1 PATERSON OROGEN SYNTHESIS

Compiled by Lesley Wyborn

1.1 Executive Summary - Geology

The Paterson Orogen contains Telfer, one of Australia's largest Au deposits hosted by Proterozoic sediments, as well as the Kintyre U deposit and the Nifty Cu deposit. The regional geology of the Paterson Orogen was reviewed by Hickman *et al*. (1994) and substantially modified by Bagas *et al*. (1995).

The Paterson Orogen consists of two major packages of rocks. The older package is the Rudall Complex, which contains two distinguishable units: older banded orthogneiss (50% of outcrop) and paragneiss, and younger quartzite and schist. The Rudall Complex contains some highly reactive rock types including graphitic schist and quartz-magnetite rock. The Rudall Complex has been highly deformed and metamorphosed, in some areas up to granulite facies.

The younger package, formerly called the Yeneena Group, has been subdivided into three groups (Bagas *et al*. 1995): the Lamil Group in the north, the Throssell Group in the west to southwest and the much younger Tarcunyah Group overlying the Throssell Group. The Lamil Group occurs mainly in the Telfer area and contains what has been informally called the 'Telfer Succession'. The Telfer Succession contains highly reactive dolomite and calcareous rocks, with quartzite and some carbonaceous and pyritic shale. The Throssell Group contains the Broadhurst Formation, host to the Nifty Cu mineralisation.

The earliest known granites were emplaced at around 1910 Ma. Although an older age has been documented at ~ 2015 Ma, this is thought to be inherited (Bagas and Smithies 1996). A major period of granite intrusion, the Kalkan Supersuite, occurred at around ~ 1780 Ma. A suite of poorly known granites, the Krackatinny Supersuite, on TABLETOP and western RUDALL was possibly emplaced at between 1490 and 1310 Ma (Smithies and Bagas 1997). The most metallogenically important suite, the O'Callaghans Supersuite, was emplaced at ~ 625 Ma and is thought by some to be related to the Telfer Au deposit.

1.2 Executive Summary - Metallogenic Potential

The assessment of the potential of each granite suite in the Paterson Orogen based on the criteria set out in the Project Proposal has been hindered by the limited data available, particularly for the granites in the southern part. Suites identified as having some potential for granite-related mineralisation are:

The <u>Kalkan Supersuite</u> at ~1780 Ma, which shows some indications of fractionation. Potential on current information is equivocal, but areas surrounding this suite may be worth some follow-up exploration.

The <u>Krackatinny Supersuite</u> at ~ 1310 Ma (?) which crops out in the far east of the Orogen, mainly on TABLETOP. Data on this suite are very limited, and exposures are scattered amongst sand dunes. The granites appear to intrude rocks of the Rudall Complex. Some banded quartz-magnetite-amphibole gneiss occurs in the vicinity and are clearly potential hosts for mineralisation. It is to be stressed that there are insufficient data to confidently recommend this suite for further exploration, but there are enough sufficiently interesting characteristics both in the granite and their hosts to argue that further investigations in this area may be profitable.

The <u>O'Callaghans Supersuite</u> at ~ 625 Ma has a proven spatial relationship with mineralisation. The Supersuite shows fractionation and evidence for the activity of a fluid phase. It can be divided into two suites: the oxidised Mount Crofton Suite, which contains magnetite, but very little mineralisation, and the reduced O'Callaghans Suite which is ilmenite-stable. Any fluids which came off the O'Callaghans Suite would be reduced and have potential to carry Au, Cu,W and Mo. Exploration to date has focused on targets similar in composition to the hosts of the mineralisation at Telfer. However, some mineralisation may be associated with the more oxidised Mount Crofton Suite. If so, the host rocks could have a different composition, and the resultant mineralisation may be more Cu-rich.

1.3 Future Work

More sampling is required on the granites, particularly on TABLETOP. The orthogneiss of the Rudall Complex has barely been investigated chemically ,and needs more chemical work to fully assess its potential.

1.4 Methods

Information Sources: Ph.D theses, 1:250 000 maps and notes, 1:100 000 maps and commentaries where available, published ages, AGSO OZCHEM database supplemented with data from the GSWA, AGSO Minloc database, AGSO magnetics and gravity.

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, three supersuites have been defined. (Table 1.1). They have been given 'supersuite' status as there is insufficient geochemical and geochronological information available to define these units as suites within the strict definition.

Host Rocks: The country rocks which are thought to be intruded by each supersuite have been summarised, and classified according to mineralogical characteristics thought to be important in determining the metallogenic potential of a granite intrusive event. In the southern Paterson Orogen, particularly in the Rudall Complex, identification of potentially reactive host rocks within the vicinity of the granites has proved difficult due to high metamorphic grade in some areas, combined with limited outcrops.

Relating Mineralisation: Again this has been difficult in the southern Paterson Orogen, particularly in the Rudall Complex. Known occurrences of mineralisation are not in the vicinity of areas where geochemical and petrological data are available.

1.5 Acknowledgements

This section has benefited greatly from help provided by Hugh Smithies and Leon Bagas of the GSWA who provided data, preliminary notes and much assistance on the telephone. Anyone interested in following up data on this area should contact these two people. Thanks also to discussions held over the years to Nicky Netherway (née Goellnicht) on the granites of the Telfer region, and special thanks to Newcrest who paid for a trip to the Telfer area to enable me to see what these granites actually look like in their field context.

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1.7 Table 1.1

Chpt #	Grouping (Type)	Age (Ma)	Potential					Confid Level	Pluton
			Cu	Au	Pb/Zn	Sn	Mo/W		
2	Kalkan (Cullen?)	1780	Mod	Mod	Low	Low	Mod	111	PRga
									PRgh
									PRgp
									PRgm
									PRgg
									PRgb
									PRge
									PRgd
									PRgo
3	Krackatinny (Sally Downs)	1310-1490	Mod	Mod	Low	Low	Mod	110	Krackatinny Tonalite
									Kutakuta Tonalite
									Harbutt Leucogranite
									Runton Adamellite
4	**O'Callaghans** (Cullen)	**625**	**High**	**High**	Low	Low	Mod	323	Mount Crofton Granite
									Hansens Folly Gneiss
									Desert's Revenge Granite
									O'Callaghans Granite
									Tyama Granite
									Minyari Granite
									Koolyu Granite

2 KALKAN SUPERSUITE

2.1 Timing

~ 1780 Ma

2.2 Individual Ages

Primary Ages:

1.	Granodiorite gneiss (Dunn Creek west)[1]	1802 ± 14 Ma, U-Pb
2.	Monzonite gneiss (Graphite Valley)[1]	1801 ± 4 Ma, U-Pb
3.	Monzogranite gneiss (Poynton Creek)[1]	1795 ± 11 Ma, U-Pb
4.	Monzonite gneiss (Larry Creek)[2]	1792 ± 9 Ma, U-Pb
5.	Granodiorite gneiss (Rooney Creek)[1]	1790 ± 17 Ma, U-Pb
6.	Biotite monzogranite (Watrara Inlier)[1]	1787 ± 5 Ma, U-Pb
7.	Syenogranite gneiss (Green Pygmy)[1]	1787 ± 12 Ma, U-Pb
8.	Granodiorite gneiss (Poonemerlarra Ck)[1]	1778 ± 17 Ma, U-Pb
9.	Meta-aplite dyke (Rudall airstrip)[1]	1778 ± 16 Ma, U-Pb
10.	Orthogneiss (near South Rudall Dome)[2]	1777± 7 Ma, U-Pb
11.	Monzonite gneiss (Graphite Valley)[1]	1775 ± 10 Ma, U-Pb
12.	Granodiorite gneiss (Cotton Creek)[1]	1769 ± 7 Ma, U-Pb
13.	Biotite monzogranite (Split Rock)[1]	1765 ± 15 Ma, U-Pb

Sources: [1] Nelson (1995), [2] Nelson (1996).

2.3 Regional Setting

The Kalkan Supersuite intrudes the Rudall Complex, the older of the two major rock packages in the Paterson Orogen. The Rudall Complex has a long and involved history of multiple deformation, and contains two distinguishable units: older banded orthogneiss and paragneiss, and younger quartzite and schist. Approximately 50% of the Rudall Complex comprises orthogneiss, of which the Kalkan Supersuite is the predominant unit.

In the metasedimentary units, the oldest unit, the Larry Creek Formation, consists of quartz-feldspar-mica paragneiss which is conformably overlain by the Fingoon Quartzite, a sequence of quartzite and minor mica schist. This unit is conformably overlain by the Yandagooge Formation, which is predominantly a pelitic assemblage of quartz, muscovite schist and contains the highly reactive Cassandra Member, a unit of iron-rich graphitic pelitic schist, banded iron formation and chert. The Yandagooge Formation is overlain in turn by the Butler Creek Formation, a sequence of banded paragneiss and minor amphibole-chlorite schist, and then by the Poynton Formation, a unit comprising quartzite and quartz-feldspar-mica gneiss. The Kalkan Supersuite intruded mainly into the Yandagooge Formation and the Butler Creek Formation as a series of interlayered sheets.

2.4 Summary

There are sufficient data to clearly define the Kalkan Supersuite as a fractionated oxidised I-(granodioritic) type. It has the characteristic large K-feldspar augen and the typical Sr-depleted, Y-undepleted trace-element pattern of Australian Proterozoic granites. However, beyond that the geochemical and more importantly the petrographic data are sparse.

2.5 Potential

The assessment of this suite has been very difficult. From a personal visit, the rocks are reminiscent of the Sybella type which are dominant throughout Australia during the period 1760 to 1650 Ma, and as such, their potential would be down-graded. However, there are no fluorine data available to confirm this classification and there are no petrographic descriptions that mention fluorite nor do they mention the presence of ‘rapakivi’ textures (albite rims around K-feldspars which can be taken as an indicator of high F content). Smithies (*pers. comm.* 1997) has checked 15 thin sections and did not find fluorite or rapakivi textures. For this reason we have classified the suite as ‘Cullen type’, based also in part on the spatial association with Au, Mo and Bi prospects. The host rocks surrounding the Kalkan Supersuite also contain reactive hosts such as quartz-magnetite rocks and graphitic schist.

For all these reasons we have given units of this Supersuite a relatively high classification. Note this rating is based on a limited amount of data (and feminine intuition is not a scientific methodolgy!!).

Cu:	**Moderate**
Au:	**Moderate**
Pb/Zn:	**Low**
Sn:	**Low**
Mo/W:	**Moderate**
Confidence Level:	**111**

2.6 Descriptive Data

Location: This suite crops out on the southern Paterson Orogen, mainly on RUDALL . It also extends onto northeastern GUNANYA, southwestern TABLETOP and northwestern RUNTON.

Dimensions and area: The Kalkan Supersuite extends in a south-southeasterly belt 140 km long by 50 km wide. Total area covered by the Supersuite is 704 km^2.

2.7 Intrusives

Component plutons: No units have been formally named and the Supersuite consists of the following units (preceeded by the relevant 1:100 000 Sheet names):

Broadhurst: PRga, PRgm, PRgp
Rudall: PRga, PRgm, PRgp, PRgg, PRgb, PRge, PRgd
Connaughton: PRga, PRgm, PRgh, PRgo
Throssell: PRga
Gunanya: PRga

Form: Intruded as a series of large elongate sheets that form fairly continuous outcrop. Smithies, however, suggests that the sheets are probably thrust slices, not intrusive sheets (*pers. comm.* 1997).

Metamorphism and Deformation: High degree of deformation and metamorphism throughout. The Supersuite shows strong evidence of the effects of D_2 deformation and all textures described are recrystallised.

Dominant intrusive rock types: The dominant rock type is a coarse-grained K-feldspar augen gneiss. *Specifically:* PRga - augen gneiss, even-grained gneiss, orthogneiss. PRgm - muscovite-rich orthogneiss. PRgo - compositionally layered orthogneiss with layers of quartz-feldspar-muscovite-biotite gneiss alternating with biotite-rich gneiss, quartz-feldspar gneiss and gneissic pegmatite. PRgp - pegmatite. PRgh - amphibole-bearing orthogneiss. PRgb - banded garnetiferous granodioritic othogneiss. PRge - even-grained monzogranitic orthogneiss. PRgd - biotite granodioritic orthogneiss.

Colour: Pink.

Veins, Pegmatites, Aplites, Greisens: Aplites have been recorded. Pegmatites are also prominent, but probably formed during metamorphism (Smithies, *pers. comm.* 1997), as has been described in the Sybella Suite in the Mount Isa Inlier. *Specifically:* PRga - on the Broadhurst 1:100 000 sheet area orthogneiss is complexly interlayered with quartz + microcline rock that is interpreted to be a pre-D_2 pegmatite. A broad zone of aplite and microgranite stockworks and microgranite veins occurs within a radius of 10 km southeast and southwest of Rudall Crossing. PRgp - aplite and pegmatite are constituents, but are too small to map.

Distinctive mineralogical characteristics: Rocks of the Kalkan Supersuite are dominated by megacrysts of K-feldspar. The dominant ferromagnesian mineral is biotite, with some hornblende. *Specifically:* PRga - microcline, quartz, plagioclase, biotite; commonly contains megacrystic K-feldspar and some muscovite and hornblende; accessory zircon, garnet, titanite, allanite, apatite and opaques. PRgm - quartz, microcline, plagioclase, muscovite, biotite ± garnet. PRgx - quartz, microcline, plagioclase, muscovite, biotite. PRgp - quartz, plagioclase, and muscovite in quartz-rich varieties.

Breccias: None recorded.

Alteration in the granite: *Specifically*: PRga - plagioclase grains partly to completely altered to sericite and epidote.

2.8 Extrusives

None recorded.

2.9 Country Rock

Contact metamorphism: Post-intrusive metamorphism and deformation have destroyed original contact metamorphic textures and assemblages.

Reaction with country rock: Post-intrusive metamorphism and deformation have destroyed original syn-intrusion reaction effects.

Units the granite intrudes: Yandagooge Formation, Butler Creek Formation, Poynton Formation, Fingoon Formation and Larry Formation, as well as unnamed quartzite, gneiss and amphibolite of the Rudall Complex on the Connaughton, Gunanya and Broadhurst 1:100 000 map sheet areas

Dominant rock types: Quartz-feldspar-mica paragneiss, quartzite, mica schist, graphitic pelitic schist, banded iron formation and chert, banded paragneiss and minor amphibole-chlorite schist.

Potential hosts: Graphitic schist, quartz-magnetite rock, micaceous schist.

2.10 Mineralisation

Several small prospects occur within the vicinity of the Supersuite and contain granitophile metals such as Au, Mo, Bi, Cu, La, Y, Ba as well as Pb, Zn, U. Some of these deposits occur in the Yeneena Supergroup, which unconformably overlies the Rudall Complex. There is a spatial association between some of these prospects and the granites, although Hickman and Bagas (1995) argue that most of the Au, Mo, and Ba mineralisation is hosted by D_4 or younger structures.

2.11 Geochemical Data

Data source: GSWA. All samples were collected as part of a regional mapping program.

Data quality: The data quality is good.

Are the data representative? No. There are too few samples.

Are the data adequate? Nowhere near good enough to assess the potential of this suite.

SiO_2 range (Fig. 2.1): The range is from 63 to 74 wt% SiO_2.

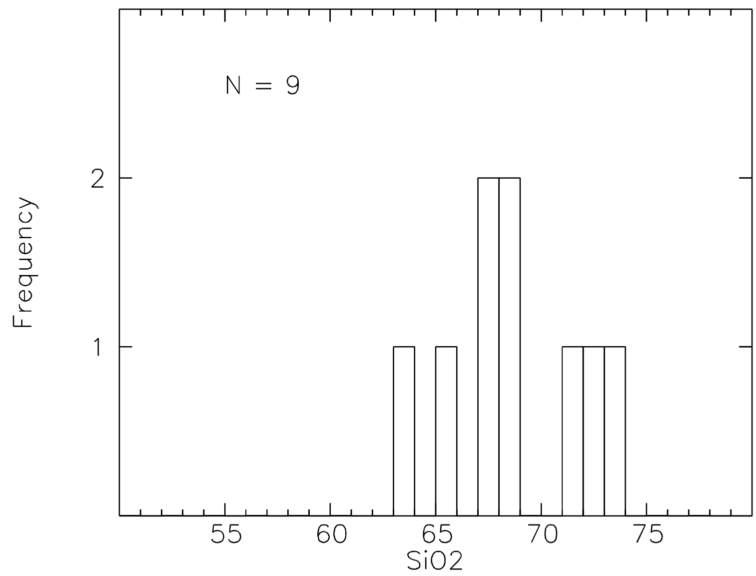

Figure 2.1. Frequency histogram of SiO_2 values for the Kalkan Supersuite

Alteration (Figs. 2.1 & 2.2):

- ***SiO_2:*** No silicification noted.
- ***K_2O/Na_2O:*** One sample has high Na_2O.
- ***Th/U:*** Some high Th/U ratios, which is not surprising given the metamorphic grade.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$):*** The samples are within the normal range.

Fractionation Plots (Fig. 2.3):

- ***Rb:*** Some strong Rb enrichment with increasing SiO_2.
- ***U:*** A weak increase in U with increasing SiO_2.
- ***Y:*** Y increases with increasing SiO_2.
- ***P_2O_5:*** Values are low and decrease with increasing SiO_2.
- ***Th:*** Scattered plot.
- ***K/Rb:*** Values decrease with increasing SiO_2.
- ***Rb-Ba-Sr:*** One sample plots in the strongly differentiated field, the remainder in the granite and anomalous granite fields.
- ***Sr:*** Values are low and decrease with increasing SiO_2.
- ***Rb/Sr:*** There is a weak increase with increasing SiO_2.
- ***Ba:*** Values decrease with increasing SiO_2.
- ***F:*** No data available.

Metals (Fig. 2.4):

- ***Cu:*** Values are extremely low for Australian Proterozoic Granites.
- ***Pb:*** Values are moderate for Australian Proterozoic Granites.
- ***Zn:*** Values decrease with increasing SiO_2.
- ***Sn:*** No data available.

High field strength elements (Fig. 2.5):

- ***Zr:*** Values are low to moderate for Australian Proterozoic Granites.
- ***Nb:*** Values are low for Australian Proterozoic Granites.
- ***Ce:*** Values are low to moderate for Australian Proterozoic Granites.

Classification (Fig. 2.6):

- ***The $CaO/Na_2O/K_2O$ plot of White, quoted in Sheraton and Simons (1992):*** Samples plot in the granite to granodiorite range.
- ***Zr/Y vs Sr/Sr*:*** Insufficient trace element data available.
- ***Spidergram:*** The plot is typical Sr-depleted, Y-undepleted for Australian Proterozoic Granites.
- ***Oxidation plot of Champion and Heinemann (1994):*** All samples plot in the oxidised field, reflecting their pink colour.
- ***ASI:*** Samples are metaluminous to weakly peraluminous.
- ***A-type plot of Eby (1990):*** The points straddle the boundary between the normal and A-type granite fields for Australian Proterozoic granites.

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

Australian Proterozoic granite type: Cullen type (?)

2.12 Geophysical Signature

Radiometrics (Fig. 2.7): Most samples would appear white, but those that had lost U due to alteration and/or metamorphism would be yellow.

Gravity: The signature is variable, and the data are too coarse to define a clear relationship.

Magnetics: The magnetic signature is variable, but mostly forms a magnetic high.

2.13 References

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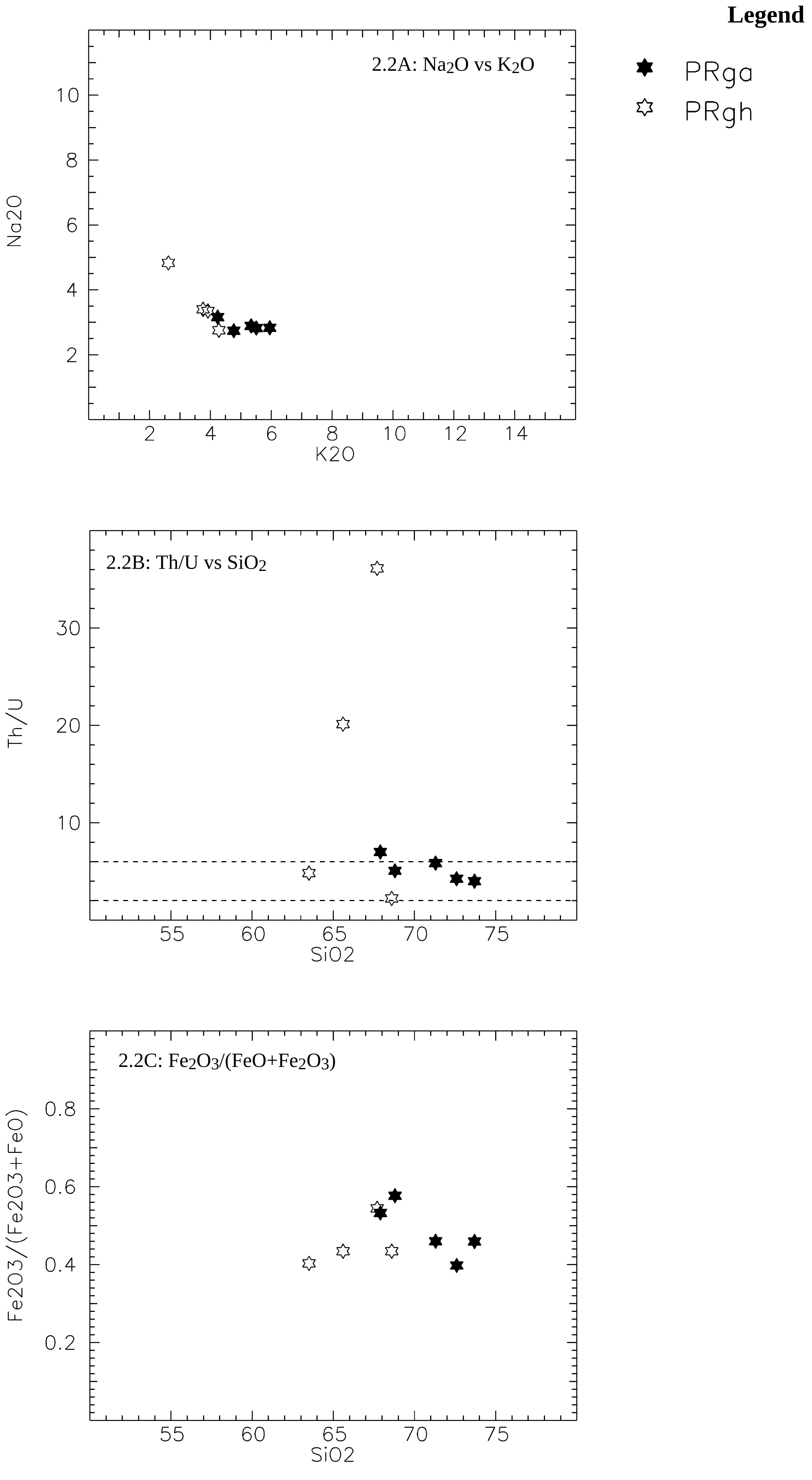
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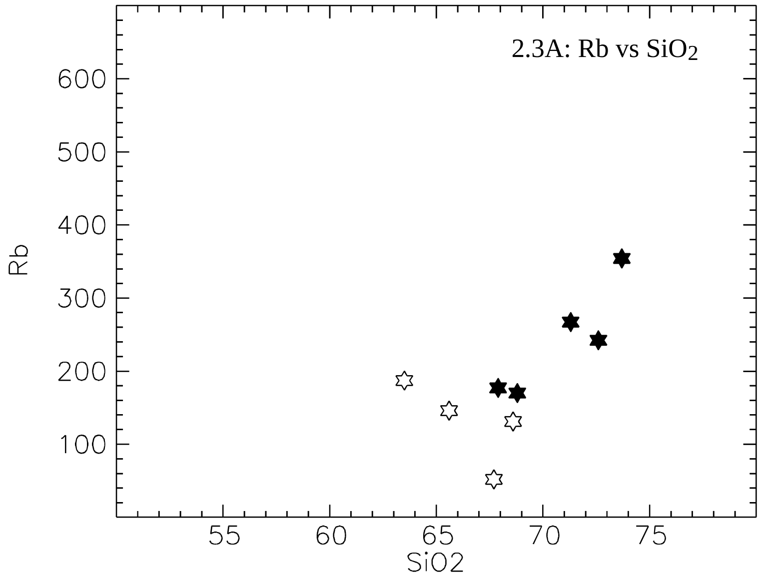

