1 TENNANT CREEK/DAVENPORT SYNTHESIS

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1.1 Executive Summary - Geology

Due to its high economic endowment and potential, the geology of the Tennant Creek Province has been the focus of many detailed studies over the years. The most recent summary of the whole province was by Le Messurier *et al.* (1990). The Tennant Creek Province is currently being remapped at 1:100 000 scale by the Northern Territory Geological Survey (Donnellan *et al.* 1994, 1995, in prep.). The Davenport Province was remapped in the early 1980's as part of a major 1:100 000-scale geological mapping program by the BMR (Blake *et al.* 1987). In this report, the Tennant Creek and Davenport Provinces are treated as the one entity.

The oldest unit in the Tennant Creek and Davenport Provinces is the Warramunga Formation, a polydeformed succession consisting of lithic and sublithic, arenite, wacke and siltstone, terrigenous mudstone and hematitic shale. The sediments contain immature volcanic detritus and are regarded as medium-grained turbidites of proximal to distal fan facies apparently derived as part of a prograding (coarsening upwards) succession. Magnetite is ubiquitous and locally forms distinct laminae; it is a major component in the hematite shales (Donnellan 1994; Donnellan *et al.* 1994; Le Messurier *et al.* 1990). Carbonaceous shales are not common (N. Donnellan, *pers comm*); one occurrence of hematitic shale with 0.2% C was reported by Reveleigh (1997). The Warramunga Formation was deformed and metamorphosed to greenschist facies, and ironstone hosts to Au mineralisation appear to have formed early in the deformation history (Ding and Giles 1993). Felsic volcanics and volcaniclastic and clastic sediments of the Flynn Subgroup and Ooradidgee Subgroup were deposited on deformed Warramunga Formation. The Tennant Creek Supersuite was emplaced throughout this part of the geological history as volcanics within the Warramunga Formation (~1870 Ma, mainly in the Davenport Province), as granites (1940-1858 Ma) which are pre-, syn- and post- deformation, and as bimodal volcanics in the lower Flynn and Ooradidgee Subgroups (~1840 Ma; Hussey *et al.* 1994). Sedimentation continued through to the Tomkinson Creek, Wauchope and Hanlon Subgroups, under predominantly orogenic terrigenous and stable shelf conditions (Donnellan *et al.*, in prep.). A compositionally different suite of bimodal volcanics and shallow-level intrusions, the Treasure Suite was emplaced at ~1820 Ma. Sedimentation continued after this suite, but all known mineral deposits are hosted by rocks equivalent in age or older than this suite. After sedimentation, a final magmatic episode at about 1700 Ma resulted in the intrusion of shoshonitic lamphrophyres and a syenite body of the Devils Suite.

Synthesis: Sediments of the Tennant Creek and Davenport Provinces are dominated by clastics, with felsic and mafic volcanics. The clastic sequences are relatively oxidised, containing magnetite and hematite. Carbonaceous sediments are extremely rare, and carbonate rocks are rare. The paucity of carbonate rocks within the sequences mean that skarn mineralisation will be limited (Hoatson and Cruickshank 1985), and the lack of carbonaceous sediments implies that reduction of oxidised magmatic fluids by interaction with methane-bearing connate brines is unlikely. The best hosts are the secondary ironstone bodies, although fluid mixing may be a viable alternative.

1.2 Executive Summary - Metallogenic Potential

This compilation has assessed the potential of each granite suite based on the criteria set out in the Project Proposal. All three suites have been identified as having potential for granite-related mineralisation, but only the Treasure Suite is considered to be highly significant.

The <u>Tennant Creek Supersuite</u> was emplaced at around 1850 Ma. It is a restite-rich I-(granodiorite) type which shows limited fractionation in the most felsic end members due to restite separation. The supersuite is associated with very minor W mineralisation. Although similar in age to the proposed time of formation of the ironstones, the supersuite is not believed to have played any role in their formation other than to act as a possible heat source to enhance circulation of basinal brines. Also, the supersuite has no relationship to the Au mineralisation.

The Treasure Suite at ~1820 Ma is mainly volcanics, intrusive granophyre and porphyry in the Davenport Province, and diorite to monzodiorite in the Tennant Creek Province. The suite is I-(granodiorite) fractionated, with the more mafic end members preserved in the northwest Tennant Creek area, and the more felsic fractionated members in the southeast. The suite is believed to be associated with the Au, Bi, Cu mineralisation at Tennant Creek and with W, Cu, Bi, Mo mineralisation in the Hatches Creek area. The more significant Au mineralisation associated with this suite is predominantly hosted by ironstones, but there is potential for quartz-vein Au mineralisation independent of the ironstone bodies.

The Devils Suite at 1700 Ma is an extremely fractionated I-(granodiorite) type which is associated with minor vein W-mineralisation. The granite is oxidised and is associated with extensive alteration of the country rocks. However, the granite crystallised over a very narrow and high SiO_2 range and seems to contain high F. Its potential is therefore limited to vein W deposits. Although abundant cassiterite has been recorded in stream sediments from the area, the oxidised nature of the granite means that vein Sn is unlikely to be well developed.

1.3 Future Work

There are two aspects worthy of follow up in the Tennant Creek Province:

1) There is a wealth of alteration data within the AGSO dataset. Many of the members of the Tennant Creek Supersuite have either a Na or K alteration overprint, whilst the younger suites have a K overprint only. Much effort has been expended in using geochemistry to distinguish between barren and mineralised ironstones (e.g., McMillan and Debnam 1961; Dunnet and Harding 1967; Smith 1980). Huston and Cozens (1994) documented mineralisation-associated K-rich alteration of a post-ironstone porphyry. This alteration is very similar to the K-alteration geochemistry as portrayed in the AGSO dataset. Rather than using ironstone geochemistry as a pathfinder to ore, perhaps a more effective method would be to look at the alteration compositions of the porphyries, granites and quartzofeldspathic sediments surrounding these ironstones as a means of determining whether the mineralisation-related alteration had affected the environs of the ironstone.

2) More geochemical analyses are required of the more mafic end members of the Treasure Suite in the northwestern Tennant Creek Province. This may not be all that easy, for, as pointed out by Dunnet and Harding (1967), these realtively mafic rocks are poorly exposed, strongly lateritised and difficult to distinguish from lateritised Cambrian and Warramunga Formation sediments. They may also be confused with the abundant tholeiitic gabbros and dolerites that are coeval with both the Tennant Creek Supersuite and the Treasure Suite.

1.4 Methods

Information Sources: 1:250 000 maps and notes, 1:100 000 maps and commentaries where available, published ages, AGSO OZCHRON databases, AGSO OZCHEM database supplemented with data from NTGS, 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, approximately three suites are recognised (Table 1.1).

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

Relating Mineralisation: A combination of geochronology, relative stratigraphic position, and relationship to known structures was used to relate known mineralisation to the igneous suites.

The Tennant Creek and Davenport Provinces were two of the better chronologically controlled provinces examined, with many age determinations available on both the mineralisation and

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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	Tennant Creek	1850	None	None	None	Low	Low	321	Tennant Creek Granite
	(Kalkadoon)								Red Bluff Granite
									Mumbilla Granodiorite
									Unnamed intrusive porphyries
									Channingum Granite
									Hill of Leaders Granite
									Gosse River North Granite
									Cabbage Gum Granite
									Warranmuga Formation
									Bernborough Formation
									Epenarra Volcanics
									Warrego Volcanics
									Gecko Volcanics
									Yungkulungu Formation
3	**Treasure**	**1820**	**High**	**High**	Low	Mod	**High**	323	unnamed granophyres
	(Cullen)								unnamed porphyries
									unnamed diorites
									Treasure Volcanics
									Mia Mia Volcanics
									Newlands Volcanics
									Arabulja Volcanics
4	Devils	1710	None	None	None	Low	Mod	321	Warrego Granite
	(Sybella)								Devils Marbles Granite
									Elkedra Granite
									unnamed granites
5	Lamprophyres (Unclassified)	1690	Low	Low	Low	Low	Low	320	Unnamed lamprophyres
5	Gosse River East (Unclassified)	1712	Low	Low	Low	Low	Low	210	Gosse River East syenite

2 TENNANT CREEK SUPERSUITE

2.1 Timing 1850 Ma

2.2 Individual Ages

1.	Volcanic in Warramunga Formation	1872 ± 9 Ma, SHRIMP
2.	Gecko volcanic	1862 ± 9 Ma, SHRIMP
3.	Tennant Creek Granite	1858 ± 12 Ma, SHRIMP
4.	dolerite cutting Tennant Ck Granite	1858 ± 9 Ma, SHRIMP
5.	Tennant Ck. Granite at Red Bluff	1853 ± 10 Ma, SHRIMP
6.	Porphyry at White Devil Mine	1853 ± 8 Ma, SHRIMP
7.	Mumbilla Granodiorite	1850 ± 6 Ma, SHRIMP
8.	Tennant Ck. Granite at Red Bluff	1849 ± 7 Ma, SHRIMP
9.	Cabbage Gum Granite	1848 ± 7 Ma, SHRIMP
10.	Hill of Leaders Granite	1848 ± 7 Ma, SHRIMP
11.	Porphyry at Peko smelter	1848 ± 8 Ma, SHRIMP
12.	Bernborough Formation	1845 ± 4 Ma, SHRIMP
13.	Bernborough Formation	1844 ± 5 Ma, SHRIMP
14.	Dolerite Dyke	1842 ± 8 Ma, SHRIMP
15.	Gabbro	1841 ± 6 Ma, SHRIMP
16.	Channingum Granite	1840 ± 9 Ma, SHRIMP
17.	Bernborough Formation	1840 ± 8 Ma, SHRIMP
18.	Porphyry at the Jubilee Mine	1838 ± 9 Ma, SHRIMP
19.	Epenarra Volcanics	1837 ± 5 Ma, SHRIMP

Sources: Compston 1994, 1995; OZCHRON

2.3 Regional Setting

The Tennant Creek Supersuite includes all felsic igneous rocks emplaced in the Tennant Creek Province and the adjacent Davenport Province between about 1870 to 1840 Ma. The supersuite was emplaced in a wide variety of geological settings and first appeared as either extrusive volcanics (Blake *et al*. 1987) or as synsedimentary intrusive porphyries (McPhie 1993) during the latter phases of sedimentation of the Warramunga Formation. Emplacement of the supersuite continued through the compressional deformation that affected these sediments, and several members were emplaced as either syn-, late- or post-tectonic granites and porphyries. At least two generations of later porphyries have been identified based on either their deformation characteristics (Mendum and Tonkin 1976) or by their relationship to major regional alteration events (Huston and Cozens 1994). The youngest members of the supersuite occur either as volcanics within sedimentary packages which unconformably overlie the Warramunga Formation; in particular in the older part of the Flynn Subgroup (Bernborough Formation) and the Hatches Creek Group (Epenarra Volcanics), or as porphyries intruding these younger sedimentary groups.

It is probable that there is more than one suite of igneous rocks present in the Tennant Creek Supersuite, but as there are broad chemical and petrogenetic similarities between the felsic igneous rocks throughout the various events described above, they are all included as one supersuite.

2.4 Summary

The Tennant Creek Supersuite is an I-(granodiorite) type, restite-dominated suite, with some fractionation occurring late in the history, particularly in the granites in the southeastern part of the Tennant Creek Block (Gosse River North Granite, Mumbilla Granodiorite, and possibly Hill of Leaders Granite).

There were two major, but distinctive regional hydrothermal alteration events which affected the Tennant Creek area. The first involved the formation of the ironstones from basinal brines (Wedekind *et al.* 1989; Zhaw 1994a, b) early in the deformation paragenesis (Ding and Giles 1993), and the second is related to mineralisation, which occurred late in the deformation history (Ding and Giles 1993). The mineralisation event, which occurred at around 1820 Ma (Compston 1994; Compston and McDougall 1994), is believed to be related to the Treasure Suite and is fully discussed in Section 3 (below). Although Compston (1994) and Compston and McDougall (1994) maintain that the two alteration events are synchronous on the basis of Ar-Ar dating of muscovite related to either the ironstone-forming event or the mineralising event, Ding and Giles (1993) argue for a different timing on the basis of deformation. In detail, as the samples dated (Compston 1994; Compston and McDougall 1994) from the ironstones and the mineralisation are all from mineralised ironstones, it is possible that the early ironstone-related muscovites have been reset.

Age determinations suggest that granitic members of this suite were intruded over at least 18 Ma, which would include the time during which the ironstones were believed to have formed based on structural evidence (Ding and Giles 1993). Although Ding and Giles (1993) also argued that the granites were emplaced after the ironstones, Crohn and Oldershaw (1965) noted an older strongly foliated granite intruded by two less foliated phases of porphyritic or equigranular granite. Although the Supersuite intrudes throughout the time during which the Tennant Creek ironstones were developed, because of the restite dominance it is unlikely that the members of the Supersuite contributed any magmatic fluid into the alteration system at this time. This is supported by hydrogen and oxygen isotope data of Wedekind (1989) who argued that there is unlikely to be a magmatic fluid involved in the production of the ironstones. The ironstones are believed to have formed from hot connate brines and developed parallel to fold axes during the regional deformation of the Warramunga Formation (Wedekind *et al*. 1989; Zhaw *et al*. 1994a, b). It is possible however, that those members of the suite that were synchronous with the deformation may have contributed some additional heat into the system and thus helped to heat and enhance the circulation of the connate brines.

2.5 Potential

Because it is a restite-dominated suite, the mineral potential of the Tennant Creek Supersuite is in general not rated highly. The exception is in the southern Tennant Creek Province, where granites such as the Gosse River North Granite, the Mumbilla Granodiorite and the Hill of Leaders Granite show evidence of weak fractionation in the more felsic end members. This fractionation is believed to have occurred after the restite had separated. Because this fractionation has occurred over such a high and narrow SiO_2 range, there is potential only for small deposits of W (such as the Mosquito W field) and Sn.

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

2.6 Descriptive Data

Location: This supersuite occurs throughout the Tennant Creek Province and the northern part of the Davenport Province, in the TENNANT CREEK and BONNEY WELL 1250 000 Sheet areas.

Dimensions and area: The Supersuite extends in a southwesterly direction for over 300 km and a width of 120 km. Total area of outcrop is 2200 km^2.

2.7 Intrusives

Component plutons: Tennant Creek Granite, Red Bluff Granite (now regarded as part of the Tennant Creek Granite, Donnellan *et al.*[1995]), Cabbage Gum Granite, Hill of Leaders Granite, Channingum Granite (including the New Hope granite of Mendum and Tonkin (1976)), Mumbilla Granodiorite (including the North Seismic monzogranite, Gosse River South monzogranite, South Gosse monzogranite of Mendum and Tonkin [1976]) and unnamed intrusive porphyries. The Gosse River North Granite has been retained as a separate entity due to its distinctive chemical characteristics, whereas Donnellan *et al*. (1995, in prep) have included it as part of the Mumbilla Granodiorite.

Form: The granites occur as large elliptical intrusions trending east-west in the northern part of the Tennant Creek Province (Tennant Creek and Red Bluff Granites) and northwesterly in the southern part of the Province and adjacent Davenport Province (Mumbilla Granodiorite and Hill of Leaders Granite).

Metamorphism and Deformation: Most of the granites appear to have been deformed or metamorphosed to some degree. The deformation occurred after the granite intrusion (Crohn and Oldershaw 1965, Ding and Giles 1993). Strong foliations are recorded in most granites, and in the Tennant Creek Granite, an older strongly foliated granite is intruded by less foliated granite (Crohn and Oldershaw 1965). Actinolite after biotite also suggests that the granites have at least an upper greenschist facies metamorphic overprint. *Specifically:* Tennant Creek Granite - cut by shears and appears to have a low grade metamorphic overprint, possibly up to biotite grade (based on fine-grained biotite recorded by Mendum and Tonkin [1976]). Cabbage Gum granite - cut by a wide shear zone containing quartz veins. Channingum Granite - strongly foliated and mylonitised (Donnellan *et al.* 1995).

Dominant intrusive rock types: The dominant intrusive rock type is a porphyritic granite. *Specifically:* Tennant Creek Granite (including Red Bluff granite descriptions in Mendum and Tonkin 1976) - medium to coarse even-grained massive monzogranite, coarse-grained porphyritic granite, and fine-grained granite. Channingum Granite - massive coarse-grained leucocratic monzogranite, coarse-grained porphyritic granite. Mumbilla Granodiorite - more plagioclase-rich variety which contains rapakivi granite and granodiorite, coarse to medium-grained porphyritic biotite granodiorite, massive medium-grained granodiorite, (Donnellan *et al.* 1995). Gosse River North Granite - massive medium-grained biotite granite and granophyre (Medium and Tonkin 1976), Cabbage Gum Granite - medium-grained porphyritic monzogranite. Hill of Leaders Granite - grey medium to coarse-grained porphyritic muscovite to biotite granite with feldspar phenocrysts up to 5 cm across (Stewart and Blake 1986). Mendum and Tonkin (1976) noted that there were two types of intrusive porphyries; quartz porphyry and quartz-feldspar porphyry.

Colour: Ivanac (1954) observed that the granites in the north are pink whereas those in the southeast are grey, and that the colour is controlled by the colour of the phenocrysts. *Specifically:* Tennant Creek Granite - some red granite recorded, but mostly pink to grey (Dunnet and Harding 1976). Channingum Granite - white to pink. Hill of Leaders Granite - grey (Stewart and Blake (1986).

Xenoliths. Xenoliths of quartz, biotite, sericite and feldspar appear abundant in all intrusions. Crohn and Oldershaw (1965) noted that they were not from the country rock. Mendum and Tonkin (1976), noted that few xenoliths of country rock have been recorded. Donnellan *et al.* (1995) also noted a dominance of cognate xenoliths in the Mumbilla Granodiorite and the Tennant Creek Granite, which are mineralogically identical to the host granodiorite. They also noted that these types of xenoliths are rare in the Channingum Granite. Specifically: Tennant Creek Granite - both accidental and cognate xenoliths have been recorded (Donnellan *et al.* 1995; Ivanac 1954). Crohn and Oldershaw (1965) noted xenoliths formed up to 30% by volume of the rock. Mumbilla Granodiorite - xenoliths of quartz and biotite are recorded, and are more prominent in the foliated porphyritic granite near the center (Mendum and Tonkin 1976). Hill of Leaders Granite - mica-rich xenoliths, some with tourmaline (Stewart and Blake 1986).

Veins, Pegmatites, Aplites, Greisens: Little evidence of a late magmatic fluid present. Virtually no pegmatites recorded. Ivanac (1954) suggested that aplites up to 2 m wide intersect the granites but do not extend into the Warramunga Formation. Donnellan *et al.* (1995) also noted the widespread presence of aplite dykes but commented that muscovite and tourmaline-bearing pegmatites are minor. Extensive areas of quartz veins are shown surrounding the Mumbilla

Granodiorite on the TENNANT CREEK 1:250 000 1st edition geological map and also surrounding the Hill of Leaders Granite. *Specifically:* Tennant Creek Granite - aplite veins recorded, quartz veins abound near Station Hill, and late leucocratic bodies were noted in altered fractured zones around the margins of the granite. Mumbilla Granodiorite - rare aplites noted. Hill of Leaders Granite - tourmaline present in greisens (Stewart and Blake 1986).

Distinctive mineralogical characteristics: The dominant ferromagnesian mineral recorded in the supersuite is biotite, although rare hornblende is recorded. *Specifically:* Tennant Creek Granite - biotite dominates with some hornblende which is in places pseudomorphed by chlorite, some tourmaline present, some pyrite. Channingum Granite - biotite and rare hornblende with accessory pyrite, fluorite and magnetite. Mumbilla Granodiorite - mainly a biotite-bearing unit; quartz-tourmaline pods with chalcopyrite recorded (Mendum and Tonkin 1976). Gosse River North Granite -biotite, fluorite, magnetite and hematite. The unnamed quartz-feldspar porphyries contain mainly K-feldspar phenocrysts, with some andesine.

Breccias: None recorded in any of the literature.

Alteration in the granite: Alteration is widespread and probably reflects either a post-intrusion low-grade metamorphic or late alteration overprint associated with either the ironstone event or the mineralising event. Plagioclase is commonly altered to clinozoisite, K-feldspar to sericite, and biotite to chlorite. *Specifically:* Tennant Creek Granite - disc-shaped patches of radiating tourmaline needles have been noted in foliated granite (Dunnet and Harding (1965). Donnellan *et al.* (1995) noted albitisation in the Channingum Granite and around the margins of the Tennant Creek Granite. Sericitisation and tourmalinisation of the Mumbilla Granodiorite were noted by Donnellan *et al.* (1995).

2.8 Extrusives

Some of the porphyries previously considered intrusive into the Warramunga Formation are now regarded as extrusive. McPhie (1993) recorded peperite surrounding the Tennant Creek porphyry, and interpreted that the volcanics were intruded into wet sediments. Extrusive volcanics have also been recorded in the Warramunga Formation in the Davenport Province (Blake *et al.* 1987). Younger extrusive volcanics include tuffs, lavas and ignimbrites of porphyritic dacite to rhyodacite composition of the Bernborough Formation and Epenarra Volcanics, and lapilli-bearing tuffs and ignimbrites of the Warrego Volcanics.

2.9 Country Rock

Contact metamorphism: Contact effects appear to be minor, involving mainly baking and silicification. Ivanac (1954) recorded slight silicification up to 12 m from the contact, whilst low-grade metamorphism of the Warramunga Formation sediments at the granite contact is noted by Crohn and Oldershaw (1965). Silicification of the adjacent sediments was recorded where undeformed quartz-feldspar porphyry cuts cleaved sediments, and some phenocrysts of quartz are noted in the contact rocks (Mendum and Tonkin 1976). Donnellan *et al.* (1995) noted a 100 m-wide contact metamorphic aureole of spotty hornfelses where the Tennant Creek Granite intrudes the Warramunga Formation sediments.

Reaction with country rock: A zone of muscovite developed around the Gosse River North Granite (Mendum and Tonkin 1976) and the Channingum Granite (Donnellan *et al.* 1995). Crohn and Oldershaw (1965) noted thin quartz-tourmaline ±feldspar veins. Marginal and more highly fractured zones of the Tennant Creek Granite are albitised and tourmalinised (Donnellan *et al*. (1995).

Units the granite intrudes: Warramunga Formation, Flynn Subgroup and lower Hatches Creek Group.

Dominant rock types: Warramunga Formation: hematitic shale, greywacke, siltstone and sandstone. Donnellan *et al.* (1994, 1995) have divided the Warramunga Formation into two facies: a siltstone and a sandstone facies. Donnellan *et al.* (1995) noted that ‘there appears to be a distinct, but not exclusive correlation between well developed banded ironstones and the sandstone facies. Banded ironstone is well developed to the south of Tennant Creek between Mount Samuel and Nobles Nob. Blake (*pers. comm.*) noted that hematitic shales are more prevalent in the Tennant Creek Province than in the Davenport Province, and that the siltstone facies was dominant in the Davenport Province. The ironstones which host the major Au ± Cu deposits in the area are believed to have formed during early deformation of the Warramunga Formation, and predate the mineralisation. The units within the Hatches Creek Group or Flynn Subgroup below (or lateral equivalents of the volcanic members of this suite) consist mainly of siltstone and arenite.

Potential hosts: The best hosts are the secondary ironstones within the Warramunga Formation, which are better developed in the Tennant Creek Province.

2.10 Mineralisation

The Mosquito Creek Tungsten Field occurs in the Hill of Leaders Granite (Stewart and Blake 1986) and the deposits are concentrated in the biotite-rich phases (possibly greisenised?) and most have grey-green aplite dykes as a subsidiary wallrock (Ferenczi, *written comm.*). The field contains scheelite- and wolframite-bearing quartz veins which contain muscovite and tourmaline. Some of these veins are bounded by greisen. Although Blake *et al.* (1987) suggested that this mineralisation might be related to the intrusion of the lamprophyres, there is an obvious spatial relationship between these veins and the more fractionated parts of the Supersuite in the southern Tennant Creek Province. Although there is also a possibility that the Mosquito Creek W deposits are related to younger magmatic suites, only one deposit, the Old Ghans, contains a significant amount of Cu mineralisation (Ferenczi, *written comm.*).The absence of Bi and other metals which are known to occur in these other deposits could imply that the Mosquito Creek deposits are not related to the Treasure Suite. Ferenczi (*written comm.*) has suggested that W mineralisation in the Hill of Leaders Granite could be related to intrusives of the Devils Suite.

There are obviously numerous Au ± Cu deposits in the area, but these are discussed in the Treasure Suite chapter below.

2.11 Geochemical Data

Data source: The total number of analysed samples in this supersuite is 184. Most of the samples came from a major geochemical program carried out by BMR in the Tennant Creek area to assess the geochemistry of the Tennant Creek ironstones and major lithological units of the Tennant Creek Inlier. The dataset also includes analyses of samples collected as part of the AGSO/NTGS Davenport Province mapping program carried out in the early 1980's and geochemical analyses of the age determination samples of Compston (1994). All of these analyses are stored in the AGSO OZCHEM database. The dataset is complemented by samples from Stolz and Morrison (1994) and from NTGS unpublished data.

Data quality: The data quality is very good.

Are the data representative? The data set is representative of the dominant rock types in the area, but there are no samples of the greisens and more fractionated parts of the Hill of Leaders Granite and Gosse River North Granite.

Are the data adequate? The data set is fairly comprehensive. Unfortunately the number of samples with both FeO and Fe_2O_3 values is very limited, and there are few F values.

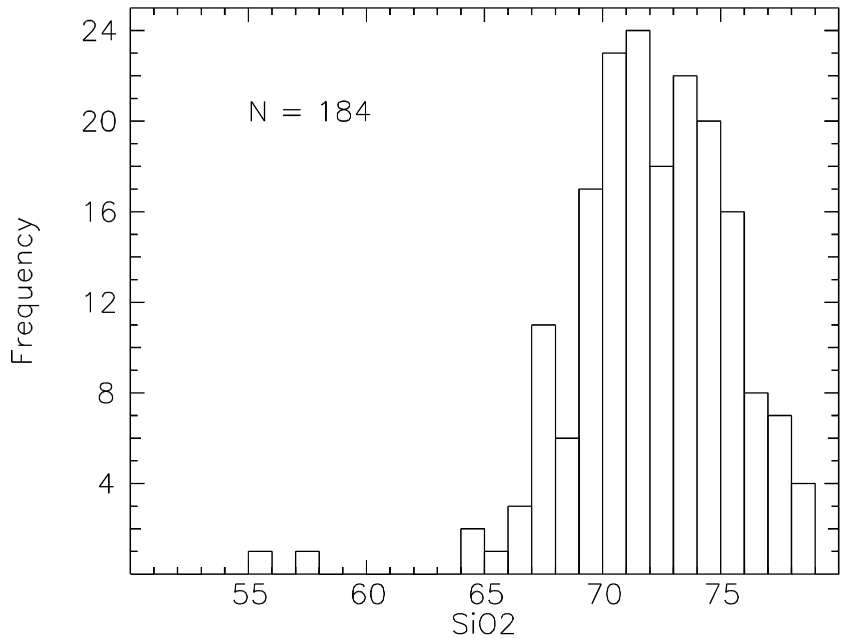

Figure 2.1: Histogram of SiO_2 values for the Tennant Creek Supersuite

SiO_2 range (Fig. 2.1): The range of analyses are mostly in the felsic range, with some coeval dolerites (Compston 1994).

