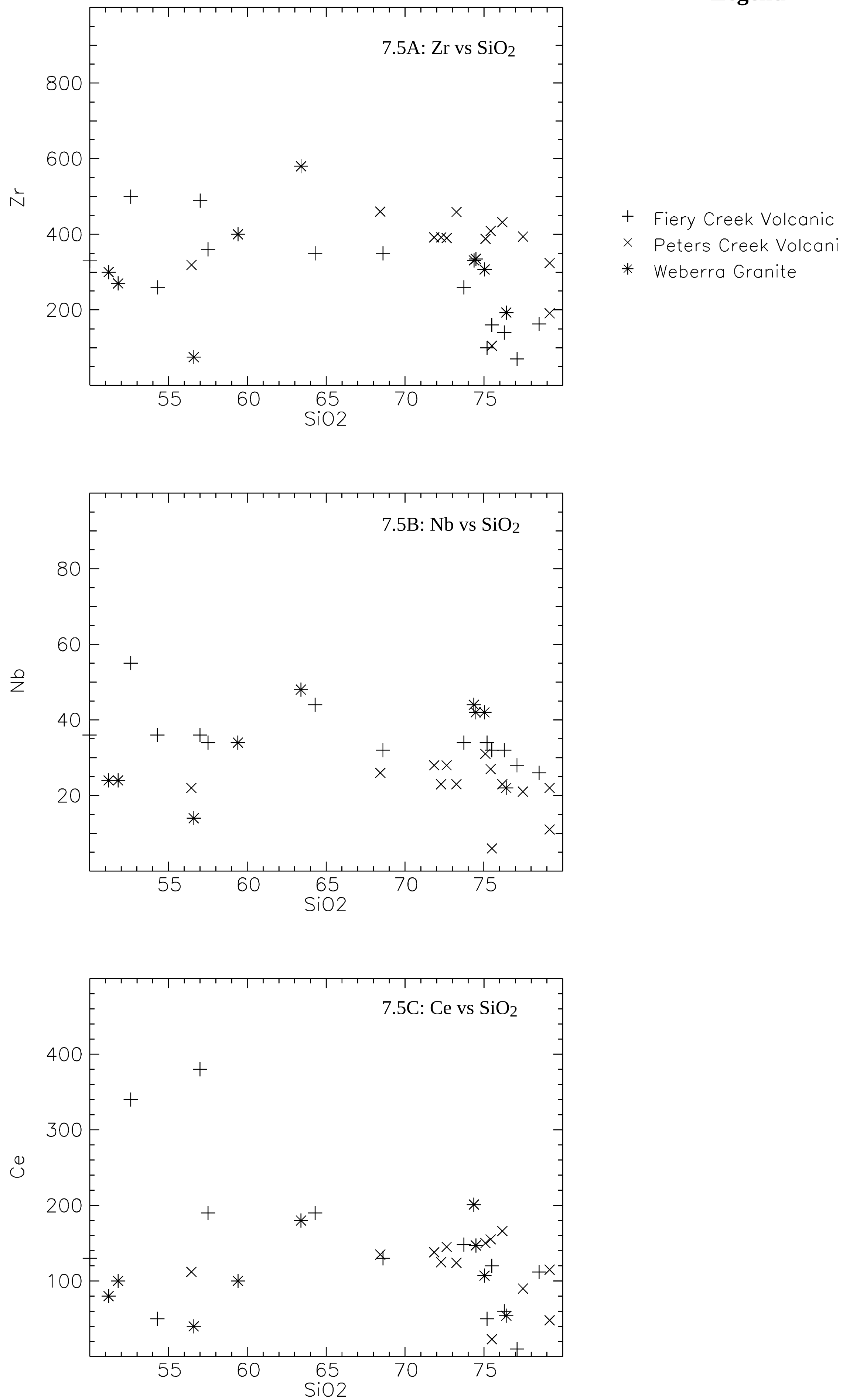

7.3J: Ba vs SiO_2
Ba
SiO2
2000
1500
1000
500
55
60
65
70
75
Fiery Creek Volcanic
Peters Creek Volcani
Weberra Granite

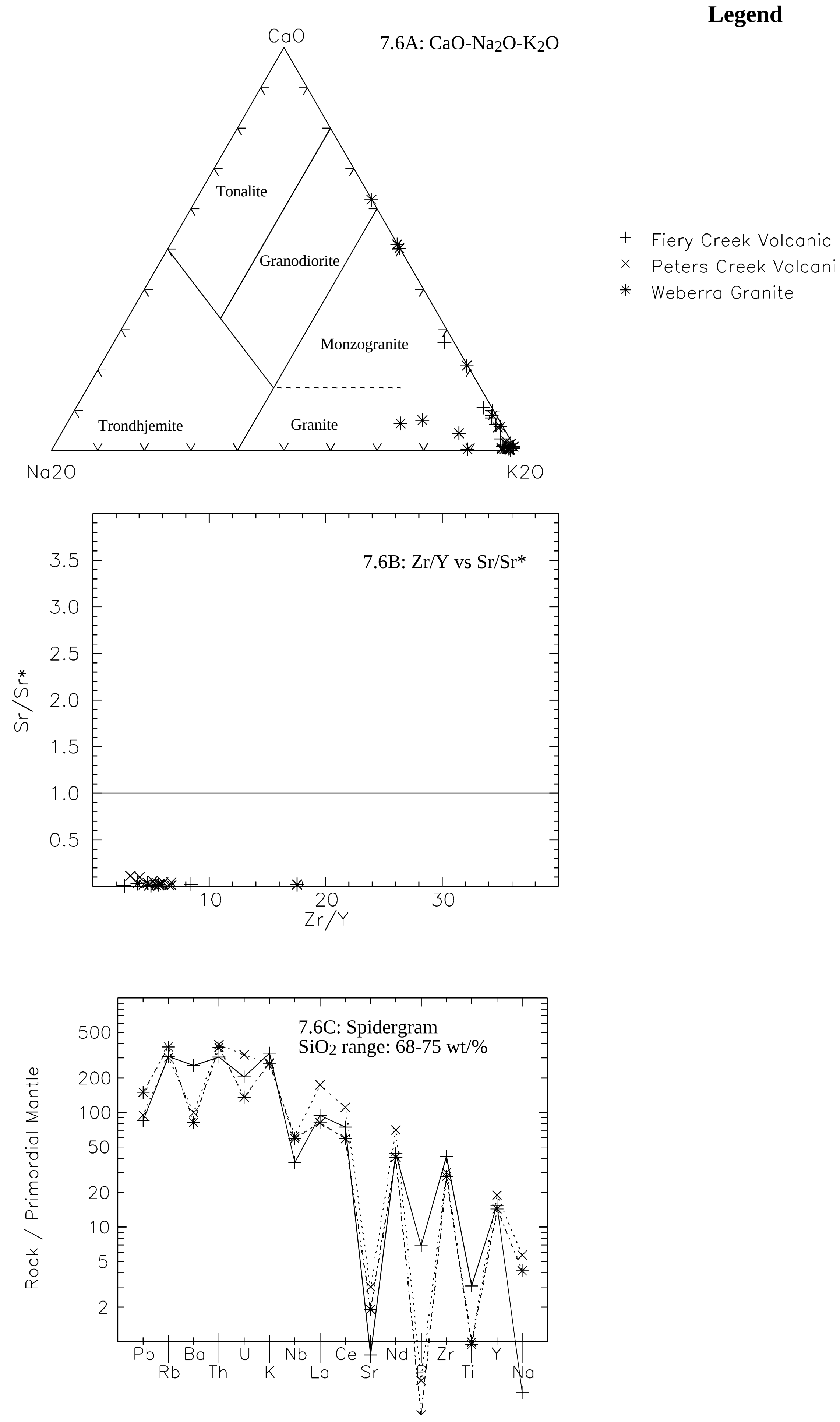

7.3K: F vs SiO_2
F
SiO2
3000
2000
1000
55
60
65
70
75


7.4A: Cu vs SiO_2
Cu
SiO2
80
60
40
20
55
60
65
70
75


Legend
Fiery Creek Volcanic
Peters Creek Volcani
Weberra Granite
7.4B: Pb vs SiO2
Pb
SiO2
7.4C: Zn vs SiO2
Zn
SiO2
7.4D: Sn vs SiO2
Sn
SiO2

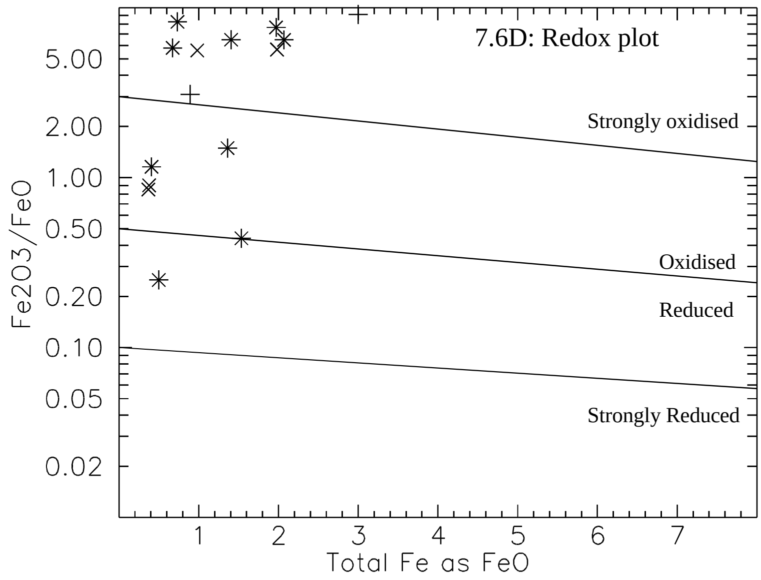
Legend

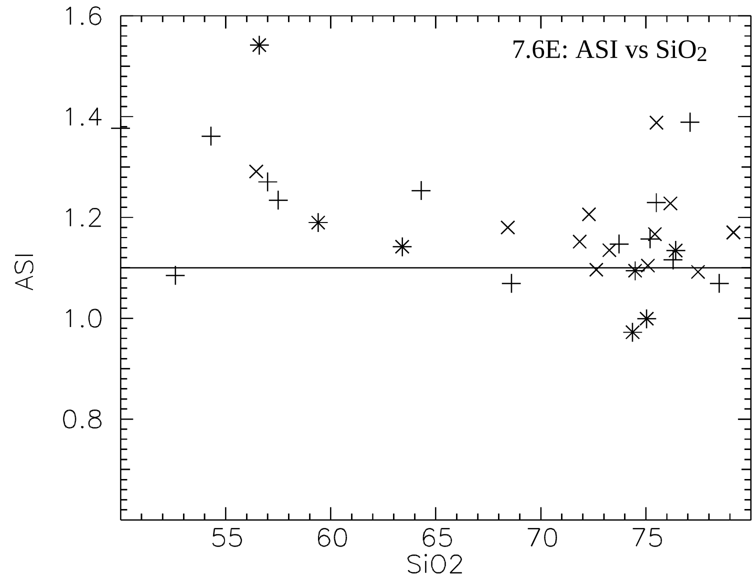

7.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
Fiery Creek Volcanic
Peters Creek Volcani
Weberra Granite
7.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
7.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

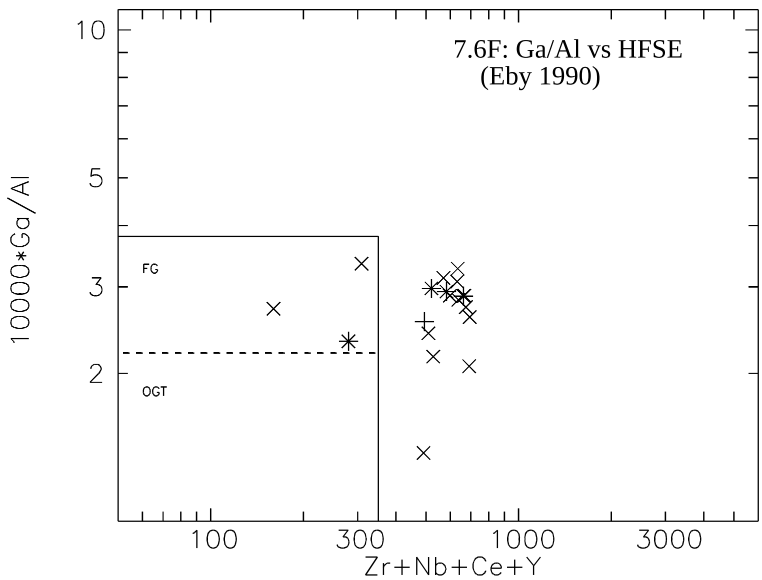

Legend
7.6A: CaO-Na2O-K2O
CaO
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
Na2O
K2O
+ Fiery Creek Volcanic
× Peters Creek Volcani
✳ Weberra Granite
7.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
3.5
3.0
2.5
2.0
1.5
1.0
0.5
10
20
30
Zr/Y
7.6C: Spidergram
SiO2 range: 68-75 wt/%
Rock / Primordial Mantle
500
200
100
50
20
10
5
2
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na

Legend

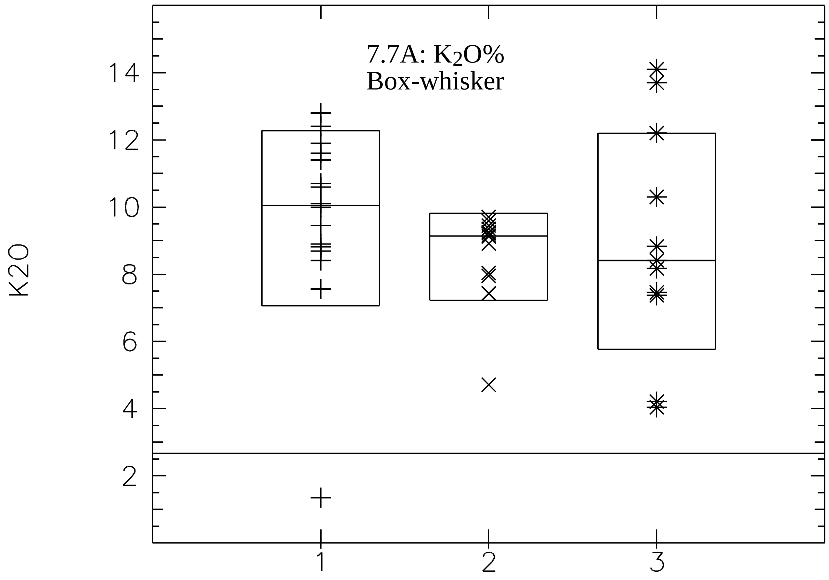
+ Fiery Creek Volcanic
× Peters Creek Volcani
✳ Weberra Granite







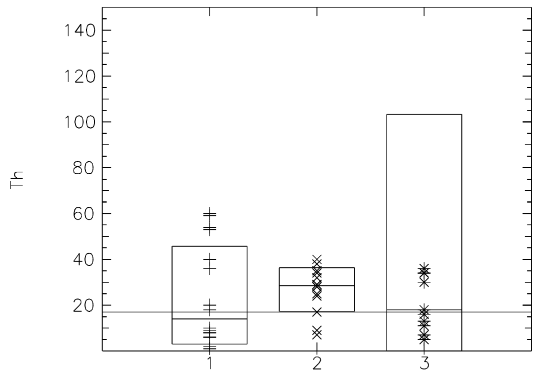
Legend



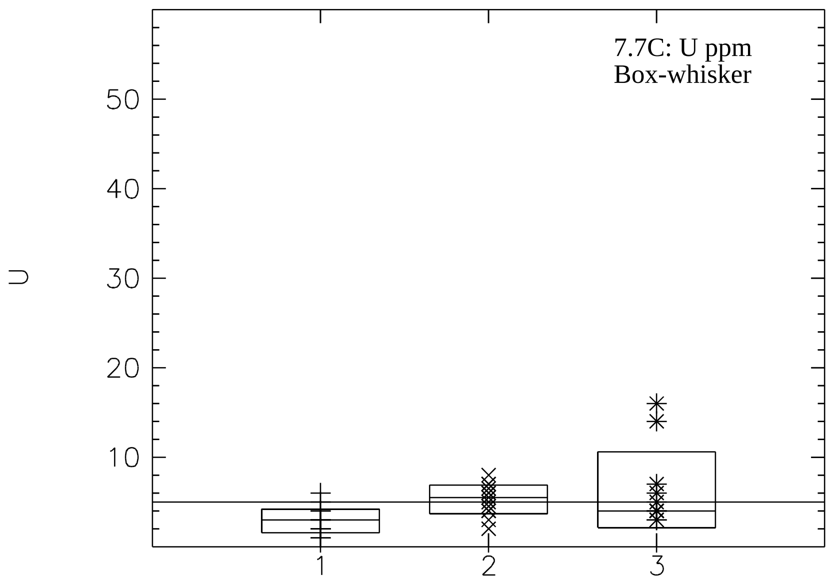
+ Fiery Creek Volcanic
× Peters Creek Volcani
* Weberra Granite

Proterozoic median

7.7B: Th ppm
Box-whisker



Proterozoic median



Proterozoic median

Fiery Creek Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	62.88	60.9	11.91	46.6	78.5	16
TiO2	1.38	1.88	1.15	01	2.89	16
Al2O3	13.72	13.85	2.32	10.5	17.5	16
Fe2O3	7.28	3.7	6.09	0.68	17	16
FeO	0.67	0.3	1.59	0.04	6.61	16
MnO	0.01	0.01	0.01	01	0.05	16
MgO	1.37	0.17	4.41	0.02	17.9	16
CaO	0.41	0.09	0.46	0.01	1.23	16
Na2O	0.11	0.11	0.07	0.03	0.27	16
K2O	9.67	10.05	2.69	1.35	12.8	16
P2O5	0.38	0.22	0.37	0.03	0.93	16
H2O+	1.36	0.95	1.9	0.2	8.06	15
H2O-	0.19	0.15	0.12	0.08	0.54	15
CO2	0.11	0.1	0.06	05	0.27	14
LOI	0.75	0.75	-	0.75	0.75	1
Ba	1068.31	780	1531.4	45	6600	16
Li	4	4	-	4	4	1
Rb	217.31	218.5	79.87	30	390	16
Sr	42.25	30	31.86	10	100	16
Pb	6.72	5	7.89		35	16
Th	24.38	14	22.07		60	16
U	2.88	3	1.36	1	6	16
Zr	292.63	275	160.02	70	660	16
Nb	36.38	34	12.88	20	75	16
Y	44.88	45	16.76	18	80	16
La	71.06	65	44.94		160	16
Ce	151.88	125	106.05		380	16
Pr	16	16	-	16	16	1
Nd	77.33	60	36.25	53	119	3
Sc	2	2	-	2	2	1
V	10	10	-	10	10	1
Cr	10.93		10.08		40	15
Mn	88	88	-	88	88	1
Co	10.18	5	13.43		55	14
Ni	3	3	-	3	3	1
Cu	6	5	7.32	2	32	16
Zn	7.94	5	13.13		55	16
Sn	5	6	1.73	3	6	3
Mo	1		-			1
Ga	16	16	-	16	16	1
As	2.5	2.5	-	2.5	2.5	1
S	130	130	-	130	130	1
C	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	3	3	-	3	3	1
Ag	2	2	-	2	2	1
Bi	1		-			1
Hf	5	5	-	5	5	1
Ta	1		-			1
Cs	1.5		-			1
Ge	1.5	1.5	-	1.5	1.5	1
Se	0.5		-			1

Peters Creek Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	73.81	75.26	5.99	56.45	80.46	14
TiO2	0.6	0.39	0.63	0.25	2.57	14
Al2O3	11.01	11.58	1.61	6.98	13.31	14
Fe2O3	3.86	3.08	3.37	0.17	11.64	14
FeO	0.27	0.2	0.12	0.15	0.5	14
MnO	0.01	0.01	0.01	0.01	0.03	14
MgO	0.22	0.12	0.25	0.01	0.83	14
CaO	0.14	0.03	0.24	0.02	0.92	14
Na2O	0.15	0.13	0.07	0.06	0.3	14
K2O	8.52	9.14	1.34	4.71	9.7	14
P2O5	0.12	0.04	0.21	0.01	0.79	14
H2O+	0.71	0.72	0.46	0.22	1.82	14
H2O-	0.24	0.09	0.29	0.04	1.07	14
CO2	0.04	0.04	0.01	0.03	0.05	4
LOI	0.05	0.01	0.04	13	0.1	4
Ba	1252.64	1260.5	347.5	489	1774	14
Li	5.86	5.5	3.21	3	15	14
Rb	168.29	165	42.2	83	254	14
Sr	30.93	24.5	20.51	8	79	14
Pb	8.5	8.5	4.22	4	17	14
Th	26.79	28.5	9.9	7	40	14
U	5.29	5.5	1.66	2	8	14
Zr	357.14	391	99.59	105	460	14
Nb	22.36	23	6.64	6	31	14
Y	64.86	68	13.08	26	79	14
La	56.36	61	23.62	16	85	14
Ce	112.21	124.5	44.56	23	166	14
Pr	12.93	14.5	4.84	3	20	14
Nd	51.57	57.5	18.69	14	79	14
Sc	8.86	5	8.1	3	27	14
V	47.5	12.5	80.65	4	281	14
Cr	9.57	4	15.79	1	58	14
Mn	72.75	57.5	51.66	29	147	4
Co	-	-	-	-	-	-
Ni	1.18	0.75	1.08		4	14
Cu	6.5	2.5	13.16		51	14
Zn	14.29	12.5	7.47	2	27	14
Sn	5.64	5	1.45	4	9	14
Mo	2.64	2	1.6		6	14
Ga	15.64	17	3.93	7	21	14
As	1.61	1.75	0.63	0.5	2.5	14
S	39.54	44	17.23		64	14
C	100	Â	-	Â	Â	1
F	288.89	Â	301.85	Â	1000	9
Cl	225.5	161	137.94	104	503	10
Be	1.71	1.5	0.83	1	3	14
Ag	1	1	-	1	1	4
Bi	0.86		0.23		1	14
Hf	10	11	3.26	3	13	14
Ta	1.57		0.76		3	14
Cs	5.54	4.75	3.89		11	12
Ge	1.79	1.5	1.27	0.5	4	14
Se	0.38	50	0.13		0.5	14

Weberra Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	61.74	59.4	11.52	47.3	76.42	11
TiO2	1.53	1.23	1.29	0.2	3.12	11
Al2O3	14.15	12.5	3.01	11.55	20.3	11
Fe2O3	2.16	0.82	2.97	0.1	8.16	11
FeO	1.54	0.28	2.68	0.08	7.32	11
MnO	0.08	0.02	0.1	0.01	0.24	11
MgO	1.18	0.34	1.73	0.15	4.77	11
CaO	3.08	0.74	4.97	0.03	14.6	11
Na2O	0.55	0.06	0.79	0.01	2.22	11
K2O	8.98	8.41	3.37	4.04	14.1	11
P2O5	0.3	0.12	0.34	01	0.79	11
H2O+	1.51	0.74	1.59	0.45	4.96	11
H2O-	0.24	0.25	0.11	0.12	0.45	11
CO2	2.21	0.18	3.93	0.06	11.7	11
LOI	-	-	-	-	-	-
Ba	644	566	402.54	150	1600	11
Li	3.5	3.5	0.58	3	4	4
Rb	208.09	189	92.01	100	420	11
Sr	45.64	46	19.6	11	75	11
Pb	31	20	26.54		80	11
Th	40.09	18	66.29	5	237	11
U	6.36	4	4.46	3	16	11
Zr	288.73	300	139.4	75	580	11
Nb	29.82	24	12.54	14	48	11
Y	43.18	42	23.92	6	86	11
La	52.91	43	30.97	20	122	11
Ce	106.27	100	51.13	40	201	11
Pr	-	-	-	-	-	-
Nd	61.25	60	26.89	30	95	4
Sc	1		-			4
V	1.75	1.5	0.96		3	4
Cr	10.91	10	9.87		30	11
Mn	-	-	-	-	-	-
Co	54.68	5	93.41		310	11
Ni	3.5	3	1.73	2	6	4
Cu	2302	38	5574.33	4	18000	11
Zn	61.64	18	116.69	2	390	11
Sn	7.25	7	2.63	5	10	4
Mo	-	-	-	-	-	-
Ga	18	19	2	15	19	4
As	1	1	-	1	1	4
S	-	-	-	-	-	-
C	-	-	-	-	-	-
F	466.67	400	115.47	400	600	3
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

8 SYBELLA SUITE

8.1 Timing 1670 Ma

8.2 Individual Ages

Primary Ages:

1. Kitty Plain microgranite [1,2]	1780 ± 20 or 1670 Ma with inheritance of 1900 Ma U-Pb
2. Carters Bore Rhyolite [1,2]	1678 ± 1 Ma, U-Pb
3. Carters Bore Rhyolite [1]	1678 ± 2 Ma, SHRIMP
4. Keithys Granite [1,2]	1671 ± 8 Ma, U- Pb
5. Keithys Granite [1,2]	1668 ± 23 Ma, U- Pb
6. Queen Elizabeth Granite [1,3]	1660 ± 5 Ma, SHRIMP
7. Queen Elizabeth Granite [1,3]	1655 ± 4 Ma, SHRIMP

Sources: [1] OZCHRON, [2] Page and Bell (1986), [3] Connors and Page (1995). Note that the dated sample of the Kitty Plain microgranite is atypical of the bulk of this pluton and is possibly from a small localised patch of S-type granite.

8.3 Regional Setting

The Sybella Suite is a major body of fluorine-enriched, hornblende-bearing I-(granodiorite) types which were emplaced into the Western Fold Belt at ~ 1670 Ma. The suite is fairly felsic and most samples have > 68 wt.% SiO_2. Most of the Suite is intrusive, but we are placing the Carters Bore Rhyolite within this suite. Although highly altered, the Carters Bore Rhyolite occurs only adjacent to the Sybella Suite, and does have some chemical similarities. Coeval with these granites are a suite of tholeiitic dolerite intrusions (Ellis and Wyborn 1984) which form extensive net-veined complexes (Blake 1981). The suite predates the formation of the Mount Isa Group (Wyborn *et al.* 1988; Connors and Page 1995) and also appears to be coeval with minor ‘felsic volcanics’ in Gandry Dam gneiss of the Maronan Supergroup in the far eastern part of the Mount Isa Inlier. Within the vicinity of the suite are some small biotite-rich S-types and older I-types which will not be considered further as they are volumetrically insignificant and are obviously not comagmatic.

The whole Sybella Suite has been affected by the major D_2 regional metamorphic event, and the metamorphic grade in the Mount Isa 1:100 000 sheet area ranges from lower greenschist in the northwest to uppermost amphibolite in the southeast. Near Mica Creek, the granite is locally migmatised and pegmatitic segregations developed parallel to the main D_2 foliation.

8.4 Summary

Although chemically the granite clearly shows evidence of fractionation, and it could be loosely classed as an oxidised fractionated metaluminous granite, there are several factors which downgrade its mineral potential. These are:

1) high F content, and high Zr, Nb, La, and Ce throughout all phases;
2) limited silica range over which the granite has crystallised; and
3) lack of suitable host rocks.

Fluorite-rich granites of this type are not noted for mineralisation, and there is very little mineralisation which can unequivocally be assigned to magmatic processes associated with this suite. The best economic potential is in their high U, which was remobilised during metamorphism. The pegmatitic segregations which were probably generated during the D_2 metamorphism are anomalous in Be, Th and Sn.

Due to the high content of heat-producing elements (U, Th, K) in this suite, there is also a possibility of the resultant high heat production causing secondary low-T fluid circulation. This process has been considered by Solomon and Heinrich (1992) to be an ingredient in forming the nearby Mount Isa Pb-Zn deposit. However, it is only required if it is assumed that the ore fluids carrying the Pb and Zn are reduced. Granites similar to this type are associated with Mo deposits such as Climax. If the interpretation of the emplacement of the members of this suite as sheets at considerable depth is correct, then this may also downgrade the potential for this style of mineralisation as the plutons are too small to generate sufficient late-stage fluids, and the depth of emplacement also significantly reduces the ability to exsolve a late fluid phase.

8.5 Potential

The Sybella Suite is not considered to have any significant potential for mineralisation. Some small Sn and Be pegmatites that occur adjacent to the Queen Elizabeth Granite could be magmatic, however, it is more probable that they were generated during the ~1530 Ma metamorphic event, particularly as these pegmatites are parallel to the main D_2 foliation and also occur within the envelope of highest metamorphic grade.

Cu:	**None**
Au:	**None**
Pb/Zn:	**None**
Sn:	**Low**
Mo/W:	**Low**
Confidence level:	**321**

8.6 Descriptive Data

Location: Western part of the Mount Isa Inlier.

Dimensions and area: Elongate, northerly trending belt 195 km by 36 km. Total outcrop area is 1200 km^2.

8.7 Intrusives

Component plutons: The Sybella Suite includes: the Annable Granite, Briar Granite, Dingo Granite, Easter Egg Granite, Garden Creek Porphyry, Gidya Granite, Guns Knob Granite, Hay Mill Granite, Kahko Granodiorite, Keithys Granite, most of the Kitty Plain microgranite, Queen Elizabeth Granite, Steeles Granite, Widgewarra Granite and Wonomo Granite. The Kahko Granodiorite comprises grey, foliated to gneissic, medium- to coarse-grained biotite-hornblende granodiorite and minor diorite, contains xenoliths of granodiorite, amphibolite and quartzite and may not all be part of the Sybella Suite. Joplin and Walker (1961) suggested that parts the Sybella Suite in this area have more affinities with the Kalkadoon Granodiorite in the central Mount Isa Inlier. There is insufficient age data to validate this hypothesis, however, some samples from the Kahko pluton plot on a distinctly different geochemical trend.

Form: The suite consists of a series of elongate plutons, some of which are narrow and 'dyke-like' (especially the Annable Granite and Garden Creek Porphyry). In the third dimension some intrusions are relatively thin, e.g., the Queen Elizabeth pluton has been modelled to be <2 km thick (Leaman *pers comm*. 1995), suggesting that it may have been emplaced as sheets at deeper crustal levels. This thin shape has recently been verified by the Mount Isa seismic survey (Goleby *et al.* 1996). In contrast, the Kitty Plain microgranite west of Kitty Plains in the far northeast of the Sybella Suite may be substantially thicker (Leaman *pers comm.* 1995).

Metamorphism and Deformation: The Sybella Suite is mostly foliated, and has been metamorphosed to upper amphibolite facies; the eastern edge of the Queen Elizabeth pluton has become a granite 'migmatite'. Pegmatites in the Mica Creek area (Mount Isa 1:100 000 Sheet area) are believed to be formed by metamorphism. *Specifically:* Briar Granite, Dingo Granite - foliated especially near the margins; Garden Creek Porphyry - massive to locally sheared; Guns Knob Granite - strongly foliated and fine-grained within 1-2 km of the contact, and more massive and coarser toward its centre; Kahko Granodiorite - two foliations are preserved, one parallel to the regional foliation (N-S), and one defined by quartz dykes (NE); Kitty Plain microgranite - massive to weakly foliated; Queen Elizabeth Granite - strongly foliated throughout and metamorphosed to upper amphibolite facies: mylonitised at the contact with Mount Guide Quartzite in the northwest.

Dominant intrusive rock types: The suite is characterised by four main mineralogical types: 1) megacrystic K-feldspar granite and leucogranite which are characterised by strong joint patterns; 2) K-feldspar-bearing granite which is characterised by *ß*-quartz phenocrysts; 3) aplite; and 4) pegmatite. The dominant intrusive rock types are porphyritic biotite granite, biotite leucogranite, biotite-muscovite leucogranite, muscovite leucogranite, gneissic biotite-hornblende granodiorite, gneissic biotite-granite and rare quartz diorite. *Specifically:* Briar Granite - leucocratic (biotite-) muscovite granite, porphyritic biotite granite; Dingo Granite - porphyritic biotite granite; Easter Egg Granite - medium to coarse-grained ocellar quartz diorite, diorite, granodiorite and granite; Garden Creek Porphyry - porphyritic microgranite; Guns Knob Granite - variably porphyritic medium to coarse-grained biotite granite; Hay Mill Granite - variably porphyritic medium to coarse-grained biotite granite; Kahko Granodiorite - foliated to gneissic medium- to coarse-grained biotite-hornblende granodiorite and minor diorite, extensively intruded by porphyritic biotite granite, leucogranite, and tourmaline-bearing pegmatite; Keithys Granite - medium- to coarse-grained, slightly porphyritic biotite granite which grades into microgranite at its margins; Kitty Plain microgranite - slightly porphyritic, fine to medium-grained alkali-feldspar granite to granodiorite; Queen Elizabeth Granite - mostly variably porphyritic medium to coarse-grained biotite granite. The northeastern margin consists of a distinctive highly leucocratic phase and there are also minor magnetite-rich phases of granite and gneiss in contact with Eastern Creek Volcanics in the north; Steeles Granite - composite pluton containing a younger phase of porphyritic biotite granite intruding an older strongly foliated and gneissic granodiorite to diorite phase; Wonomo Granite - composite pluton with a strongly foliated to gneissic older phase in the south and younger biotite granite in the north.

Colour: Grey to pink to red. *Specifically*: Briar Granite - pink or grey; Dingo Granite - pink or grey; Garden Creek Porphyry - pink to grey; Guns Knob Granite - grey to pink; Hay Mill Granite - pink; Kahko Granodiorite - grey; Keithys Granite - pink to grey; Kitty Plain microgranite - mainly pink; Queen Elizabeth Granite - pink to red.

Veins, Pegmatites, Aplites, Greisens: Ubiquitous cross-cutting aplite veins and pegmatitic segregations occur throughout the Sybella Suite, and tend to be concentrated in the more felsic phases. Be and Sn-bearing pegmatites in the Mica Creek area are probably developed as a result of metamorphism. Paterson and Poole (1981) noted that the Sn-bearing pegmatites concentrate near the northeastern margin of the Queen Elizabeth pluton. In this area the local granite melted during the main D_2 metamorphism and produced major pegmatitic segregations. *Specifically:* Briar Granite - the leucocratic muscovite granite phase is intruded by a tourmaline-bearing muscovite pegmatite, and pegmatitic segregations are common; Garden Creek Porphyry - quartz-veined; Keithys Granite - intruded by aplite and pegmatite; Kitty Plain microgranite - intruded by several small dykes of sodic aplite, albitite, quartz-tourmaline rock and pegmatite; Queen Elizabeth Granite - intruded by the Mica Creek pegmatites on the northern end of the pluton which contain microcline, quartz, albite, muscovite, and minor beryl, tourmaline, garnet, tantalite-columbite minerals, cassiterite, monazite, and fluorite; Widgewarra Granite - beryl occurs in pegmatite at the Big River prospect in the south of the pluton and also on the northern margin.

Distinctive mineralogical characteristics: The suite has been extensively metamorphosed and heavily recrystallised making determination of the original minerals very difficult in some plutons. Rapakivi textures are common (i.e., albite rims around K-feldspars), and fluorite is ubiquitous throughout. Appears to be dominantly a megacrystic K-feldspar, plagioclase, biotite ± hornblende suite. Titanite, zircon, allanite, apatite and opaque oxide occur as accessories. Tourmaline is locally abundant in aplite and pegmatite. *Specifically:* Briar Granite - rapakivi textures are locally common, and feldspar phenocrysts common, some up to 15 cm, hornblende is usually present, although there may be some muscovite: accessories include titanite, fluorite, zircon, allanite, apatite and opaque oxide; Dingo Granite - contains sparse to abundant feldspar phenocrysts up to 8 cm long, rapakivi textures are locally common, accessory minerals include titanite, allanite, fluorite, apatite, zircon, opaque oxide; Easter Egg Granite - quartz ocelli and rapakivi textures present; Garden Creek Porphyry - pink microcline phenocrysts, accessory biotite, apatite, opaques and zircon; Keithys Granite - phenocrysts of K-feldspar and rounded *ß*-quartz, abundant fluorite, well developed rapakivi textures; Kitty Plain microgranite - hornblende-poor, contains more K-feldspar and less ferromagnesian minerals than most Sybella Suite phases, granophyric intergrowths common; Queen Elizabeth Granite - main phase has hornblende, biotite, K-feldspar megacrysts, plagioclase, quartz: fluorite is ubiquitous throughout. Rapakivi textures are common; Steeles Granite - pale pink feldspar phenocrysts up to 8 cm long, accessory minerals include biotite, hornblende, titanite, allanite, zircon, apatite, opaque oxides rimmed by titanite. Rapakivi textures are locally common.

Xenoliths: Xenoliths of mafic inclusions have been noted, but these appear to be associated with net-veined complexes. *Specifically:* Kahko Granodiorite - contains xenoliths of granodiorite, amphibolite and quartzite; Kitty Plain microgranite - locally abundant metasedimentary and mafic xenoliths, as well as mafic 'pillows'/enclaves.

Breccias: Not noted in the literature.

Alteration in the granite: Some alteration is locally pervasive but may be a result of subsequent metamorphism.

8.8 Extrusives

The Carters Bore Rhyolite is believed to be a comagmatic extrusive. Although previously correlated with the Fiery Creek Volcanics, recent dating confirms that the two are separate events in agreement with the original concept of Wilson *et al.* (1979) that the Carters Bore Rhyolite is comagmatic with the Sybella Suite. The Carters Bore Rhyolite consists of porphyritic rhyolite, rhyolitic tuff and ignimbrite; with minor schistose quartz porphyry dykes, amygdaloidal andesite, and altered basalt. It is strongly foliated and commonly silicified. It contains accessory hematite, zircon, apatite, rutile and tourmaline.

8.9 Country Rock

Contact metamorphism: Contact aureole generally less than 5 m wide, but difficult to tell as the whole suite has been affected by later high-grade regional metamorphism.

Reaction with country rock: Adjacent country rock is extensively intruded by tourmaline - muscovite - pink feldspar pegmatite veins. Tourmaline in sediments adjacent to granite contacts is due to boron metasomatism. However whether this is a magmatic or metamorphic effect is difficult to tell. *Specifically*: Kitty Plain microgranite - net-veined complexes in Kittys Plain area between Kittys Plain Microgranite, Kittys Plain Dolerite and Eastern Creek Volcanics are partially due to hybridization but may also involve magma mixing. The contact zone is magnetic and contains mafic xenoliths. The country rocks on the NE margin are greisenised and large dykes of mica pegmatite cut the granite in this area.

Units the granite intrudes: Intrudes Myally Subgroup, Eastern Creek Volcanics, Mount Guide Quartzite, Jayah Creek Metabasalt, Oroopo Metabasalt, Saint Ronans Metamorphics, Kallala Quartzite, and Sulieman Gneiss.

Dominant rock types: Basalt, quartzite, some feldspathic sediments and shales.

Potential hosts: There are no abundant strong reductants in the hosts, and no evidence of an older metasomatic alteration which could have produced favourable magnetite-rich host rocks.

8.10 Mineralisation

There are minor Sn, Be and U deposits near this granite system which are more likely to be related to later regional metamorphism rather than to magmatic processes, particularly as they occur in the area of highest metamorphic grade. Paterson and Poole (1981) and Wyborn (1987) suggested that the U in these deposits has been mobilised from the granite by later deformation and metamorphism. In the northwest, small Au deposits occur in the May Downs Gold Field, concentrated along the May Downs Fault. Most are hosted by sediments of the McNamara Group and as field evidence (Hill *et al.* 1975; Wilson *et al.* 1979) and recent dating (Connors and Page 1995) suggest that the Sybella Suite predates this group, they are not considered to be related to the granite.

8.11 Geochemical Data

Data source: The samples come from three sources:
1) age determination samples collected by Page (1978), Page and Bell (1986) and Connors and Page (1995). As most of these samples were collected for Rb-Sr dating, the samples are heavily biased towards more felsic end members or aplite. Most of these samples are strongly deformed and/or very altered;
2) collections made by Mock (1978) and Bultitude (1982) as part of 1:100 000 scale geological mapping; and
3) collections made by Wyborn from 1983-1984 (Wyborn *et al.* 1988). Unfortunately these samples are biased heavily towards the Queen Elizabeth pluton.

Data quality: Good. All of the samples were analysed within the one laboratory at AGSO.

Are the data representative? Not really. Too much of the collection is biased towards more felsic end members as it was collected for Rb-Sr dating.

Are the data adequate? Barely. It is possible to classify this granite, but not to fully understand the controls on all of the chemical variations.

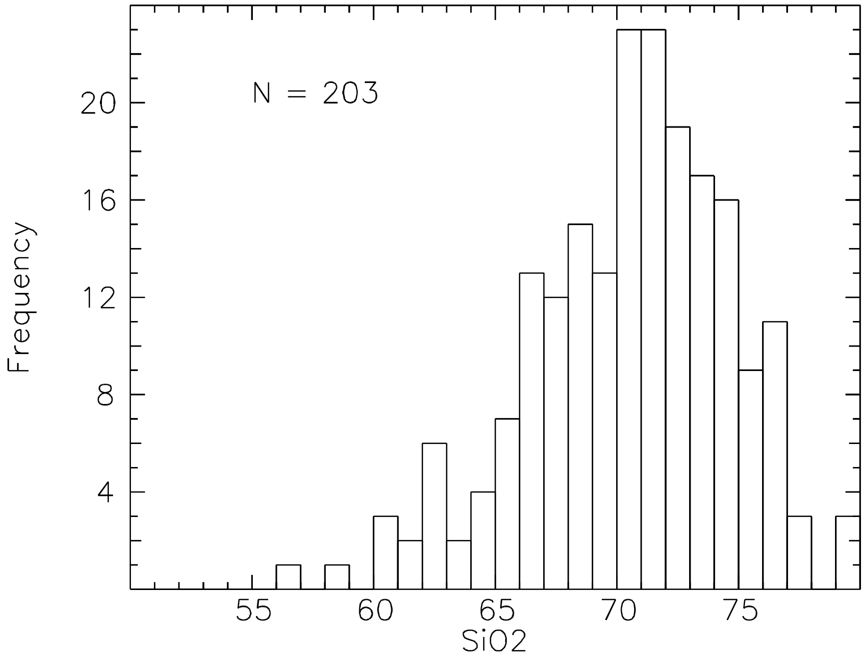


Figure 8.1. Frequency histogram of SiO_2 values for the Sybella Suite

SiO_2 range (Fig.8.1): The range is relatively restricted and most samples are more felsic than 68%. This is reflected in the dominance of compositions from monzogranite to granite.

Alteration (Fig. 8.2):

- ***SiO_2:*** High values may reflect silicification, although some samples with >80 wt.% are aplites.
- ***K_2O/Na_2O:*** The most extreme examples in this plot are the Carters Bore Rhyolite and the aplite dykes. These samples can have either extremely high K_2O and no Na_2O (all samples of the Carters Bore Rhyolite and some aplites), whilst others have high Na_2O and low K_2O (some aplites and pegmatites and some granites).
- ***Th/U:*** The Th/U values are somewhat high, and extreme in some altered samples. This suggests loss of U during metamorphism, and the small U deposits on the northeastern corner of the Mount Isa 1:100 000 Sheet area may be related to this mobilisation (Paterson and Poole 1981; Wyborn 1987).
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** This plot shows extensive oxidation of some samples (especially the Carters Bore Rhyolite), whilst a few, mostly from the Keithys Granite and the Steeles Granite, are relatively reduced.

Fractionation Plots (Fig. 8.3):

- ***Rb:*** Samples show exponentially increasing Rb with increasing SiO_2. The Na-enriched aplites are depleted in Rb.
- ***U:*** Samples show exponentially increasing U with increasing SiO_2: the late aplites have the highest values.
- ***Y:*** Some plutons show increasing Y with increasing SiO_2. Samples of the main phase of the highly metamorphosed Queen Elizabeth Granite and the Keithys Granite are high throughout, whilst some samples of the Kahko Granodiorite are anomalously low.
- ***P_2O_5:*** Samples show decreasing P_2O_5 with increasing SiO_2. Samples of the main phase of the highly metamorphosed Queen Elizabeth Granite plot on a much lower trend.
- ***Th:*** Samples show exponentially increasing Th with increasing SiO_2.
- ***K/Rb:*** Samples show a general decrease in K/Rb with increasing SiO_2.
- ***Rb-Ba-Sr:*** The samples range from normal granite to strongly differentiated granite, with a considerable number plotting in the strongly differentiated field.
- ***Sr:*** Values of Sr are low (all but one below 300 ppm) and decrease with increasing SiO_2. Some samples of the Kahko Granodiorite are anomalously high and are similar to values of the Kalkadoon Supersuite. This potential correlation was predicted from petrographic observations made in 1961 (Joplin and Walker 1961).
- ***Rb/Sr:*** Samples show exponentially increasing Rb/Sr with increasing SiO_2.

- ***Ba:*** Values of Ba are high (>2000 ppm) and decrease with increasing SiO_2. Samples of the main phase of the highly metamorphosed Queen Elizabeth Granite and the Keithys Granite appear to plot on a separate and higher trend from the other plutons.
- ***F:*** F is high throughout most of the five granites analysed and shows increasing values with increasing SiO_2, with values up to 1.1 wt.% in a pegmatite (off graph scale).

Metals (Fig. 8.4):

- ***Cu:*** Most values are low, <30 ppm.
- ***Pb:*** Values are moderate. The Carters Bore Rhyolite samples are anomalously low and may reflect alteration.
- ***Zn:*** Values decrease with increasing SiO_2. Samples of the main phase of the highly metamorphosed Queen Elizabeth Granite and the Keithys Granite appear to plot on a separate and higher trend from the other plutons.
- ***Sn:*** Most values are in the low range for Sn.

High field strength elements (Fig. 8.5):

- ***Zr:*** Values are high and up to 800 ppm, with the highest values being in the main phase of the highly metamorphosed Queen Elizabeth Granite.
- ***Nb:*** Values are high and up to 80 ppm: highest values are in both phases of the Queen Elizabeth Granite, the Keithys Granite, pegmatite and aplite.
- ***Ce:*** Most values are very high for Proterozoic granites and range up to 600 ppm: highest values are in the main phase of the Queen Elizabeth Granite, the Gidya Granite and aplite.

Classification (Fig. 8.6):

- ***The CaO/Na_2O/K_2O plot of White, quoted in Sheraton and Simons (1992):*** Most granites plot in the monzogranite to granite field reflecting the high SiO_2 range of this suite. The sodic-altered samples plot in the trondhjemite field.
- ***Zr/Y vs Sr/Sr*:*** All samples plot below 1 signifying that all samples are Sr-depleted, Y-non depleted.
- ***Spidergram:*** The selected spidergrams for this suite are Sr-depleted, Y-non depleted.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples are oxidised with some samples of the altered Carters Bore Rhyolite and some of the aplite samples being strongly oxidised. Some samples of the Steeles and Keithys Granites are reduced.
- ***ASI:*** The majority of samples have an ASI of <1.1 and are metaluminous to weakly peraluminous. A group of aplites has an interesting, separate trend.
- ***A-type plot of Eby (1990):*** The Sybella Suite plots clearly in the A-type field as defined for Palaeozoic granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-granodiorite, non-restite.

Australian Proterozoic granite type: Type example of the Sybella type.

8.12 Geophysical Signature

Radiometrics (Fig. 8.7): The majority of samples plot above the Proterozoic median for K and Th. Some plutons, particularly those that have been metamorphosed to upper amphibolite facies (the main more mafic phase of the Queen Elizabeth Granite and the Widgewarra Granite) appear to have lost U. These regions would appear yellowish on a RGB image.

Gravity: Most of the plutons are coincident with regional gravity lows.

Magnetics: Most of the plutons are coincident with regional magnetic lows.

8.13 References

Blake, D.H. 1981. Intrusive felsic-mafic net-veined complexes in north Queensland. *BMR Journal of Australian Geology and Geophysics*, 5, 243-256.

Blake, D.H. 1987. Geology of the Mount Isa Inlier and environs, Queensland and Northern Territory. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin*, 225.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981a. Definitions of new and revised Precambrian stratigraphic and intrusive rock units in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report*, 233, *(BMR Microfilm* MF 164*).*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981b. Summary of new and revised Precambrian stratigraphic nomenclature in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Queensland Government Mining Journal*, 82, 580-589.