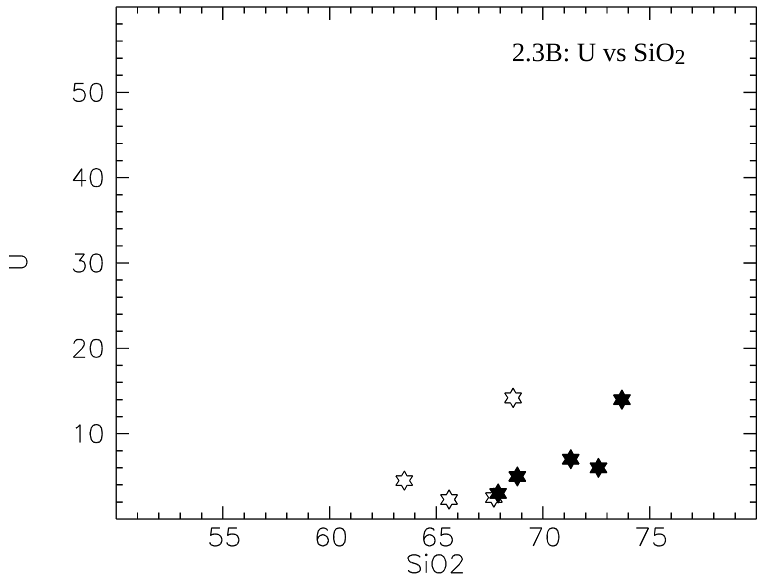

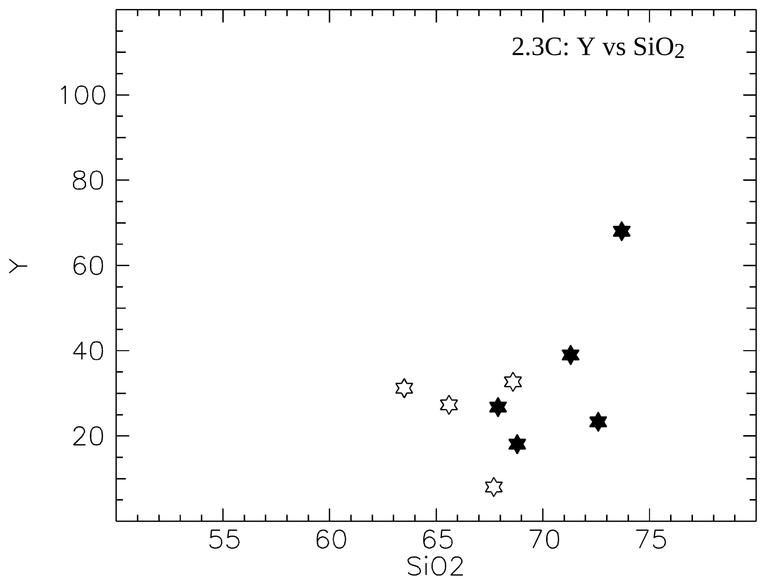

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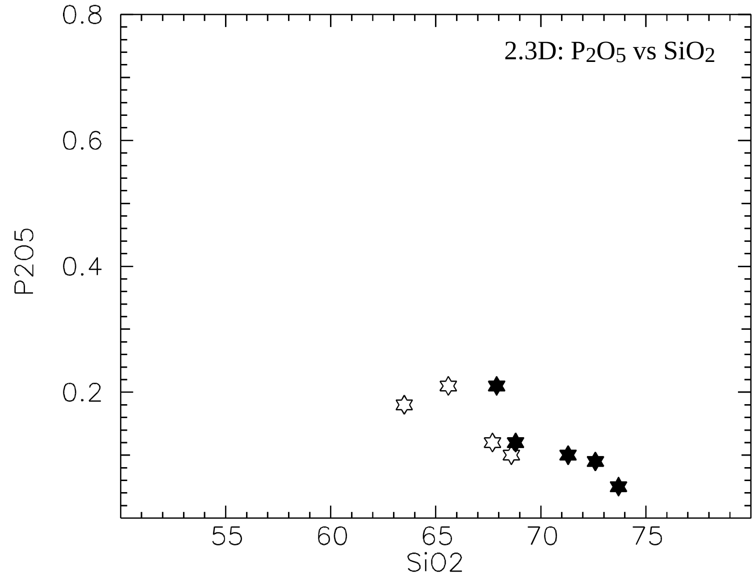

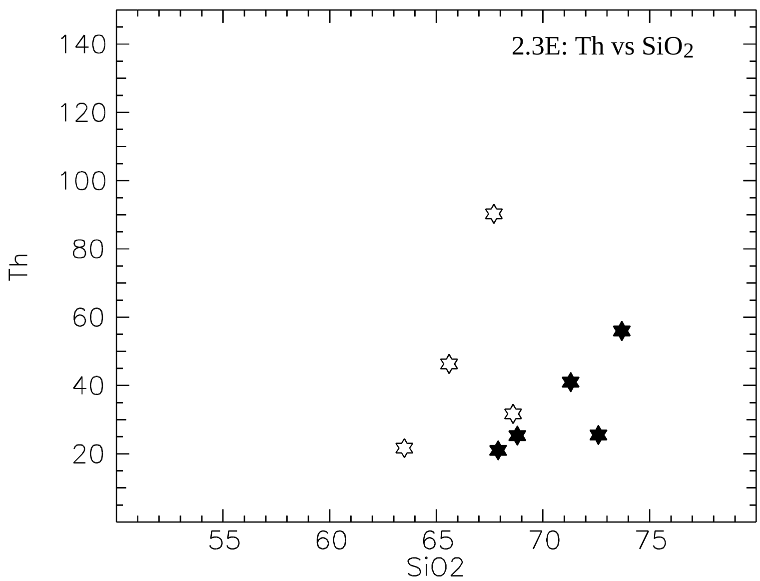

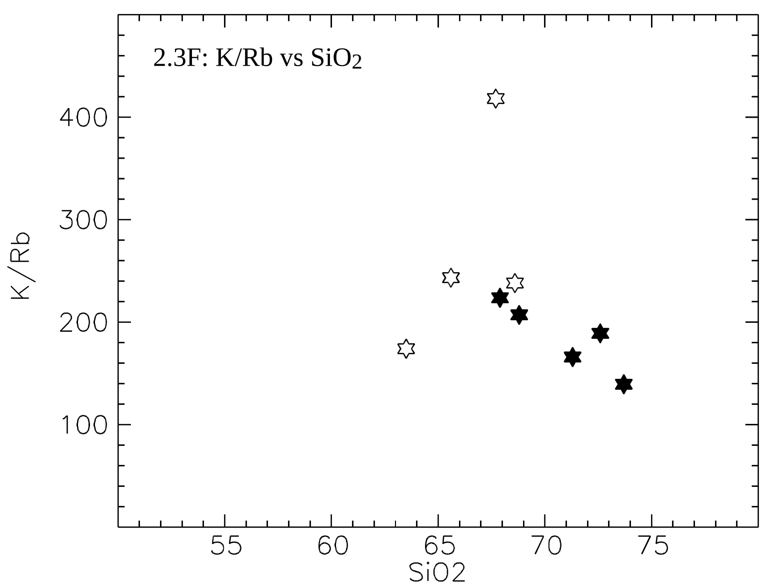

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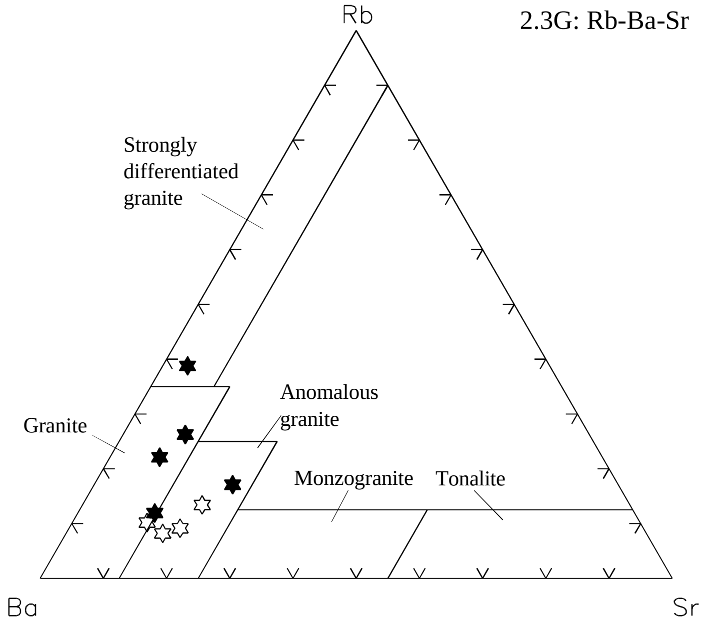

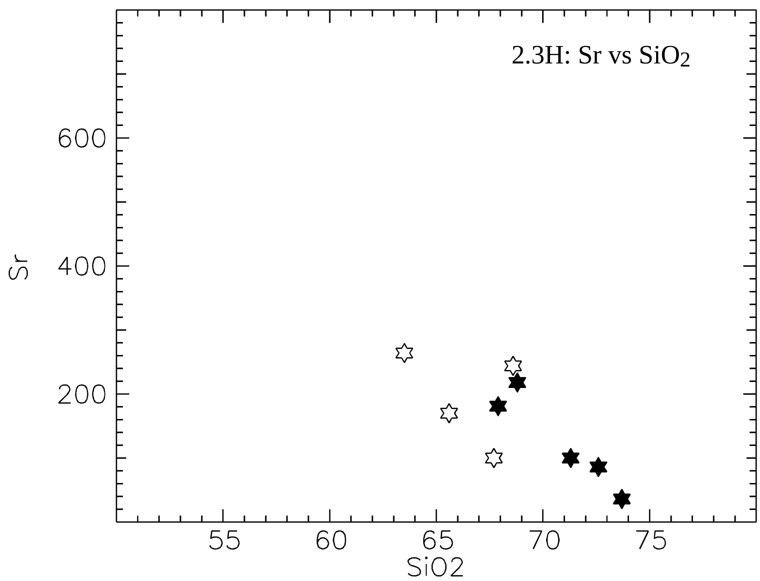

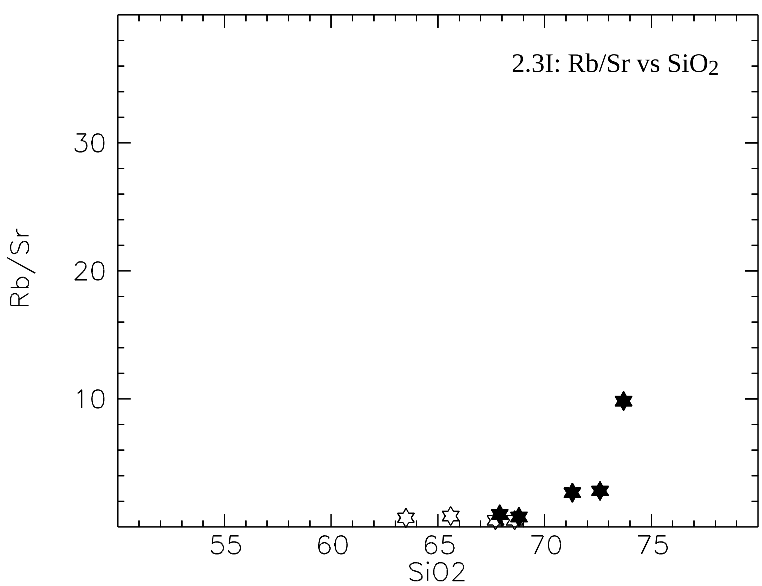

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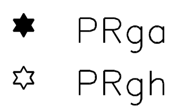

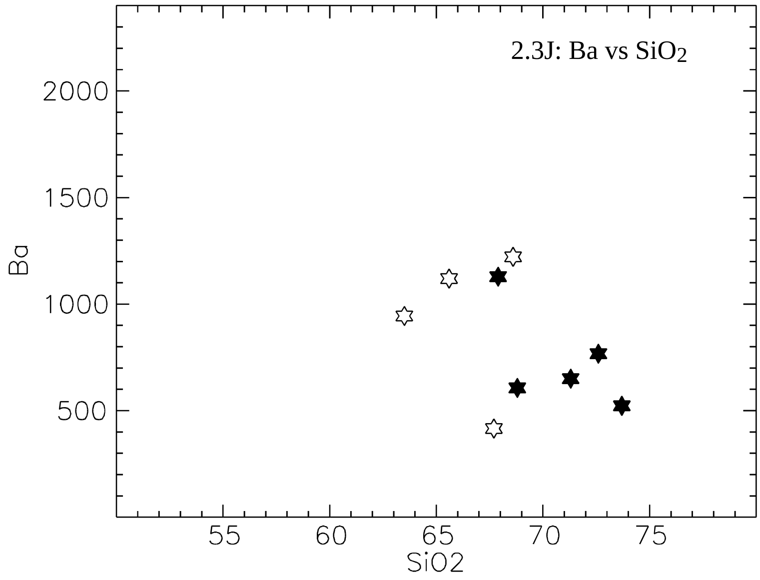

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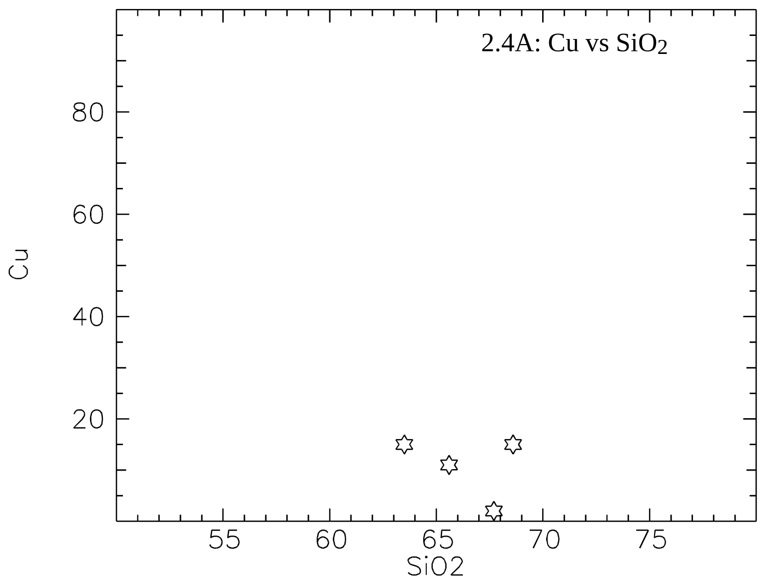

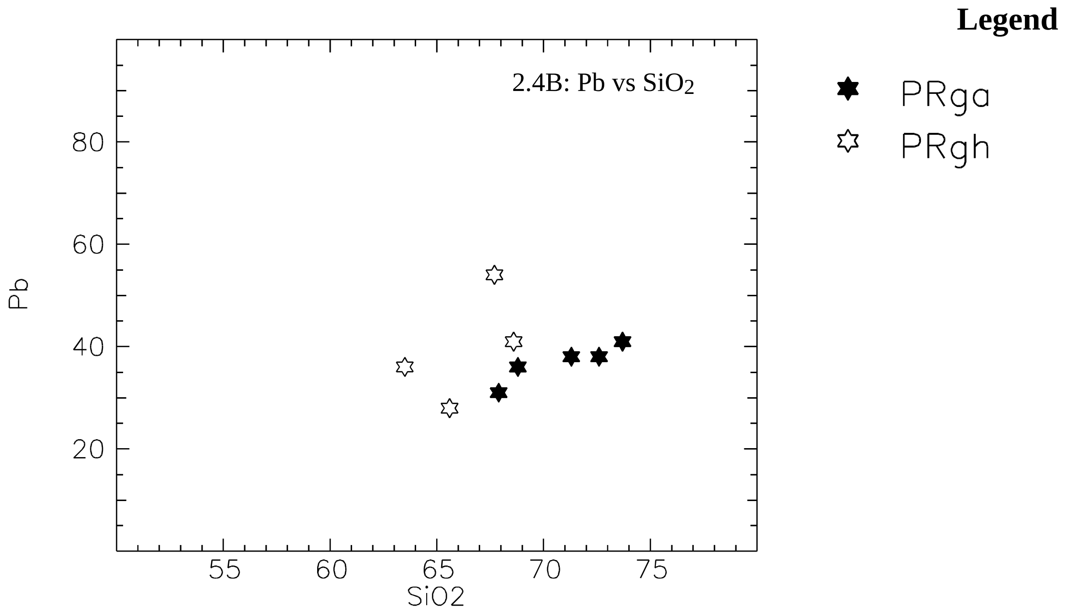

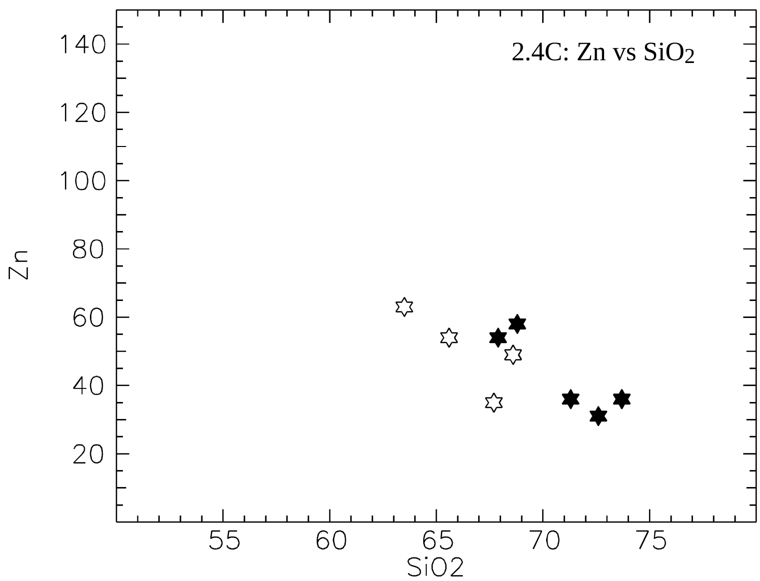

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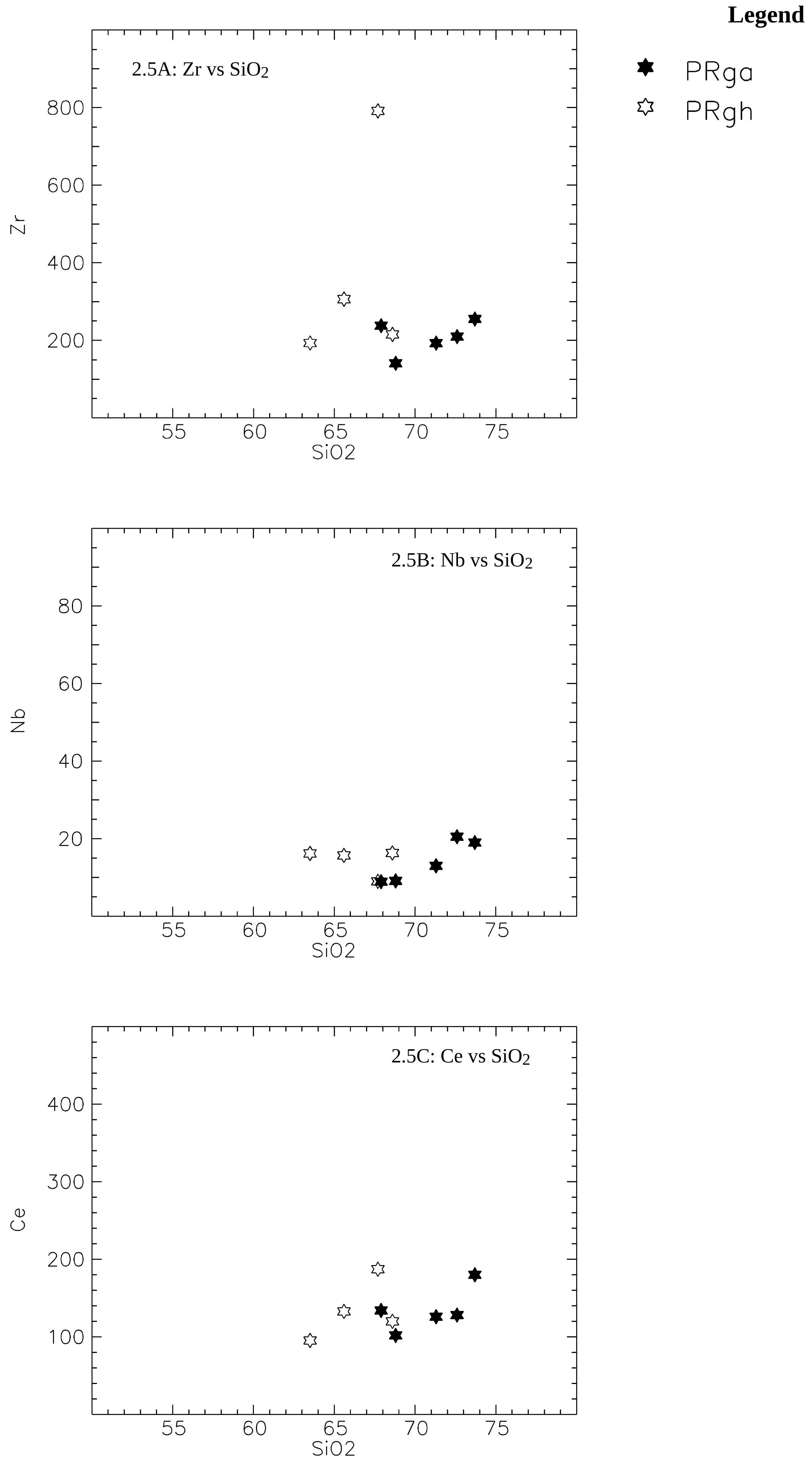
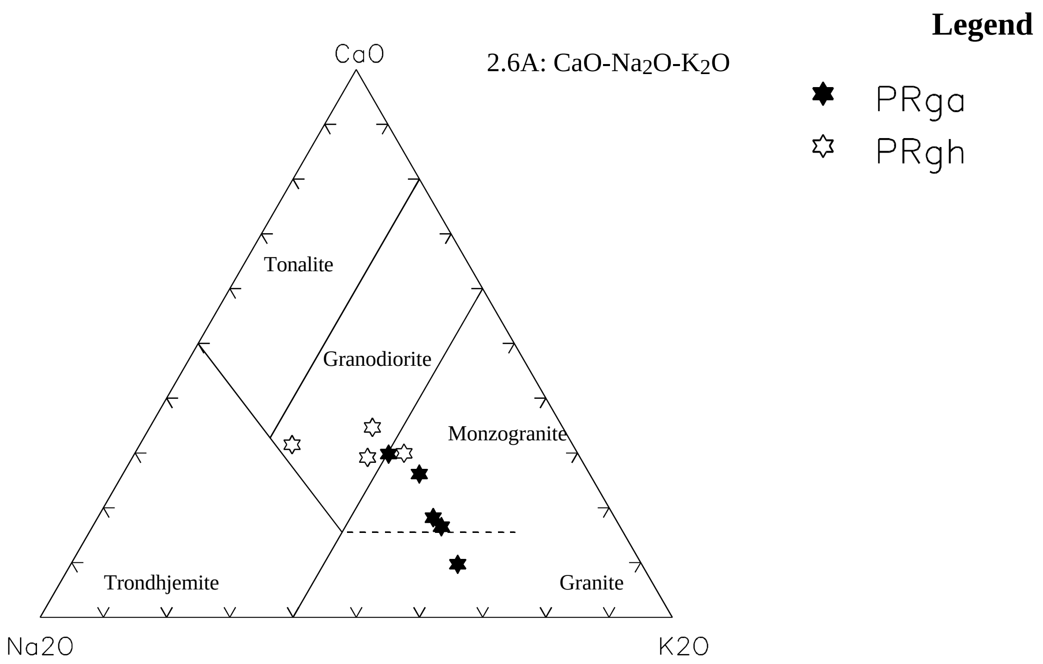

Legend
PRga
PRgh
2.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
2.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
2.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2



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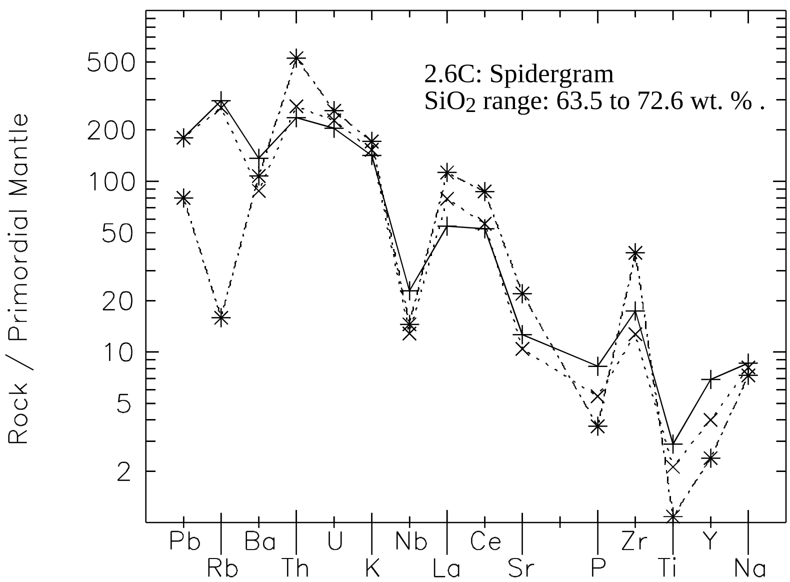