Alteration (Figs. 2.1 & 2.2):

- ***SiO2:*** There is reported evidence of silicification, but it was not prominent in the samples analysed.
- ***K2O/Na2O:*** The Tennant Creek and Red Bluff Granites which occur in the northern part of the Tennant Creek province are dominantly Na- altered, whilst Mumbilla Granodiorite, the porphyries and the volcanics within the sedimentary pile are dominantly K-altered. Donnellan *et al.* (1995) noted that the Na-alteration is more prevalent in the Tennant Creek Granite and those granites which intrude the Flynn Subgroup. In contrast, the K-alteration is more prevalent in the porphyries intruding the Warramunga Formation (Donnellan *et al*. 1995). Huston and Cozens (1994) noted K-alteration associated with the formation of hydrothermal biotite in the mineralisation phase, but not the ironstone phase, was prevalent in the porphyries at the White Devil Mine. Thus these K-altered samples may indicate interaction with mineralising fluids, and as such may be used as pathfinders or vectors to ore.
- ***Th/U:*** There has obviously been considerable U loss in some granites, in particular, those samples of the Red Bluff and Tennant Creek granites that have been affected by Na loss.
- ***Fe2O3/(FeO+Fe2O3):*** Some samples are extremely oxidised. This could be the effect of weathering or of alteration associated with the mineralisation. Samples from the Bernborough Formation and Epenarra Volcanics are more oxidised. This could reflect their presence within a more oxidised part of the stratigraphy and/or weathering. Blake (*pers. comm.*) noted that the Epenarra Volcanics were often very hematised and weathered in the field and difficult to sample.

Fractionation Plots (Fig. 2.3):

- ***Rb:*** Only some late phases of the Gosse River North Granite show evidence of exponentially increasing Rb. The Na-altered samples of the Tennant Creek Granite are unusually low in Rb.
- ***U:*** Again, only samples of the the Gosse River North Granite show evidence of exponentially increasing U. Two anomalously high samples from the Cabbage Gum Granite are also high in K_2O.
- ***Y:*** Again, only samples of the the Gosse River North Granite show evidence of exponentially increasing Y. Some of the Na-altered samples of the Tennant Creek Granite are high in Y.
- ***P2O5:*** Decreases with increasing SiO_2.
- ***Th:*** Flat trend.
- ***K/Rb:*** Samples of the Mumbilla Granodiorite and the Gosse River North Granite show decreasing K/Rb with increasing SiO_2.
- ***Rb-Ba-Sr:*** Samples of the Mumbilla Granodiorite and the Gosse River North Granite plot in the strongly differentiated field.
- ***Sr:*** Flat trend.
- ***Rb/Sr:*** Some increase observed in samples of the Mumbilla Granodiorite and the Gosse River North Granite, other samples are affected by alteration, particularly the unnamed porphyries.
- ***Ba:*** Very high in the K-altered porphyries, and very low in the fractionated samples of the Mumbilla Granodiorite and the Gosse River North Granite, and also in some of the Na altered samples of the Tennant Creek Granite.
- ***F:*** Data too limited to comment.

Metals (Fig. 2.4):

- ***Cu:*** Generally decreases with increasing SiO_2.
- ***Pb:*** Higher in the fractionated samples of the Gosse River North Granite.
- ***Zn:*** Decreases with increasing SiO_2.
- ***Sn:*** No particular trend.

High field strength elements (Fig. 2.5):

- ***Zr:*** Decreases with increasing SiO_2. Zr is higher in the Berborough Formation and the Epenarra Volcanics; this may be primary magmatic feature or it may be a function of a winnowing effect of the heavy minerals during explosive volcanic eruptions.
- ***Nb:*** Flat trend and low values relative to other Proterozoic granite suites.

- ***Ce:*** Again higher values in the Bernborough Formation (see comment on Zr).

Classification (Fig. 2.6):

- ***The CaO/Na2O/K2O plot of White, quoted in Sheraton and Simons (1992):*** Most samples plot in the monzogranite/granite field with a smaller number in the granodiorite field. Na-altered samples plot in the trondjhemite field.
- ***Zr/Y vs Sr/Sr*:*** All samples are Sr-depleted.
- ***Spidergram:*** All samples are Sr-depleted Y-non depleted.
- ***Oxidation plot of Champion and Heinemann (1994):*** Difficult to interpret, because of limited data and the late alteration overprints. Most granites are plotting just within the oxidised field, and close to the reduced field whilst the volcanics and porphyries are more oxidised (presumably reflecting alteration).
- ***ASI:*** Samples range from metaluminous to peraluminous, with altered samples having an unusually high ASI value.
- ***A-type plot of Eby (1990):*** the samples straddle the boundaries between Palaeozoic A-types and normal granites.

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

Australian Proterozoic granite type: Dominantly Kalkadoon with some late fractionation appearing in the Gosse River North Granite, as happens in the Nicholson type.

2.12 Geophysical Signature

Radiometrics (Fig. 2.7): Fresh samples would appear white in an RGB image. Altered samples of the Tennant Creek Granite, Cabbage Gum Granite, Red Bluff Granite and Mumbilla Granodiorite have lost U, and would appear yellow. If it can be shown that this alteration is associated with mineralisation, radiometrics may be a way of remotely detecting it. The albitised samples of the Tennant Creek and Red Bluff Granites have also lost K and would appear green.

Gravity: Blake *et al*. (1987) note that the Hill of Leaders granite has a higher density (2.68 to 2.74 t/m^3) than the post-Hatches Creek Group granites. The majority of the granites plot as gravity highs.

Magnetics: The granites of this suite correspond to magnetic lows.

2.13 References

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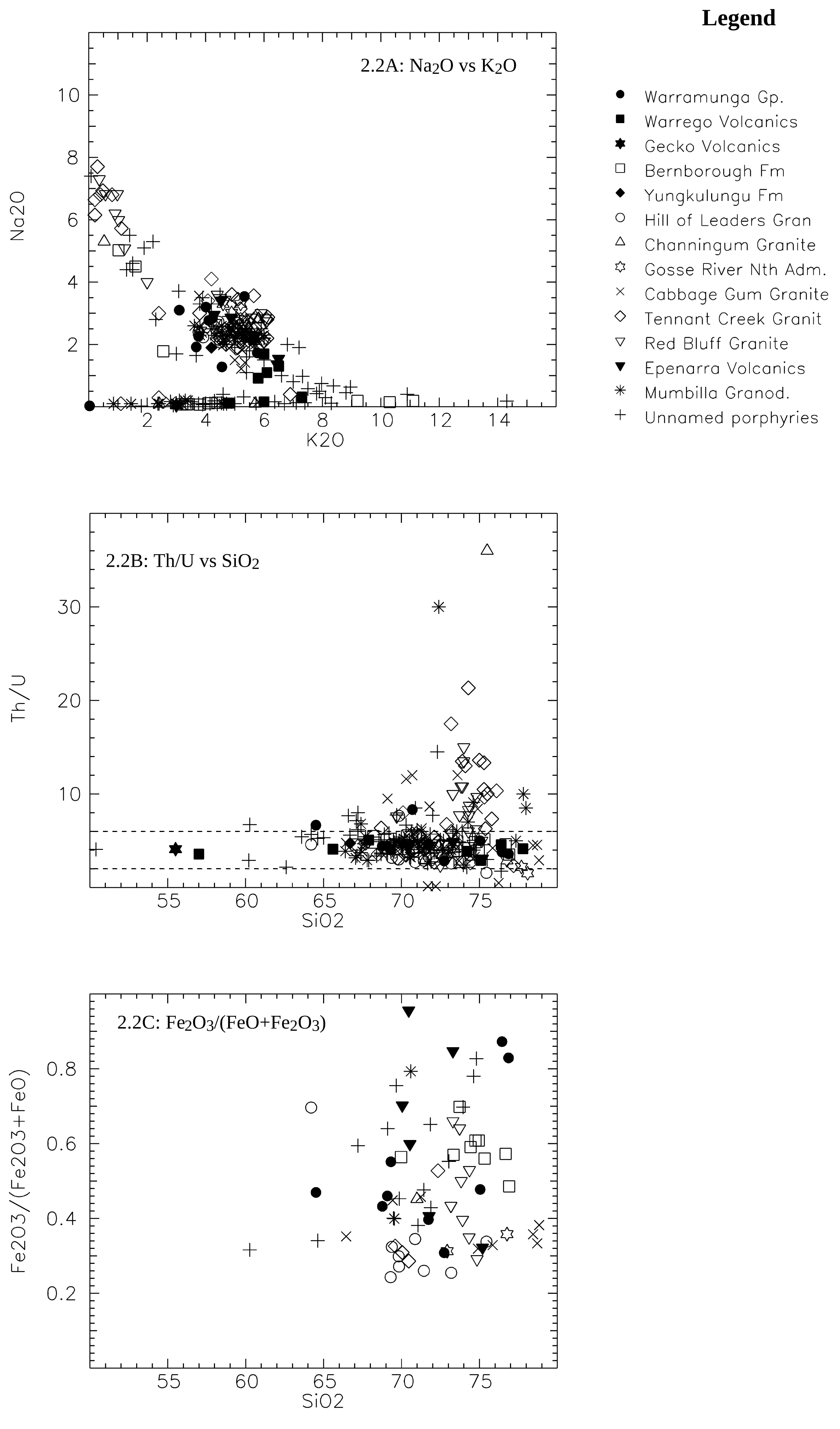
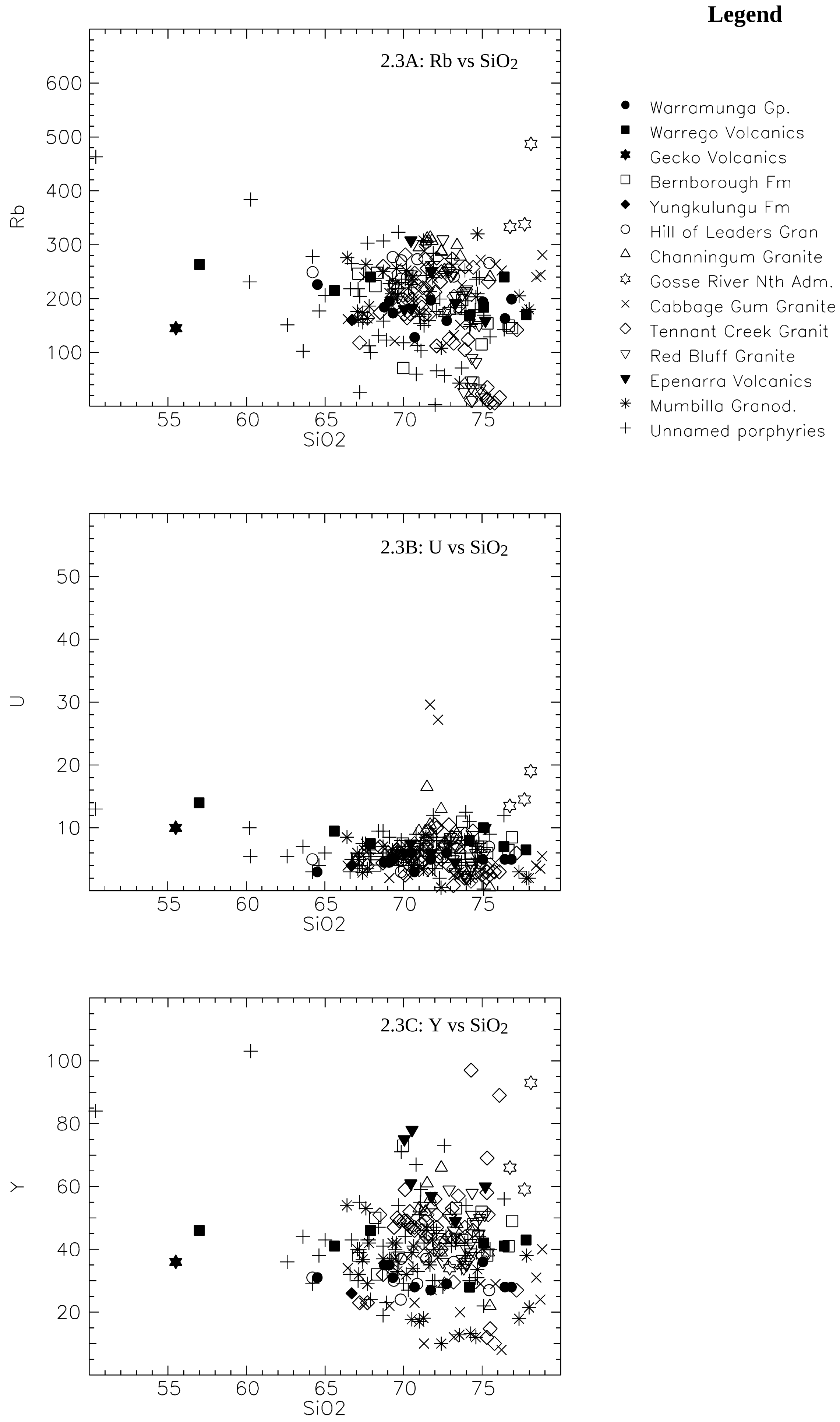
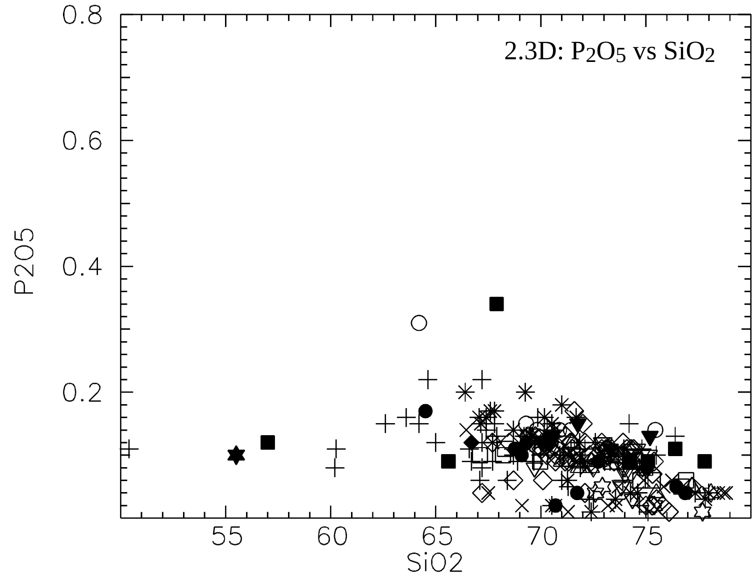
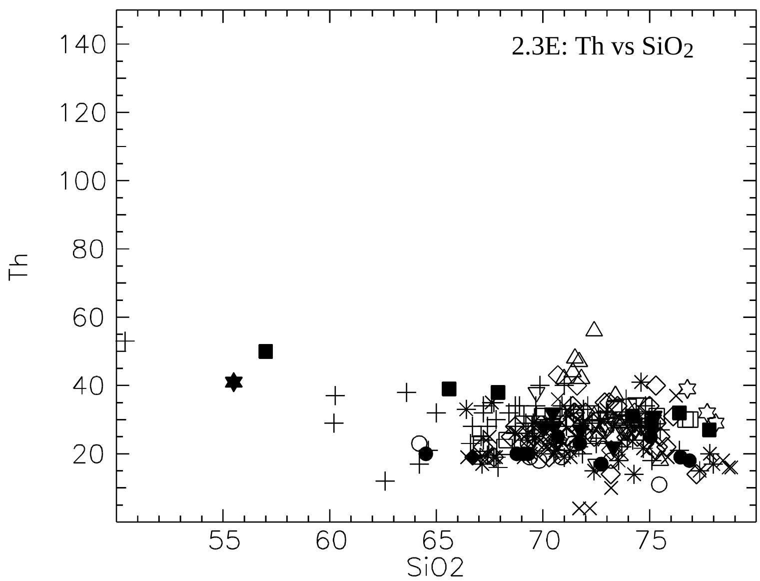
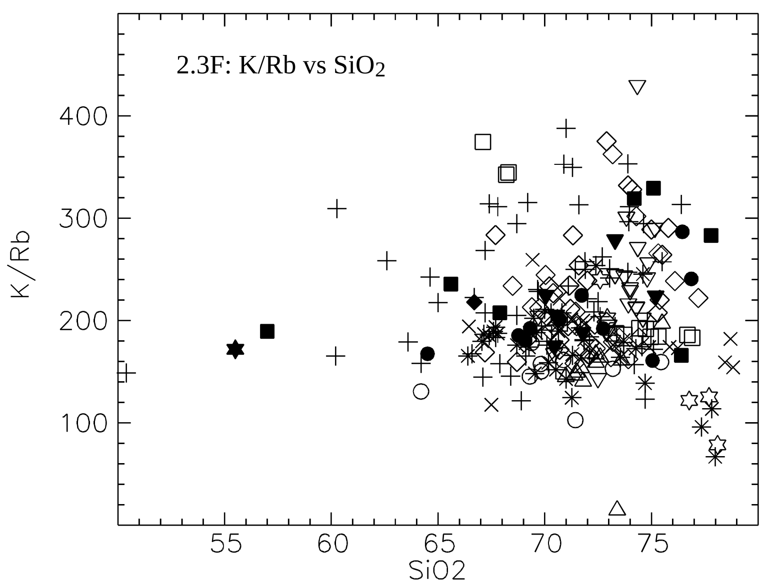

Legend
2.2A: Na2O vs K2O
Na2O
K2O
10
8
6
4
2
2
4
6
8
10
12
14
Warramunga Gp.
Warrego Volcanics
Gecko Volcanics
Bernborough Fm
Yungkulungu Fm
Hill of Leaders Gran
Channingum Granite
Gosse River Nth Adm.
Cabbage Gum Granite
Tennant Creek Granit
Red Bluff Granite
Epenarra Volcanics
Mumbilla Granod.
Unnamed porphyries
2.2B: Th/U vs SiO2
Th/U
SiO2
30
20
10
55
60
65
70
75
2.2C: Fe2O3/(FeO+Fe2O3)
Fe2O3/(Fe2O3+FeO)
SiO2
0.8
0.6
0.4
0.2
55
60
65
70
75


Legend
2.3A: Rb vs SiO2
Rb
600
500
400
300
200
100
55
60
65
70
75
SiO2
Warramunga Gp.
Warrego Volcanics
Gecko Volcanics
Bernborough Fm
Yungkulungu Fm
Hill of Leaders Gran
Channingum Granite
Gosse River Nth Adm.
Cabbage Gum Granite
Tennant Creek Granit
Red Bluff Granite
Epenarra Volcanics
Mumbilla Granod.
Unnamed porphyries
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

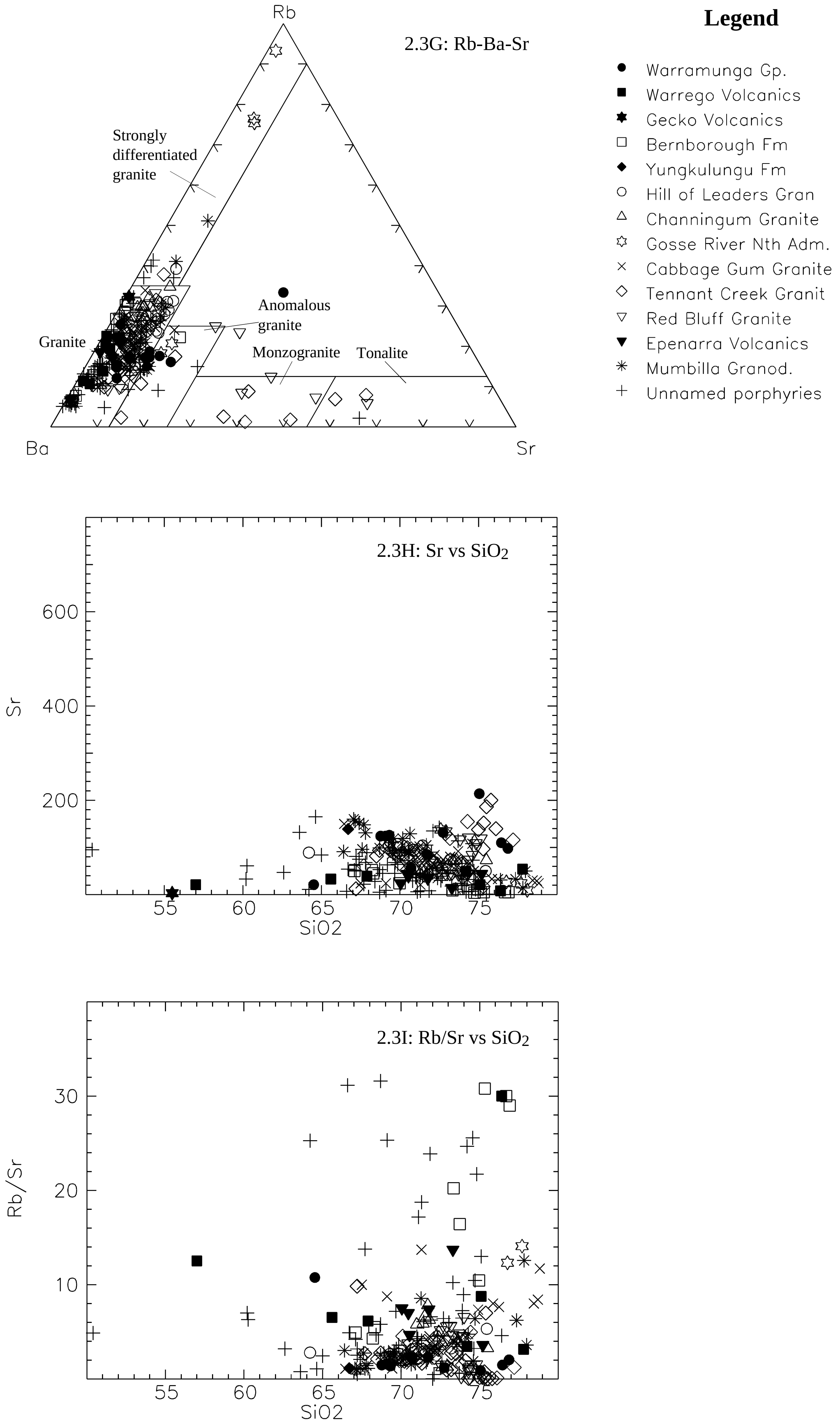






Legend

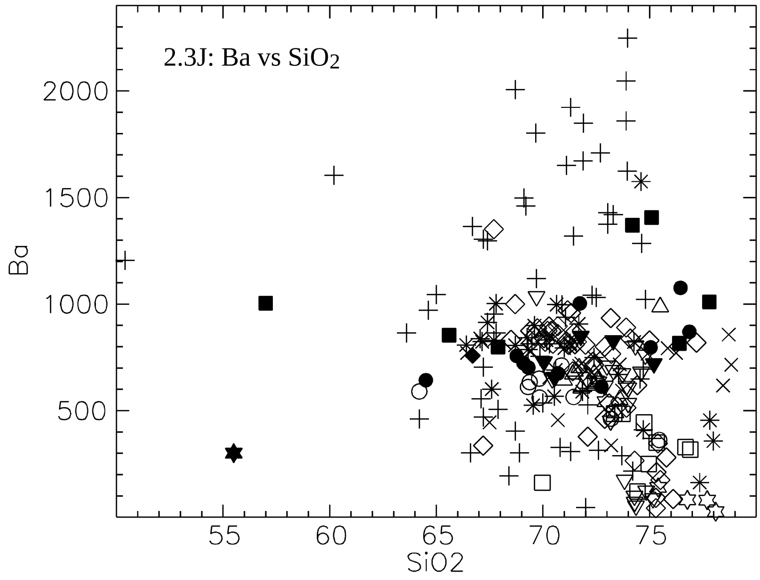
- ● Warramunga Gp.
- ■ Warrego Volcanics
- ✱ Gecko Volcanics
- □ Bernborough Fm
- ◆ Yungkulungu Fm
- ○ Hill of Leaders Gran
- △ Channingum Granite
- ✡ Gosse River Nth Adm.
- × Cabbage Gum Granite
- ◇ Tennant Creek Granit
- ▽ Red Bluff Granite
- ▼ Epenarra Volcanics
- ✳ Mumbilla Granod.
- + Unnamed porphyries

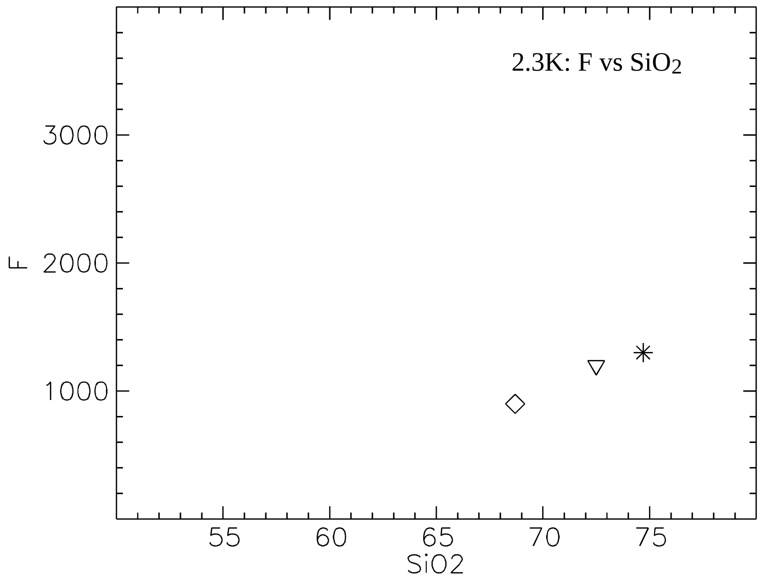


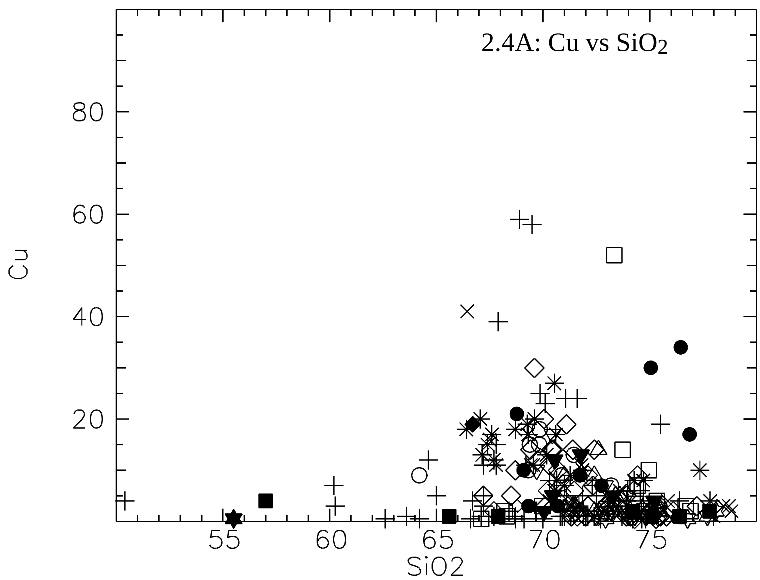
Rb
2.3G: Rb-Ba-Sr
Strongly differentiated granite
Anomalous granite
Granite
Monzogranite
Tonalite
Ba
Sr
Legend
Warramunga Gp.
Warrego Volcanics
Gecko Volcanics
Bernborough Fm
Yungkulungu Fm
Hill of Leaders Gran
Channingum Granite
Gosse River Nth Adm.
Cabbage Gum Granite
Tennant Creek Granit
Red Bluff Granite
Epenarra Volcanics
Mumbilla Granod.
Unnamed porphyries
2.3H: Sr vs SiO2
Sr
600
400
200
55
60
65
70
75
SiO2
2.3I: Rb/Sr vs SiO2
Rb/Sr
30
20
10
55
60
65
70
75
SiO2