Bultitude, R.J. 1980, Precambrian geology of the Ardmore 1:100 000 sheet area, northwestern Queensland - preliminary data. *Bureau of Mineral Resources, Geology and Geophysics, Record*, 1980/16.

Bultitude, R.J. 1982, Ardmore, Queensland, 1:100 000 Geological map commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Bultitude, R.J., Blake, D.H., Donchak, P.J.T. and Mock, C.M. 1982, Duchess Region, Queensland, 1:100 000 Geological map commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

Connors, K.A. and Page, R.W. 1995. Relationships between magmatism, metamorphism and deformation in the western Mount Isa Inlier, Australia. *Precambrian Research*, 71, 131-153.

Ellis, D.J. and Wyborn, L.A.I. 1984. Petrology and geochemistry of Proterozoic dolerites from the Mount Isa Inlier. *BMR Journal of Australian Geology and Geophysics*, 9, 19-32.

Goleby, B., Drummond, B. and MacCready, T. 1996. The Mount Isa geodynamic transect. The deep seismic reflection profile south of Mount Isa and Cloncurry. *AGSO Research Newsletter*, 24, 6-8.

Hill, R.M., Wilson, I.H. and Derrick, G.M. 1975. Geology of the Mount Isa 1:100,000 sheet area, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin, Record* 1975/175.

Joplin, G.A. and Walker, K.W. 1961. The Precambrian granites of north-western Queensland. *Proceedings of the Royal Society of Queensland*, 72, 2, 21-57.

Mock, C.M. 1978, Geology of the Oban 1:100,000 sheet area, northwestern Queensland: Progress report. *Bureau of Mineral Resources, Geology and Geophysics, Record*, 1978/87.

Page, R.W. 1978. Response of U-Pb zircon and Rb-Sr total-rock and mineral systems to low-grade regional metamorphism in Proterozoic igneous rocks, Mount Isa, Australia. *Journal of the Geological Society of Australia*, 25, 141-164.

Page, R.W. and Bell, T.H. 1986. Isotopic and structural responses of granite to successive deformation and metamorphism. *Journal of Geology*, 94, 365-379.

Paterson, D.J. and Poole, J.R. 1981. The Sybella Granite and associated mineralisation in the Mica Creek area, Mount Isa. *Abstracts of the joint meeting on Mount Isa Geology - the Australasian Institute of Mining and Metallurgy, the Bureau of Mineral Resources, Geology and Geophysics, Australia and the Geological Survey of Queensland.*

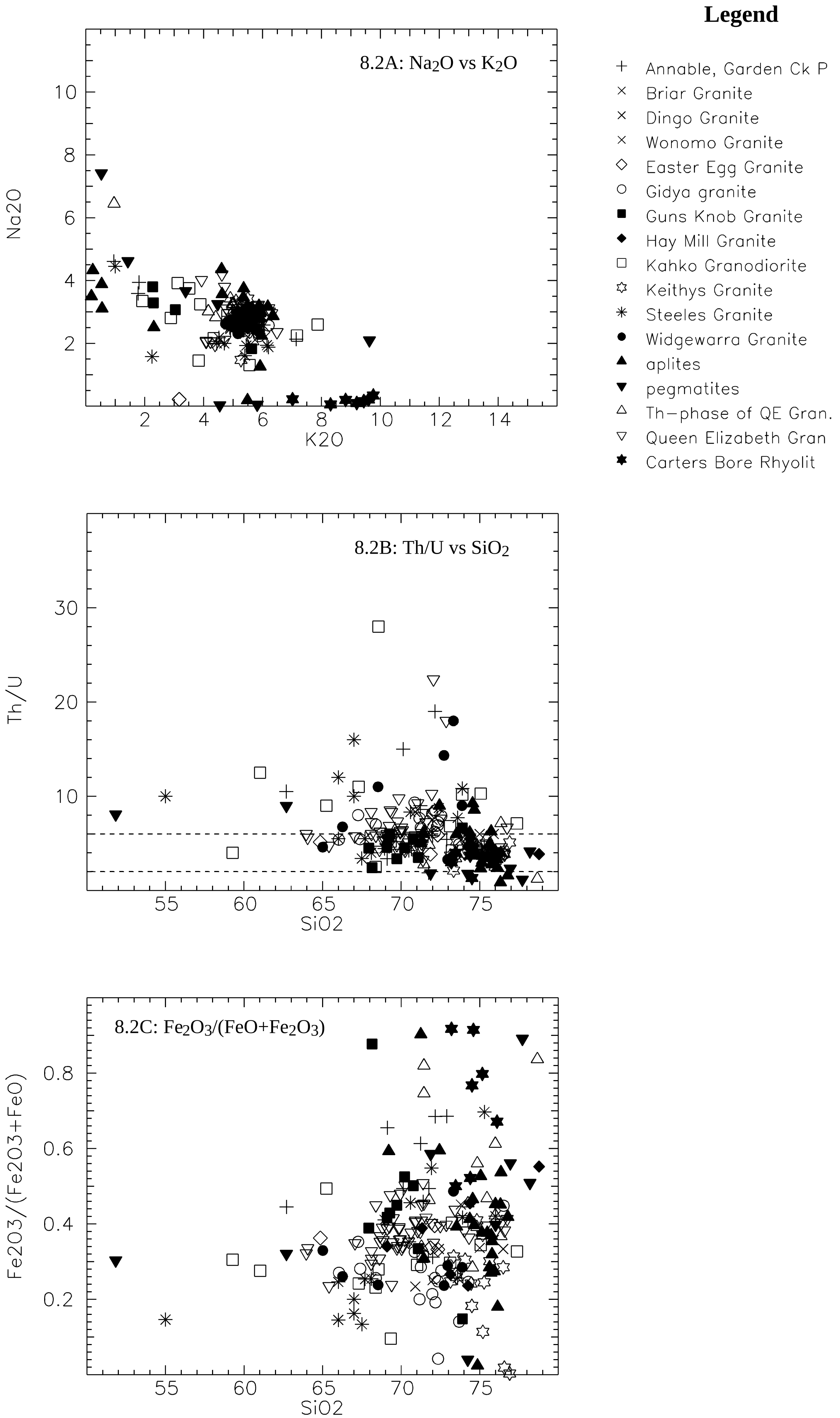
Solomon, M. and Heinrich, C.A. 1992. Are high-heat producing granites essential to the origin of giant lead-zinc deposits at Mount Isa and McArthur River, Australia? *Journal of Exploration and Mining Geology*, 1, 85-91.

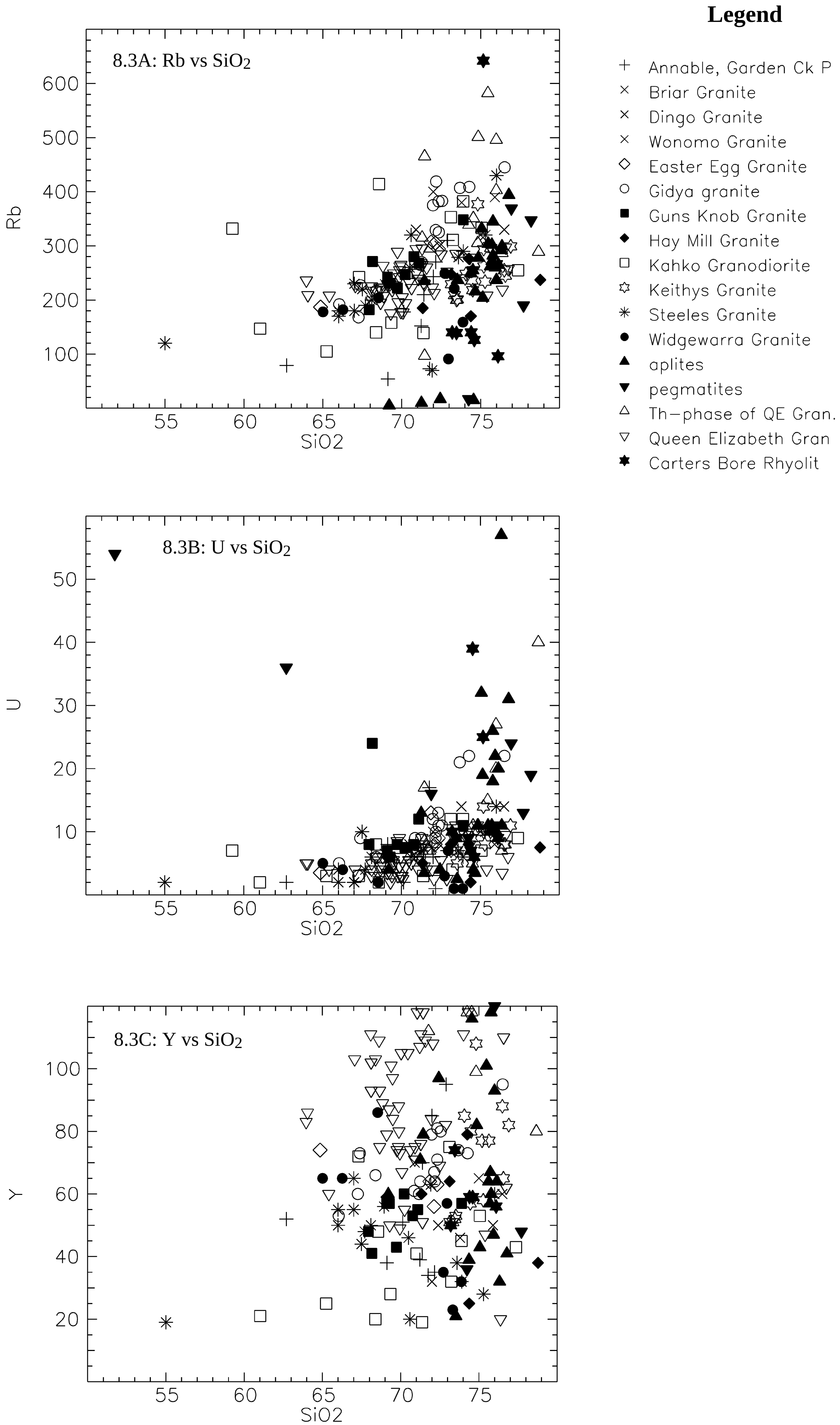
Wilson, I.H. 1987. Geochemistry of Proterozoic volcanics, Mount Isa Inlier, Australia. In: Pharaoh, T.C., Beckinsale, R.D. and Rickard, D.(editors), Geochemistry and Mineralisation of Proterozoic Volcanic Suites, *Geological Society of London, Special Publication*, 33, 409-423.

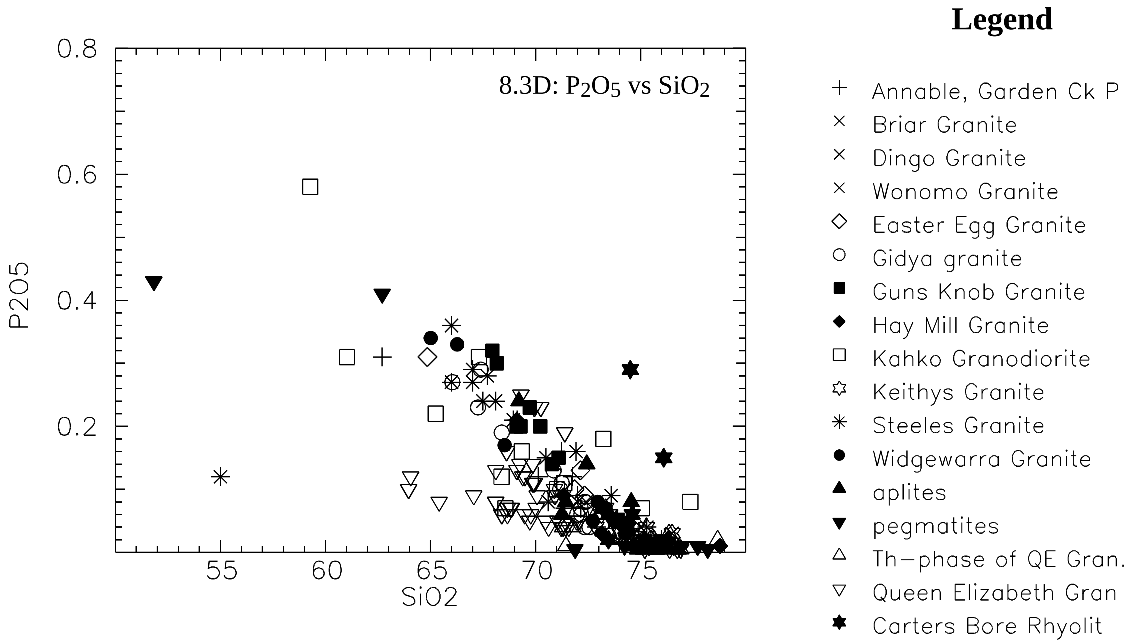
Wilson, I.H., Hill, R.M., Noon, T.A., Duff, B.A. and Derrick, G.M. 1979. Geology of the Kennedy Gap 1:100,000 sheet area (6757), Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record*, 1979/24.

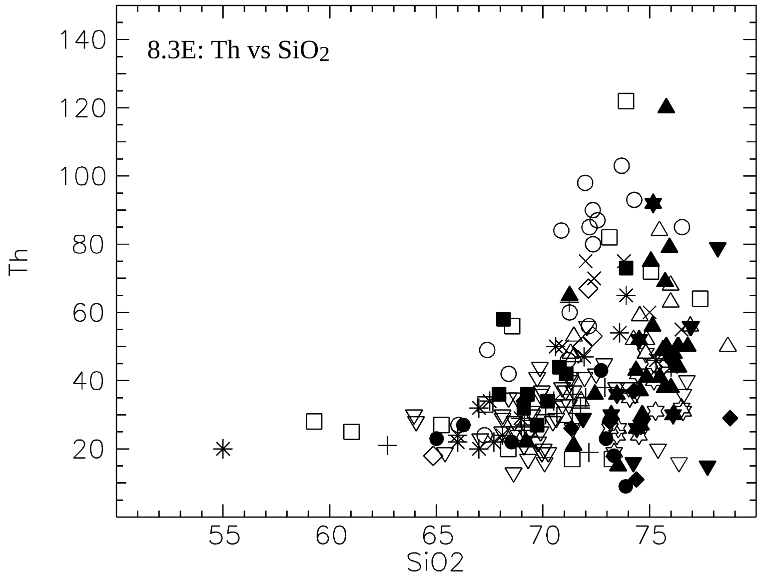
Wyborn, L.A.I. 1987. The petrology and geochemistry of alteration assemblages in the Eastern Creek Volcanics, as a guide to copper and uranium mobility associated with regional metamorphism and deformation, Mount Isa, Queensland. In: Pharaoh, T.C., Beckinsale, R.D. and Rickard, D., (editors), Geochemistry and Mineralisation of Proterozoic Volcanic Suites. *Geological Society of London, Special Publication*, 33, 425-434.

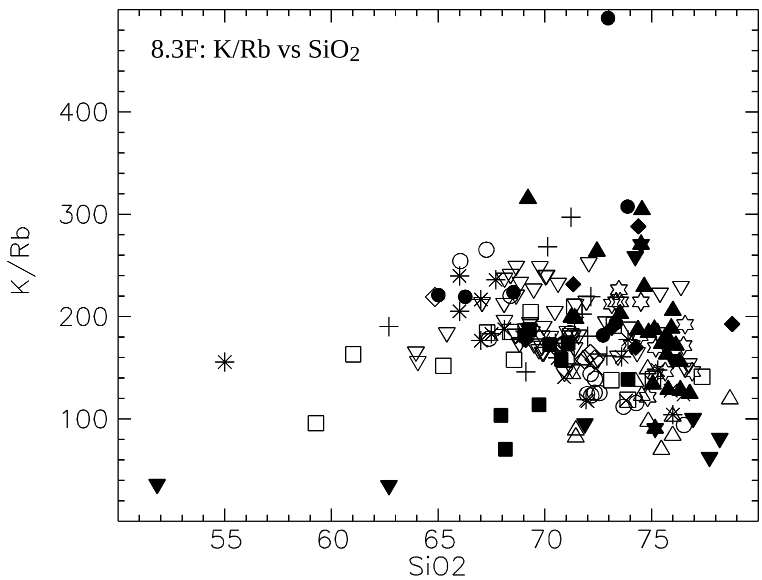
Wyborn, L.A.I., Page, R.W. and McCulloch, M.T. 1988, Petrology, geochronology and isotope geochemistry of the post-1820 Ma granites of the Mount Isa Inlier: Mechanisms for the generation of Proterozoic anorogenic granites. *Precambrian Research*, 40/41, 509-541.

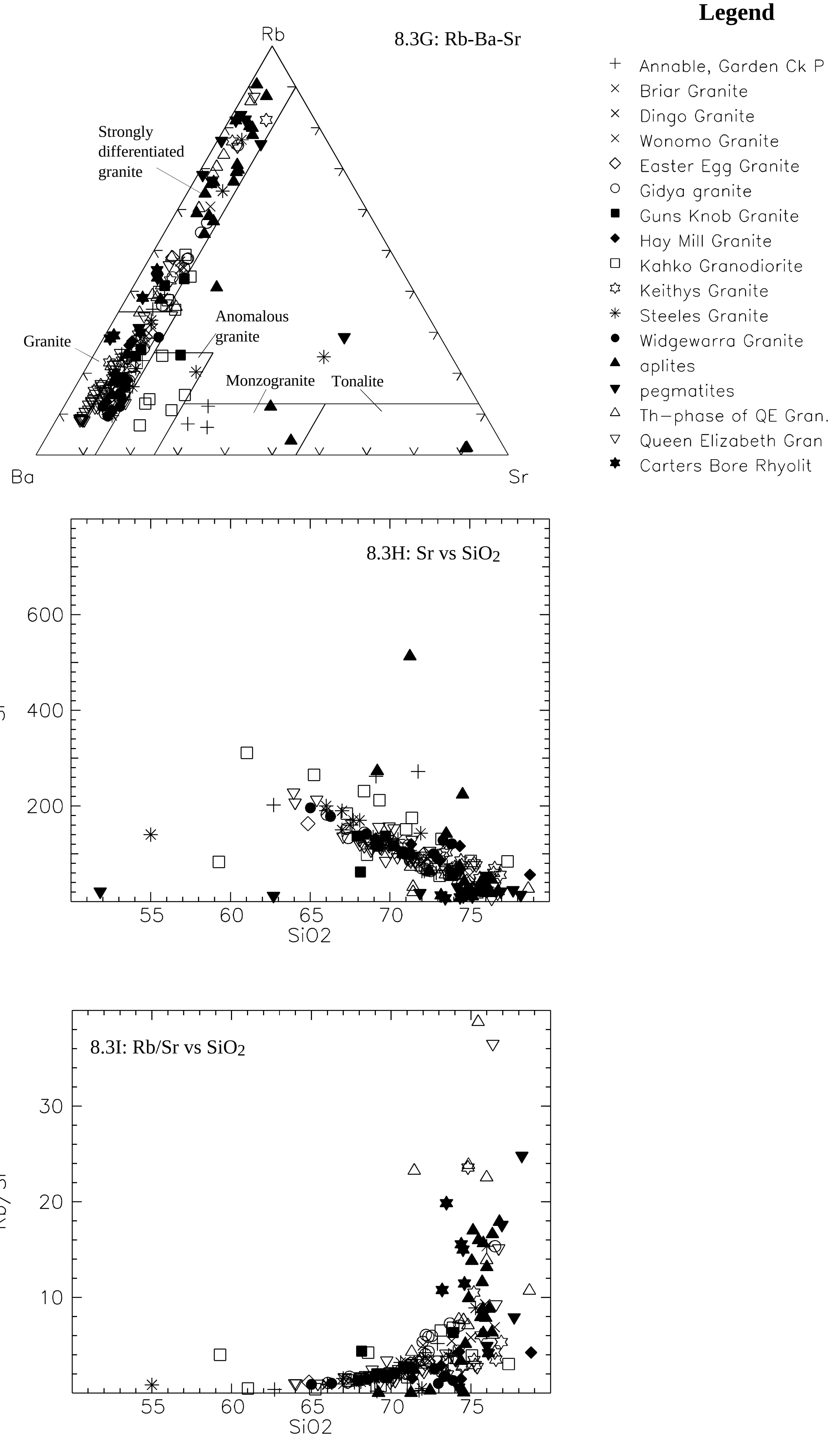

Legend
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit
8.2A: Na_2O vs K_2O
Na2O
K2O
8.2B: Th/U vs SiO_2
Th/U
SiO2
8.2C: $Fe_2O_3/(FeO+Fe_2O_3)$
Fe2O3/(Fe2O3+FeO)
SiO2

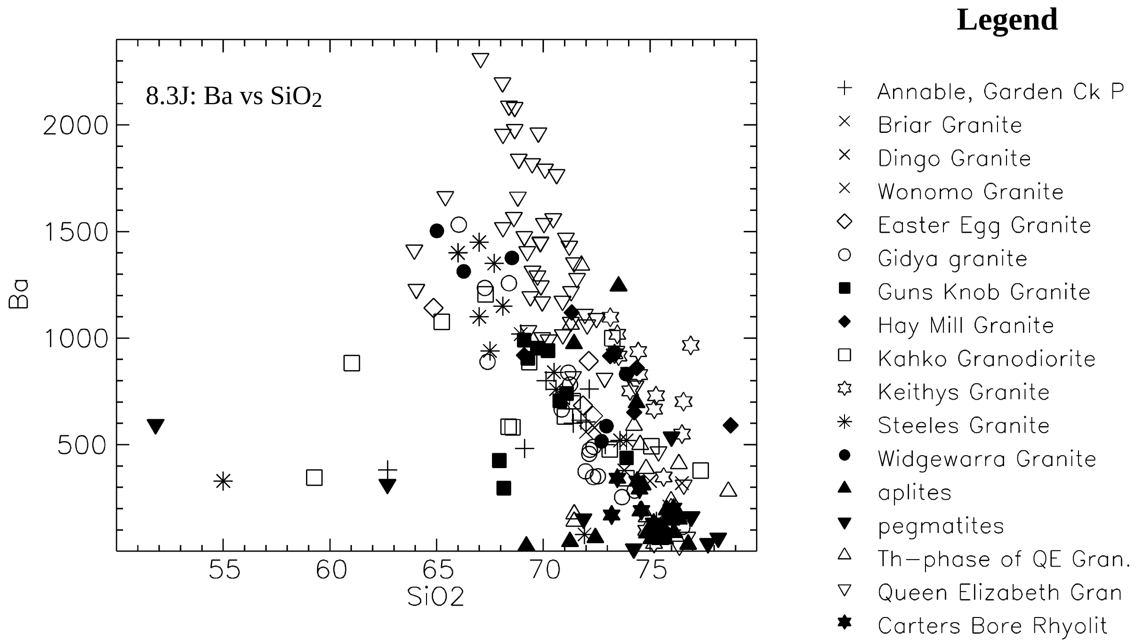

Legend
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit
8.3A: Rb vs SiO2
Rb
100
200
300
400
500
600
55
60
65
70
75
SiO2
8.3B: U vs SiO2
U
10
20
30
40
50
55
60
65
70
75
SiO2
8.3C: Y vs SiO2
Y
20
40
60
80
100
55
60
65
70
75
SiO2

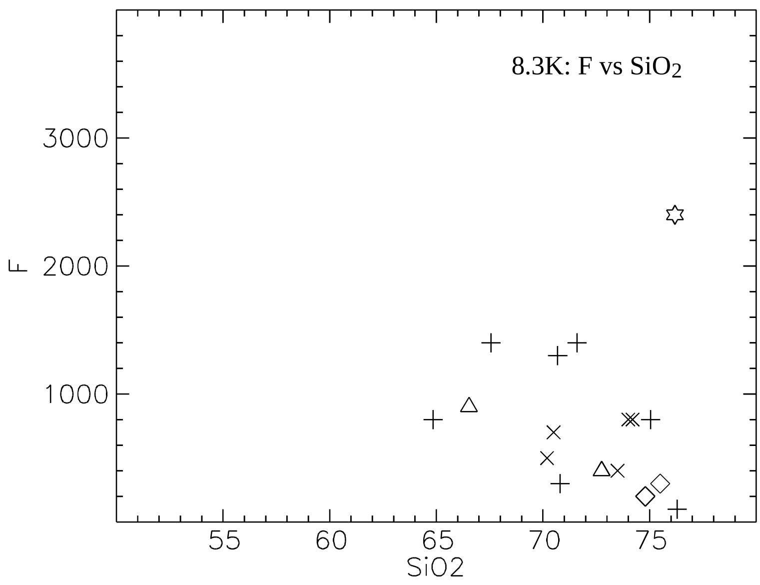

Legend
8.3D: P2O5 vs SiO2
P2O5
SiO2
0.8
0.6
0.4
0.2
55
60
65
70
75
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th-phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit

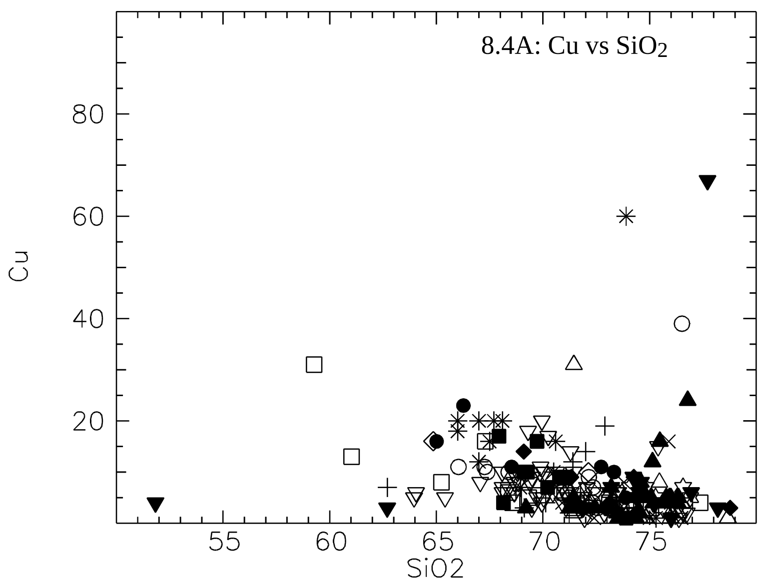

8.3E: Th vs SiO2
Th
SiO2
140
120
100
80
60
40
20
55
60
65
70
75

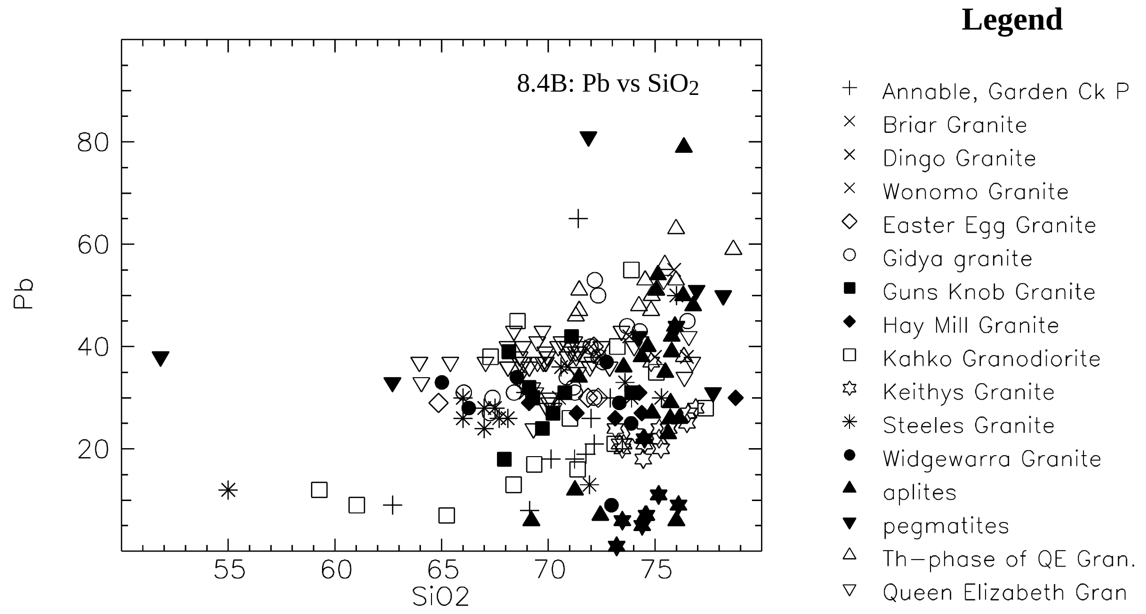

8.3F: K/Rb vs SiO2
K/Rb
SiO2
400
300
200
100
55
60
65
70
75

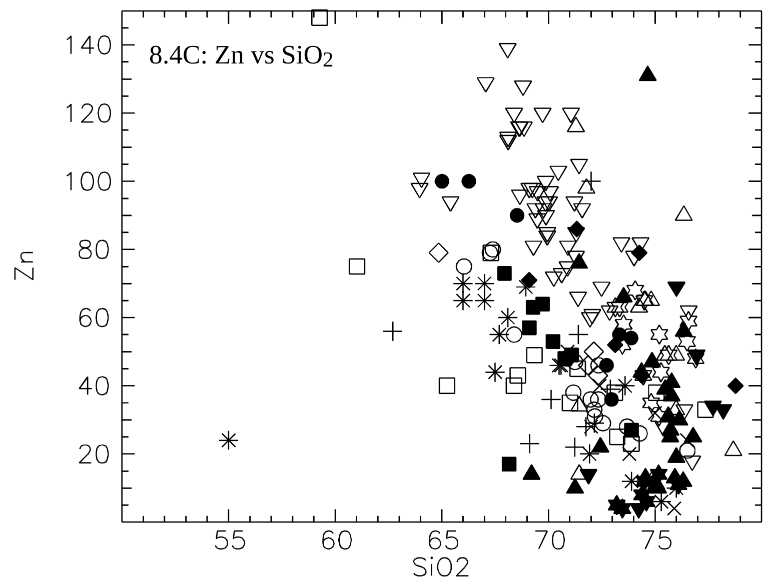

Legend
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit
8.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Granite
Anomalous granite
Monzogranite
Tonalite
8.3H: Sr vs SiO2
Sr
SiO2
8.3I: Rb/Sr vs SiO2
Rb/Sr
SiO2

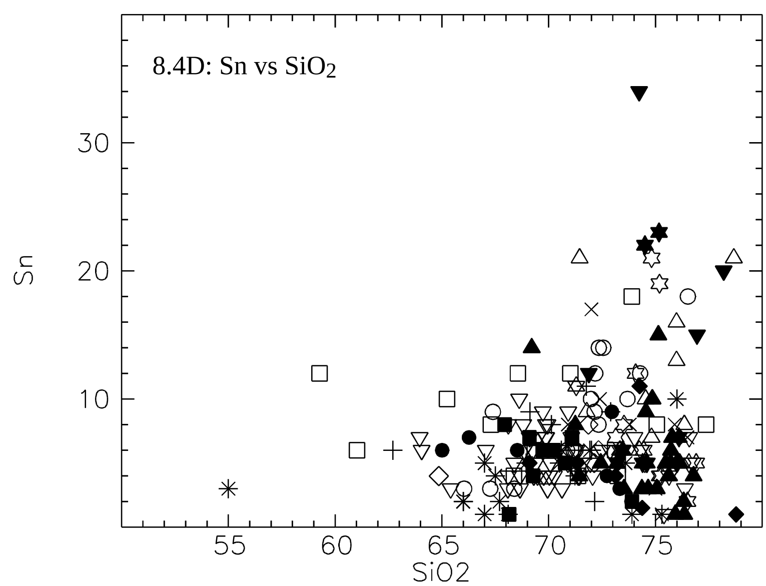

8.3J: Ba vs SiO2
2000
1500
1000
500
Ba
55
60
65
70
75
SiO2
Legend
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit

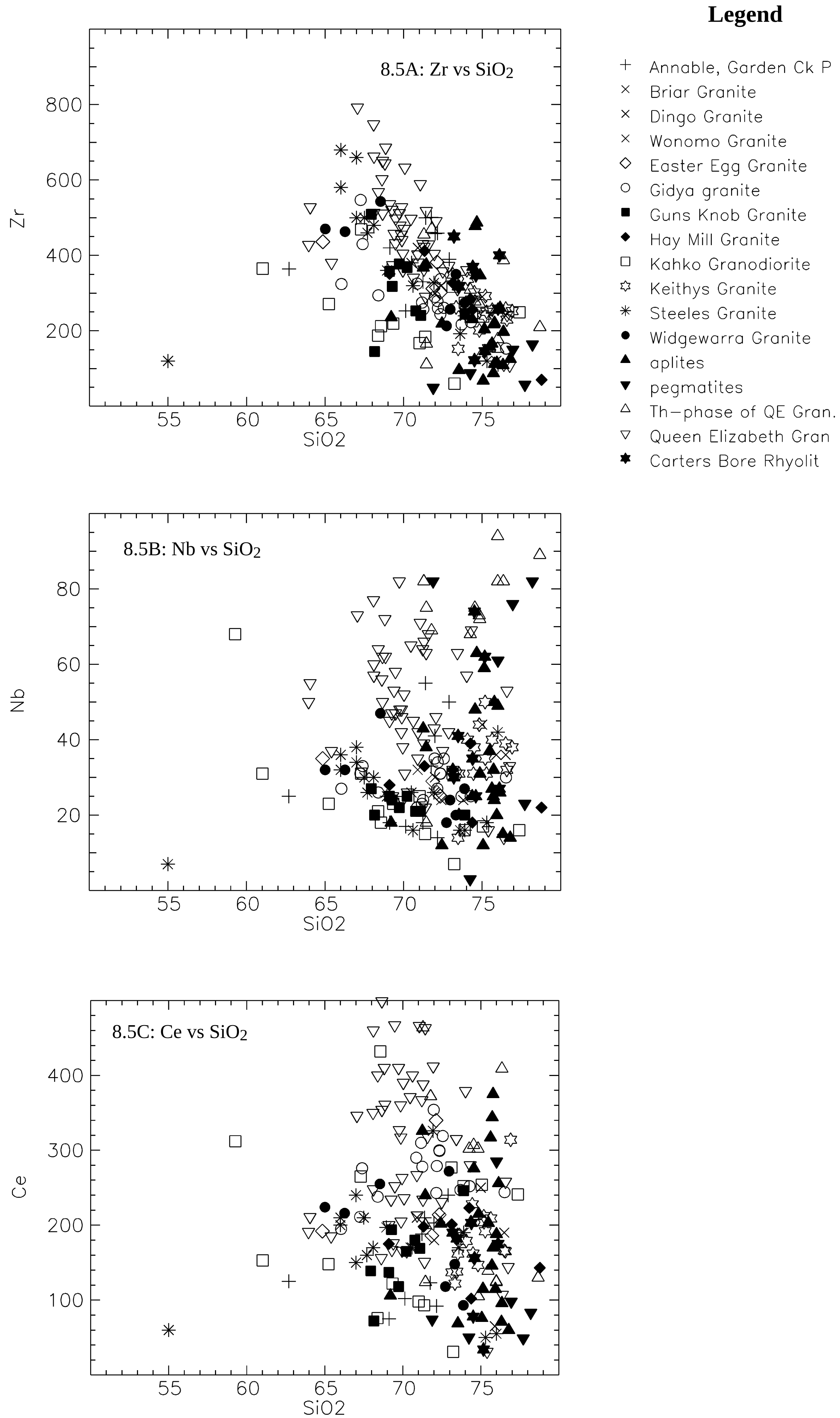

8.3K: F vs SiO2
3000
2000
1000
F
55
60
65
70
75
SiO2

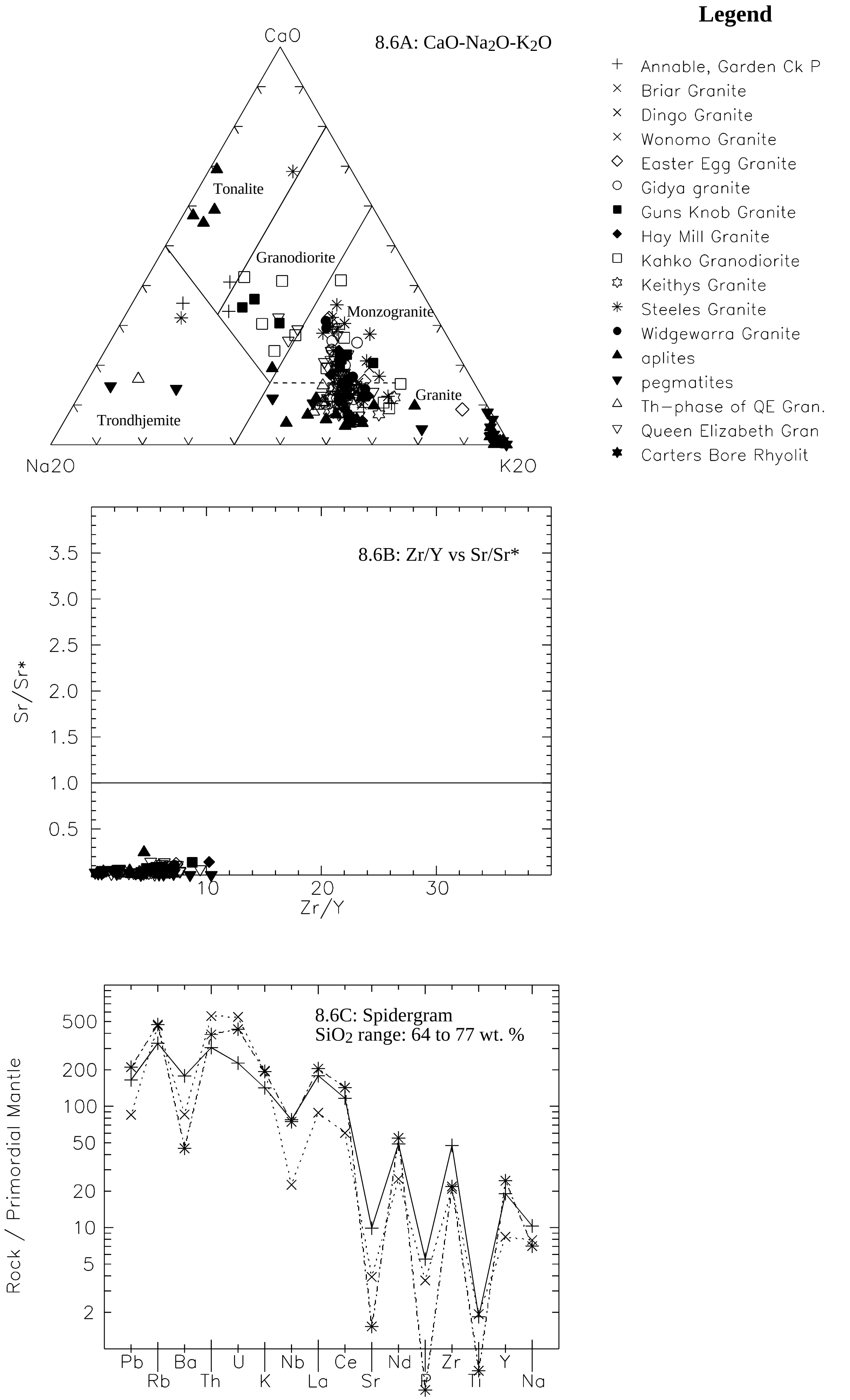

8.4A: Cu vs SiO2
80
60
40
20
Cu
55
60
65
70
75
SiO2

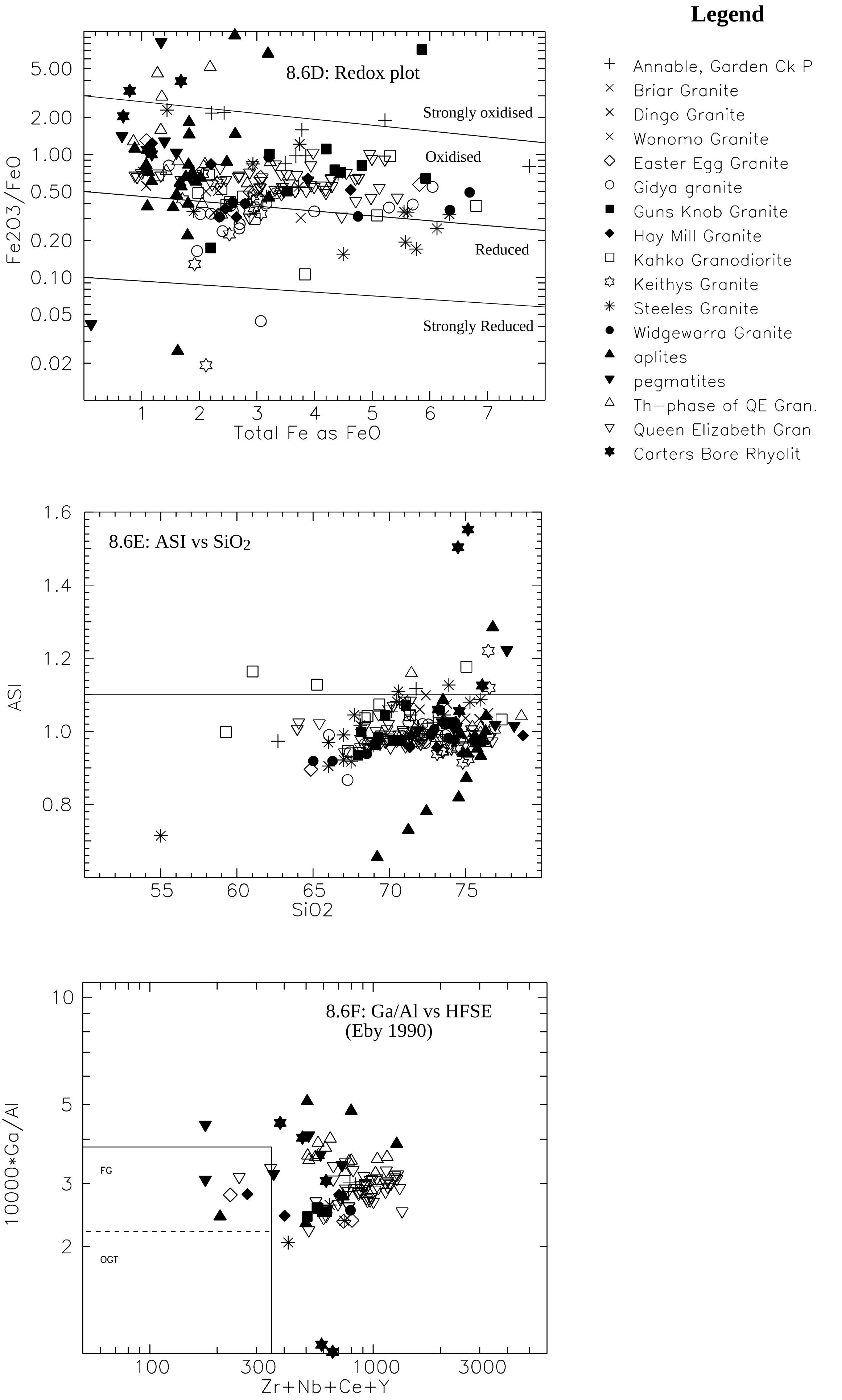

Legend
8.4B: Pb vs SiO2
Pb
SiO2
80
60
40
20
55
60
65
70
75
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th-phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit

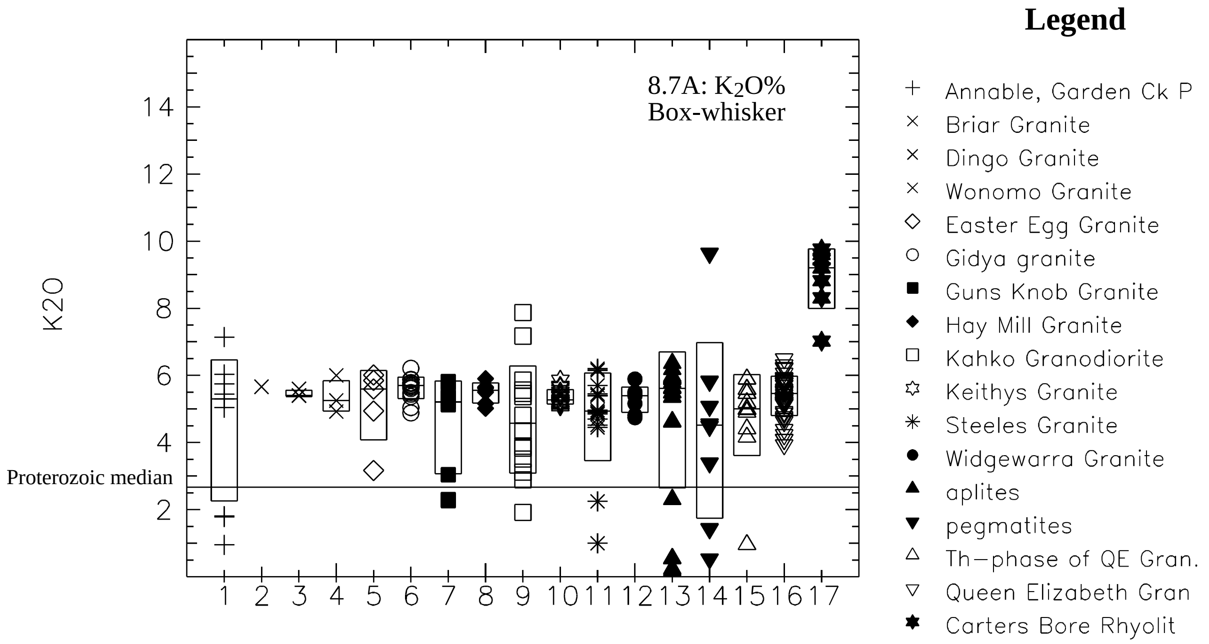

8.4C: Zn vs SiO2
Zn
SiO2
140
120
100
80
60
40
20
55
60
65
70
75

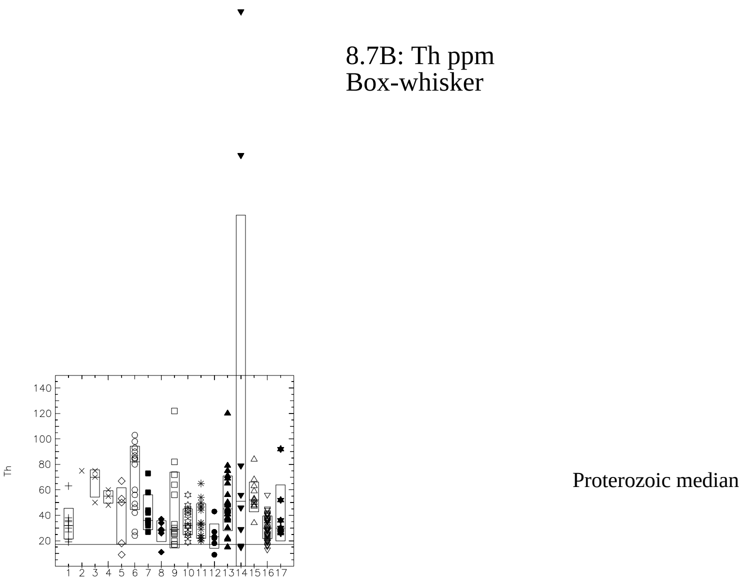

8.4D: Sn vs SiO2
Sn
SiO2
30
20
10
55
60
65
70
75

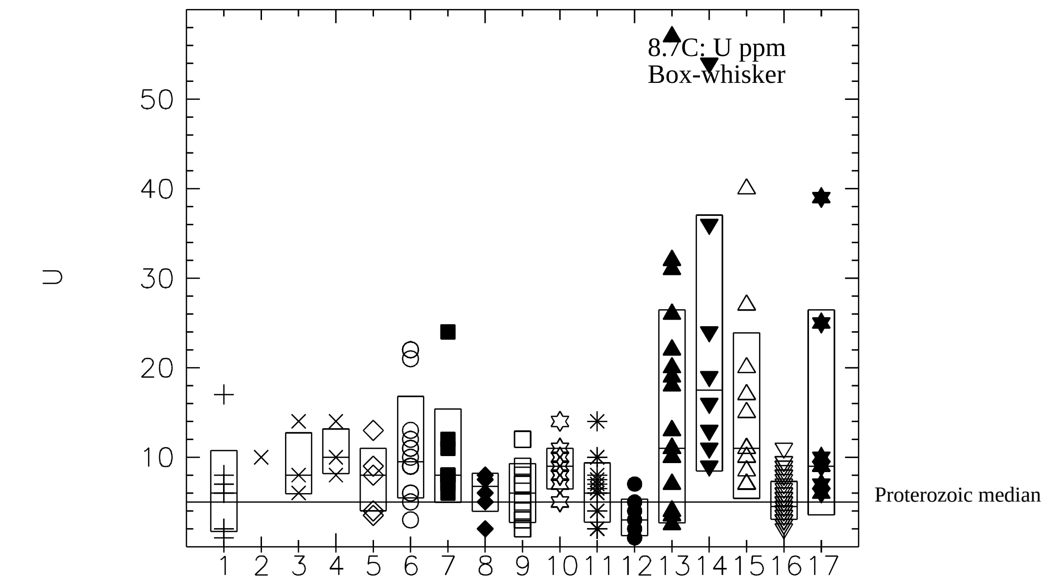

Legend
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit
8.5A: Zr vs SiO2
Zr
200
400
600
800
SiO2
55
60
65
70
75
8.5B: Nb vs SiO2
Nb
20
40
60
80
SiO2
55
60
65
70
75
8.5C: Ce vs SiO2
Ce
100
200
300
400
SiO2
55
60
65
70
75