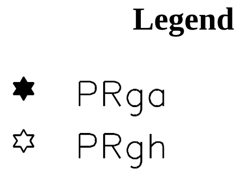
Legend
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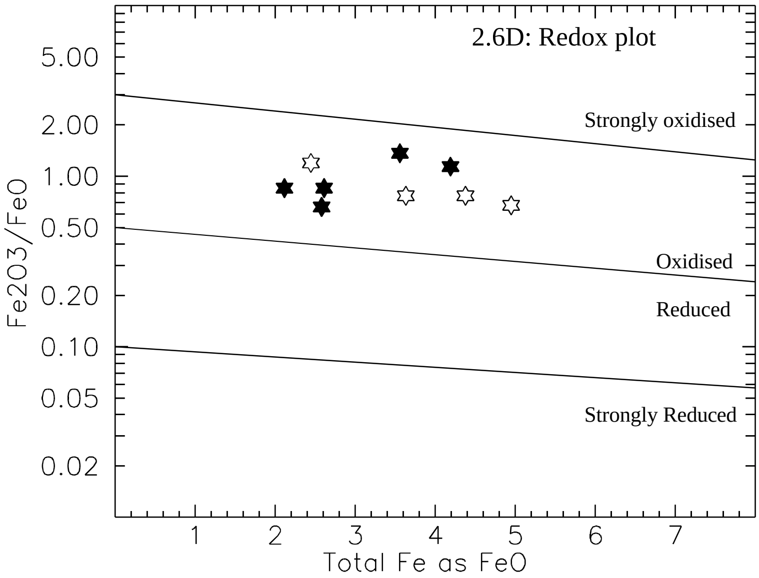
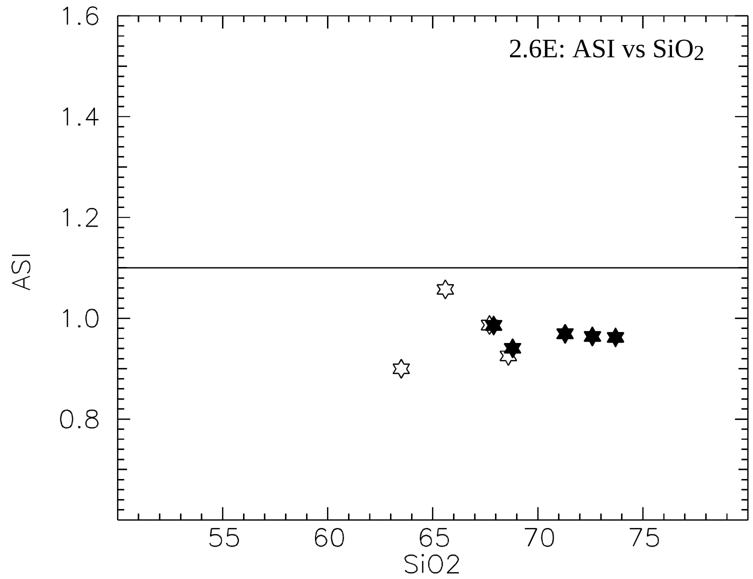
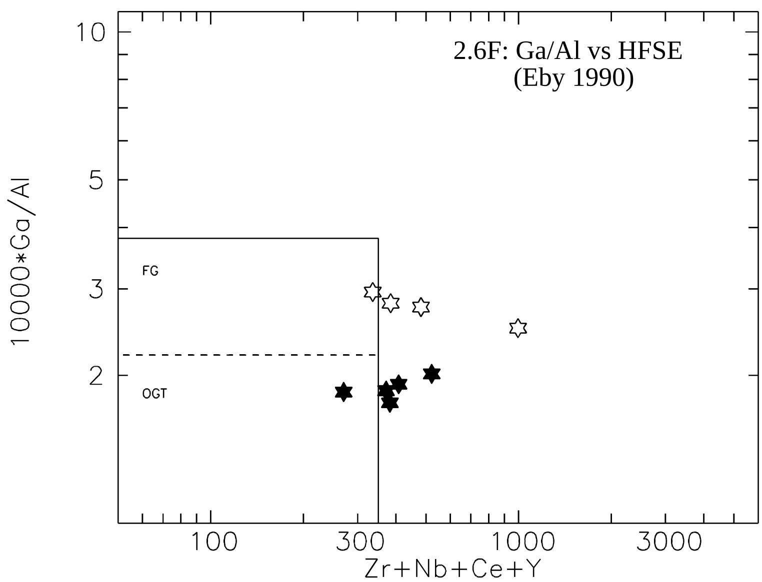
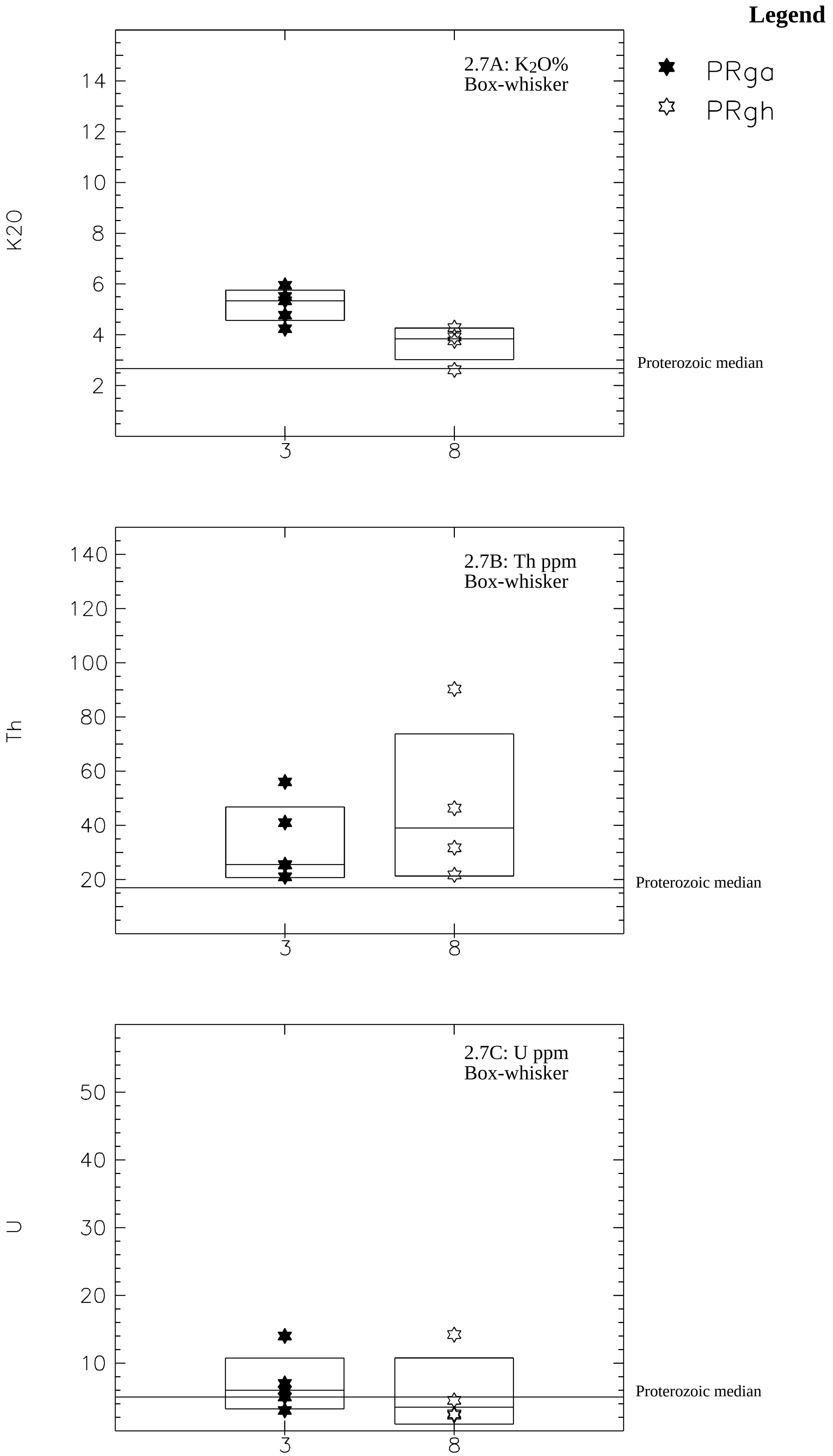

2.6D: Redox plot
Strongly oxidised
Oxidised
Reduced
Strongly Reduced
Fe2O3/FeO
5.00
2.00
1.00
0.50
0.20
0.10
0.05
0.02
1
2
3
4
5
6
7
Total Fe as FeO


2.6E: ASI vs SiO2
ASI
1.6
1.4
1.2
1.0
0.8
55
60
65
70
75
SiO2


2.6F: Ga/Al vs HFSE
(Eby 1990)
10000*Ga/Al
10
5
3
2
FG
OGT
100
300
1000
3000
Zr+Nb+Ce+Y


Legend
PRga
PRgh
2.7A: K_2O%
Box-whisker
K2O
14
12
10
8
6
4
2
3
8
Proterozoic median
2.7B: Th ppm
Box-whisker
Th
140
120
100
80
60
40
20
3
8
Proterozoic median
2.7C: U ppm
Box-whisker
U
50
40
30
20
10
3
8
Proterozoic median

PRga

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.86	71.3	2.46	67.9	73.7	5
TiO2	0.44	0.41	0.15	0.27	0.67	5
Al2O3	13.28	13.2	0.81	12.2	14.3	5
Fe2O3	1.58	1.26	0.64	1.02	2.36	5
FeO	1.59	1.6	0.31	1.2	2.07	5
MnO	0.07	0.06	0.02	0.05	0.1	4
MgO	0.81	0.88	0.22	0.5	1.08	5
CaO	2.04	1.83	0.87	0.94	3.14	5
Na2O	2.89	2.83	0.16	2.74	3.16	5
K2O	5.16	5.34	0.67	4.24	5.95	5
P2O5	0.11	0.1	0.06	0.05	0.21	5
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	0.92	0.82	0.29	0.64	1.39	5
Ba	735	650	236.66	523	1128	5
Rb	242	242	75.13	170	354	5
Sr	124.2	100	73.91	36	218	5
Pb	36.8	38	3.7	31	41	5
Th	33.76	25.5	14.57	21	56	5
U	7	6	4.18	3	14	5
Zr	207.4	210	44.23	141	255	5
Nb	14.1	13	5.44	8.9	20.5	5
Y	35.04	26.8	19.97	18.1	68	5
La	69.68	65.6	15.4	55.3	96	5
Ce	134	128	28.46	102	180	5
V	37.4	32	20.44	11	60	5
Cr	13.4	15	5.86	7	21	5
Ni	4.6	5	1.14	3	6	5
Cu	-	-	-	-	-	-
Zn	43	36	12.12	31	58	5
Ga	13.2	13	0.84	12	14	5
S	-	-	-	-	-	-

PRgh

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	66.35	66.65	2.28	63.5	68.6	4
TiO2	0.5	0.51	0.16	0.31	0.66	4
Al2O3	14.96	14.82	1.17	13.68	16.5	4
Fe2O3	1.78	1.82	0.31	1.41	2.08	4
FeO	2.25	2.37	0.81	1.18	3.08	4
MnO	0.08	0.08	0.03	0.04	0.11	4
MgO	1.31	1.32	0.65	0.51	2.1	4
CaO	3.31	3.22	0.42	2.95	3.86	4
Na2O	3.59	3.38	0.88	2.76	4.83	4
K2O	3.64	3.84	0.72	2.62	4.28	4
P2O5	0.15	0.15	0.05	0.1	0.21	4
H2O+	0.99	1	0.16	0.82	1.13	4
H2O-	0.09	0.09	0.03	0.06	0.13	4
CO2	0.08	0.07	0.02	0.07	0.11	4
LOI	-	-	-	-	-	-
Ba	925.75	1032	358.08	417	1222	4
Rb	129	138.5	56.53	52	187	4
Sr	194.5	207	74.86	100	264	4
Pb	39.75	38.5	10.9	28	54	4
Th	47.5	39	30.27	21.7	90.3	4
U	5.88	3.5	5.64	2.3	14.2	4
Zr	376.42	260.6	280.95	193.1	791.4	4
Nb	14.3	15.95	3.54	9	16.3	4
Y	24.8	29.25	11.43	8	32.7	4
La	64.25	58.95	26.38	38.2	100.9	4
Ce	133.8	126.35	38.76	95.4	187.1	4
V	56	62	32.05	13	87	4
Cr	36	31.5	27.12	10	71	4
Ni	16	15.5	11.92	2	31	4
Cu	10.75	13	6.13	2	15	4
Zn	50.25	51.5	11.7	35	63	4
Ga	21.72	21.8	1.11	20.3	23	4
S	-	-	-	-	-	-

3 KRACKATINNY SUPERSUITE

3.1 Timing

1310 Ma

3.2 Individual Ages

Primary Ages:

1. Gneissic granodiorite (NE Karara 24 well)[1]	1476 ± 10 Ma, SHRIMP
2. Harbutt Leucogranite[2]	1310 ± 4 Ma, SHRIMP
3. Porphyritic monzonite (SW Blanche sheet)[2]	1286 ± 6 Ma, SHRIMP

Source: [1] Bagas and Smithies (1996), [2] Nelson (1996).

3.3 Regional Setting

The Krackatinny Supersuite intrudes the Rudall Complex. The area in which these units occur has been termed the Tabletop Terrane (Bagas *et al.* 1995) and comprises a sequence of mafic and ultramafic schists, amphibolite, metasedimentary rocks including metamorphosed banded iron formation and orthogneiss. The granites were intruded post-D_2 (Bagas and Smithies 1996).

3.4 Summary

There are very few data on these granites. They have been classified as a supersuite because of the broad time range over which they appear to have been intruded. They have appear to have undergone weak fractionation and they are I-(granodioritic) type. They are also unusual in the context of the Proterozoic of Australia in that they are Sr-undepleted, Y-depleted.

3.5 Potential

There are insufficient data to confidently recommend this suite for further exploration. Indicators of weak fractionation in the felsic end members combined with the presence of quartz-magnetite bearing units in the country rock suggest that this suite does warrant further investigation. As the suite is I-(granodioritic) any potential mineralisation is likely to be distant from the granite plutons.

Cu:	**Moderate**
Au:	**Moderate**
Pb/Zn:	**Low**
Sn:	**Low**
Mo/W:	**Moderate**
Confidence Level:	**110**

3.6 Descriptive Data

Location: Southeastern Paterson Orogen. Isolated granite outcrops on the southwestern TABLETOP, northern RUNTON, and southeastern RUDALL 1:250 000 Sheet areas.

Dimensions and area: Crops out in an east-west belt sporadically between sand dunes. The belt is about 80 km long (east-west) and 40 km wide (north-south). Total area of outcrop is only 72 km^2.

3.7 Intrusives

Component plutons: For this study we have included all units mapped as Pgm, Pge, Pgp, Pgl and Pgf on the Connaughton 1:100 000 sheet area, units Pgg, Pgh and Pgt on southwestern TABLETOP, and unit Pgb on the RUNTON. On the project map these have been classified according to new, unpublished data supplied by the GSWA as Harbutt Leucogranite (Pgl and Pgm), Runton Adamellite, Krackatinny Tonalite and Kutakuta Tonalite.

Form: Isolated outcrops amongst sand dunes; true pluton boundaries difficult to delineate.

Metamorphism and Deformation: Variable; ranges from massive to a cataclastite. *Specifically:* Runton Adamellite - weakly foliated phase.

Dominant intrusive rock types: Runton Adamellite - even and fine to medium-grained monzogranite. Kutakuta Tonalite - porphyritic tonalite. Krackatinny Tonalite - medium, even-grained to slightly porphyritic tonalite. Harbutt Leucogranite - medium-grained, generally even-grained leucogranite.

Colour: Grey (Smithies, *pers. comm.* 1997).

Veins, Pegmatites, Aplites, Greisens: Some late pegmatite on RUDALL may be related to this supersuite.

Distinctive mineralogical characteristics: Runton Adamellite - quartz, microcline, oligoclase, biotite. Kutakuta Tonalite - phenocrysts of plagioclase in a groundmass of quartz, plagioclase biotite and hornblende; accessories include titanite, apatite, opaques and zircon. Krackatinny Tonalite - quartz, plagioclase, microcline, biotite, hornblende; accessory titanite, apatite, opaques and zircon. Harbutt Leucogranite - quartz, K-feldspar, plagioclase, biotite; accessories include apatite, opaques, zircon, allanite and titanite. Some rocks contain K-feldspar phenocrysts up to 1 cm in size.

Breccias: None noted.

Alteration in the granite: Runton Adamellite - feldspars sericitised.

3.8 Extrusives

Some 'schists' with subhedral plagioclase phenocrysts occur and may be comagmatic volcanics. The rocks are too deformed to allow a definite identifiaction of the undeformed parent (Smithies, *pers. comm.* 1997).

3.9 Country Rock

Contact metamorphism: Garnets form locally in some pelitic rocks (Smithies, *pers. comm.* 1997; Smithies and Bagas 1997).

Reaction with country rock: There are some local chondrodite-bearing skarns that are possibly related to granite (Smithies, *pers. comm.* 1997).

Units the granite intrudes: Rudall Complex.

Dominant rock types: Sequence of quartz-feldspar-biotite gneiss, amphibole gneiss, amphibolite, serpentinite, marble, quartzite, talc schist, tremolite-actinolite schist and banded quartz-magnetite-grunerite gneiss, banded quartz-magnetite rock, banded iron formation.

Potential hosts: Biotite gneiss and in particular the banded quartz-magnetite gneiss.

3.10 Mineralisation

No recorded deposits, prospects or occurrences.

3.11 Geochemical Data

Data source: All data were supplied by the Geological Survey of Western Australia.

Data quality: Good

Are the data representative? No; too few samples.

Are the data adequate? Given the possible potential, not enough samples were collected.

SiO_2 range (Fig. 3.1): The SiO_2 range is from 55 to 76 wt% SiO2 with a peak at 76 wt%.

Alteration (Figs 3.1 & 3.2):

- ***SiO_2:*** No evidence of silicification
- ***K_2O/Na_2O:*** Some of the more mafic rocks are quite sodic.
- ***Th/U:*** Most values are within the normal range, but some samples have clearly lost U.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** Some samples are quite reduced.

Fractionation Plots (Fig 3.3):

- ***Rb:*** Values increase weakly with increasing SiO_2.
- ***U:*** Very weak increase in values with increasing SiO_2.
- ***Y:*** Values increases exponentially with increasing SiO_2.
- ***P_2O_5:*** Values decrease with increasing SiO_2.
- ***Th:*** Weak late increase with increasing SiO_2.
- ***K/Rb:*** No specific change with increasing SiO_2.

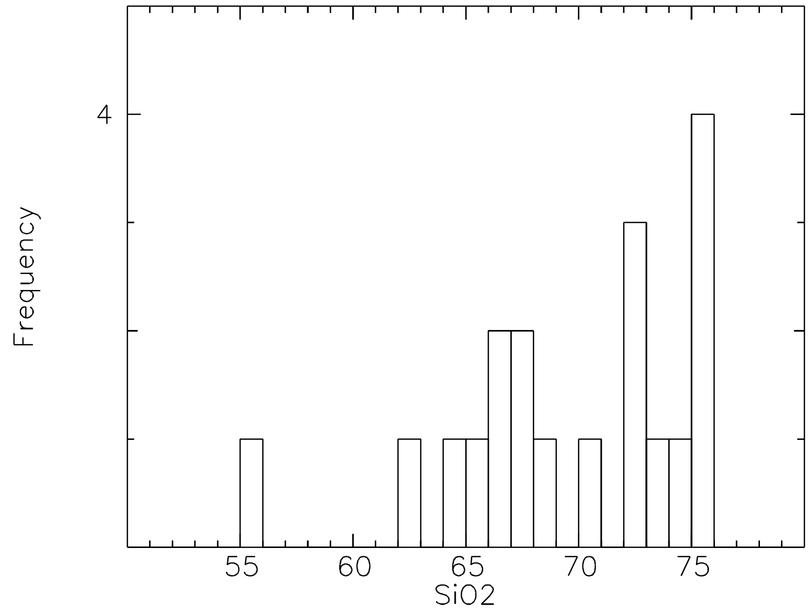


Figure 3.1. Frequency histogram of SiO_2 values for the Krackatinny Supersuite.

- ***Rb-Ba-Sr:*** Only one sample plots in the strongly differentiated field.
- ***Sr:*** Some very high values in the rocks from TABLETOP.
- ***Rb/Sr:*** Late exponential increase with increasing SiO_2.
- ***Ba:*** No pattern discernible with increasing SiO_2.
- ***F:*** No data available.

Metals (Fig. 3.4):

- ***Cu:*** Too few values to allow any comment.
- ***Pb:*** Values increase with increasing SiO_2.
- ***Zn:*** Values decrease with increasing SiO_2.
- ***Sn:*** No data available.

High field strength elements (Fig. 3.5):

- ***Zr:*** Values are low for Australian Proterozoic granites.
- ***Nb:*** Values are low for Australian Proterozoic granites.
- ***Ce:*** Values are low for Australian Proterozoic granites.

Classification (Fig. 3.6):

- ***The CaO/Na$_2$O/K$_2$O plot of White, quoted in Sheraton and Simons (1992):*** The granites range from tonalite through to granodiorite, monzogranite and granite.
- ***Zr/Y vs Sr/Sr*:*** No Nd data available to calculate Sr*.
- ***Spidergram:*** The most felsic sample is Sr-depleted, Y-undepleted. The rocks from TABLETOP are Sr-undepleted, Y-depleted.
- ***Oxidation plot of Champion and Heinemann (1994):*** Samples range from oxidised to reduced.
- ***ASI:*** Samples are metaluminous to weakly peraluminous.
- ***A-type plot of Eby (1990):*** Only limited data available, but most samples plot in the field for fractionated granites.

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

Australian Proterozoic granite type: Sally Downs type.

3.12 Geophysical Signature

Radiometrics (Fig 3.7): Relative to the Australian Proterozoic median most samples are depleted in U and would appear yellow.

Gravity: The data are coarse, but the Krackatinny Supersuite appears to coincide with a high.

Magnetics: The data are too coarse, but some of the leucogranites appear to be magnetic.