Legend

- ● Warramunga Gp.
- ■ Warrego Volcanics
- ✱ Gecko Volcanics
- □ Bernborough Fm
- ◆ Yungkulungu Fm
- ○ Hill of Leaders Gran
- △ Channingum Granite
- ✡ Gosse River Nth Adm.
- × Cabbage Gum Granite
- ◇ Tennant Creek Granit
- ▽ Red Bluff Granite
- ▼ Epenarra Volcanics
- ✳ Mumbilla Granod.
- \+ Unnamed porphyries







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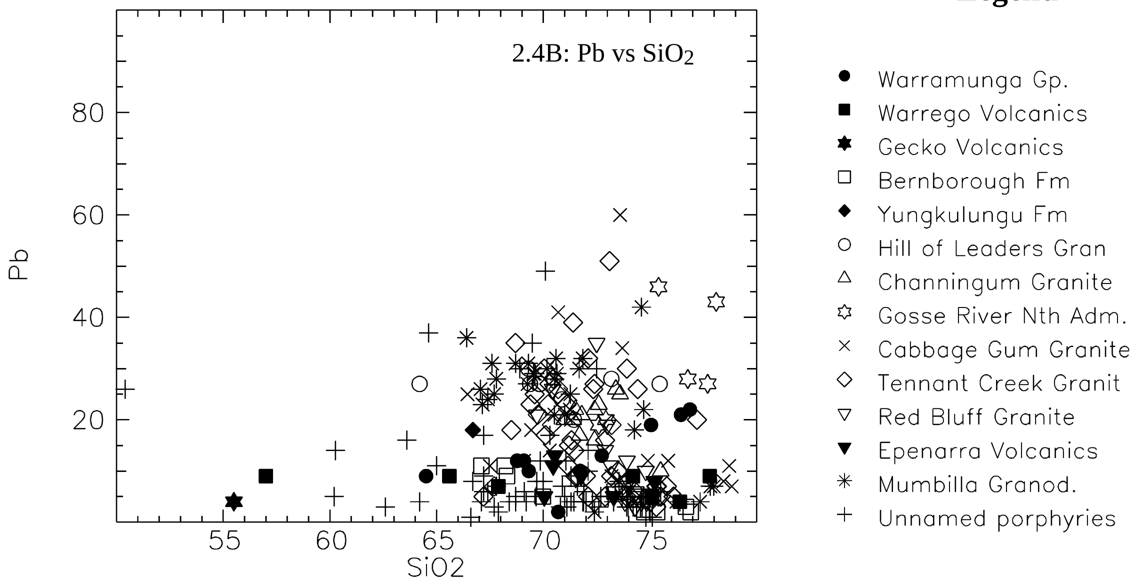
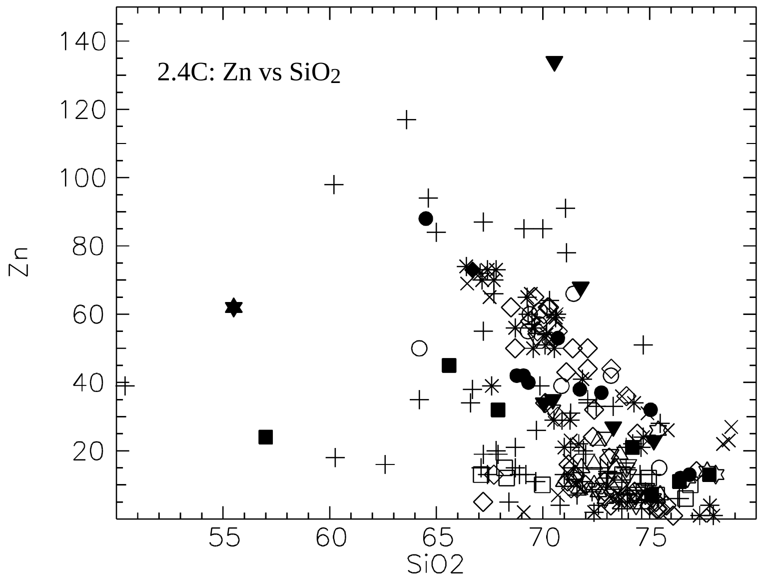
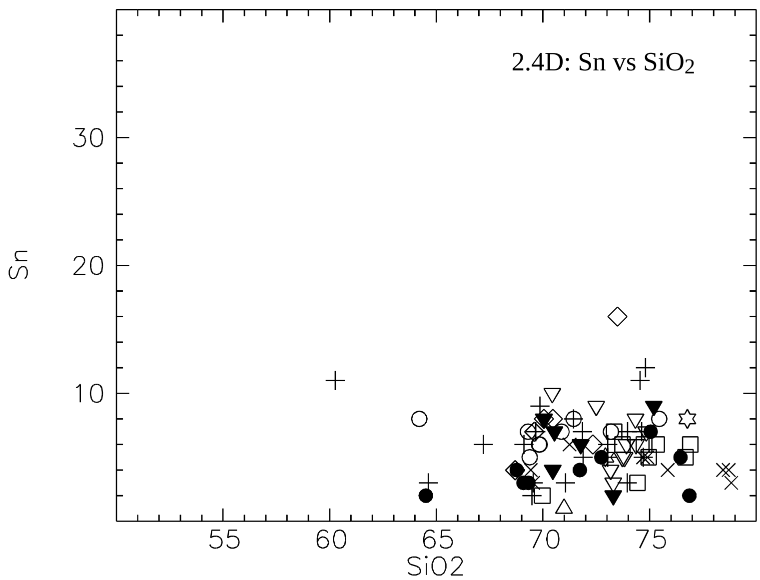
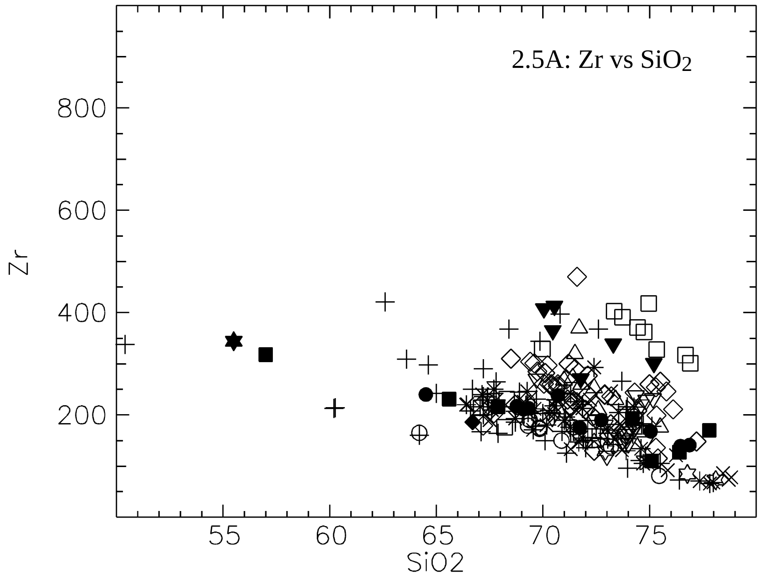

2.4B: Pb vs SiO2
Pb
SiO2
Warramunga Gp.
Warrego Volcanics
Gecko Volcanics
Bernborough Fm
Yungkulungu Fm
Hill of Leaders Gran
Channingum Granite
Gosse River Nth Adm.
Cabbage Gum Granite
Tennant Creek Granit
Red Bluff Granite
Epenarra Volcanics
Mumbilla Granod.
Unnamed porphyries

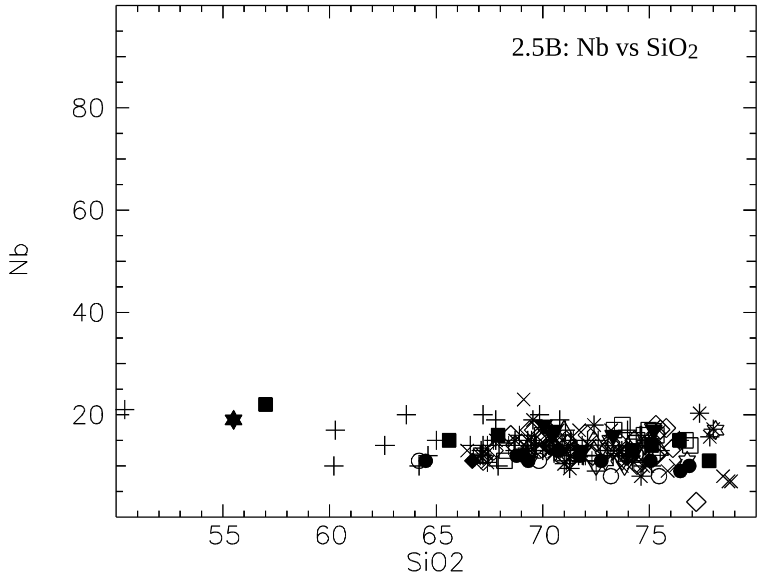

2.4C: Zn vs SiO2
Zn
SiO2

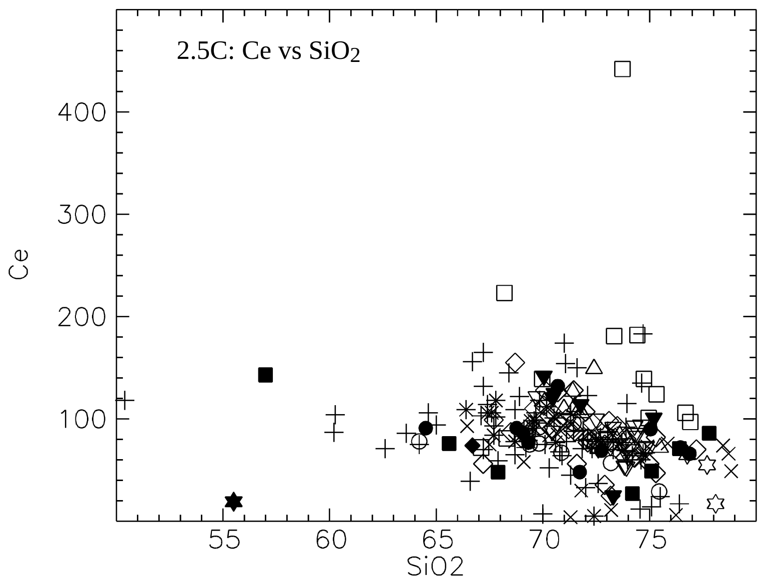

2.4D: Sn vs SiO2
Sn
SiO2

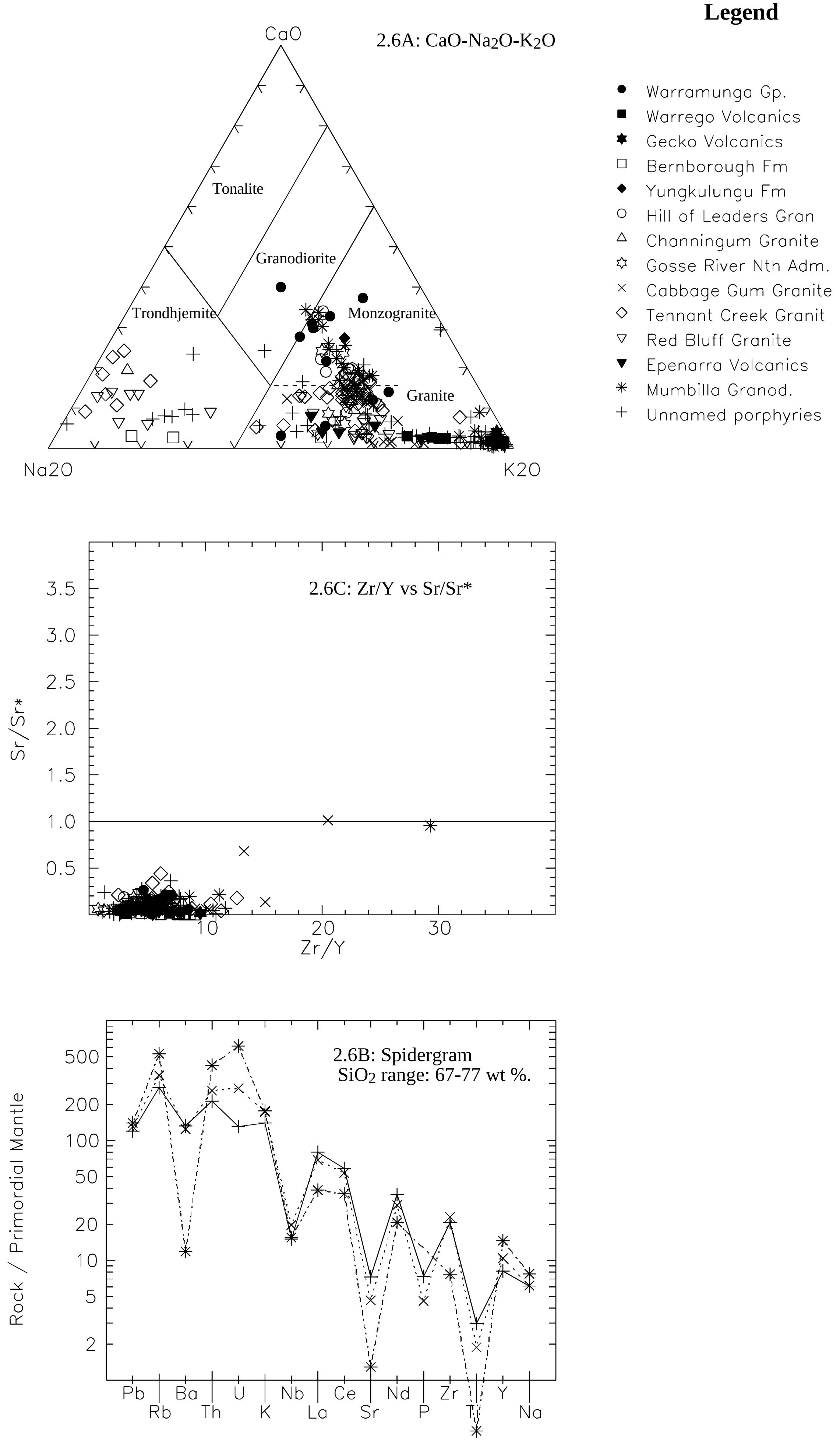
Legend

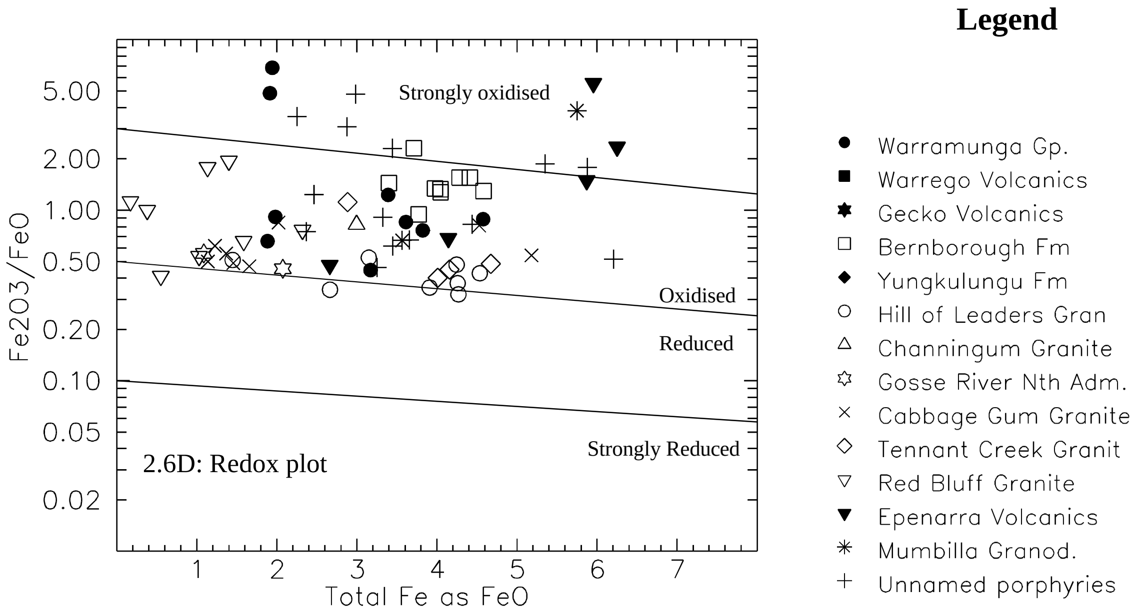
- ● Warramunga Gp.
- ■ Warrego Volcanics
- ✱ Gecko Volcanics
- □ Bernborough Fm
- ◆ Yungkulungu Fm
- ○ Hill of Leaders Gran
- △ Channingum Granite
- ✡ Gosse River Nth Adm.
- × Cabbage Gum Granite
- ◇ Tennant Creek Granit
- ▽ Red Bluff Granite
- ▼ Epenarra Volcanics
- ✳ Mumbilla Granod.
- + Unnamed porphyries

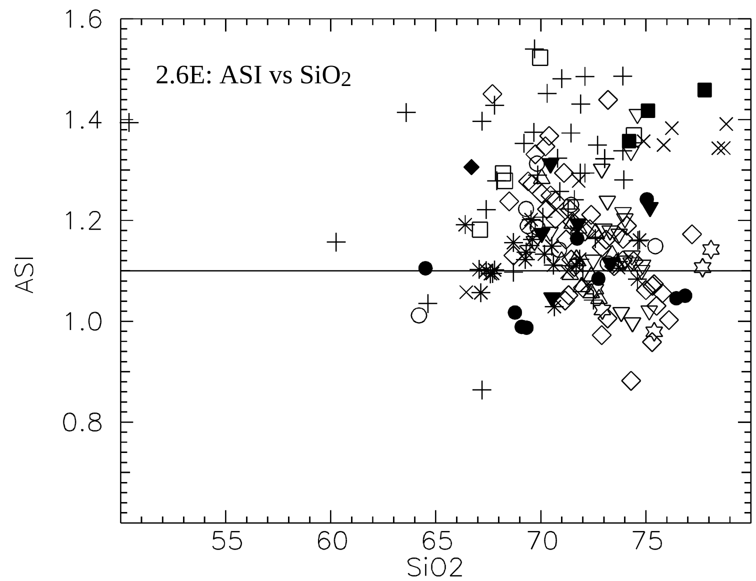


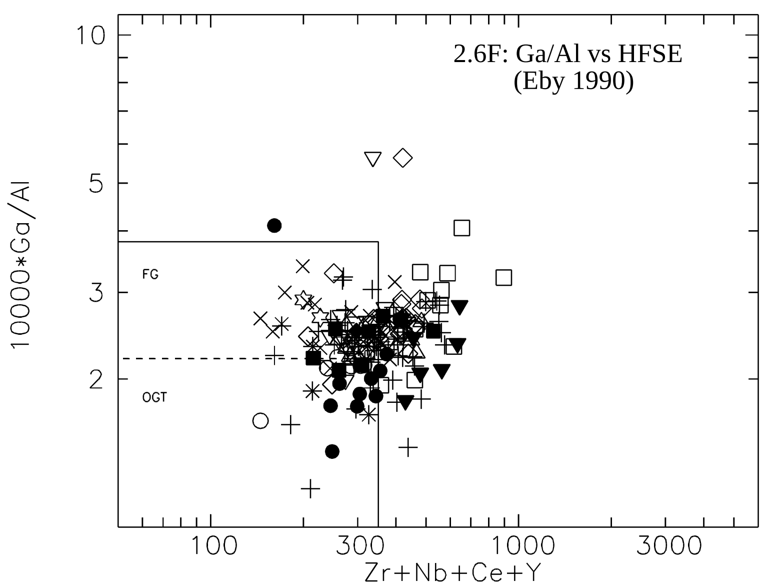


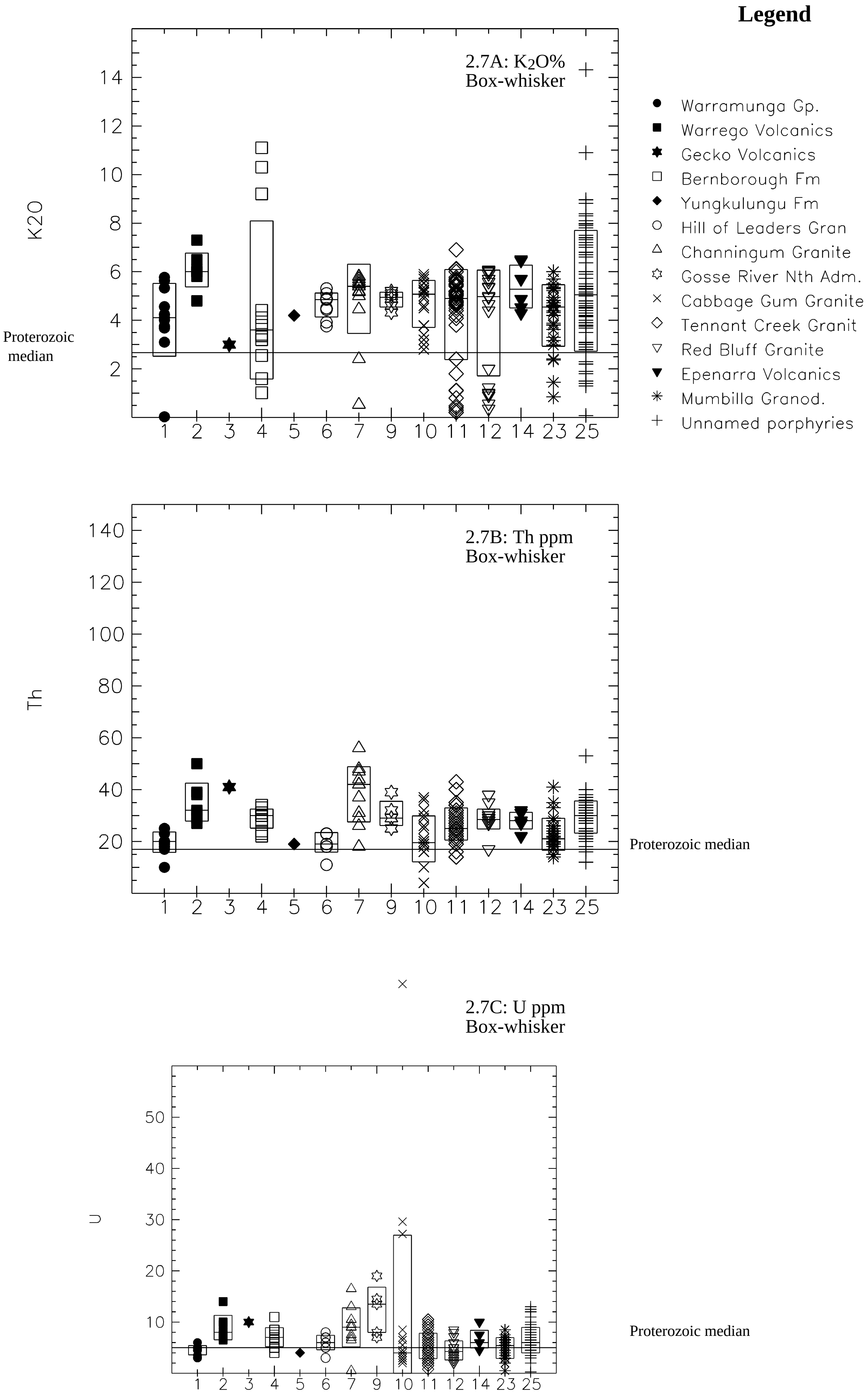



Legend
Warramunga Gp.
Warrego Volcanics
Gecko Volcanics
Bernborough Fm
Yungkulungu Fm
Hill of Leaders Gran
Channingum Granite
Gosse River Nth Adm.
Cabbage Gum Granite
Tennant Creek Granit
Red Bluff Granite
Epenarra Volcanics
Mumbilla Granod.
Unnamed porphyries
2.6A: CaO-Na2O-K2O
CaO
Na2O
K2O
Tonalite
Granodiorite
Trondhjemite
Monzogranite
Granite
2.6C: Zr/Y vs Sr/Sr*
Sr/Sr*
Zr/Y
2.6B: Spidergram
SiO2 range: 67-77 wt %.
Rock / Primordial Mantle
Pb Rb Ba Th U K Nb La Ce Sr Nd P Zr Ti Y Na


Legend
Warramunga Gp.
Warrego Volcanics
Gecko Volcanics
Bernborough Fm
Yungkulungu Fm
Hill of Leaders Gran
Channingum Granite
Gosse River Nth Adm.
Cabbage Gum Granite
Tennant Creek Granit
Red Bluff Granite
Epenarra Volcanics
Mumbilla Granod.
Unnamed porphyries
Strongly oxidised
Oxidised
Reduced
Strongly Reduced
2.6D: Redox plot
Fe2O3/FeO
Total Fe as FeO


2.6E: ASI vs SiO2
ASI
SiO2


2.6F: Ga/Al vs HFSE
(Eby 1990)
FG
OGT
10000*Ga/Al
Zr+Nb+Ce+Y


Legend
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
1 2 3 4 5 6 7 9 10 11 12 14 23 25
Warramunga Gp.
Warrego Volcanics
Gecko Volcanics
Bernborough Fm
Yungkulungu Fm
Hill of Leaders Gran
Channingum Granite
Gosse River Nth Adm.
Cabbage Gum Granite
Tennant Creek Granit
Red Bluff Granite
Epenarra Volcanics
Mumbilla Granod.
Unnamed porphyries

Extrusive Warramunga Formation Volcanics

MEANS AND STANDARD DEVIATIONS

Element Mean	Median	Standard	Minimum Deviation	Maximum	Number of Items	
SiO2	72.38	71.73	4.65	64.51	81	11
TiO2	0.37	0.35	0.18	0.15	0.67	11
Al2O3	12.84	14.15	2.93	4.61	15	11
Fe2O3	1.88	1.67	0.98	0.75	3.9	11
FeO	1.85	1.75	1.49	0.25	5.48	10
MnO	0.06	0.06	0.03	0.03	0.12	10
MgO	0.89	0.94	0.51	0.26	1.93	11
CaO	1.79	1.66	1.26	0.04	3.47	11
Na2O	2.26	2.26	1.01	0.03	3.54	11
K2O	4.02	4.11	1.57	0.03	5.77	11
P2O5	0.08	0.08	0.04	0.02	0.17	11
H2O+	0.92	0.81	0.53	0.42	2.2	9
H2O-	0.07	0.06	0.06	0.02	0.21	7
CO2	0.49	0.17	0.92	0.04	2.56	7
LOI	2.42	2.42	0.18	2.3	2.55	2
Ba	714.64	723	277.77		1076	11
Li	7.55	7	3.59	3	12	11
Rb	165.45	184	60.04	2	226	11
Sr	99.36	110	58.19	2	214	11
Pb	11.91	12	6.85		22	11
Th	19.73	20	4.15	10	25	11
U	4.5	5	0.95	3	6	11
Zr	183.91	190	46.48	91	240	11
Nb	10.91	11	1.45	8	13	11
Y	29.55	29	5.26	17	36	11
La	38.09	40	7.71	23	46	11
Ce	78.82	77	23.89	45	132	11
Pr	7.5	7.5	6.36	3	12	2
Nd	29.82	32	6.35	18	38	11
Sc	8.82	8	4.71	2	15	11
V	30.18	24	19	9	55	11
Cr	12.09	10	7.78	3	22	11
Mn	464.5	464.5	91.22	400	529	2
Co	8.75	6	6.69	4	24	8
Ni	6.09	7	3.81		11	11
Cu	102.73	17	225.6	3	749	11
Zn	39.82	40	20.18	12	88	11
Sn	3.7	3.5	1.64	2	7	10
W	4.44	4	1.95		8	8
Mo	2.3	2	1.01		4	10
Ga	13.91	14	3.45	9	21	11
As	2.91	2	1.77	1	6	11
S	600	01	1039.23	01	1800	3
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	2	2	1.41	1	3	2
Ag	2	2	1.41	1	3	2
Bi	2.5	2.5	2.12	1	4	2
Hf	4	4	4.24		7	2
Ta	2	2	-	2	2	1
Cs	6.25	6.25	5.3		10	2
Ge	2.5	2.5	1.41	1.5	3.5	2
Se	0.38	75	0.18		50	2