Legend
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit
8.6A: CaO-Na2O-K2O
CaO
Na2O
K2O
Tonalite
Granodiorite
Monzogranite
Granite
Trondhjemite
8.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
3.5
3.0
2.5
2.0
1.5
1.0
0.5
10
20
30
Zr/Y
8.6C: Spidergram
SiO2 range: 64 to 77 wt. %
Rock / Primordial Mantle
500
200
100
50
20
10
5
2
Pb Rb Ba Th U K Nb La Ce Sr Nd P Zr Ti Y Na


Legend
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit
8.6D: Redox plot
Strongly oxidised
Oxidised
Reduced
Strongly Reduced
Fe2O3/FeO
Total Fe as FeO
8.6E: ASI vs SiO2
ASI
SiO2
8.6F: Ga/Al vs HFSE
(Eby 1990)
FG
OGT
10000*Ga/Al
Zr+Nb+Ce+Y


Legend
8.7A: K2O%
Box-whisker
K2O
Proterozoic median
14
12
10
8
6
4
2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Annable, Garden Ck P
Briar Granite
Dingo Granite
Wonomo Granite
Easter Egg Granite
Gidya granite
Guns Knob Granite
Hay Mill Granite
Kahko Granodiorite
Keithys Granite
Steeles Granite
Widgewarra Granite
aplites
pegmatites
Th−phase of QE Gran.
Queen Elizabeth Gran
Carters Bore Rhyolit


8.7B: Th ppm
Box-whisker
Proterozoic median


8.7C: U ppm
Box-whisker
U
50
40
30
20
10
Proterozoic median
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Annable and Garden Creek Porphyries

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.38	71.4	3.09	62.7	72.9	9
TiO2	0.59	0.55	0.3	0.23	1.26	9
Al2O3	13.35	13.3	0.59	12.6	14.53	9
Fe2O3	2.2	1.91	0.9	1.02	3.66	9
FeO	1.98	1.96	1.08	0.75	4.49	9
MnO	0.05	0.05	0.02	0.02	0.09	9
MgO	0.8	0.53	0.58	0.31	2.11	9
CaO	1.93	1.52	1.07	0.89	3.98	9
Na2O	3.11	2.8	0.79	2.13	4.61	9
K2O	4.36	5.3	2.23	0.95	7.14	9
P2O5	0.13	0.12	0.08	0.04	0.31	9
H2O+	0.74	0.64	0.41	0.43	1.73	9
H2O-	0.09	0.07	0.06	0.03	0.2	9
CO2	0.09	0.05	0.1	05	0.31	9
LOI	-	-	-	-	-	-
Ba	608.67	607	138.89	382	801	9
Li	7.14	7	2.19	5	11	7
Rb	174.33	178	92.12	54	310	9
Sr	138.67	107	84.64	60	272	9
Pb	23.78	19	16.98	8	65	9
Th	33.44	32	12.86	19	63	9
U	6.22	6	4.79		17	9
Zr	408.33	420	82.71	253	501	9
Nb	30.11	25	15.38	14	55	9
Y	55.44	51	22.73	34	95	9
La	86.33	69	37.37	38	140	9
Ce	150.89	125	59.78	75	240	9
Pr	-	-	-	-	-	-
Nd	82.33	87	14.57	66	94	3
Sc	2.67	3	1.53		4	3
V	26.39	20	26.14		91	9
Cr	9.67	8	3.79	7	14	3
Co	-	-	-	-	-	-
Ni	6.44	4	5.41	2	16	9
Cu	7.89	6	5.82	2	19	9
Zn	43.11	36	24.72	22	100	9
Sn	6.78	6	2.77	2	11	9
W	-	-	-	-	-	-
Mo	1.5		-			2
Ga	20.33	21	1.15	19	21	3
As	0.5		-			3
S	-	-	-	-	-	-
F	100	100	-	100	100	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Se	-	-	-	-	-	-

Briar Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72	72	-	72	72	1
TiO2	0.31	0.31	-	0.31	0.31	1
Al2O3	14	14	-	14	14	1
Fe2O3	0.58	0.58	-	0.58	0.58	1
FeO	1.73	1.73	-	1.73	1.73	1
MnO	0.03	0.03	-	0.03	0.03	1
MgO	0.47	0.47	-	0.47	0.47	1
CaO	1.26	1.26	-	1.26	1.26	1
Na2O	3.03	3.03	-	3.03	3.03	1
K2O	5.66	5.66	-	5.66	5.66	1
P2O5	0.08	0.08	-	0.08	0.08	1
H2O+	0.71	0.71	-	0.71	0.71	1
H2O-	0.03	0.03	-	0.03	0.03	1
CO2	-	01	-	01	01	1
LOI	-	-	-	-	-	-
Ba	560	560	-	560	560	1
Li	-	-	-	-	-	-
Rb	400	400	-	400	400	1
Sr	80	80	-	80	80	1
Pb	40	40	-	40	40	1
Th	75	75	-	75	75	1
U	10	10	-	10	10	1
Zr	300	300	-	300	300	1
Nb	30	30	-	30	30	1
Y	32	32	-	32	32	1
La	80	80	-	80	80	1
Ce	180	180	-	180	180	1
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	20	20	-	20	20	1
Cr	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	-	-	-	-	-	-
Cu	2	2	-	2	2	1
Zn	28	28	-	28	28	1
Sn	17	17	-	17	17	1
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	-	-	-	-	-	-
As	-	-	-	-	-	-
S	-	-	-	-	-	-
F	1900	1900	-	1900	1900	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Se	-	-	-	-	-	-

Dingo Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.37	72.4	1.45	70.9	73.8	3
TiO2	0.39	0.35	0.18	0.24	0.59	3
Al2O3	13.2	13.2	0.1	13.1	13.3	3
Fe2O3	0.99	1.02	0.08	0.9	1.05	3
FeO	2.1	2.1	0.86	1.24	2.95	3
MnO	0.05	0.05	-	0.05	0.05	3
MgO	0.48	0.5	0.18	0.3	0.65	3
CaO	1.48	1.42	0.31	1.2	1.81	3
Na2O	2.29	2.3	0.32	1.97	2.6	3
K2O	5.47	5.4	0.12	5.4	5.6	3
P2O5	0.09	0.08	0.05	0.05	0.14	3
H2O+	0.72	0.65	0.26	0.5	1	3
H2O-	0.08	0.08	0.03	0.06	0.11	3
CO2	0.14	0.15	0.04	0.1	0.18	3
LOI	-	-	-	-	-	-
Ba	560	580	170.88	380	720	3
Li	-	-	-	-	-	-
Rb	336.67	330	40.41	300	380	3
Sr	86.67	90	15.28	70	100	3
Pb	38.67	38	3.06	36	42	3
Th	65	70	13.23	50	75	3
U	9.33	8	4.16	6	14	3
Zr	326.67	320	90.19	240	420	3
Nb	26.67	24	4.62	24	32	3
Y	55.33	50	12.86	46	70	3
La	116.67	110	11.55	110	130	3
Ce	203.33	210	11.55	190	210	3
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	26.67	30	15.28		40	3
Cr	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	-	-	-	-	-	-
Cu	4.33	4	3.51		8	3
Zn	36.67	40	15.28	20	50	3
Sn	8.67	8	1.15	8	10	3
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	-	-	-	-	-	-
As	-	-	-	-	-	-
S	-	-	-	-	-	-
F	2300	2300	424.26	2000	2600	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Se	-	-	-	-	-	-

Easter Egg Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	73.8	72.13	8.44	64.85	87.81	5
TiO2	0.55	0.47	0.37	0.14	1.15	5
Al2O3	11.49	12.79	3.41	5.42	13.67	5
Fe2O3	1.23	1.04	0.58	0.65	2.19	5
FeO	2.06	1.99	1.19	0.5	3.85	5
MnO	0.05	0.05	0.02	0.02	0.09	5
MgO	0.64	0.48	0.41	0.38	1.37	5
CaO	1.7	1.59	1.15	0.33	3.52	5
Na2O	2.1	2.59	1.06	0.22	2.74	5
K2O	5.11	5.59	1.16	3.17	6.01	5
P2O5	0.13	0.1	0.11	0.03	0.31	5
H2O+	0.61	0.63	0.07	0.51	0.68	4
H2O-	0.11	0.12	0.02	0.08	0.12	4
CO2	0.16	0.14	0.06	0.1	0.25	4
LOI	0.8	0.8	-	0.8	0.8	1
Ba	753.2	684	275.44	414	1141	5
Li	20	23	4.12	15	23	5
Rb	303.8	305	84.68	187	426	5
Sr	96.2	89	43.38	42	163	5
Pb	27	30	12.57	6	40	5
Th	39.4	50	24.7	9	67	5
U	7.5	8	3.91	3.5	13	5
Zr	318.8	312	103.25	162	436	5
Nb	23.8	26	11.73	4	35	5
Y	55.8	63	19.95	22	74	5
La	112.6	107	68.68	25	216	5
Ce	194.6	192	106.29	41	340	5
Pr	3	3	-	3	3	1
Nd	58	74	36.72	16	84	3
Sc	7.33	4	7.57	2	16	3
V	28.2	18	27.2	9	76	5
Cr	2.33		2.31		5	3
Co	10	10	7	3	17	3
Ni	4.6	5	1.67	3	7	5
Cu	8.8	6	4.38	6	16	5
Zn	48.6	46	19.5	25	79	5
Sn	4.8	5	2.59		8	5
W	5.67	6	0.58	5	6	3
Mo	3.33	4	2.08		5	3
Ga	13.67	16	4.93	8	17	3
As	1	1	0.5	0.5	1.5	3
S	119.67	36	162.54	16	307	3
F	2233.33	2300	208.17	2000	2400	3
Cl	270.67	224	250.28	47	541	3
Be	3.75	4	1.26	2	5	4
Bi	1		-			3
Se	0.5		-			1

Gidya Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.28	72.07	2.78	66.04	76.52	16
TiO2	0.45	0.38	0.26	0.14	0.93	16
Al2O3	13.02	12.92	0.6	11.54	14.33	16
Fe2O3	0.85	0.69	0.54	0.13	2.21	16
FeO	2.43	2.18	0.97	0.85	4.22	16
MnO	0.05	0.04	0.02	0.03	0.1	16
MgO	0.49	0.39	0.26	0.1	0.96	16
CaO	1.65	1.46	0.59	0.88	2.8	16
Na2O	2.7	2.73	0.19	2.23	2.98	16
K2O	5.63	5.7	0.33	4.88	6.21	16
P2O5	0.11	0.08	0.09	0.02	0.29	16
H2O+	0.66	0.68	0.13	0.42	0.92	16
H2O-	0.04	0.03	0.03	0.01	0.11	16
CO2	0.06	0.05	0.02	0.05	0.1	16
LOI	-	-	-	-	-	-
Ba	646.81	483	410.26	114	1532	16
Li	21.88	23	6.54	8	29	16
Rb	317.75	327	88.86	168	445	16
Sr	92.75	78	41.83	29	182	16
Pb	37.25	35.5	7.84	27	53	16
Th	69.31	82	25.68	24	103	16
U	11.13	9.5	5.85	3	22	16
Zr	294.75	277	90.84	153	547	16
Nb	28.69	28.5	4.35	22	35	16
Y	70.06	69	10.42	53	95	16
La	158.13	155.5	27.82	110	211	16
Ce	270.94	277	41.44	195	354	16
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	16.44	12	14.23		48	16
Cr	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	1.44		0.73		3	16
Cu	8.38	6	8.7	3	39	16
Zn	44.25	37	19.01	21	80	16
Sn	8.94	9	4.37	3	18	16
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	-	-	-	-	-	-
As	-	-	-	-	-	-
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Se	-	-	-	-	-	-

Guns Knob Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.02	69.73	1.81	67.94	73.9	9
TiO2	0.74	0.75	0.25	0.3	1.07	9
Al2O3	12.97	13	0.22	12.56	13.24	9
Fe2O3	2.2	1.95	1.45	0.33	5.64	9
FeO	2.31	2.43	0.83	0.79	3.77	9
MnO	0.06	0.06	0.01	0.03	0.07	9
MgO	0.83	0.83	0.29	0.27	1.26	9
CaO	2.3	2.17	0.66	1.14	3.23	9
Na2O	2.75	2.61	0.57	1.83	3.8	9
K2O	4.45	5.21	1.46	2.27	5.81	9
P2O5	0.2	0.2	0.08	0.05	0.32	9
H2O+	0.64	0.64	0.16	0.4	0.89	9
H2O-	0.1	0.1	0.05	0.02	0.21	9
CO2	0.11	0.1	0.07	0.04	0.24	9
LOI	-	-	-	-	-	-
Ba	710.67	740	263.71	296	991	9
Li	24.22	25	8.17	9	33	9
Rb	254.56	247	45.99	182	348	9
Sr	105.11	116	29.41	55	137	9
Pb	30.44	31	7.23	18	42	9
Th	42.44	36	14.49	27	73	9
U	10.17	8	5.52	6	24	9
Zr	312.56	318	105.68	145	509	9
Nb	22.78	22	2.54	20	27	9
Y	52.33	55	6.76	41	60	9
La	88.22	93	28.59	41	142	9
Ce	157.78	165	49.36	72	246	9
Pr	-	-	-	-	-	-
Nd	54.4	53	9.71	40	66	5
Sc	10	10	2.74	7	14	5
V	29.44	33	13.73	6	45	9
Cr	3.4	3	1.67		5	5
Co	8	8	2.55	5	11	5
Ni	4.22	4	1.72	2	7	9
Cu	9.22	9	5.09		17	9
Zn	50.11	53	17.94	17	73	9
Sn	5.11	6	2.37		8	9
W	5.6	6	0.55	5	6	5
Mo	3.1	3	1.02		4	5
Ga	17.2	17	0.45	17	18	5
As	0.9	1	0.22	0.5	1	5
S	48	36	37.91	17	114	5
F	1700	1800	244.95	1400	2000	5
Cl	252.4	243	66.59	193	365	5
Be	4.11	4	1.05	3	6	9
Bi	1		-			5
Se	-	-	-	-	-	-

Hay Mill Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	73.5	73.69	3.27	69.1	78.78	6
TiO2	0.33	0.23	0.24	0.11	0.77	6
Al2O3	12.27	12.43	0.77	10.79	12.88	6
Fe2O3	1.04	0.87	0.46	0.64	1.63	6
FeO	1.9	1.96	0.91	0.56	3.16	6
MnO	0.05	0.05	0.02	0.02	0.08	6
MgO	0.32	0.19	0.29	0.1	0.87	6
CaO	1.27	1.11	0.66	0.51	2.33	6
Na2O	2.73	2.74	0.34	2.31	3.11	6
K2O	5.48	5.56	0.33	5.02	5.9	6
P2O5	0.07	0.03	0.08	0.01	0.21	6
H2O+	0.61	0.6	0.16	0.39	0.86	6
H2O-	0.09	0.09	0.04	0.02	0.15	6
CO2	0.13	0.14	0.05	0.05	0.2	6
LOI	-	-	-	-	-	-
Ba	843.17	888	194.04	591	1120	6
Li	20	21	8.02	7	29	6
Rb	225	236	39.88	170	276	6
Sr	95.67	101	31.61	56	132	6
Pb	28.33	28	1.97	26	31	6
Th	27.5	28.5	9.05	11	37	6
U	6.08	6.75	2.33	2	8	6
Zr	283.33	305.5	117.73	70	412	6
Nb	28.67	30	7.69	18	39	6
Y	54.17	59.5	19.41	25	79	6
La	92.17	97.5	22.99	56	119	6
Ce	173.67	186.5	44.39	102	223	6
Pr	-	-	-	-	-	-
Nd	48.67	47	19.55	30	69	3
Sc	4.67	5	1.53	3	6	3
V	10	2.5	16.12		42	6
Cr	1		-			3
Co	3.33	4	1.15	2	4	3
Ni	2.83	1.5	2.79		8	6
Cu	6.83	6.5	4.62	2	14	6
Zn	61.83	61.5	19.45	40	86	6
Sn	4.58	4.5	3.58		11	6
W	4.67	5	1.53	3	6	3
Mo	3.33	3	0.58	3	4	3
Ga	17	16	1.73	16	19	3
As	1	1	-	1	1	3
S	17	16	7.55	10	25	3
F	733.33	900	472.58	200	1100	3
Cl	165.33	152	67.99	105	239	3
Be	3.67	4	1.03	2	5	6
Bi	1		-			3
Se	-	-	-	-	-	-

Kahko Granodiorite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.58	70.18	5.16	59.27	77.37	14
TiO2	0.56	0.32	0.5	0.16	2.07	14
Al2O3	13.9	13.77	1.7	10.87	16.6	14
Fe2O3	1.23	0.87	0.99	0.37	3.91	14
FeO	2.83	2.07	2.09	0.8	8.91	14
MnO	0.06	0.05	0.04	0.03	0.18	14
MgO	0.86	0.69	0.67	0.25	2.29	14
CaO	2.25	2.04	1.1	0.95	3.99	14
Na2O	2.69	2.7	0.76	1.31	3.92	14
K2O	4.69	4.57	1.66	1.92	7.87	14
P2O5	0.17	0.11	0.15	0.05	0.58	14
H2O+	0.84	0.7	0.33	0.56	1.58	14
H2O-	0.04	0.03	0.03	01	0.11	14
CO2	0.07	0.05	0.03	05	0.15	14
LOI	-	-	-	-	-	-
Ba	685.07	608	281.63	343	1205	14
Li	22.57	20.5	12.09	4	39	14
Rb	254.43	253	102.51	105	414	14
Sr	151.43	141	81.09	54	311	14
Pb	25.86	23.5	14.8	7	55	14
Th	44.21	29	30.93	17	122	14
U	6	6	3.42	2	12	14
Zr	302.07	243.5	227.17	60	1017	14
Nb	24.43	22	14.35	7	68	14
Y	49.71	42	39.99	19	174	14
La	112.93	106	65.61	20	265	14
Ce	196.71	197	111.1	31	432	14
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	32.86	22	35.2	2	118	14
Cr	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	3.64	1.5	4.89		19	14
Cu	7.79	4.5	7.76	3	31	14
Zn	50.79	40	32.22	23	148	14
Sn	8.43	8	4.01	4	18	14
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	-	-	-	-	-	-
As	-	-	-	-	-	-
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Se	-	-	-	-	-	-

Keithys Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.84	74.82	1.22	73.14	76.91	15
TiO2	0.24	0.23	0.08	0.11	0.36	15
Al2O3	12.06	11.95	0.25	11.82	12.58	15
Fe2O3	0.62	0.75	0.31	01	0.96	15
FeO	1.88	1.88	0.35	1.23	2.37	15
MnO	0.04	0.05	0.01	0.03	0.06	15
MgO	0.22	0.23	0.08	0.11	0.4	15
CaO	1.01	1.01	0.26	0.64	1.4	15
Na2O	2.89	2.99	0.5	1.47	3.42	15
K2O	5.36	5.27	0.22	5.1	5.85	15
P2O5	0.03	0.03	0.02	01	0.07	15
H2O+	0.61	0.62	0.07	0.44	0.71	15
H2O-	0.07	0.08	0.03	0.02	0.12	15
CO2	0.1	0.1	0.04	0.05	0.15	15
LOI	-	-	-	-	-	-
Ba	705	753	322.09	37	1098	15
Li	12.93	11	5.13	6	24	15
Rb	253.53	245	47.13	200	377	15
Sr	68.47	72	25.03	16	103	15
Pb	23.67	23	4.58	18	37	15
Th	34.87	32	10.58	19	56	15
U	8.73	9	2.34	5	14	15
Zr	262.8	256	51.32	152	349	15
Nb	35.07	35	8.08	14	50	15
Y	74.33	77	23.06	51	131	15
La	96.93	90	26.95	70	173	15
Ce	182.47	166	47.73	122	314	15
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	5.87	5	3.91		11	15
Cr	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	2.6	3	0.91		4	15
Cu	5.27	5	1.28	3	7	15
Zn	52.4	53	10.89	31	68	15
Sn	7.6	6	5.53	2	21	15
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	-	-	-	-	-	-
As	-	-	-	-	-	-
S	-	-	-	-	-	-
F	1725	1600	550	1200	2500	4
Cl	-	-	-	-	-	-
Be	4.89	5	1.36	3	7	9
Bi	-	-	-	-	-	-
Se	-	-	-	-	-	-

aplites

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	75.29	75.62	2.74	69.21	82.66	25
TiO2	0.22	0.13	0.22	0.04	1.03	25
Al2O3	12.08	12.3	1.37	7.03	13.53	25
Fe2O3	0.88	0.65	0.68	0.04	3.04	25
FeO	1.03	1.11	0.44	0.28	2.29	25
MnO	0.03	0.02	0.02	0.01	0.09	25
MgO	0.26	0.16	0.24	0.06	1.24	25
CaO	1.66	0.74	2.16	0.01	8.29	25
Na2O	2.97	3.02	0.87	0.19	4.36	25
K2O	4.68	5.61	2.07	0.19	6.36	25
P2O5	0.04	0.01	0.05	01	0.24	25
H2O+	0.52	0.53	0.14	0.21	0.72	25
H2O-	0.08	0.08	0.06	01	0.2	25
CO2	0.1	0.05	0.1	0.04	0.44	25
LOI	-	-	-	-	-	-
Ba	213.92	97	303.25	25	1244	25
Li	15.72	12	15.05	2	58	25
Rb	235.68	262	116.39	5	443	25
Sr	76	33	111.79	7	513	25
Pb	33.36	35	18.28	6	79	25
Th	49.32	45	21.98	15	120	25
U	14.58	11	12.14	2.5	57	25
Zr	221.52	217	114.13	68	487	25
Nb	40.8	27	39.38	12	196	25
Y	84.44	67	70.06	21	386	25
La	112.36	104	75.41	7	322	25
Ce	202.36	202	126.64	20	583	25
Pr	-	-	-	-	-	-
Nd	67.33	53.5	64.58	5	187	6
Sc	3.67	4	2.42		7	6
V	5.36	2	9.81		49	25
Cr	1		-			6
Co	5.83	6	3.13		9	6
Ni	2.12	2	0.93		4	25
Cu	5.32	4	5.06		24	25
Zn	36.4	27	29.68	10	131	25
Sn	5.76	5	3.6		15	25
W	10	8.5	6.57	3	21	6
Mo	3.25	2.25	2.91		9	6
Ga	21.17	19	5.98	16	32	6
As	0.58	0.5	0.34	50	1	6
S	18.67	19	4.89	11	26	6
F	1183.33	1000	767.9	400	2400	6
Cl	181.5	162.5	77.76	111	324	6
Be	4.53	4	1.47	2	8	19
Bi	1.17		0.41		2	6
Se	-	-	-	-	-	-

pegmatites

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.19	75.13	9.3	51.83	78.2	8
TiO2	0.42	0.07	0.67	01	1.67	8
Al2O3	12.31	11.88	2.16	8.6	15.35	8
Fe2O3	1.99	0.85	2.44	01	6.41	8
FeO	3.65	0.74	5.86	0.12	14.72	8
MnO	0.13	0.03	0.21	01	0.53	8
MgO	0.24	0.08	0.33	0.03	0.89	8
CaO	0.82	0.91	0.36	0.31	1.37	8
Na2O	2.99	3.02	2.42	0.03	7.41	8
K2O	4.36	4.52	2.79	0.53	9.63	8
P2O5	0.11	0.01	0.19	01	0.43	8
H2O+	0.93	0.54	0.86	0.25	2.48	7
H2O-	0.17	0.18	0.11	0.06	0.32	7
CO2	0.15	0.04	0.18	0.04	0.5	7
LOI	0.35	0.35	-	0.35	0.35	1
Ba	233.75	157	226.31	12	595	8
Li	277.63	45	459.08	3	1148	8
Rb	555.5	358	470.61	17	1336	8
Sr	24.25	21	13.27	12	54	8
Pb	46.25	43	15.78	31	81	8
Th	125	51	161.35	15	436	8
U	22.75	17.5	15.29	9	54	8
Zr	1308.5	157	2189.86	49	5052	8
Nb	158.63	79	194.89	3	473	8
Y	229.25	169	195.33	36	589	8
La	574.75	56.5	963.52	21	2288	8
Ce	954.13	90.5	1585.58	49	3894	8
Pr	6	6	-	6	6	1
Nd	311.38	50	501.42	18	1225	8
Sc	11.13	4	14.51		36	8
V	4.13		5.84		15	8
Cr	1		-			8
Co	5.63	5.5	3.11		10	8
Ni	1.38		0.52		2	8
Cu	12	3.5	22.35		67	8
Zn	177.75	41.5	271.28	4	697	8
Sn	38.13	27	30.21	5	78	8
W	19.13	16.5	10.58	6	37	8
Mo	3.63	.50	4.39		14	8
Ga	31.5	25	13.08	21	59	8
As	1.38	0.75	1.55	50	4.5	8
S	58.13	15	86	3	225	8
F	4035.71	3500	3423.05	950	11300	7
Cl	206.88	105	222.23	39	584	8
Be	6.75	6.5	2.96	3	13	8
Bi	2.13		1.81		5	8
Se	0.83		0.29			3

Steeles Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.07	68.52	4.99	55	76	16
TiO2	0.66	0.71	0.35	0.09	1.18	16
Al2O3	13.29	13.25	0.43	12.8	14.3	16
Fe2O3	1.19	1.22	0.48	0.45	2.17	16
FeO	3.22	3.33	1.92	0.47	6.95	16
MnO	0.06	0.06	0.02	0.03	0.13	16
MgO	1.18	0.88	1.6	0.06	7	16
CaO	2.68	2.63	1.75	0.96	8.4	16
Na2O	2.36	2.29	0.68	1.58	4.45	16
K2O	4.76	4.93	1.35	1	6.2	16
P2O5	0.18	0.19	0.1	0.02	0.36	16
H2O+	0.78	0.73	0.34	0.35	1.85	16
H2O-	0.13	0.08	0.23	0.04	1	16
CO2	0.09	0.08	0.07	05	0.18	16
LOI	-	-	-	-	-	-
Ba	818.63	890	486.2	79	1450	16
Li	13.67	18	8.39	4	19	3
Rb	230.5	224.5	86.41	70	430	16
Sr	130.31	141.5	54.09	28	200	16
Pb	28.31	29	8.58	12	50	16
Th	35.44	33	13.92	20	65	16
U	6.06	6	3.42		14	16
Zr	376.81	370	186.78	110	680	16
Nb	26.13	26	9.51	7	42	16
Y	45.56	49	14.45	19	65	16
La	100.13	100	39.95	30	194	16
Ce	170.5	170	70.56	50	326	16
Pr	-	-	-	-	-	-
Nd	70.67	62	19.5	57	93	3
Sc	8	11	6.08		12	3
V	33.88	30	14.07		60	16
Cr	6	5	4.58	2	11	3
Co	11.5	11.5	0.71	11	12	2
Ni	3.67	3	2.08	2	6	3
Cu	21.31	16	27.33		110	16
Zn	43.88	46	22.89	6	70	16
Sn	3.69	3.5	2.52		10	16
W	5	5	2.83	3	7	2
Mo	2.25	2.25	1.06		3	2
Ga	16	16	2	14	18	3
As	0.58	50	0.38		1	3
S	31.5	31.5	3.54	29	34	2
F	1175	1300	888.35	100	2000	4
Cl	239	239	59.4	197	281	2
Be	5	5	1.41	4	6	2
Bi	1		-			2
Se	-	-	-	-	-	-

Carters Bore Rhyolite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.49	74.51	0.98	73.2	76.1	7
TiO2	0.29	0.25	0.17	0.05	0.47	7
Al2O3	11.68	11.6	0.78	10.7	12.76	7
Fe2O3	1.64	0.66	1.52	0.49	3.88	7
FeO	0.38	0.35	0.15	0.2	0.62	7
MnO	0.01	0.01	-	0.01	0.01	7
MgO	0.74	0.94	0.5	0.13	1.31	7
CaO	0.18	0.17	0.14	01	0.45	7
Na2O	0.18	0.2	0.09	0.06	0.34	7
K2O	8.88	9.2	0.96	7.02	9.76	7
P2O5	0.09	0.06	0.1	0.02	0.29	7
H2O+	0.44	0.53	0.23	0.1	0.6	4
H2O-	0.19	0.2	0.11	0.05	0.29	4
CO2	0.2	0.04	0.33	05	0.7	4
LOI	1.27	1.33	0.27	0.97	1.51	3
Ba	237	202	83.22	132	342	7
Li	14.83	5.5	16.19	3	39	6
Rb	219.71	140	192.74	96	642	7
Sr	13	11	5.42	7	23	7
Pb	8.71	7	6.65		22	7
Th	41.86	30	23.82	26	92	7
U	15	9	12.37	6	39	7
Zr	307.57	347	125.79	122	450	7
Nb	42	35	18.85	25	74	7
Y	92.43	59	59.75	50	208	7
La	74.57	87	36.49	14	110	7
Ce	145.43	175	64.02	34	203	7
Pr	11	9	9.17	3	21	3
Nd	60.83	72	26.58	14	83	6
Sc	2.2	2	0.84		3	5
V	7.5	5.5	4.76		12	6
Cr	3.36		2.46		6	7
Mn	60	60	-	60	60	1
Co	2.5		-			1
Ni	2.67	1.5	2.73	1	8	6
Cu	25.71	6	53.96	2	148	7
Zn	8.57	8	3.82	4	14	7
Sn	10.43	6	8.28	5	23	7
W	-	-	-	-	-	-
Mo	10	6	11.53		23	3
Ga	17.6	19	11.33	6	30	5
As	1.44	0.63	1.74		4	4
S	32.33	30	6.81	27	40	3
F	-	-	-	-	-	-
Cl	55.5	55.5	28.99	35	76	2
Be	4.33	4	0.58	4	5	3
Ag	1	1	-	1	1	1
Bi	1		-			3
Hf	13	13	-	13	13	1
Ta	3	3	-	3	3	1
Cs	1.5		-			1
Ge	2	2	-	2	2	1
Se	0.5		-			3

Widgewarra Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.39	72.73	3.7	65.01	73.88	7
TiO2	0.57	0.39	0.35	0.24	1.07	7
Al2O3	12.98	13.07	0.4	12.33	13.47	7
Fe2O3	1.28	1.16	0.62	0.57	2.28	7
FeO	2.96	2.06	1.39	1.73	4.82	7
MnO	0.07	0.05	0.03	0.04	0.1	7
MgO	0.53	0.35	0.33	0.23	1.06	7
CaO	2.1	1.56	0.83	1.34	3.32	7
Na2O	2.57	2.62	0.18	2.31	2.83	7
K2O	5.28	5.39	0.41	4.74	5.89	7
P2O5	0.16	0.08	0.13	0.05	0.34	7
H2O+	0.71	0.69	0.18	0.44	1.04	7
H2O-	0.09	0.1	0.05	0.01	0.14	7
CO2	0.14	0.15	0.09	0.05	0.25	7
LOI	-	-	-	-	-	-
Ba	1007.86	929	393.77	516	1503	7
Li	17.43	16	7.23	6	27	7
Rb	183.43	182	50.51	91	249	7
Sr	136.57	128	38.75	91	196	7
Pb	27.86	29	9.25	9	37	7
Th	23.57	23	10.29	9	43	7
U	3.29	3	2.21		7	7
Zr	367.14	350	126.2	213	543	7
Nb	28.57	27	9.76	18	47	7
Y	51.86	57	22.54	23	86	7
La	107.57	118	36.75	60	156	7
Ce	189.43	216	69.68	93	272	7
Pr	-	-	-	-	-	-
Nd	73	73	-	73	73	1
Sc	16	16	-	16	16	1
V	23.29	14	18.25	6	48	7
Cr	4	4	-	4	4	1
Co	13	13	-	13	13	1
Ni	3.71	4	1.5	2	6	7
Cu	11.29	11	6.7	3	23	7
Zn	68.71	55	27.08	36	100	7
Sn	5.29	6	2.43	2	9	7
W	6	6	-	6	6	1
Mo	6	6	-	6	6	1
Ga	18	18	-	18	18	1
As	2	2	-	2	2	1
S	239	239	-	239	239	1
F	1500	1500	565.69	1100	1900	2
Cl	654	654	-	654	654	1
Be	3.75	4	1.26	2	5	4
Bi	1		-			1
Se	-	-	-	-	-	-

Wonomo Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	75.8	75.9	0.76	75	76.5	3
TiO2	0.17	0.2	0.06	0.1	0.22	3
Al2O3	12.3	12.3	0.6	11.7	12.9	3
Fe2O3	0.65	0.73	0.22	0.4	0.81	3
FeO	1.26	1.46	0.47	0.72	1.6	3
MnO	0.04	0.04	0.01	0.03	0.05	3
MgO	0.16	0.2	0.1	0.05	0.24	3
CaO	1.02	0.96	0.12	0.94	1.16	3
Na2O	2.56	2.54	0.03	2.54	2.6	3
K2O	5.39	5.25	0.55	4.92	6	3
P2O5	0.03	0.03	0.01	0.02	0.04	3
H2O+	0.45	0.45	0.05	0.4	0.5	3
H2O-	0.2	0.05	0.26	0.05	0.5	3
CO2	0.2	0.05	0.26	0.05	0.5	3
LOI	-	-	-	-	-	-
Ba	286.67	320	66.58	210	330	3
Li	-	-	-	-	-	-
Rb	346.67	330	37.86	320	390	3
Sr	48.33	48	6.51	42	55	3
Pb	43.67	38	9.81	38	55	3
Th	54.33	55	6.03	48	60	3
U	10.67	10	3.06	8	14	3
Zr	216.67	240	87.37	120	290	3
Nb	38.67	36	4.62	36	44	3
Y	58.33	60	7.64	50	65	3
La	86.67	100	51.32	30	130	3
Ce	168.33	190	94.38	65	250	3
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	13.33		5.77		20	3
Cr	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	-	-	-	-	-	-
Cu	6		8.66		16	3
Zn	20	24	14.42	4	32	3
Sn	6	7	2.65	3	8	3
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	-	-	-	-	-	-
As	-	-	-	-	-	-
S	-	-	-	-	-	-
F	2300	2300	-	2300	2300	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Se	-	-	-	-	-	-

Th-rich phase of Queen Elizabeth Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.38	74.82	2.28	71.29	78.67	13
TiO2	0.14	0.1	0.09	0.02	0.29	13
Al2O3	12.75	12.49	1.32	11.04	16.46	13
Fe2O3	1.02	1	0.41	0.51	2	13
FeO	1.05	0.91	0.67	0.25	2.32	13
MnO	0.04	0.04	0.02	0.02	0.08	13
MgO	0.1	0.1	0.04	0.04	0.16	13
CaO	1.11	1.01	0.26	0.65	1.51	13
Na2O	3.34	3.16	0.95	2.82	6.45	13
K2O	4.82	5	1.25	0.96	5.89	13
P2O5	0.02	0.02	0.01	0.01	0.05	13
H2O+	0.39	0.39	0.11	0.24	0.57	13
H2O-	0.17	0.17	0.06	0.06	0.29	13
CO2	0.07	0.06	0.04	0.02	0.15	13
LOI	-	-	-	-	-	-
Ba	428.23	281	378.94	76	1341	13
Li	56.46	48	31.2	19	125	13
Rb	363.46	339	125.74	97	582	13
Sr	39	31	21.73	15	89	13
Pb	49.92	50	7.25	38	63	13
Th	54.46	52	12.11	34	84	13
U	14.65	11	9.63	7	40	13
Zr	251.62	210	122.66	111	470	13
Nb	76.15	75	21.07	18	111	13
Y	164.46	153	59.28	80	260	13
La	127.08	92	74.25	52	259	13
Ce	238.69	200	126.02	105	464	13
Pr	-	-	-	-	-	-
Nd	80.77	77	36.38	43	148	13
Sc	4.62	3	2.93	2	11	13
V	1.38		1.12		5	13
Cr	1		-			13
Co	5.46	5	1.13	4	7	13
Ni	1.38		0.51		2	13
Cu	4.69	2	8.15		31	13
Zn	54.54	49	32.58	12	116	13
Sn	18.69	11	17.55	6	66	13
W	13.31	12	5.51	7	24	13
Mo	2.38		1.26		5	13
Ga	24.08	23	2.9	21	31	13
As	0.54	0.5	0.22	50	1	13
S	18.69	16	12.06	4	50	13
F	4115.38	3900	1950.15	400	7300	13
Cl	157.08	153	93.06	46	345	13
Be	9.08	8	4.46	5	22	13
Bi	1.08		0.28		2	13
Se	-	-	-	-	-	-

Queen Elizabeth Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.62	69.99	3.09	63.96	81.8	52
TiO2	0.38	0.37	0.17	0.06	0.86	52
Al2O3	13.43	13.19	1.35	9.18	17.82	52
Fe2O3	1.39	1.4	0.51	0.37	2.62	52
FeO	2.29	2.32	0.76	0.55	3.88	52
MnO	0.07	0.08	0.03	0.01	0.13	52
MgO	0.36	0.26	0.25	0.07	1.13	52
CaO	1.78	1.74	0.6	0.7	3.75	52
Na2O	2.86	2.89	0.42	1.95	4.2	52
K2O	5.39	5.46	0.59	3.93	6.49	52
P2O5	0.08	0.07	0.06	01	0.25	52
H2O+	0.56	0.54	0.22	0.18	1.61	52
H2O-	0.19	0.16	0.1	0.05	0.58	52
CO2	0.15	0.15	0.07	0.03	0.37	52
LOI	-	-	-	-	-	-
Ba	1302.1	1303.5	512.48	25	2312	52
Li	41.79	44	14.44	1	76	52
Rb	234.46	228.5	31.47	175	297	52
Sr	109.65	112.5	41.79	6	228	52
Pb	37.13	37	4.71	24	53	52
Th	30.48	30	9.01	13	56	52
U	5.18	4.5	2.13	2	11	52
Zr	447.19	436.5	146.66	108	792	52
Nb	49.5	49	15.92	14	82	52
Y	87.27	86.5	24.29	20	140	52
La	170.44	163.5	73.92	13	402	52
Ce	303.21	297.5	124.48	31	702	52
Pr	-	-	-	-	-	-
Nd	98.28	98	33.07	31	205	50
Sc	8.76	9	3.05		14	50
V	8.46	4	10.59		43	52
Cr	2.16		3.63		15	50
Co	6.36	5.5	3.34		16	50
Ni	2.31	2	2.21		11	52
Cu	13.58	6.5	46.07		338	52
Zn	88.5	92	25.53	18	139	52
Sn	5.58	6	2.02		11	52
W	6.34	6.5	1.72	3	10	50
Mo	3.57	4	0.98		5	50
Ga	20.66	21	2.99	13	29	50
As	0.63	0.5	0.31	50	1.5	50
S	35.38	30	32.08	6	240	50
F	2138	2200	630.16	600	3600	50
Cl	305.86	325	127.98	89	640	50
Be	5.78	5	2.09	3	17	51
Bi	1.34		1.32		10	50
Se	-	-	-	-	-	-

9 MARAMUNGEE SUITE

9.1 Timing

1545 Ma

9.2 Individual Ages

Primary Ages:

1. Maramungee Granite [1, 2, 3] 1545 ± 11 Ma, SHRIMP

Sources: [1] OZCHRON, [2] Page and Sun (1996), [3] Page and Sun (1998).

9.3 Regional Setting

The Maramungee Granite is a small pluton in the eastern part of the Eastern Fold Belt which appears to have been emplaced syn or just pre-D_2 (Williams and Heineman 1993). The Maramungee Granite is a distinct granite type as it has a Sr-undepleted and Y-depleted trace element pattern, which is unusual for Proterozoic granites in Australia (Wyborn *et al.* 1992). Although this trace element pattern has usually been taken as indicating derivation in a subduction-related environment, its emplacement during or shortly before a major high-temperature low-pressure province-wide metamorphic event suggests that it was formed as a result of crustal melting during this event.

9.4 Summary

The Maramungee Granite is predominantly trondhjemitic with some tonalitic compositions preserved. It is classed as an I-(granodiorite) type. It shows no sign of fractionation, and there is a possibility that the unusual geochemical signature has been produced by metasomatism, particularly as the Maramungee granite occurs in an area of extreme metasomatism (Williams and Blake 1993; Williams and Heineman 1993). The generation of trondhjemite from tonalite by metasomatism has been documented by Drummond *et al*. (1986).

9.5 Potential

Although the Maramungee Granite is close to the sub-economic Maramungee zinc deposit, there is no evidence that the granite itself played a direct role in the mineralisation (Williams and Heinemann 1993). The granite itself shows no evidence of fractionation, it is of small volume and it is unlikely to play a primary role in any form of mineralisation.

Cu:	**None**
Au:	**None**
Pb/Zn:	**None**
Sn:	**None**
Mo/W:	**None**
Confidence level:	**321**

9.6 Descriptive Data

Location: Selwyn 1:100 000 sheet area.

Dimensions and area: Narrow pluton 5 km long, covering an area of 4 km^2.

9.7 Intrusives

Component plutons: Maramungee Granite and several other small unnamed intrusions in the vicinity.

Form: Small elongate pluton.

Metamorphism and Deformation: Parts of the granite are strongly foliated.

Dominant intrusive rock types: Heterogeneous, mainly medium to fine-grained leucocratic granite, granodiorite and tonalite.

Colour: White to grey.

Veins, Pegmatites, Aplites, Greisens: Some pegmatite and aplite present.

Distinctive mineralogical characteristics: Quartz, plagioclase (An_{15-20}), microcline; ferromagnesian minerals < 5% (mainly biotite); accessories include titanite and magnetite.

Breccias: Brecciation recorded by Williams and Heinemann (1993) but this may be the result of later deformation.

Alteration in the granite: Extensive alteration has been recorded by Williams and Heinemann (1993) but this may be the result of later deformation and metamorphism.

9.8 Extrusives

No comagmatic volcanics have been recorded.

9.9 Country Rock

Contact metamorphism: None discernible due to later deformation and metamorphism.

Reaction with country rock: None discernible due to later alteration and metamorphism.

Units the granite intrudes: Soldiers Cap Group (Gandry Dam gneiss, Glen Idol schist of Beardsmore *et al.* 1988).

Dominant rock types: Migmatitic gneiss, quartzofeldspathic gneiss, graphitic biotite sillimanite gneiss, schist, amphibolite.

Potential hosts: Graphitic schist and amphibolite.

9.10 Mineralisation

The sub-economic Maramungee Zn deposit occurs close to the granite. This granite is not considered to have played a direct role in the mineralisation (Williams and Heinemann 1993).

9.11 Geochemical Data

Data source: AGSO OZCHEM data set.

Data quality: Good, done as part of the AGSO routine analyses.

Are the data representative? Reasonably.

Are the data adequate? For assessing the mineral potential, yes: more sampling may help to resolve whether or not the trondhjemitic compositions are derived from the tonalitic compositions by alteration.

SiO_2 range (Fig. 9.1): The SiO_2 range is from 62 to 72 wt.%.

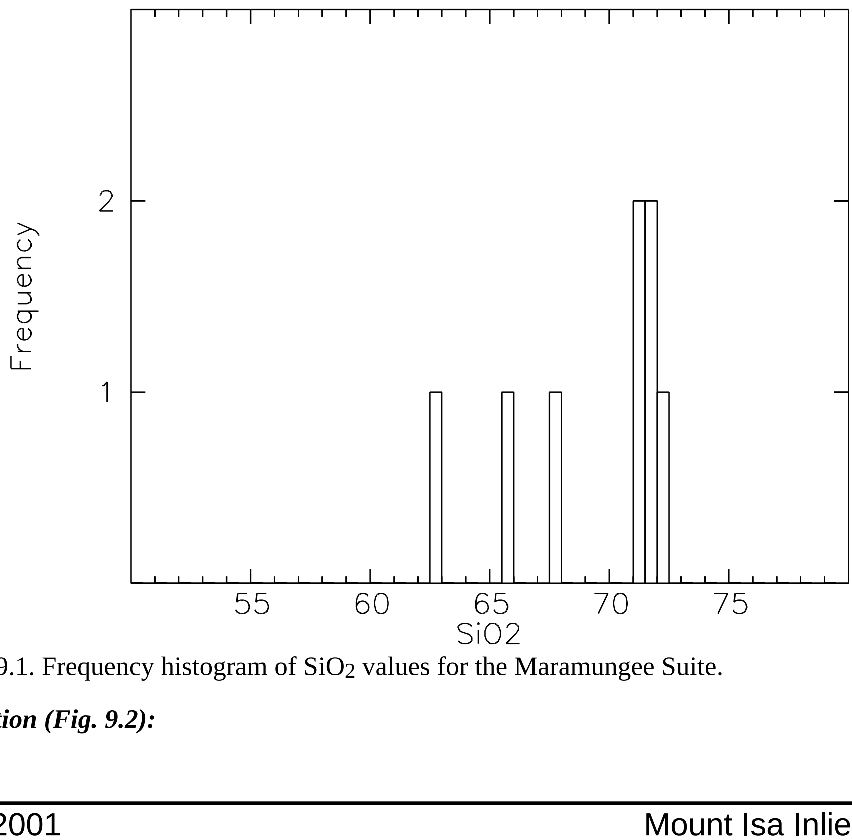


Figure 9.1. Frequency histogram of SiO_2 values for the Maramungee Suite.

Alteration (Fig. 9.2):

- ***SiO_2:*** No evidence of silicification.
- ***K_2O/Na_2O:*** This suite is very enriched in Na_2O and depleted in K_2O.
- ***Th/U:*** Two samples have lost U relative to Th.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** Most samples are relatively oxidised.

Fractionation Plots (Fig 9.3):

- ***Rb:*** The values are low and show no increase with increasing SiO_2.
- ***U:*** With the exception of one sample, the values are low and show no increase with increasing SiO_2.
- ***Y:*** The most mafic samples have high values, whilst the other values are low and show no increase with increasing SiO_2.
- ***P_2O_5:*** The most mafic samples have high values, whilst the other values are low and show a weak decrease with increasing SiO_2.
- ***Th:*** The values are low and show no increase with increasing SiO_2.
- ***K/Rb:*** The values are high and show an increase with increasing SiO_2.
- ***Rb-Ba-Sr:*** No samples plot in the strongly differentiated field.
- ***Sr:*** The most mafic samples have low values, whilst the other samples have moderate to high values.
- ***Rb/Sr:*** Values for all samples are low and show no increase with increasing SiO_2.
- ***Ba:*** Values for all samples are low and show no increasewith increasing SiO_2.
- ***F:*** Values for all samples are low and show no increase with increasing SiO_2.