3.13 References

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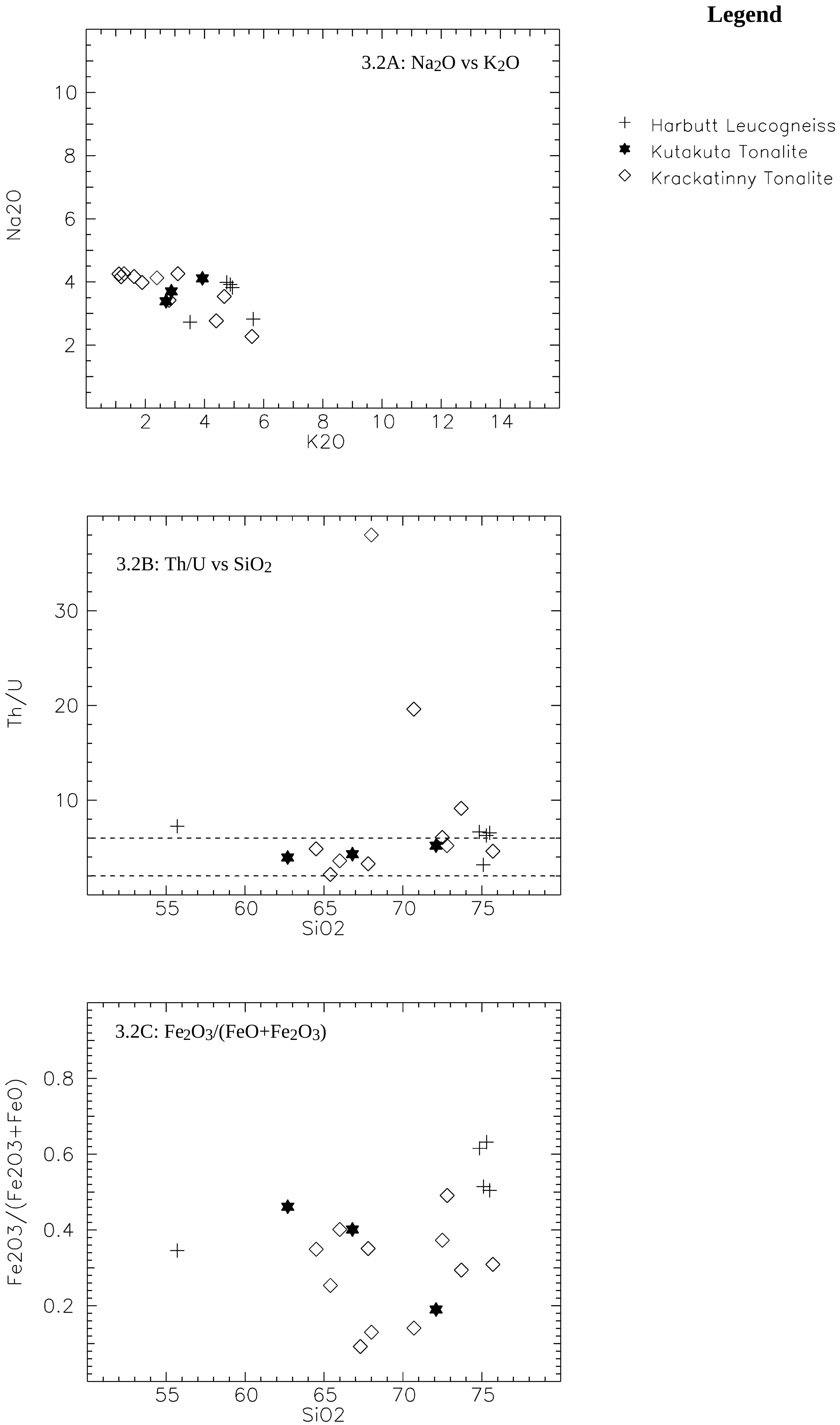
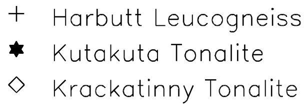
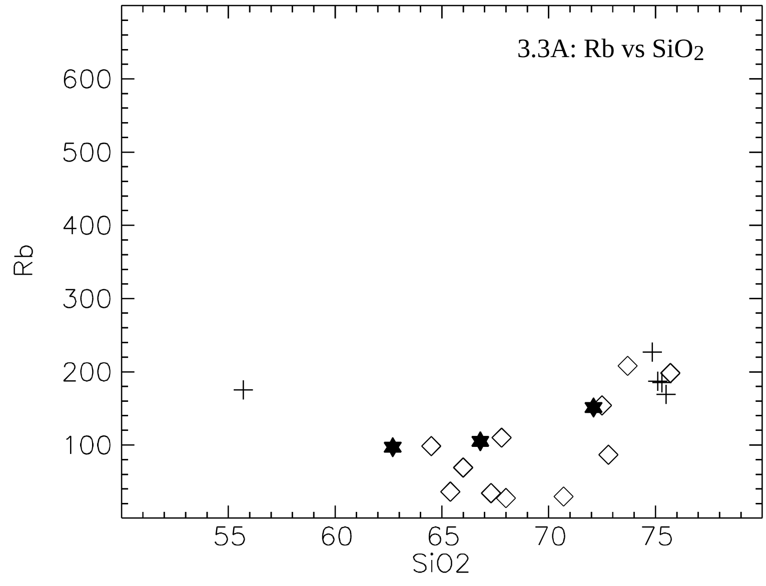
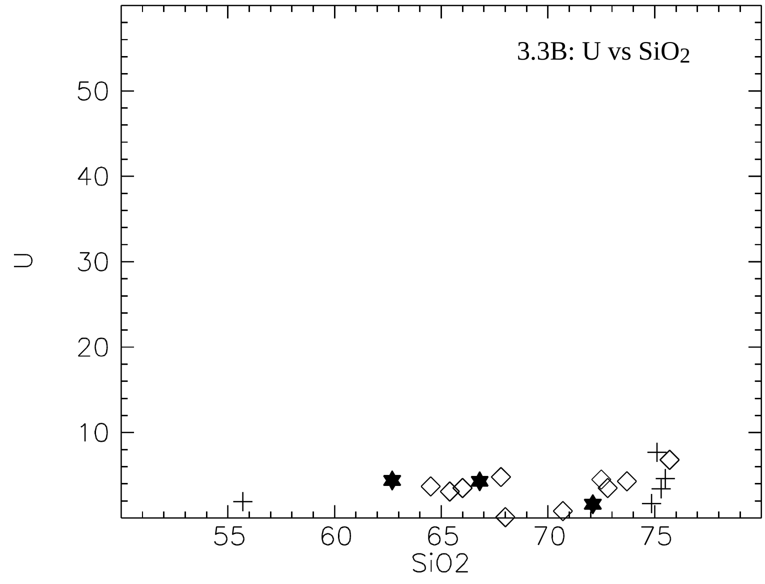
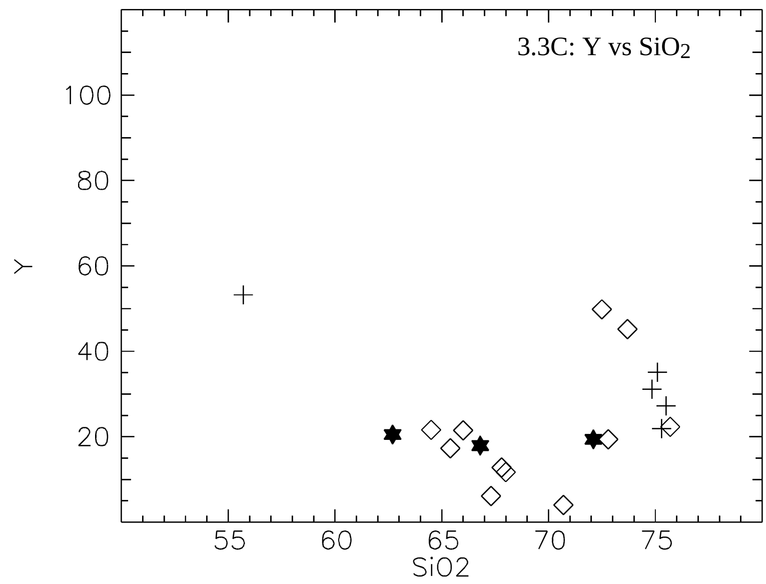

Legend
Harbutt Leucogneiss
Kutakuta Tonalite
Krackatinny Tonalite
3.2A: Na2O vs K2O
Na2O
K2O
3.2B: Th/U vs SiO2
Th/U
SiO2
3.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2

Legend

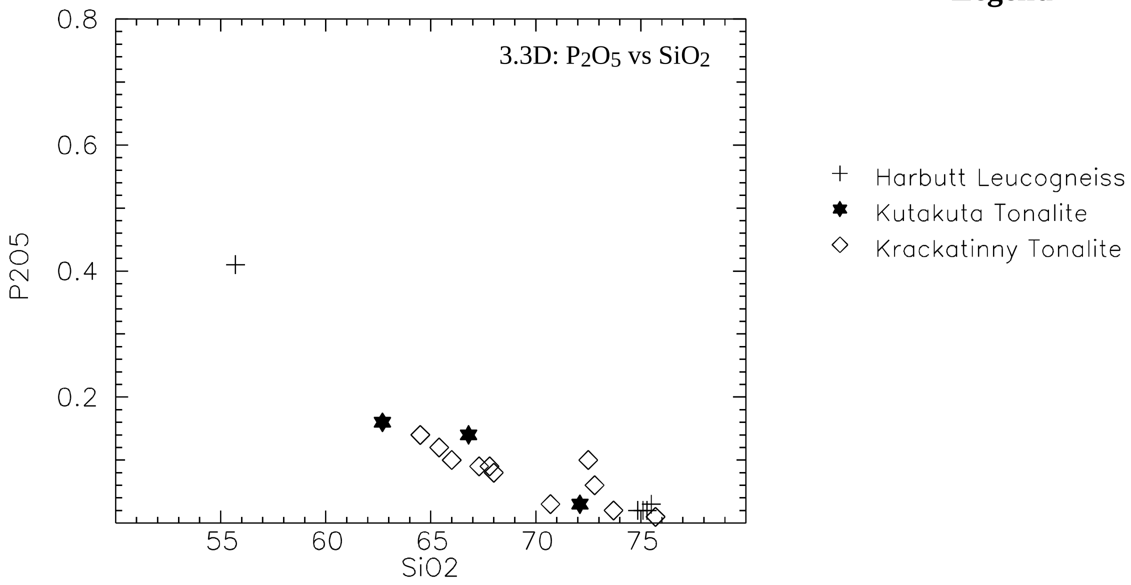

Harbutt Leucogneiss
Kutakuta Tonalite
Krackatinny Tonalite

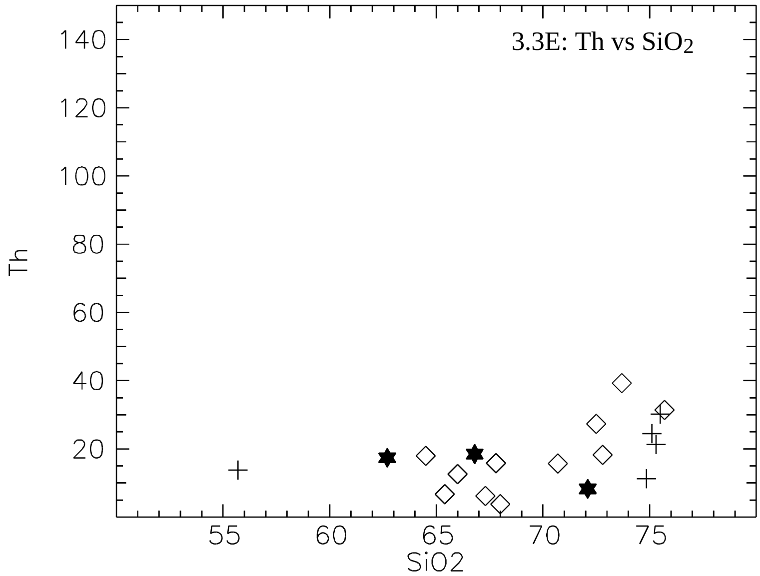

3.3A: Rb vs SiO2
Rb
600
500
400
300
200
100
55
60
65
70
75
SiO2

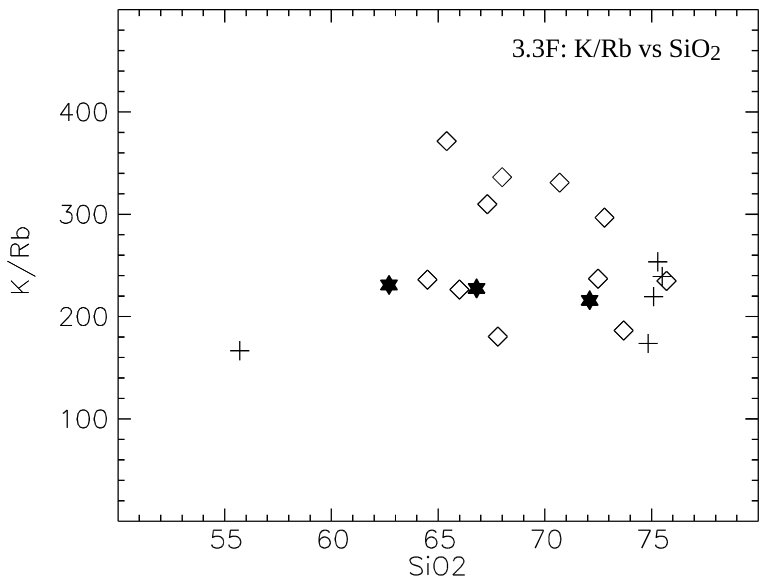

3.3B: U vs SiO2
U
50
40
30
20
10
55
60
65
70
75
SiO2


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

Legend

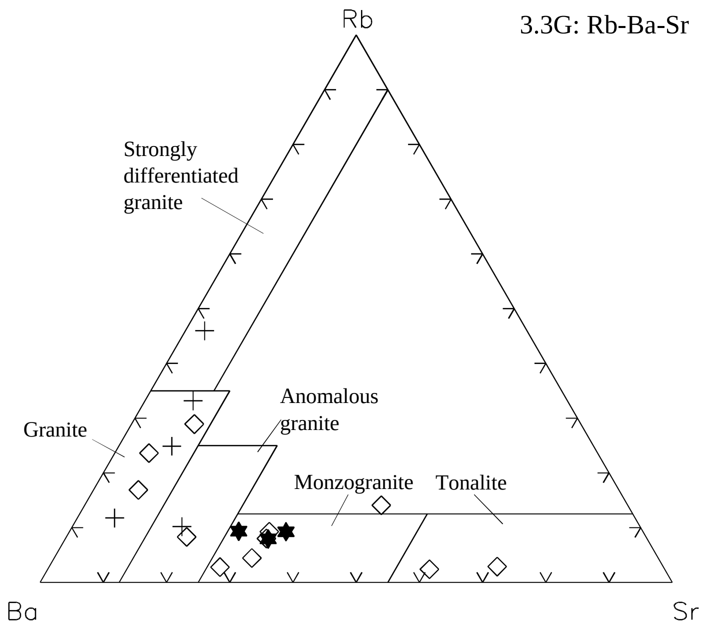

3.3D: P2O5 vs SiO2
P2O5
0.8
0.6
0.4
0.2
SiO2
55
60
65
70
75
Harbutt Leucogneiss
Kutakuta Tonalite
Krackatinny Tonalite

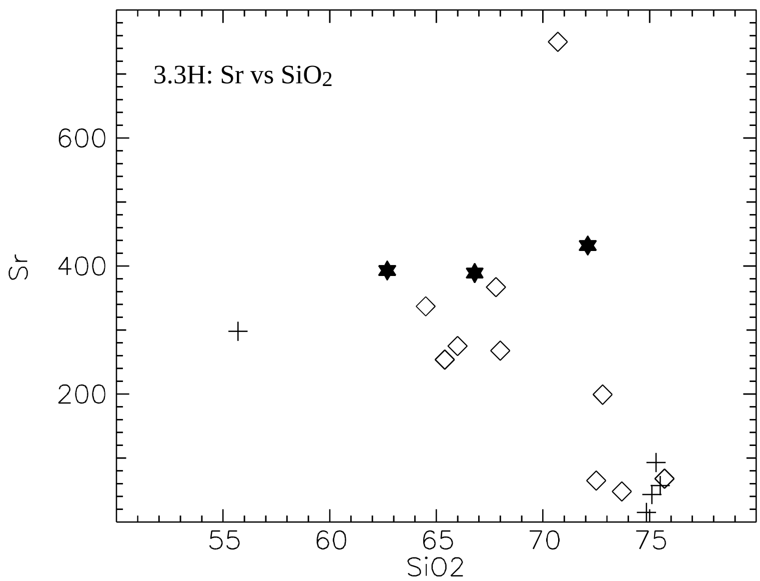

3.3E: Th vs SiO2
Th
140
120
100
80
60
40
20
SiO2
55
60
65
70
75

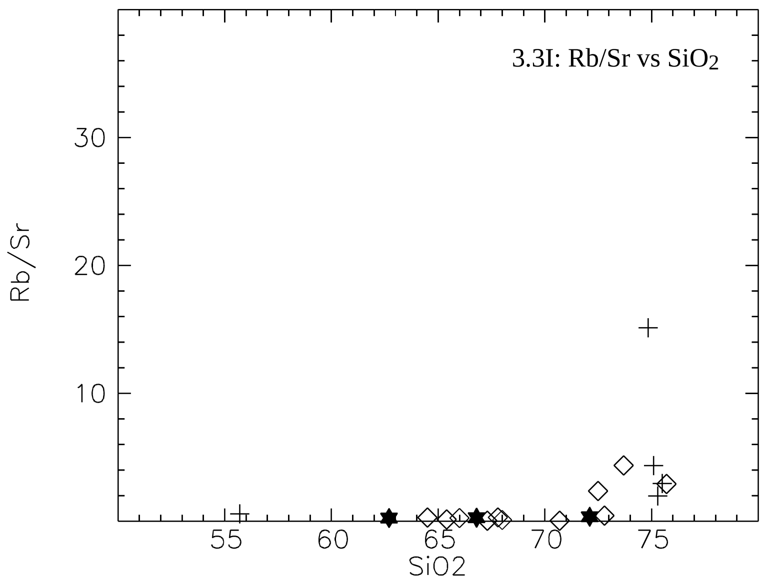

3.3F: K/Rb vs SiO2
K/Rb
400
300
200
100
SiO2
55
60
65
70
75

Legend

+ Harbutt Leucogneiss
★ Kutakuta Tonalite
◇ Krackatinny Tonalite







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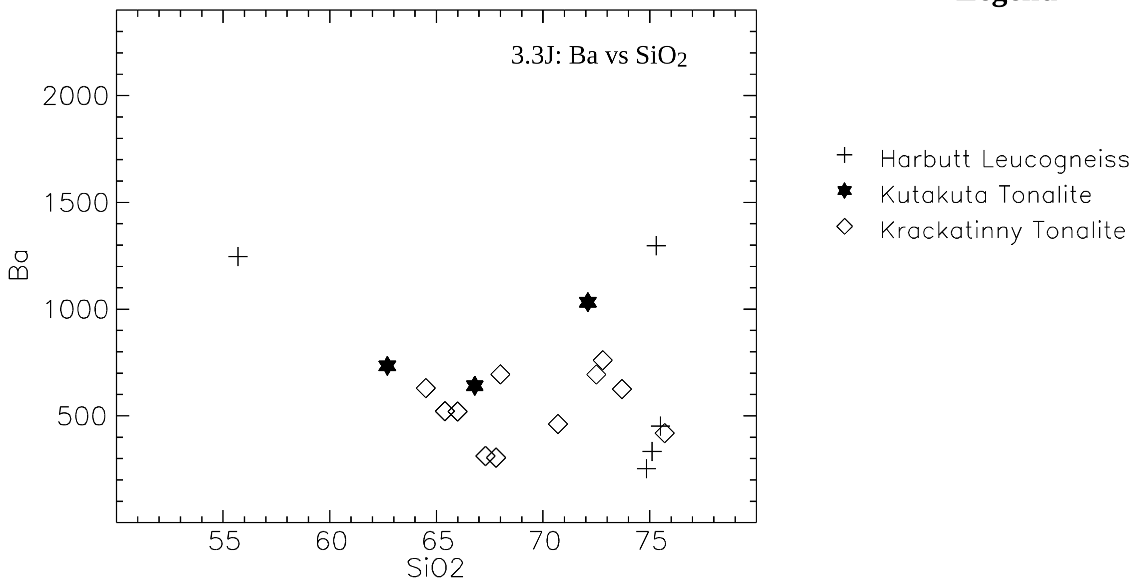

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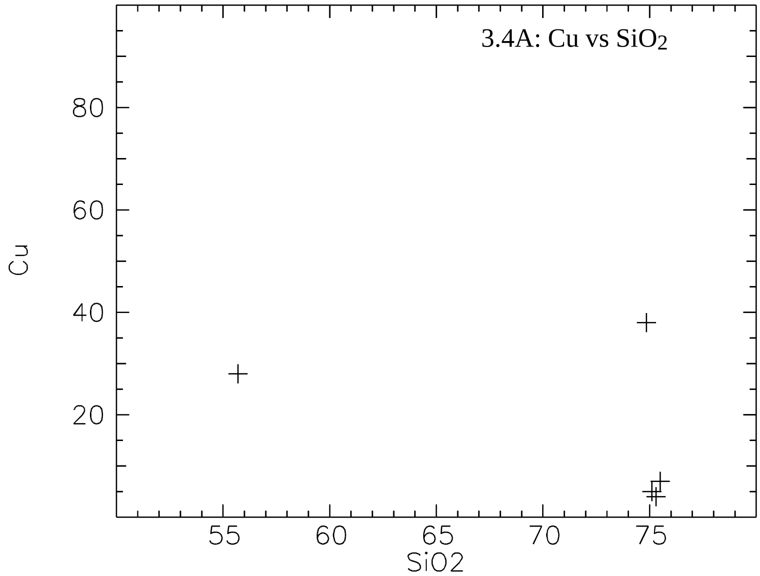
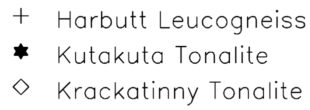
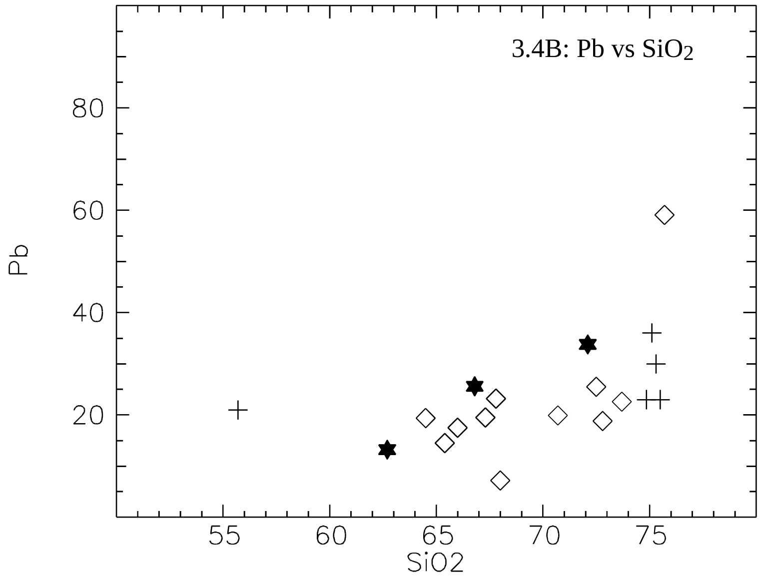
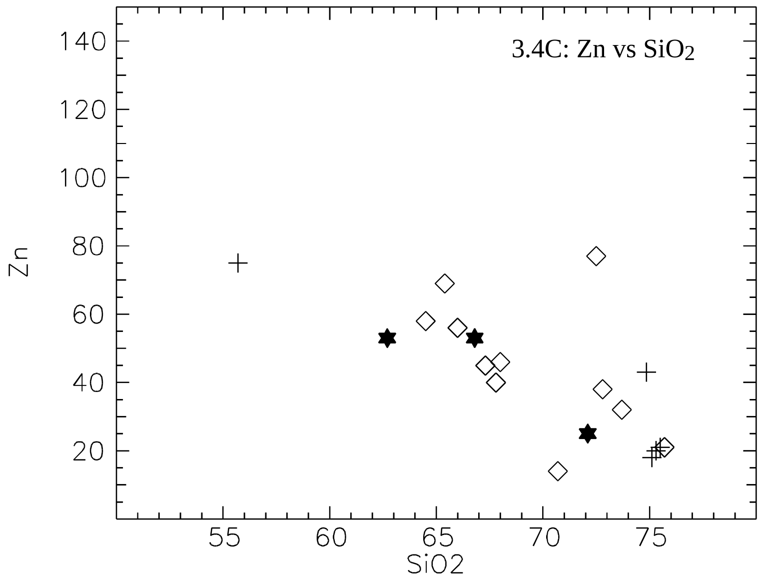


Legend



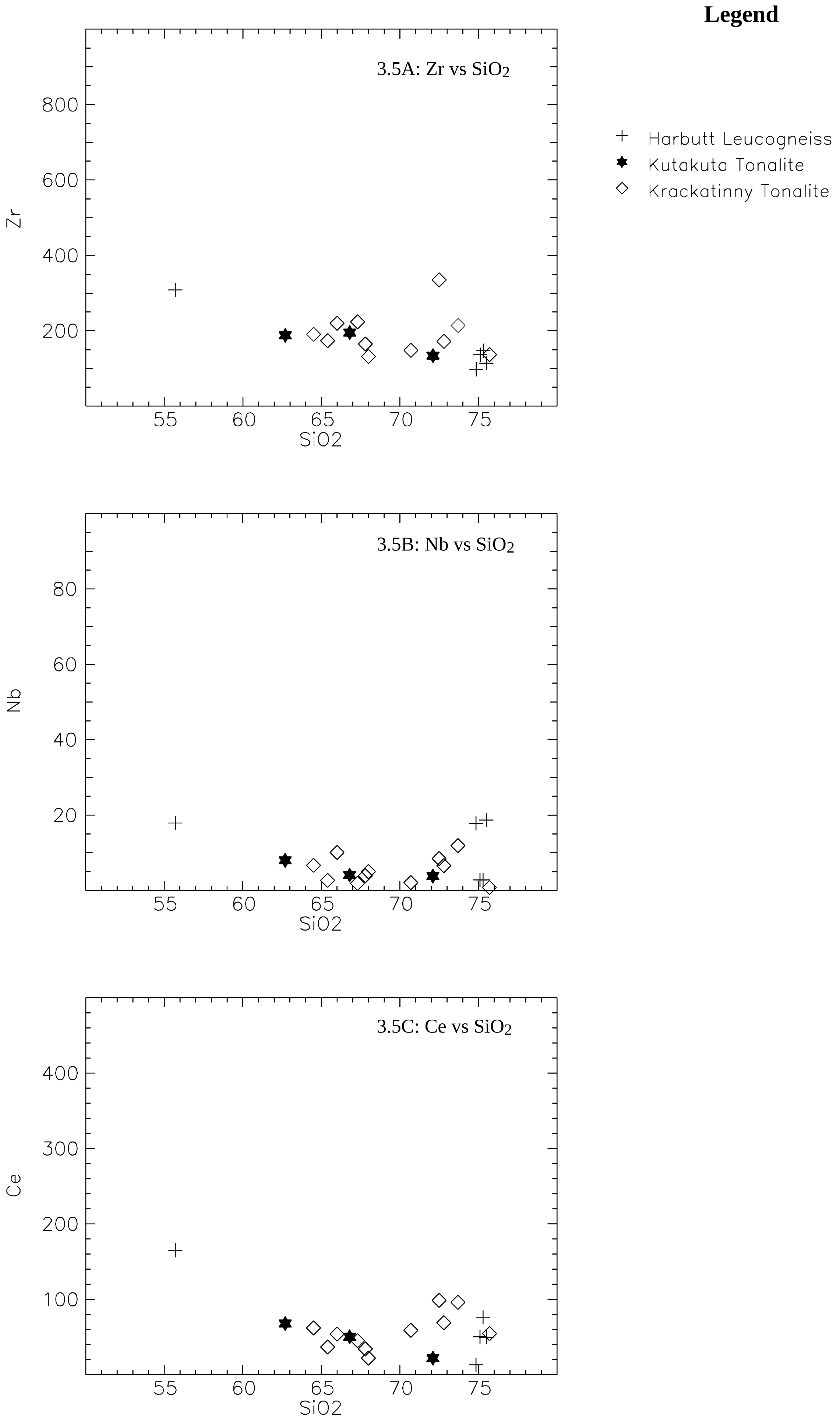


3.4B: Pb vs SiO_2

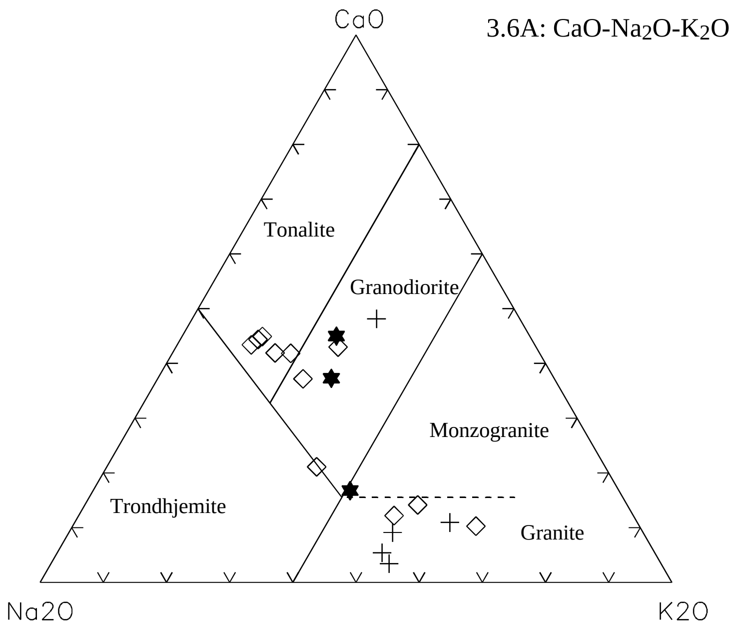


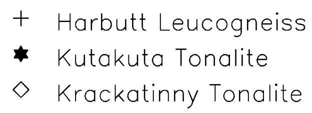
3.4C: Zn vs SiO_2

NO TIN DATA AVAILABLE


Legend
Harbutt Leucogneiss
Kutakuta Tonalite
Krackatinny Tonalite
3.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
3.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
3.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