Warrego Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.57	74.2	7.48	57	77.8	7
TiO2	0.43	0.4	0.18	0.23	0.76	7
Al2O3	14.7	12.7	3.68	11.5	21.9	7
Fe2O3	3.29	2.9	1.8	1.3	7	7
FeO	-	-	-	-	-	-
MnO	-	-	-	-	-	-
MgO	1.6	1.2	0.99	0.72	3.7	7
CaO	0.17	0.17	0.05	0.11	0.24	7
Na2O	0.8	0.92	0.61	0.12	1.7	7
K2O	6.07	6	0.75	4.8	7.3	7
P2O5	0.13	0.09	0.09	0.09	0.34	7
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	2.21	1.9	1.23	1.1	4.3	7
Ba	1037	1004	254.24	799	1406	7
Li	6.14	5	3.53	3	12	7
Rb	211.57	215	37.8	169	263	7
Sr	32.14	33	16.54	8	54	7
Pb	7.43	9	2.15	4	9	7
Th	35.14	32	7.9	27	50	7
U	8.93	8	2.57	6.5	14	7
Zr	195	193	69.93	110	318	7
Nb	15.14	15	3.44	11	22	7
Y	41	42	6.11	28	46	7
La	36.86	37	19.84	12	75	7
Ce	71.43	71	37.38	27	143	7
Pr	8.29	8	4.75		17	7
Nd	32	29	17.01	10	65	7
Sc	9.14	7	3.98	5	16	7
V	31.43	22	25.53	6	80	7
Cr	16.29	17	8.64	3	29	7
Mn	152.71	103	97.09	60	296	7
Co	6.29	5	3.77	3	14	7
Ni	8.71	6	6.47	3	22	7
Cu	1.71	1	1.11	1	4	7
Zn	21.86	21	13.3	7	45	7
Sn	-	-	-	-	-	-
W	8.14	8	1.77	6	11	7
Mo	1.14		0.38		2	7
Ga	18.71	17	5.91	13	29	7
As	0.68	0.5	0.43	50	1.5	7
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	2.71	3	1.25	1	5	7
Ag	1.14	1	0.38	1	2	7
Bi	0.93	1	0.19		1	7
Hf	5.29	5	2.56	2	10	7
Ta	1.29		0.49		2	7
Cs	5.93	5	3.35		11	7
Ge	1.43	1.5	0.53	1	2.5	7
Se	0.25	50	-	50	50	7

Gecko Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	55.5	55.5	-	55.5	55.5	1
TiO2	0.69	0.69	-	0.69	0.69	1
Al2O3	16.4	16.4	-	16.4	16.4	1
Fe2O3	13.8	13.8	-	13.8	13.8	1
FeO	-	-	-	-	-	-
MnO	-	-	-	-	-	-
MgO	4.6	4.6	-	4.6	4.6	1
CaO	0.13	0.13	-	0.13	0.13	1
Na2O	0.05	0.05	-	0.05	0.05	1
K2O	3	3	-	3	3	1
P2O5	0.1	0.1	-	0.1	0.1	1
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	4.4	4.4	-	4.4	4.4	1
Ba	301	301	-	301	301	1
Li	13	13	-	13	13	1
Rb	145	145	-	145	145	1
Sr	3	3	-	3	3	1
Pb	4	4	-	4	4	1
Th	41	41	-	41	41	1
U	10	10	-	10	10	1
Zr	344	344	-	344	344	1
Nb	19	19	-	19	19	1
Y	36	36	-	36	36	1
La	6	6	-	6	6	1
Ce	19	19	-	19	19	1
Pr	4	4	-	4	4	1
Nd	7	7	-	7	7	1
Sc	11	11	-	11	11	1
V	32	32	-	32	32	1
Cr	28	28	-	28	28	1
Mn	726	726	-	726	726	1
Co	35	35	-	35	35	1
Ni	9	9	-	9	9	1
Cu	0.5		-			1
Zn	62	62	-	62	62	1
Sn	-	-	-	-	-	-
W	8	8	-	8	8	1
Mo	1		-			1
Ga	23	23	-	23	23	1
As	0.5	0.5	-	0.5	0.5	1
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	2	2	-	2	2	1
Ag	2	2	-	2	2	1
Bi	1	1	-	1	1	1
Hf	10	10	-	10	10	1
Ta	1		-			1
Cs	8	8	-	8	8	1
Ge	2	2	-	2	2	1
Se	0.25	50	-	50	50	1

Bernborough Formation

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.81	74.08	3.47	67.1	76.91	12
TiO2	0.41	0.39	0.05	0.33	0.5	12
Al2O3	12.79	12.76	1.18	11.23	14.6	12
Fe2O3	2.91	2.61	1.05	1.84	5.2	12
FeO	1.69	1.74	0.27	1.13	2.01	9
MnO	0.01	0.01	0.01	0.01	0.02	9
MgO	1.43	1.48	0.3	0.93	1.86	12
CaO	0.11	0.11	0.05	0.05	0.19	12
Na2O	1.03	0.14	1.81	0.07	5.02	12
K2O	4.84	3.61	3.4	1.02	11.1	12
P2O5	0.08	0.09	0.02	0.05	0.11	12
H2O+	2.24	2.35	0.39	1.34	2.62	9
H2O-	0.13	0.14	0.02	0.09	0.15	9
CO2	0.05	05	0.06	05	0.21	9
LOI	1.94	2.34	0.79	0.7	2.71	12
Ba	1051.33	397	1321.16	121	3479	12
Li	4.42	4.5	0.9	3	6	12
Rb	161.58	159	63.75	44	248	12
Sr	21.25	11.5	18.86	4	52	12
Pb	5.58	5	3.26	2	11	12
Th	28.83	30	3.86	22	34	12
U	7.04	7	1.94	4	11	12
Zr	320.08	328.5	77.64	176	418	12
Nb	15	15.5	2.13	11	18	12
Y	46.75	46	10.44	32	73	12
La	86.25	69.5	60.36	38	260	12
Ce	157.25	131.5	100.39	72	442	12
Pr	15	10	9.54	9	26	3
Nd	57.08	47	34.07	30	149	12
Sc	9.5	10	2.07	6	12	12
V	15.08	15.5	6.39	8	24	12
Cr	4.83	4.5	3.35		13	12
Mn	108	104	25.24	85	135	3
Co	32.92	38	18.86	3	59	12
Ni	4.5	4	1.09	3	6	12
Cu	8.38	3	14.32		52	12
Zn	10.33	10.5	2.84	6	15	12
Sn	5.11	6	1.62	2	7	9
W	7	7	1	6	8	3
Mo	2.42	3	0.97		4	12
Ga	18.92	19.5	3.65	14	27	12
As	1.13	1	0.57	0.5	2.5	12
S	15.67	9	13.13	6	48	9
F	-	-	-	-	-	-
Cl	110.11	112	13.46	88	132	9
Be	2.42	2	1.36		4	12
Ag	1.33	1	0.58	1	2	3
Bi	0.96		0.14		1	12
Hf	5.67	5	1.15	5	7	3
Ta	2.33	3	1.15		3	3
Cs	10	9	3.61	7	14	3
Ge	1.17	1	0.29	1	1.5	3
Se	0.25	50	-	50	50	3

Yungkulungu Formation

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	66.7	66.7	-	66.7	66.7	1
TiO2	0.5	0.5	-	0.5	0.5	1
Al2O3	15.1	15.1	-	15.1	15.1	1
Fe2O3	5.2	5.2	-	5.2	5.2	1
FeO	-	-	-	-	-	-
MnO	-	-	-	-	-	-
MgO	1.4	1.4	-	1.4	1.4	1
CaO	2.3	2.3	-	2.3	2.3	1
Na2O	1.9	1.9	-	1.9	1.9	1
K2O	4.2	4.2	-	4.2	4.2	1
P2O5	0.12	0.12	-	0.12	0.12	1
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	2	2	-	2	2	1
Ba	758	758	-	758	758	1
Li	14	14	-	14	14	1
Rb	160	160	-	160	160	1
Sr	139	139	-	139	139	1
Pb	18	18	-	18	18	1
Th	19	19	-	19	19	1
U	4	4	-	4	4	1
Zr	186	186	-	186	186	1
Nb	11	11	-	11	11	1
Y	26	26	-	26	26	1
La	39	39	-	39	39	1
Ce	74	74	-	74	74	1
Pr	9	9	-	9	9	1
Nd	32	32	-	32	32	1
Sc	13	13	-	13	13	1
V	56	56	-	56	56	1
Cr	-	-	-	-	-	-
Mn	666	666	-	666	666	1
Co	12	12	-	12	12	1
Ni	10	10	-	10	10	1
Cu	19	19	-	19	19	1
Zn	73	73	-	73	73	1
Sn	-	-	-	-	-	-
W	3	3	-	3	3	1
Mo	3	3	-	3	3	1
Ga	20	20	-	20	20	1
As	6	6	-	6	6	1
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	2	2	-	2	2	1
Ag	1	1	-	1	1	1
Bi	1	1	-	1	1	1
Hf	6	6	-	6	6	1
Ta	3	3	-	3	3	1
Cs	8	8	-	8	8	1
Ge	1	1	-	1	1	1
Se	0.25	50	-	50	50	1

Hill of Leaders Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.39	69.84	3.08	64.2	75.45	9
TiO2	0.54	0.54	0.29	0.18	1.23	9
Al2O3	13.67	13.66	0.58	12.64	14.24	9
Fe2O3	1.56	1.09	1.61	0.49	5.78	9
FeO	2.54	2.88	0.75	0.96	3.24	9
MnO	0.07	0.06	0.03	0.05	0.13	9
MgO	1.1	1.25	0.36	0.5	1.52	9
CaO	1.74	1.68	0.62	0.76	3.17	9
Na2O	2.36	2.29	0.22	2.07	2.73	9
K2O	4.63	4.85	0.52	3.76	5.31	9
P2O5	0.15	0.14	0.06	0.11	0.31	9
H2O+	1	1.01	0.17	0.76	1.33	9
H2O-	0.09	0.08	0.02	0.06	0.13	8
CO2	0.13	0.09	0.11	0.04	0.31	8
LOI	-	-	-	-	-	-
Ba	571.89	590	104.49	363	712	9
Li	48.33	37	25.6	21	88	9
Rb	260.56	266	24.1	227	304	9
Sr	92.89	101	19.66	50	112	9
Pb	26.33	27	2.83	20	30	9
Th	19.67	19	3.97	11	23	9
U	6	6	1.5	3	8	9
Zr	158.56	173	33.06	81	190	9
Nb	11.11	12	1.9	8	13	9
Y	31.44	31	4.56	24	37	9
La	34.33	36	9.66	14	48	9
Ce	72.89	76	20.39	29	96	9
Pr	-	-	-	-	-	-
Nd	29	31	7.28	13	38	9
Sc	8.89	10	2.8	4	12	9
V	46	56	17.18	17	62	9
Cr	23.56	26	10.33	5	35	9
Mn	-	-	-	-	-	-
Co	8.25	7.5	3.24	4	14	8
Ni	9.22	10	4.41		14	9
Cu	11	10	4.66	3	18	9
Zn	49.44	55	15.65	15	66	9
Sn	6.89	7	1.05	5	8	9
W	5.88	4	3.83	3	12	8
Mo	2.17		1.35		5	9
Ga	15.44	16	1.74	11	17	9
As	1	1	0.61		2	9
S	-	01	-	01	01	1
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Channingum Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.62	72.4	1.79	70.05	77.2	15
TiO2	0.41	0.4	0.07	0.25	0.51	15
Al2O3	13.37	13.4	0.28	12.84	14	15
Fe2O3	2.71	2.9	0.84	1	3.6	11
FeO	1.65	1.65	-	1.65	1.65	1
MnO	0.01	0.01	0.01	0.01	0.03	5
MgO	0.64	0.7	0.24	0.06	0.97	15
CaO	1.08	1.2	0.44	0.02	1.49	15
Na2O	2.36	2.46	1.18	0.1	5.3	15
K2O	4.88	5.4	1.47	0.53	5.81	15
P2O5	0.09	0.09	0.02	0.04	0.12	15
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	1.52	1	1.41	0.6	5.99	15
Ba	661.36	649	124.56	490	987	11
Li	8.6	10	4.22	3	14	5
Rb	288.82	295	23.73	240	313	11
Sr	58.55	58	11.51	40	73	11
Pb	20.18	21	4.51	10	26	11
Th	38.18	42	11.17	18	56	11
U	8.95	9	4	0.5	16.5	11
Zr	250.6	256.5	65.45	146	370	10
Nb	14.4	14	1.67	13	17	5
Y	48.82	52	11.97	22	66	11
La	54.09	56	12	38	77	11
Ce	100	106	24.84	72	149	11
Pr	10.27	8	3.41	7	18	11
Nd	40.55	44	11.38	19	59	11
Sc	8.36	8	1.36	6	10	11
V	25.82	26	4.94	14	33	11
Cr	15.86	16	1.95	13	18	7
Mn	102	120	38.16	36	130	5
Co	5.9	6	2.23	1	9	10
Ni	6.64	7	1.69	2	9	11
Cu	5.09	3	3.96	2	14	11
Zn	13.55	13	4.68	7	23	11
Sn	1		-			1
W	3.9	4.5	1.6	1	6	10
Mo	1.2		0.45		2	5
Ga	17	17	0.89	16	18	11
As	1.68	1.5	0.68	1	3	11
S	100	100	-	100	100	1
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	2.35	2.3	0.62	1	3	11
Ag	1.2	1	0.45	1	2	5
Bi	0.77		0.26		1	11
Hf	8.09	8	3.48	4	14	11
Ta	1.73	2	0.9		4	11
Cs	9.18	8	2.4	7	15	11
Ge	1.82	1.5	1.25	1	5.5	11
Se	0.55		0.5		2	11

Gosse River North Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	75.58	76.08	2.37	72.6	78.1	6
TiO2	0.15	0.1	0.09	0.07	0.25	5
Al2O3	12.75	12.3	0.89	12.05	14.3	6
Fe2O3	1.03	0.91	0.63	0.39	2.2	6
FeO	1.06	1.06	0.52	0.7	1.43	2
MnO	0.02	0.02	0.01	0.01	0.03	2
MgO	0.34	0.37	0.16	0.1	0.52	5
CaO	1.12	0.69	0.9	0.3	2.3	6
Na2O	2.92	2.9	0.36	2.4	3.3	6
K2O	4.85	4.94	0.33	4.32	5.2	6
P2O5	0.03	0.04	0.02	0.01	0.05	5
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	0.76	0.69	0.25	0.5	1.17	6
Ba	251.17	111	266.17	26	636	6
Li	26.4	22	15.5	10	46	5
Rb	301.6	333	131.1	173	487	5
Sr	66.4	27	63.92	9	138	5
Pb	30.5	27.5	11.47	19	46	6
Th	30.8	29	5.22	25	39	5
U	12.4	13.5	4.94	7	19	5
Zr	96	85	30.05	73	130	3
Nb	13	11	3.46	11	17	3
Y	53.33	49	24.24	29	93	6
La	27.2	27	14.41	5	40	5
Ce	58.6	65	25.67	17	85	5
Pr	5.8	7	3.42		10	5
Nd	24	28	9.92	7	32	5
Sc	5.5	5	0.84	5	7	6
V	8		9.59		19	5
Cr	4.88	5	4.25		9	4
Mn	198	199.5	91.72	85	308	4
Co	2.67	3	1.53	1	4	3
Ni	4.1	2	5.62		14	5
Cu	1.17	1	0.68		2	6
Zn	13.17	12.5	7	6	26	6
Sn	6.5	6.5	2.12	5	8	2
W	6.33	5	3.21	4	10	3
Mo	1		-			3
Ga	17	17	1.41	15	19	5
As	0.9	1	0.63	50	1.5	5
S	7.5	7.5	3.54		10	2
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	3.22	3.25	0.72	2	4	6
Ag	1	1	-	1	1	3
Bi	0.8		0.27		1	5
Hf	3.8	4	1.3	2	5	5
Ta	1.2		0.45		2	5
Cs	13.8	10	15.02	3	40	5
Ge	2.4	2.5	0.65	1.5	3	5
Se	0.45		0.11		50	5

Cabbage Gum Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.76	72	3.57	66.45	78.83	20
TiO2	0.35	0.34	0.18	0.12	0.66	20
Al2O3	13.98	13.74	2.11	10.72	18.3	20
Fe2O3	1.62	1.2	1.41	0.38	5.6	17
FeO	1.44	1.04	0.97	0.76	3.37	8
MnO	0.03	0.02	0.02	0.02	0.07	11
MgO	0.73	0.67	0.44	0.2	1.8	20
CaO	0.59	0.12	0.81	0.03	3.12	19
Na2O	1.59	1.9	1.1	0.06	3.56	20
K2O	4.68	5.07	0.99	2.8	5.9	20
P2O5	0.06	0.05	0.04	0.01	0.14	20
H2O+	1.2	1.11	0.21	1	1.58	7
H2O-	0.1	0.11	0.02	0.08	0.12	7
CO2	0.13	0.1	0.13	05	0.41	7
LOI	2.45	1.33	1.9	0.5	6.1	20
Ba	687.2	719	136.6	337	857	20
Li	15.71	16	10.76	5	50	17
Rb	219.4	240	53.63	120	288	20
Sr	57.5	42	35.84	21	150	20
Pb	156.4	13	425.51	4	1400	20
Th	21	19.5	9.07	4	37	20
U	10.09	4	17.31	2	76	20
Zr	168.35	186	60.44	73	246	20
Nb	12.65	13	3.9	7	23	20
Y	28.54	29	11.21	8	53	20
La	38.6	38.5	19.6	3.8	81	20
Ce	65.85	74.5	30.92	4	110	20
Pr	7.6	7	4.97		17	10
Nd	28.6	27	15.13		61	20
Sc	7.79	7.5	3.94	1	16	20
V	24.05	21	18.97	5	73	20
Cr	16.25	10.5	16.97		63	16
Mn	183.1	143	180.21	19	579	10
Co	35.5	9.5	37.81	1	105	16
Ni	6.76	6	4.59	2	19	17
Cu	7.47	4	9.43	2	41	17
Zn	28.71	23	22.01	2	69	17
Sn	4.29	4	0.95	3	6	7
W	4.11	4	2.47		8	9
Mo	2.44		2.33		9	17
Ga	19.1	19	2.81	15	26	20
As	1.49	1	2.22	50	10	17
S	44.75	23.5	62.95	15	200	8
F	-	-	-	-	-	-
Cl	110.14	84	78.91	68	288	7
Be	2.03	2	0.72		3	17
Ag	1.3	1	0.67	1	3	10
Bi	1.47	.50	1.31		5	18
Hf	5	5	1.41	3	7	10
Ta	1.8	2	0.79		3	10
Cs	10.95	7.5	9.04		32	10
Ge	1.55	1.5	0.72	1	3.5	10
Se	0.35	50	0.24	50	1	10

Tennant Creek Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.41	72.1	2.76	67.2	82.5	49
TiO2	0.45	0.46	0.1	0.17	0.68	48
Al2O3	13.56	13.57	0.81	9.8	15.7	49
Fe2O3	2.79	3.1	1.73	0.4	6.8	33
FeO	2.57	2.88	0.81	1.37	3.16	4
MnO	0.03	0.02	0.02	0.01	0.06	21
MgO	0.83	0.89	0.38	0.08	1.6	49
CaO	1	1.1	0.47	0.04	2.3	49
Na2O	3.03	2.51	1.71	0.1	7.7	48
K2O	4.24	4.9	1.87	0.21	6.9	49
P2O5	0.09	0.1	0.04	0.01	0.17	49
H2O+	1.68	1.31	0.87	1.06	2.68	3
H2O-	0.1	0.1	0.02	0.08	0.11	3
CO2	0.27	0.2	0.28	05	0.58	3
LOI	1.48	1.1	1.25	0.6	6.5	49
Ba	681.76	811	285.3	43	1351	49
Li	13	10	7.41	4	30	23
Rb	167.54	185	83.79	6	281	49
Sr	85.49	81	38	12	200	49
Pb	16.61	16	11.08	3	51	49
Th	26.73	25	6.29	14	43	49
U	5.34	5	2.5	0.8	10.5	49
Zr	233.49	239	60.12	115	470	49
Nb	14.03	14.05	2.69	3	18	38
Y	44.99	47	15.98	10	97	49
La	44.06	44	17.02	10.2	95	38
Ce	85.41	89	28.6	14	155	38
Pr	8.69	9	3.04	2	15	29
Nd	37.28	38.5	11.31	4	58	38
Sc	9.6	10	3.52	1.3	17	48
V	27.96	30	12.68	2	58	49
Cr	35.97	18	62.15	3	252	34
Mn	172.37	120	135.42	12	420	19
Co	6.81	6	3.63	1	15	31
Ni	7.8	9	3.62	1	14	49
Cu	6	3	6.21		30	49
Zn	25.8	14	21.91	1	65	49
Sn	8.17	7.5	4.12	4	16	6
W	4.86	4.5	2.75		13	32
Mo	1.91		1.74		6	22
Ga	18.88	18	4.41	13	42	34
As	1.8	1.5	0.95	50	5	33
S	54.8	51	10.85	d	70	5
F	900	900	-	900	900	1
Cl	261	319	118.2	125	339	3
Be	2.75	3	0.81	1	5	33
Ag	1.26	1	0.54		2	19
Bi	0.93	1	0.4		2	48
Hf	7.2	7	2.67	4	17	30
Ta	1.2		0.48		3	30
Cs	7.41	7	4.34		16	28
Ge	1.6	1.5	0.62	0.5	4	30
Se	0.42	50	0.32		2	30

Red Bluff Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	73.56	73.96	1.39	69.7	75.16	20
TiO2	0.37	0.34	0.11	0.2	0.66	20
Al2O3	13.57	13.49	0.51	12.4	14.63	20
Fe2O3	1.62	1.01	1.4	0.09	5	17
FeO	0.56	0.44	0.41	0.08	1.32	8
MnO	0.01	0.01	0.01	01	0.03	12
MgO	0.8	0.9	0.28	0.25	1.3	20
CaO	0.78	0.7	0.42	0.23	1.6	20
Na2O	3.85	2.93	1.81	2.1	7.3	20
K2O	3.89	4.97	2.23	0.36	6.08	20
P2O5	0.09	0.09	0.02	0.03	0.12	20
H2O+	0.93	0.96	0.26	0.47	1.31	8
H2O-	0.11	0.12	0.02	0.07	0.13	8
CO2	0.17	0.12	0.12	05	0.41	8
LOI	1.1	1.1	0.25	0.64	1.6	20
Ba	504.1	615.5	293.37	54	1035	20
Li	5.93	5	3.12	2	13	14
Rb	152.26	204	97.83	11	310	20
Sr	69	59	29.66	33	121	20
Pb	10.45	6.5	8.64	3	35	20
Th	28.65	28.5	3.92	17	38	20
U	4.46	4.25	1.91	2	8.5	20
Zr	183.45	175.5	38.03	120	270	20
Nb	13.33	13	2.01	10	17.3	17
Y	44.3	44.5	7.46	34	59	20
La	39.56	38	12.28	20	66	18
Ce	80.5	79	16.77	53	122	18
Pr	9.67	9	1.8	8	13	9
Nd	34	35	7.66	20	52	18
Sc	6.63	7	2.52	1.6	14	20
V	21.2	19	10.51	11	60	20
Cr	51.87	12	84.41	7	245	15
Mn	133.83	114.5	70.66	66	267	6
Co	30.63	9	33.51	1	78	16
Ni	6.26	5	3.72		13	19
Cu	3.35	2	3.96		17	20
Zn	13.6	9	11.57	4	53	20
Sn	6.3	6	2.21	3	10	10
W	63.27	5	194.27	2	649	11
Mo	2.11		1.5		5	14
Ga	18.83	17.5	5.53	14	40	18
As	1.38	1	0.76	0.5	3	17
S	21.89	12	29.74	5	100	9
F	1200	1200	-	1200	1200	1
Cl	357.63	307.5	117.3	254	607	8
Be	2.64	2	0.8	1.8	4	17
Ag	1.5	1.5	0.55	1	2	6
Bi	0.97		0.31		2	19
Hf	6.56	6	3.17	3	12	9
Ta	1.56	2	0.53		2	9
Cs	4.67	4	2.11		8	9
Ge	1.72	1.5	1.06	1	4.5	9
Se	0.53	50	0.57		2	9