Metals (Fig 9.4):

- ***Cu:*** Values for all samples are low and show no increase with increasing SiO_2.
- ***Pb:*** Values for all samples are low and show a weak increase with increasing SiO_2.
- ***Zn:*** Values are low to moderate.
- ***Sn:*** Values for all samples are low and show no increase with increasing SiO_2.

High field strength elements (Fig 9.5):

- ***Zr:*** Values for all samples are low and show a weak decrease with increasing SiO_2
- ***Nb:*** Values for all samples are low and show no increasewith increasing SiO_2.
- ***Ce:*** Values for all samples are low and show no increase with increasing SiO_2.

Classification (Fig 9.6):

- ***The $CaO/Na_2O/K_2O$ plot of White, quoted in Sheraton and Simons (1992):*** Most samples plot in the trondhjemite field, with one sample having a higher K_2O/Na_2O ratio plotting in the tonalite field.
- ***Zr/Y vs Sr/Sr*:*** The samples with the highest K_2O/Na_2O ratios have values of Sr/Sr* of <1, indicating that they are Sr-depleted, Y-undepleted. All other samples with low K_2O/Na_2O ratios have values >1 indicating that they are Sr-undepleted, Y-depleted.
- ***Spidergram:*** The contrasting patterns are shown: the solid line is a tonalite whilst the dashed lines are the trondhjemites. It is possible that the trondhjemites have been produced by alteration of the tonalites. The generation of trondhjemitic compositions from normal tonalitic compositions has been documented by Drummond *et al.* (1986) and this process may have applications in the area surrounding the intrusion of the Maramungee Granite as Na-metasomatism is widespread (Williams and Blake 1993; Williams and Heinemann 1993).
- ***Oxidation plot of Champion and Heinemann (1994):*** Samples are oxidised to strongly oxidised.
- ***ASI:*** The samples range from metaluminous to weakly peraluminous.
- ***A-type plot of Eby (1990):*** All but one of the samples plot in the field for normal granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-(granodiorite) type.

Australian Proterozoic granite type: Type example of the Maramungee type.

9.12 Geophysical Signature

Radiometrics (Fig. 9.7): All samples plot below the median values for K_2O and Th, and some plot above for U. These high U samples would appear blue, whilst the remainder would possibly be black in an RGB image.

Gravity: Because of the small size of the intrusion the regional gravity data are too coarse for a meaningful assessment to be made.

Magnetics: Because of the small size of the intrusion the regional magnetic data are too coarse for a meaningful assessment to be made.

9.13 References

Beardsmore, T.J., Newberry, S.P. and Laing, W.P. 1988. The Maronan Supergroup: an inferred early volcanosedimentary rift sequence in the Mount Isa Inlier and its implications for ensialic rifting in the Middle Proterozoic of northwest Queensland. *Precambrian Research,* 40/41, 487-507.

Blake, D.H., Jaques, A.L. and Donchak, P.J.T. 1979. Precambrian geology of the Selwyn Region, Northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1979/86.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981a. Definitions of new and revised Precambrian stratigraphic and intrusive rock units in the Duchess and Urandangi 1:250 000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report,* 233*, (BMR Microform* MF 164*).*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981b. Summary of new and revised Precambrian stratigraphic nomenclature in the Duchess and Urandangi 1:250 000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Queensland Government Mining Journal*, 82, 580-589.

Blake, D.H., Jaques, A.L. and Donchak, P.J.T. 1983. Selwyn Region, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Australia.*

Blake, D.H., Bultitude, R.J., Donchak, P.J.T., Wyborn, L.A.I. and Hone, I.G. 1984, Geology of the Duchess-Urandangi region, Mount Isa Inlier, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin,* 219, 96 pp.

Drummond, M.S., Ragland, P.C. and Wesolowski, D. 1986. An example of trondhjemite genesis by means of alkali metasomatism: Rockford Granite, Alabama Appalachians. *Contributions to Mineralogy and Petrology,* 93, 98-113.

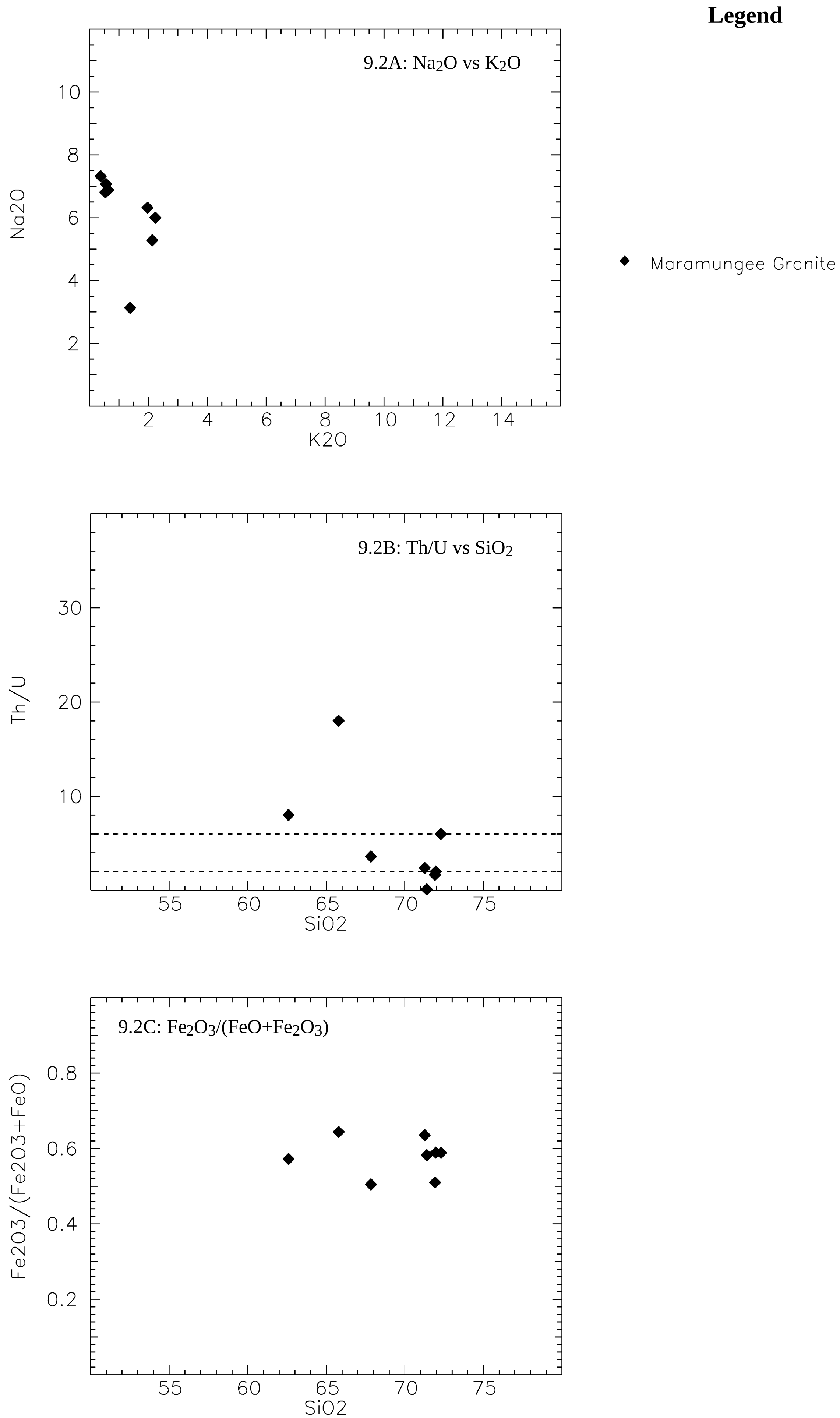
Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, *EGRU Contribution 55,* 95-98.

Page, R.W. and Sun, .S-S. 1998. Aspects of geochronology and crustal evolution in the Eastern Fold Belt, Mount Isa Inlier. *Australian Journal of Earth Sciences,* 45, 343-361.

Williams, P.J. and Heinemann, M. 1993. Maramungee: a Proterozoic Zn skarn in the Cloncurry District, Mount Isa Inlier, Queensland, Australia. *Economic Geology,* 88, 1114-1134.

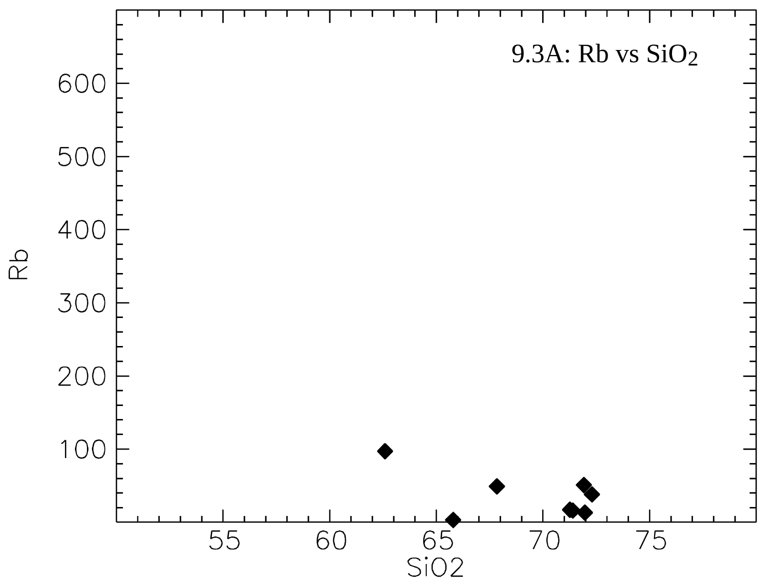
Williams, P.J. and Blake, K.L. 1993. Alteration in the Cloncurry District. *James Cook University Economic Geology Research Unit Contribution* 40.

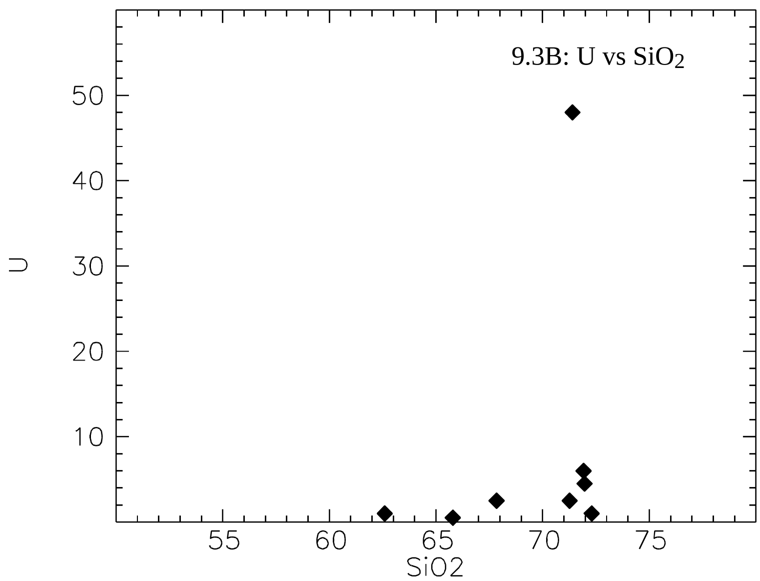
Wyborn, L.A.I., Wyborn, D., Warren, R.G. and Drummond, B.J. 1992. Proterozoic granite types in Australia: implications for lower crust composition, structure and evolution. *Transactions of the Royal Society of Edinburgh, Earth Sciences*, 83, 201-209.

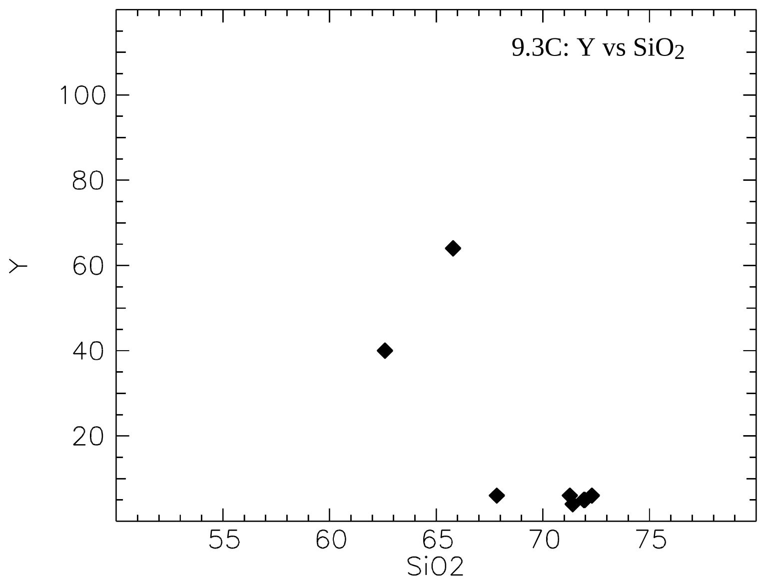

Legend
Maramungee Granite
9.2A: Na2O vs K2O
Na2O
K2O
10
8
6
4
2
2
4
6
8
10
12
14
9.2B: Th/U vs SiO2
Th/U
SiO2
30
20
10
55
60
65
70
75
9.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2
0.8
0.6
0.4
0.2
55
60
65
70
75

Legend

◆ Maramungee Granite

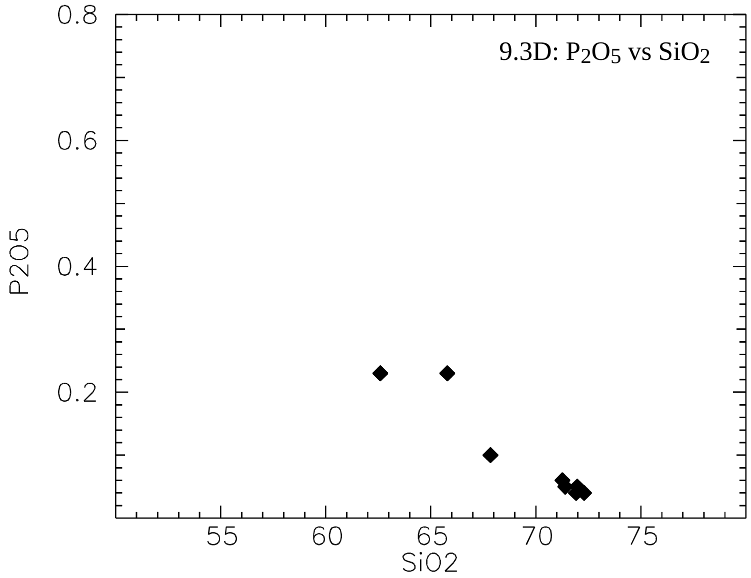


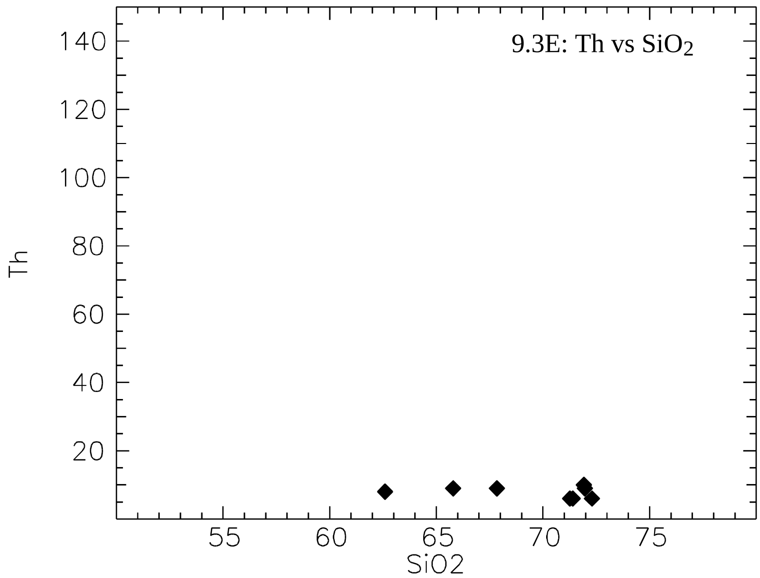


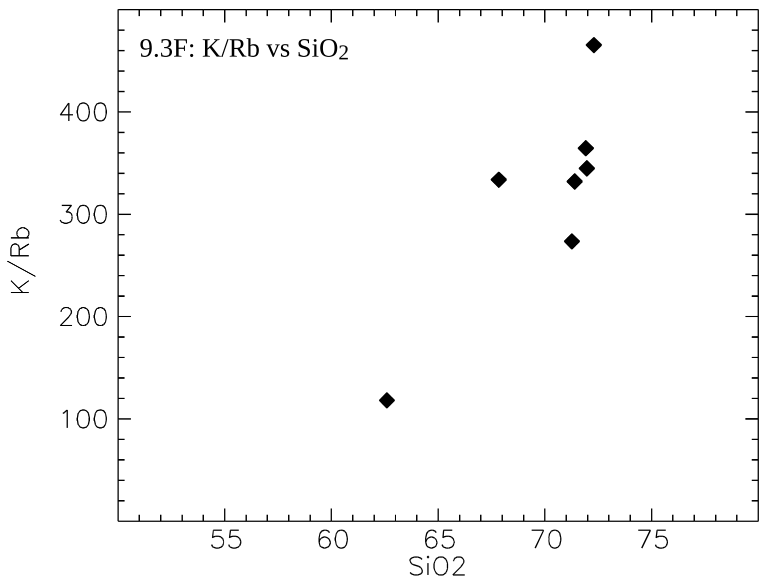


Legend

◆ Maramungee Granite

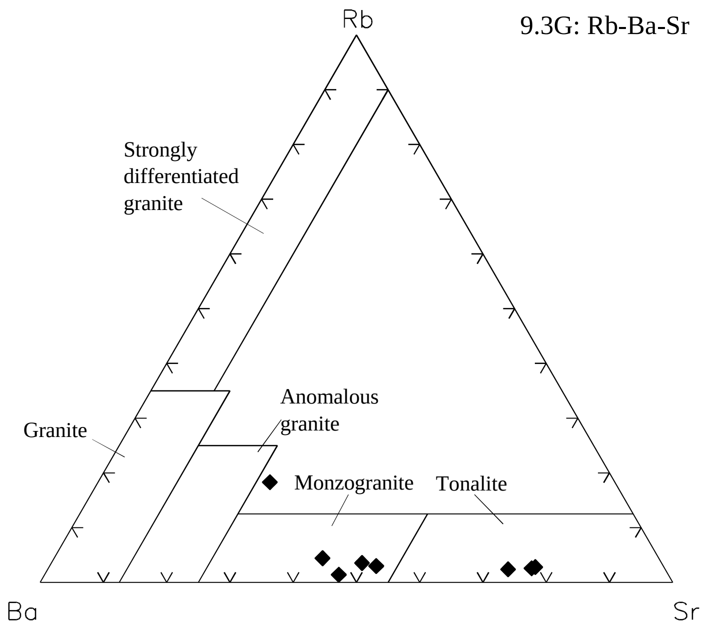


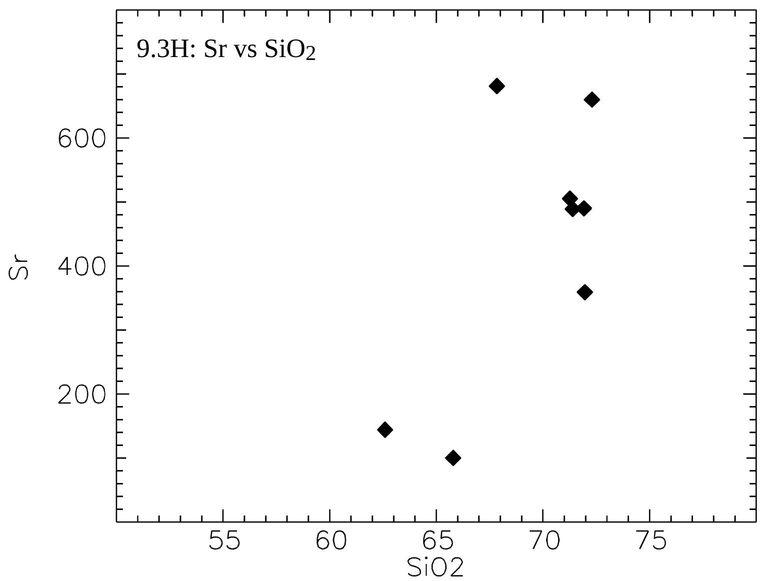


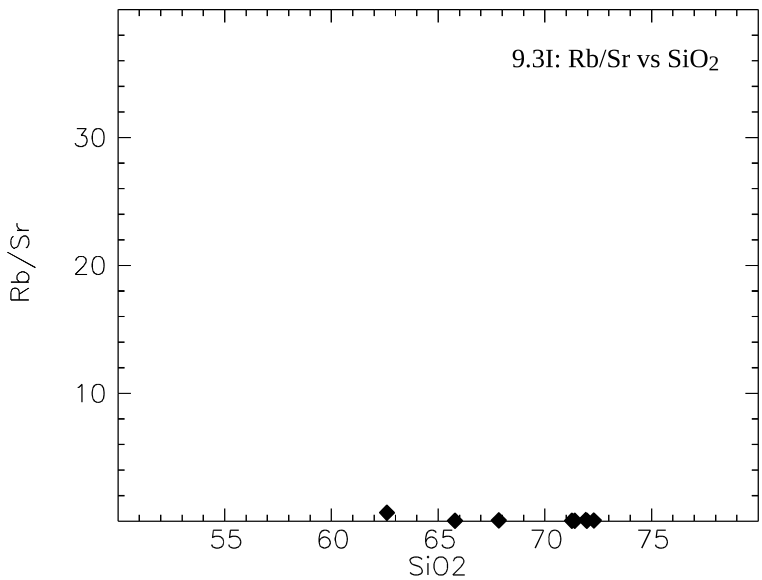


Legend

◆ Maramungee Granite

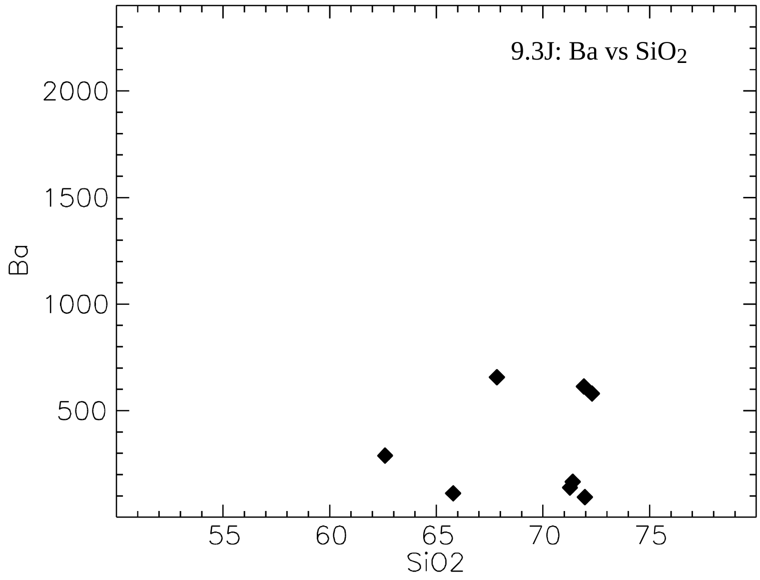


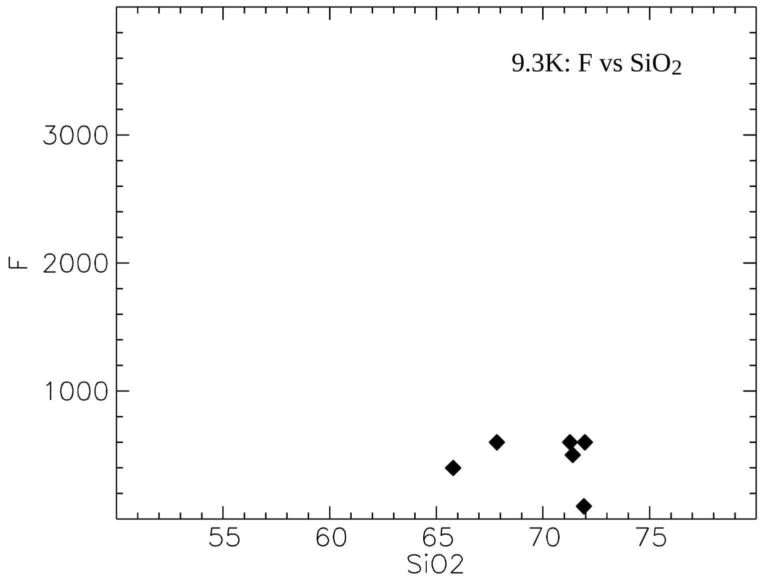


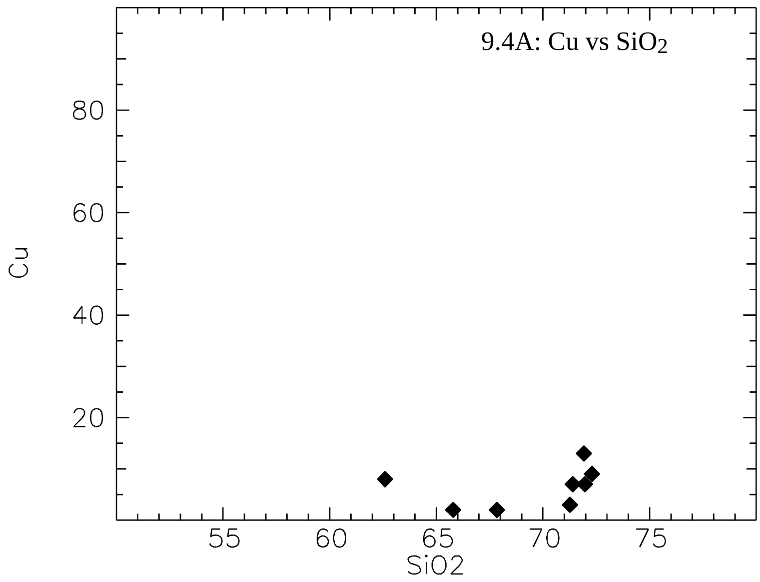


Legend

◆ Maramungee Granite

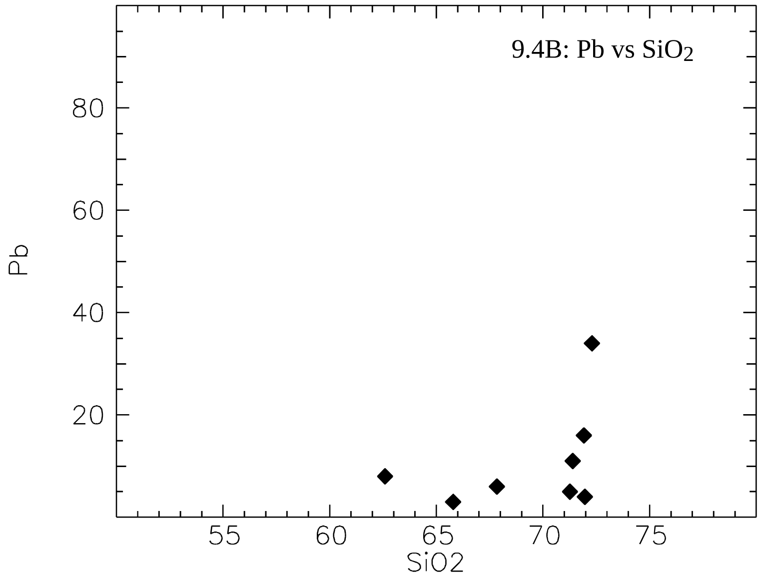




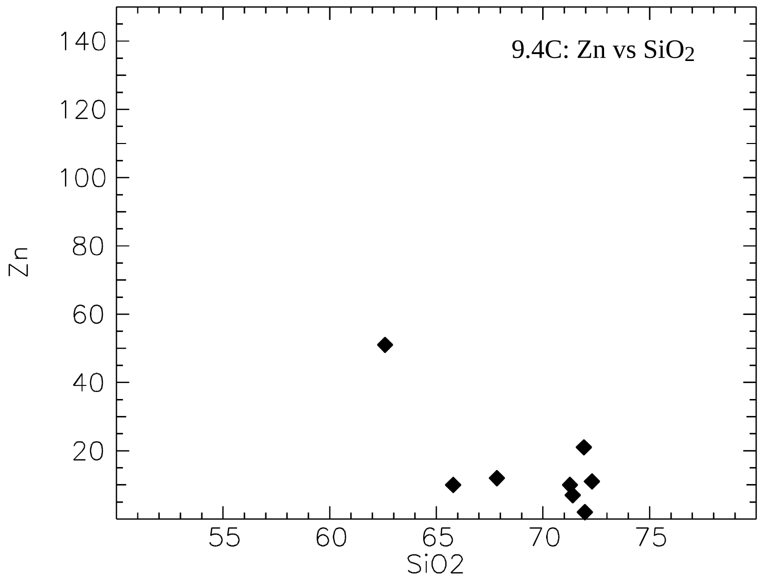


Legend

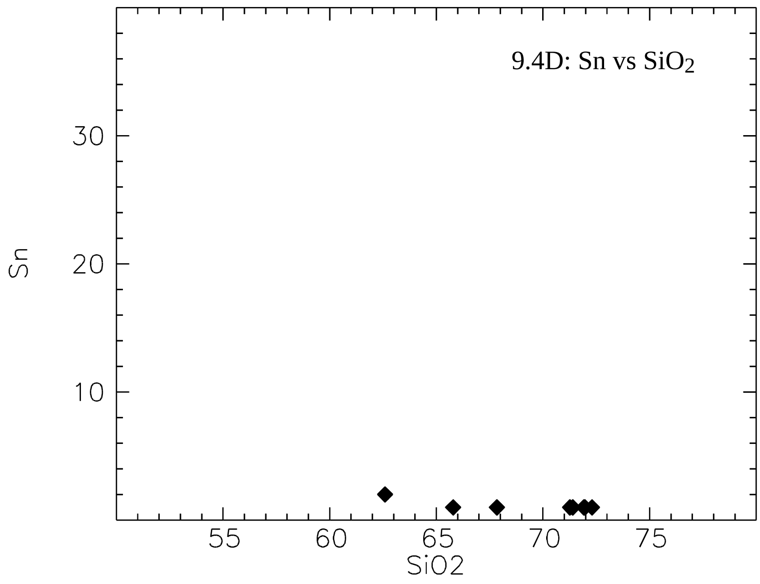
◆ Maramungee Granite



9.4B: Pb vs SiO_2



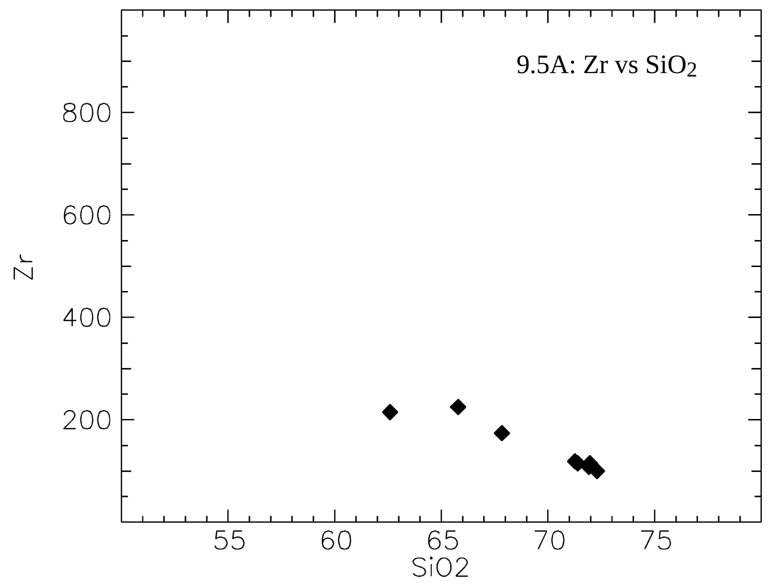
9.4C: Zn vs SiO_2

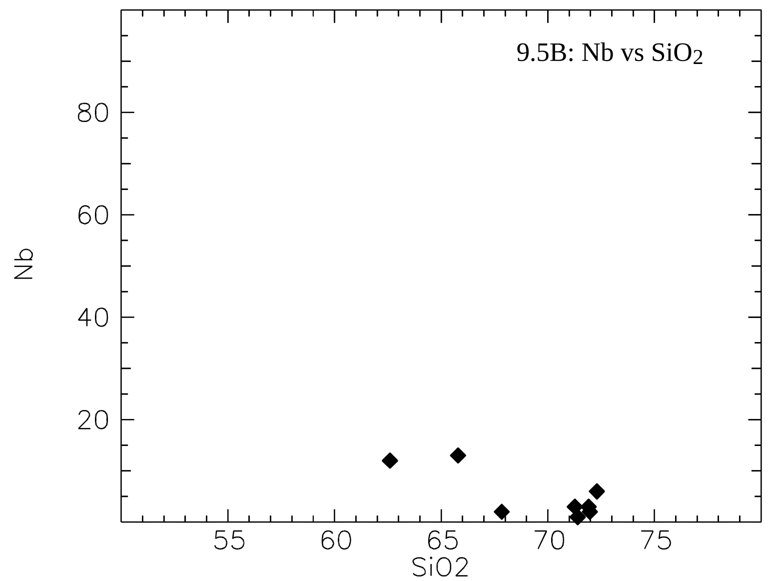


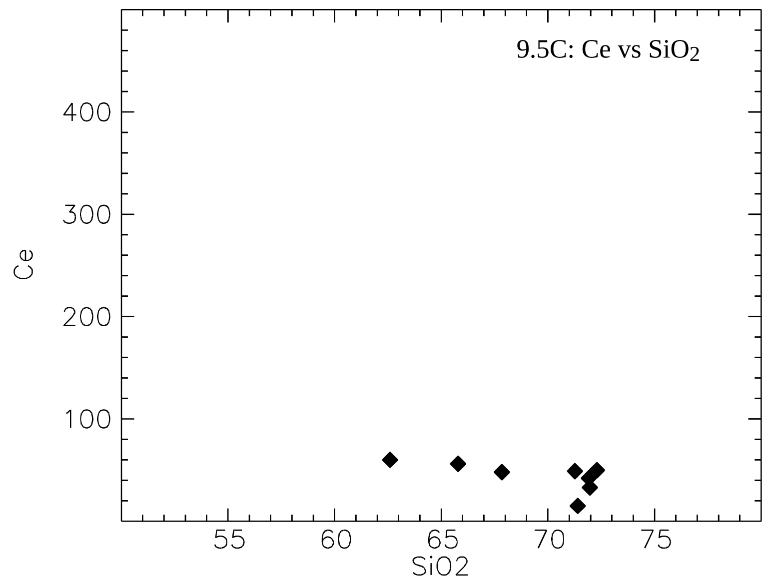
9.4D: Sn vs SiO_2

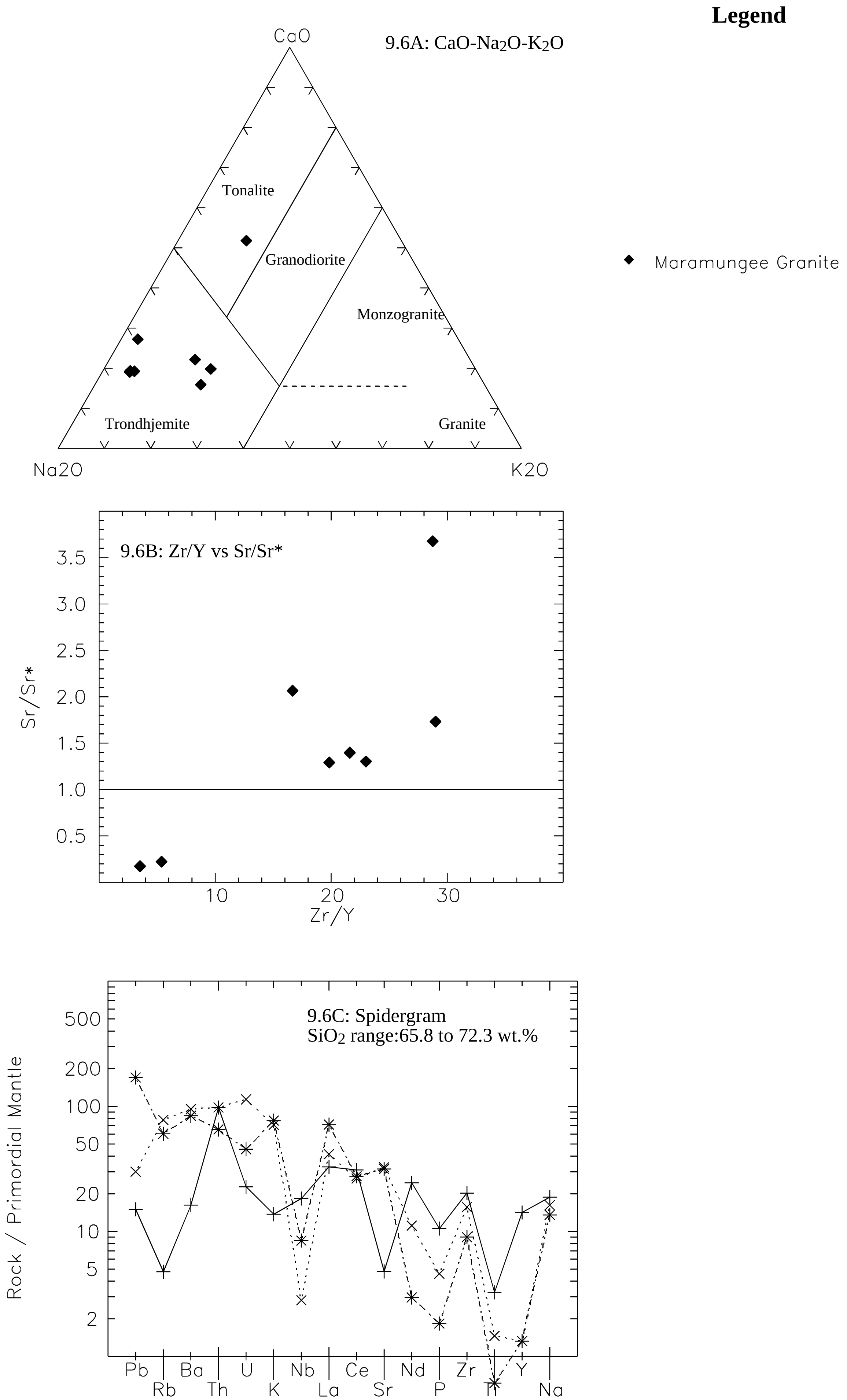
Legend

◆ Maramungee Granite

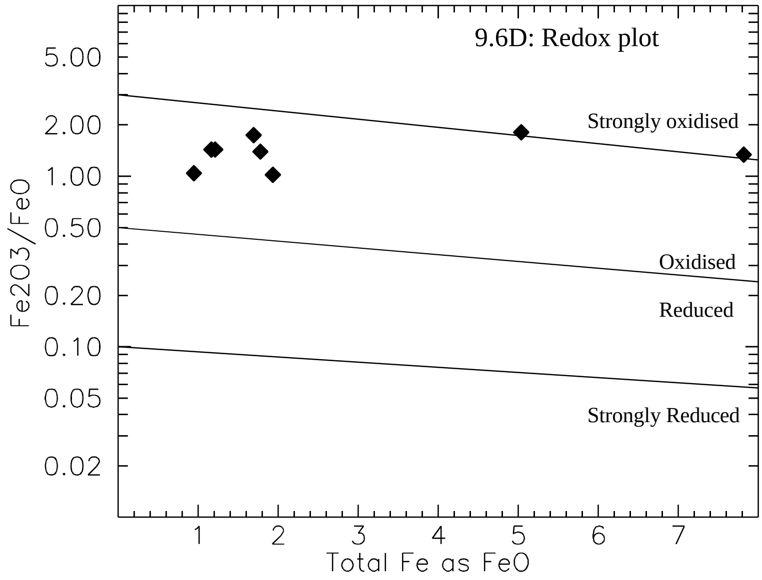




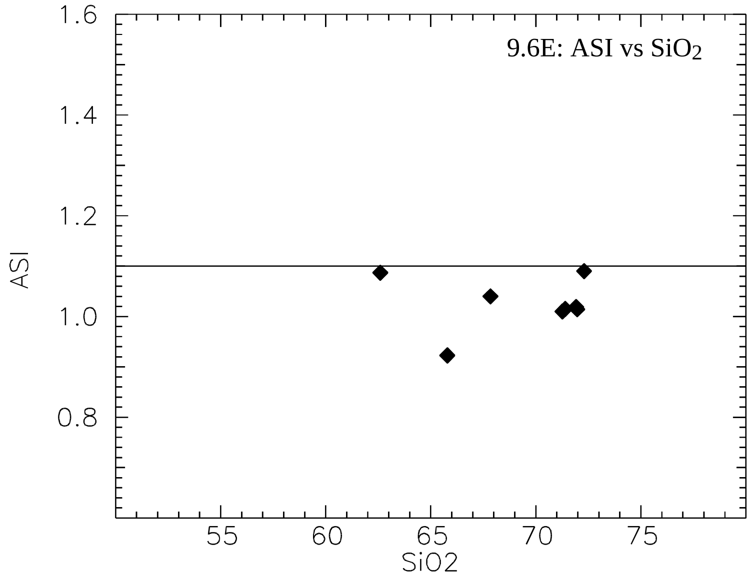


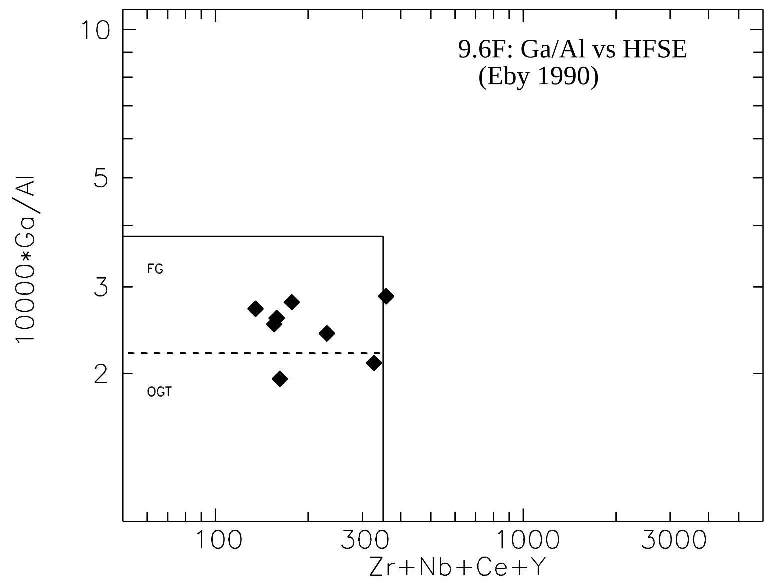

Legend
Maramungee Granite
9.6A: CaO-Na2O-K2O
CaO
Na2O
K2O
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
9.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
Zr/Y
9.6C: Spidergram
SiO2 range:65.8 to 72.3 wt.%
Rock / Primordial Mantle
Pb Rb Ba Th U K Nb La Ce Sr Nd P Zr Ti Y Na

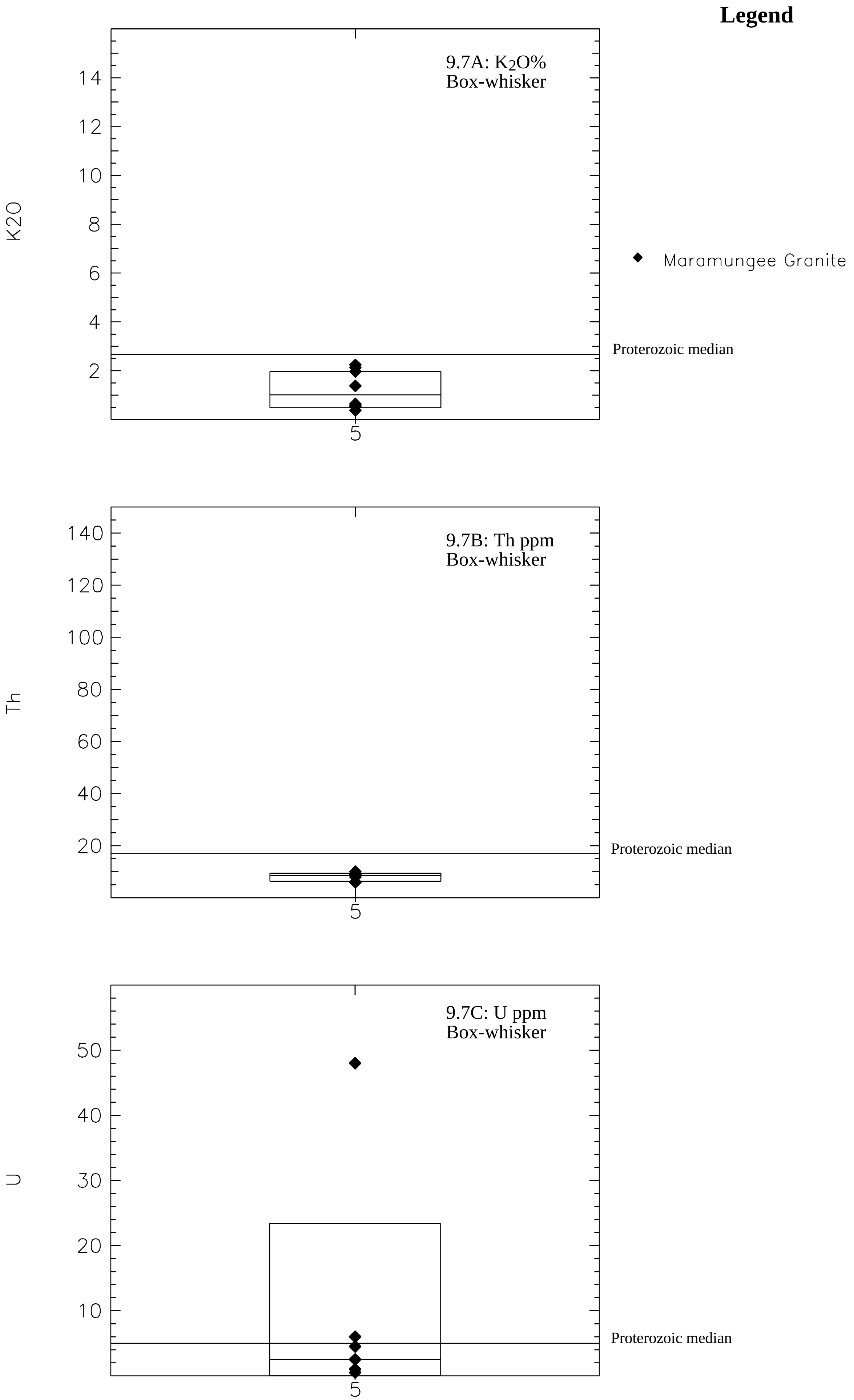
Legend


9.6D: Redox plot
Strongly oxidised
Oxidised
Reduced
Strongly Reduced
Fe2O3/FeO
Total Fe as FeO


Maramungee Granite


9.6E: ASI vs SiO2
ASI
SiO2


9.6F: Ga/Al vs HFSE
(Eby 1990)
FG
OGT
10000*Ga/Al
Zr+Nb+Ce+Y


Legend
Maramungee Granite
9.7A: K2O%
Box-whisker
K2O
14
12
10
8
6
4
2
5
Proterozoic median
9.7B: Th ppm
Box-whisker
Th
140
120
100
80
60
40
20
5
Proterozoic median
9.7C: U ppm
Box-whisker
U
50
40
30
20
10
5
Proterozoic median

Maramungee Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.39	71.33	3.6	62.6	72.3	8
TiO2	0.31	0.16	0.26	0.13	0.74	8
Al2O3	15.75	15.53	0.7	15.02	17.24	8
Fe2O3	1.69	1.07	1.55	0.51	4.75	8
FeO	1.18	0.73	1.07	0.49	3.55	8
MnO	0.02	01	0.04	01	0.12	8
MgO	0.49	0.31	0.31	0.23	1.04	8
CaO	2.35	1.83	1.1	1.56	4.85	8
Na2O	6.1	6.57	1.37	3.13	7.32	8
K2O	1.23	1.01	0.79	0.38	2.24	8
P2O5	0.1	0.05	0.08	0.04	0.23	8
H2O+	0.82	0.82	0.72	0.31	1.33	2
H2O-	0.14	0.14	0.07	0.09	0.19	2
CO2	0.09	0.09	0.1	05	0.16	2
LOI	0.98	0.94	0.34	0.53	1.54	6
Ba	331.63	228	244.23	95	657	8
Li	5.71	5	1.98	3	8	7
Rb	35.5	27.5	30.46	3	97	8
Sr	428.5	489.5	215.25	100	681	8
Pb	10.88	7	10.26	3	34	8
Th	7.88	8.5	1.64	6	10	8
U	8.25	2.5	16.17	0.5	48	8
Zr	146.38	117	50.7	100	225	8
Nb	5.25	3	4.71	1	13	8
Y	17	6	22.55	4	64	8
La	25.63	26	12.37	8	50	8
Ce	44.13	48.5	14.36	15	60	8
Pr	3.67	4	1.83		6	6
Nd	17	14	12.47	4	39	8
Sc	5.75	3.5	5.6		18	8
V	17	15	7.76	6	27	8
Cr	4.5	4	3.07		10	8
Mn	-	-	-	-	-	-
Co	5.43	5	2.37	3	9	7
Ni	4.25	5	2.05		7	8
Cu	6.38	7	3.85	2	13	8
Zn	15.5	10.5	15.3	2	51	8
Sn	1.13		0.35		2	8
W	1.5		1.22		4	6
Mo	1.5		-			7
Ga	20.75	21.5	2.66	16	24	8
As	0.63	0.5	0.33		1	8
S	63.83	42.5	57.76	18	166	6
F	466.67	550	196.64	Â	600	6
Cl	306	280	145.59	133	505	6
Be	3.33	3	0.52	3	4	6
Ag	-	-	-	-	-	-
Bi	1		-			6
Cs	1.5		-			6
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

10 WILLIAMS SUPERSUITE

10.1 Timing 1510 Ma

10.2 Individual Ages

Primary Ages:

1. Saxby Granite [1]	~1520 Ma, SHRIMP
2. Mount Dore Granite [2]	1509 ± 22, Rb-Sr
3. Wimberu Granite [3,4,5]	1508 ± 4, SHRIMP
4. Malakoff Granite [3,4,5]	1505 ± 5, SHRIMP
5. *The Mavis Granodiorite [3,4,5]	1501 ± 6, SHRIMP
6. Yellow Waterhole Granite [3,4,5]	1493 ± 8, SHRIMP

Sources: [1] McNaughton and Pollard, *pers. comm.*, [2] Nesbitt *et al.* (1983), [3] OZCHRON, [4] Page and Sun (1996), [5] Page and Sun (*in press*), *listed in references[4] and [5] as the Capsize granodiorite.