Legend





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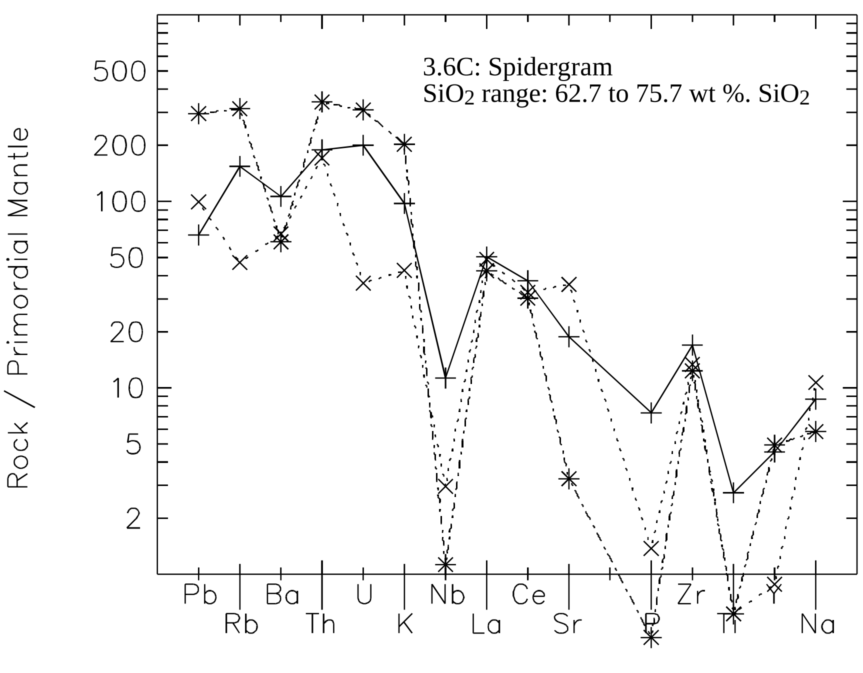
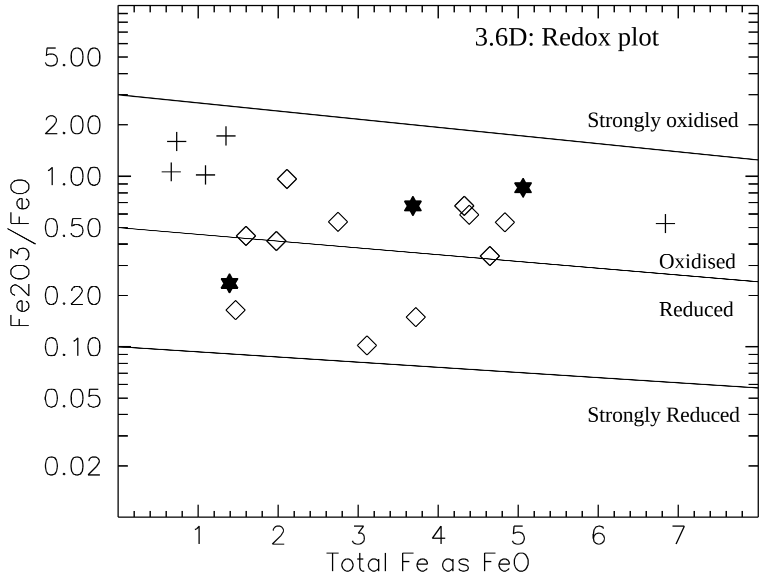
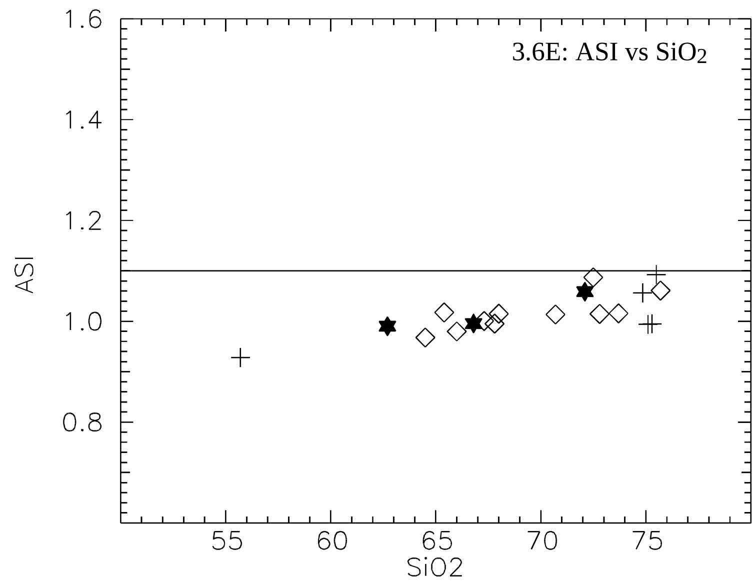
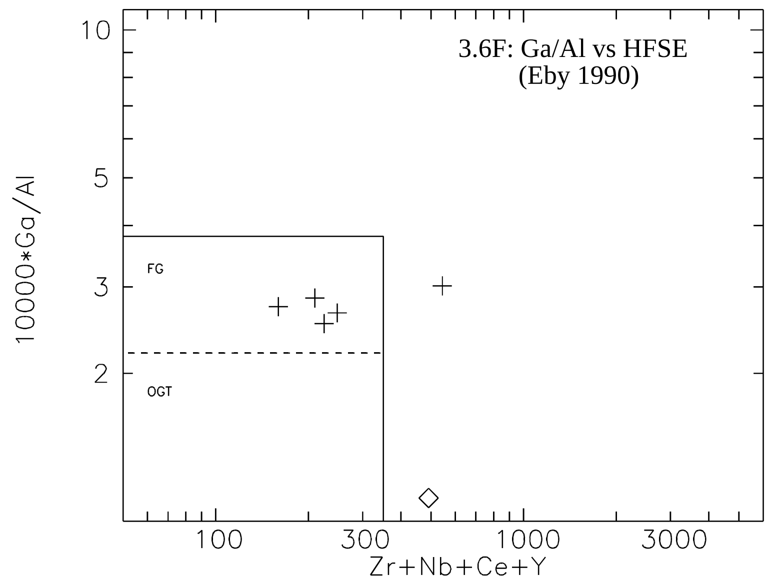


Legend

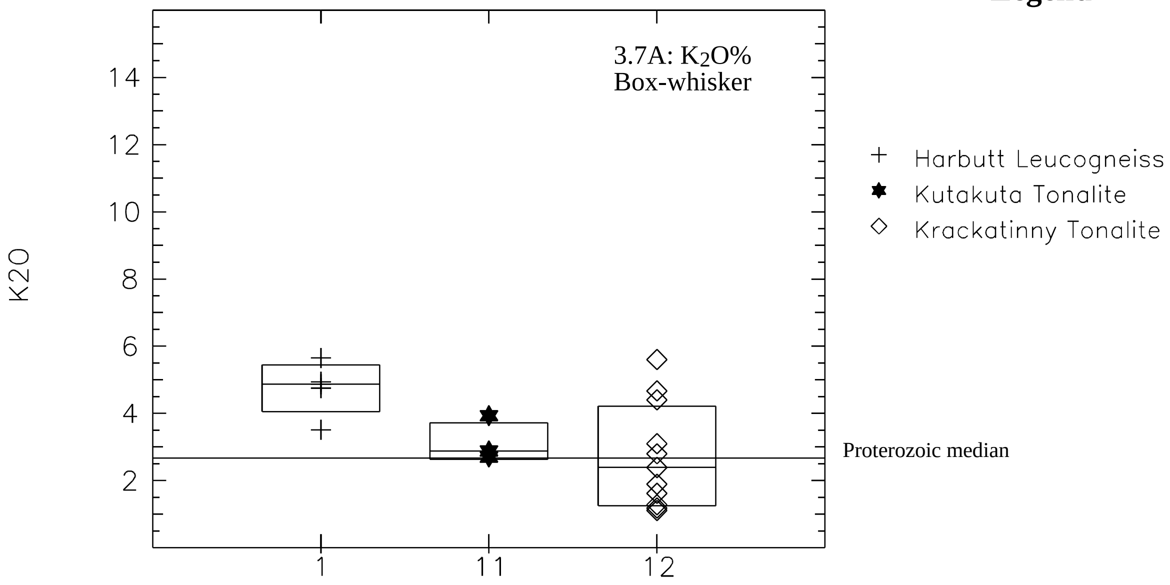
+ Harbutt Leucogneiss
✱ Kutakuta Tonalite
◇ Krackatinny Tonalite

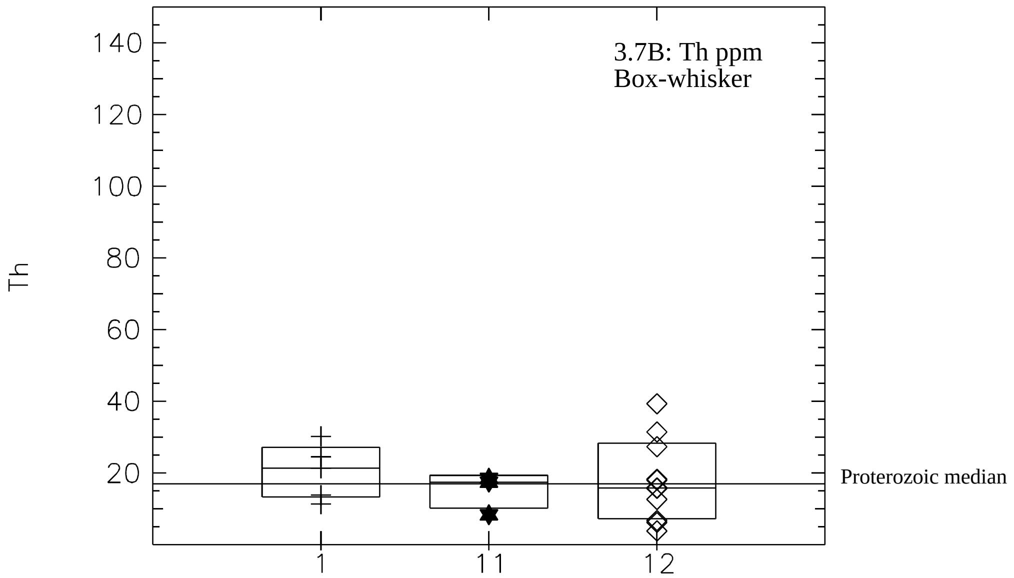


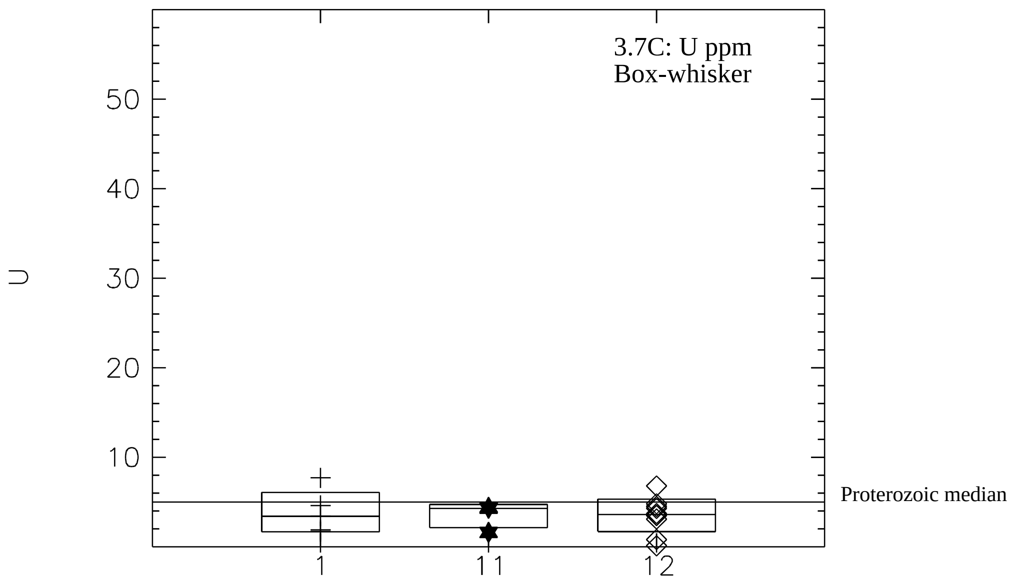




Legend


3.7A: K_2O%
Box-whisker
K2O
Harbutt Leucogneiss
Kutakuta Tonalite
Krackatinny Tonalite
Proterozoic median
14
12
10
8
6
4
2
1
11
12


3.7B: Th ppm
Box-whisker
Th
Proterozoic median
140
120
100
80
60
40
20
1
11
12


3.7C: U ppm
Box-whisker
U
Proterozoic median
50
40
30
20
10
1
11
12

Harbutt Leucogneiss

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.29	75.1	8.72	55.7	75.5	5
TiO2	0.27	0.07	0.39	0.06	0.97	5
Al2O3	13.76	13.27	1.59	12.53	16.55	5
Fe2O3	0.96	0.58	0.86	0.36	2.45	5
FeO	1.28	0.53	1.88	0.3	4.64	5
MnO	0.05	0.03	0.05	0.01	0.14	5
MgO	1.02	0.18	1.74	0.12	4.11	5
CaO	1.7	0.88	2.3	0.31	5.79	5
Na2O	3.46	3.82	0.63	2.73	3.99	5
K2O	4.74	4.87	0.77	3.51	5.65	5
P2O5	0.1	0.02	0.17	0.02	0.41	5
H2O+	0.74	0.54	0.59	0.28	1.77	5
H2O-	0.13	0.11	0.09	0.03	0.25	5
CO2	0.12	0.11	0.07	0.04	0.22	5
LOI	-	-	-	-	-	-
Ba	716.2	453	511.78	252	1296	5
Rb	188.6	185	22.69	169	227	5
Sr	101.2	57	113.54	15	298	5
Pb	26.6	23	6.27	21	36	5
Th	20.22	21.3	7.74	11.3	30.2	5
U	3.86	3.4	2.45	1.7	7.7	5
Zr	160.84	136.5	84.7	97.9	308.4	5
Nb	12	17.8	8.41	2.8	18.7	5
Y	33.7	31.1	11.94	21.9	53.2	5
La	34.76	36.3	22.72	7.3	68.6	5
Ce	70.82	50.3	57.18	13.1	164.9	5
V	33	5	63.75	3	147	5
Cr	21.4	7	28.12	5	71	5
Ni	12.4	3	17.49	2	43	5
Cu	16.4	7	15.6	4	38	5
Zn	35.4	21	24.36	18	75	5
Ga	20.16	19.2	3.66	17.5	26.4	5
S	0.01	0.01	-	0.01	0.01	1

Kutakuta Tonalite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	67.2	66.8	4.71	62.7	72.1	3
TiO2	0.38	0.44	0.23	0.13	0.58	3
Al2O3	15.87	15.9	1.15	14.7	17	3
Fe2O3	1.42	1.54	1.09	0.27	2.45	3
FeO	2.1	2.3	0.87	1.15	2.86	3
MnO	0.06	0.06	0.03	0.03	0.08	3
MgO	1.02	1.05	0.69	0.32	1.69	3
CaO	3.5	3.91	1.72	1.62	4.98	3
Na2O	3.73	3.7	0.36	3.39	4.11	3
K2O	3.17	2.88	0.66	2.7	3.93	3
P2O5	0.11	0.14	0.07	0.03	0.16	3
H2O+	0.63	0.62	0.15	0.49	0.78	3
H2O-	-	-	-	-	-	-
CO2	0.26	0.26	0.04	0.22	0.29	3
LOI	-	-	-	-	-	-
Ba	802.33	734	204.26	641	1032	3
Rb	117.7	105	29.11	97.1	151	3
Sr	404.67	393	23.76	389	432	3
Pb	24.2	25.6	10.37	13.2	33.8	3
Th	14.73	17.4	5.6	8.3	18.5	3
U	3.43	4.3	1.59	1.6	4.4	3
Zr	172.33	188	33.38	134	195	3
Nb	5.3	4.1	2.34	3.8	8	3
Y	19.27	19.4	1.31	17.9	20.5	3
La	25.73	30	12.27	11.9	35.3	3
Ce	46.73	50.4	23.22	21.9	67.9	3
V	53.67	53	40	14	94	3
Cr	39.33	42	18.15	20	56	3
Ni	6.67	6	3.06	4	10	3
Cu	-	-	-	-	-	-
Zn	43.67	53	16.17	25	53	3
Ga	7.43	7.4	0.15	7.3	7.6	3
S	493.33	580	185.83	280	620	3

Krackatinny Tonalite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.49	68	3.76	64.5	75.7	11
TiO2	0.32	0.32	0.14	0.13	0.54	11
Al2O3	14.89	15.7	1.7	12.1	16.4	11
Fe2O3	0.97	1	0.59	0.21	1.81	11
FeO	2.3	2.7	0.95	1.13	3.56	11
MnO	0.05	0.04	0.03	0.01	0.08	11
MgO	0.75	0.72	0.41	0.21	1.6	11
CaO	3.18	4.11	1.53	0.9	4.69	11
Na2O	3.75	4.13	0.68	2.27	4.26	11
K2O	2.73	2.39	1.55	1.11	5.6	11
P2O5	0.08	0.09	0.04	0.01	0.14	11
H2O+	0.74	0.59	0.31	0.42	1.35	11
H2O-	0.04	0.04	0.02	0.02	0.07	6
CO2	0.33	0.29	0.18	0.15	0.77	11
LOI	-	-	-	-	-	-
Ba	540.45	522	154.95	305	760	11
Rb	95.64	86.7	66.19	27.4	208	11
Sr	315.69	268	261.94	47.7	842	11
Pb	22.47	19.5	13.08	7.2	59.1	11
Th	17.73	15.8	11.08	3.8	39.3	11
U	3.51	3.6	1.92	0.1	6.8	10
Zr	192	174	57.23	132	335	11
Nb	5.47	5	3.62	0.8	11.9	11
Y	21.06	19.4	14.49	4	49.8	11
La	30.51	28.9	11.29	16	52	11
Ce	57.35	54.7	23.94	22.1	98.7	11
V	32.82	27	25.21	6	90	11
Cr	33.73	35	9.6	18	46	11
Ni	5.36	5	1.69	3	9	11
Cu	-	-	-	-	-	-
Zn	45.09	45	19.16	14	77	11
Ga	6.45	6.7	1.54	2.1	8.1	11
S	417.27	450	206.45	130	800	11

4 O'CALLAGHAN'S SUPERSUITE

4.1 Timing ~625 Ma

4.2 Individual Ages

Primary Ages:

1. Minyari Granite	633 ± 13 Ma, U-Pb
2. Mount Crofton Granite	614 ± 8 Ma, U-Pb

Source: Nelson (1995).

4.3 Regional Setting

The O'Callaghan's Supersuite intrudes the Lamil Group of the Yeneena Supergroup. This Supergroup, believed to have a minimum depositional age of about 900-850 Ma (Hickman *et al.* 1994), comprises the Isdell Formation, Malu Quartzite, Telfer Formation, Puntapunta Formation, Wilki Quartzite and Kaliranu Beds (Williams and Myers 1990). Rock types within these sequences consist of quartzite, carbonate, dolomite, mudstone, sandstone, and carbonaceous limestone. The granites were intruded at around 625 Ma (Dimo 1990), long after sedimentation ceased. The entire sequence consists of a regular alternation of arenaceous units with carbonate and fine-grained clastic units which are believed to be part of a marine-shelf sequence (Williams 1990).

4.4 Summary

The O'Callaghan's Supersuite is a fractionating I-(granodioritic) type with obvious potential for mineralisation. The Supersuite has a variable oxidation state, with the earlier intrusions being reduced and the later ones being quite oxidised. The subdivision of Goellnicht *et al.* (1991) and Goellnicht (1992) into an ilmenite-bearing Mount Crofton Group (Mount Crofton Granite, Hansens Folly Granite, Desert's Revenge Granite) and the Minyari Group (Koolyu Granite, Minyari Granite, O'Callaghan's Granite) has not been continued. This project argues that there are two main differences between the granite types: firstly the Mount Crofton Granite is more oxidised than all of the other plutons; and secondly, the Minyari Granite has a distinctively different Pb isotopic signature (Sun, *pers. comm.*) which may argue for a different source region. For this reason, the project has used the term 'Supersuite' as there is evidence that all plutons do not meet the strict definition of a 'suite' as defined by White (1995). In a broad sense, there are two suites, the Crofton Suite (Mount Crofton Granite) and the O'Callaghan's Suite (O'Callaghan's Granite, Hansens Folly Granite, Desert's Revenge Granite, Koolyu Granite, Minyari Granite). The whole Supersuite is believed to have originally been fairly oxidised at its source region, but the earlier phases were reduced by interaction with reduced basinal brines. Mineralisation is believed to be related to the more reduced granite types. Although known predominantly as a Au mine, the Telfer mine carries significant Cu, and some base metal skarns have been described in the vicinity of the O'Callaghan's Granite.

4.5 Potential

The O'Callaghans Supersuite has obvious potential and is highly prospective for further discoveries. The area has a unique assemblage of a fractionated granite system combined with highly reactive rock types and suitable structures. If the concept is correct that the granite system has been relatively reduced by interaction with reduced basinal fluids, then any ore-bearing fluids derived from the granite will be similarly reduced. Hence rather than precipitation being a function of wall-rock interaction or fluid-fluid mixing, it is highly likely that precipitation will result from rapid changes in the physico-chemical conditions, such as drop in pressure following breaching of sealing structures such anticlines.

Cu:	**High**
Au:	**High**
Pb/Zn:	**Low**
Sn:	**Low**
Mo/W:	**Mod**
Confidence Level:	**323**

4.6 Descriptive Data

Location: Northern Paterson Province on the Paterson Range 1:250 000 Sheet area.

Dimensions and area: Much of the outcrop is under cover. The full extent is clearly visible on the magnetic image (Sexton 1994) and figures portraying its extent have been published in Hickman *et al.* (1994) and Bagas *et al.* (1995). The intrusion has an inverted 'V' shape about 60 km long and 60 km wide. The total outcrop area plus the area under cover is around 666 km^2.

4.7 Intrusives

Component plutons: The Supersuite comprises the Koolyu Granite (formerly the Minyari Gneiss of Goellnicht 1992), Minyari Granite, Mount Crofton Granite, Hansens Folly Granite (formerly the Wilki Gneiss of Goellnicht 1992), Desert's Revenge Granite, O'Callaghan's Granite and the Tyama Granite.

Form: The Supersuite forms an inverted 'V' shape with one arm trending north, and the other northwesterly. Aeromagnetic data clearly show that the two arms of granite consist of composite intrusions. Geophysical data suggest that the granite bodies are thin sheets with subhorizontal tops (Dimo 1990).