Epenarra Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.89	71.15	2.01	70.05	75.2	6
TiO2	0.56	0.58	0.08	0.42	0.64	6
Al2O3	11.93	12.03	0.77	10.46	12.66	6
Fe2O3	3.46	3.98	1.81	0.86	5.15	6
FeO	1.61	1.85	0.87	0.24	2.47	6
MnO	0.04	0.03	0.02	0.02	0.08	6
MgO	0.75	0.77	0.18	0.52	0.98	6
CaO	0.37	0.31	0.19	0.2	0.7	6
Na2O	2.4	2.57	0.82	1.36	3.41	6
K2O	5.39	5.28	0.97	4.29	6.5	6
P2O5	0.13	0.13	0.01	0.11	0.15	6
H2O+	1.1	1.07	0.24	0.76	1.51	6
H2O-	0.07	0.07	0.03	10	0.1	4
CO2	0.08	0.06	0.04	10	0.13	4
LOI	-	-	-	-	-	-
Ba	1347.5	779.5	1447.73	656	4299	6
Li	8	5.5	5.83	3	18	6
Rb	212.17	187.5	56.23	159	308	6
Sr	33.17	36.5	12.01	14	44	6
Pb	8.5	8.5	3.21	5	13	6
Th	28	28	3.52	22	32	6
U	6.67	6	1.89	4.5	10	6
Zr	349.5	352	57.13	271	413	6
Nb	16.17	16.5	1.72	13	18	6
Y	63.33	60.5	11.08	49	78	6
La	54.67	61.5	23.21	9	73	6
Ce	104.67	117.5	41.28	25	142	6
Pr	-	-	-	-	-	-
Nd	40.33	46	22.05	16	59	3
Sc	10.83	11.5	2.14	7	13	6
V	19.17	17	5.98	13	28	6
Cr	4.17	4	2.79		9	6
Mn	-	-	-	-	-	-
Co	9.25	9.5	1.71	7	11	4
Ni	2.17	1.5	1.6		5	6
Cu	6.83	5	4.54	2	13	6
Zn	53.5	34.5	42.53	23	134	6
Sn	6	6.5	2.61	2	9	6
W	6.75	7	0.5	6	7	4
Mo	2.5		1.58		5	6
Ga	14.33	14.5	2.73	10	18	6
As	1.17	1	0.68		2.5	6
S	0.03	0.03	0.03	01	0.05	2
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Mumbilla Granodiorite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.98	70.53	3.26	66.4	77.99	29
TiO2	0.48	0.53	0.18	0.07	0.74	29
Al2O3	13.91	13.84	0.48	13	14.9	29
Fe2O3	4.45	4.8	1.52	1.43	5.9	11
FeO	1.68	1.68	0.67	1.2	2.15	2
MnO	0.04	0.04	0.02	0.01	0.08	19
MgO	0.86	0.92	0.42	0.15	1.5	29
CaO	1.46	1.7	1.09	0.01	3.26	29
Na2O	1.66	2.2	1.06	0.1	2.65	29
K2O	4.2	4.55	1.29	0.85	6	29
P2O5	0.11	0.13	0.06	0.01	0.2	29
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	2.24	1.19	2.02	0.5	6.58	29
Ba	851.24	808	587.5	163	3611	29
Li	27.73	31	14.34	2	50	11
Rb	207.79	205	56.87	43	320	29
Sr	88.64	93	43.35	11.6	160	29
Pb	24.07	27	9.84	2	42	29
Th	22.77	21	6.26	14	41	29
U	4.93	5.4	2.06	0.5	8.5	29
Zr	191.83	210	56.12	66	293	29
Nb	13.36	12.8	3	8	20.3	25
Y	31.47	34	12.24	10	54	29
La	45.15	46	15.18		65	15
Ce	86	91	28.36	5	118	15
Pr	8.82	9	3.19		13	11
Nd	35.9	38	13.01		51	15
Sc	11.34	12.4	4.02	3	17	29
V	42.48	50	22.19	4	73	29
Cr	24.91	30	13.83	2	42	23
Mn	369.29	441	192.8	39	625	7
Co	9	10	3.89	1	13	10
Ni	9.4	11	5.05	0.5	16	29
Cu	11.31	11	6.66	1	27	29
Zn	41.9	50	24.88	1	74	29
Sn	4	4	1.41	3	5	2
W	4.55	4	2.07	2	8	11
Mo	1.57		0.79		3	7
Ga	17.25	18	2.42	12	20	12
As	1.14	1	0.5	0.5	2	11
S	100	100	-	100	100	1
F	1300	1300	-	1300	1300	1
Cl	-	-	-	-	-	-
Be	2.03	2	0.68	1	3	11
Ag	1.29	1	0.49	1	2	7
Bi	0.97	1	0.26		2	29
Hf	6.82	6	3.16	3	12	11
Ta	2	2	1.34		5	11
Cs	14	14	5.12	4	23	11
Ge	1.73	1.5	1.03	0.5	4.5	11
Se	0.52	50	0.51		2	11

Unnamed intrusive porphyries

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	69.95	70.95	4.32	50.4	76.4	66
TiO2	0.44	0.41	0.18	0.08	1.22	66
Al2O3	13.88	13.6	1.79	10.9	21.3	66
Fe2O3	3.93	3.74	1.97	1.02	10.6	66
FeO	1.82	1.82	1.07	0.5	4.11	16
MnO	0.04	0.02	0.03	0.01	0.1	18
MgO	1.42	1.22	0.84	0.3	4.1	66
CaO	0.47	0.22	0.65	0.01	3.5	66
Na2O	1.55	0.78	1.69	0.03	7.4	66
K2O	5.21	5.05	2.51	0.08	14.31	66
P2O5	0.1	0.1	0.04	0.01	0.22	66
H2O+	1.21	1.33	0.38	0.36	1.48	7
H2O-	0.09	0.09	0.03	05	0.13	7
CO2	0.2	0.2	0.11	0.07	0.39	7
LOI	2.27	1.9	1.46	0.08	8.1	63
Ba	1152.97	1027	708.3	45	2870	66
Li	8.03	7	4.37	2	22	61
Rb	189.55	181.5	80.08	3	463	66
Sr	52.56	45	36.98	0.8	165	66
Pb	8.59	5	9.3		49	66
Th	29.39	30	6.29	12	53	66
U	6.47	6	2.51	50	13	66
Zr	207.18	200.5	71.53	73	421	66
Nb	13.92	14	2.65	9	21	62
Y	44.52	40.5	22.92	19	189	66
La	44.97	42.5	22.03	3	127	66
Ce	87.11	82.5	38.35	7	183	66
Pr	10	9	4.41	2	28	59
Nd	37.31	34	16.74	4	103	65
Sc	9.29	9	3.46	3	20	65
V	33.09	31	19.33		75	66
Cr	28.39	16	37.09	3	171	59
Mn	285.67	256	243.43	40	1223	55
Co	16.21	8	29.46		205	56
Ni	9.9	8	12.33		96	66
Cu	38.55	2.5	244.13		1987	66
Zn	31.65	20	28.19	3	117	66
Sn	6.56	6.5	2.89	2	12	18
W	8.85	5	23.19		170	51
Mo	1.66		1.11		6	61
Ga	17.47	17	3.41	9	28	66
As	1.25	1	1.25	50	8	65
S	108.44	20	243.57	5	1000	16
F	-	-	-	-	-	-
Cl	124.4	112	29.64	96	168	5
Be	2.46	2	1.1	1	6	64
Ag	1.35	1	0.55	1	3	55
Bi	1.41	1	1.42		8	64
Hf	5.98	6	2.01		11	59
Ta	1.51		1.01		6	59
Cs	6.91	7	3.41		24	57
Ge	1.65	1.5	0.86	0.5	4	59
Se	0.42	50	0.4		2	59

3 TREASURE SUITE

3.1 Timing

1820 Ma

3.2 Individual Ages

Primary Ages:

1.	Wundirgi Formation (dyke)	1829 ± 8 Ma, SHRIMP
2.	Wundirgi Formation (granite)	1827± 9 Ma, SHRIMP
3.	Tennant Creek Au Mineralisation	1830-1820 Ma, Ar-Ar
4.	Unnamed diorite (NW of Tennant Creek)	1821 ± 7 Ma, SHRIMP
4.	Treasure Volcanics	1819 ± 8 Ma, SHRIMP
3.	Arabulja Volcanics	1819 ± 8 Ma, SHRIMP
4.	Newlands Volcanics	1818 ± 10 Ma, SHRIMP
5.	Treasure Volcanics	1816 ± 11 Ma, SHRIMP
6.	Tennant Creek Au Mineralisation	1820-1805 Ma, Rb-Sr

Sources: Black 1977; Compston 1994, 1995; Compston and McDougall 1994; OZCHRON

3.3 Regional Setting

The Treasure Suite comprises all igneous rocks emplaced in the Tennant Creek Province and the adjacent Davenport Province between about 1830 to 1815 Ma. The suite is bimodal and is mainly present as extrusive volcanics in the upper Ooradidgee Subgroup (Treasure and Mia Mia Volcanics) and lower Hanlon Subgroup (Arabulja and Newlands Volcanics) of the Hatches Creek Group, and as felsic to intermediate volcanics of the Hayward Creek Formation of the Tomkinson Creek Subgroup. The suite has a strike length in outcrop of 600 km, and Tucker *et al.* (1979) suggested that the Hatches Creek Group could be traced eastwards for at least 300 km beneath the Georgina Basin. Intrusives are found mainly as granophyre or porphyry sills within the lower Hatches Creek Group of the Davenport Province or as diorite to monzodiorite intrusions in the Tomkinson and Flynn Subgroups to the north of the Warrego Mine. Although dominantly felsic, there are dolerites and mafic volcanics coeval with this suite, which also appears to be emplaced synchronously with extension within the host sedimentary units.

3.4 Summary

The suite is classified as a fractionated I-(granodiorite) type. It has been classified as a ‘Cullen Type’. The intrusives mainly form granophyric sills, but modelling of geophysical data suggests that there are intrusive granites in the vicinity of the volcanic members of this suite (Tucker *et al.* 1979; Blake *et al.* 1986) and underneath the Tennant Creek Province (Rattenbury 1994). The suite is more mafic to intermediate in composition in the northern Tennant Creek Province, and more felsic and fractionated in the Hatches Creek Region. The more mafic end members of this suite were first suggested as having a relationship to the Au mineralisation by Dunnet and Harding (1967). Gold and W mineralisation is hosted by units equivalent in age or older than this suite in the Davenport Province. In the Tennant Creek Province the mineralisation is hosted mainly by ironstone units developed during an older hydrothermal event.

3.5 Potential

There appears to be a relationship with Au mineralisation in the Tennant Creek Province with some of the W and Au mineralisation in the Davenport Province. Not only is Au mineralisation in the Tennant Creek Province of the same age as the members of this suite, but also a magmatic input has been postulated for the ore fluid (Zhaw *et al.* 1994a, b; Wedekind *et al*. 1989). The suite of metals in the Hatches Creek W field (and to some extent the Wauchope W field) consists of W, Cu, Co, Bi, Mo with minor U and Sn, whilst the elements associated with the Au deposits at Tennant Creek are Cu, Bi, Mo, Co, with minor W and Sn. The best Au deposits are hosted by ironstones in the Tennant Creek Province that formed during the emplacement of the earlier Tennant Creek Supersuite. Blake *et al.* (1987), noted that similar ironstone hosts are missing from the Warramunga Formation in the Davenport Province, which may explain the absence of this style of deposit in that Province.

In the younger sequences in both the Davenport and the Tennant Creek Provinces, the style of Au mineralisation is completely different, consisting of quartz-vein Au deposits within arenite-rich units, and mafic and felsic intrusives/extrusives (Ferenczi, *written communication*). This may mean that deposits similar to the Mount Todd Au deposit at Pine Creek could occur, but more importantly, exploration techniques based on magnetics, which is so commonly used in the Tennant Creek area, would completely miss this style of deposit. W is restricted to the more felsic members of the suite, and the paucity of carbonates in the host sedimentary packages would restrict the development of W-skarn deposits.

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

3.6 Descriptive Data

Location: Northern Tennant Creek Province and throughout the Davenport Province.

Dimensions and area: The suite extends for over 600 km from the Tennant Creek Province northwest of Warrego to the southeastern-most portions of the Davenport Province. Some of the granitic basement identified by Rattenbury (1994) beneath the Tennant Creek Inlier may be part of this suite. Tucker *et al.* (1979) suggested that the Hatches Creek Group could be traced eastwards for at least 300 km beneath the Georgina Basin. Total outcrop area of the suite is 1500 km^2.

3.7 Intrusives

Component plutons: In the northwest of the Tennant Creek Province the suite consists of small mafic to intermediate intrusives (<0.4 km^2) comprising monzonite, quartz monzonite and quartz diorite which intrude the Warramunga Formation, Flynn Subgroup and the lower Tomkinson Creek Subgroup (Mendum and Tonkin 1976; Dunnet and Harding 1967; Donnellan *et al*., in prep). These have been loosely termed diorite, and we have not included coeval dolerite and gabbro of tholeiitic affinity. The members of this suite in the Davenport Province include the Treasure, Mia Mia, Arabulja and Newlands Volcanics and unnamed granophyres and porphyries of the lower Hatches Creek Group (Blake *et al.* 1987).

Form: Intrusions are mostly sills or small stocks.

Metamorphism and Deformation: The sills have been folded with the country rocks, and metamorphosed to upper greenschist facies (biotite present).

Dominant intrusive rock types: <u>Diorite</u> - quartz monzonite, quartz diorite, monzonites, monzodiorite. <u>Unnamed granophyre</u> - granitic to granodioritic in composition.

Colour: pink or maroon to dark grey.

Veins, Pegmatites, Aplites, Greisens: Miarolitic cavities recorded in some of the sills. Sulphur-stained quartz veins carrying hematite, magnetite and possibly Au cut porphyritic granophyre in the Hatches Creek area (Blake and Wyche 1983).

Distinctive mineralogical characteristics: <u>Diorite</u> - hornblende, magnetite, plagioclase, minor augite. <u>Unnamed granophyre and porphyry</u>- phenocrysts of sanidine and plagioclase, and small crystals of apatite; biotite is the dominant ferromagnesian mineral. Some disseminated sulphide minerals recorded. The porphyries differ in not having a micrographic groundmass.

Breccias: None recorded.

Alteration in the granite: <u>Granophyre and porphyry</u> - chlorite pseudomorphs after pyroxene or biotite, actinolite and epidote, calcite, hematite, sericite/muscovite.

3.8 Extrusives

Treasure Volcanics - iron-stained grey to pinkish-grey porphyritic, with subordinate even-grained dacitic to rhyolitic lava flows, ignimbrite, volcanic breccia, basaltic lava. Mia Mia Volcanics - iron-stained felsic tuff and lavas, some with tourmaline. Newlands Volcanics - porphyritic felsic ignimbrite, bedded tuff, phenocrysts of feldspar, hornblende and biotite. Arabulja Volcanics - lavas, tuffs, ashstones. Hayward Creek Formation - intensely lateritised intermediate volcanic rocks. Whittington Range Member (?) - vesicular andesitic lavas.

3.9 Country Rock

Contact metamorphism: Sandstones are indurated and iron-stained near the diorite intrusives, country rocks are metamorphosed to hornfelses within a few metres of the granophyre contacts.

Reaction with country rock: Net-veined complexes recorded.

Units the granite intrudes: In the northwest Tennant Creek Province, diorite intrudes the lower Tomkinson Creek Subgroup as a series of concordant sills. In the Davenport Province, granophyre and porphyry sills intrude the Unimbra Sandstone of the Wauchope Subgroup, the Taragan Sandstone, Kurinelli Sandstone, Warnes Sandstone, Rooneys Formation and Epenarra Volcanics of the Ooradigee Subgroup, and the Warramunga Formation.

Dominant rock types: Feldspathic and lithic arenites, rhyolitic and mafic lavas, siltstones, rare calcareous beds.

Potential hosts: Hydrothermal ironstones of the Warramunga Formation in the Tennant Creek Province. Although Blake *et al.* (1986) noted that there are some highly magnetic rocks within the Warramunga Formation, Blake *et al*. (1987) stated that no ironstones of the type found in the Tennant Creek Province have been found in the Warramunga Formation from the Davenport Province. Feldspathic arenites of the Flynn, Tomkinson, Ooradigee and Wauchope Subgroups host both W and Au mineralisation suggesting that these form competent and reactive units suitable for hosting quartz-vein Au and W deposits.

3.10 Mineralisation

In the Davenport Province, members of this suite have a close spatial association with W deposits, in particular the Hatches Creek Tungsten Field. As noted by Hoatson and Cruickshank (1985), most W, Cu and Au deposits are hosted by formations in the oldest part of the Hatches Creek Group, the Ooradidgee Subgroup, and several are hosted in the Treasure Volcanics. Ryan (1961) divided these W deposits into three groups: a wolfram-scheelite group, a wolfram-copper group and a wolfram group. Most of these deposits contain Cu, Bi and Mo, with traces of Au and Sn. Although attributed to the nearby Devils Marbles Granite, the Wauchope Tungsten Field, being hosted by the lower Hatches Creek Group, may also be related to the Treasure Suite. It too contains minor Cu, Mo, and Bi. Gold-only deposits occur only in the lowermost parts of the Hatches Creek Group below the extrusive volcanic members of the Treasure Suite (Hoatson and Cruickshank 1985). The gold deposits are all quartz vein types which cut arenite, siltstone and felsic volcanics and associated gabbro and dolerite.

In the Tennant Creek Province, Au-bearing quartz veins occur at the Last Hope deposit, which is in the Wundirgi Formation close to the unnamed diorite that was dated by Compston (1994, 1995). Another quartz vein Au deposit in arenite of the Wundirgi Formation is the Bull Pup mine (Donnellan *et al*., in prep). Rubidium-strontium dating by Black (1977), Compston (1994) and Compston (1995) has suggested that the ironstone-hosted Tennant Creek Au mineralisation formed at around 1830-1810 Ma, which overlaps the age of the members of this suite. The Au mineralisation was derived from a fluid that was distinct from the one that generated the ironstone bodies, was higher-temperature and had a magmatic component (e.g., Wedekind *et al*. 1989; Zhaw *et al*. 1994a,b). Elements associated with the Au include Bi, Cu, Mo, Co, Pb, U, Sn and W (Large 1974; Ferenczi 1994; Donnellan *et al*., *in prep.*), an assemblage which is not all that dissimilar from the elements associated with the W deposits in the Davenport Province to the south.

3.11 Geochemical Data

Data source: There are 84 samples in this suite: all are in OZCHEM and are either part of the BMR Tennant Creek data set collected in the early 1970's or were collected as part of the 1:100 000 regional mapping program carried out in the Davenport Ranges in the early 1980's. Analysed samples from Compston (1994) are also included.

Data quality: The data quality is good.

Are the data representative? The samples are representative of the more felsic end members, and only one sample was from the diorites and more intermediate rock types present in the Flynn and Tomkinson Subgroups north of the Warrego Mine.

Are the data adequate? There are insufficient FeO and F data.

SiO_2 range (Fig. 3.1): The samples analysed from this suite probably do not reflect the true distribution. The Treasure and Arabulja Volcanics are definitely more SiO_2-rich (>70 wt %.) than other members of this suite. The other groups tend to have a gradual increase in SiO_2 from

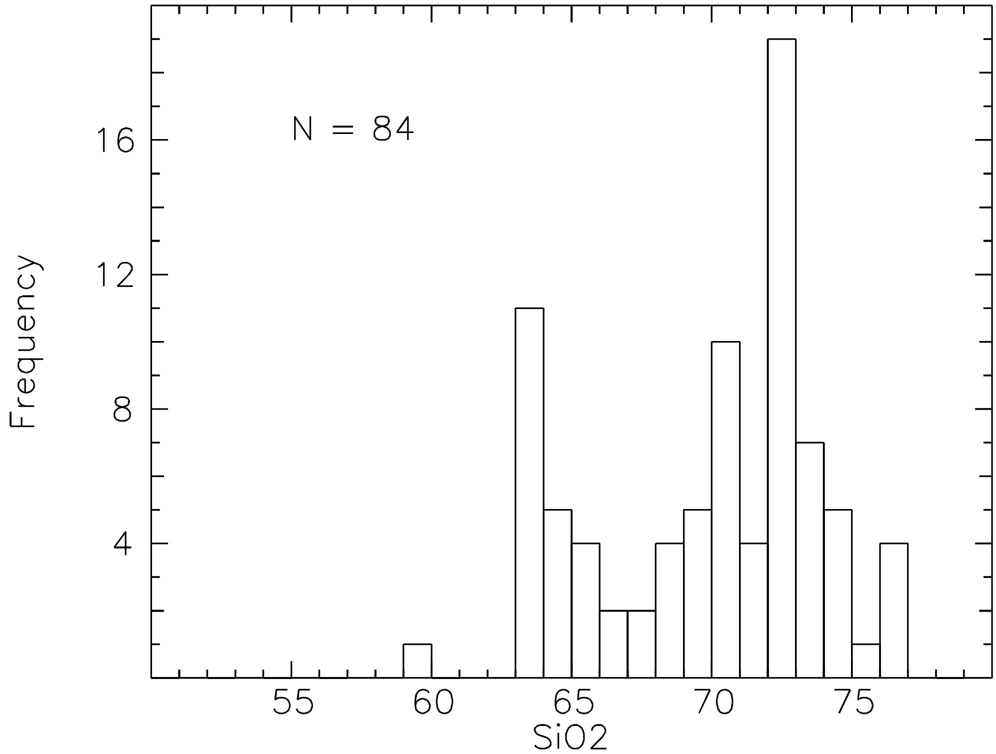


Fig. 3.1: Histogram of SiO_2 values

about 63 wt.% SiO_2.

Alteration (Figs. 3.1 & 3.2):

- ***SiO_2:*** No major evidence of silicification within the samples analysed.
- ***K_2O/Na_2O:*** Alteration is predominantly K-rich, and there is no evidence of the Na alteration which was reasonably abundant in the Tennant Creek Supersuite.
- ***Th/U:*** Most samples are within average crustal values.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** Some samples, particularly the extrusive volcanics, are almost totally oxidised. This is expected, as most of the field descriptions of these units describe the rocks as either hematised or iron-stained.

Fractionation Plots (Fig. 3.3):

- ***Rb:*** Shows exponentially increasing values with increasing SiO_2, particularly in the Treasure Volcanics. One lowest silica sample of Mia Mia Volcanics is aberrant as it is highly altered.
- ***U:*** Only slight increases observed with increasing SiO_2 in the Newlands Volcanics.
- ***Y:*** Some strong increases with increasing SiO_2.
- ***P_2O_5:*** Decreases with increasing SiO_2.
- ***Th:*** Weak increase with increasing SiO_2.
- ***K/Rb:*** Decreases with increasing SiO_2, particularly in the Treasure Volcanics.
- ***Rb-Ba-Sr:*** Some samples of Treasure Volcanics plot in the ‘Strongly Differentiated Field’.
- ***Sr:*** Generally decreases with increasing SiO_2.
- ***Rb/Sr:*** Increases with increasing SiO_2.
- ***Ba:*** Some increase with increasing SiO_2. Highest values are in the K-altered samples, e.g., the sample of Mia Mia Volcanics with 2257 ppm Ba, has 12.88 wt% K_2O, O.21 wt% Na_2O, 0.20 wt% P_2O_5, and is highly oxidised.
- ***F:*** No data available.

Metals (Fig. 3.4):

- ***Cu:*** Some higher values particularly in the more mafic end members.
- ***Pb:*** Decreases with increasing SiO_2, and the highest values are in the granophyres.
- ***Zn:*** Values are high and generally decrease with increasing SiO_2.
- ***Sn:*** No general trend.

High field strength elements (Fig. 3.5):

- ***Zr:*** No real trend, and values are not all that high.
- ***Nb:*** Slightly increases with increasing SiO_2, and values are not all that high.
- ***Ce:*** No real trend, and some values have been affected by alteration.

Classification (Fig. 3.6):

- ***The CaO/Na₂O/K₂O plot of White, quoted in Sheraton and Simons (1992):*** Most samples fit in the granite to monzogranite field with some samples in the granodiorite range.
- ***Zr/Y vs Sr/Sr*:*** All samples are Sr-depleted.
- ***Spidergram:*** Typical Proterozoic Sr-depleted, Y-undepleted pattern indicating a plagioclase-stable source.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples fit in the oxidised field, with those in the strongly oxidised field having been affected by the hematisation described in outcrop specimens.
- ***ASI:*** Ranges from metaluminous to peraluminous.
- ***A-type plot of Eby (1990):*** Plots in the A-type field, presumably reflecting the higher Y values.

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

Australian Proterozoic granite type: Cullen.

3.12 Geophysical Signature

Radiometrics (Fig 3.7): The median value of most groups plots above the Proterozoic median, indicating that most of these groups would appear white on an RGB image.

Gravity: The regional gravity data are too coarse for meaningful correlations to be made.

Magnetics: Diorites show up as large crescent shaped linear magnetic anomalies (Mendum and Tonkin 1976). Felsic volcanics of the Newlands Volcanics and Treasure Volcanics and also the granophyres are quite magnetic (Blake *et al*. 1986).

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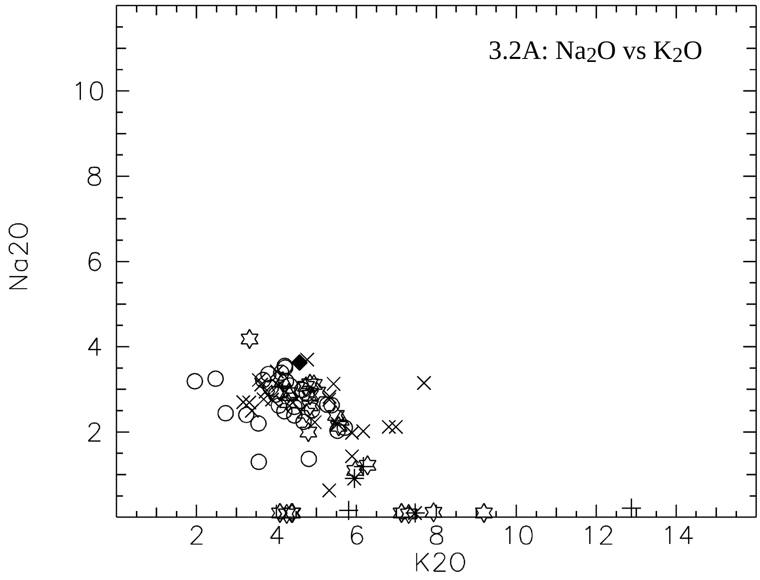
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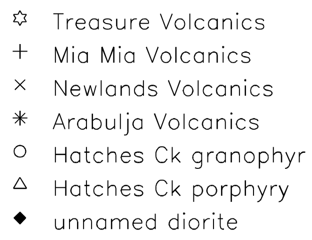
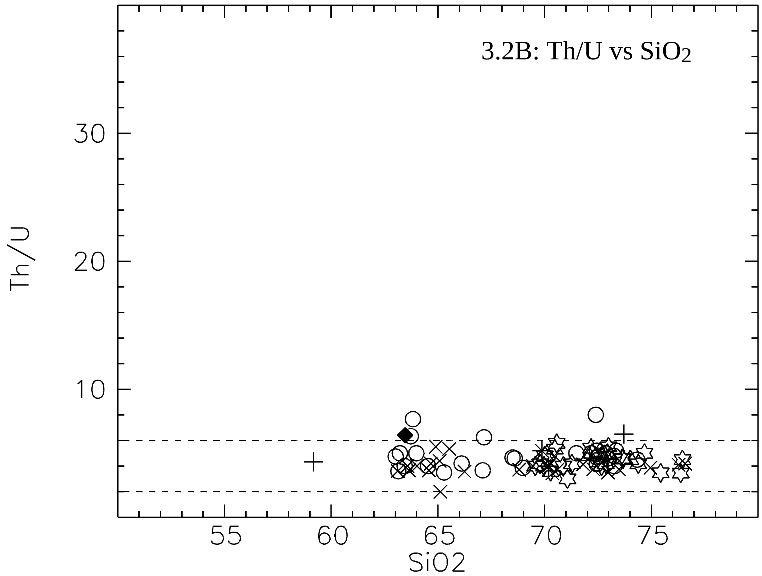
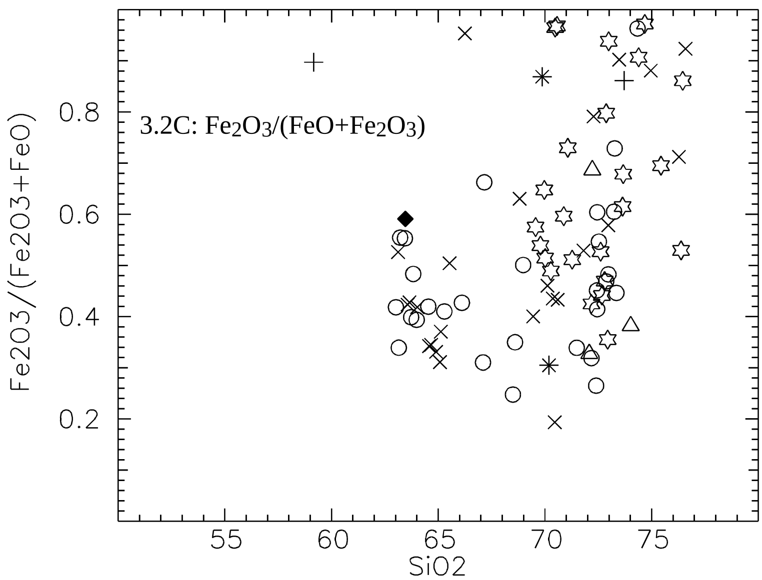
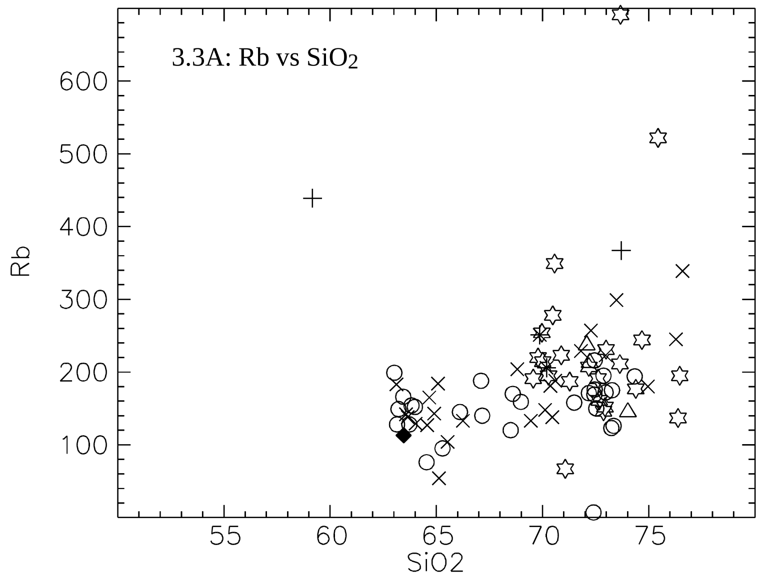
Na2O
K2O
2
4
6
8
10
12
14