10.3 Regional Setting

The majority of plutons making up the Williams Supersuite were emplaced in the Eastern Fold Belt of the Mount Isa Inlier after the deformation and metamorphic event (D_2) that produced major north-trending structures. The Supersuite crops out over at least 2400 km^2 and dominates the Williams and Naraku Batholiths (Carter *et al.* 1961; Joplin and Walker 1961). The Supersuite is inferred from geophysical data to extend to the north and south of the Mount Isa Inlier beneath the Carpentaria, Eromanga and Georgina Basins (Wellman 1992). The Supersuite is notably heterogeneous and indirect evidence suggests that it may have been emplaced at temperatures of >1000°C, immediately after a high-T, low-P metamorphic event. Although the Williams Supersuite is predominantly felsic, some coeval diorites and gabbros have been recorded and net-vein complexes noted indicating that the total magmatic event was bimodal and likely to have formed in an extensional environment.

10.4 Summary

Plutons of the Williams Supersuite are mineralogically and chemically distinct from any other felsic intrusives in the Mount Isa Inlier, and consist of a series of coeval, but compositionally distinct plutons. Rock types present are very heterogeneous ranging from mafic magnetite-hornblende-biotite diorite and monzonite, through coarse porphyritic granodiorite and monzogranite to high-SiO_2 leucogranite enriched in U, Th and F. The Williams Supersuite is also one of the more mafic granite suites in the Mount Isa Inlier. Metasomatic alteration of both the country rocks and the intrusives is widespread, and brecciation is common, particularly in the calc-silicate country rocks. The alteration, which commonly occurs around the more felsic plutons, is complex with end-members varying from albitites to late cross-cutting K-feldspar + hematite veins (with up to 15 wt. % K_2O). For exploration purposes, the presence of late high-K alteration combined with appropriate structures and suitable host rocks are considered more important than the primary compositions of the individual intrusions. These ~1500 Ma intrusions of the eastern Mount Isa Inlier closely resemble, in their chemical composition and association with regional-scale breccia systems, the ~1590 Ma granites of the Stuart Shelf Region, including those hosting the major Cu-Au-U deposit at Olympic Dam.

10.5 Potential

Deposits of Cu and Au and minor occurrences/deposits of Ag, U and Co occur both within and around the margins of the Williams Supersuite, although the most significant deposits are hosted by Fe-rich facies some distance from known intrusions. The suite is considered to have high potential for further discoveries of Cu and Au.

Cu:	**High**
Au:	**High**
Pb/Zn:	**None**
Sn:	**None**
Mo/W:	**Low**
Confidence level:	**323**

10.6 Descriptive Data

Location: Eastern Mount Isa Inlier.

Dimensions and area: Generally northerly trending belt 190 km long by 90 km wide. Total outcrop area is 1900 km^2, but the subsurface extent is far larger (Wellman 1992; Wyborn 1992 1998).

10.7 Intrusives

Component plutons: The Mavis Granodiorite (formerly the Capsize granodiorite of Wyborn (1998), and Page and Sun 1996, 1998), Malakoff Granite, Saxby Granite, Mount Angelay Granite, Squirrel Hills Granite, Yellow Waterhole Granite, Wimberu Granite, Mount Cobalt Granite, Mount Dore Granite.

Form: Large circular to elliptical intrusions.

Metamorphism and Deformation: Mostly undeformed, but there are some very strong NNW/NNE trending shear zones within the granite.

Dominant intrusive rock types: Porphyritic biotite and biotite-hornblende granite, monzograniteand granite. *Specifically:* The Mavis Granodiorite - granodiorite, tonalite, diorite, monzogranite; Malakoff Granite - monzogranite, granite, minor granodiorite; Saxby Granite - medium to coarse-grained, porphyritic and even-grained granite with minor leucogranite, granodiorite, diorite, monzonite; Mount Angelay Granite - coarse to medium-grained, locally porphyritic granite with minor pods of hornblende and biotite-bearing quartz diorites which show net-veining relationships; Squirrel Hills Granite - massive, medium to coarse-grained porphyritic and subordinate non-porphyritic granite, minor porphyritic microgranite; Yellow Waterhole Granite - heterogeneous composite intrusion consisting of massive, porphyritic medium to coarse-grained biotite granite and fine-grained microgranite; Mount Cobalt Granite - massive, medium to fine-grained granite; Wimberu Granite - zoned pluton from coarse-grained, porphyritic granodiorite to a core of leucogranite; Mount Dore Granite - medium to coarse-grained even-grained to porphyritic granite.

Colour: Pink to red felsic varieties: grey colours dominate the more mafic types (which have little or no K-feldspar). Where albitised, the granite is white, and where it intrudes sulphide-bearing country rocks it is pale green. *Specifically:* The Mavis Granodiorite - grey; Malakoff Granite - pink; Mount Angelay Granite - pink; Squirrel Hills Granite - pink; Yellow Waterhole Granite - pink; Mount Cobalt Granite - pink; Wimberu Granite - pink; Mount Dore Granite - pink.

Veins, Pegmatites, Aplites, Greisens: In the more felsic end members aplite, pegmatite and greisen are very common.

Distinctive mineralogical characteristics: The more mafic end members of this granite are characterised by magnetite, biotite and hornblende. In the more mafic samples, biotite usually dominates over hornblende, which is unusual in Proterozoic I-(granodiorite) types. Fluorite occurs in the more fractionated end members. *Specifically:* The Mavis Granodiorite - plagioclase, K-feldspar, quartz, biotite, hornblende, magnetite and titanite with accessory apatite, allanite and zircon; Malakoff Granite - K-feldspar, quartz, plagioclase, biotite, and minor hornblende; Saxby Granite - K-feldspar, quartz, plagioclase, hornblende, biotite, magnetite and titanite; Mount Angelay Granite - K-feldspar, quartz, plagioclase, hornblende, biotite; Squirrel Hills Granite - K-feldspar, plagioclase, quartz, ferromagnesians can constitute 5 to 15 % and are dominated by biotite, with hornblende, clinopyroxene and up to 2% or more of titanite and magnetite; Yellow Waterhole Granite - K-feldspar, quartz, plagioclase, biotite, hornblende, allanite, titanite, magnetite, zircon; Mount Cobalt Granite - K-feldspar, quartz, plagioclase, biotite magnetite and titanite - no hornblende recorded; Wimberu Granite - K-feldspar, quartz, plagioclase, biotite, magnetite, minor hornblende, titanite, fluorite; Mount Dore Granite - K-feldspar, quartz, plagioclase, biotite, minor hornblende, magnetite.

Breccias: Occur locally within the granite. Those present can have a hematite-dominated matrix. Breccias are more common in the granites which have intruded to higher levels in the crust (Wyborn 1992).

Alteration in the granite: Alteration is ubiquitous. Some can be classified as wall rock reaction formed during the emplacement of the granites: where the granites intrude calc-silicate rocks, assemblages of albite + clinopyroxene + titanite are developed. In contrast, where the granite intrudes sulphide or graphite-bearing sediments, the granite becomes green and sulphide-bearing: where the granite intrudes magnetite-bearing rocks, hematitic alteration becomes prominent and where the granite intrudes pelitic rocks, sericitic alteration appears more common. Vertical pipe-like stocks of albitic alteration also occur both within the granite and adjacent calc-silicate country rocks. All phases of the granite are cut by late red-coloured hematite + K-feldspar alteration veins: some of which carry pyrite.

10.8 Extrusives

No comagmatic volcanics have been identified. The Quamby Conglomerate contains clasts of metamorphic rocks with randomly orientated magnetisation, and recent palaeomagnetic data suggest that it was deposited at ~1500 Ma (Idnurm, unpublished data).

10.9 Country Rock

Contact metamorphism: The Supersuite intrudes rocks that have been metamorphosed from upper greenschist to amphibolite grade. Narrow contact aureoles of hornfels have been noted in which cordierite, andalusite and sillimanite are locally developed (Jaques *et al.* 1982).

Reaction with country rock: Extensive wall rock reactions have occured, and the alteration patterns within the granites described above extend into the country rock. In the country rocks albite-rich rocks are very common, especially in calc-silicate rocks of the Corella and Doherty Formations. These albite-rich rocks are everywhere overprinted by late high-K hematite and sulphide-bearing alteration assemblages.

Units the granite intrudes: Mary Kathleen Group, Soldiers Cap Group, Argylla Formation, Malbon Group.

Dominant rock types: Felsic and mafic volcanics, fine-grained clastic sedimentary rocks (some of which are quite carbonaceous), greywacke, quartzite, calc-silicate rocks, carbonate.

Potential hosts: Most of the mineral deposits are hosted by either magnetite-rich rocks or carbonaceous shale.

10.10 Mineralisation

Many Cu-Au deposits in the vicinity of the Williams Supersuite are related to the intrusion of the granites. These deposits include Eloise, Ernest Henry, Osborne, Starra, Mount Dore and Mount Elliott. Other associated metals are Co, W and Ag. Unlike the Gawler Craton, U is not abundant in most of the deposits (it can be present as a minor commodity). This is possibly because in the regional alteration systems within the granites U appears to be locked up in resistate minerals. The better Cu-Au deposits are hosted by either ironstone or carbonaceous shale and the ore appears to avoid carbonate rocks. Other potential hosts include magnetite-bearing felsic and mafic volcanics. The gangue assemblages are ‘skarn’-like, although they appear to have formed by reaction with silicate rather than carbonate hosts.

10.11 Geochemical Data

Data source: Most of the samples of the Williams Supersuite were collected by L. Wyborn during specialised granite sampling programs carried out by BMR in 1978, and from 1985-1986. In the Duchess 1:250 000 sheet area additional samples were collected as part of a regional 1:100 000 mapping program.

Data quality: Good, all of the samples were analysed within the one laboratory by AGSO.

Are the data representative? The data, although sparse, are considered to be representative of the major magmatic phases. Collections of altered granites were made in the Williams Batholith: unfortunately this was not done for the Naraku Batholith.

Are the data adequate? The data are good enough to understand the broad geochemical evolution of the supersuite. More detailed sampling may help understand the relationship between the primary and alteration signatures.

SiO_2 range (Fig. 10.1): The SiO_2 range of this suite is quite extensive and is one of the widest SiO_2 ranges for granite suites in the Mount Isa Inlier. The range is dominantly from 60 wt.% SiO_2 with a peak at around 74 wt.%. Some values extend below 60 wt.% SiO_2, which is unusual in the Mount Isa Inlier.

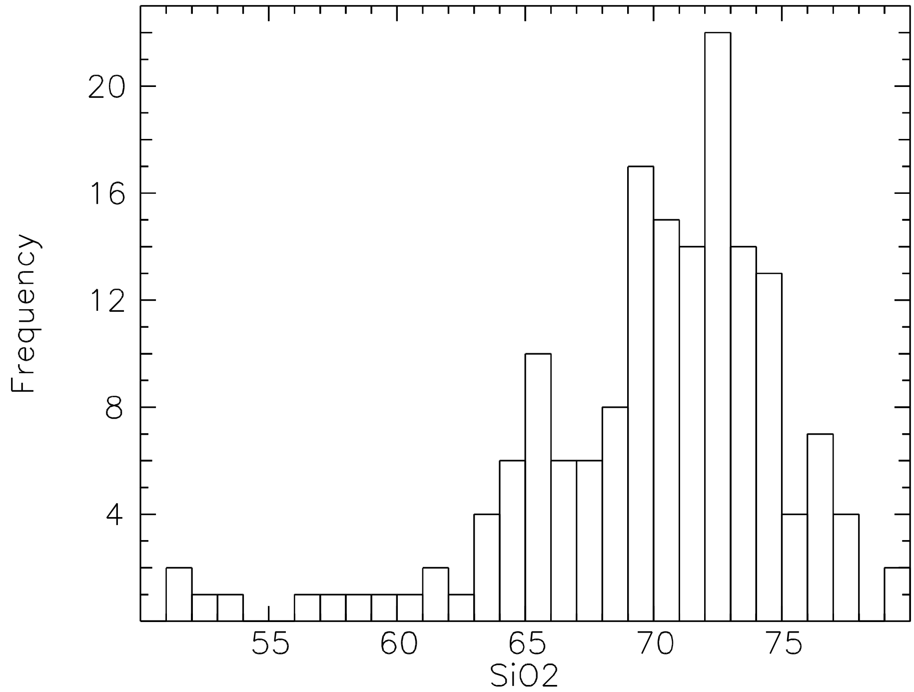


Figure 10.1. Frequency histogram of SiO_2 values for the Williams Supersuite.

Alteration (Fig. 10.2):

- ***SiO_2:*** High values may reflect silicification, whilst some of the lower values are generated by albitisation. Regardless of the high degree and regional extent of the alteration, the SiO_2 distribution is fairly typical of Proterozoic I-(granodiorite) types, suggesting that SiO_2 has not been extensively remobilised during the alteration.
- ***K_2O/Na_2O:*** The extreme alteration shown on this plot reflects the degree of alteration noted in field descriptions. There is a progression from rocks with normal Na_2O/K_2O ratios to rocks with high Na_2O and low K_2O values, which reflects the progressive sodic alteration. In contrast the late overprinting hematite-K-feldspar veins have extremely high K_2O and low Na_2O values; these samples plot as a distinct group away from the other compositions.
- ***Th/U:*** The Th/U values are somewhat high, and extreme in some altered samples. Values >10 reflect alteration.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** This plot shows some extensive oxidation of some samples, which is related to the late hematite K-feldspar overprint.

Fractionation Plots (Fig. 10.3):

- ***Rb:*** Samples generally show exponentially increasing Rb with increasing SiO_2. Rb has not increased as markedly in this system as it has in other fractionated Proterozoic granites. The lack of strong enrichment of Rb in the more fractionated end-members may be a result of Rb preferentially entering biotite rather than K-feldspar during fractionation.
- ***U:*** Samples show exponentially increasing U with increasing SiO_2. The values of U are extremely high, and it is possible that secondary circulation caused by high radiogenic heat production of this suite may have occured long after emplacement. Despite the extensive alteration, the U trend is predominantly magmatic and is only weakly affected by the sodic or potassic alteration. This suggests that U is unlikely to have been extensively mobilised in the regional metasomatic environment, and may explain why U is not a major commodity in the associated mineral deposits.
- ***Y:*** The plot is scattered, but some samples show a strong decrease with increasing SiO_2. This directly contrasts with the more reduced gold-dominated suites of the Proterozoic (e.g., Cullen Suite).
- ***P_2O_5:*** Samples show decreasing P_2O_5 with increasing SiO_2.
- ***Th:*** Samples show increasing Th with increasing SiO_2.
- ***K/Rb:*** Some of the least altered samples show a decrease in K/Rb with increasing SiO_2.
- ***Rb-Ba-Sr:*** The more fractionated samples plot in the strongly differentiated field.

- ***Sr:*** Values of Sr are moderate (below 400 ppm) and decrease with increasing SiO_2.
- ***Rb/Sr:*** The plot is somewhat scattered, presumably because of alteration, but shows a general increase with increasing SiO_2.
- ***Ba:*** Values of Ba are high (<2500 ppm) and decrease with increasing SiO_2. In some plutons (not Saxby) Ba initially increases, before decreasing. This trend is often observed in fractionating suites (Wyborn *et al*. 1987).
- ***F:*** F is high throughout most of the granites and shows increasing values with increasing SiO_2 with values up to 0.3 wt.%. This is within the range noted by Eby (1990) of 0.07-1.7 wt.% for Palaeozoic A-type granites. These values are not as high as those recorded for the Sybella Suite.

Metals (Fig. 10.4):

- ***Cu:*** Values are moderate to low, with some altered samples having relatively high values.
- ***Pb:*** Values are low.
- ***Zn:*** Values are low.
- ***Sn:*** Values are very low.

High field strength elements (Fig. 10.5):

- ***Zr:*** Zr values are moderate.
- ***Nb:*** Values are moderate to low.
- ***Ce:*** Values are moderate to low.

Classification (Fig. 10.6):

- ***The CaO/Na_2O/K_2O plot of White, quoted in Sheraton and Simons (1992):*** The granites plot in the tonalite to granite field reflecting the wide SiO_2 range of this Supersuite. Those samples that plot in the trondhjemite field are the Na_2O-rich altered samples or the albitites.
- ***Zr/Y vs Sr/Sr*:*** Most values plot below 1: those that plot above are albitites.
- ***Spidergram:*** All spidergrams for this Supersuite are Sr-depleted, Y-undepleted.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples plot in the oxidised field with at least two plutons (Wimberu and Mount Angelay) becoming more oxidised with increasing fractionation. These fractionated samples plot in the strongly oxidised field.
- ***ASI:*** The majority of samples have an ASI index of <1.1 and are metaluminous to weakly peraluminous. The ASI does not increase markedly with increasing fractionation.
- ***A-type plot of Eby (1990):*** The Williams Supersuite straddles the boundary between the A-type field and the fractionated granites field as defined for Palaeozoic granites.

Granite type (Chappell and White 1974; Chappell and Stephens 1988): I-granodiorite, non-restite.

Australian Proterozoic granite type: Hiltaba type.

10.12 Geophysical Signature

Radiometrics (Fig. 10.7): Most samples plot above the Proterozoic median line for K_2O, Th and U and would appear white in a RGB image. The exceptions are the more mafic parts of The Mavis Granodiorite, which would appear yellow in a RGB image, and the albites which should appear black, as they are depleted in all three elements relative to the Proterozoic median.

Gravity: The larger plutons correspond to major regional gravity lows and there is a substantial low corresponding to a possible roof zone in the area between the Malakoff Granite in the north and the Mount Angelay and Wimberu Granites to the south. Numerous small Au and Cu deposits occur in this zone.

Magnetics: The mafic phases of the younger intrusions have high magnetic susceptibilities (over 4000 x 10^{-5} SI units) due to the presence of abundant magnetite, and appear as broad circular magnetic domes in the regional magnetic data. The surrounding aureoles can also have high magnetic susceptibility, particularly where the plutons intrude calc-silicate rocks. Where the plutons are non-magnetic (usually because they are more felsic), the aureoles appear as circular rims on regional magnetic images. Utilising this magnetic character of the individual intrusions and the surrounding country rock, Wellman (1992) mapped extensions of the Williams Supersuite intrusives in a linear belt up to 600 km long beneath the Eromanga, Carpentaria and Georgina Basins.

10.13 References

Anonymous 1937. Annual report of the Aerial, Geological and Geophysical Survey of Northern Australia for the period ending 31st December 1936.

Blake, D.H. 1987. Geology of the Mount Isa Inlier and environs, Queensland and Northern Territory. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin,* 225, 83 pp.

Blake, D.H., Jaques, A.L. and Donchak, P.J.T. 1979. Precambrian geology of the Selwyn Region, Northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record,* 1979/86.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981a. Definitions of new and revised Precambrian stratigraphic and intrusive rock units in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report,* 233, *(BMR Microform* MF 164*).*

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981b. Summary of new and revised Precambrian stratigraphic nomenclature in the Duchess and Urandangi 1:250000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Queensland Government Mining Journal,* 82, 580-589.

Blake, D.H., Jaques, A.L. and Donchak, P.J.T. 1983. Selwyn Region, Queensland, 1:100 000 Geological Map Commentary. B*ureau of Mineral Resources, Geology and Geophysics, Australia.*

Blake, D.H., Bultitude, R.J. Donchak, P.J.T., Wyborn, L.A.I. and Hone, I.G. 1984, Geology of the Duchess-Urandangi region, Mount Isa Inlier, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin,* 219, 96 pp.

Carter, E.K., Brooks, J.H. and Walker, K.W. 1961. The Precambrian mineral belt of north-western Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin,* 61, 344 pp.

De Jong, G. and Williams, P.J. 1995. Giant metasomatic system formed during exhumation of mid-crustal Proterozoic rocks in the vicinity of the Cloncurry Fault, northwest Queensland. *Australian Journal of Earth Sciences,* 42, 281-290.

Derrick, G.M., Wilson, I.H., Hill, R.M. and Mitchell, J.E. 1971. Geology of the Marraba 1:100000 Sheet area. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record,* 1971/56.

Donchak, P.J.T., Blake, D.H. and Jaques, A.L. 1979. Precambrian geology of the Mount Angelay 1:100 000 Sheet area (7055), Northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record,* 1979/93.

Donchak, P.J.T., Blake, D.H., Noon, T.A. and Jaques, A.L. 1983. Kuridala Region, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics, Australia,* 32 pp.

Drummond, M.S., Ragland, P.C. and Wesolowski, D. 1986. An example of trondhjemite genesis by means of alkali metasomatism: Rockford Granite, Alabama Appalachians. *Contributions to Mineralogy and Petrology,* 93, 98-113.

Jaques, A.L., Blake, D.H. and Donchak, P.J.T. 1982. Regional metamorphism in the Selwyn Range area, Northwestern Queensland. *BMR Journal of Australian Geology and Geophysics,* 7, 181-196.

Joplin, G.A. 1955. A preliminary account of the petrology of the Cloncurry Mineral Field. *Proceedings of the Royal Society of Queensland,* LXVI, 33-67.

Joplin, G.A. 1957. On the association of albitites and soda aplites with potash granites in the Precambrian and older Palaeozoic of Australia. *Journal and Proceedings of the Royal Society of New South Wales*, 90, 80-86.

Joplin, G.A. and Walker, K.R. 1961. The Precambrian Granites of North-Western Queensland. *Proceedings of the Royal Society of Queensland, 72, 21-57.*

Mark, G. 1996. Interrelationships between episodic regional alteration and granites of the Mount Angelay pluton, Cloncurry district, northwest Queensland. *Geological Society of Australia, Abstract*, 41, 268.

Mark, G. and De Jong, G. 1996. Synchronous granitoid emplacement and episodic sodic-calcic alteration in the Cloncurry district: Styles, timing and metallogenic significance. In: Baker, T., Rotherham, J., Richmond, J., Mark, G. & Williams, P. (editors), MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, *Extended Conference Abstracts, EGRU Contribution* 55, 77-80.

Nisbett, B., Devlin, S.P. and Joyce, P.J. 1983. Geology and suggested genesis of cobalt-tungsten mineralisation at Mount Cobalt, northwestern Queensland. *Proceedings of the Australasian Institute of Mining and Metallurgy*, 287, 9-17.

Noon, T.A. 1978. Progress report of the geology of the Malbon 1:100 000 Sheet area (6955), northwestern Queensland. *Geological Survey of Queensland, Record*, 1978/7.

Nye, P.B. and Rayner, E.O. 1940. The Cloncurry copper deposits, with special reference to the gold-copper ratios of the ores. *Aerial, Geological and Geophysical Survey of Northern Australia, Report Queensland,* No. 35, 38 pp.

Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, *EGRU Contribution, 55,* 95-98.

Page, R.W. and Sun, S.-S. 1998. Aspects of geochronology and crustal evolution in the Eastern Fold Belt, Mount Isa Inlier. *Australian Journal of Earth Sciences*, 45, 343-361.

Perkins, C. and Wyborn, L.A.I. 1996. The age of Cu-Au mineralisation, Cloncurry District, Mount Isa Inlier, as determined by 40Ar/39Ar dating. *AGSO Research Newsletter,* 25, 8-9.

Pollard, P.J., Mark, G. and Mitchell, L. 1996. Granitoids of the Mount Angelay and Wiley Igneous Complexes: links to alteration and Cu-Au-Co mineralisation in the Cloncurry district. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, *Extended Conference Abstracts, EGRU Contribution, 55,* 104-107.

Ryburn, R.J., Wilson, I.H., Grimes, R.M. and Hill, R.M. 1988. Cloncurry, Queensland, 1:100000 geological map commentary. *Bureau of Mineral Resources, Geology and Geophysics, Australia,* 30 pp.

Wellman, P. 1992. Structure of the Mount Isa region inferred from gravity and magnetic anomalies. In: Stewart, A.J. & Blake, D.H., (*Editors*), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Australia, Bulletin*, 243, 15-27.

Williams, P.J. and Blake, K.L. 1993. Alteration in the Cloncurry District. *James Cook University Economic Geology Research Unit Contribution*, 40.

Williams, P.J., Adshead, N.D., Blake, K.L., De Jong, G., Mark, G. and Rotherham, J.F. 1995. Magnetite-Cu-Cu deposits in deeply eroded magmatic arcs: lessons from Proterozoic terrains. *PACRIM'95*, 631-636.

Wilson, I.H., Noon, T.A., Hill, R.M. and Duff, B.A. 1979. Geology of the Quamby 1:100 000 sheet area (6957), Queensland. B*ureau of Mineral Resources, Geology and Geophysics, Australia, Record,* 1979/56, 123 pp.

Wyborn, L.A.I. 1992. The Williams and Naraku Batholiths, Mount Isa Inlier: an analogue of the Olympic Dam Granites. *BMR Research Newsletter* 16, 13-16.

Wyborn, L.A.I. 1994. Exploration criteria to determine which Australian Proterozoic granites may be associated with gold + base metal mineralisation. *Geological Society of Australia, 12th Australian Geological Convention, Perth, 1994, Abstracts* 37, 471-472.

Wyborn, L.A.I. 1998. Younger ~1500 Ma granites of the Williams and Naraku Batholiths, Cloncurry district, eastern Mount Isa Inlier: geochemistry, origin, metallogenic significance and exploration indicators. *Australian Journal of Earth Sciences,*45, 397-411

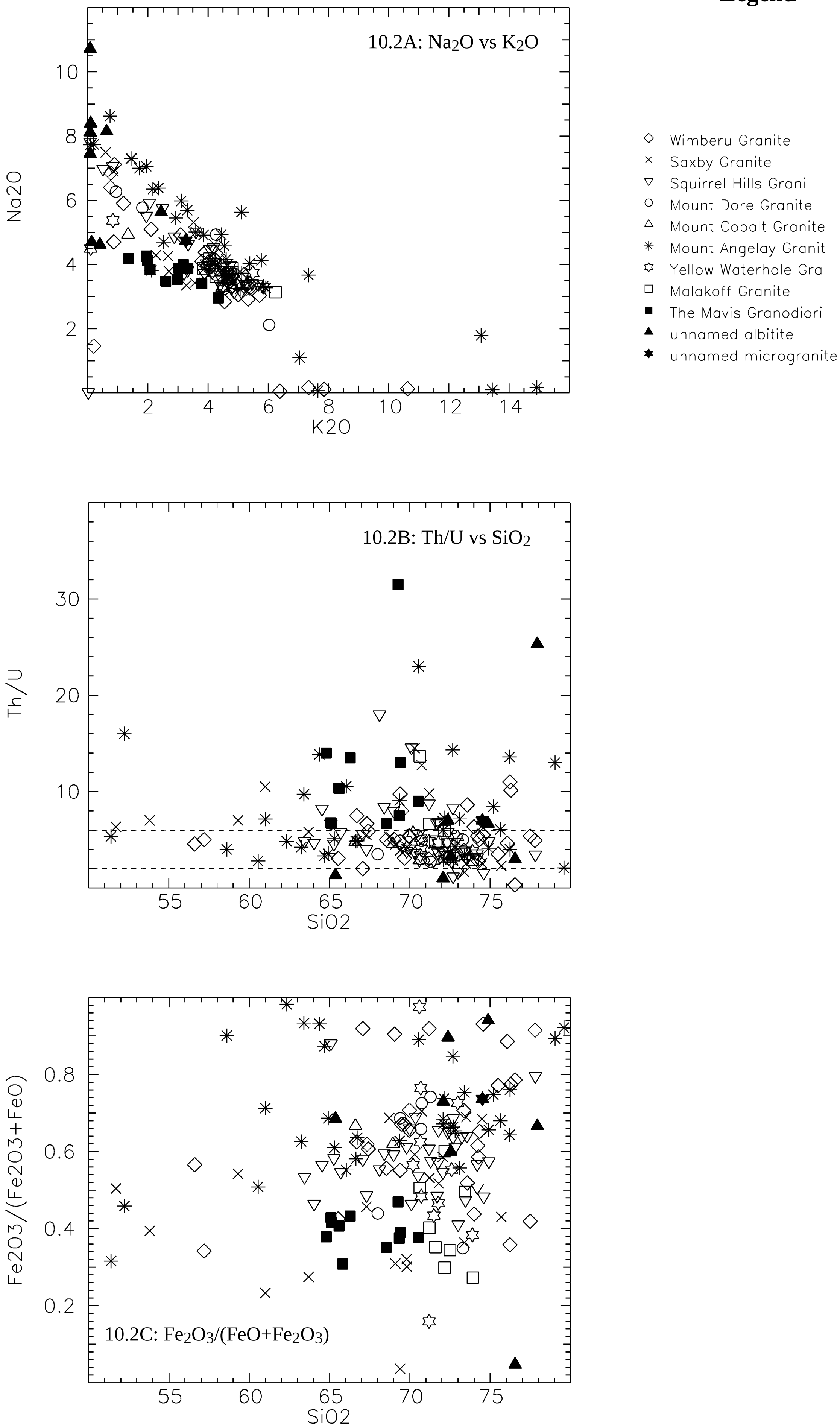
Wyborn, L.A.I. and Heinrich, C.A. 1993a. Empirical observations on granite-associated gold + base-metal mineral deposits in the Proterozoic of Australia: delineating exploration criteria. *AGSO Research Newsletter,* 19, 3-4.

Wyborn, L.A.I. and Heinrich, C.A. 1993b. The relationship between late-tectonic felsic intrusives and Cu-Au mineralisation in the Eastern Fold Belt, Mount Isa Inlier. *Australian Institute of Geoscientists, Bulletin*, 13, 27-30.

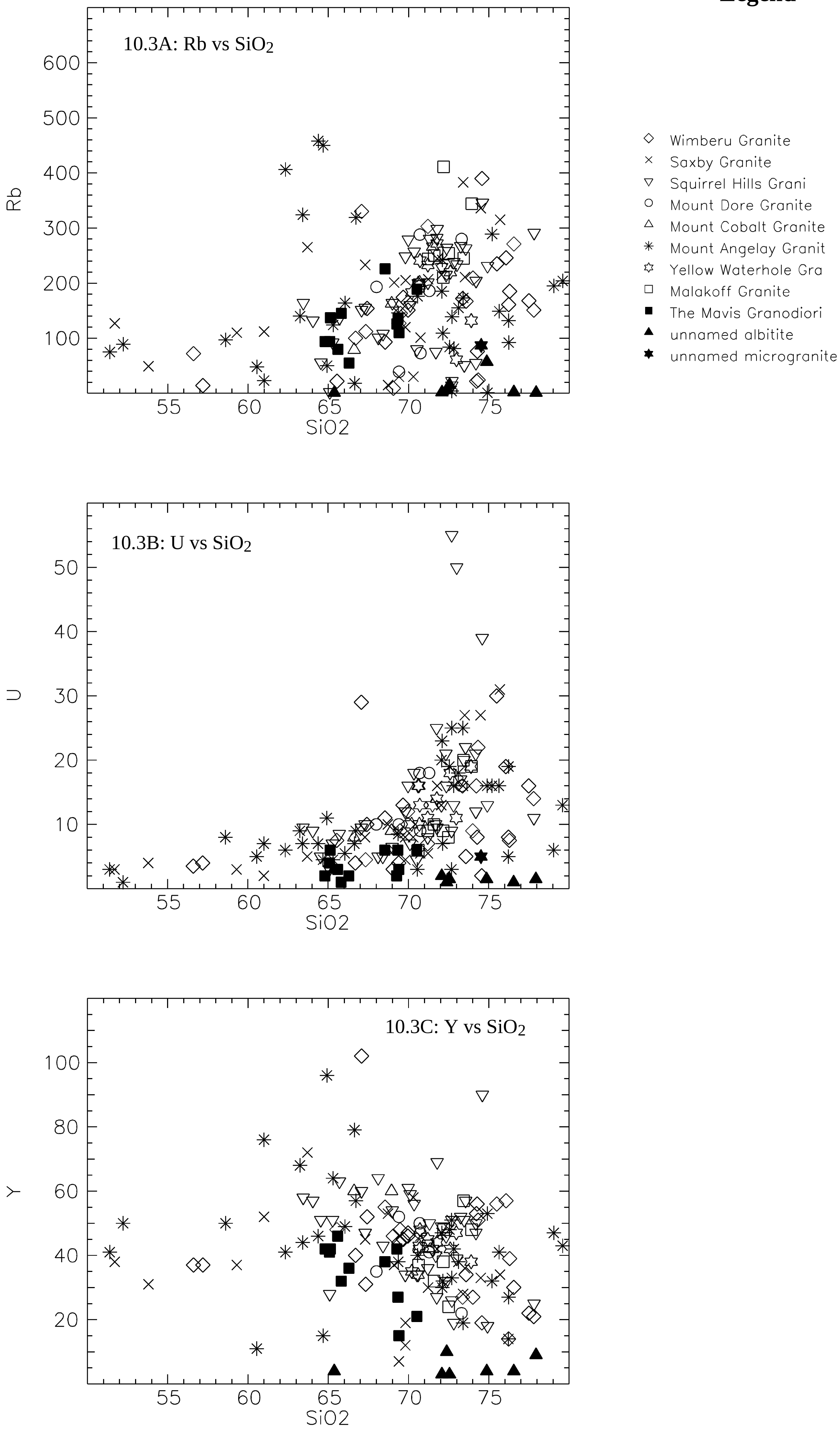
Wyborn, L.A.I., Page, R.W. and McCulloch, M.T. 1988 - Petrology, geochronology, and isotope geochemistry of the post- 1820 Ma granites of the Mount Isa Inlier: mechanisms for the generation of Proterozoic anorogenic granites. *Precambrian Research*, 40/41, 509-541.

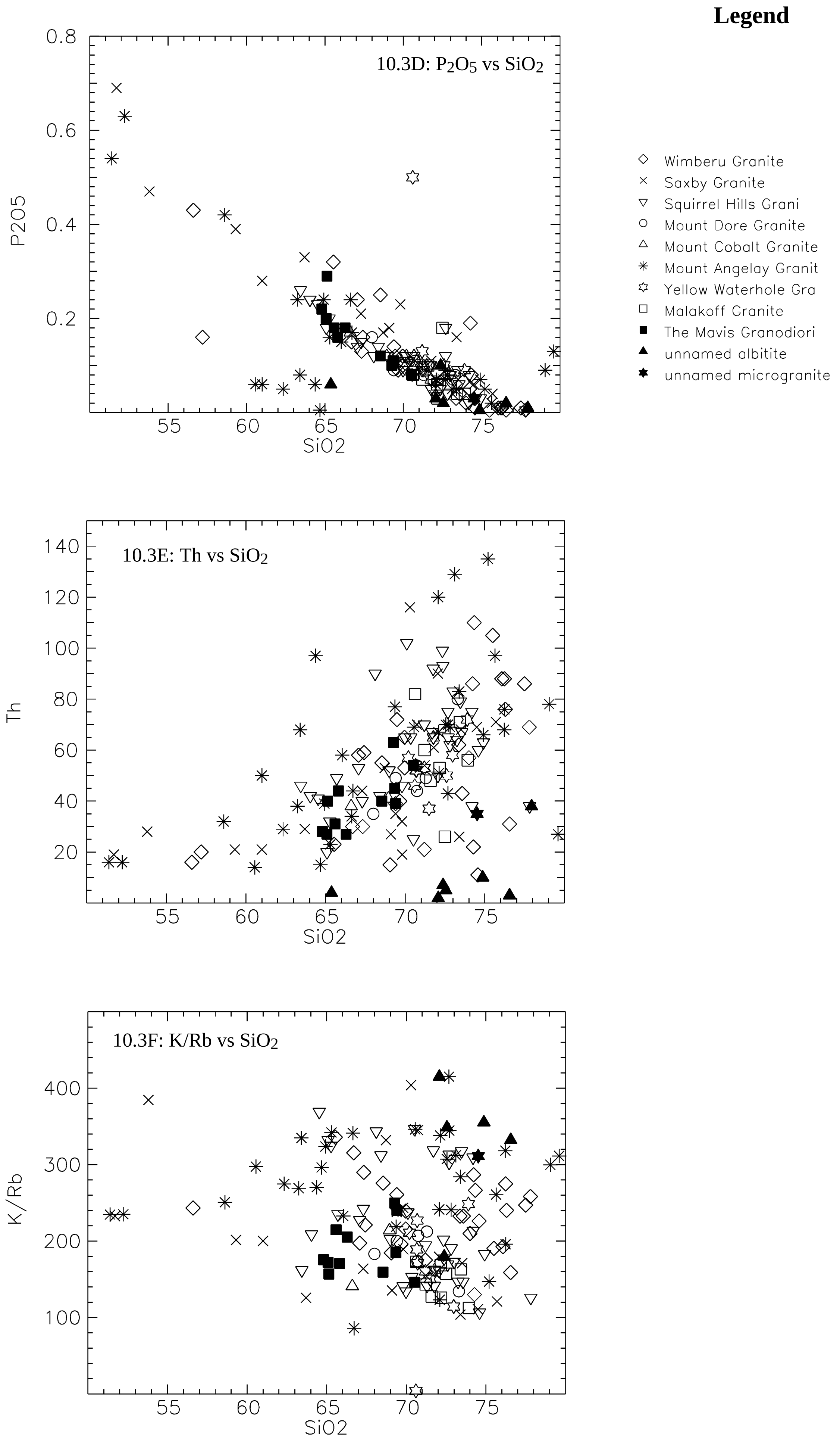
Wyborn, D., Turner, B.S. and Chappell, B.W. 1987. The Boggy Plain Supersuite: a distinctive belt of I-type igneous rocks of potential economic significance in the Lachlan Fold Belt. *Australian Journal of Earth Sciences*, 34, 21-43.

Legend

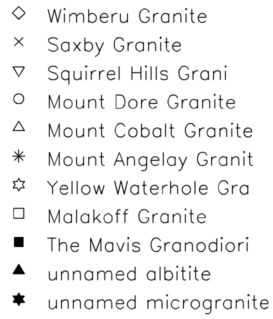

10.2A: Na_2O vs K_2O
Na2O
K2O
10.2B: Th/U vs SiO_2
Th/U
SiO2
10.2C: $Fe_2O_3/(FeO+Fe_2O_3)$
Fe2O3/(Fe2O3+FeO)
SiO2
Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite

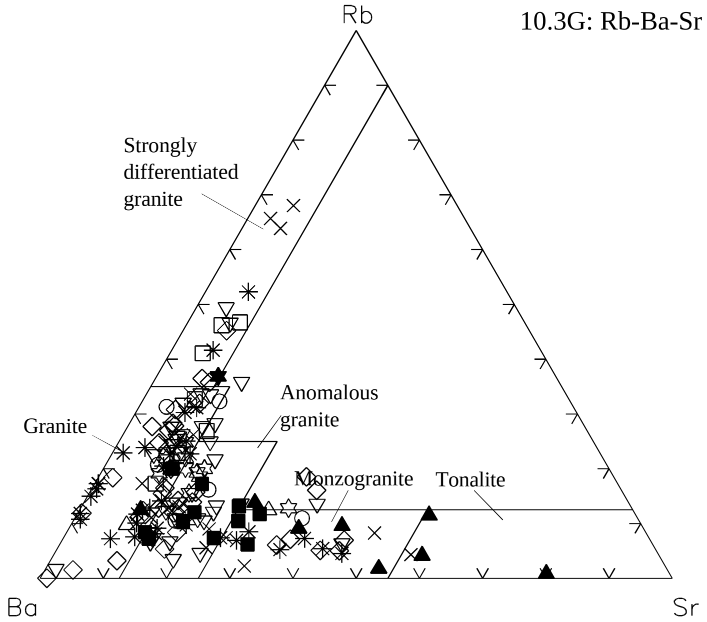
Legend

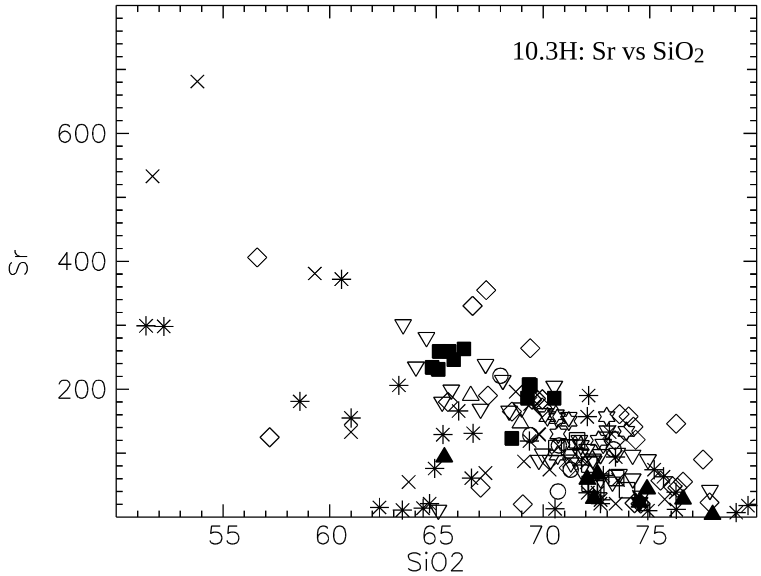

10.3A: Rb vs SiO2
Rb
SiO2
10.3B: U vs SiO2
U
SiO2
10.3C: Y vs SiO2
Y
SiO2
Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite

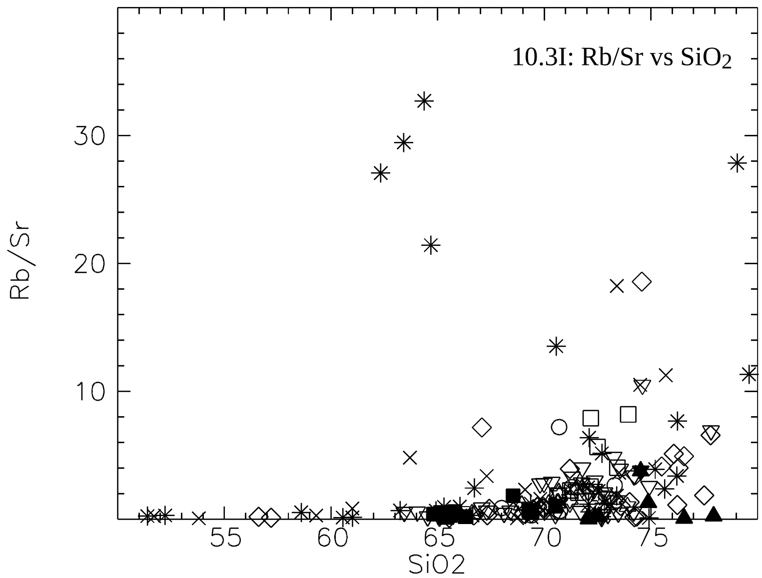

Legend
Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite
10.3D: P2O5 vs SiO2
P2O5
0.8
0.6
0.4
0.2
SiO2
55
60
65
70
75
10.3E: Th vs SiO2
Th
140
120
100
80
60
40
20
SiO2
55
60
65
70
75
10.3F: K/Rb vs SiO2
K/Rb
400
300
200
100
SiO2
55
60
65
70
75

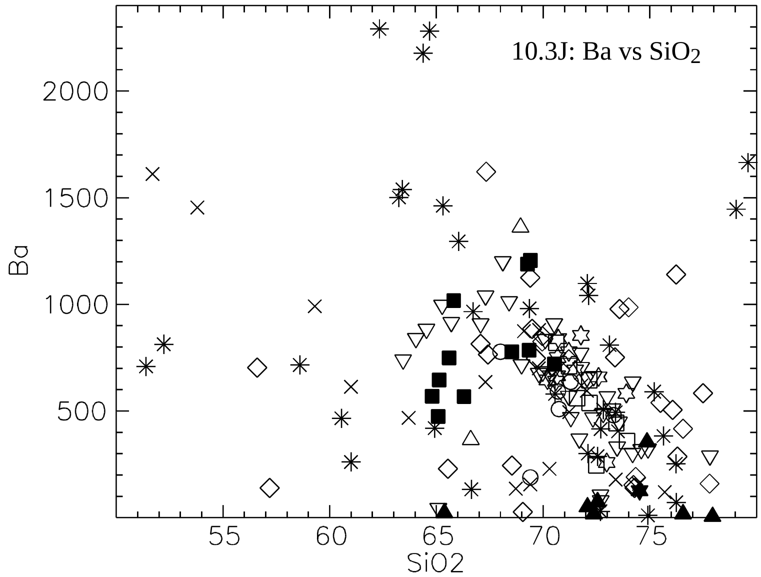
Legend


Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite


10.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Anomalous granite
Granite
Monzogranite
Tonalite