Metamorphism and Deformation: Most of the granites appear to have been affected to some degree by deformation, and Traves *et al*. (1956) report metamorphic textures in a sample from the Minyari Hills area. Goellnicht (1992) describes the Minyari Granite, Koolyu Granite and O'Callaghan's Granite as all having fabrics indicative of magmatic flow, high-temperature solid-state deformation and moderate to low-temperature solid-state deformation. Within the more massive Mount Crofton Granite, Desert's Revenge Granite and Hansens Folly Granite, Goellnicht (1992) notes that all quartz grains show undulose extinction, suggesting that they too have been affected to some degree by late deformation.

Dominant intrusive rock types: Equigranular even and medium-grained monzogranite to syenogranite which commonly grade into coarse porphyritic textures. Granite compositions are extremely variable. *Specifically:* Mount Crofton Granite - coarse to medium-grained biotite monzogranite cut by more fractionated fine even-grained leucocratic syenogranite, which in turn is intruded by late-stage porphyritic granite and granite porphyry. Hansens Folly Granite - coarse-grained biotite syenogranite. Desert's Revenge Granite - syenogranite to alkali-feldspar granite. Minyari Granite - monzogranite to syenogranite. Koolyu Granite - monzogranite to syenogranite. O'Callaghans Granite - syenogranite.

Colour: Variable, and depends on oxidation state. *Specifically:* Mount Crofton Granite - pink. Koolyu Granite, Minyari Granite, Hansens Folly Granite - grey.

Veins, Pegmatites, Aplites, Greisens: Pegmatite, aplite and granite dykes intrude the sediments along cleavage (Chin *et al.* 1982), patches of granophyre are common. *Specifically:* Mount Crofton Granite - pegmatite, aplite; pyrite and fluorite occur in rare miarolitic cavities. Desert's Revenge Granite - aplite with pegmatitic pods common. O'Callaghans Granite - patches of greisenisation (quartz-muscovite ± K-feldspar alteration) which overprint the granite close to the contact.

Distinctive mineralogical characteristics: Quartz, K-feldspar, plagioclase, with biotite as the dominant ferromagnesian mineral. Accessory minerals include epidote, muscovite, magnetite, ilmenite, titanite, apatite, chlorite and rare fluorite. The Mount Crofton Granite, Hansens Folly Granite and Desert's Revenge Granite have less than 3 vol. % biotite and 1 vol. % magnetite, whilst the Koolyu Granite, Minyari Granite and O'Callaghan's Granite have 5 to 8 vol. % biotite, accessory ilmenite (rare magnetite) and hornblende. *Specifically:* Mount Crofton Granite - quartz, K-feldspar, plagioclase (An_{25} to An_7), biotite, magnetite, and trace titanite, zircon, monazite, apatite, hornblende, rare fluorite, and muscovite. Hansens Folly Granite - quartz, K-feldspar, plagioclase (An_{26}), biotite; accessory apatite and zircon. Desert's Revenge Granite - quartz, K-feldspar, plagioclase (An_{23}), biotite, trace of fluorite and hornblende. Minyari Granite - quartz, K-feldspar, plagioclase (An_{25}), biotite; trace ilmenite, hornblende, titanite, apatite and rare magnetite. Koolyu Granite - quartz, K-feldspar, plagioclase (An_{23}), biotite, hornblende (3%), magnetite (1%); trace ilmenite, titanite, apatite. O'Callaghan's Granite - quartz, K-feldspar, plagioclase (An_{30}), biotite, ilmenite: trace titanite, zircon, apatite, rare hornblende, pyrite, allanite.

Breccias: Brecciation within the granites is not commonly recorded. *Specifically:* Mount Crofton Granite - some brecciation associated with late-stage intrusion of the late granite porphyries.

Alteration in the granite: The most common alteration is hematite, saussuritisation of feldspars, sericite, and chloritisation of biotite. *Specifically:* Mount Crofton Granite - hematite in fractures and after magnetite, chloritisation of biotite, saussuritisation of feldspar, muscovite. Hansens Folly Granite - muscovite in plagioclase. Desert's Revenge Granite - weak saussuritisation of feldspars, epidote, sericite. Minyari Granite - hematite, saussurite, epidote, chlorite. O'Callaghans Granite - chloritisation of biotite, saussuritisation of feldspar.

4.8 Extrusives

None are recorded.

4.9 Country Rock

Contact metamorphism: The development of contact aureoles is variable. In some areas, extensive contact aureoles are up to 2 km wide (Goellnicht 1992) and grade up to pyroxene-hornfels facies (Chin *et al*. 1982). Overall the grade is generally low and characterised by the growth of muscovite and tourmaline (schorl with a dravite margin) which forms spotted hornfels. However, near the Hansens Folly Granite, the contact metamorphic grade is hornblende hornfels facies with green hornblende replacing original clinopyroxene in the mafic rocks and the assemblage quartz-hornblende-diopside-scapolite in calc-silicate rocks. Northeast of the Telfer Dome (which hosts the Telfer Au deposit) metamorphosed shale and siltstone contain garnet (Chin *et al*. 1982). Traves *et al.* (1956) report the occurrence of melilite in a calcite-quartz-actinolite-diopside-vesuvianite hornfels which is indicative of pyroxene-hornfels contact metamorphism. The Desert's Revenge Granite highest-grade contact assemblage is only 1 mm wide and it is absent at the O'Callaghan's prospect, suggesting that these intrusions were emplaced at very shallow levels (Goellnicht 1992).

Reaction with country rock: There is evidence of assimilation of carbonate rocks with monzogranite being more prominent due to enrichment of calcium at the expense of potassium: these rocks contain abundant accessory diopside, hornblende and chlorite. There is also an abundance of microcline in the calc-silicate hornfelses suggesting potassium metasomatism.

Units the granite intrudes: Malu Quartzite, Wilki Quartzite, Puntapunta Formation, Telfer Formation.

Dominant rock types: Quartzite, quartz sandstone, dark grey shale, siltstone, dolomite, calcarenite.

Potential hosts: Carbonate, dark grey shale.

4.10 Mineralisation

On a regional scale there are several styles of Au-Cu and base-metal (± W) mineralisation, which can be divided into two groups: proximal and distal. Members of the distal group are generally >1 km from a known granite and have phyllic to argillic alteration, whereas the proximal deposits are characterised by hornfelsed host rocks and phyllic to potassic or calc-silicate alteration. The distal group consists of either stratiform to stratabound reefs, stockwork and sheeted-vein deposits or fault-related breccia veining, and metasomatic deposits whilst the proximal group comprises porphyry and skarn-style mineralisation. There is also a zonation with the distal deposits being Au-dominated and the proximal deposits being predominantly Cu, base metals and W-dominated.

Within the district, the Telfer Au deposit is representative of the distal group and is the most economically significant. Although touted as a Au deposit, it does contain significant amounts of Cu as well as anomalous Fe, Ag, B, Ce, La, Y, As, Co, Ni, Pb and Mo (Dimo 1990). At the deposit, stratabound to stratiform quartz-sulphide reefs and low-grade stockwork vein mineralisation are hosted by calcareous to argillaceous sandstone and siltstone of the Telfer Formation within two asymmetric doubly plunging anticlines, Main Dome and West Dome. Wall rock alteration at Telfer is typical of greisens and includes quartz, sericite, tourmaline and trace amounts of rutile, xenotime and monazite. The main controls on mineralisation are structure (thrust faults and widespread bedding-plane slip) and replacement of favourable sedimentary units (*e.g.*, impure limestone and calcareous siltstone). Pb isotope and fluid inclusion studies suggest that the mineralising fluid is a mixture of high-temperature, high-salinity, magmatic-derived fluids and cooler, lower-salinity host-rock-derived fluids (Goellnicht *et al*. 1989; Netherway 1994). The late timing of mineralisation and the interpreted magmatic signature of the ore fluids suggests that there is a connection between mineralisation at Telfer and granites of the O’Callaghan’s Supersuite (Netherway 1994).

Apart from Telfer, other stratiform/stratabound and stockwork deposits and sheeted vein deposits which carry mainly Au-Cu-As-(Pb-Zn), include Big Tree, Lamil, Hasties and Thomsons. These are characterised by phyllic alteration that produced quartz, sericite, pyrite ± tourmaline (Goellnicht 1992; Netherway 1994). The other style of distal deposit, the fault-related breccia veining and metasomatic type, carries Au-As. This style is represented by the Grace and Trotmans East prospects and has carbonate-albite-leucoxene-quartz-carbonate-sulphide alteration.

Cu is more prominent in the proximal deposits, which are either porphyry-Cu style fracture-controlled vein deposits or skarn-style metasomatic and replacement vein deposits. Seventeen Mile Hill is an example of a porphyry-style Cu deposit and the alteration is potassic (K-feldspar, quartz, biotite, tourmaline, with pyrite, pyrrhotite and chalcopyrite) phyllic and propylitic. The skarn-style mineralisation is represented by the Minyari Cu-As-Co prospect with amphibole, albite, quartz, diopside, scapolite and biotite alteration and the O’Callaghans W-Zn-Pb-Cu-(Mo)-(Sn) prospect with pyroxene, amphibole, biotite, quartz, carbonate alteration.

4.11 Geochemical Data

Data source: Seventy four samples were utilised in this study. All analyses are housed in OZCHEM and were obtained from a collaborative project between Nicky Netherway (née Goellnicht) of UWA and AGSO during her Ph.D. studies.

Data quality: Good.

Are the data representative? Reasonably, although there is much to be gained by analysing more drill core.

Are the data adequate? The data are adequate for the fresh granites, but deliberate sampling of altered drill core would be a worthwhile project.

SiO_2 range (Fig. 4.1): The SiO_2 range is very narrow from 66 to 78 wt% SiO_2 with a peak at 76

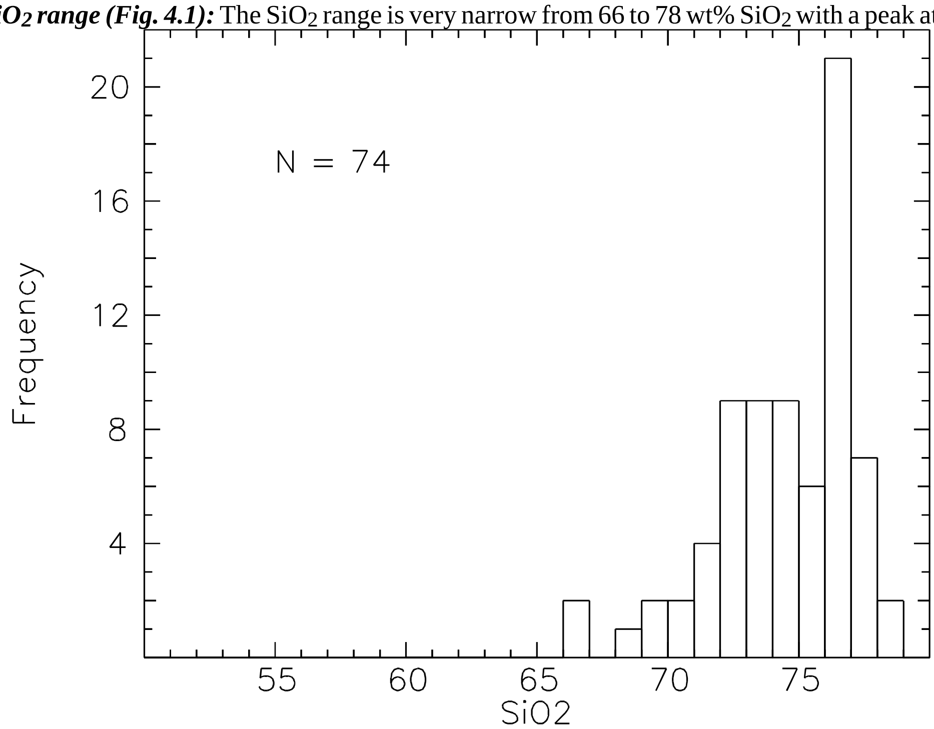


Figure 4.1. Histogram of SiO_2 values for the O’Callaghan’s Supersuite.

wt% SiO_2.

Alteration (Figs. 4.1 & 4.2):

- ***SiO_2:*** No evidence of silicification.

- ***K_2O/Na_2O:*** Despite the degree of alteration of feldspars described in the samples, there is little disturbance of these elements. The two samples with lowest Na_2O values are probably sericitised.
- ***Th/U:*** Most of the Th/U values are within the normal range.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** This plot clearly distinguishes between the oxidised and magnetite-bearing Mount Crofton Granite and the predominantly ilmenite-bearing other units. The high oxidation state of the Mount Crofton Granite is primary, given its pink colour in the field.

Fractionation Plots (Fig. 4.3):

- ***Rb:*** Rb increases weakly with increasing SiO_2.
- ***U:*** Increases sharply with increasing SiO_2. Some samples have anomalously high U; this may reflect alteration rather than fractionation.
- ***Y:*** Decreases with increasing SiO_2 for the reduced plutons, but increases with increasing SiO_2 for the oxidised Mount Crofton Granite.
- ***P_2O_5:*** Values are extremely low for Australian Proterozoic granites; decreases with increasing SiO_2.
- ***Th:*** Increases weakly with increasing SiO_2.
- ***K/Rb:*** No substantial change with increasing SiO_2, presumably because this is a biotite-rich granite suite.
- ***Rb-Ba-Sr:*** Most of the Mount Crofton and Desert’s Revenge Granites plot in the strongly differentiated field, while the other granites plot in the granite and anomalous granite fields.
- ***Sr:*** Decreases with increasing SiO_2. Values are noticeably higher for the O’Callaghans Granite, which has the most An-rich plagioclase.
- ***Rb/Sr:*** Late exponential increase with increasing SiO_2.
- ***Ba:*** Values decrease with increasing SiO_2.
- ***F:*** Only three results are available: all are very low.

Metals (Fig. 4.4):

- ***Cu:*** Most Cu values are very low for Australian Proterozoic Granites.
- ***Pb:*** Pb values are low to moderate for Australian Proterozoic Granites.
- ***Zn:*** Zn values are low for Australian Proterozoic Granites and decrease with increasing SiO_2.
- ***Sn:*** Sn values are low for Australian Proterozoic Granites.

High field strength elements (Fig. 4.5):

- ***Zr:*** Values decrease with increasing SiO_2.
- ***Nb:*** Nb values are low for Australian Proterozoic Granites.
- ***Ce:*** Ce values are low for Australian Proterozoic Granites and show a weak decrease with increasing SiO_2.

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 reflecting the high and narrow range of SiO_2 values.
- ***Zr/Y vs Sr/Sr*:*** All samples are Sr-depleted.
- ***Spidergram:*** The pattern is Sr-depleted, Y un-depleted as is typical of Australian Proterozoic granites.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples plot in the oxidised field with the O’Callaghans Granite, Desert’s Revenge Granite and the Hansens Folly Granite, the three closest granites to the Telfer deposit, plotting in the reduced field.
- ***ASI:*** All samples have ASI < 1.1 and are weakly peraluminous.
- ***A-type plot of Eby (1990):*** Most samples (excepting the Koolyu Granite) plot in the normal granite field. This is one of the few Australian Proterozoic Granite suites to do so and it is also one of the youngest.

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

Australian Proterozoic granite type: Cullen.

4.12 Geophysical Signature

Radiometrics (Fig. 4.7): The samples would all appear white in a RGB image.

Gravity: The regional gravity data are too coarse to allow comment, although Sexton (1994) shows that most of the granites form gravity lows in the detailed surveys.

Magnetics: The Mount Crofton Granite (oxidised) is a magnetic high; the remainder (which are reduced) are magnetic lows.

4.13 References

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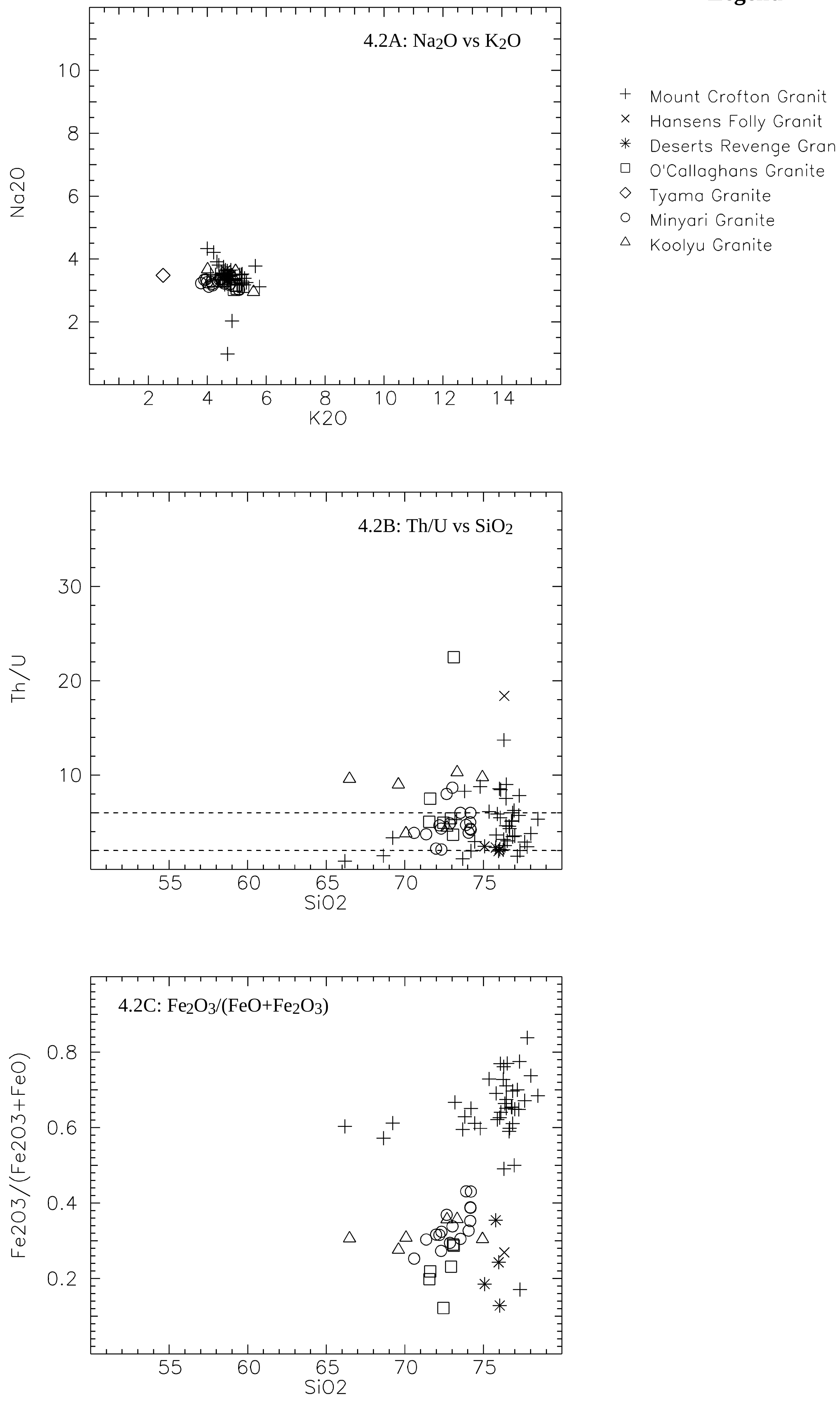
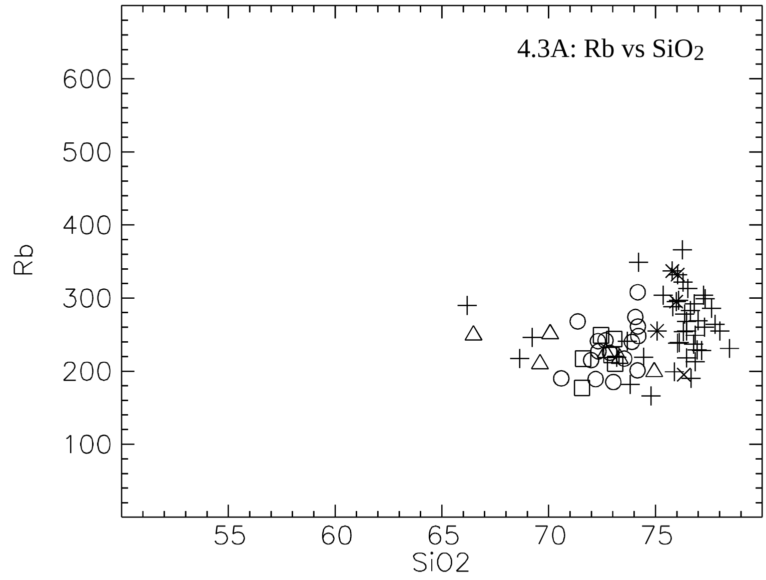
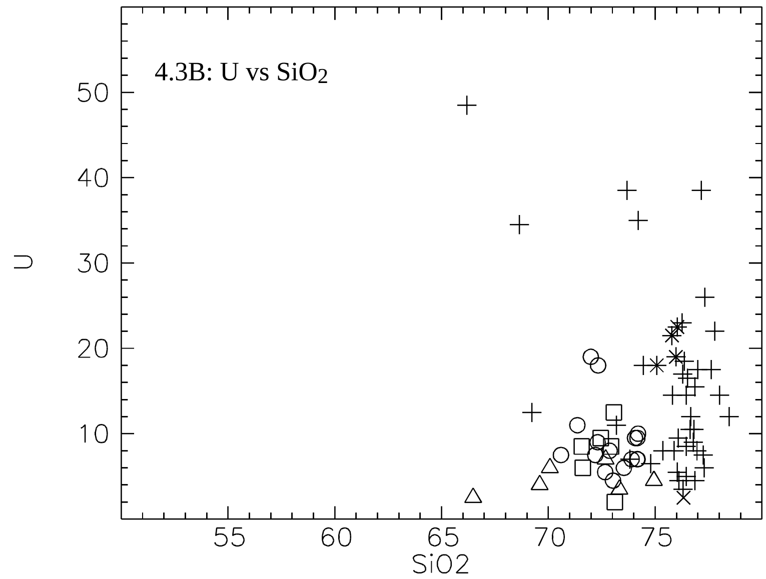
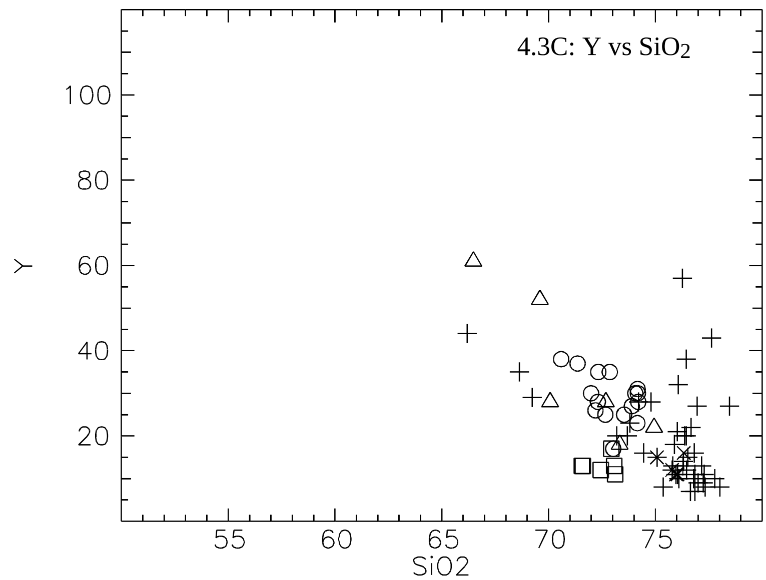

4.2A: Na_2O vs K_2O
Na2O
K2O
2
4
6
8
10
12
14
4.2B: Th/U vs SiO_2
Th/U
SiO2
10
20
30
55
60
65
70
75
4.2C: $Fe_2O_3/(FeO+Fe_2O_3)$
Fe2O3/(Fe2O3+FeO)
SiO2
0.2
0.4
0.6
0.8
55
60
65
70
75
Mount Crofton Granit
Hansens Folly Granit
Deserts Revenge Gran
O'Callaghans Granite
Tyama Granite
Minyari Granite
Koolyu Granite