Legend

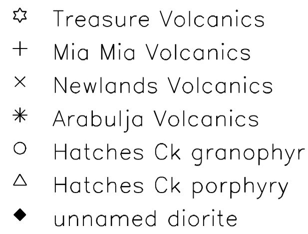

Treasure Volcanics
Mia Mia Volcanics
Newlands Volcanics
Arabulja Volcanics
Hatches Ck granophyr
Hatches Ck porphyry
unnamed diorite


3.2B: Th/U vs SiO_2
Th/U
SiO2
10
20
30
55
60
65
70
75


3.2C: $Fe_2O_3/(FeO+Fe_2O_3)$
Fe2O3/(Fe2O3+FeO)
SiO2
0.2
0.4
0.6
0.8
55
60
65
70
75


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

Legend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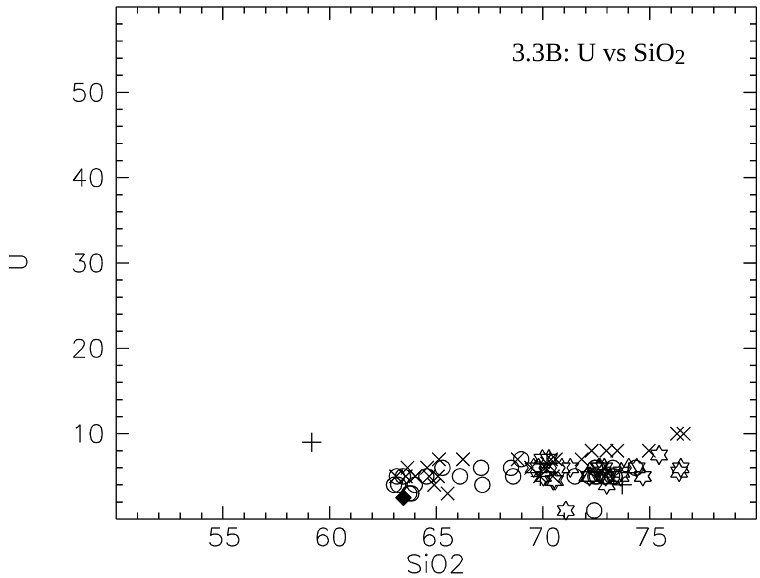
Mia Mia Volcanics
Newlands Volcanics
Arabulja Volcanics
Hatches Ck granophyr
Hatches Ck porphyry
unnamed diorite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SiO2
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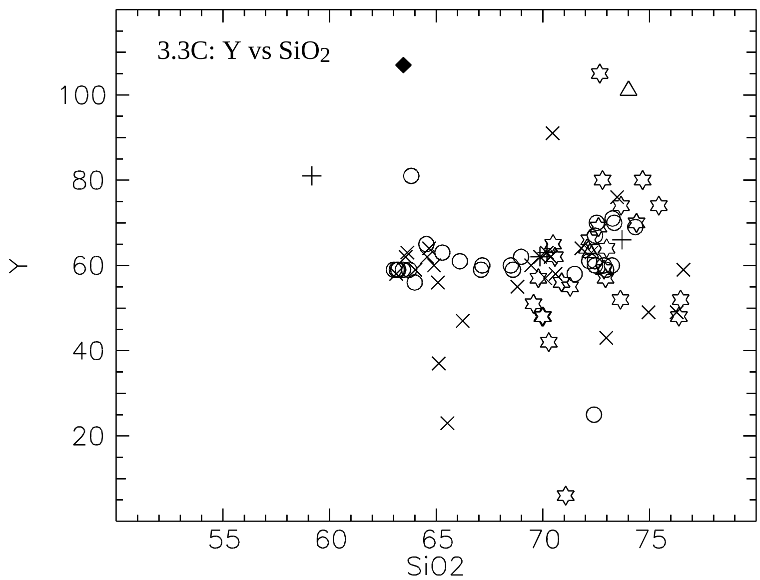
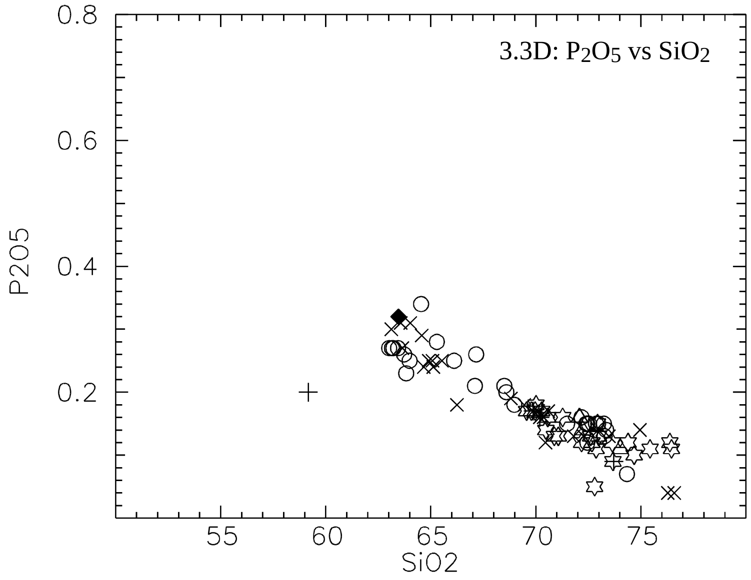
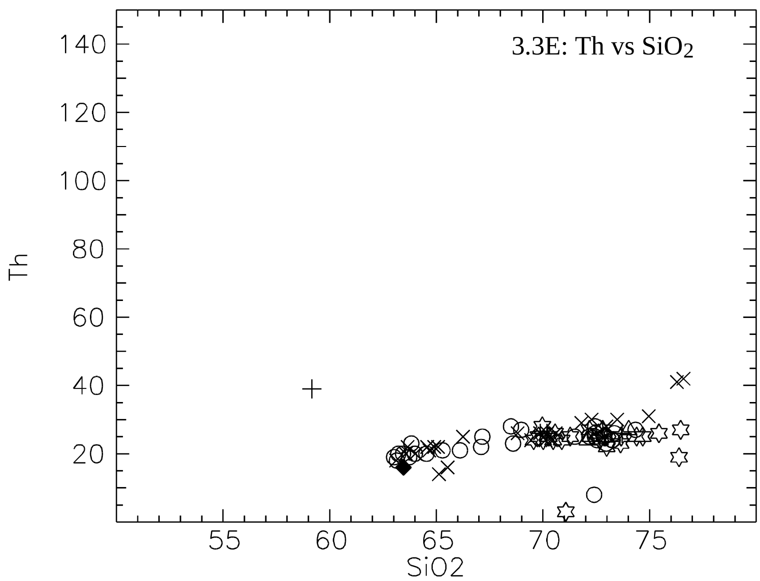
20
30
40
50
55
60
65
70
75

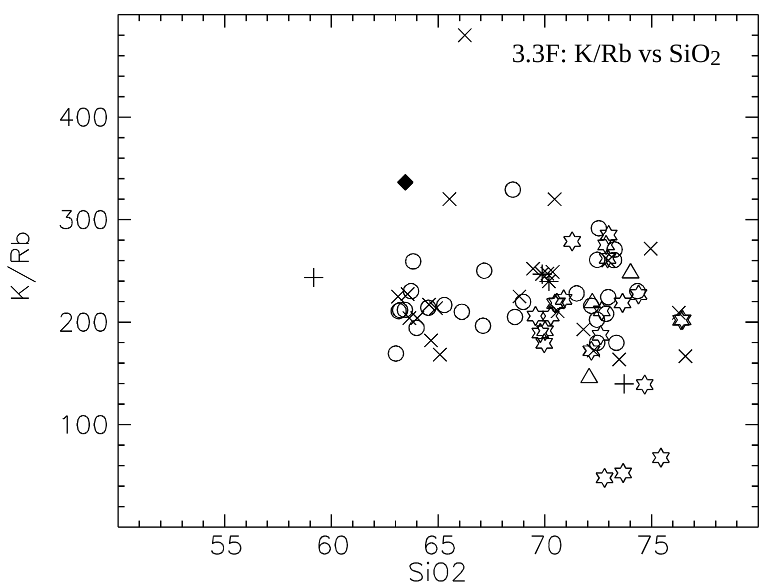

3.3C: Y vs SiO2
Y
SiO2
20
40
60
80
100
55
60
65
70
75

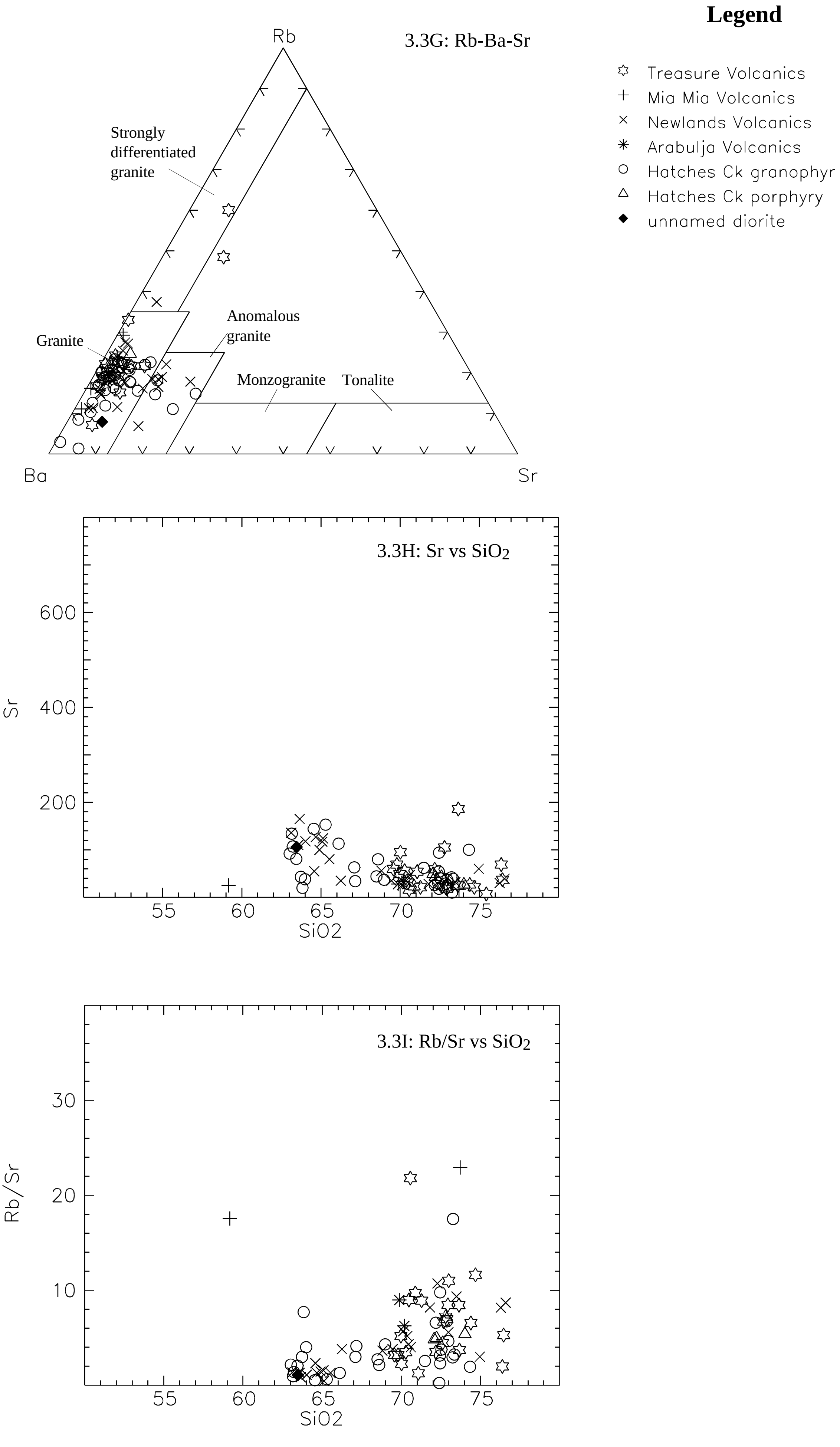
Legend

- ✡ Treasure Volcanics
- + Mia Mia Volcanics
- × Newlands Volcanics
- ✳ Arabulja Volcanics
- ○ Hatches Ck granophyr
- △ Hatches Ck porphyry
- ◆ unnamed diorite

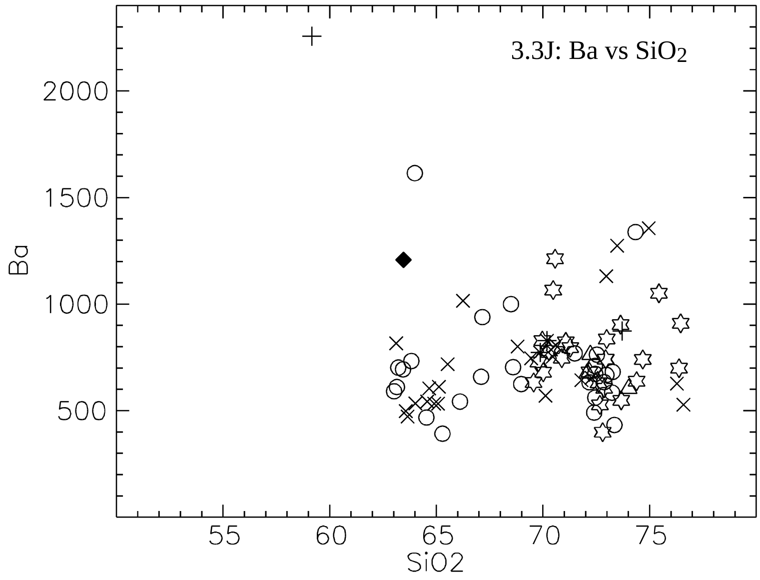






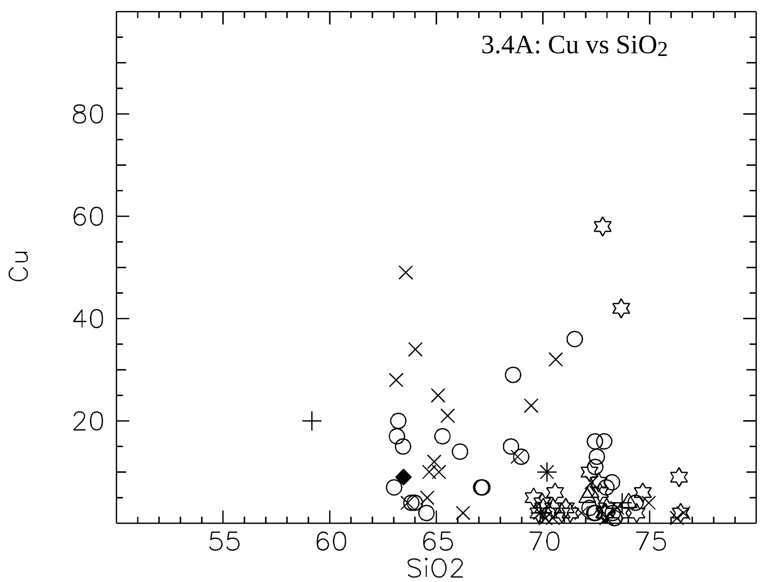

Legend
Treasure Volcanics
Mia Mia Volcanics
Newlands Volcanics
Arabulja Volcanics
Hatches Ck granophyr
Hatches Ck porphyry
unnamed diorite
3.3G: Rb-Ba-Sr
Rb
Ba
Sr
Strongly differentiated granite
Granite
Anomalous granite
Monzogranite
Tonalite
3.3H: Sr vs SiO2
Sr
200
400
600
SiO2
55
60
65
70
75
3.3I: Rb/Sr vs SiO2
Rb/Sr
10
20
30
SiO2
55
60
65
70
75

Legend



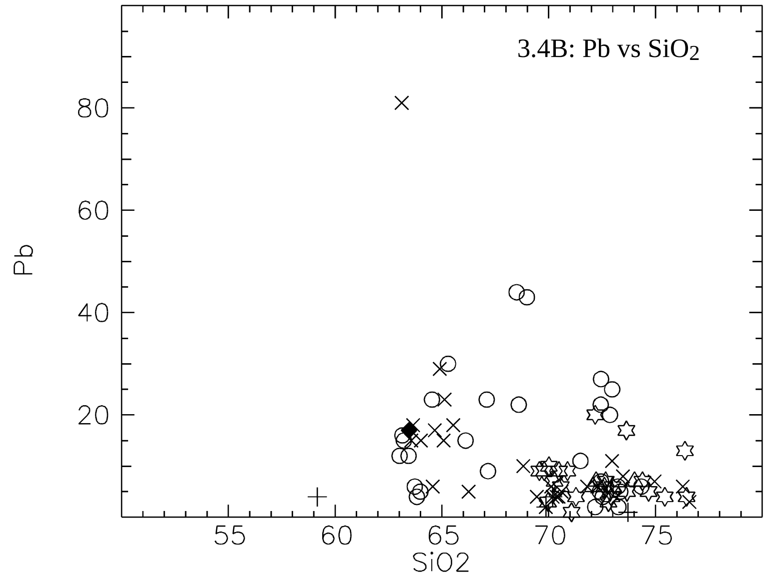
Treasure Volcanics
Mia Mia Volcanics
Newlands Volcanics
Arabulja Volcanics
Hatches Ck granophyr
Hatches Ck porphyry
unnamed diorite

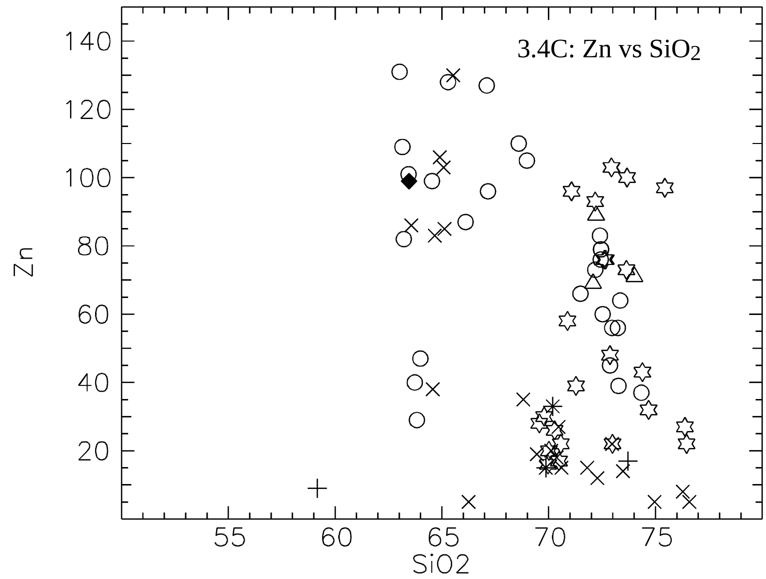
NO FLUORINE DATA AVAILABLE

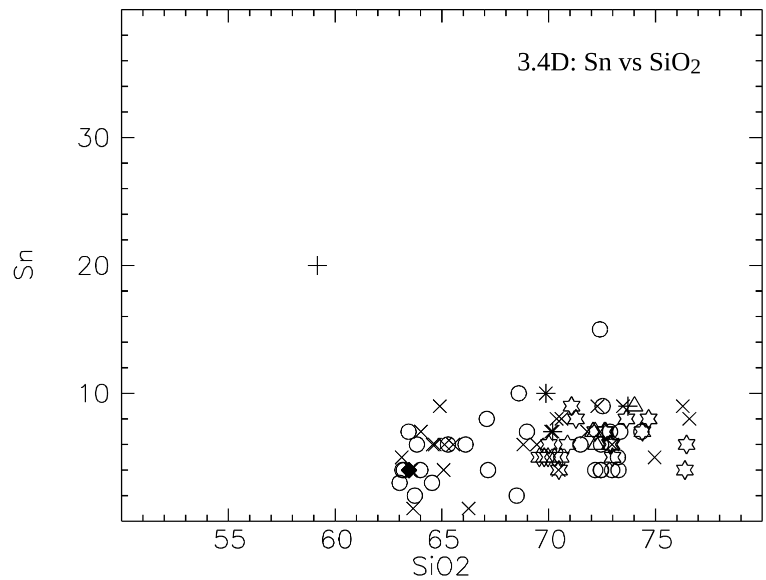


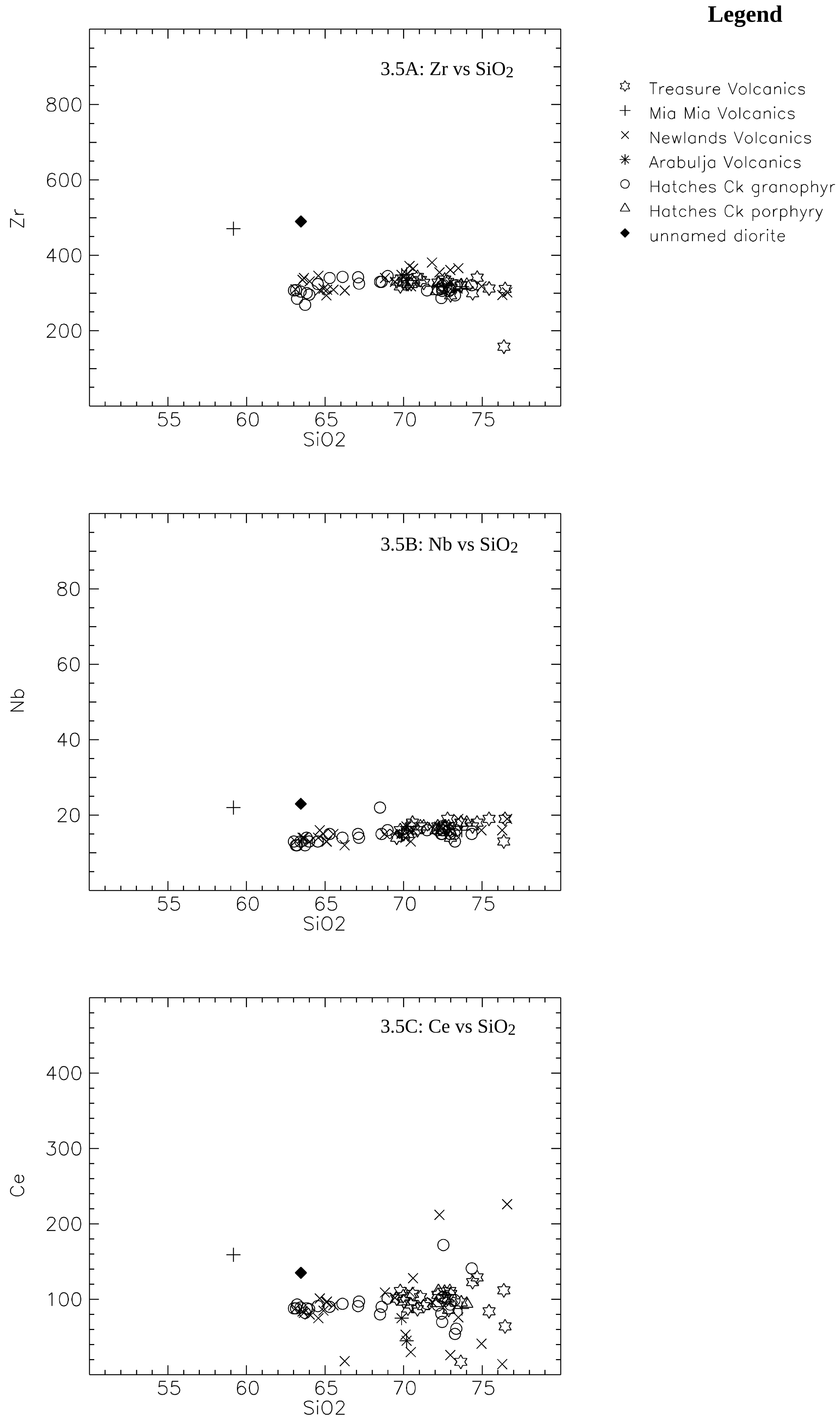
Legend

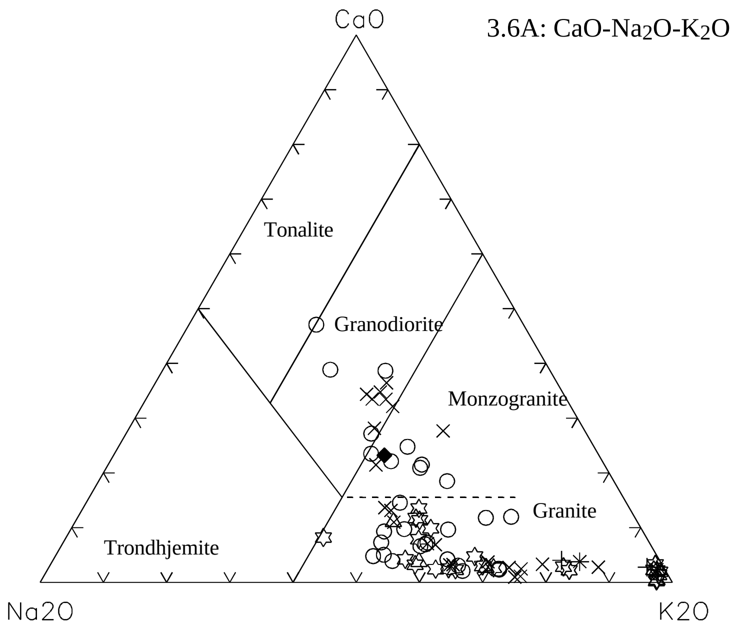
- Treasure Volcanics
- Mia Mia Volcanics
- Newlands Volcanics
- Arabulja Volcanics
- Hatches Ck granophyr
- Hatches Ck porphyry
- unnamed diorite