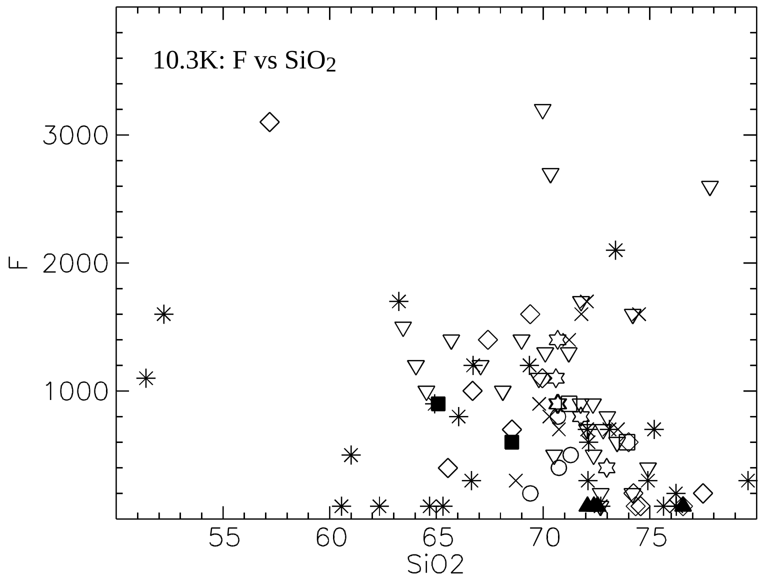

10.3H: Sr vs SiO2
Sr
600
400
200
55
60
65
70
75
SiO2

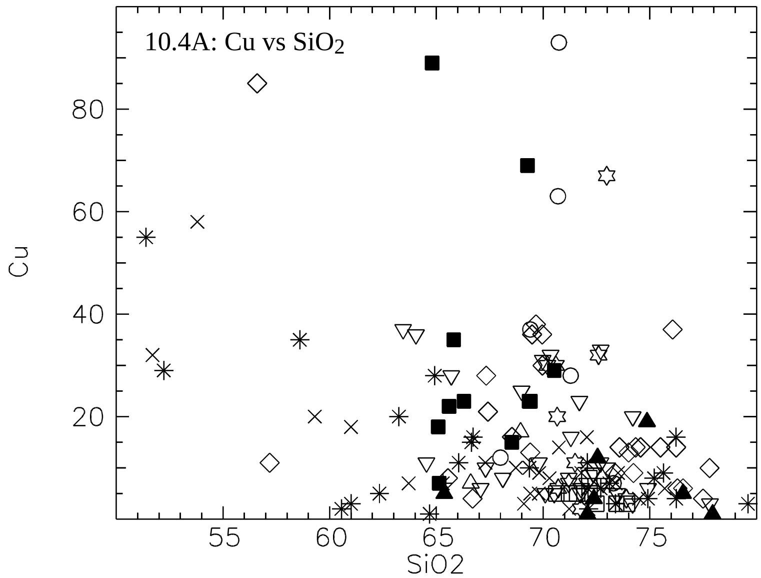

10.3I: Rb/Sr vs SiO2
Rb/Sr
30
20
10
55
60
65
70
75
SiO2

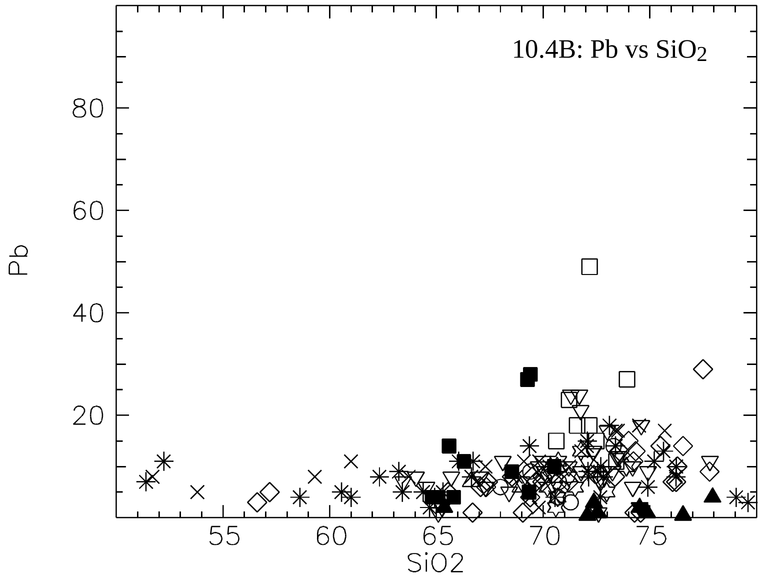

10.3J: Ba vs SiO2
Ba
2000
1500
1000
500
55
60
65
70
75
SiO2

Legend

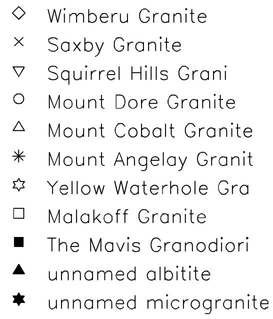

Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite

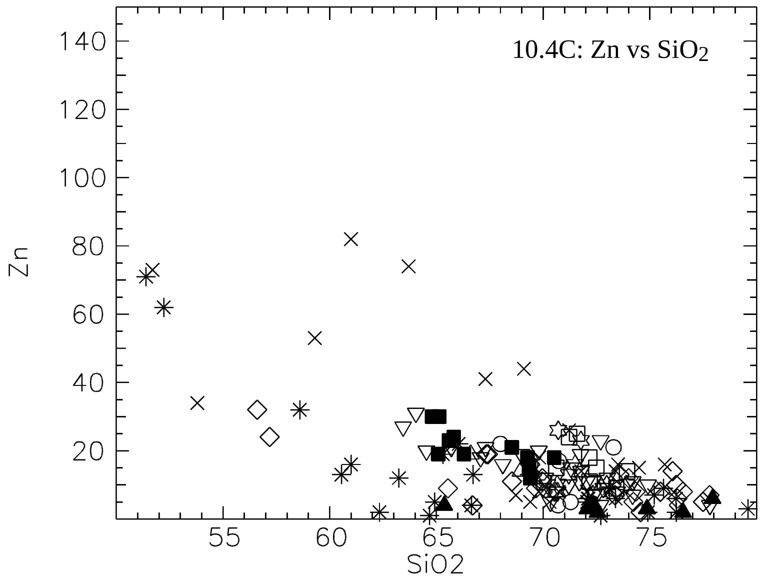

10.3K: F vs SiO2
F
3000
2000
1000
55
60
65
70
75
SiO2

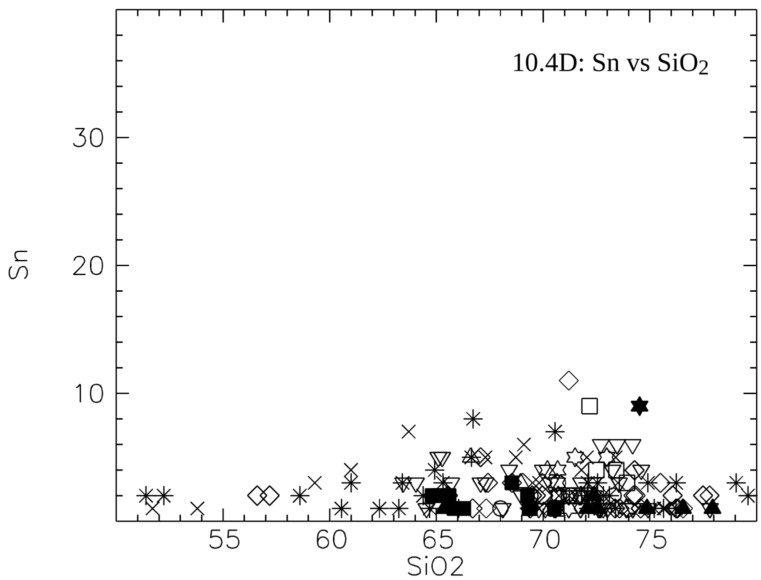

10.4A: Cu vs SiO2
Cu
80
60
40
20
55
60
65
70
75
SiO2

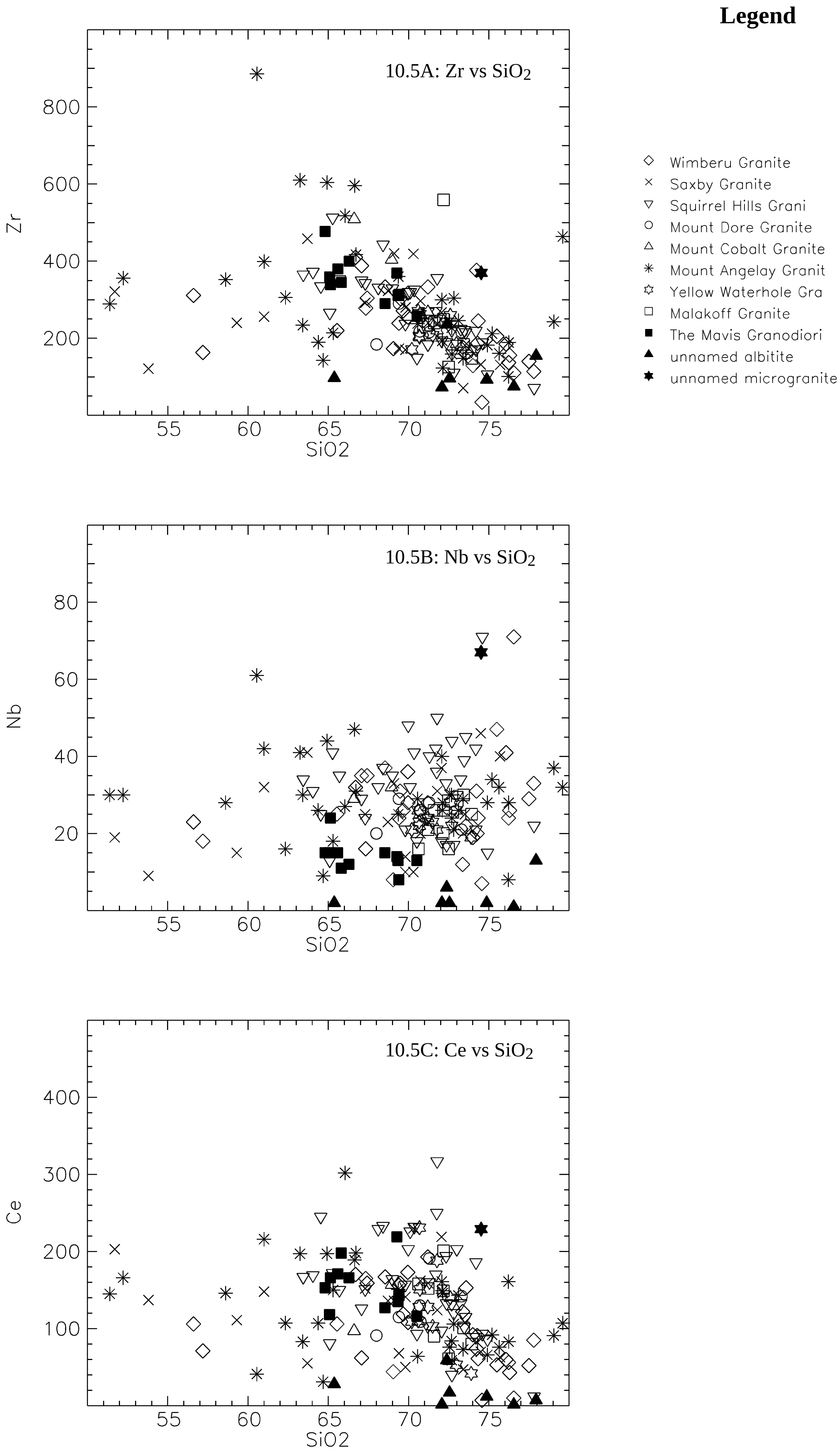

10.4B: Pb vs SiO2
Pb
80
60
40
20
55
60
65
70
75
SiO2

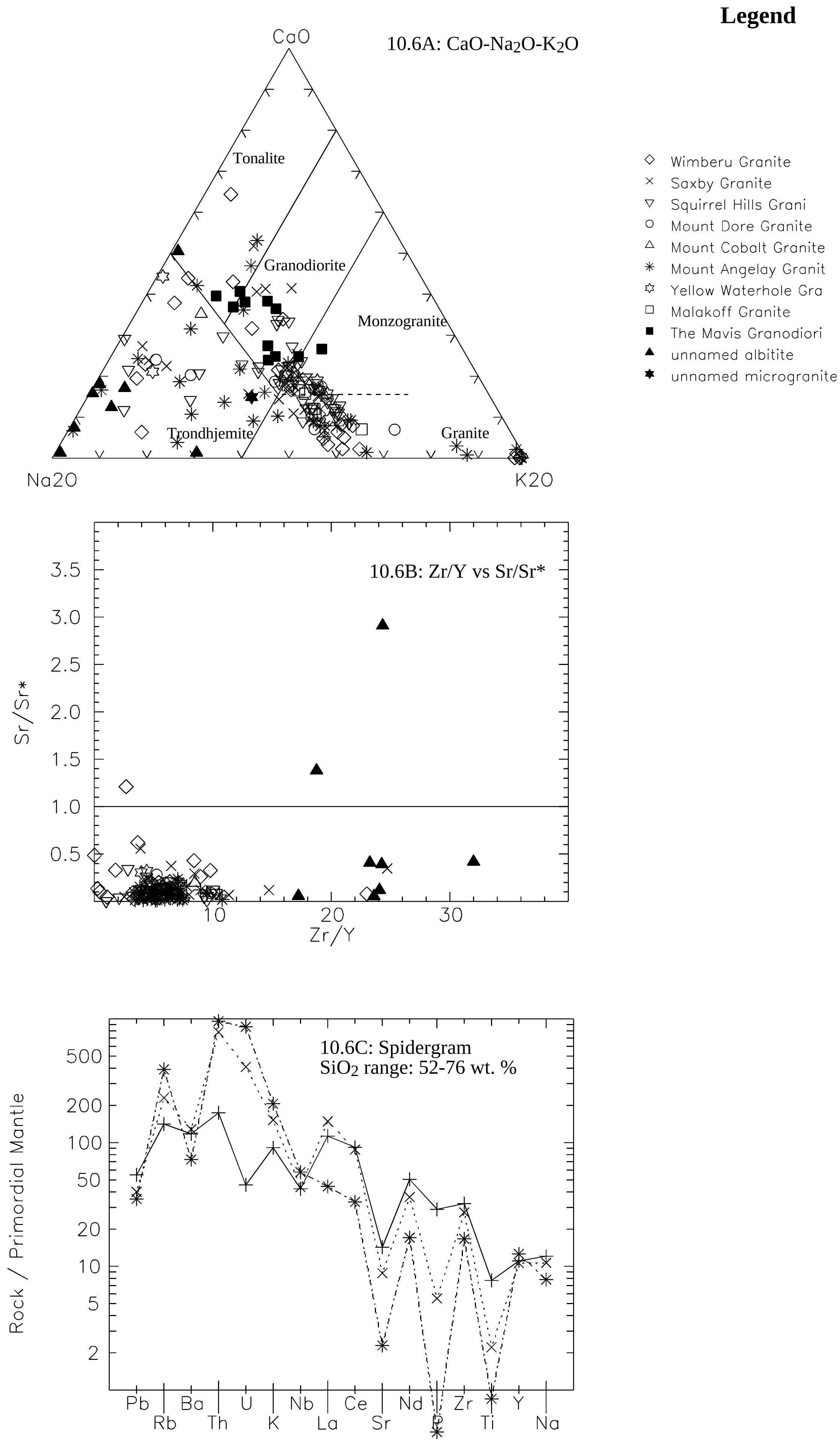
Legend


Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite


10.4C: Zn vs SiO2
Zn
140
120
100
80
60
40
20
55
60
65
70
75
SiO2

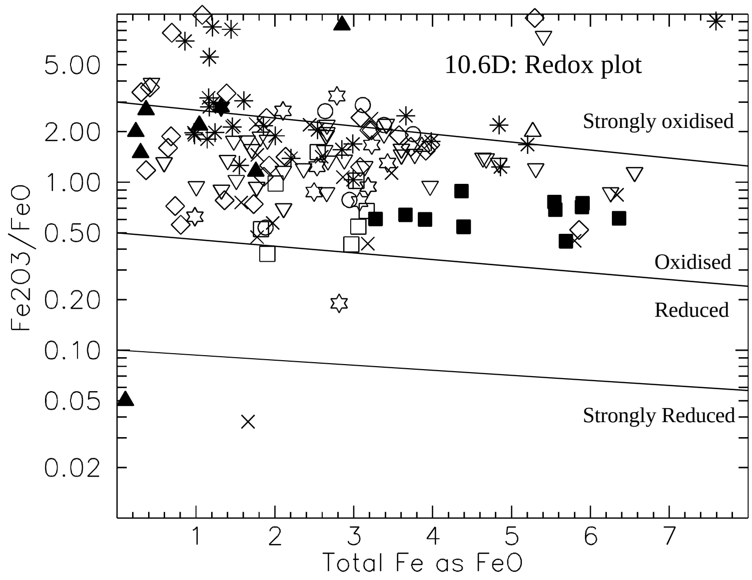

10.4D: Sn vs SiO2
Sn
30
20
10
55
60
65
70
75
SiO2

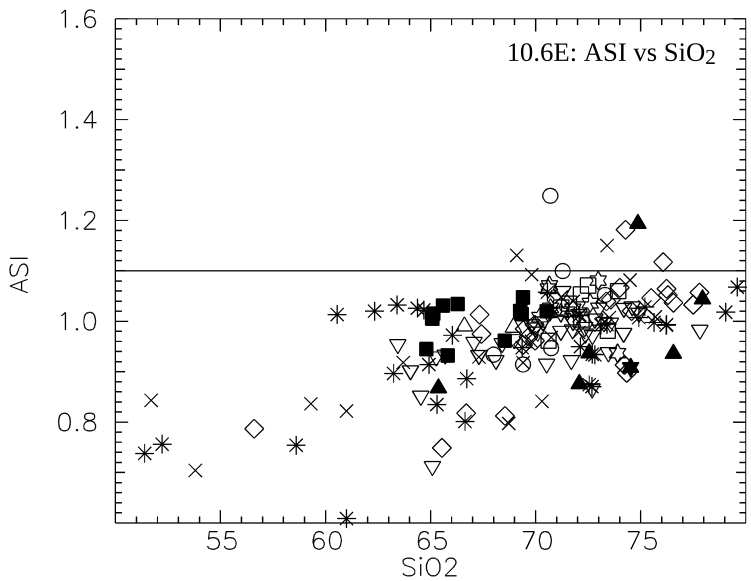

Legend
Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite
10.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
10.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
10.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

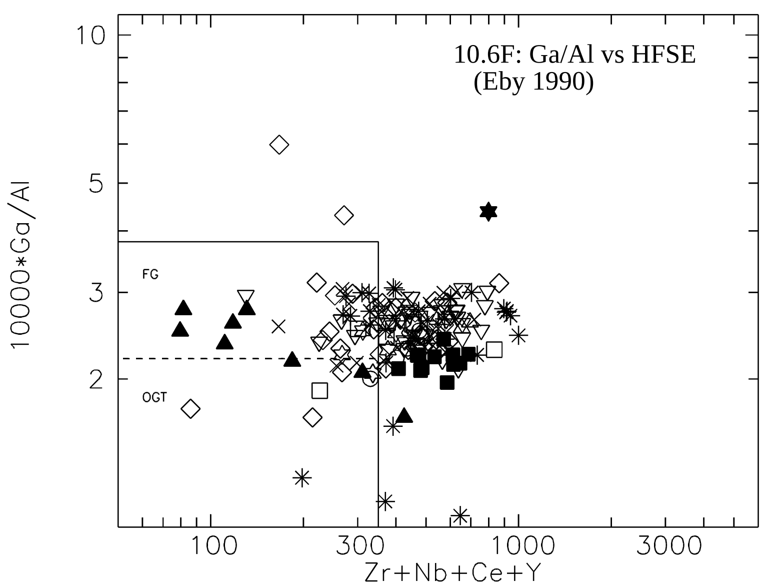

Legend
Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite
10.6A: CaO-Na2O-K2O
CaO
Na2O
K2O
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
10.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
Zr/Y
3.5
3.0
2.5
2.0
1.5
1.0
0.5
10
20
30
10.6C: Spidergram
SiO2 range: 52-76 wt. %
Rock / Primordial Mantle
500
200
100
50
20
10
5
2
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na

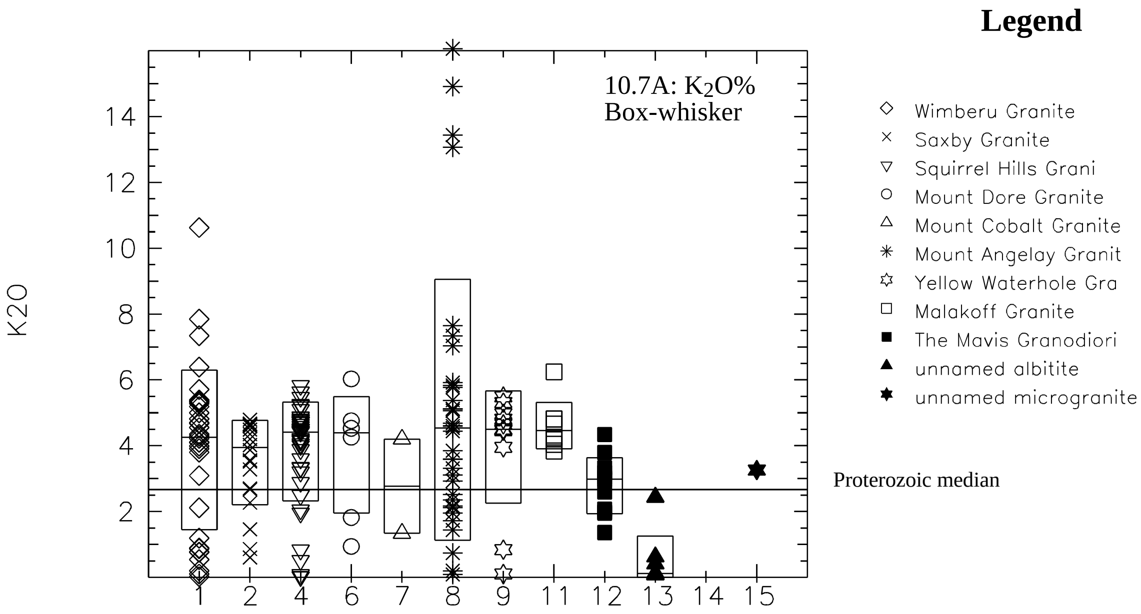
Legend

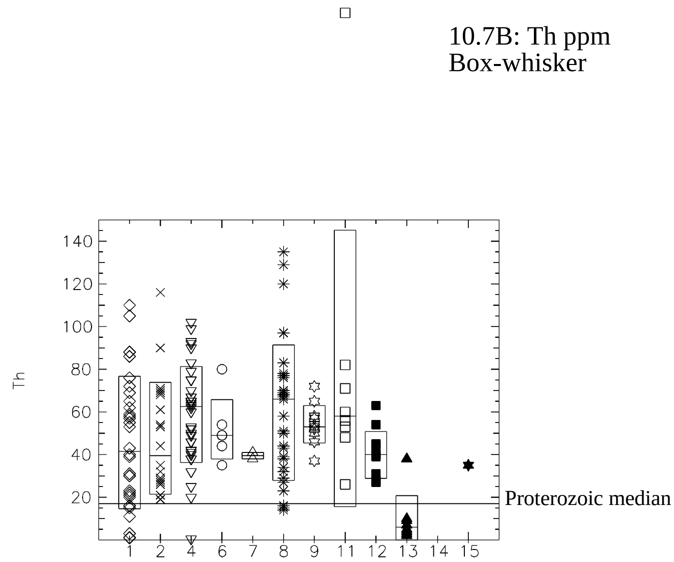
- ◇ Wimberu Granite
- × Saxby Granite
- ▽ Squirrel Hills Grani
- ○ Mount Dore Granite
- △ Mount Cobalt Granite
- ✳ Mount Angelay Granit
- ✡ Yellow Waterhole Gra
- □ Malakoff Granite
- ■ The Mavis Granodiori
- ▲ unnamed albitite
- ✶ unnamed microgranite

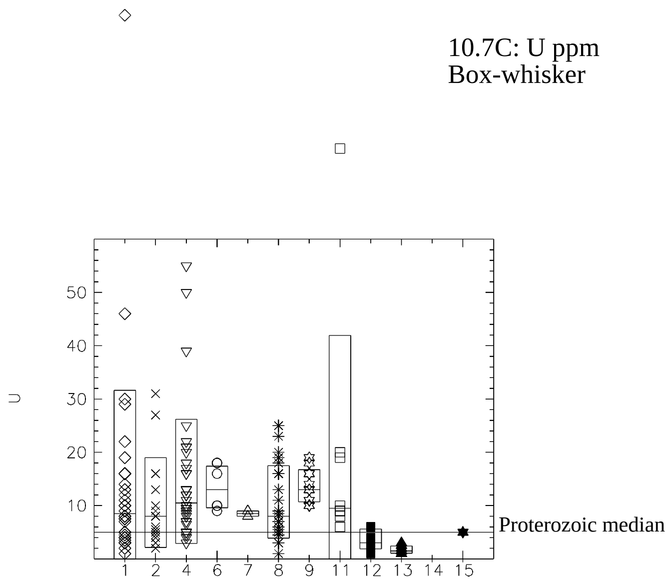







Legend
10.7A: K2O%
Box-whisker
K2O
Proterozoic median
Wimberu Granite
Saxby Granite
Squirrel Hills Grani
Mount Dore Granite
Mount Cobalt Granite
Mount Angelay Granit
Yellow Waterhole Gra
Malakoff Granite
The Mavis Granodiori
unnamed albitite
unnamed microgranite


10.7B: Th ppm
Box-whisker
Th
Proterozoic median


10.7C: U ppm
Box-whisker
U
Proterozoic median

Wimberu Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	66.76	70.58	17.2	7.25	81.4	34
TiO2	0.35	0.3	0.26	0.04	1.21	34
Al2O3	12.18	13.48	3.81	0.4	15.56	34
Fe2O3	8.78	1.31	23.41	0.2	92.78	34
FeO	0.8	0.51	0.92	0.07	3.97	34
MnO	0.02	0.02	0.02	01	0.1	34
MgO	0.86	0.43	1.52	01	8.63	34
CaO	1.76	1.27	2.09	01	10.07	31
Na2O	3.6	3.68	1.81	0.05	7.12	31
K2O	3.87	4.26	2.46	0.02	10.63	34
P2O5	0.12	0.09	0.16	01	0.85	34
H2O+	0.49	0.5	0.12	0.29	0.73	9
H2O-	0.13	0.14	0.1	0.01	0.27	9
CO2	0.09	0.08	0.04	0.03	0.17	9
LOI	0.97	0.88	0.51	0.42	2.42	25
Ba	794.79	723.5	734.31	27	2865	34
Li	8.23	7	5.76	1	28	30
Rb	144.93	151	103.42		390	34
Sr	124	120.5	101.89	6	406	34
Pb	7.44	7	5.65		29	34
Th	45.65	41.5	31.49		110	34
U	13.65	8.5	18.25	1	102	34
Zr	203.78	186	109.29		410	34
Nb	24.62	24.5	13.98		71	34
Y	50.71	45.5	50.19	7	311	34
La	50.4	37.5	37.12		116	34
Ce	88.26	79.5	57.31	4	193	34
Pr	7.34	7	4.94		19	25
Nd	29.62	33	18.3		68	33
Sc	8.05	6	9.14		38	33
V	33.59	21	41.02		178	34
Cr	25.44	3	118.25		683	33
Mn	47.5	27.5	50.88	4	158	8
Co	33.44	8	60.19	2	295	32
Ni	12.76	5	29.37	2	147	25
Cu	19.23	14	17.16	4	85	26
Zn	11.04	9.5	6.76	2	32	26
Sn	4.12	2	6.68		32	34
W	6.8	4	13.27	2	63	20
Mo	2.04		2.27		12	28
Ga	16.79	18	5.59	4	33	33
As	5.05	0.5	14.03		59	33
S	123.8	38.5	297.92		1566	28
F	771.43	500	839.81	Â	3100	14
Cl	226.4	216.5	88.55	97	515	20
Be	3.22	3	1.69		7	25
Ag	1.63	1	1.19	1	4	8
Bi	1.04		0.19		2	28
Cs	1.73		0.9		5	15
Ge	0.63	0.63	0.4	50	1	8
Se	0.53		0.12		1	18

Saxby Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	67.84	69.81	6.63	51.7	75.7	20
TiO2	0.6	0.42	0.46	0.12	1.66	20
Al2O3	13.86	13.7	0.7	12.4	15.1	20
Fe2O3	1.94	1.61	1.5	0.06	6.25	20
FeO	2.55	1.5	2.14	0.47	6.62	20
MnO	0.05	0.03	0.04	0.01	0.15	20
MgO	1.21	0.73	1.36	0.19	5.3	20
CaO	2.4	1.75	1.69	0.6	7.03	20
Na2O	4.4	3.83	1.31	3.35	7.49	20
K2O	3.49	3.94	1.32	0.6	4.79	20
P2O5	0.24	0.16	0.22	0.04	0.85	20
H2O+	0.72	0.69	0.31	0.25	1.39	18
H2O-	0.21	0.22	0.05	0.1	0.28	18
CO2	0.2	0.09	0.25	05	1.05	18
LOI	0.87	0.87	0.01	0.86	0.88	2
Ba	601.1	604.5	416.72	120	1611	20
Li	7.68	7	4.38	2	17	19
Rb	175.45	203	105.89	15	383	20
Sr	157.9	89	174.28	21	681	20
Pb	10.5	10	4.47	2	18	20
Th	47.65	39.5	26.89	19	116	20
U	10.57	8	8.63	2	31	20
Zr	251.55	248	105.21	71	458	20
Nb	24.05	23	11.49	8	46	20
Y	37.85	37	15.29	7	72	20
La	68.65	69	29.98	19	121	20
Ce	125.95	136	55.04	47	230	20
Pr	14.5	14.5	6.36	10	19	2
Nd	48.58	49	21.61	15	98	19
Sc	7.21	6	5.96		20	19
V	63.55	34	74.8	5	258	20
Cr	15.95	8	24.33		105	19
Mn	-	-	-	-	-	-
Co	8.33	8	6.76		30	15
Ni	9.89	4	14.42	1	52	19
Cu	12.65	9	12.78	2	58	20
Zn	28.05	16	24.92	5	82	20
Sn	3.05	3	1.96		7	20
W	4.14	4	0.69	3	5	7
Mo	1.5		-			7
Ga	19.11	19	1.33	17	21	19
As	0.86	1	0.45		2	19
S	106.57	59	117.25	16	339	7
F	1077.78	900	504.42	300	1700	9
Cl	764.14	326	1200.86	183	3483	7
Be	4.71	5	1.89	2	7	7
Ag	-	-	-	-	-	-
Bi	1		-			7
Cs	2.25	2.25	1.06		3	2
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Squirrel Hills Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.93	71.3	10.52	10.06	77.82	37
TiO2	0.41	0.37	0.21	0.07	1.02	37
Al2O3	13.36	13.63	2.32	0.26	15.3	37
Fe2O3	3.67	1.67	11.9	0.34	73.86	37
FeO	1.49	1.07	1.84	0.09	11.52	37
MnO	0.02	0.02	0.02	01	0.09	37
MgO	0.73	0.62	0.6	01	3.2	37
CaO	1.79	1.7	0.84	0.02	3.64	37
Na2O	4.14	3.82	1.34	0.02	7.82	37
K2O	3.82	4.41	1.52	0.02	5.83	37
P2O5	0.11	0.1	0.06	01	0.26	37
H2O+	0.55	0.52	0.2	0.29	0.82	6
H2O-	0.2	0.22	0.04	0.12	0.24	6
CO2	0.17	0.1	0.17	05	0.48	6
LOI	1.15	1.04	0.39	0.67	2.36	31
Ba	599.81	657	296.11	29	1201	37
Li	7.16	6	4.44		16	35
Rb	171.53	164	96.86		346	37
Sr	123.8	99	71.97		301	37
Pb	10.19	9	5.1		24	37
Th	58.76	62.5	22.78		102	36
U	14.56	10.5	11.81	3	55	36
Zr	253.65	243	104.35	4	513	37
Nb	31.31	32	12.97		71	37
Y	45.89	50	16.56	4	90	37
La	82.49	87	39.49	6	166	37
Ce	149.95	151	67.22	12	317	37
Pr	13.53	14	6.02		30	31
Nd	48.14	51	19.62	7	89	35
Sc	6.81	6	3.67		16	35
V	43.57	27	76.63		469	36
Cr	7.42	5	10.66		57	37
Mn	338.33	264	267.6	145	861	6
Co	23.94	8	33.09	2	112	32
Ni	4.74	3	4.68		22	31
Cu	14.97	10	11.56	3	38	31
Zn	13.71	12	6.73	4	31	31
Sn	2.61	2.5	1.61		6	36
W	3.76	4	1.76		10	25
Mo	2.42		2.97		18	32
Ga	19.46	19	2.51	16	30	35
As	1.26	1	0.93		4	35
S	164.52	72	235.86		889	31
F	1100	1000	766.43	Â	3200	28
Cl	488.4	447	223.14	55	944	25
Be	4.82	5	2		10	31
Ag	1.17	1	0.41	1	2	6
Bi	1		-			31
Cs	2.02		1.33		8	31
Ge	1	1	-	1	1	6
Se	0.5		-			6

Mount Dore Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.57	70.72	1.79	68	73.3	6
TiO2	0.38	0.38	0.06	0.29	0.48	6
Al2O3	13.98	13.81	0.57	13.57	15.1	6
Fe2O3	1.84	2.13	0.72	0.66	2.49	6
FeO	1.13	1.15	0.34	0.73	1.66	6
MnO	0.03	0.03	0.01	0.02	0.05	6
MgO	0.89	0.9	0.22	0.51	1.19	6
CaO	1.54	1.78	0.73	0.61	2.28	6
Na2O	4.35	4.35	1.59	2.12	6.27	6
K2O	3.72	4.4	1.93	0.94	6.03	6
P2O5	0.1	0.09	0.03	0.08	0.16	6
H2O+	0.78	0.69	0.29	0.48	1.27	6
H2O-	0.23	0.22	0.06	0.15	0.3	6
CO2	0.55	0.53	0.42	0.05	1.14	6
LOI	-	-	-	-	-	-
Ba	531	550.5	197.95	189	778	6
Li	11.67	11	3.72	7	18	6
Rb	176.5	189.5	103.08	39	288	6
Sr	113.5	109	61.3	40	221	6
Pb	7.17	6.5	3.97	3	14	6
Th	51.83	49	15.22	35	80	6
U	13.5	13	4.28	9	18	6
Zr	229.67	217	36.95	184	290	6
Nb	25	26	3.69	20	29	6
Y	41.17	44	11.27	22	52	6
La	70.83	70	32.8	38	124	6
Ce	129.67	122.5	34.79	91	191	6
Pr	-	-	-	-	-	-
Nd	43.5	46	6.09	34	49	6
Sc	5.33	6.5	2.66	2	8	6
V	28.83	30	9.02	12	37	6
Cr	2.5	2	1.87		6	6
Mn	-	-	-	-	-	-
Co	9.25	9	0.5	9	10	4
Ni	2.67	2.5	1.37		5	6
Cu	40	32.5	32.75	7	93	6
Zn	14.17	16.5	7.83	4	22	6
Sn	2	2	0.63		3	6
W	5.5	5	1	5	7	4
Mo	1.5		-			4
Ga	17.33	17.5	1.21	16	19	6
As	0.5	0.5	-		0.5	6
S	366.75	356.5	249.88	126	628	4
F	475	450	250	200	800	4
Cl	295.25	235.5	150.64	191	519	4
Be	3.25	3	0.5	3	4	4
Ag	-	-	-	-	-	-
Bi	1		-			4
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Mount Cobalt Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	67.78	67.78	1.65	66.61	68.94	2
TiO2	0.65	0.65	0.09	0.59	0.72	2
Al2O3	14.66	14.66	0.76	14.13	15.2	2
Fe2O3	2.97	2.97	0.8	2.41	3.54	2
FeO	1.63	1.63	0.21	1.48	1.77	2
MnO	0.01	0.01	0.01	0.01	0.02	2
MgO	0.98	0.98	0.16	0.87	1.09	2
CaO	2.7	2.7	1	1.99	3.41	2
Na2O	4.42	4.42	0.72	3.91	4.93	2
K2O	2.77	2.77	2.02	1.34	4.2	2
P2O5	0.14	0.14	0.04	0.12	0.17	2
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	1.2	1.2	0.01	1.19	1.21	2
Ba	864	864	704.28	366	1362	2
Li	16.5	16.5	0.71	16	17	2
Rb	121	121	59.4	79	163	2
Sr	168.5	168.5	30.41	147	190	2
Pb	6.5	6.5	0.71	6	7	2
Th	39.5	39.5	2.12	38	41	2
U	8.5	8.5	0.71	8	9	2
Zr	456.5	456.5	74.25	404	509	2
Nb	30.5	30.5	2.12	29	32	2
Y	60	60	-	60	60	2
La	66.5	66.5	36.06	41	92	2
Ce	127	127	42.43	97	157	2
Pr	13	13	5.66	9	17	2
Nd	55.5	55.5	4.95	52	59	2
Sc	9.5	9.5	2.12	8	11	2
V	44.5	44.5	10.61	37	52	2
Cr	1		-			2
Mn	-	-	-	-	-	-
Co	7.5	7.5	2.12	6	9	2
Ni	4	4	-	4	4	2
Cu	12	12	7.07	7	17	2
Zn	16.5	16.5	3.54	14	19	2
Sn	4	4	1.41	3	5	2
W	5	5	-	5	5	2
Mo	1		-			2
Ga	20	20	1.41	19	21	2
As	0.5	0.5	-	0.5	0.5	2
S	177	177	200.82	35	319	2
F	-	-	-	-	-	-
Cl	330.5	330.5	89.8	267	394	2
Be	5	5	1.41	4	6	2
Ag	-	-	-	-	-	-
Bi	1		-			2
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	0.5		-			2

Mount Angelay Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.54	70.56	7.04	51.39	79.6	33
TiO2	0.52	0.31	0.43	0.1	1.63	33
Al2O3	14.41	14.26	2.16	8.96	20.81	33
Fe2O3	2.02	1.32	1.69	0.65	7.75	33
FeO	1.03	0.47	1.56	0.11	7.54	33
MnO	0.02	0.01	0.03	01	0.14	33
MgO	0.77	0.4	1.15	01	5.38	33
CaO	1.76	0.94	1.91	01	6.73	33
Na2O	4.41	4.58	2.34	0.07	8.62	33
K2O	5.09	4.54	4.02	0.09	16.06	33
P2O5	0.13	0.07	0.14	01	0.63	33
H2O+	0.55	0.51	0.15	0.42	0.72	3
H2O-	0.19	0.19	0.02	0.17	0.21	3
CO2	0.15	05	0.22	05	0.4	3
LOI	0.98	0.88	0.42	0.25	2.62	30
Ba	848.36	709	649.15	11	2291	33
Li	2.78	2	2.24		12	32
Rb	161.85	140	120.55	1	458	33
Sr	98.58	65	94.94	7	372	33
Pb	8.09	8	3.92	2	18	33
Th	59.64	66	32.23	14	135	33
U	10.7	8	6.91	1	25	33
Zr	309.33	244	174.09	101	886	33
Nb	29.91	29	10.26	8	61	33
Y	44.3	43	18.4	11	96	33
La	62.09	60	33.69	18	170	33
Ce	126.15	107	58.86	31	302	33
Pr	12.83	12.5	5.87	3	26	30
Nd	49.15	45	22.16	11	105	33
Sc	7.42	6	6.51		28	33
V	37.95	17	52.1		210	33
Cr	9.76	3	25.53		143	33
Mn	108.71	72	73.09	23	211	7
Co	26.5	7	35.36	2	118	30
Ni	7.35	3	14.06		69	26
Cu	12.15	7.5	12.52		55	26
Zn	13.35	6.5	17.29		71	26
Sn	2.33	2	1.69		8	33
W	3.13	3	1.29		6	23
Mo	1.82		1.05		5	30
Ga	18.33	20	5.22	5	27	33
As	1.2	1	0.75		4	33
S	127.85	45	276.97		1227	30
F	636	500	571.46	Â	2100	25
Cl	672.22	550	477.88	76	2071	23
Be	4.05	4	3.72		21	30
Ag	1.29	1	0.49	1	2	7
Bi	1.1		0.31		2	30
Cs	2.25		1.96		12	30
Ge	0.46	50	0.37	50	1	7
Se	0.5		-			7

Yellow Waterhole Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.53	71.2	1.18	70.2	73.9	11
TiO2	0.36	0.38	0.07	0.23	0.44	11
Al2O3	13.61	13.65	0.24	13.2	13.9	11
Fe2O3	1.42	1.54	0.58	0.38	2.15	11
FeO	1.17	1.22	0.66	0.04	2.37	11
MnO	0.11	0.02	0.31	0.01	1.05	11
MgO	0.84	0.76	0.35	0.35	1.66	11
CaO	1.73	1.56	0.7	0.97	3.66	11
Na2O	3.74	3.38	0.66	3.28	5.37	11
K2O	3.96	4.5	1.78	0.1	5.49	11
P2O5	0.14	0.1	0.12	0.07	0.5	11
H2O+	0.62	0.69	0.19	0.15	0.88	11
H2O-	0.2	0.2	0.08	0.1	0.39	11
CO2	0.24	0.18	0.17	0.05	0.56	11
LOI	-	-	-	-	-	-
Ba	669.82	665	161.16	259	855	11
Li	11.8	11.5	4.61	7	21	10
Rb	200.45	201	60.79	61	272	11
Sr	134.91	134	22.11	97	160	11
Pb	6.91	6	3.83		13	11
Th	54.18	53	9.21	37	72	11
U	13.73	13	3.17	10	19	11
Zr	220.36	208	38.91	168	270	11
Nb	23.45	23	2.66	19	28	11
Y	41.82	42	4.51	34	48	11
La	74.36	74	42.49	17	172	11
Ce	125.73	128	54	42	231	11
Pr	-	-	-	-	-	-
Nd	39.78	40	9.68	23	51	9
Sc	5.33	5	1.5	3	7	9
V	32.09	35	12.52	13	50	11
Cr	7.4	7.5	3.5	2	13	10
Mn	-	-	-	-	-	-
Co	5.57	5	1.4	4	8	7
Ni	3.9	4	2.33		7	10
Cu	39.64	20	64.95	2	227	11
Zn	12.91	10	6.24	8	26	11
Sn	2.64	2	1.63		5	11
W	4	4	1.22	3	6	5
Mo	2		1.12		4	5
Ga	16.89	17	1.17	15	18	9
As	0.56	0.5	0.27		1	9
S	74.2	51	48.26	25	146	5
F	916.67	900	331.16	400	1400	6
Cl	249.4	207	77.83	180	336	5
Be	4	3	1.41	3	6	5
Ag	-	-	-	-	-	-
Bi	1		-			5
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Malakoff Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.2	72.17	1.1	70.62	73.93	8
TiO2	0.27	0.27	0.07	0.19	0.37	8
Al2O3	13.68	13.8	0.38	13.17	14.21	8
Fe2O3	1.06	1.04	0.38	0.52	1.54	8
FeO	1.52	1.45	0.43	1.02	2.09	8
MnO	0.03	0.03	0.01	0.01	0.04	8
MgO	0.4	0.43	0.13	0.23	0.6	8
CaO	1.34	1.32	0.44	0.71	2.05	8
Na2O	3.73	3.78	0.3	3.14	4.18	8
K2O	4.61	4.46	0.75	3.84	6.24	8
P2O5	0.07	0.06	0.05	0.03	0.18	8
H2O+	0.34	0.37	0.07	0.23	0.41	8
H2O-	0.19	0.17	0.15	0.03	0.38	8
CO2	0.12	0.09	0.09	0.05	0.32	8
LOI	-	-	-	-	-	-
Ba	540.13	549	188.17	245	820	8
Li	10.63	9.5	6.59	2	20	8
Rb	269	247.5	72.39	194	411	8
Sr	77.38	71.5	31.6	42	120	8
Pb	22	18	11.99	11	49	8
Th	80.38	58	69.3	26	247	8
U	19.75	9.5	23.7	6	77	8
Zr	250	237.5	134.32	125	559	8
Nb	22.5	23	5.07	16	30	8
Y	40.88	40.5	10.37	24	57	8
La	70.38	70	33.56	28	125	8
Ce	124	125	47.93	61	201	8
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	4	5	1.83		6	7
V	15.88	13	8.08	9	30	8
Cr	2.88	2.5	2.03		5	8
Mn	-	-	-	-	-	-
Co	6.25	6	1.58	4	8	8
Ni	1.88	2	0.64		3	8
Cu	4.63	5	1.69	3	8	8
Zn	16.38	15	5.71	9	25	8
Sn	3.38	2.5	2.5		9	8
W	-	-	-	-	-	-
Mo	1.5		-			7
Ga	17.14	17	1.77	14	19	7
As	0.5		-			7
S	-	-	-	-	-	-
F	750	750	212.13	600	900	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

The Mavis Granodiorite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	67.25	66.29	2.15	64.8	70.52	11
TiO2	0.55	0.59	0.12	0.34	0.71	11
Al2O3	14.62	14.52	0.55	13.55	15.32	11
Fe2O3	1.96	2.06	0.49	1.24	2.54	11
FeO	3.02	3.16	0.68	2.05	3.97	11
MnO	0.04	0.04	0.01	0.02	0.07	11
MgO	1.09	1.21	0.32	0.58	1.48	11
CaO	3.17	3.63	0.71	2.26	4.19	11
Na2O	3.78	3.88	0.39	2.96	4.26	11
K2O	2.78	2.98	0.89	1.36	4.34	11
P2O5	0.16	0.16	0.06	0.08	0.29	11
H2O+	0.73	0.71	0.16	0.39	0.97	11
H2O-	0.13	0.1	0.12	0.03	0.39	11
CO2	0.1	0.09	0.05	0.05	0.24	11
LOI	-	-	-	-	-	-
Ba	791.27	749	246.76	475	1206	11
Li	11.27	11	1.68	9	15	11
Rb	126.55	126	49	55	226	11
Sr	218.18	231	42.35	123	263	11
Pb	23.73	10	41.13	4	145	11
Th	39.82	40	11.53	27	63	11
U	3.73	3	1.95	1	6	11
Zr	349.18	345	59.31	257	477	11
Nb	14.09	14	3.94	8	24	11
Y	34.73	38	9.91	15	46	11
La	96.45	92	21.23	71	138	11
Ce	155.64	153	32.65	116	219	11
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	9.18	11	2.79	5	12	11
V	59.73	72	21.28	35	88	11
Cr	8.27	10	4.17	3	15	11
Mn	-	-	-	-	-	-
Co	13.27	15	3.13	9	18	11
Ni	6.73	8	2.76	3	11	11
Cu	32.09	23	24.68	7	89	11
Zn	20.82	19	5.64	12	30	11
Sn	1.64	2	0.67		3	11
W	-	-	-	-	-	-
Mo	1.5		-			11
Ga	16.82	16	1.25	15	19	11
As	0.73		0.47		2	11
S	-	-	-	-	-	-
F	750	750	212.13	600	900	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

unnamed albitite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.04	73.71	4.6	65.37	80.53	8
TiO2	0.17	0.13	0.07	0.1	0.29	8
Al2O3	13.41	14.05	3.35	8.25	18.45	8
Fe2O3	0.79	0.5	0.87	01	2.58	8
FeO	0.24	0.11	0.25	0.08	0.82	8
MnO	0.03	0.01	0.04	01	0.11	8
MgO	0.22	0.09	0.25	0.01	0.7	8
CaO	1.5	1.14	1.56	0.1	4.92	8
Na2O	7.22	7.78	2.11	4.62	10.72	8
K2O	0.49	0.11	0.81	0.08	2.44	8
P2O5	0.05	0.02	0.06	01	0.18	8
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	1.73	1.51	1.62	0.48	5.55	8
Ba	79.75	37	115.41	6	355	8
Li	1	1	0.46		2	8
Rb	13.25	4	19.27	1	57	8
Sr	46	43.5	27.53	4	94	8
Pb	1.75	1.5	1.25		4	8
Th	9.75	6	11.76	2	38	8
U	1.75	1.5	0.71	1	3	8
Zr	148.25	96.5	101.73	73	361	8
Nb	4.38	2	4.1	1	13	8
Y	6.5	4	4.38	3	15	8
La	10.06	7	10.34		31	8
Ce	21	14.5	20.66		59	8
Pr	2.69		1.98		7	8
Nd	8.63	6.5	7.7		24	8
Sc	4.38	3	4.89		16	8
V	13.13	11	8.54	3	26	8
Cr	7.5	3	10.2		29	8
Mn	-	-	-	-	-	-
Co	22.71	8	22.91	3	58	7
Ni	3.75	2.5	2.92		10	8
Cu	6.75	5	6.07		19	8
Zn	4.63	3.5	3.62	2	13	8
Sn	1.13		0.35		2	8
W	11.17	4.5	13.88	2	37	6
Mo	1.5		-			8
Ga	17.25	19	6.36	8	27	8
As	2.91	0.75	5.03	50	15	8
S	35	26.5	19.5	17	62	6
F	120	Â	44.72	Â	200	5
Cl	191.17	188.5	80.03	83	315	6
Be	1.56	1.5	0.82		3	8
Ag	-	-	-	-	-	-
Bi	0.81		0.26			8
Cs	1.5		-			8
Ge	0.5	0.5	-	0.5	0.5	1
Se	0.25	50	-	50	50	1

unnamed microgranite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.52	74.52	-	74.52	74.52	1
TiO2	0.13	0.13	-	0.13	0.13	1
Al2O3	12.53	12.53	-	12.53	12.53	1
Fe2O3	0.98	0.98	-	0.98	0.98	1
FeO	0.35	0.35	-	0.35	0.35	1
MnO	0.01	0.01	-	0.01	0.01	1
MgO	0.25	0.25	-	0.25	0.25	1
CaO	1.4	1.4	-	1.4	1.4	1
Na2O	4.74	4.74	-	4.74	4.74	1
K2O	3.26	3.26	-	3.26	3.26	1
P2O5	0.03	0.03	-	0.03	0.03	1
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	0.99	0.99	-	0.99	0.99	1
Ba	126	126	-	126	126	1
Li	-	-	-	-	-	-
Rb	87	87	-	87	87	1
Sr	23	23	-	23	23	1
Pb	2	2	-	2	2	1
Th	35	35	-	35	35	1
U	5	5	-	5	5	1
Zr	370	370	-	370	370	1
Nb	67	67	-	67	67	1
Y	132	132	-	132	132	1
La	111	111	-	111	111	1
Ce	229	229	-	229	229	1
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	1.5		-			1
Cr	-	-	-	-	-	-
Mn	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	-	-	-	-	-	-
Cu	-	-	-	-	-	-
Zn	-	-	-	-	-	-
Sn	9	9	-	9	9	1
W	-	-	-	-	-	-
Mo	1.5		-			1
Ga	29	29	-	29	29	1
As	1	1	-	1	1	1
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	1		-			1
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	1		-			1

11 OTHER UNITS/SUITES

11.1 Introduction

This section contains brief descriptions of granites not otherwise included in the preceding chapters. These units either have no or few geochemical analyses, do not fit into any of the suites described in the preceding chapters, or are of a very small size extent and are considered to have no mineralisation potential.