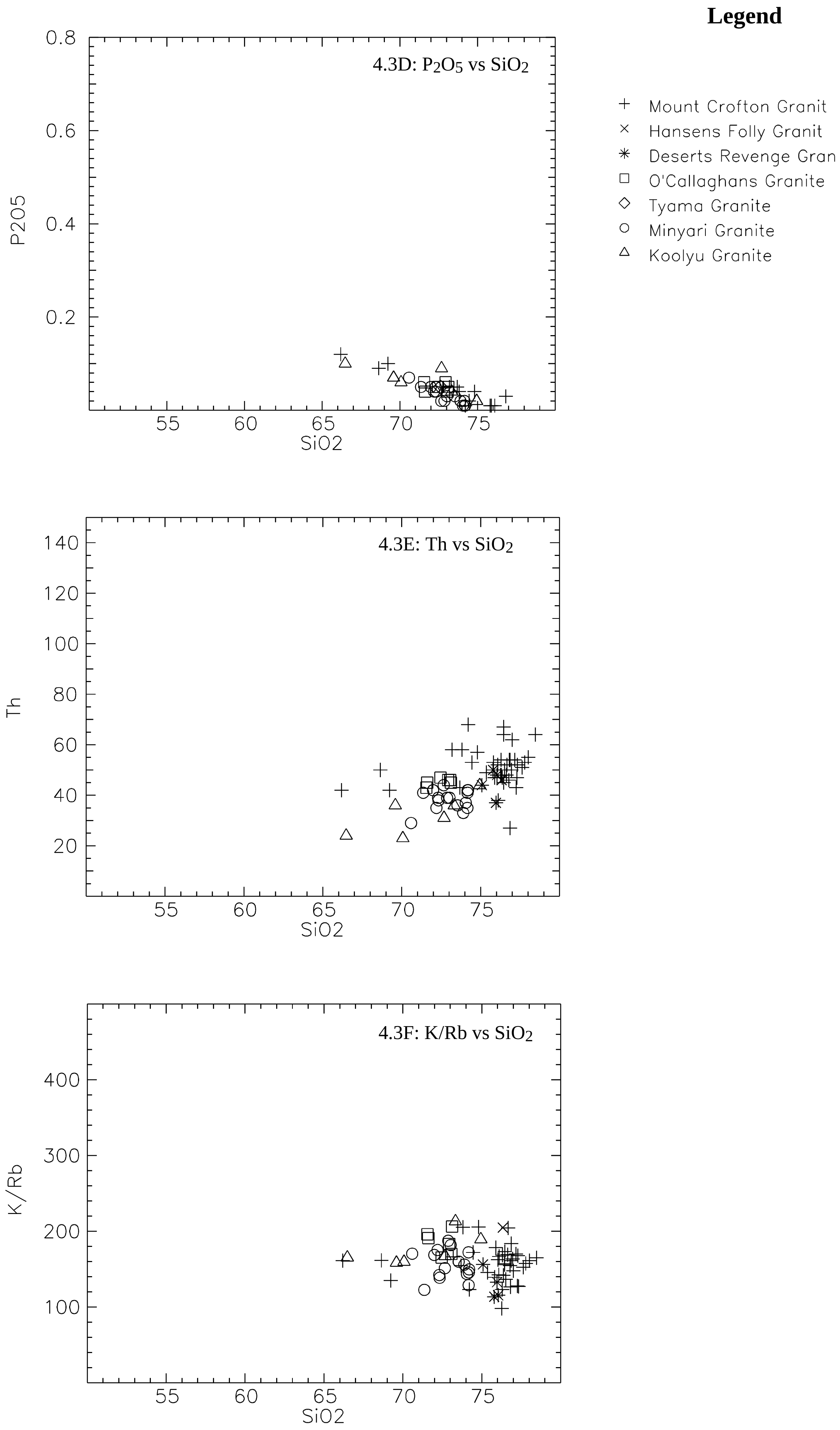
Legend

+ Mount Crofton Granit
× Hansens Folly Granit
✳ Deserts Revenge Gran
□ O'Callaghans Granite
◇ Tyama Granite
○ Minyari Granite
△ Koolyu Granite





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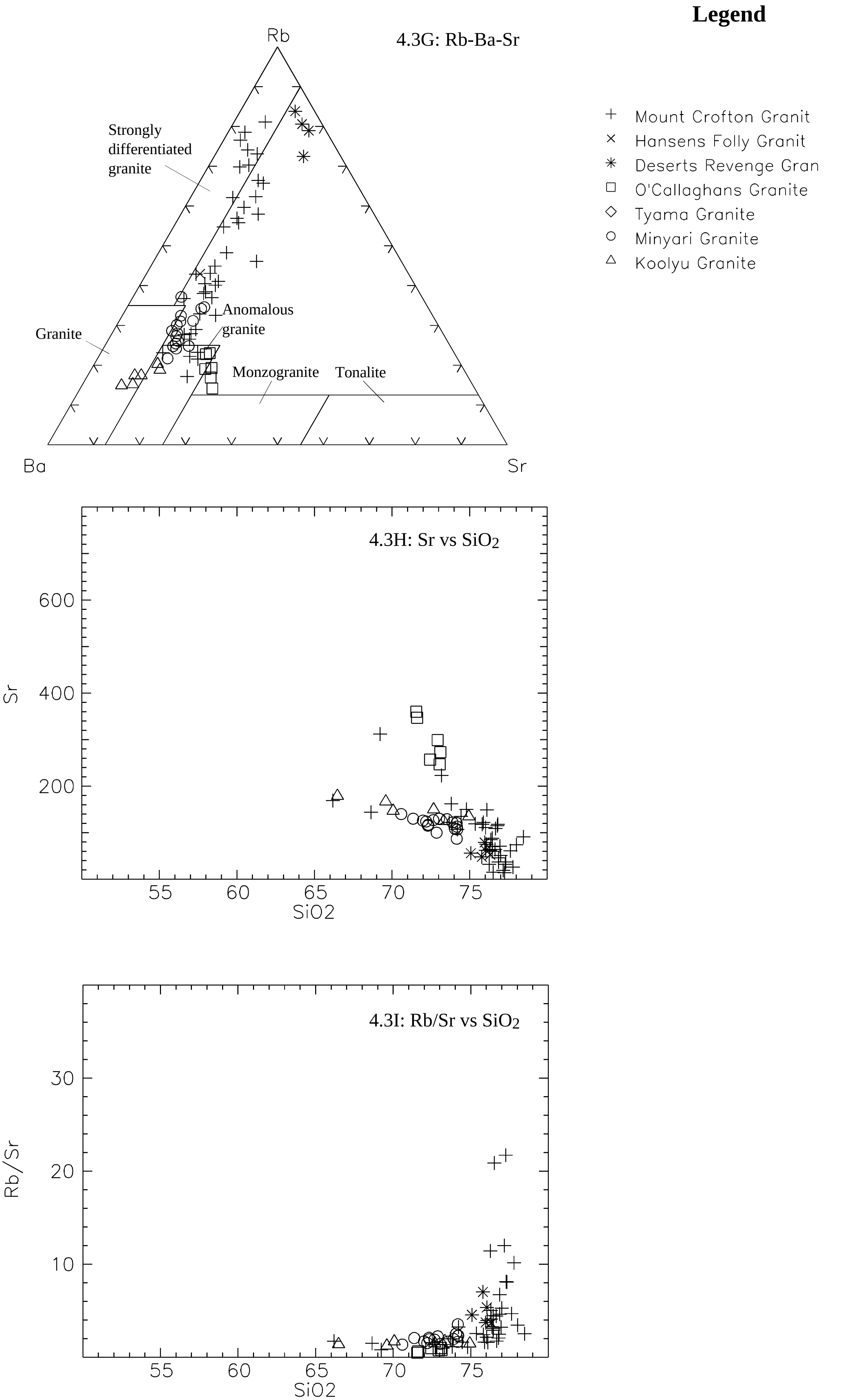
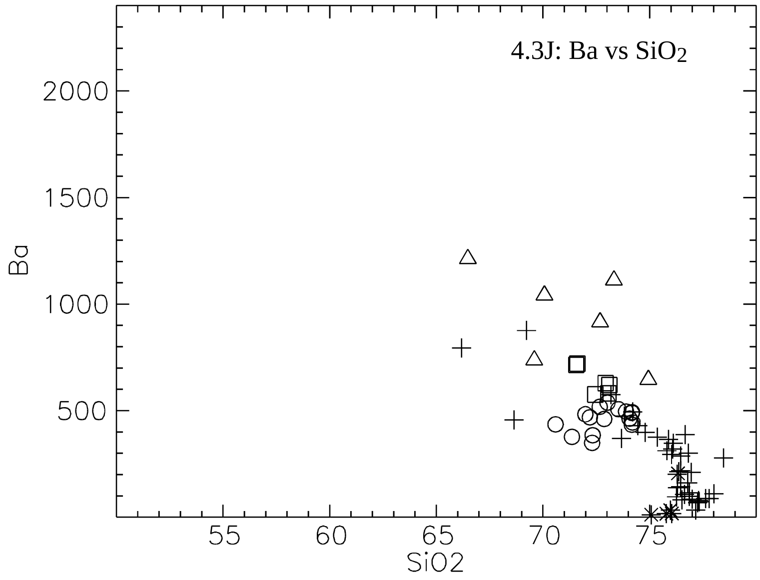
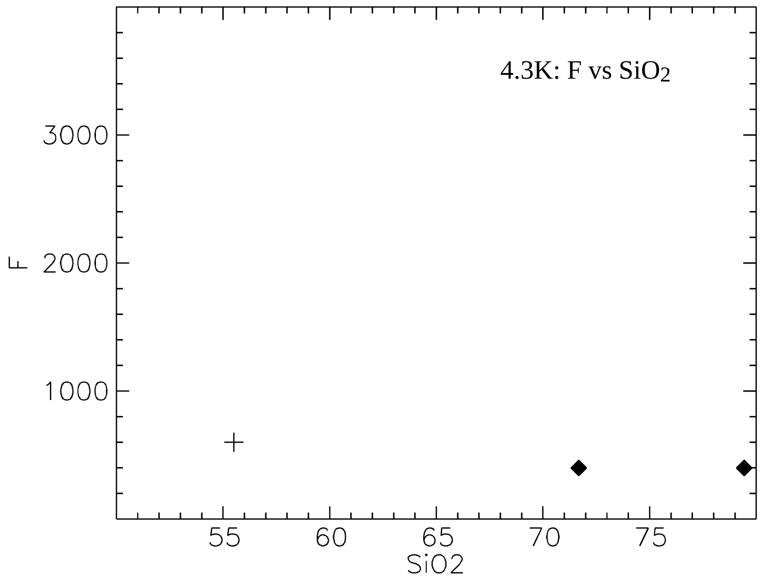
Mount Crofton Granit
Hansens Folly Granit
Deserts Revenge Gran
O'Callaghans Granite
Tyama Granite
Minyari Granite
Koolyu Granite
4.3D: P2O5 vs SiO2
P2O5
0.8
0.6
0.4
0.2
SiO2
55
60
65
70
75
4.3E: Th vs SiO2
Th
140
120
100
80
60
40
20
SiO2
55
60
65
70
75
4.3F: K/Rb vs SiO2
K/Rb
400
300
200
100
SiO2
55
60
65
70
75

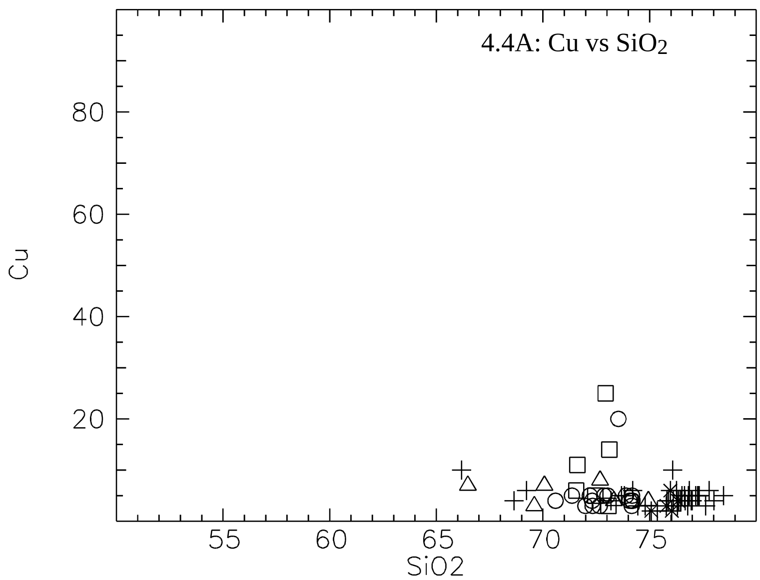

Legend
+ Mount Crofton Granit
× Hansens Folly Granit
✳ Deserts Revenge Gran
□ O'Callaghans Granite
◇ Tyama Granite
○ Minyari Granite
△ Koolyu Granite
4.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Anomalous granite
Granite
Monzogranite
Tonalite
4.3H: Sr vs SiO2
Sr
600
400
200
55
60
65
70
75
SiO2
4.3I: Rb/Sr vs SiO2
Rb/Sr
30
20
10
55
60
65
70
75
SiO2

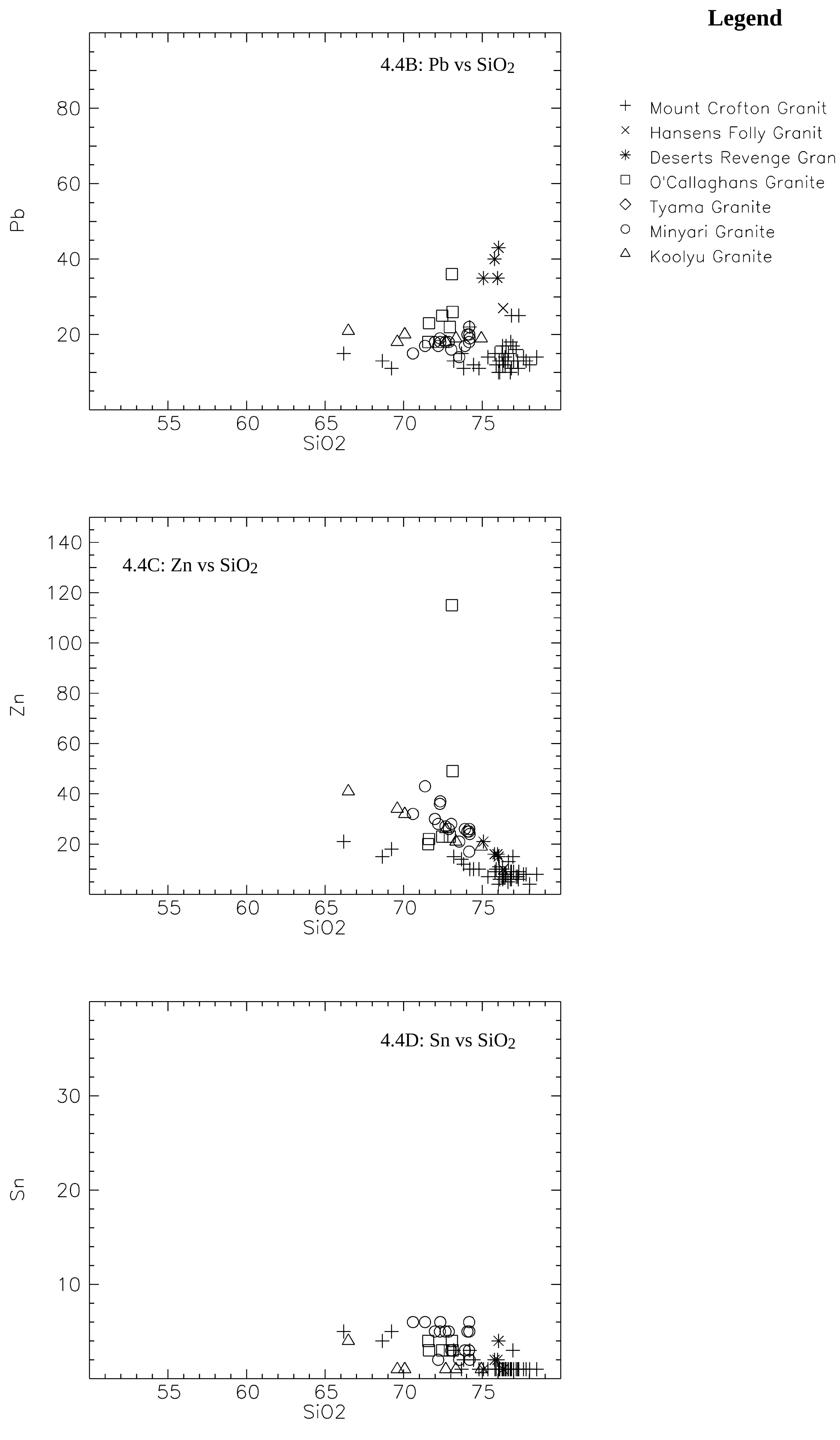
Legend

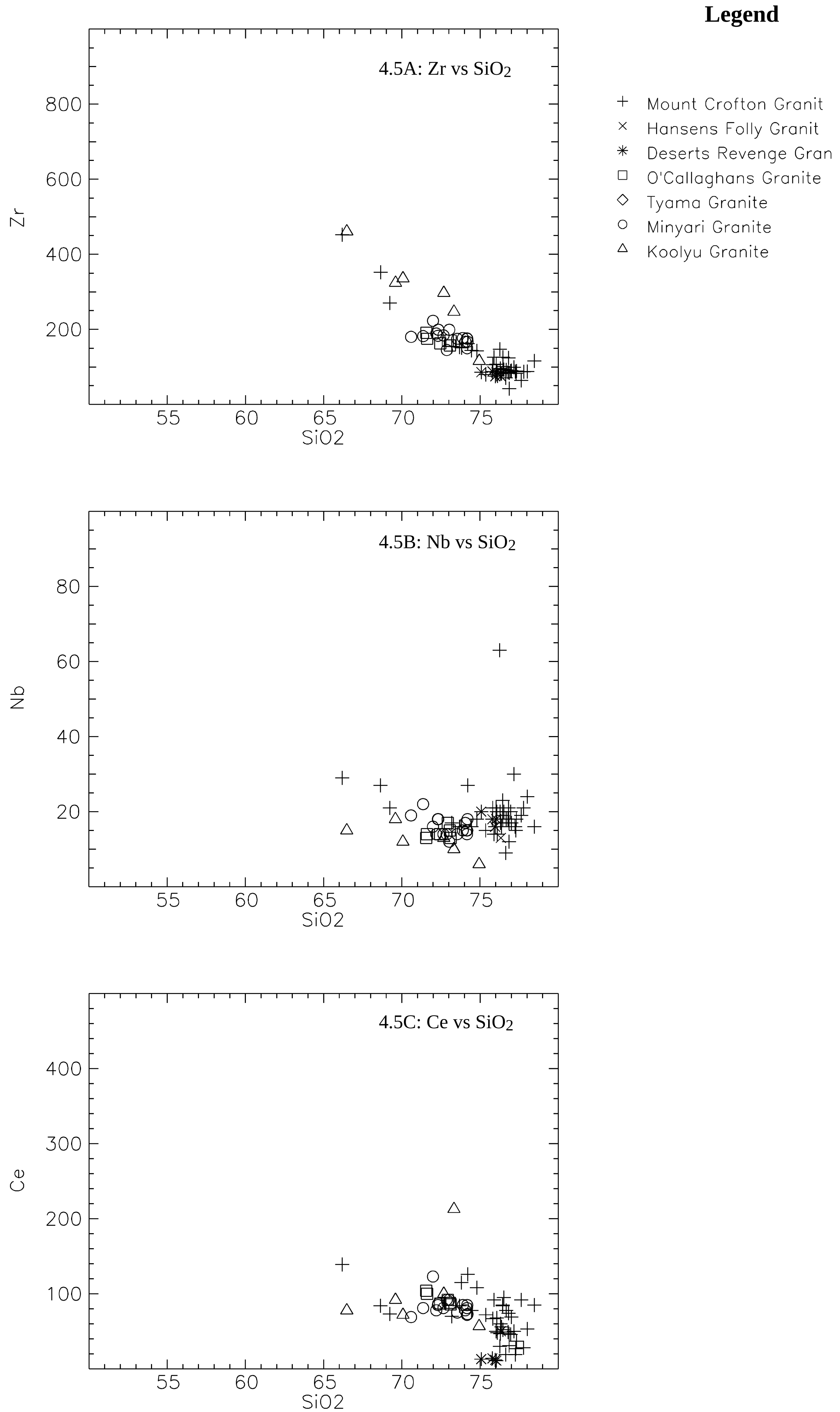


+ Mount Crofton Granit
× Hansens Folly Granit
✳ Deserts Revenge Gran
□ O'Callaghans Granite
◇ Tyama Granite
○ Minyari Granite
△ Koolyu Granite






Legend
Mount Crofton Granit
Hansens Folly Granit
Deserts Revenge Gran
O'Callaghans Granite
Tyama Granite
Minyari Granite
Koolyu Granite
4.4B: Pb vs SiO2
Pb
80
60
40
20
55
60
65
70
75
SiO2
4.4C: Zn vs SiO2
Zn
140
120
100
80
60
40
20
55
60
65
70
75
SiO2
4.4D: Sn vs SiO2
Sn
30
20
10
55
60
65
70
75
SiO2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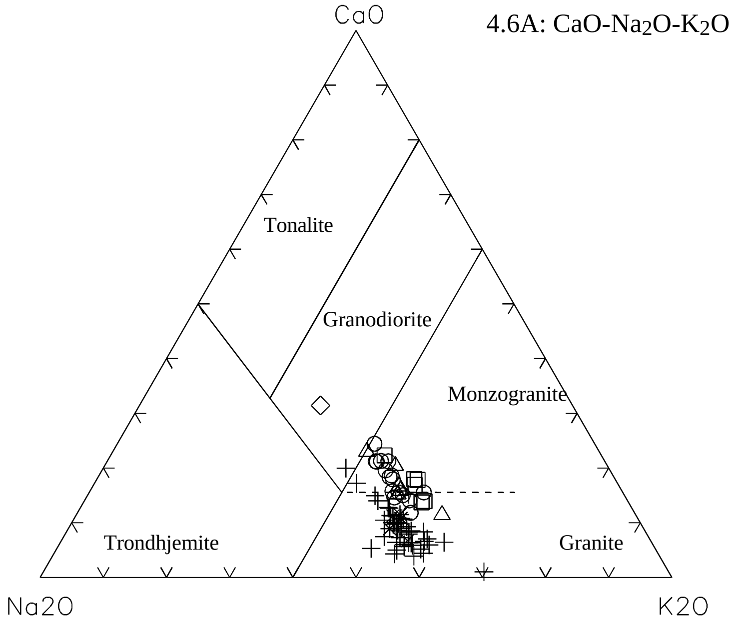
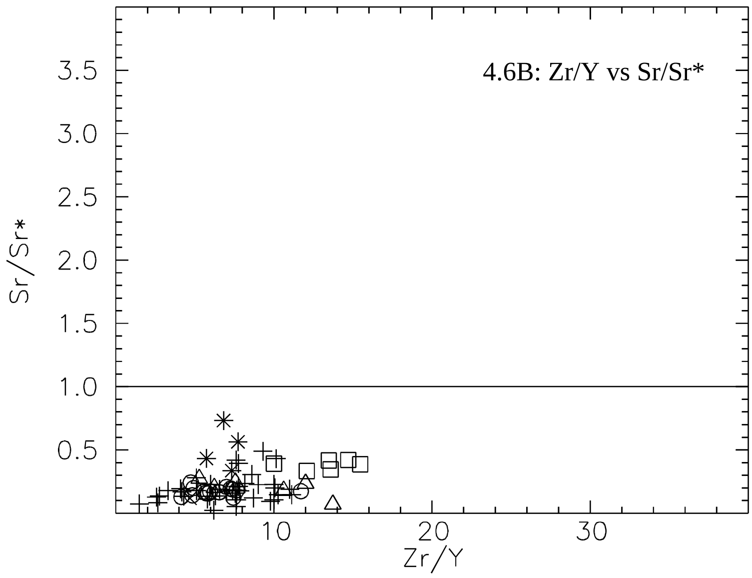
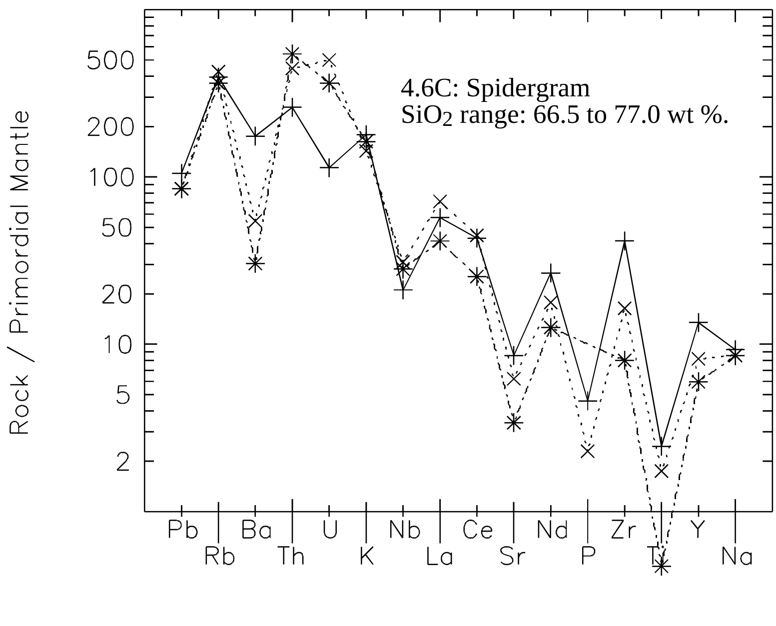
Mount Crofton Granit
Hansens Folly Granit
Deserts Revenge Gran
O'Callaghans Granite
Tyama Granite
Minyari Granite
Koolyu Granite
4.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
4.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
4.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