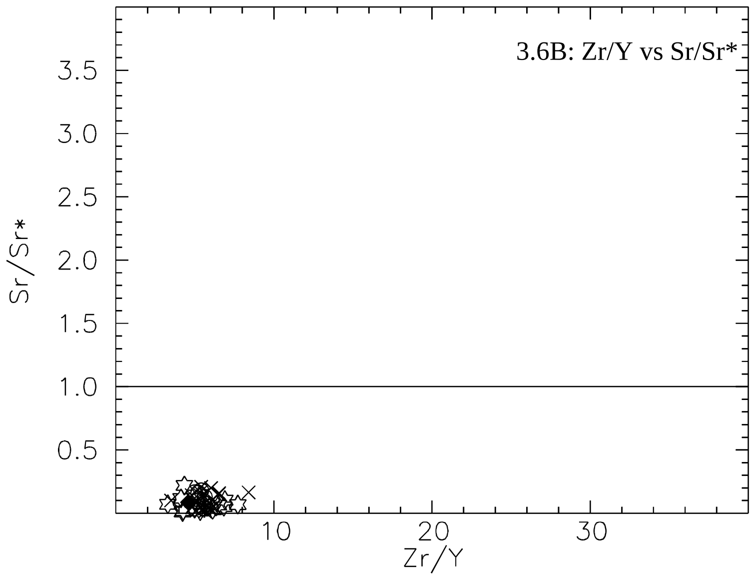


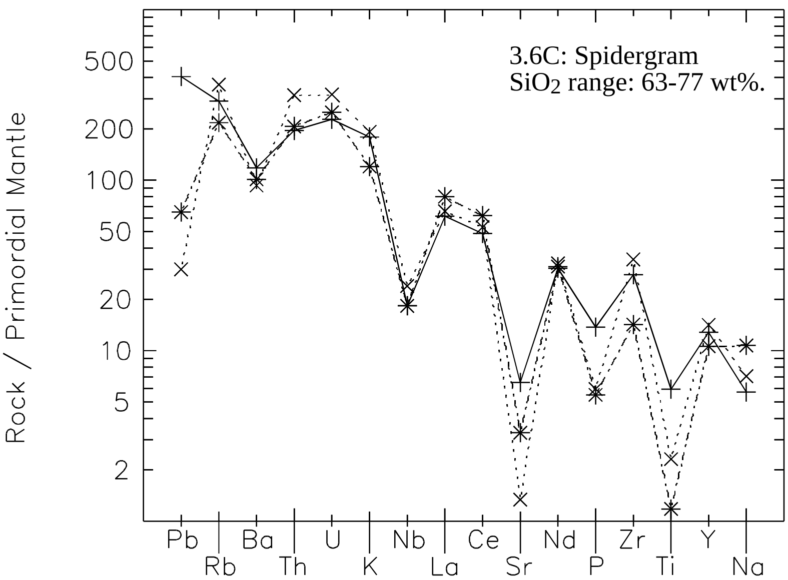

Legend
Treasure Volcanics
Mia Mia Volcanics
Newlands Volcanics
Arabulja Volcanics
Hatches Ck granophyr
Hatches Ck porphyry
unnamed diorite
3.5A: Zr vs SiO_2
Zr
SiO2
200
400
600
800
55
60
65
70
75
3.5B: Nb vs SiO_2
Nb
SiO2
20
40
60
80
55
60
65
70
75
3.5C: Ce vs SiO_2
Ce
SiO2
100
200
300
400
55
60
65
70
75



Legend

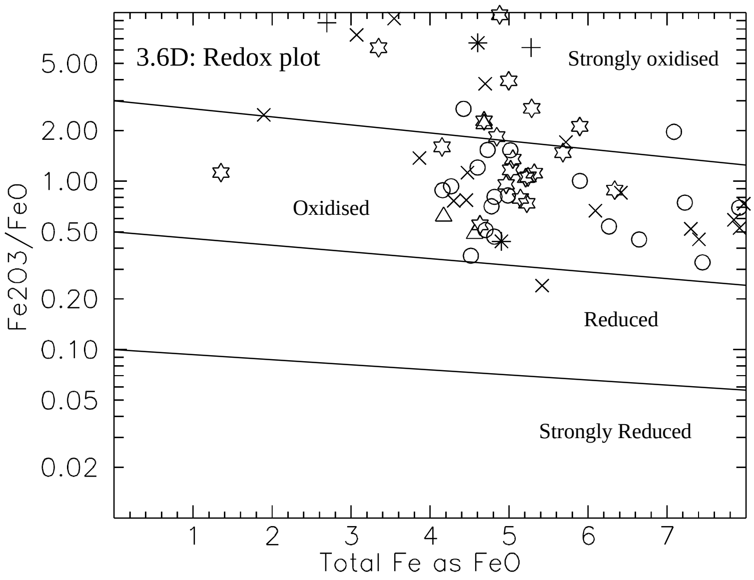
- Treasure Volcanics
- Mia Mia Volcanics
- Newlands Volcanics
- Arabulja Volcanics
- Hatches Ck granophyr
- Hatches Ck porphyry
- unnamed diorite

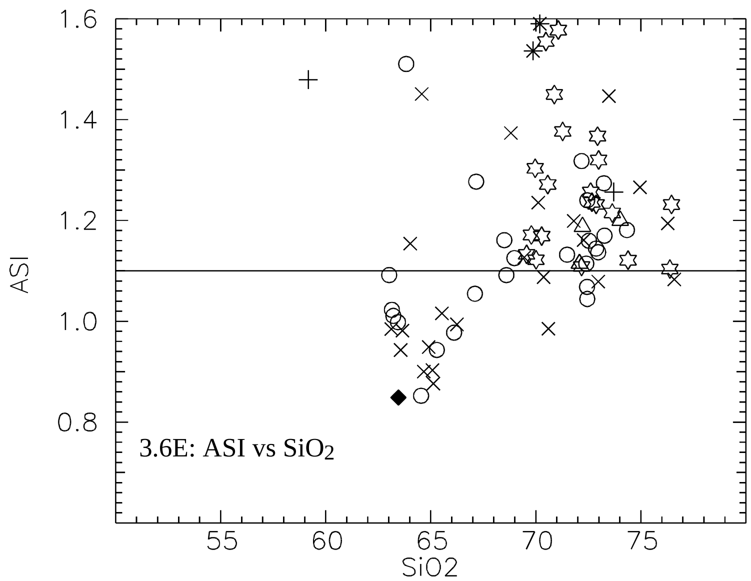


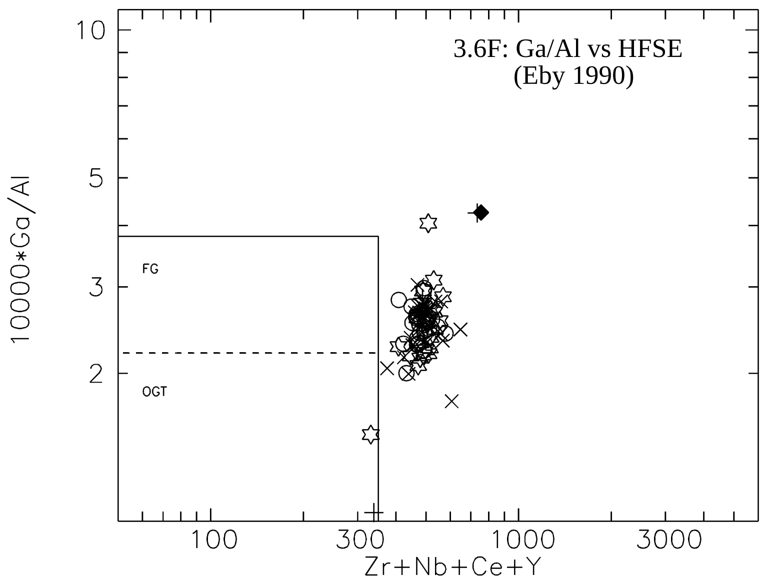


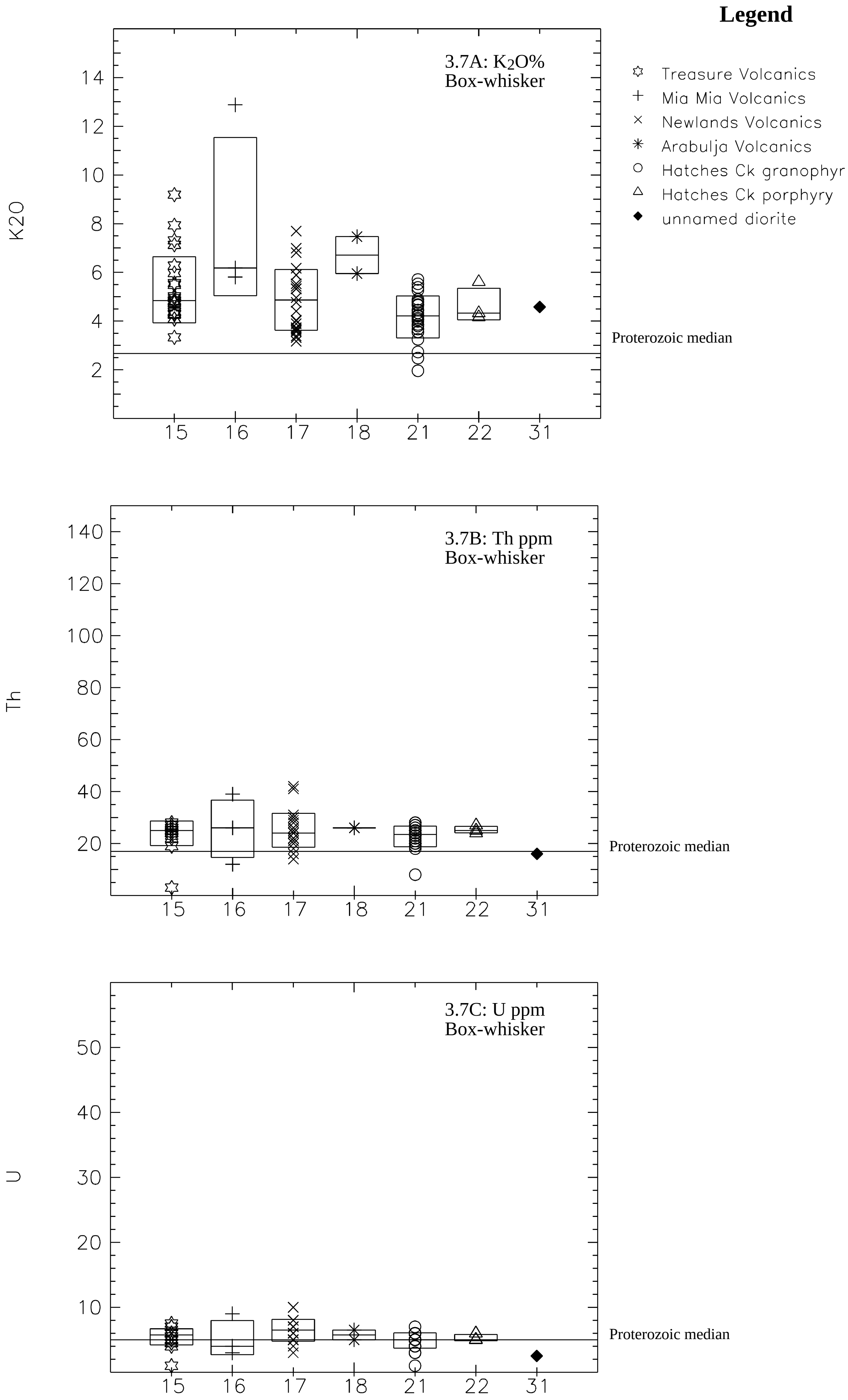
Legend

- Treasure Volcanics
- Mia Mia Volcanics
- Newlands Volcanics
- Arabulja Volcanics
- Hatches Ck granophyr
- Hatches Ck porphyry
- unnamed diorite








Legend
Treasure Volcanics
Mia Mia Volcanics
Newlands Volcanics
Arabulja Volcanics
Hatches Ck granophyr
Hatches Ck porphyry
unnamed diorite
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
15
16
17
18
21
22
31

Treasure Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.4	72.64	2.07	69.56	76.46	24
TiO2	0.53	0.55	0.09	0.25	0.64	24
Al2O3	12.26	12.15	0.67	11.21	13.4	24
Fe2O3	3.25	2.95	1.12	0.72	5.12	24
FeO	1.7	1.82	1.05	0.14	3.38	24
MnO	0.05	0.05	0.03	0.01	0.12	23
MgO	0.94	0.96	0.4	0.11	1.51	24
CaO	0.35	0.21	0.34	0.01	1.09	24
Na2O	1.77	2.26	1.35	0.08	4.18	24
K2O	5.28	4.84	1.39	3.33	9.19	24
P2O5	0.13	0.13	0.03	0.05	0.18	24
H2O+	1.33	1.13	0.57	0.65	2.51	24
H2O-	0.1	0.09	0.05	10	0.22	16
CO2	0.12	0.1	0.09	10	0.34	16
LOI	-	-	-	-	-	-
Ba	758.5	740.5	181.9	399	1212	24
Li	26.96	7	56.99	2	205	24
Rb	258.33	209	166.56	67	757	24
Sr	47.38	34	38.94	7	186	24
Pb	7.21	6	4.41		20	24
Th	23.92	25	4.82	3	28	24
U	5.46	5.75	1.26	1	7.5	24
Zr	316.58	325.5	35.84	158	343	24
Nb	16.63	17	1.64	13	19	24
Y	60	58	17.96	6	105	24
La	48.29	49.5	11.91	6	64	24
Ce	97.08	101.5	21.79	17	129	24
Pr	-	-	-	-	-	-
Nd	41.69	41	4.27	34	50	13
Sc	11.63	12	2.39	6	16	24
V	15.17	11.5	9.65	6	35	24
Cr	5.08	1.5	5.98		18	24
Mn	-	-	-	-	-	-
Co	6.81	7	2.14	3	11	16
Ni	2.88	2	2.17		8	24
Cu	14.63	3	35.11	2	167	24
Zn	54.83	41	36.86	16	152	24
Sn	19.17	6	37.5	4	160	24
W	4.97	5	1.35		7	16
Mo	2.5		1.53		6	24
Ga	15.71	16	4.31	2	26	24
As	1.78	2	0.96		4	24
S	0.01	01	0.01	01	0.04	8
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Mia Mia Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO_2	71.02	73.71	10.76	59.17	80.17	3
TiO_2	0.54	0.5	0.21	0.35	0.77	3
Al_2O_3	13.16	11.3	7.02	7.26	20.93	3
Fe_2O_3	4.17	4.59	1.57	2.44	5.49	3
FeO	0.4	0.28	0.3	0.19	0.74	3
MnO	0.02	0.01	0.02	0.01	0.04	3
MgO	0.49	0.65	0.39	0.05	0.77	3
CaO	0.22	0.19	0.08	0.17	0.31	3
Na_2O	0.52	0.21	0.58	0.16	1.19	3
K_2O	8.29	6.18	3.98	5.81	12.88	3
P_2O_5	0.15	0.15	0.06	0.09	0.2	3
H_2O+	0.94	0.77	0.82	0.22	1.84	3
H_2O-	0.07	10	0.03	10	0.1	3
CO_2	0.08	10	0.05	10	0.13	3
LOI	-	-	-	-	-	-
Ba	1499	1367	701.38	873	2257	3
Li	8.33	10	5.69	2	13	3
Rb	326.33	367	137.58	173	439	3
Sr	21	22	4.58	16	25	3
Pb	3	4	1.73		4	3
Th	25.67	26	13.5	12	39	3
U	5.33	4	3.21	3	9	3
Zr	321	317	148.04	175	471	3
Nb	15.33	16	7.02	8	22	3
Y	75.67	80	8.39	66	81	3
La	51.67	42	23.07	35	78	3
Ce	107.67	88	44.86	76	159	3
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	13.33	11	7.77	7	22	3
V	17.33	13	9.29	11	28	3
Cr	4	5	2.65		6	3
Mn	-	-	-	-	-	-
Co	5.33	5	1.53	4	7	3
Ni	1.33		0.58		2	3
Cu	8.67	4	9.87	2	20	3
Zn	10.67	9	5.69	6	17	3
Sn	10	9	9.54		20	3
W	9	7	5.29	5	15	3
Mo	1.5		-			3
Ga	22.67	17	22.05	4	47	3
As	1	1	-	1	1	3
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Newlands Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.69	69.13	4.32	63.12	76.59	24
TiO2	0.79	0.67	0.33	0.29	1.26	24
Al2O3	12.72	12.96	0.56	11.6	13.46	24
Fe2O3	2.97	2.74	1.29	1.05	7.38	24
FeO	3.06	3.58	1.88	0.14	5.43	24
MnO	0.08	0.05	0.05	0.01	0.21	24
MgO	1.19	1.16	0.7	0.19	3.1	24
CaO	1.41	0.75	1.36	0.08	3.56	24
Na2O	2.59	2.73	0.67	0.63	3.7	24
K2O	4.87	4.86	1.28	3.17	7.69	24
P2O5	0.19	0.18	0.08	0.04	0.31	24
H2O+	1.07	1.05	0.51	0.26	2.28	24
H2O-	0.09	0.08	0.06	10	0.31	22
CO2	0.2	0.11	0.21	10	0.85	22
LOI	-	-	-	-	-	-
Ba	731.5	648.5	241.7	472	1356	24
Li	9.83	10	4.24	1	19	24
Rb	177.75	172.5	63.75	54	339	24
Sr	68.79	51	43.5	24	165	24
Pb	13.42	7.5	15.94	3	81	24
Th	25.04	24	6.64	14	42	24
U	6.46	6.5	1.72	3	10	24
Zr	330.79	330.5	25.73	294	381	24
Nb	15.04	15	1.85	12	19	24
Y	57.38	59	12.81	23	91	24
La	44.75	43	29.15	7	131	24
Ce	88.38	86.5	50.64	14	226	24
Pr	-	-	-	-	-	-
Nd	40.5	41	22.17	9	94	20
Sc	12.83	13	5.55	2	21	24
V	35.29	22.5	25.19	6	73	24
Cr	5.58	6	3.05		10	24
Mn	-	-	-	-	-	-
Co	9.86	9	6.11		23	22
Ni	2.83	2	2.51		10	24
Cu	18.08	9	29.65		143	24
Zn	61.71	24.5	69.63	5	259	24
Sn	6.13	6	2.23		9	24
W	4.39	4.5	1.23		7	22
Mo	2.17		1.4		7	24
Ga	15.83	16.5	4.14	4	21	24
As	3.23	2	3.22		13	24
S	-	01	-	01	01	2
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Arabulja Volcanics

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	70.03	70.03	0.23	69.87	70.19	2
TiO2	0.59	0.59	0.01	0.58	0.6	2
Al2O3	12.67	12.67	0.17	12.55	12.79	2
Fe2O3	2.77	2.77	1.8	1.5	4.04	2
FeO	2.02	2.02	1.99	0.61	3.42	2
MnO	0.04	0.04	0.01	0.03	0.04	2
MgO	1.94	1.94	0.54	1.56	2.33	2
CaO	0.23	0.23	0.06	0.18	0.27	2
Na2O	0.5	0.5	0.57	0.1	0.91	2
K2O	6.71	6.71	1.07	5.95	7.47	2
P2O5	0.16	0.16	0.01	0.16	0.17	2
H2O+	2	2	0.44	1.69	2.31	2
H2O-	0.23	0.23	-	0.23	0.23	1
CO2	0.13	0.13	-	0.13	0.13	1
LOI	-	-	-	-	-	-
Ba	800.5	800.5	38.89	773	828	2
Li	20	20	11.31	12	28	2
Rb	228.5	228.5	31.82	206	251	2
Sr	30.5	30.5	3.54	28	33	2
Pb	3	3	1.41	2	4	2
Th	26	26	-	26	26	2
U	5.75	5.75	1.06	5	6.5	2
Zr	349	349	1.41	348	350	2
Nb	16	16	1.41	15	17	2
Y	62.5	62.5	0.71	62	63	2
La	27.5	27.5	12.02	19	36	2
Ce	60	60	21.21	45	75	2
Pr	-	-	-	-	-	-
Nd	30.5	30.5	10.61	23	38	2
Sc	11.5	11.5	2.12	10	13	2
V	24	24	1.41	23	25	2
Cr	9	9	-	9	9	2
Mn	-	-	-	-	-	-
Co	10	10	-	10	10	1
Ni	5	5	2.83	3	7	2
Cu	6	6	5.66	2	10	2
Zn	24	24	12.73	15	33	2
Sn	8.5	8.5	2.12	7	10	2
W	4	4	-	4	4	1
Mo	3.25	3.25	2.47		5	2
Ga	18	18	-	18	18	2
As	2.25	2.25	1.06	1.5	3	2
S	-	01	-	01	01	1
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Hatches Creek granophyres

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	68.81	68.79	4.09	63.02	74.34	28
TiO2	0.8	0.8	0.29	0.49	1.22	28
Al2O3	12.41	12.36	0.63	11.33	13.59	28
Fe2O3	2.93	3.01	1.06	1.2	5.22	28
FeO	3.52	3.31	1.5	0.12	6.04	28
MnO	0.09	0.07	0.05	0.04	0.19	27
MgO	1.31	1.22	0.77	0.06	3.14	28
CaO	1.26	0.78	1.19	0.17	4.58	28
Na2O	2.7	2.64	0.58	1.3	3.55	28
K2O	4.17	4.22	0.88	1.96	5.71	28
P2O5	0.2	0.19	0.06	0.07	0.34	28
H2O+	1.28	1.02	0.62	0.75	3.07	28
H2O-	0.13	0.1	0.1	10	0.45	28
CO2	0.16	0.13	0.15	10	0.66	28
LOI	-	-	-	-	-	-
Ba	836.68	670.5	708.92	392	4212	28
Li	9.93	9	6.29	1	29	27
Rb	150.04	156	42.08	7	216	28
Sr	63	43.5	40.1	10	153	28
Pb	15.04	12	11.55	2	44	28
Th	22.71	23.5	4.07	8	28	28
U	4.89	5	1.2	1	7	28
Zr	313.54	310.5	18.4	269	345	28
Nb	14.79	15	2.01	12	22	28
Y	61.14	60	8.92	25	81	28
La	46.29	44.5	12.85	28	92	28
Ce	92.79	90.5	21.53	54	172	28
Pr	-	-	-	-	-	-
Nd	43.89	44	2.62	41	50	9
Sc	15.74	15	3.35	11	23	27
V	35.2	24	26.93		84	28
Cr	16.82	5.5	63.02		338	28
Mn	-	-	-	-	-	-
Co	12.43	9.5	5.99	4	25	28
Ni	5.13	2	13.63		74	28
Cu	16.79	9.5	32.69		178	28
Zn	85.86	79	50.97	29	300	28
Sn	5.64	5.5	2.71		15	28
W	4.5	4	1.64		9	28
Mo	1.7		0.61		4	27
Ga	16.54	16	1.79	12	20	28
As	2.26	2	1.84		8	27
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Hatches Creek porphyries

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.77	72.22	1.08	72.08	74.02	3
TiO2	0.51	0.5	0.04	0.48	0.55	3
Al2O3	11.85	11.74	0.38	11.54	12.28	3
Fe2O3	2.11	1.6	0.98	1.5	3.24	3
FeO	2.38	2.59	0.82	1.48	3.08	3
MnO	0.04	0.04	0.02	0.03	0.06	3
MgO	0.83	0.88	0.22	0.59	1.03	3
CaO	0.47	0.28	0.38	0.22	0.91	3
Na2O	2.77	2.85	0.46	2.28	3.19	3
K2O	4.7	4.33	0.79	4.16	5.61	3
P2O5	0.14	0.14	0.03	0.11	0.16	3
H2O+	0.88	0.95	0.2	0.66	1.04	3
H2O-	0.08	10	0.06	10	0.15	3
CO2	0.07	10	0.03	10	0.1	3
LOI	-	-	-	-	-	-
Ba	680.67	676	80.1	603	763	3
Li	12	11	6.56	6	19	3
Rb	198.33	213	47.72	145	237	3
Sr	39.67	43	11.37	27	49	3
Pb	6.67	7	0.58	6	7	3
Th	25.33	25	1.53	24	27	3
U	5.33	5	0.58	5	6	3
Zr	317.33	322	10.79	305	325	3
Nb	16.67	16	1.15	16	18	3
Y	76	64	21.66	63	101	3
La	47.33	44	6.66	43	55	3
Ce	100	95	9.54	94	111	3
Pr	-	-	-	-	-	-
Nd	-	-	-	-	-	-
Sc	13.33	14	1.15	12	14	3
V	12	10	4.36	9	17	3
Cr	4	3	3.61		8	3
Mn	-	-	-	-	-	-
Co	8	8	1	7	9	3
Ni	1.33		0.58		2	3
Cu	5	5	1	4	6	3
Zn	76.33	71	11.02	69	89	3
Sn	7.33	7	1.53	6	9	3
W	5.67	7	2.31	3	7	3
Mo	1.5		-			3
Ga	14.67	15	0.58	14	15	3
As	0.83	1	0.29		1	3
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

unnamed diorite from northwest Tennant Creek

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	63.46	63.46	-	63.46	63.46	1
TiO2	1.08	1.08	-	1.08	1.08	1
Al2O3	12.45	12.45	-	12.45	12.45	1
Fe2O3	5.29	5.29	-	5.29	5.29	1
FeO	3.66	3.66	-	3.66	3.66	1
MnO	0.1	0.1	-	0.1	0.1	1
MgO	0.84	0.84	-	0.84	0.84	1
CaO	2.48	2.48	-	2.48	2.48	1
Na2O	3.63	3.63	-	3.63	3.63	1
K2O	4.58	4.58	-	4.58	4.58	1
P2O5	0.32	0.32	-	0.32	0.32	1
H2O+	-	-	-	-	-	-
H2O-	-	-	-	-	-	-
CO2	-	-	-	-	-	-
LOI	1.47	1.47	-	1.47	1.47	1
Ba	1208	1208	-	1208	1208	1
Li	8	8	-	8	8	1
Rb	113	113	-	113	113	1
Sr	106	106	-	106	106	1
Pb	17	17	-	17	17	1
Th	16	16	-	16	16	1
U	2.5	2.5	-	2.5	2.5	1
Zr	490	490	-	490	490	1
Nb	23	23	-	23	23	1
Y	107	107	-	107	107	1
La	62	62	-	62	62	1
Ce	135	135	-	135	135	1
Pr	18	18	-	18	18	1
Nd	59	59	-	59	59	1
Sc	20	20	-	20	20	1
V	10	10	-	10	10	1
Cr	2	2	-	2	2	1
Mn	804	804	-	804	804	1
Co	1		-			1
Ni	5	5	-	5	5	1
Cu	9	9	-	9	9	1
Zn	99	99	-	99	99	1
Sn	4	4	-	4	4	1
W	-	-	-	-	-	-
Mo	1		-			1
Ga	28	28	-	28	28	1
As	9.5	9.5	-	9.5	9.5	1
S	40	40	-	40	40	1
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	4	4	-	4	4	1
Ag	1	1	-	1	1	1
Bi	1		-			1
Hf	12	12	-	12	12	1
Ta	1		-			1
Cs	21	21	-	21	21	1
Ge	3.5	3.5	-	3.5	3.5	1
Se	0.5		-			1

4 DEVILS SUITE

4.1 Timing

1710 Ma

4.2 Individual Ages

Primary Ages:

1.	Elkedra Granite	1720 ± 6 Ma, SHRIMP
2.	Devils Marbles Granite	1711 ± 11 Ma, SHRIMP
3.	Warrego Granite	1677 ± 4 Ma, Ar-Ar
4.	Warrego Granite	1662 ± 20 Ma, Rb-Sr, initial $^{87}Sr/^{86}Sr$ 0.702 ± 0.002
5.	Warrego Granite	1650 Ma (imprecise), SHRIMP

Sources: Black 1977; Compston 1994, 1995; OZCHRON

4.3 Regional Setting

The Elkedra Suite was emplaced late in the history of the Tennant Creek and Davenport Provinces between about 1720 to 1680 Ma. The suite postdates any known sedimentation and is compositionally very similar to the Jinka Suite of the Arunta Inlier. The suite is possibly related to a mantle 'hot spot', as the ages of the plutons increase in a southeasterly direction. The suite is also coeval with the intrusions of the lamprophyre suites (Duggan and Jaques 1996) and Gosse River East syenite in the Tennant Creek Province..