11.2 Tommy Creek Suite

Location: The Tommy Creek Suite occurs in the central part of the Marraba Sheet area in the Tommy Creek Block. It comprises the volumetrically minor Tommy Creek Microgranite and volcanics of the Lalor beds and the Milo beds. Most of the rocks within the Block have been metamorphosed to upper amphibolite facies. (Note: the Lalor beds are a new name registered with the Australian Stratigraphic Names Index by this project for the lower Tommy Creek Sequence including the FV1 volcanic unit of Hill (1991) and Hill *et al*. (1992), whilst Milo beds is a new name registered for the upper Tommy Creek Sequence including the volcanic units FV2, vm, vt, vi of Hill (1991) and Hill *et al*. (1992). All of these volcanic units were previously informally termed 'Tommy Creek Volcanics'. The name 'Beacon beds' introduced by Derrick (1992, 1993) for the same units is unacceptable to the Stratigraphic Names committee as this name has been used for the Palaeozoic Beacon Mudstone in Queensland and New South Wales.

Timing & Relationships: The interpretation of the ages of volcanic units of the Tommy Creek Block is controversial. Age determinations are as follows: volcanic - 1762 ± 5 Ma (SHRIMP), volcanic - 1758 ± 4 Ma (SHRIMP), volcanic - 1650 ± 3 Ma (SHRIMP), volcanic - 1629 ± 8 Ma (SHRIMP), volcanic - 1625 ± 4 Ma (SHRIMP), brecciated and altered sediment - 1618 ± 4 Ma (SHRIMP).These constitute a wide range of ages and are difficult to reconcile within a single event. Hill (1991) mapped a stratigraphic sequence within the main Tommy Creek Block, and four of the six dated samples are from sites on this map. From this it can be seen that there are two alternatives for interpreting the conflicting ages. On the map of Hill (1991) one of the ~1760 Ma ages comes from the Lalor beds (unit FV1 of the lower part of the Tommy Creek Block sequence (as defined by Hill *et al*. 1992)), whilst most of the ages ~ 1620 Ma are from the Milo beds (unit V_m which is in the upper part of the Tommy Creek Block sequence (as defined by Hill *et al*. 1992)). This observation suggests that there may be an unrecognised unconformity within the sequence and as the Lalor beds (in particular unit FV1dominates (Hill 1991)), then the bulk of the Tommy Creek Block is likely to be ~1760 Ma. This suggestion has also been considered by Lally (1996) who argued that the calc-silicate granofels of the 'Lalor beds' of Hill *et al.* (1992), is part of the Corella Formation.

Unfortunately the 1625 ± 4 Ma age comes from an outcrop assigned by Hill (1991) to the Lalor beds (the FV1 unit of Hill 1991), although in the past this particular outcrop has been described as an intrusive sill (Page 1983). Assuming that the 1625 ± 4 Ma outcrop of unit FV1 is a volcanic (as is asserted by Hill *et al.* 1992), then an alternative interpretation is that the ~1620 Ma population has been reset by deformation, particularly as the younger ages are all from a more intensely deformed part of the sequence (Blake *pers. comm.*) that has been strongly affected by the D^T_1 phase of deformation (Hill *et al*. 1992). Both Hill *et al*. (1992) and Lally (1996) note that many of the rocks in the area from where the younger age determinations come are mylonitised. Some support for this interpretation of this young growth of unzoned zircon during deformation comes from the adjacent Wonga Belt where an anomalously younger unzoned zircon population of 1660 ± 5 Ma was noted by Pearson *et al.* (1992) in a sample of Wonga Granite dated at 1729 ± 5 Ma. Although in the ~1620 Ma volcanic samples from the Tommy Creek Block no inheritance at ~1760 Ma was noted, it is likely that any original primary magmatic zircons in the volcanics were fine-grained and hence were dissolved (e.g., Watson 1996) during the intense D^T_1 shearing event that affected the area where the younger ~1620 Ma age determinations are found (Hill 1991; Hill *et al*. 1992). This interpretation has validity when it is noted that most of the Tommy Creek Suite regardless of age forms a very coherent geochemical trend (Figure 11.2 - 11.7) which is remarkably similar to the trends of the Burstall Suite. If it is true that the Tommy Creek Block is older than previously thought, then it would resolve the long-standing anomaly of the Tommy Creek Block belonging to a much younger part of the sequence, yet being affected by the highest metamorphic grade, whilst the surrounding older rocks are low-greenschist grade (see discussion in Hill *et al.* 1992).

Description: The Lalor beds (the lower sequence of Hill *et al.* 1992) contains calcareous granofels interbedded with massive bodies of porphyritic felsic rock (FV1). Unit FV1 consists of thick but laterally discontinuous layers of felsic porphyritic volcanics that have been extensively recrystallised. The Milo beds (the upper sequence of Hill *et al.* 1992) consists of marble (Unit M), graphitic schist (Unit S) and volcanics (Units V and FV2). Unit V consists of subunits V_m, V_t, and V_i. Unit V_m comprises porphyritic mafic lavas, fragmentary mafic and intermediate lavas, minor sediments, finely banded tuff and massive intermediate lavas. Unit V_t consists of finely banded tuff whilst Unit V_i consists of massive intermediate lavas. The interpretation of these units as volcanics is controversial as previous workers have considered some of these units to be intrusive (e.g., Derrick *et al.* 1971; Derrick 1980; Page 1983).

Petrographically the rocks consist of phenocrysts up to 5 mm of quartz, K-feldspar and plagioclase, set in a fine-grained quartzofeldspathic groundmass with an average grain size of 0.2 mm. Primary mafic minerals constitute 5% of the rock and include hornblende and biotite. Titanite (up to 2%), apatite, calcite, fluorite and zircon are the main accessory minerals.

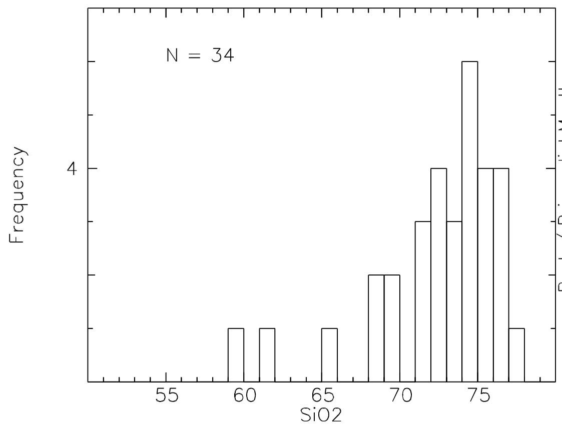


Figure 11.1a Frequency histogram of SiO_2 values for the Tommy Creek Suite.

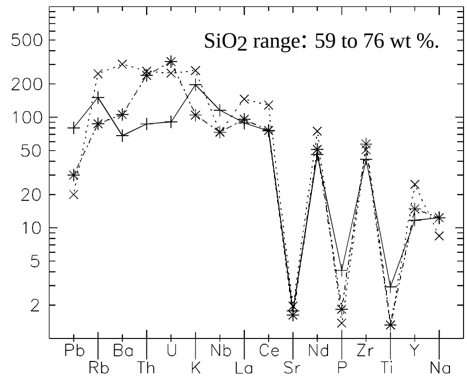


Figure11.6c. Spidergram for selected samples for the Tommy Creek Suite.

Geochemically, given the degree of metamorphism and deformation that has affected the area, the Tommy Creek Suite forms a remarkably coherent grouping. The Lalor beds are virtually indistinguishable from the Milo beds, in particular on the Ba, Zr, Nb, and ASI (Figs. 11.3J, 5A, 5B, 6E respectively). This supports the suggestion that all the felsic igneous rocks in the Tommy Creek Suite are the one age and that the younger ages are caused by resetting within mylonite zones.

The SiO_2 range is from 59 to 78 wt.% SiO_2 with a peak at 74 wt.% (Fig. 11.1a). The metamorphism has affected the U (and possibly Rb) values which are anomalously low (Figs. 11.3A, B). Zr, Nb, Y, Ce and F values are high relative to other Proterozoic felsic igneous suites (Figs. 11.3K, 5A, B, C). The suite as a whole is relatively peraluminous. The spidergram pattern is Sr-depleted, Y-undepleted (Fig. 11.6c). The Tommy Creek Suite is very similar chemically to the Burstall Suite, and to the Playboy Granite of the Wonga Suite. Based on the new ages of ~1760 Ma from relatively undeformed parts of the Tommy Creek Suite, there is a strong possibility that it is actually part of the Burstall Suite.

Country Rocks: The units intrude graphitic shale, marble, quartzite, siltstone, chert.

Potential: The rocks of this suite would be classified as I-(granodiorite) type with affinities to the Hiltaba type. Several small Cu, Au, As, and U prospects/deposits occur in the vicinity of members of the Tommy Creek Suite, and it is possible that these may be related to epithermal mineralisation emanating from the volcanic activity. As there are graphitic units in the vicinity, this suite has been rated as having moderate potential for Au and low potential for Cu.

References: Derrick (1980, 1992, 1993), Derrick *et al.* (1971), Hill (1991), Hill *et al.* (1992), Page (1983), Page *et al.* (1997), Pearson *et al.* (1992), Watson (1996).

11.3 Little Toby granite

Location: Southern part of the Big Toby Batholith in the central part of the Mount Isa 1:100 000 sheet area, west of the Sybella Batholith.

Timing & Relationships: No age determinations available. The granite is intrusive into the ~1890 Ma Yaringa Metamorphics and unconformably overlain by sediments of the Cambrian Georgina Basin.

Description: Very little is known of this intrusion other than it is pink, coarse-grained and strongly foliated.

Country Rocks: Yaringa Metamorphics consist of quartzofeldspathic metasediments, quartz-mica schist, quartzite, migmatite.

Potential: Insufficient data to assess.

References: Blake (1987), Hill *et al.* (1975), Wyborn *et al.* (1988).

11.4 Monaghans granite

Location: Northern part of the Big Toby Batholith in the central part of the Mount Isa 1:100000 sheet area. Occurs west of the Sybella Batholith.

Timing & Relationships: The Monaghans granite is intrusive into the 1890 ± 8 Ma Yaringa Metamorphics. A conventional U-Pb zircon date of 1804 ± 15 has been determined on the granite (Wyborn *et al.* 1988) and it is unconformably overlain by the ~1680 Ma Carters Bore Rhyolite.

Description: The Monaghans granite is heterogeneous and in places strongly foliated. It contains numerous xenoliths and ranges from biotite tonalite to monzogranite, with granodiorite being the most abundant composition. Quartz is recrystallised and K-feldspar is mainly microcline. Biotite usually forms large plates, although some decussate aggregates are present; allanite, apatite and zircon are common accessories. Muscovite forms large plates and also occurs in altered plagioclase grains. The alteration assemblage suggests an upper greenshist facies metamorphic overprint. Although not markedly peraluminous (Fig. 11.6E) the abundance of metasedimentary xenoliths and coarse muscovite suggests that this is a restite-rich S-type, albeit derived from a relatively immature metasediment.

Country Rocks: Yaringa Metamorphics consist of quartzofeldspathic metasediments, quartz-mica schist, quartzite, migmatite.

Potential: None as this is a restite system.

References: Blake (1987), Hill *et al.* (1975), Wyborn *et al.* (1988).

11.5 Yeldham Granite

Location: ~200 km north of Mount Isa in the elongate Kamarga Dome. It covers < 20 km^2.

Timing & Relationships: The Yeldham Granite intrudes the Kamarga Volcanics and is unconformably overlain by the ~1670 Ma McNamara Group. An age of ~1820 Ma was obtained from some xenotime grains and a 2-point zircon discordia.

Description: The Yeldham Granite consists of fine to medium-grained muscovite-rich monzogranite to alkali-feldspar granite.

Country Rocks: The Kamarga Volcanics consist of lower greenschist facies basalt and feldspathic sandstone.

Potential: Insufficient data to assess.

References: Hutton and Sweet (1980), Sweet and Hutton (1980), Sweet and Hutton (1982), Wyborn *et al.* (1988).

11.6 Cowie Suite

Location: Southeastern part of the Eastern Fold Belt, Mount Isa Inlier. Comprises the Cowie Granite, Blackeye Granite and possibly Boorama Tank gneiss.

Timing & Relationships: Both plutons are foliated and are considered to be older than the ~1500 Ma post-D_2 intrusives of the Williams Supersuite. No ages have been obtained from either unit. The informally named ‘Boorama Tank gneiss’ has been dated at 1547 ± 5 Ma (SHRIMP) and may be a correlative.

Description: Both granites are foliated. The Blackeye Granite consists of medium to fine-grained, even-grained, foliated, leucocratic granodiorite with minor quartz-feldspar pegmatite. The granodiorite contains about 5% ferromagnesian minerals (amphibole ± biotite ± clinopyroxene). The Cowie Granite is heterogeneous and consists of biotite leucogranite, granodiorite and tonalite.

Country Rocks: Both units intrude the Doherty Formation, and the Cowie Granite locally forms migmatitic complexes with the Soldiers Cap Group.

Potential: Insufficient data to assess.

References: Blake (1987), Blake *et al.* (1979, 1981a, 1981b, 1983, 1984), Page and Sun (1996, *in press*).

11.7 Levian Granite

Location: North and northwest of Cloncurry in the Eastern Fold Belt.

Timing & Relationships: The Levian Granite was emplaced at 1746 ± 6 (SHRIMP). It intrudes Mitakoodi Quartzite and Argylla Formation. It was informally named the 'Jessie granite' by Page and Sun (*in press* 1996) and Wyborn (*in press*), but this name is not acceptable to the Australian Stratigraphic Names Committee.

Description: Fine-grained granite with a distinct foliation and metamorphic overprint. Consists of microcline, quartz, biotite, plagioclase, titanite, apatite and zircon. Some muscovite is present although it is not possible to determine if this is primary or related to the metamorphism.

Country Rocks: Quartzite and felsic volcanics.

Potential: Insufficient data to assess.

References: Page and Sun (1996, *in press*), Wyborn *et al.* (1988), Wyborn (*in press*).

11.8 Mount Margaret Granite

Location: Small isolated outcrop of granite occurring 12 kms to the east of the Ernest Henry Cu deposit.

Timing & Relationships: Two U-Pb SHRIMP zircon ages, 1530 ± 8 and 1528 ± 6 (Page and Sun 1996, *in press*) have been obtained from this rock. As the outcrop of this granite forms an isolated monolith surrounded by Cainozoic cover, the relationships to other Proterozoic units are unknown.

Description: The granite is highly altered and consists predominantly of albitised granite. The original primary composition is unknown. The degree of alteration is extreme, and it is possible that the zircons are dating a metasomatic event (e.g., Drummond *et al.* 1986). This suggestion is supported by dating of hornblende at the Ernest Henry deposit that gave a $^{40}Ar/^{39}Ar$ age of ~1526 Ma (Perkins and Wyborn 1996, *in press*).

Country Rocks: Unknown.

Potential: Insufficient data to assess. However, it is quite clear that the granite is unlikely to have any relationship to the Cu mineralisation at Ernest Henry, as Perkins and Wyborn (1996, *in press)* have shown that the $^{40}Ar/^{39}Ar$ age of biotite associated with the mineralisation is ~1478 Ma and hence the mineralisation is more likely to be related to the younger Malakoff intrusion date at 1505 ± 5 Ma (Page and Sun 1996, *in press*). Further Williams *et al.* (1995) and Wyborn (*in press*) have argued that this sodic alteration overprint does not carry the mineralisation.

References: Drummond *et al.* (1986), Page and Sun (1996, *in press*), Perkins and Wyborn (1996, *in press*), Williams *et al.* (1995), Wyborn (*in press*).

11.9 Gin Creek Granite

Location: An elongate composite pluton west of the Starra Au deposit in the Eastern Fold Belt.

Timing & Relationships: An age of 1741 ± 7 has been obtained on a foliated muscovite-tourmaline granite (Page and Sun 1996, *in press*). The Gin Creek Granite intrudes the 1740 ± 6 Ma Double Crossing Metamorphics, Answer Slate, Staveley Formation, Kuridala Formation and metadolerite.

Description: Blake *et al.* (1981a) describe three types of granite in the unit: mainly foliated xenolithic biotite granite, fine-grained to pegmatitic leucogranite, and mainly massive biotite granite containing feldspar phenocrysts up to 5 cm across. The foliated types contain an abundance of muscovite and tourmaline and are typical of the dated sample. The massive variety has associated greisen and is likely to be related to the ~1510 Ma Williams Supersuite.

The samples analysed all have > 70 wt. % SiO_2 and come from the foliated parts of the granite. The one distinctive feature of the Gin Creek Granite is that all samples are weakly to strongly peraluminous (Fig. 11.6E). This is the only pluton in the Mount Isa Inlier to show this characteristic. It is possible that the Gin Creek Granite and its high-grade metamorphic envelope form a core complex and that the granite is a peraluminous S-type derived by local melting of the adjacent sediments.

Country Rocks: Graphitic slate, slate, calcareous and non-calcareous schist, phyllite, arenite, metarhyolite, chert, marble, quartz-feldspar-mica gneiss and schist, migmatitic gneiss, feldspathic quartzite, quartz-hematite rock, quartz-tourmaline rock, amphibolite, dolerite.

Potential: Insufficient data to assess, although if the Gin Creek Granite is predominantly an S-type, restite-rich granite of the Forsayth type then it is unlikely to have potential. Although the unfoliated type is not of significant geographical extent, it is possible that the current level of erosion is in the roof zone of a younger ~1510 Ma Williams Supersuite type. If so, then Fe-rich and or reductant-rich rocks in the surrounding area would make significant targets.

References: Brooks (1960), Blake *et al.* (1979, 1981a, 1981b, 1983), Page and Sun (1996, *in press*), White (1957), Wyborn (*in press*).

11.10 References

Blake, D.H. 1987. Geology of the Mount Isa Inlier and environs, Queensland and Northern Territory. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin*, 225, 83 pp.

Blake, D.H., Jaques, A.L. and Donchak, P.J.T. 1979. Precambrian geology of the Selwyn Region, Northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record*, 1979/86.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981a. Definitions of new and revised Precambrian stratigraphic and intrusive rock units in the Duchess and Urandangi 1:250 000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Report*, 233, *(BMR Microform* MF 164*)*.

Blake, D.H., Bultitude, R.J. and Donchak, P.J.T. 1981b. Summary of new and revised Precambrian stratigraphic nomenclature in the Duchess and Urandangi 1:250 000 Sheet areas, Mount Isa Inlier, northwestern Queensland. *Queensland Government Mining Journal*, 82, 580-589.

Blake, D.H., Jaques, A.L. and Donchak, P.J.T. 1983. Selwyn Region, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics, Australia.*

Blake, D.H., Bultitude, R.J. Donchak, P.J.T., Wyborn, L.A.I. and Hone, I.G. 1984, Geology of the Duchess-Urandangi region, Mount Isa Inlier, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin*, 219, 96 pp.

Brooks, J.H. 1960. The Uranium deposits of northwestern Queensland. *Geological Survey of Queensland, Publication*, 297.

Derrick, G.M. 1980. Marraba, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics, Australia*, 33 pp.

Derrick, G.M. 1992. Brothers in arms: the interaction of geology and geophysics in the Mount Isa Inlier. *Exploration Geophysics*, 23, 117-122.

Derrick, G.M. 1993. GST in the Mount Isa Inlier, 1961-1993 – 32 years of value adding. *Australian Institute of Geoscientists*, 13, 1-12.

Derrick, G.M., Wilson, I.H., Hill, R.M. and Mitchell, J.E. 1971. Geology of the Marraba 1:100000 Sheet area. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record*, 1971/56.

Drummond, M.S., Ragland, P.C. and Wesolowski, D. 1986. An example of trondhjemite genesis by means of alkali metasomatism: Rockford Granite, Alabama Appalachians. *Contributions to Mineralogy and Petrology*, 93, 98-113.

Hill, E.J. 1991. Geology of the Tommy Creek Block, Queensland, *1:25 000 scale map, Bureau of Mineral Resources, Geology and Geophysics, Australia.*

Hill, E.J., Loosveld, R.J.H. and Page, R.W. 1992. Structure and geochronology of the Tommy Creek Block, Mount Isa Inlier, In Stewart, A.J. and Blake, D.H. (Editors), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin*, 243, 329-348.

Hill, R.M., Wilson, I.H. and Derrick, G.M. 1975, Geology of the Mount Isa 1:100 000 sheet area, northwest Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Record*, 1975/175, 112 pp.

Hutton, L.J. and Sweet, I.P. 1980. Kamarga Volcanics and Yeldham Granite - new stratigraphic units in the Lawn Hill 1:100 000 Sheet area. *Queensland Government Mining Journal*, 81, 513-518.

Lally, J.H. 1996. Structural development of the Tommy Creek Block, Eastern Fold Belt, Mount Isa Inlier. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, *EGRU Contribution 55*, 69-71.

Page, R.W. 1983. Timing of superposed volcanism in the Proterozoic Mount Isa Inlier. *Precambrian Research*, 21, 223-245.

Page, R.W. and Sun, S.-S. 1996. Age and provenance of granites and host sequences in the Eastern Fold Belt of the Mount Isa Inlier. MIC'96: New developments in metallogenic research: the McArthur, Mount Isa, Cloncurry Minerals Province, Extended Conference Abstracts, *EGRU Contribution 55,* 95-98.

Page, R.W. and Sun, S.-S. 1998. Aspects of geochronology and crustal evolution in the Eastern Fold Belt, Mount Isa Inlier. *Australian Journal of Earth Sciences,* 45, 343-361.

Page, R.W., Sun, S.-S. and McCready, T. 1997. New geochronological results in the central and eastern Mount Isa Inlier and implications for mineral exploration. *Abstracts, Geodynamics and Ore Deposits Conference, Australian Geodynamics Cooperative Research Centre, Ballarat, Victoria*, 46-48.

Pearson, P.J., Holcombe, R.J. and Page, R.W. 1992. Synkinematic emplacement of the Middle Proterozoic Wonga Batholith into a mid-crustal extensional shear zone, Mount Isa Inlier, Queensland, Australia, In Stewart, A.J. and Blake, D.H. (editors), Detailed studies of the Mount Isa Inlier. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin,* 243, 289-328.

Perkins, C. and Wyborn, L.A.I. 1996. The age of Cu-Au mineralisation, Cloncurry District, Mount Isa Inlier, as determined by 40Ar/39Ar dating. *AGSO Research Newsletter*, 25, 8-9.

Perkins, C. and Wyborn, L.A.I., *in press*. The age of Cu-Au mineralisation, Cloncurry District, Mount Isa Inlier, as determined by 40Ar/39Ar dating. *Australian Journal of Earth Sciences.*

Sweet, I.P. and Hutton, L.J. 1980. The geology of the Lawn Hill/Riversleigh Region, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Record,* 1980/43, 73 pp.

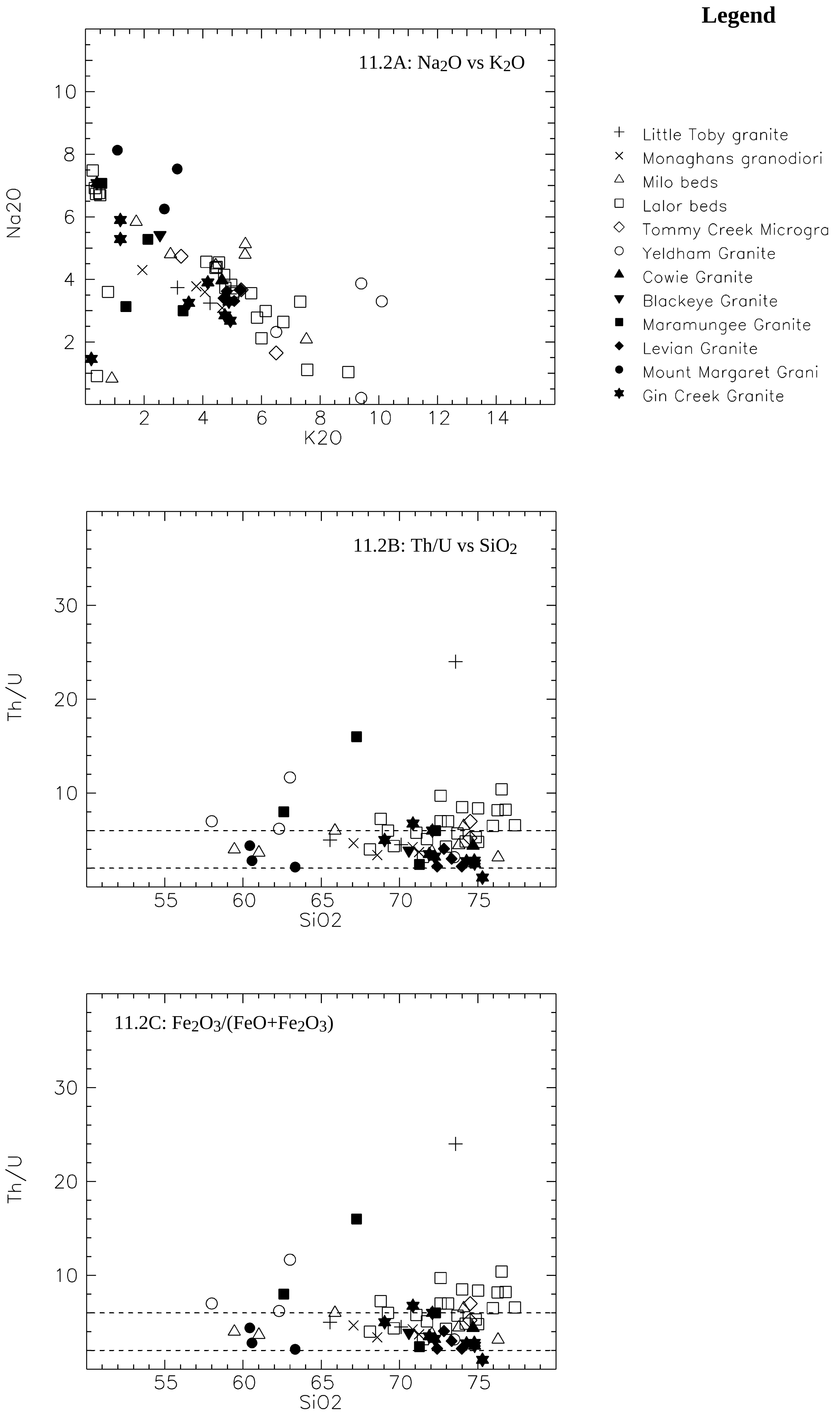
Sweet, I.P. and Hutton, L.J. 1982. The geology of the Lawn Hill Region, Queensland, 1:100 000 Geological Map Commentary. *Bureau of Mineral Resources, Geology and Geophysics.*

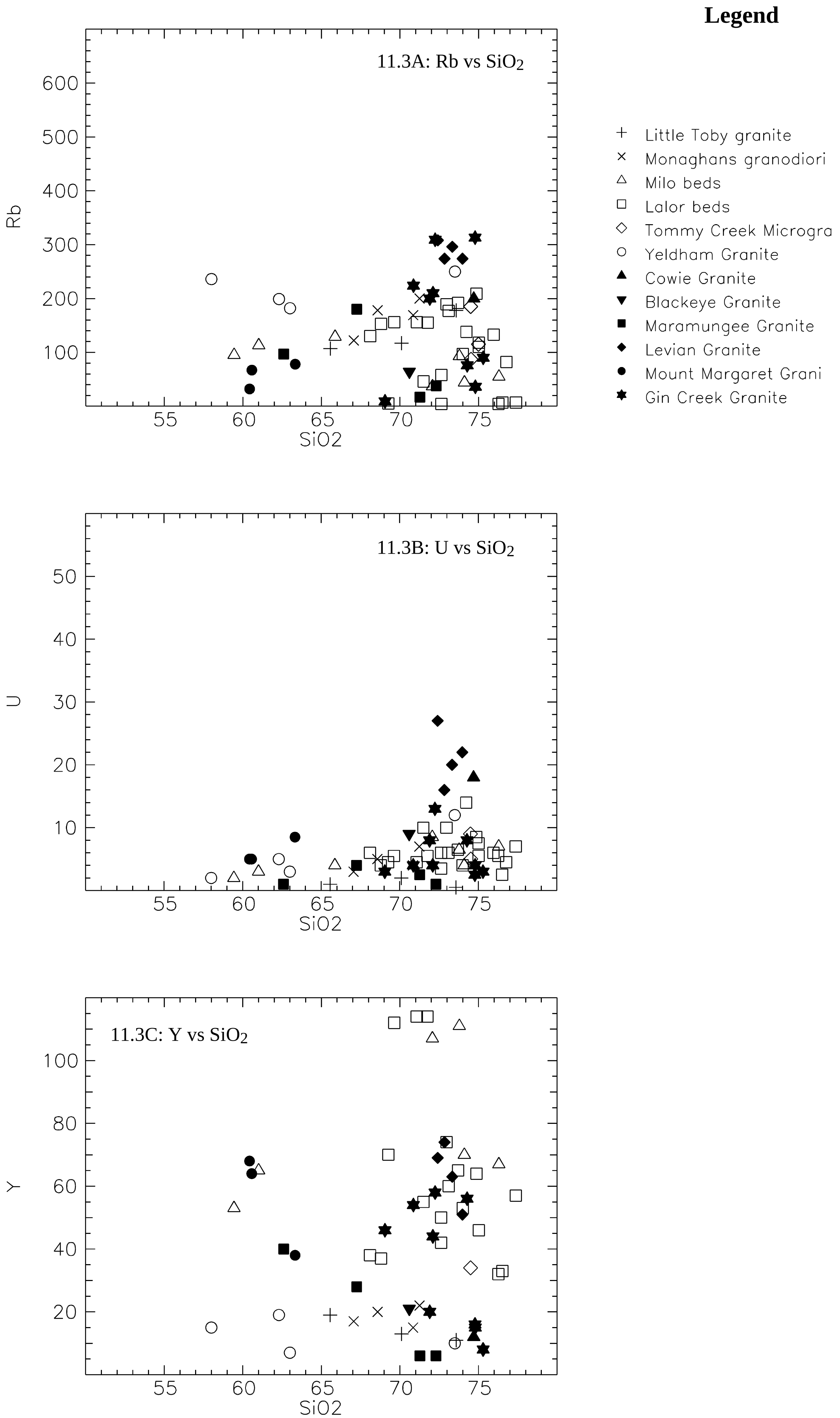
Watson, E.B. 1996. Dissolution, growth and survival of zircons during crustal fusion: kinetic principles, geological models and implications for isotopic inheritance. *Transactions of the Royal Society of Edinburgh: Earth Sciences,* 87, 43-56.

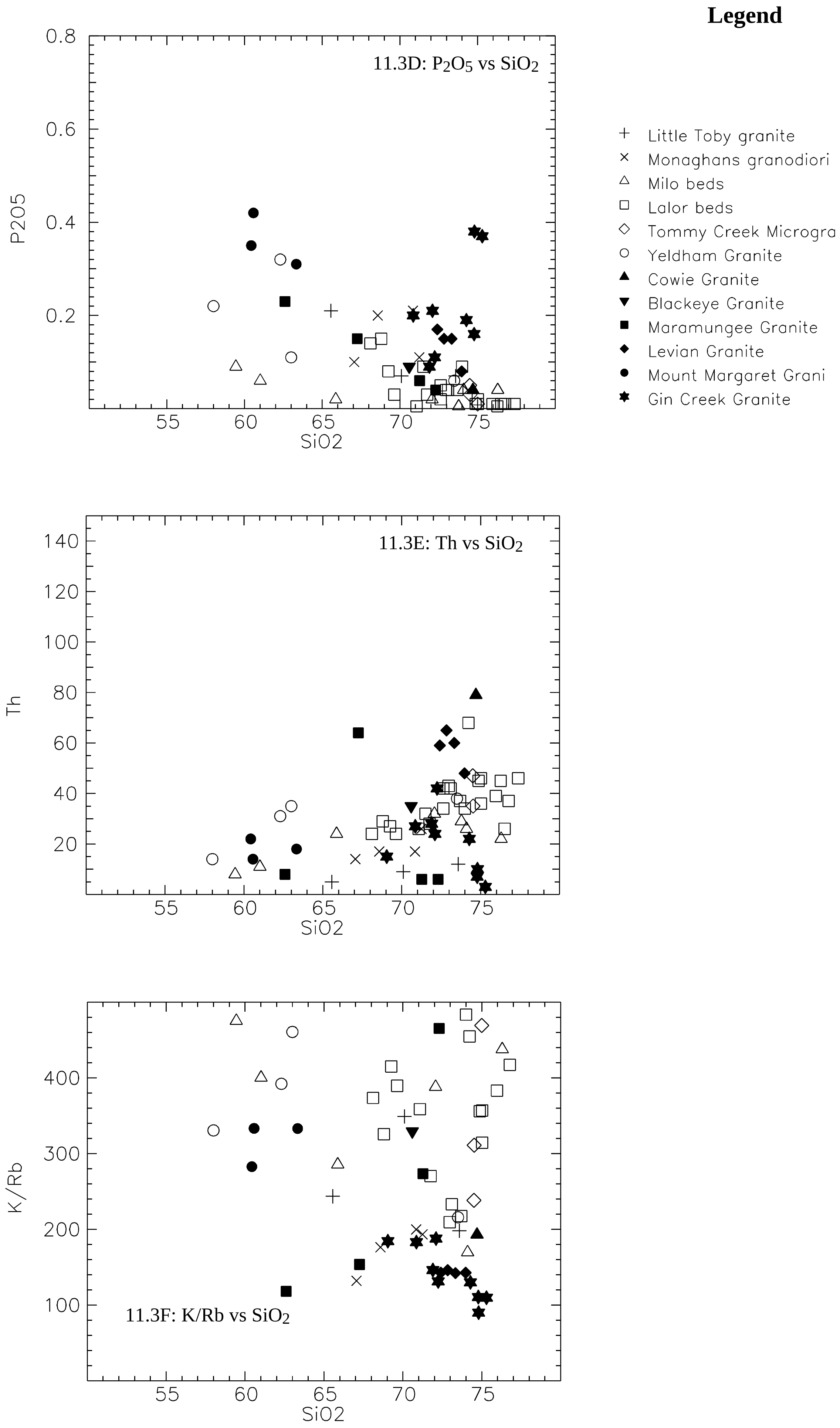
White, W.C. 1957. The geology of the Selwyn area of north Queensland. *Bureau of Mineral Resources, Australia, Record,* 1957/94.

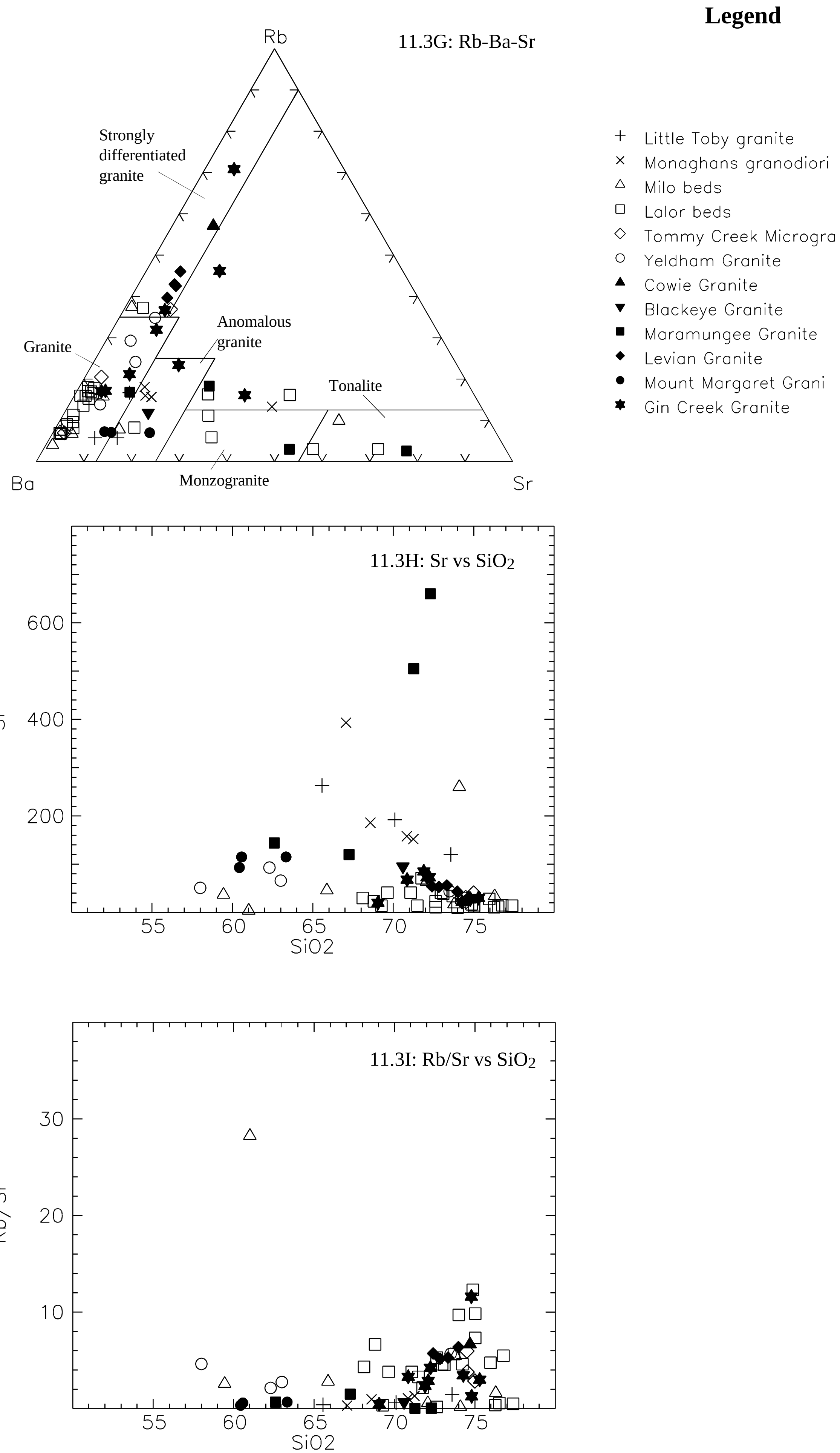
Williams, P.J., Adshead, N.D., Blake, K.L., De Jong, G., Mark, G. and Rotherham, J.F. 1995. Magnetite-Cu-Au deposits in deeply eroded magmatic arcs: lessons from Proterozoic terrains. PACRIM'95, 631-636.

Wyborn, L.A.I., Page, R.W. and McCulloch, M.T. 1988. Petrology, geochronology and isotope geochemistry of the post-1820 Ma granites of the Mount Isa Inlier: Mechanisms for the generation of Proterozoic anorogenic granites. *Precambrian Research*, 40/41, 509-541.