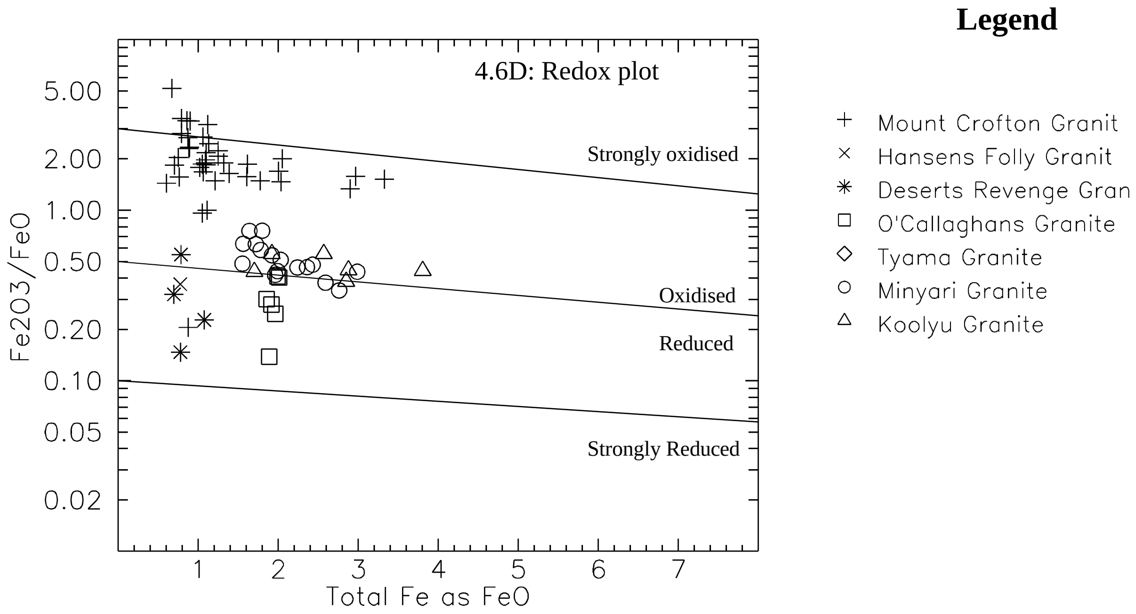
Legend

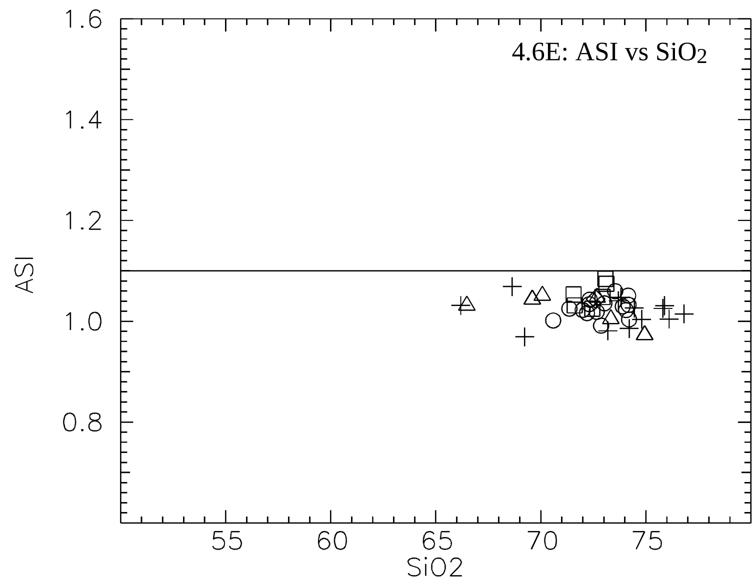

Mount Crofton Granit
Hansens Folly Granit
Deserts Revenge Gran
O'Callaghans Granite
Tyama Granite
Minyari Granite
Koolyu Granite

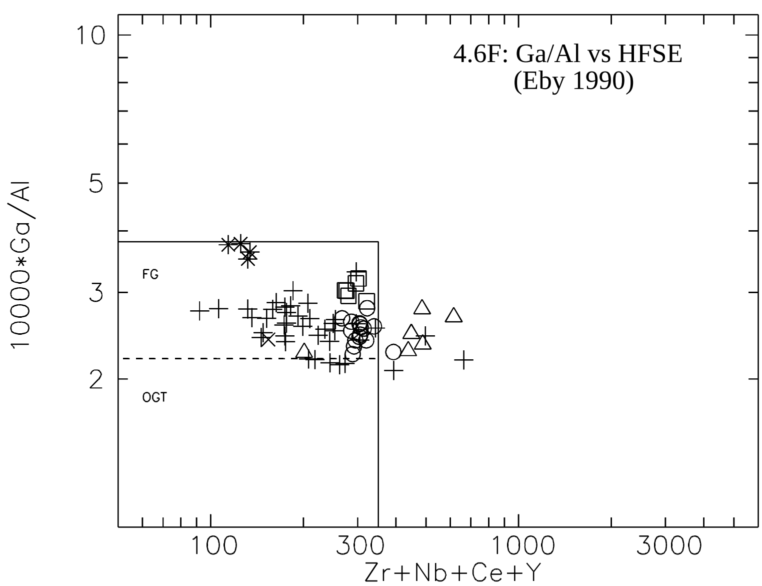

CaO
4.6A: CaO-Na2O-K2O
Tonalite
Granodiorite
Monzogranite
Trondhjemite
Granite
Na2O
K2O

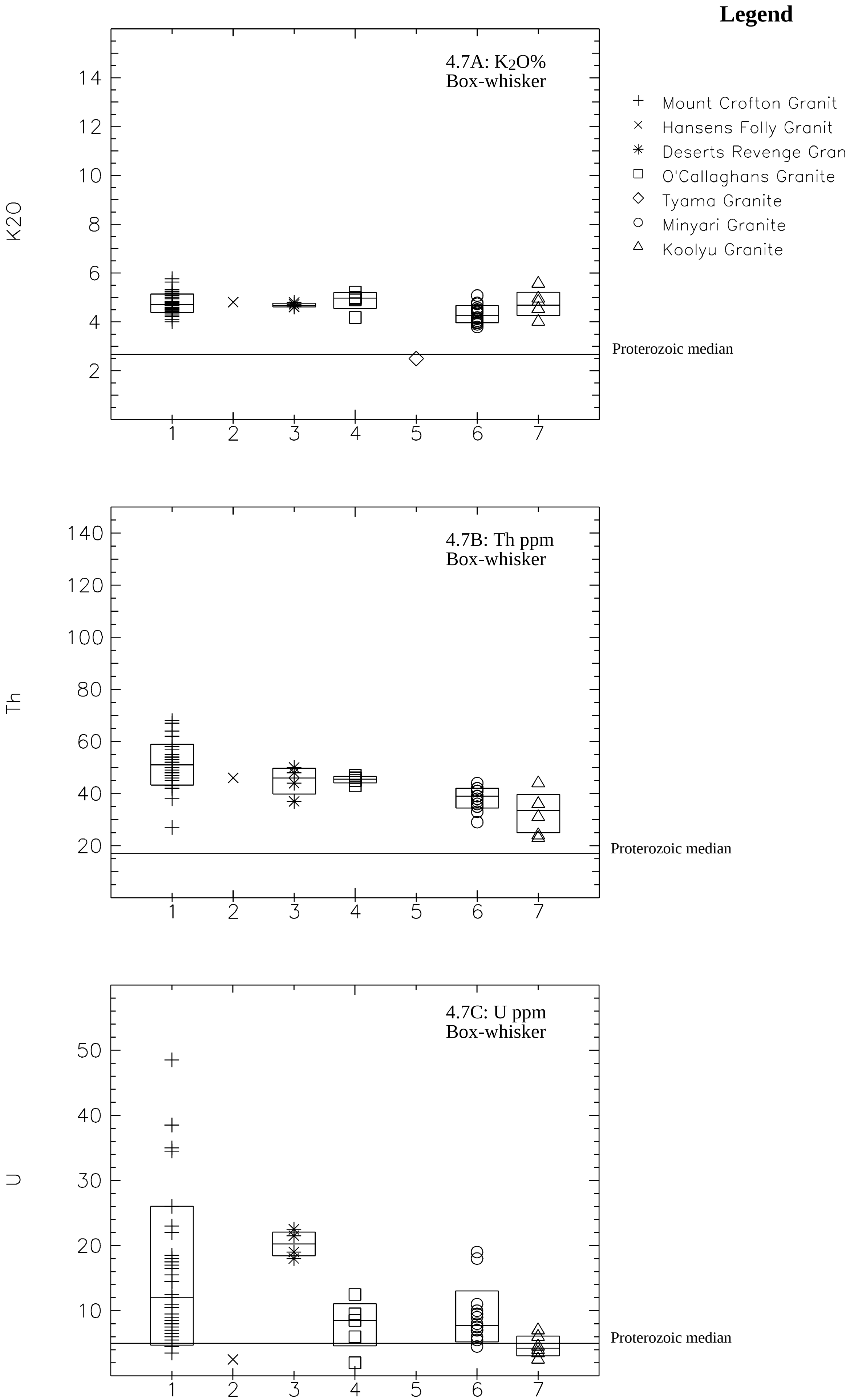

4.6B: Zr/Y vs Sr/Sr*
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Sr/Sr*
10
20
30
Zr/Y


4.6C: Spidergram
SiO2 range: 66.5 to 77.0 wt %.
500
200
100
50
20
10
5
2
Rock / Primordial Mantle
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na


Legend
Mount Crofton Granit
Hansens Folly Granit
Deserts Revenge Gran
O'Callaghans Granite
Tyama Granite
Minyari Granite
Koolyu Granite
4.6D: 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
Total Fe as FeO
1
2
3
4
5
6
7


4.6E: ASI vs SiO2
ASI
1.6
1.4
1.2
1.0
0.8
SiO2
55
60
65
70
75


4.6F: Ga/Al vs HFSE
(Eby 1990)
10000*Ga/Al
10
5
3
2
FG
OGT
Zr+Nb+Ce+Y
100
300
1000
3000


Legend
Mount Crofton Granit
Hansens Folly Granit
Deserts Revenge Gran
O'Callaghans Granite
Tyama Granite
Minyari Granite
Koolyu 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

Mount Crofton Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	75.84	76.45	2.69	66.19	82.17	41
TiO2	0.15	0.11	0.12	0.03	0.56	41
Al2O3	12.49	12.36	1.04	9.03	15.55	41
Fe2O3	0.82	0.72	0.38	0.15	2.02	39
FeO	0.47	0.38	0.29	0.11	1.33	39
MnO	0.02	0.01	0.01	0.01	0.05	21
MgO	0.2	0.14	0.19	0.01	0.73	37
CaO	0.79	0.7	0.41	0.07	2.08	40
Na2O	3.39	3.48	0.51	0.98	4.33	41
K2O	4.76	4.71	0.38	4	5.77	41
P2O5	0.04	0.04	0.04	0.01	0.12	13
LOI	0.54	0.45	0.53	0.26	3.8	41
Ba	270.59	218	196.35	34	876	39
Li	19.23	17	10.28	6	45	39
Rb	257.87	255	44.3	166	366	39
Sr	93.82	85	60.16	14	312	39
Pb	14.1	13	3.55	10	25	39
Th	51.08	51	7.95	27	68	39
U	15.37	12	10.8	3.5	48.5	39
Zr	122.54	94	77.12	42	452	39
Nb	19.97	18	8.3	9	63	39
Y	19.79	16	11.77	7	57	39
La	44.36	43	18.91	12	91	39
Ce	66.33	68	28.53	19	139	39
Pr	5.05	5	2.71		12	39
Nd	17.41	15	9.81	3	46	39
Sc	2.64	2	1.38		7	39
V	7.92	6	7.69		35	39
Cr	1.92	2	1.88		12	39
Mn	152.44	117	94.99	40	447	39
Co	2	1.5	1.41		4	4
Ni	2.45	2	0.94		7	39
Cu	4.62	4	1.63	2	10	39
Zn	9.28	8	3.73	4	21	39
Sn	1.49		1.1		5	39
Mo	1.49		0.88		5	39
Ga	16.95	17	1.65	13	22	39
As	0.6	0.5	0.4	50	2	39
Be	3.46	3	1.07	2	6	39
Ag	1.23	1	0.54	1	3	39
Bi	1		-			39
Hf	4	4	1.73	2	11	39
Ta	2.28	2	1.36		7	39
Cs	3.17		1.68		10	35
Ge	1.87	2	0.34	1	2.5	39
Se	0.5		-			39

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Hansens Folly Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	76.33	76.33	-	76.33	76.33	1
TiO2	0.07	0.07	-	0.07	0.07	1
Al2O3	12.57	12.57	-	12.57	12.57	1
Fe2O3	0.21	0.21	-	0.21	0.21	1
FeO	0.57	0.57	-	0.57	0.57	1
MnO	0.02	0.02	-	0.02	0.02	1
MgO	0.15	0.15	-	0.15	0.15	1
CaO	0.59	0.59	-	0.59	0.59	1
Na2O	3.38	3.38	-	3.38	3.38	1
K2O	4.81	4.81	-	4.81	4.81	1
P2O5	-	-	-	-	-	-
LOI	0.36	0.36	-	0.36	0.36	1
Ba	206	206	-	206	206	1
Li	16	16	-	16	16	1
Rb	195	195	-	195	195	1
Sr	53	53	-	53	53	1
Pb	27	27	-	27	27	1
Th	46	46	-	46	46	1
U	2.5	2.5	-	2.5	2.5	1
Zr	75	75	-	75	75	1
Nb	13	13	-	13	13	1
Y	16	16	-	16	16	1
La	26	26	-	26	26	1
Ce	50	50	-	50	50	1
Pr	7	7	-	7	7	1
Nd	21	21	-	21	21	1
Sc	2	2	-	2	2	1
V	2	2	-	2	2	1
Cr	1	1	-	1	1	1
Mn	279	279	-	279	279	1
Co	-	-	-	-	-	-
Ni	1	1	-	1	1	1
Cu	4	4	-	4	4	1
Zn	10	10	-	10	10	1
Sn	1		-			1
Mo	1		-			1
Ga	16	16	-	16	16	1
As	0.5	0.5	-	0.5	0.5	1
Be	3	3	-	3	3	1
Ag	1	1	-	1	1	1
Bi	1		-			1
Hf	4	4	-	4	4	1
Ta	1		-			1
Cs	2.5		-			1
Ge	1.5	1.5	-	1.5	1.5	1
Se	0.5		-			1

Deserts Revenge Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	75.72	75.88	0.44	75.08	76.04	4
TiO2	0.03	0.02	0.02	0.01	0.05	4
Al2O3	13.03	13.05	0.08	12.93	13.11	4
Fe2O3	0.19	0.19	0.07	0.1	0.28	4
FeO	0.65	0.61	0.17	0.51	0.88	4
MnO	0.02	0.02	0.01	0.01	0.03	4
MgO	0.14	0.14	0.11	0.03	0.25	3
CaO	0.97	1.01	0.11	0.81	1.06	4
Na2O	3.53	3.51	0.09	3.44	3.65	4
K2O	4.69	4.67	0.09	4.61	4.8	4
P2O5	-	-	-	-	-	-
LOI	0.46	0.49	0.07	0.36	0.52	4
Ba	20	17.5	9.06	12	33	4
Li	9.5	9	1.91	8	12	4
Rb	304.75	313.5	38.09	255	337	4
Sr	61.25	59	13.15	48	79	4
Pb	38.25	37.5	3.95	35	43	4
Th	44.75	46	5.74	37	50	4
U	20.25	20.25	2.1	18	22.5	4
Zr	83.5	85.5	5.8	75	88	4
Nb	18	18	1.63	16	20	4
Y	12.25	11.5	1.89	11	15	4
La	6	6.5	1.41	4	7	4
Ce	12.5	12.5	1.29	11	14	4
Pr	2.75	3	1.26		4	4
Nd	6.5	6.5	1.29	5	8	4
Sc	4.75	4.5	0.96	4	6	4
V	1		-			4
Cr	1.25	1.25	0.87		2	4
Mn	273.5	281.5	56.56	200	331	4
Co	-	-	-	-	-	-
Ni	1.5	1.5	0.58	1	2	4
Cu	3.25	2.5	1.89	2	6	4
Zn	17	16	2.71	15	21	4
Sn	2.25	2	1.26		4	4
Mo	1.75	1.5	0.96		3	4
Ga	25.25	25.5	0.96	24	26	4
As	1.63	1.5	0.63	1	2.5	4
Be	4.5	4.5	0.58	4	5	4
Ag	1	1	-	1	1	4
Bi	1		-			4
Hf	4	4	-	4	4	4
Ta	1.75	1.5	0.96		3	4
Cs	6.75	7	2.87	3	10	4
Ge	1.63	1.5	0.25	1.5	2	4
Se	0.5		-			4

O’Callaghans Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.46	72.69	0.72	71.56	73.12	6
TiO2	0.25	0.26	0.02	0.22	0.28	6
Al2O3	14.02	13.99	0.28	13.74	14.46	6
Fe2O3	0.44	0.43	0.13	0.23	0.58	6
FeO	1.5	1.47	0.1	1.42	1.66	6
MnO	0.01	0.01	0.01	0.01	0.03	6
MgO	0.54	0.51	0.07	0.49	0.67	6
CaO	1.66	1.68	0.32	1.28	2.15	6
Na2O	3.14	3.13	0.1	3.02	3.31	6
K2O	4.87	4.97	0.36	4.18	5.22	6
P2O5	0.05	0.05	0.01	0.04	0.06	6
LOI	0.74	0.78	0.12	0.52	0.85	6
Ba	640.33	624.5	63.69	576	721	6
Li	27.5	26.5	3.45	24	34	6
Rb	219.83	219.5	26	177	249	6
Sr	297.17	286	47.22	247	360	6
Pb	25	24	6.07	18	36	6
Th	45.33	45.5	1.37	43	47	6
U	7.83	8.5	3.54	2	12.5	6
Zr	171	170	11.64	157	191	6
Nb	14.33	14	1.51	13	17	6
Y	13.17	13	2.04	11	17	6
La	55.33	55	3.08	51	60	6
Ce	92.83	90	7.49	86	104	6
Pr	8.5	8.5	1.64	6	11	6
Nd	30.67	30.5	2.25	27	33	6
Sc	5	5	0.63	4	6	6
V	23	23	1.9	21	25	6
Cr	5	5	0.63	4	6	6
Mn	211.17	207	39.67	165	266	6
Co	-	-	-	-	-	-
Ni	4.17	4	1.47	3	7	6
Cu	10.67	8.5	8.12	3	25	6
Zn	42	23	37.37	20	115	6
Sn	3.33	3	0.52	3	4	6
Mo	1.67		1.21		4	6
Ga	22.5	22	0.84	22	24	6
As	0.83	0.75	0.58	50	1.5	6
Be	3.83	4	0.41	3	4	6
Ag	1	1	-	1	1	6
Bi	1		-			6
Hf	5	5	0.63	4	6	6
Ta	2.17	2	1.17		4	6
Cs	5.7	6	2.39		8	5
Ge	1.58	1.5	0.2	1.5	2	6
Se	0.5		-			6

Tyama Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.61	72.61	-	72.61	72.61	1
TiO2	0.39	0.39	-	0.39	0.39	1
Al2O3	13.87	13.87	-	13.87	13.87	1
Fe2O3	-	-	-	-	-	-
FeO	-	-	-	-	-	-
MnO	0.04	0.04	-	0.04	0.04	1
MgO	0.61	0.61	-	0.61	0.61	1
CaO	2.74	2.74	-	2.74	2.74	1
Na2O	3.48	3.48	-	3.48	3.48	1
K2O	2.5	2.5	-	2.5	2.5	1
P2O5	0.05	0.05	-	0.05	0.05	1
LOI	0.72	0.72	-	0.72	0.72	1
Ba	-	-	-	-	-	-
Li	-	-	-	-	-	-
Rb	-	-	-	-	-	-
Sr	-	-	-	-	-	-
Pb	-	-	-	-	-	-
Th	-	-	-	-	-	-
U	-	-	-	-	-	-
Zr	-	-	-	-	-	-
Nb	-	-	-	-	-	-
Y	-	-	-	-	-	-
La	-	-	-	-	-	-
Ce	-	-	-	-	-	-
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	-	-	-	-	-	-
V	-	-	-	-	-	-
Cr	-	-	-	-	-	-
Mn	-	-	-	-	-	-
Co	-	-	-	-	-	-
Ni	-	-	-	-	-	-
Cu	-	-	-	-	-	-
Zn	-	-	-	-	-	-
Sn	-	-	-	-	-	-
Mo	-	-	-	-	-	-
Ga	-	-	-	-	-	-
As	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Minyari Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.97	72.95	1.12	70.59	74.2	16
TiO2	0.26	0.25	0.07	0.17	0.39	16
Al2O3	13.26	13.32	0.27	12.81	13.82	16
Fe2O3	0.69	0.69	0.09	0.51	0.91	16
FeO	1.4	1.37	0.38	0.94	2.09	16
MnO	0.03	0.03	0.01	0.01	0.06	16
MgO	0.53	0.51	0.19	0.3	0.98	16
CaO	1.65	1.66	0.32	1.07	2.34	16
Na2O	3.24	3.24	0.09	3.02	3.36	16
K2O	4.32	4.27	0.36	3.79	5.08	16
P2O5	0.03	0.03	0.02	0.01	0.07	15
LOI	0.63	0.62	0.19	0.24	0.94	16
Ba	459	466	52.83	349	538	16
Li	46.88	44	15.28	26	92	16
Rb	233.19	233.5	34.18	185	308	16
Sr	118.5	121.5	13.26	87	140	16
Pb	17.88	18	1.96	14	22	16
Th	38.25	39	3.94	29	44	16
U	9.13	7.75	4.04	4.5	19	16
Zr	179.44	178.5	18.64	145	223	16
Nb	15.94	15	2.54	12	22	16
Y	29.06	29	5.48	17	38	16
La	50.81	50	7.88	41	74	16
Ce	83.56	81	12.46	69	123	16
Pr	8.44	8	1.59	6	12	16
Nd	27.56	26	4.44	23	40	16
Sc	4.81	5	1.17	3	7	16
V	21.56	20	7.46	12	35	16
Cr	9.69	6	9.79	3	34	16
Mn	358.06	337.5	93.8	229	603	16
Co	-	-	-	-	-	-
Ni	4.94	4	2.91	2	12	16
Cu	5.13	4	4.05	3	20	16
Zn	28.19	26.5	6.36	17	43	16
Sn	4.31	5	1.54	2	6	16
Mo	1.63		0.81		3	16
Ga	17.5	18	1.03	16	20	16
As	0.59	0.5	0.39	50	1.5	16
Be	1.44	1	0.63	1	3	16
Ag	1.38	1	0.5	1	2	16
Bi	1		-			16
Hf	4.75	5	0.93	3	6	16
Ta	1.81		1.11		4	16
Cs	8.56	8.5	1.97		12	16
Ge	1.53	1.5	0.34	1	2	16
Se	0.5		-			16

Koolyu Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.18	71.38	3.06	66.48	74.94	6
TiO2	0.35	0.37	0.12	0.17	0.52	6
Al2O3	13.95	13.89	1.24	12.52	15.55	6
Fe2O3	0.83	0.84	0.22	0.52	1.17	6
FeO	1.8	1.83	0.56	1.19	2.65	6
MnO	0.03	0.04	0.02	0.01	0.06	6
MgO	0.58	0.55	0.14	0.41	0.79	6
CaO	1.69	1.56	0.47	1.1	2.29	6
Na2O	3.38	3.39	0.27	2.95	3.67	6
K2O	4.74	4.68	0.52	4.01	5.57	6
P2O5	0.06	0.06	0.03	0.02	0.1	6
LOI	0.72	0.65	0.24	0.43	1.13	6
Ba	944	978	220.13	646	1212	6
Li	18.33	19	3.93	12	23	6
Rb	225.17	221	21.06	199	251	6
Sr	150.5	148.5	19.94	125	179	6
Pb	19.17	19	1.17	18	21	6
Th	32.33	33.5	8.02	23	44	6
U	4.58	4.25	1.66	2.5	7	6
Zr	296.83	310.5	113.5	116	461	6
Nb	12.33	12.5	4.13	6	18	6
Y	34.83	28	17.44	18	61	6
La	57.83	46.5	34.08	34	126	6
Ce	102	85	56.44	57	213	6
Pr	9.17	9	3.87	5	16	6
Nd	37.5	34.5	17.1	21	70	6
Sc	5.5	4.5	2.88	3	11	6
V	26.33	25	10.84	14	43	6
Cr	4.83	5	2.23	1	8	6
Mn	343	327.5	126.44	188	532	6
Co	-	-	-	-	-	-
Ni	3.5	3.5	0.55	3	4	6
Cu	5.5	5.5	2.07	3	8	6
Zn	28.83	29	8.38	19	41	6
Sn	1.5		1.22		4	6
Mo	3.17	3	2.04		7	6
Ga	18.33	17.5	3.14	15	22	6
As	0.33	50	0.13	50	0.5	6
Be	2.83	3	1.17	1	4	6
Ag	1	1	-	1	1	6
Bi	1		-			6
Hf	8.33	8.5	3.14	4	13	6
Ta	1.83	1.5	0.98		3	6
Cs	3.6		1.39		6	5
Ge	1.42	1.5	0.2	1	1.5	6
Se	0.5		-			6