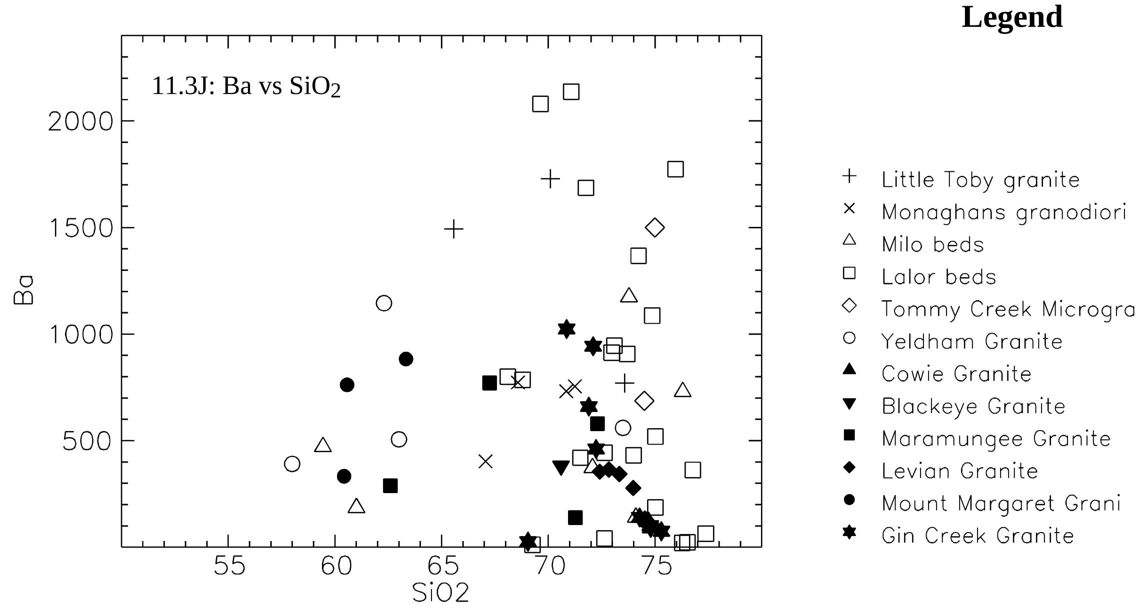

Legend
11.2A: Na2O vs K2O
Na2O
K2O
Little Toby granite
Monaghans granodiori
Milo beds
Lalor beds
Tommy Creek Microgra
Yeldham Granite
Cowie Granite
Blackeye Granite
Maramungee Granite
Levian Granite
Mount Margaret Grani
Gin Creek Granite
11.2B: Th/U vs SiO2
Th/U
SiO2
11.2C: Fe2O3/(FeO+Fe2O3)
Th/U
SiO2

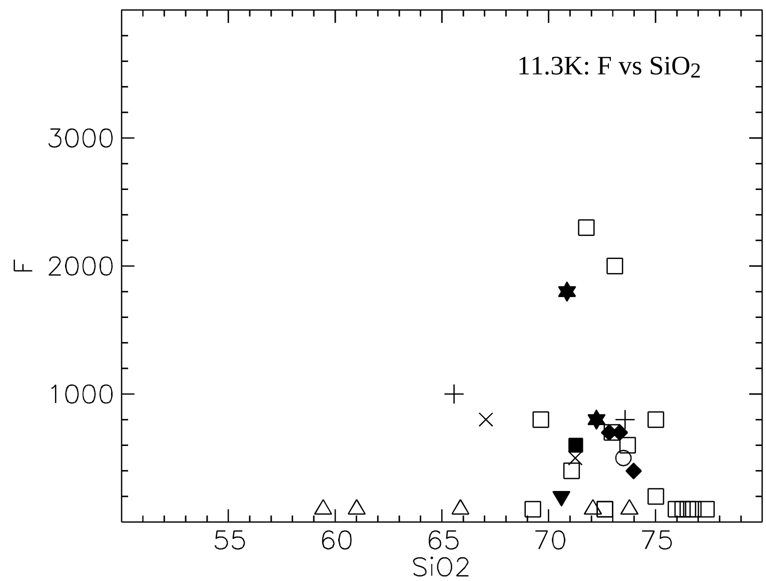

Legend
+ Little Toby granite
× Monaghans granodiori
△ Milo beds
□ Lalor beds
◇ Tommy Creek Microgra
○ Yeldham Granite
▲ Cowie Granite
▼ Blackeye Granite
■ Maramungee Granite
◆ Levian Granite
● Mount Margaret Grani
✱ Gin Creek Granite
11.3A: Rb vs SiO2
Rb
SiO2
11.3B: U vs SiO2
U
SiO2
11.3C: Y vs SiO2
Y
SiO2

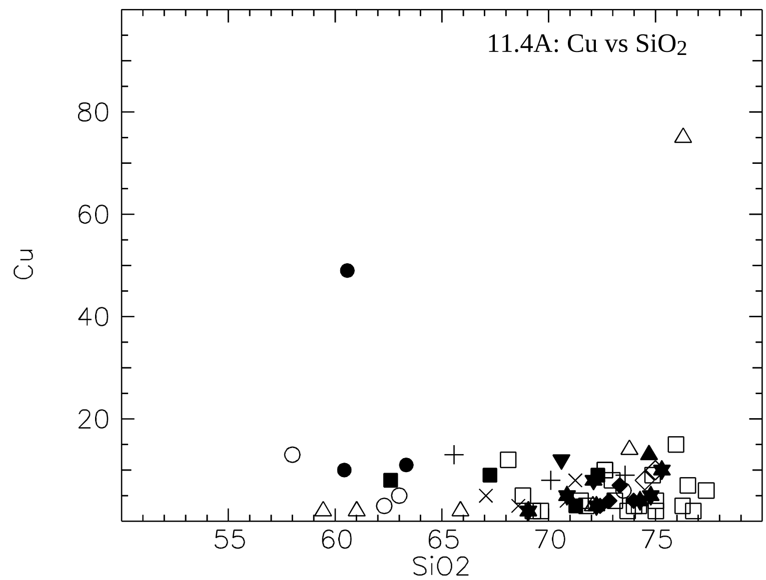

Legend
+ Little Toby granite
× Monaghans granodiori
△ Milo beds
□ Lalor beds
◇ Tommy Creek Micrognra
○ Yeldham Granite
▲ Cowie Granite
▼ Blackeye Granite
■ Maramungee Granite
◆ Levian Granite
● Mount Margaret Grani
✶ Gin Creek Granite
11.3D: P2O5 vs SiO2
P2O5
SiO2
11.3E: Th vs SiO2
Th
SiO2
11.3F: K/Rb vs SiO2
K/Rb
SiO2

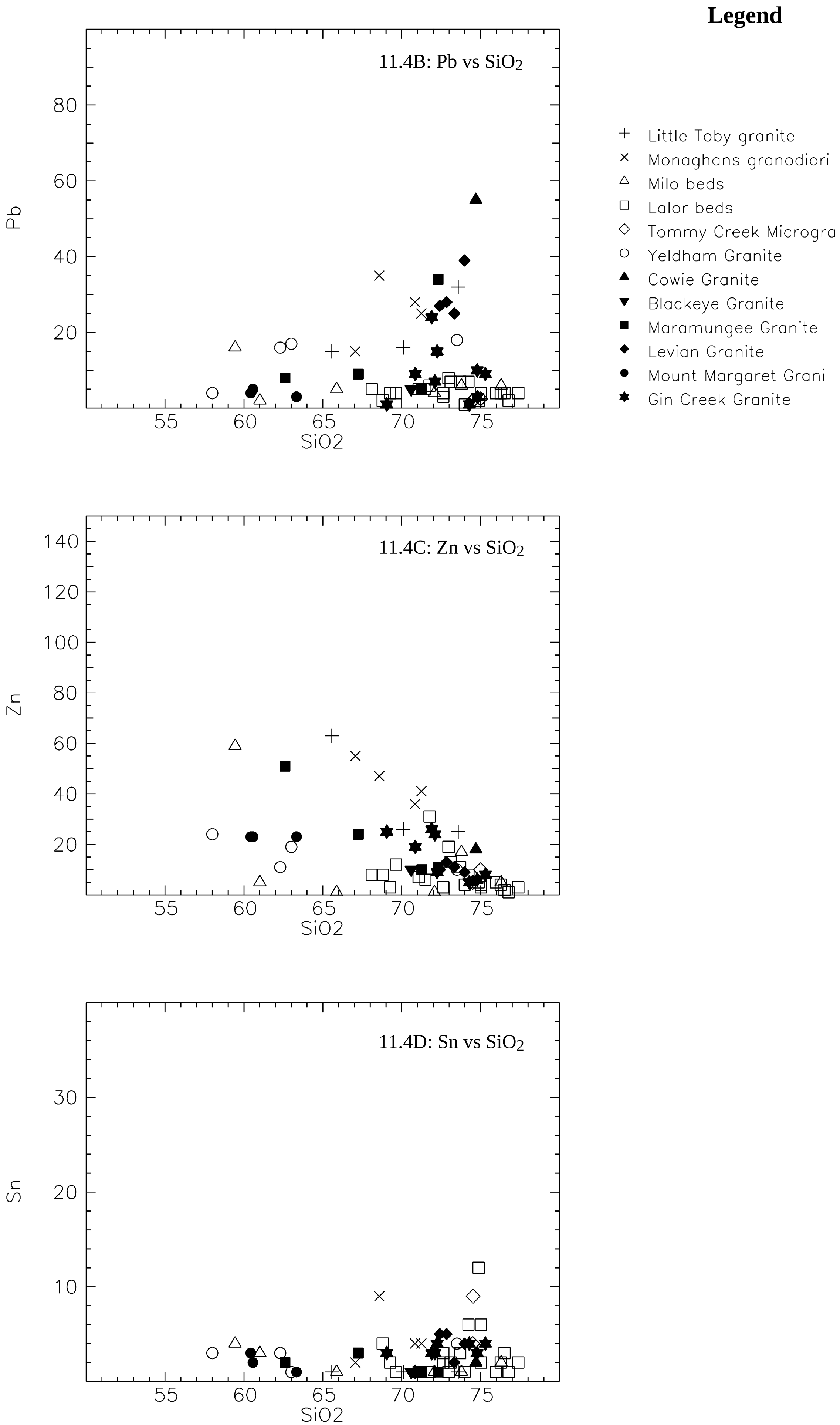

Legend
11.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Granite
Anomalous granite
Tonalite
Monzogranite
Little Toby granite
Monaghans granodiori
Milo beds
Lalor beds
Tommy Creek Microgra
Yeldham Granite
Cowie Granite
Blackeye Granite
Maramungee Granite
Levian Granite
Mount Margaret Grani
Gin Creek Granite
11.3H: Sr vs SiO2
Sr
600
400
200
55
60
65
70
75
SiO2
11.3I: Rb/Sr vs SiO2
Rb/Sr
30
20
10
55
60
65
70
75
SiO2

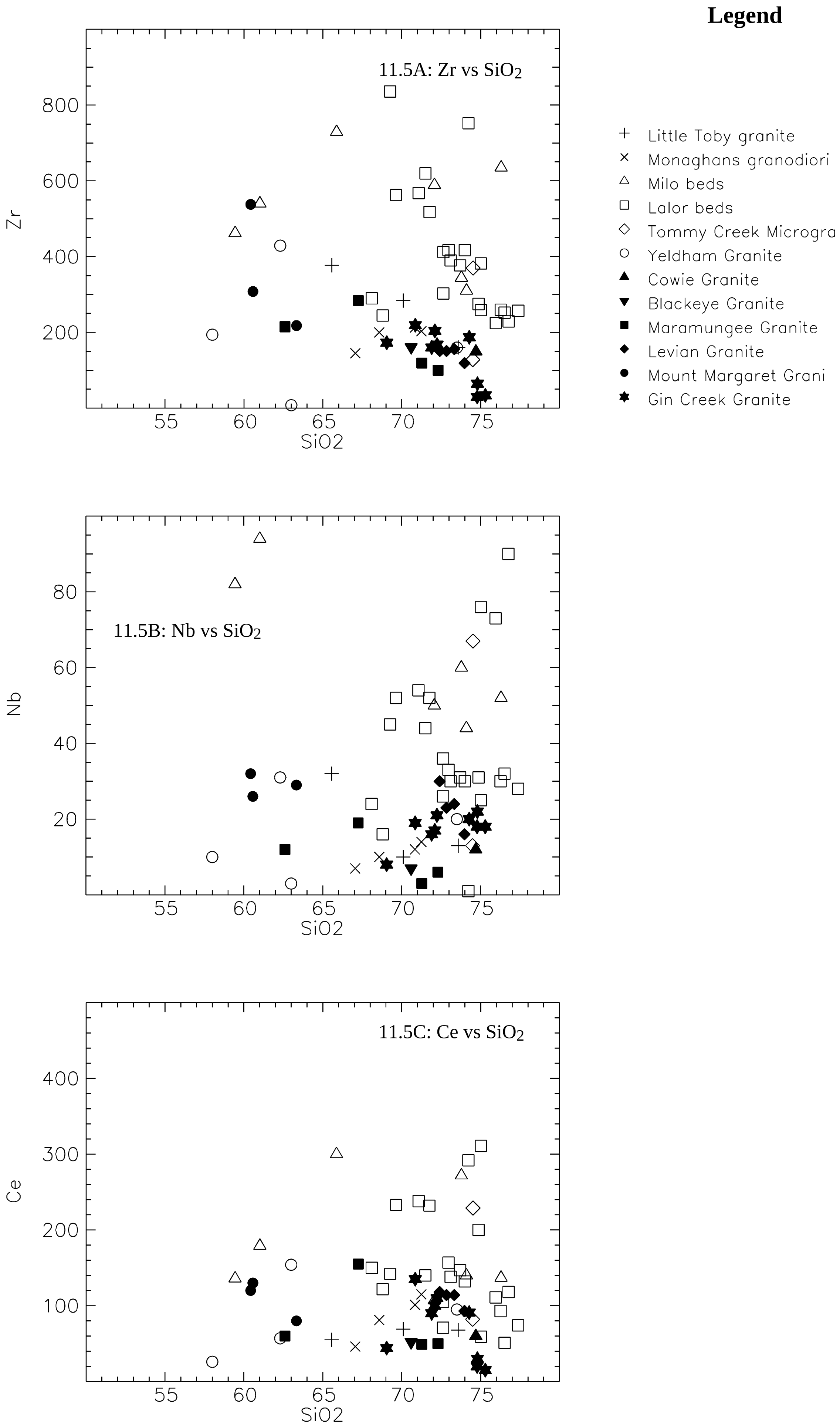
Legend

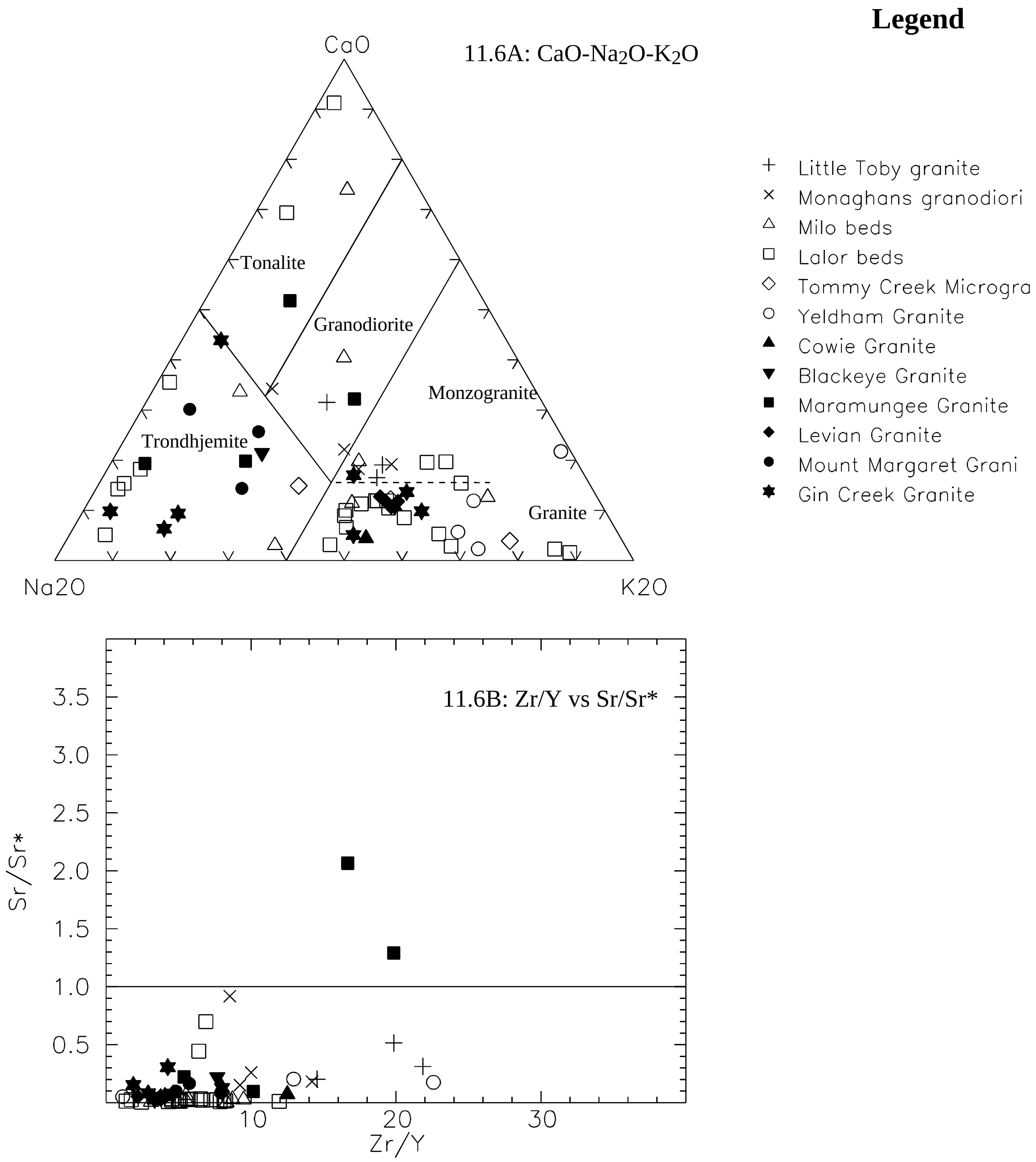

11.3J: Ba vs SiO2
Ba
SiO2
2000
1500
1000
500
55
60
65
70
75
Little Toby granite
Monaghans granodiori
Milo beds
Lalor beds
Tommy Creek Micrográ
Yeldham Granite
Cowie Granite
Blackeye Granite
Maramungee Granite
Levian Granite
Mount Margaret Grani
Gin Creek Granite


11.3K: F vs SiO2
F
SiO2
3000
2000
1000
55
60
65
70
75

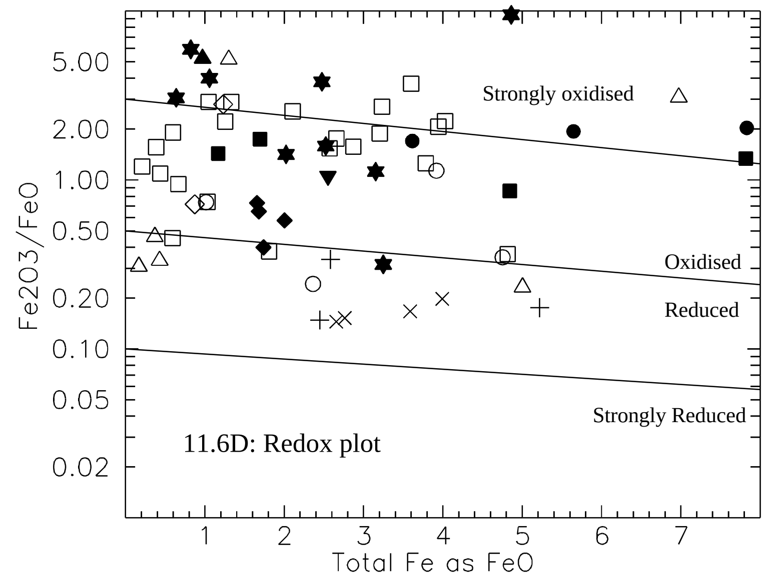

11.4A: Cu vs SiO2
Cu
SiO2
80
60
40
20
55
60
65
70
75


Legend
Little Toby granite
Monaghans granodiori
Milo beds
Lalor beds
Tommy Creek Microgra
Yeldham Granite
Cowie Granite
Blackeye Granite
Maramungee Granite
Levian Granite
Mount Margaret Grani
Gin Creek Granite
11.4B: Pb vs SiO2
Pb
SiO2
11.4C: Zn vs SiO2
Zn
SiO2
11.4D: Sn vs SiO2
Sn
SiO2

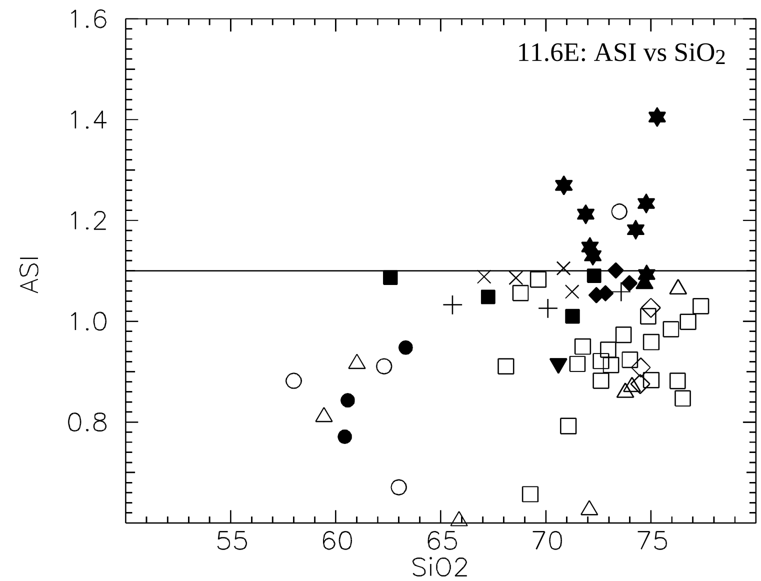

Legend
11.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
11.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
11.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2
Little Toby granite
Monaghans granodiori
Milo beds
Lalor beds
Tommy Creek Micrqgra
Yeldham Granite
Cowie Granite
Blackeye Granite
Maramungee Granite
Levian Granite
Mount Margaret Grani
Gin Creek Granite

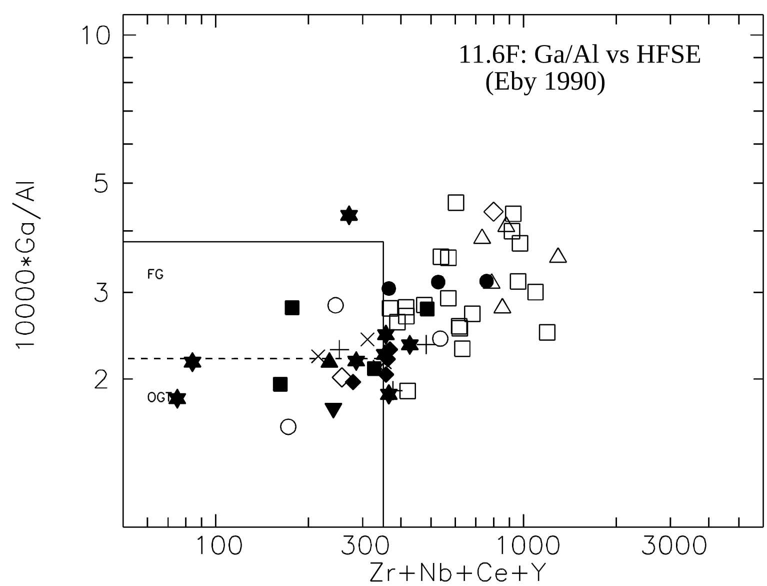

Legend
11.6A: CaO-Na2O-K2O
CaO
Na2O
K2O
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
Little Toby granite
Monaghans granodiori
Milo beds
Lalor beds
Tommy Creek Microgra
Yeldham Granite
Cowie Granite
Blackeye Granite
Maramungee Granite
Levian Granite
Mount Margaret Grani
Gin Creek Granite
11.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
Zr/Y
3.5
3.0
2.5
2.0
1.5
1.0
0.5
10
20
30

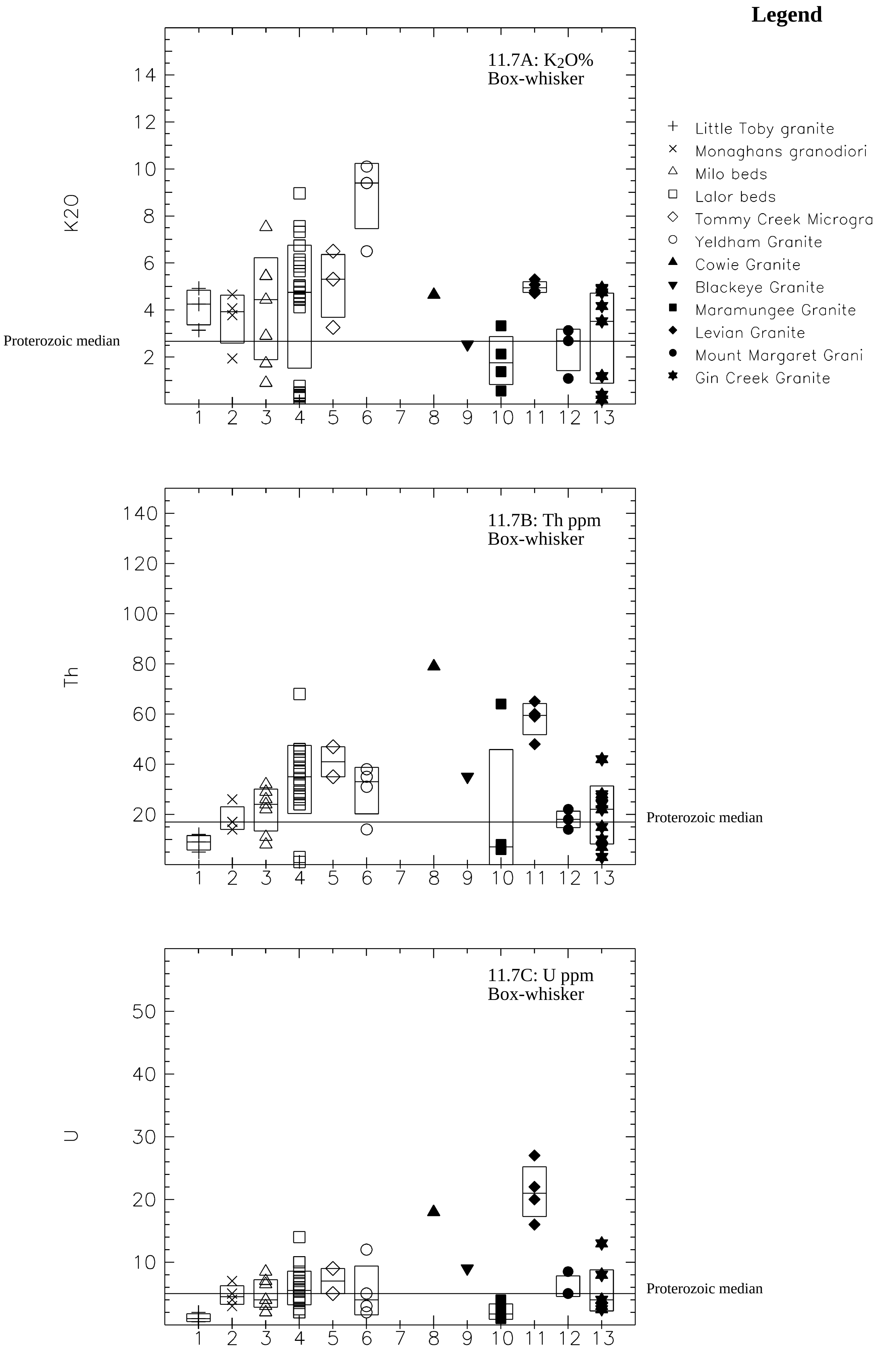
Legend


Strongly oxidised
Oxidised
Reduced
Strongly Reduced
11.6D: Redox plot
Fe2O3/FeO
5.00
2.00
1.00
0.50
0.20
0.10
0.05
0.02
1
2
3
4
5
6
7
Total Fe as FeO


Little Toby granite
Monaghans granodiori
Milo beds
Lalor beds
Tommy Creek Microgra
Yeldham Granite
Cowie Granite
Blackeye Granite
Maramungee Granite
Levian Granite
Mount Margaret Grani
Gin Creek Granite


11.6E: ASI vs SiO2
ASI
1.6
1.4
1.2
1.0
0.8
55
60
65
70
75
SiO2


11.6F: Ga/Al vs HFSE
(Eby 1990)
10000*Ga/Al
10
5
3
2
FG
OGT
100
300
1000
3000
Zr+Nb+Ce+Y


Legend
+ Little Toby granite
× Monaghans granodiori
△ Milo beds
□ Lalor beds
◇ Tommy Creek Microgra
○ Yeldham Granite
▲ Cowie Granite
▼ Blackeye Granite
■ Maramungee Granite
◆ Levian Granite
● Mount Margaret Grani
✱ Gin Creek Granite
11.7A: K_2O%
Box-whisker
K2O
Proterozoic median
11.7B: Th ppm
Box-whisker
Th
Proterozoic median
11.7C: U ppm
Box-whisker
U
Proterozoic median
1 2 3 4 5 6 7 8 9 10 11 12 13

Milo beds

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.94	72.07	6.79	59.44	76.3	7
TiO2	0.34	0.28	0.19	0.14	0.62	7
Al2O3	12.76	12.1	1.97	9.7	15.28	7
Fe2O3	1.86	0.96	2.41	0.04	5.7	7
FeO	1.56	0.33	1.8	0.13	4.14	7
MnO	0.07	0.05	0.08	01	0.24	7
MgO	0.43	0.11	0.6	0.02	1.42	7
CaO	2.9	2.52	2.1	0.24	6.04	7
Na2O	3.99	4.79	1.82	0.83	5.84	7
K2O	4.06	4.44	2.34	0.9	7.53	7
P2O5	0.04	0.04	0.03	01	0.09	7
H2O+	0.85	0.85	0.68	0.37	1.33	2
H2O-	0.2	0.2	0.11	0.12	0.27	2
CO2	0.6	0.6	-	0.6	0.6	1
LOI	3.15	2.85	1.25	1.7	5.11	5
Ba	874.71	471	1022.46	140	3050	7
Li	2.4	2	1.14	1	4	5
Rb	80.86	93	35.7	37	129	7
Sr	66	37	87.7	4	260	7
Pb	54.14	6	126.13	2	340	7
Th	21.71	24	8.99	8	32	7
U	5	4	2.36	2	8.5	7
Zr	515.57	540	152.95	310	729	7
Nb	73.57	60	31.88	44	133	7
Y	86.43	70	29.8	53	132	7
La	84.29	80	32.11	45	138	7
Ce	181.57	140	74.79	107	300	7
Pr	23.6	21	9.53	13	35	5
Nd	85	74.5	33.06	48	127	6
Sc	4.3	4	2.22		7	5
V	1		-			5
Cr	1.67		1.63			6
Mn	-	-	-	-	-	-
Co	5.17	2	7.28	2	20	6
Ni	2.4	3	1.34		4	5
Cu	42.57	3	74.34	2	200	7
Zn	49.71	5	94.97		260	7
Sn	2	1.5	1.26		4	6
W	7	8	3.61	3	12	5
Mo	3.2	3	1.89		6	5
Ga	25.2	26	6.69	17	33	5
As	3.2	1	3.98	0.5	10	5
S	260	53	450.41	43	1065	5
F	100	Â	-	Â	Â	5
Cl	375.4	328	296.44	74	765	5
Be	2.5	2	1.66		5	5
Ag	-	-	-	-	-	-
Bi	1		-			5
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	14	14	-	14	14	1
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Lalor beds

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.25	73.04	7.2	49.3	77.38	24
TiO2	0.43	0.28	0.51	0.09	2.2	24
Al2O3	12.58	12.53	1.42	8.65	17	24
Fe2O3	1.43	1.48	0.99	0.12	3.08	24
FeO	1.69	0.88	2.85	0.1	12.2	24
MnO	0.06	0.02	0.09	01	0.3	24
MgO	0.74	0.27	1.68	0.06	8	24
CaO	2.02	1.14	3.16	0.16	13.6	24
Na2O	3.97	3.67	1.86	0.91	7.48	24
K2O	4.14	4.75	2.67	0.25	8.96	24
P2O5	0.07	0.03	0.09	01	0.38	23
H2O+	0.88	0.78	0.56	0.23	1.68	6
H2O-	0.14	0.15	0.02	0.11	0.16	6
CO2	0.42	0.32	0.42	0.07	1.2	6
LOI	1.18	0.94	0.81	0.33	3.82	18
Ba	722.33	481	668.75	12	2137	24
Li	2.13	1	2.82		13	20
Rb	98.08	114	70.61	4	209	24
Sr	46.08	23	76.33	10	350	24
Pb	4.21	4	1.81		8	24
Th	33.92	35	13.88	1	68	24
U	5.88	5.5	2.73		14	24
Zr	382.79	340	179.56	110	836	24
Nb	37.79	31.5	20.26		90	24
Y	73.67	58.5	43.36	16	166	24
La	65.33	63.5	36.39		141	24
Ce	142.96	135	74.31	28	311	24
Pr	17.83	15.5	9.42	6	37	18
Nd	62.05	54.5	32.84	18	137	22
Sc	4.95	5	2.55		12	20
V	7.3	4	9.94		44	20
Cr	2.52		3.7		16	22
Mn	-	-	-	-	-	-
Co	5.38	4.5	5.64		27	20
Ni	3	3	1.45		5	20
Cu	10.25	4	25.14		127	24
Zn	8.67	5.5	8.61		35	24
Sn	2.73	2	2.55		12	22
W	9.25	4	13.36		52	16
Mo	2.06		0.98		4	18
Ga	20.25	18.5	4.85	13	30	20
As	1.85	1.5	1.89	0.5	9.5	20
S	90.5	28.5	241.58	14	1055	18
F	537.5	150	686.9	Â	2300	16
Cl	256.44	193.5	162.35	96	648	18
Be	2.89	2	2.05		7	18
Ag	1	1	-	1	1	2
Bi	0.97		0.12		1	18
Hf	15.5	15.5	9.19	9	22	2
Ta	2	2	1.41		3	2
Cs	4.79		3.75		12	7
Ge	1	1	0.71	0.5	1.5	2
Se	0.5	0.5	-	0.5	0.5	2

Tommy Creek Microgranite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.67	74.52	0.28	74.5	75	3
TiO2	0.19	0.17	0.07	0.13	0.26	3
Al2O3	11.78	12.2	1.03	10.6	12.53	3
Fe2O3	1.99	0.98	2.28	0.38	4.6	3
FeO	0.44	0.44	0.13	0.35	0.53	2
MnO	0.02	0.01	0.01	02	0.03	3
MgO	0.39	0.31	0.19	0.25	0.61	3
CaO	0.99	1.25	0.58	0.33	1.4	3
Na2O	3.35	3.67	1.57	1.65	4.74	3
K2O	5.02	5.31	1.64	3.26	6.5	3
P2O5	0.03	0.03	0.02	02	0.05	3
H2O+	0.28	0.28	0.11	0.2	0.36	2
H2O-	0.2	0.2	-	0.2	0.2	1
CO2	0.75	0.75	-	0.75	0.75	1
LOI	0.99	0.99	-	0.99	0.99	1
Ba	771	687	690.84	126	1500	3
Li	2	2	-	2	2	1
Rb	129	115	50.48	87	185	3
Sr	31.33	31	8.5	23	40	3
Pb	2.17	2	0.29		2	3
Th	41	41	8.49	35	47	2
U	7	7	2.83	5	9	2
Zr	249	249	171.12	128	370	2
Nb	40	40	38.18	13	67	2
Y	83	83	69.3	34	132	2
La	80	80	43.84	49	111	2
Ce	155.5	155.5	103.94	82	229	2
Pr	-	-	-	-	-	-
Nd	32	32	-	32	32	1
Sc	1		-			1
V	5.75	5.75	6.01		10	2
Cr	122.5	122.5	123.74	35	210	2
Mn	-	-	-	-	-	-
Co	2.5		-			1
Ni	4.75	4.75	3.18		7	2
Cu	9	9	1.41	8	10	2
Zn	7.5	7.5	3.54	5	10	2
Sn	6.5	6.5	3.54	4	9	2
W	-	-	-	-	-	-
Mo	1.5		-			1
Ga	21	21	11.31	13	29	2
As	0.75	0.75	0.35		1	2
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	1		-			1
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	1		-			1

Little Toby granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.75	70.1	4.02	65.56	73.58	3
TiO2	0.45	0.35	0.26	0.26	0.74	3
Al2O3	14.48	14.97	1.14	13.18	15.29	3
Fe2O3	0.59	0.67	0.24	0.32	0.79	3
FeO	2.88	2.16	1.41	1.98	4.51	3
MnO	0.05	0.06	0.01	0.04	0.06	3
MgO	0.65	0.44	0.39	0.4	1.1	3
CaO	2.21	1.99	0.87	1.48	3.17	3
Na2O	3.51	3.54	0.25	3.24	3.74	3
K2O	4.1	4.25	0.9	3.14	4.92	3
P2O5	0.12	0.07	0.08	0.07	0.21	3
H2O+	0.69	0.59	0.19	0.58	0.91	3
H2O-	0.09	0.09	0.01	0.09	0.1	3
CO2	0.07	0.07	0.02	0.05	0.08	3
LOI	-	-	-	-	-	-
Ba	1330.33	1493	499.29	770	1728	3
Li	10	11	2.65	7	12	3
Rb	134	117	38.43	107	178	3
Sr	191.67	192	71.5	120	263	3
Pb	21	16	9.54	15	32	3
Th	8.67	9	3.51	5	12	3
U	1.17	1	0.76		2	3
Zr	273.67	284	108.87	160	377	3
Nb	18.33	13	11.93	10	32	3
Y	14.33	13	4.16	11	19	3
La	38.33	40	7.64	30	45	3
Ce	64	68	7.81	55	69	3
Pr	-	-	-	-	-	-
Nd	26.33	26	1.53	25	28	3
Sc	2	2	1		3	3
V	16.67	11	11.59	9	30	3
Cr	5.67	6	0.58	5	6	3
Mn	-	-	-	-	-	-
Co	7.67	6	3.79	5	12	3
Ni	2.33	2	1.53	1	4	3
Cu	10	9	2.65	8	13	3
Zn	38	26	21.66	25	63	3
Sn	1		-			3
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	16.67	16	2.08	15	19	3
As	0.5		-			3
S	-	-	-	-	-	-
F	900	900	141.42	800	1000	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Monaghans granite

`

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.43	69.71	1.97	67.06	71.25	4
TiO2	0.45	0.45	0.09	0.36	0.55	4
Al2O3	14.84	14.6	0.96	13.98	16.15	4
Fe2O3	0.48	0.44	0.15	0.34	0.67	4
FeO	2.82	2.78	0.51	2.35	3.39	4
MnO	0.06	0.06	-	0.05	0.06	4
MgO	0.85	0.84	0.26	0.57	1.15	4
CaO	2.24	2	0.7	1.71	3.25	4
Na2O	3.69	3.69	0.5	3.09	4.3	4
K2O	3.61	3.93	1.17	1.94	4.66	4
P2O5	0.16	0.16	0.06	0.1	0.21	4
H2O+	0.87	0.86	0.08	0.77	0.97	4
H2O-	0.07	0.08	0.02	0.05	0.09	4
CO2	0.06	0.06	0.03	0.03	0.09	4
LOI	-	-	-	-	-	-
Ba	665.75	743.5	175.97	403	773	4
Li	7.75	7.5	0.96	7	9	4
Rb	167.25	173.5	32.86	122	200	4
Sr	222.25	172	114.79	152	393	4
Pb	25.75	26.5	8.3	15	35	4
Th	18.5	17	5.2	14	26	4
U	4.75	4.5	1.71	3	7	4
Zr	190.25	201.5	30.67	145	213	4
Nb	10.75	11	2.99	7	14	4
Y	18.5	18.5	3.11	15	22	4
La	48.25	51	16.74	26	65	4
Ce	85.75	91	29.95	46	115	4
Pr	-	-	-	-	-	-
Nd	33.5	34.5	9.68	21	44	4
Sc	4.75	5	1.26	3	6	4
V	34.75	30.5	13.94	24	54	4
Cr	6.5	6.5	1.29	5	8	4
Mn	-	-	-	-	-	-
Co	8.75	8.5	2.5	6	12	4
Ni	3.25	3	0.5	3	4	4
Cu	5	4.5	2.16	3	8	4
Zn	44.75	44	8.18	36	55	4
Sn	4.75	4	2.99	2	9	4
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	17.5	17.5	1.73	16	19	4
As	0.5		-			4
S	-	-	-	-	-	-
F	650	650	212.13	500	800	2
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Yeldham Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	64.2	62.65	6.58	58	73.5	4
TiO2	0.53	0.53	0.44	0.12	0.92	4
Al2O3	13.8	13.4	1.09	13	15.4	4
Fe2O3	1.1	0.87	0.83	0.45	2.2	4
FeO	2.03	1.94	1.23	0.61	3.62	4
MnO	0.06	0.06	0.03	0.03	0.11	4
MgO	2.18	2.08	0.84	1.28	3.3	4
CaO	1.37	1.3	1.09	0.21	2.67	4
Na2O	2.42	2.81	1.61	0.21	3.87	4
K2O	8.85	9.4	1.6	6.5	10.1	4
P2O5	0.18	0.16	0.12	0.06	0.32	4
H2O+	1.28	1.06	0.73	0.67	2.34	4
H2O-	0.21	0.21	0.05	0.15	0.28	4
CO2	1.55	1.42	1.51	0.05	3.3	4
LOI	-	-	-	-	-	-
Ba	650.5	533	337.12	391	1145	4
Li	9.33	7	4.93	6	15	3
Rb	216.75	217.5	31.62	182	250	4
Sr	63.5	58.5	21.7	44	93	4
Pb	13.75	16.5	6.55	4	18	4
Th	29.5	33	10.72	14	38	4
U	5.5	4	4.51	2	12	4
Zr	197.75	177	174.09	8	429	4
Nb	16	15	12.19	3	31	4
Y	12.75	12.5	5.32	7	19	4
La	55.25	58.5	37.99	11	93	4
Ce	83	76	55.11	26	154	4
Pr	-	-	-	-	-	-
Nd	29.67	26	18.77	13	50	3
Sc	9.33	8	6.11	4	16	3
V	59.5	40	62.24		148	4
Cr	22.67	27	12.1	9	32	3
Mn	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	16.33	8	17.1	5	36	3
Cu	6.75	5.5	4.35	3	13	4
Zn	16	15	6.68	10	24	4
Sn	2.75	3	1.26		4	4
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	17	17	6	11	23	3
As	1		0.87		2	3
S	-	-	-	-	-	-
F	500	500	-	500	500	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Cowie Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.7	74.7	-	74.7	74.7	1
TiO2	0.1	0.1	-	0.1	0.1	1
Al2O3	13.1	13.1	-	13.1	13.1	1
Fe2O3	0.89	0.89	-	0.89	0.89	1
FeO	0.17	0.17	-	0.17	0.17	1
MnO	0.01	0.01	-	0.01	0.01	1
MgO	0.44	0.44	-	0.44	0.44	1
CaO	0.4	0.4	-	0.4	0.4	1
Na2O	3.97	3.97	-	3.97	3.97	1
K2O	4.65	4.65	-	4.65	4.65	1
P2O5	0.04	0.04	-	0.04	0.04	1
H2O+	0.3	0.3	-	0.3	0.3	1
H2O-	0.2	0.2	-	0.2	0.2	1
CO2	0.11	0.11	-	0.11	0.11	1
LOI	-	-	-	-	-	-
Ba	120	120	-	120	120	1
Li	-	-	-	-	-	-
Rb	200	200	-	200	200	1
Sr	30	30	-	30	30	1
Pb	55	55	-	55	55	1
Th	79	79	-	79	79	1
U	18	18	-	18	18	1
Zr	150	150	-	150	150	1
Nb	12	12	-	12	12	1
Y	12	12	-	12	12	1
La	30	30	-	30	30	1
Ce	60	60	-	60	60	1
Pr	-	-	-	-	-	-
Nd	8	8	-	8	8	1
Sc	1		-			1
V	3	3	-	3	3	1
Cr	5	5	-	5	5	1
Mn	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	2	2	-	2	2	1
Cu	13	13	-	13	13	1
Zn	18	18	-	18	18	1
Sn	2	2	-	2	2	1
W	-	-	-	-	-	-
Mo	1.5		-			1
Ga	15	15	-	15	15	1
As	0.5		-			1
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Blackeye Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.6	70.6	-	70.6	70.6	1
TiO2	0.32	0.32	-	0.32	0.32	1
Al2O3	14.1	14.1	-	14.1	14.1	1
Fe2O3	1.38	1.38	-	1.38	1.38	1
FeO	1.31	1.31	-	1.31	1.31	1
MnO	0.04	0.04	-	0.04	0.04	1
MgO	0.89	0.89	-	0.89	0.89	1
CaO	2.17	2.17	-	2.17	2.17	1
Na2O	5.42	5.42	-	5.42	5.42	1
K2O	2.54	2.54	-	2.54	2.54	1
P2O5	0.09	0.09	-	0.09	0.09	1
H2O+	0.68	0.68	-	0.68	0.68	1
H2O-	0.21	0.21	-	0.21	0.21	1
CO2	0.25	0.25	-	0.25	0.25	1
LOI	-	-	-	-	-	-
Ba	382	382	-	382	382	1
Li	3	3	-	3	3	1
Rb	64	64	-	64	64	1
Sr	95	95	-	95	95	1
Pb	5	5	-	5	5	1
Th	35	35	-	35	35	1
U	9	9	-	9	9	1
Zr	161	161	-	161	161	1
Nb	7	7	-	7	7	1
Y	21	21	-	21	21	1
La	40	40	-	40	40	1
Ce	52	52	-	52	52	1
Pr	-	-	-	-	-	-
Nd	17	17	-	17	17	1
Sc	4	4	-	4	4	1
V	36	36	-	36	36	1
Cr	33	33	-	33	33	1
Mn	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	21	21	-	21	21	1
Cu	12	12	-	12	12	1
Zn	10	10	-	10	10	1
Sn	1		-			1
W	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	13	13	-	13	13	1
As	1	1	-	1	1	1
S	-	-	-	-	-	-
F	200	200	-	200	200	1
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Levian Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	73.14	73.08	0.67	72.41	73.98	4
TiO2	0.15	0.15	0.01	0.14	0.17	4
Al2O3	13.77	13.83	0.25	13.42	14	4
Fe2O3	0.67	0.71	0.11	0.51	0.76	4
FeO	1.16	1.17	0.16	1	1.32	4
MnO	0.02	0.02	0.01	0.02	0.03	4
MgO	0.33	0.34	0.03	0.28	0.35	4
CaO	1.13	1.11	0.07	1.07	1.23	4
Na2O	3.5	3.51	0.17	3.31	3.67	4
K2O	4.98	4.95	0.26	4.71	5.3	4
P2O5	0.14	0.15	0.04	0.08	0.17	4
H2O+	0.45	0.53	0.2	0.22	0.59	3
H2O-	0.12	0.03	0.18	01	0.33	3
CO2	0.04	0.05	0.02	0.02	0.05	3
LOI	0.55	0.55	-	0.55	0.55	1
Ba	335.25	349.5	39.03	278	364	4
Li	8	7.5	2.94	5	12	4
Rb	288	285	16.89	274	308	4
Sr	51.5	53.5	5.8	43	56	4
Pb	29.75	27.5	6.29	25	39	4
Th	58	59.5	7.16	48	65	4
U	21.25	21	4.57	16	27	4
Zr	144.25	151	17	119	156	4
Nb	23.25	23.5	5.74	16	30	4
Y	64.25	66	9.91	51	74	4
La	56.75	59	5.25	49	60	4
Ce	109.75	114	11.32	93	118	4
Pr	10	10	-	10	10	1
Nd	42	42	-	42	42	1
Sc	5.25	5	0.5	5	6	4
V	7.25	7.5	0.96	6	8	4
Cr	3.75	3.5	1.71	2	6	4
Mn	144	144	-	144	144	1
Co	4.67	5	0.58	4	5	3
Ni	1.5	1.5	0.58		2	4
Cu	4.5	4	1.73	3	7	4
Zn	10.75	10.5	1.71	9	13	4
Sn	4	4.5	1.41	2	5	4
W	-	-	-	-	-	-
Mo	1.38		0.25			4
Ga	15.5	15.5	1.29	14	17	4
As	6.38		11.75		24	4
S	180	180	-	180	180	1
F	600	700	173.21	400	700	3
Cl	-	-	-	-	-	-
Be	3	3	-	3	3	1
Ag	1	1	-	1	1	1
Bi	1		-			1
Hf	5	5	-	5	5	1
Ta	5	5	-	5	5	1
Cs	6	6	-	6	6	1
Ge	5	5	-	5	5	1
Se	0.5		-			1

Mount Margaret Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	61.44	60.57	1.64	60.43	63.33	3
TiO2	1.03	1.15	0.24	0.76	1.19	3
Al2O3	16.16	16.15	1.16	15.01	17.33	3
Fe2O3	4.02	3.99	1.6	2.43	5.63	3
FeO	2.09	2.06	0.67	1.43	2.77	3
MnO	0.09	0.09	0.01	0.09	0.1	3
MgO	1.01	1.16	0.35	0.61	1.25	3
CaO	2.95	3.09	1.1	1.79	3.98	3
Na2O	7.3	7.53	0.96	6.25	8.13	3
K2O	2.3	2.69	1.07	1.09	3.13	3
P2O5	0.36	0.35	0.06	0.31	0.42	3
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	0.87	0.77	0.22	0.72	1.12	3
Ba	659.33	762	289.02	333	883	3
Li	2.33	2	0.58	2	3	3
Rb	59	67	24.02	32	78	3
Sr	107.67	115	12.7	93	115	3
Pb	4	4	1	3	5	3
Th	18	18	4	14	22	3
U	6.17	5	2.02	5	8.5	3
Zr	354.67	308	165.03	218	538	3
Nb	29	29	3	26	32	3
Y	56.67	64	16.29	38	68	3
La	54.67	59	10.21	43	62	3
Ce	110	120	26.46	80	130	3
Pr	10.33	12	2.89	7	12	3
Nd	44.67	51	12.74	30	53	3
Sc	14.67	15	4.51	10	19	3
V	25	22	22.65	4	49	3
Cr	2.17	2	1.76		4	3
Mn	686.67	669	58.53	639	752	3
Co	-	-	-	-	-	-
Ni	1.17	1	0.76		2	3
Cu	23.33	11	22.23	10	49	3
Zn	23	23	-	23	23	3
Sn	2	2	1		3	3
W	-	-	-	-	-	-
Mo	1		-			3
Ga	26.67	27	1.53	25	28	3
As	1.83	1.5	0.58	1.5	2.5	3
S	66.67	60	50.33	20	120	3
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	2.67	3	1.53	1	4	3
Ag	1.5	2	0.87		2	3
Bi	1		-			3
Hf	8.33	7	4.16	5	13	3
Ta	1		-			3
Cs	2.33		1.44		4	3
Ge	1.58	2	1.18	50	2.5	3
Se	0.5		-			3

Gin Creek Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.81	72.24	2.12	69.05	75.3	9
TiO2	0.25	0.26	0.16	0.03	0.49	9
Al2O3	13.87	13.83	0.42	13.2	14.5	9
Fe2O3	1.63	1.26	1.32	0.52	4.84	9
FeO	0.85	0.56	0.79	0.13	2.53	9
MnO	0.02	0.02	0.01	0.01	0.04	8
MgO	0.67	0.7	0.44	0.21	1.7	9
CaO	0.9	0.83	0.35	0.43	1.39	9
Na2O	3.97	3.29	1.78	1.46	7.08	9
K2O	2.8	3.52	2.03	0.2	4.94	9
P2O5	0.28	0.2	0.23	0.09	0.85	9
H2O+	0.8	0.81	0.17	0.59	1.05	5
H2O-	0.2	0.21	0.07	0.11	0.3	5
CO2	0.09	0.09	0.06	0.02	0.17	5
LOI	1.18	1.18	0.22	0.94	1.41	4
Ba	391.33	140	395.62	27	1024	9
Li	6.33	6.5	4.13	2	11	6
Rb	163	200	113.94	9	313	9
Sr	47.33	30	26.55	20	85	9
Pb	8.78	9	7.33		24	9
Th	19.78	22	12.25	3	42	9
U	5.5	4	3.48	2.5	13	9
Zr	137.78	168	73.94	30	219	9
Nb	17.67	18	4.09	8	22	9
Y	35.22	44	20.15	8	58	9
La	31.67	30	22.45		62	9
Ce	70.56	90	43.82	15	135	9
Pr	7	5.5	6.48		16	4
Nd	28.44	29	18.74		56	8
Sc	9.25	6	10.67	2	35	8
V	19.5	21.5	13.97		43	8
Cr	7.06	6	5.06		16	8
Mn	95.67	70	54.26	59	158	3
Co	7.33	8	2.08	5	9	3
Ni	4.56	4	4.07		13	8
Cu	17.88	5	35.7	2	106	8
Zn	15.25	14	9.13	5	26	8
Sn	8.33	3	15.65		50	9
W	5.67	5	2.08	4	8	3
Mo	1.93		1.13		4	7
Ga	17.88	16	6.31	13	33	8
As	0.78	1	0.31	50	1	8
S	17.8	20	16.19		38	5
F	1300	1300	707.11	800	1800	2
Cl	374	374	82.02	316	432	2
Be	3.5	4	2.24		6	5
Ag	1	1	-	1	1	3
Bi	0.9		0.22		0.5	5
Hf	3.33	3	2.52		6	3
Ta	4.33	4	1.53	3	6	3
Cs	4		3.39		9	4
Ge	2.17	1	2.02	1	4.5	3
Se	0.5		-			3