4.4 Summary

The suite is a fractionated I-(granodiorite) type suite, but is highly felsic. It has a limited SiO_2 range and has abundant evidence of late alteration, both within the granite and in the surrounding country rocks. Although Stolz and Morrison (1994) considered the Warrego Granite to be genetically related to the Au-Cu-Bi mineralisation at the Warrego Mine, Wedekind and Love (1990) argued that the Warrego deposit has been metamorphosed by the Warrego Granite. Elsewhere, both structural and isotopic evidence argue for the Au-Cu mineralisation of the Tennant Creek Province being older than the emplacement of this suite, which has also caused considerable isotopic disturbance of the ore deposits in the northwest of the Tennant Creek Province (Black 1977; Compston 1994; Compston 1995).

4.5 Potential

This suite shows abundant evidence of late magmatic fluids which have affected both granite and country rocks. However the high and limited silica range downgrades the potential of this suite, as does the presence of fluorite. The suite is considered to have limited potential for Sn (noted in stream sediment surveys), but may have some potential for W. Also, as pointed out by Hoatson and Cruickshank (1985) the limited amount of carbonates in the adjacent host rocks limits the potential for the development of W skarn deposits. The suite is geochemically similar to 1710 Ma suites in the Arunta Inlier which are related to W mineralisation (and minor Sn, Cu and Mo).

Cu:	**low**
Au:	**low**
Pb/Zn:	**low**
Sn:	**low to moderate**
Mo/W:	**moderate to high**
Confidence Level:	**321**

4.6 Descriptive Data

Location: Western and eastern edges of the Tennant Creek and Davenport Provinces.

Dimensions and area: The suite has a strike length of 600 km and may continue into the Arunta Inlier. The actual total outcrop of the individual plutons is at least 580 km^2.

4.7 Intrusives

Component plutons: Devils Marbles Granite, Warrego Granite, Elkedra Granite, unnamed granite in the Davenport Province 75 km southeast of the Devils Marbles on the southern Davenport Range 1:100 000 Sheet area, and unnamed granite in the northeastern corner of the Hatches 1:100 000 Sheet area.

Form: Round to elliptical intrusions which cross-cut folded strata. Aeromagnetic data indicate the intrusions extend beneath Cainozoic cover.

Metamorphism and Deformation: The members of this suite post-date the main deformation and metamorphic events. Specifically: Warrego Granite - Donnellan *et al.* (in prep.) note that large muscovite books show no sign of deformation. Devils Marbles Granite - post-dates the main metamorphism and deformation. Elkedra Granite - no evidence of deformation or metamorphism.

Dominant intrusive rock types: The suite is dominantly a massive coarse to medium-grained megacrystic biotite-muscovite-two-feldspar granite. Minor hornblende-bearing phases are reported in the Warrego Granite. Specifically: Warrego Granite consists of three major granite types: coarse-grained muscovite granite, fine-grained granite with dark green muscovite and minor hornblende, and massive pink to red medium to coarse-grained aplitic granite. Some muscovite-bearing granodiorite also recorded (Donnellan *et al.*, in prep). Devils Marbles Granite - pink medium to coarse-grained, muscovite-biotite granite. Elkedra Granite - pink even-grained to slightly megacrystic medium to coarse-grained leucogranite. Unnamed Granite (Davenport Range 1:100 000 sheet area) - massive, medium to coarse-grained, muscovite-biotite granite. Unnamed Granite (Hatches 1:100 000 sheet area) - pink, fine to coarse-grained muscovite and biotite granite.

Colour: Where documented, pink appears to be the dominant colour. Specifically: Warrego Granite - pink euhedral plagioclase with grey orthoclase and quartz. Elkedra Granite - pink.

Veins, Pegmatites, Aplites, Greisens: There is abundant evidence of late magmatic fluids in the form of greisens, quartz veins and late pegmatites. Specifically: Warrego Granite, quartz veins striking north-south cut the granite; aplite dykes recorded (Mendum and Tonkin 1976), relatively abundant pegmatitic segregations noted (Donnellan *et al.*, in prep.). Devils Marbles Granite - greisens intrude the adjacent country rock; quartz veins containing wolframite cut the granite and greisen. Elkedra Granite - W occurs in a quartz-tourmaline vein surrounded by greisen, quartz-tourmaline pegmatites. Unnamed Granite (Davenport Range 1:100 000 sheet area) - greisens composed of quartz+muscovite+hematite assumed to emanate from the granite, and the granite is cut by thin pegmatite veins and quartz veinlets.

Distinctive mineralogical characteristics: The suite is dominated by biotite and muscovite with rare hornblende. Some corundum and fluorite reported as accessories. *Specifically:* Warrego Granite - quartz, feldspar, muscovite; Mendum and Tonkin (1976) report hornblende, Donnellan *et al.* (in prep.) record corundum, apatite, zircon, and coarse muscovite books up to 1 cm wide. Devils Marbles Granite - quartz, feldspar, muscovite, biotite, and fluorite. Elkedra Granite - quartz, microcline, oligoclase and biotite. Unnamed Granites (Davenport Range and Hatches 1:100 000 sheet areas) - biotite, muscovite, quartz, two feldspars.

Xenoliths: Recorded in some intrusions as being abundant, but where described seem to be composed of country rock. They also seem more abundant adjacent to the margins of the intrusions (Donnellan *et al.*, in prep.).

Breccias: Few recorded. Specifically: The unnamed granite on the Davenport Range 1:100 000 sheet area is reported to be brecciated and faulted at one locality, but it is not stated as to whether this is related to magmatism or post intrusion deformation (Stewart and Blake 1984, 1986).

Alteration in the granite: Abundant evidence of alteration in the form of chloritisation of biotite and sericitisation of feldspars. *Specifically:* Warrego Granite - feldspars extensively sericitised, chlorite replaces biotite. Devils Marbles Granite - chlorite and epidote are present as alteration minerals. Elkedra Granite - biotite altered to chlorite.

4.8 Extrusives

No comagmatic volcanics recorded.

4.9 Country Rock

Contact metamorphism: Contact aureoles at least 100 m wide have been reported around most plutons. Donnellan *et al*., (in prep.) specifically note that these aureoles are a means of distinguishing the Warrego Granite from the older members of the Tennant Creek Supersuite. *Specifically:* Warrego Granite - quartz-biotite contact aureole recorded (Donnellan *et al.,* in prep.). The granite also metamorphoses the Warrego Deposit (Wedekind and Love 1990). Elkedra Granite - spotted hornfelses and schist within 100 m of contact. Devils Marbles Granite - Dallwitz in Sullivan (1952) records possible cordierite after biotite in metaclaystones, epidote-garnet hornfelses also recorded. Unnamed granite on the Davenport Range 1:100 000 sheet area - metamorphism up to hornblende hornfels facies recorded (Stewart and Blake 1986).

Reaction with country rock: Extensive reaction with country rock commonly recorded, usually involving greisenisation and introduction of tourmaline. Blake *et al.* (1987) noted that the granites of this suite do not have magnetic contact aureoles in the Davenport Province. *Specifically:* Warrego Granite - greisenisation recorded in the surrounding country rock. Donnellan *et al.* (in prep.) also note a zone up to 400 m wide of intense high temperature hydrothermal alteration. Devils Marbles Granite - Dallwitz in Sullivan (1952) noted that metasomatism involving the formation of tourmaline, hematite and much less commonly topaz is very conspicuous and suggests that the metasomatic fluid involved the introduction of F.

Units the granite intrudes: Mainly lower parts of the Hatches Creek Group and the Flynn Subgroup. *Specifically:* Warrego Granite - sediments of the Flynn Subgroup. Devils Marbles Granite - Kurinelli, Taragan and lower parts of the Unimbra Sandstone. Elkedra Granite - Rooneys Formation,

Dominant rock types: Sandstones, felsic and mafic intrusives and extrusives.

Potential hosts: The dominant metal associated with this suite is W, and the sandstones and the granites themselves seem to be the best hosts. Dallwitz in Sullivan (1952) recorded that the mineralisation is preferentially hosted by claystones and siltstones within the sandstones. As noted by Hoatson and Cruickshank (1985) the near-absence of carbonates in the country rocks severely limits the potential for W-skarn deposits.

4.10 Mineralisation

What little mineralisation there is associated with this suite is dominantly W. Specifically: Elkedra Granite - hosts the Juggler W prospect, which is a quartz vein W deposit. The Wauchope W field has been related to the Devils Marbles Granite, but its metal association (Cu, Mo, Bi etc., Sullivan 1952) could suggest that it may be associated with the Treasure Suite. Mineralisation occurs in quartz-tourmaline veins, which are surrounded by extensive kaolinite and sericite alteration. Cassiterite was ubiquitous from stream sediments draining the Wauchope W field (Hoatson and Cruickshank 1985; Cruickshank *et al*. 1993), although cassiterite was recognised only at one deposit and only minor Sn was recorded from the treatment plant (Sullivan 1952). Cassiterite-bearing quartz veins are recorded at the Martins Gully prospect within the Wauchope W mine area. In 1980-81 about 11 t of Sn concentrate was extracted from the alluvials derived from this vein system (Ferenczi, written communication).

As the granites of the Treasure Suite are so oxidised, it is highly probable that no significant vein Sn mineralisation will be found. In the Pine Creek Inlier, vein Sn deposits were located only in those granites that were both peraluminous and reduced. Those granites that were peraluminous and oxidised only had alluvial Sn deposits associated with them (Stuart-Smith *et al.* 1993).

4.11 Geochemical Data

Data source: The number of samples used in this review totalled 34. The samples were collected as part of (i) the BMR regional geochemical sampling program in the 1970’s investigating both the ironstones and the silicate rocks, (ii) the BMR regional mapping program in the Davenport province in the early 1980’s, and (iii) AGSO analyses of samples dated by Compston (1994). All data used are stored within OZCHEM.

Data quality: The data quality are good and all were done within the AGSO geochemical laboratories.

Are the data representative? Reasonably. However, there do not appear to be any samples of the hornblende-bearing phase specifically mentioned by Mendum and Tonkin (1976).

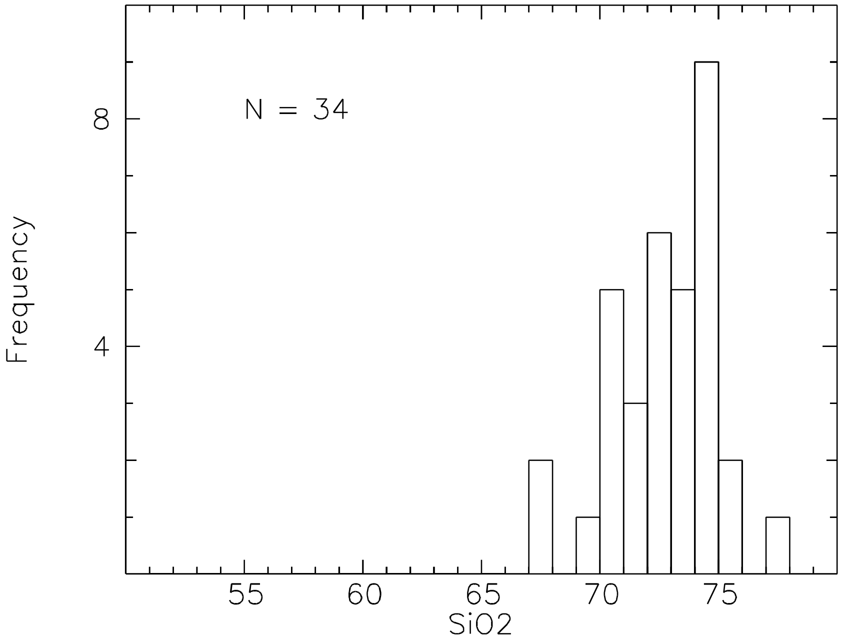


Fig. 4.1 Histogram of SiO_2 values for the Devils Suite

Are the data adequate? There are no F values, nor have all samples been analysed for both Fe^{3+} and Fe^{2+}.

SiO_2 range (Fig. 4.1): The most mafic sample collected has 67 wt% SiO_2. The majority of samples have >70 wt% SiO_2 which is as expected from the descriptions of the dominant rock types from this suite.

Alteration (Figs. 4.1 & 4.2):

- ***SiO_2:*** Some silicification evident.
- ***K_2O/Na_2O:*** The samples have been affected only by K-alteration. There is no evidence of the Na-alteration found in the ~1850 Ma Tennant Creek Supersuite.
- ***Th/U:*** Some loss of U is apparent in altered samples.
- ***$Fe_2O_3/(FeO+Fe_2O_3)$:*** Some samples appear to have been abnormally oxidised, which may be related to weathering.

Fractionation Plots (Fig. 4.3):

- ***Rb:*** Increases steeply with increasing SiO_2.
- ***U:*** Increases exponentially with increasing SiO_2.
- ***Y:*** Increases with increasing SiO_2.
- ***P_2O_5:*** Decreases in most suites, but late samples of the Elkedra Granite show an increase.
- ***Th:*** High values and variable trends.
- ***K/Rb:*** Decreases with increasing SiO_2.
- ***Rb-Ba-Sr:*** Many samples plot in the strongly differentiated field.
- ***Sr:*** Values are very low and decrease with increasing SiO_2.
- ***Rb/Sr:*** Increases with increasing SiO_2, but scattered.
- ***Ba:*** An apparent decrease with increasing SiO_2.
- ***F:*** No data available.

Metals (Fig. 4.4):

- ***Cu:*** Some reasonably high values.
- ***Pb:*** Some high values.
- ***Zn:*** Moderate values.
- ***Sn:*** Increases strongly with increasing SiO_2, which probably explains why so much cassiterite was found in streams draining the Wauchope W field.

High field strength elements (Fig. 4.5):

- ***Zr:*** Decreases with increasing SiO_2.
- ***Nb:*** Increases rapidly with increasing SiO_2.
- ***Ce:*** Decreases with increasing SiO_2.

Classification (Fig. 4.6):

- ***The CaO/Na$_2$O/K$_2$O plot of White, quoted in Sheraton and Simons (1992):*** Most samples plot in the granite field.
- ***Zr/Y vs Sr/Sr*:*** All samples are Sr-depleted.
- ***Spidergram:*** Typical Proterozoic Sr-depleted, Y-undepleted pattern.
- ***Oxidation plot of Champion and Heinemann (1994):*** Most samples plot in the oxidised field, to some extent confirming that these are not S-types.
- ***ASI:*** Samples become increasingly peraluminous with increasing SiO_2 reflecting the muscovite and corundum minerals noted in the rocks. This however, does not mean that the rock is S-type (c.f., Stolz and Morrison 1994). It has become more peraluminous with extreme fractionation. The observation of hornblende-bearing phases by Mendum and Tonkin (1976) confirms that the early members of this suite were definitely I-type.
- ***A-type plot of Eby (1990):*** The samples straddle the fractionated and A-type granite fields derived for Palaeozoic granites.

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

Australian Proterozoic granite type: Sybella.

4.12 Geophysical Signature

Radiometrics (Fig. 4.7): The means of all samples plot above the Proterozoic median and would appear white in a RGB image.

Gravity: Blake *et al.* (1987) noted that the granites intruding the Hatches Creek Group have lower densities than those predating it. The Devils Marbles Granite is interpreted to be a steep-sided pluton extending to at least 15 km (Blake *et al*. 1987). On the regional gravity data the members of this suite are mainly lows.

Magnetics: The granites are magnetic lows and Blake *et al.* (1987) noted that the aureoles are non-magnetic.

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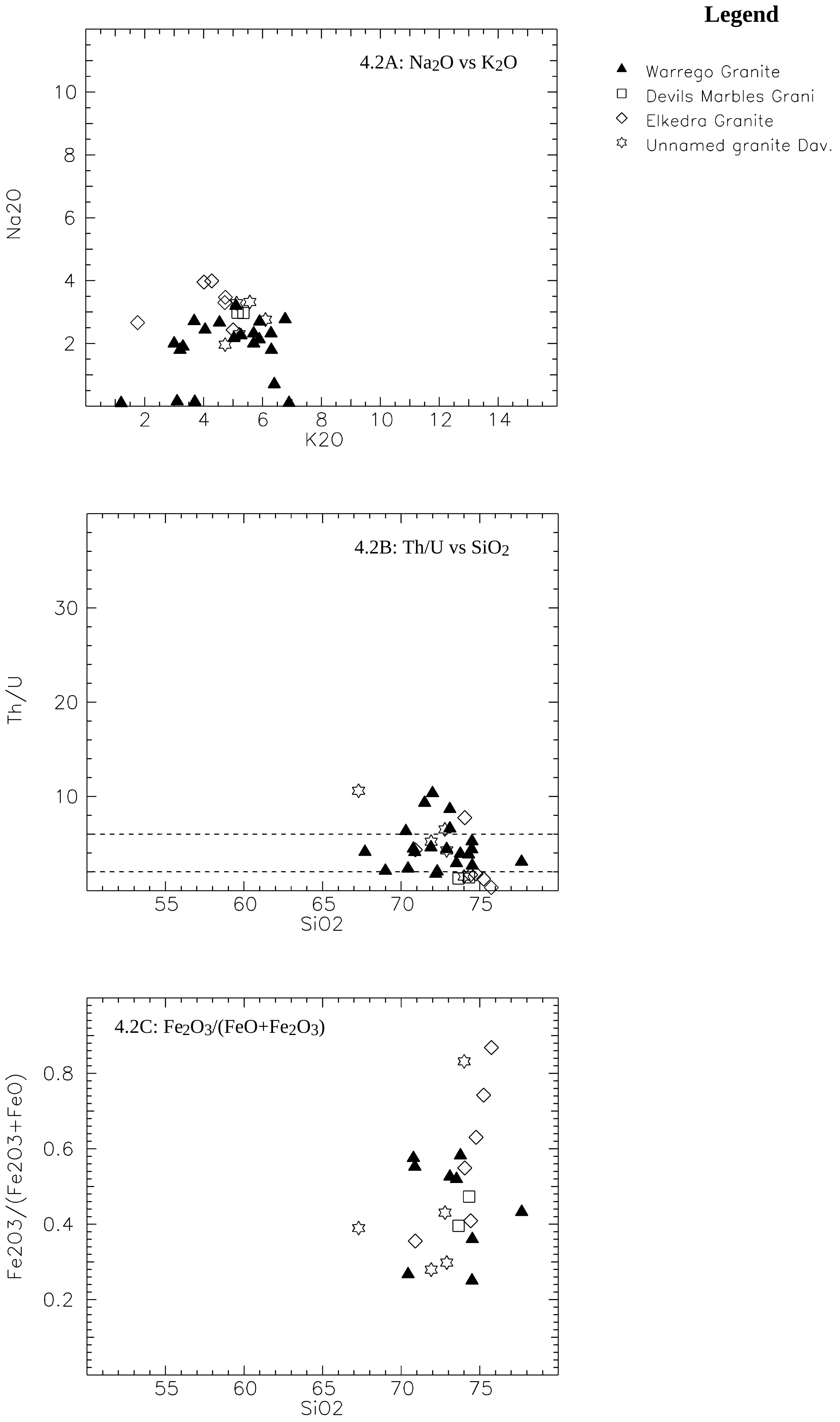
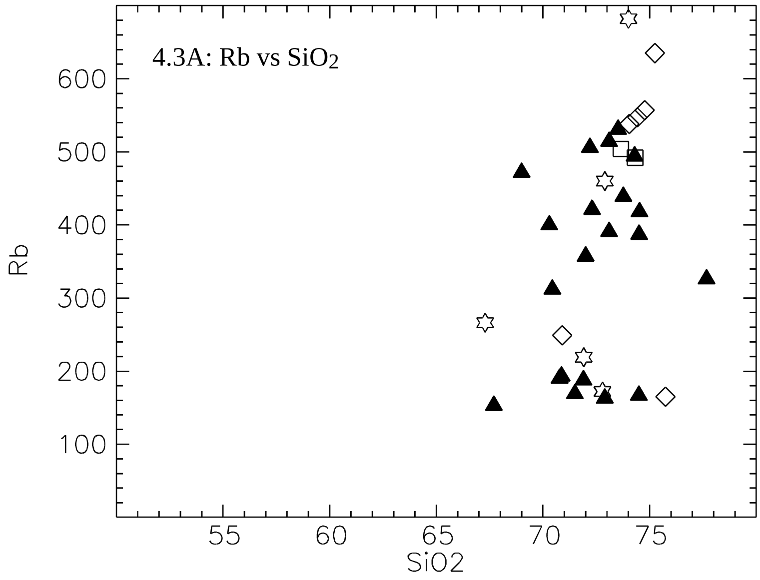
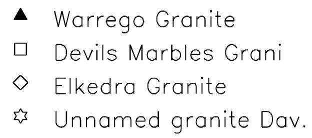
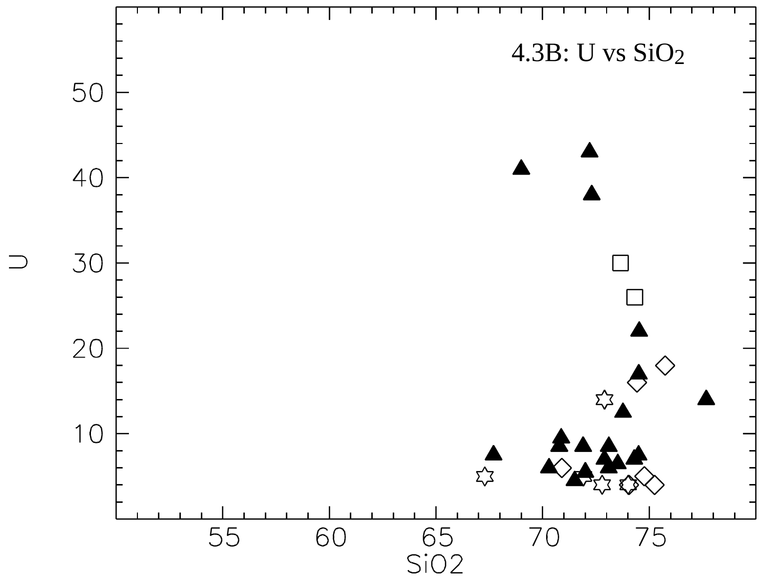
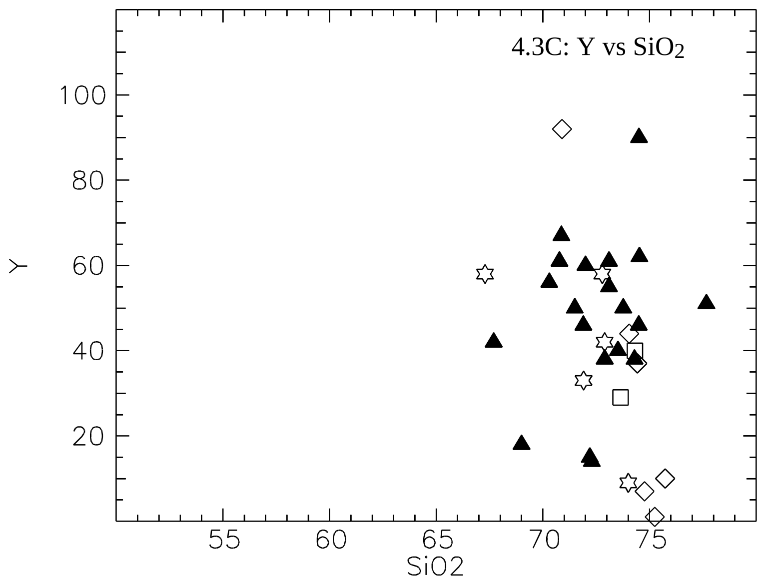

Legend
Warrego Granite
Devils Marbles Grani
Elkedra Granite
Unnamed granite Dav.
4.2A: Na_2O vs K_2O
Na2O
K2O
4.2B: Th/U vs SiO_2
Th/U
SiO2
4.2C: $Fe_2O_3/(FeO+Fe_2O_3)$
Fe2O3/(Fe2O3+FeO)
SiO2


4.3A: Rb vs SiO_2
Rb
SiO2
600
500
400
300
200
100
55
60
65
70
75

Legend

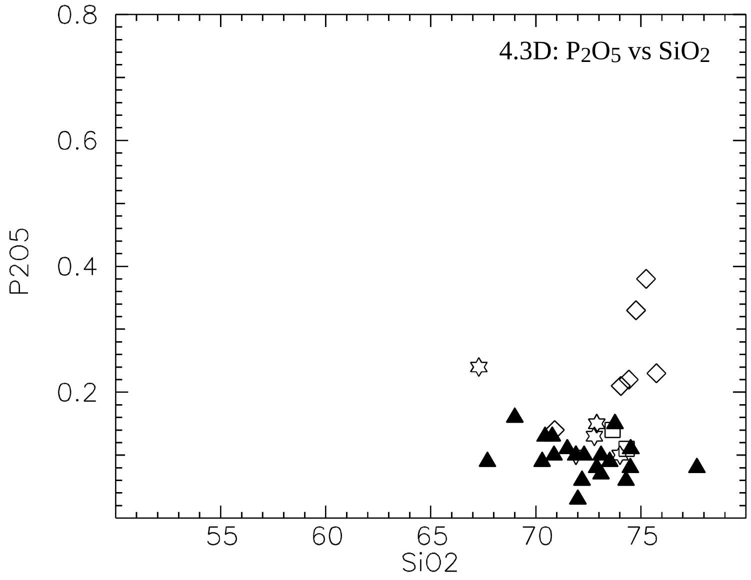

Warrego Granite
Devils Marbles Grani
Elkedra Granite
Unnamed granite Dav.

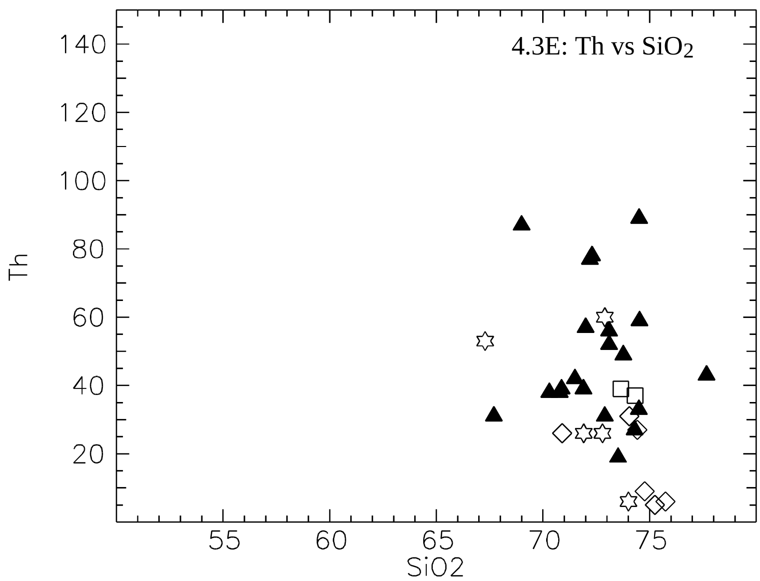

4.3B: U vs SiO_2
U
SiO2
50
40
30
20
10
55
60
65
70
75

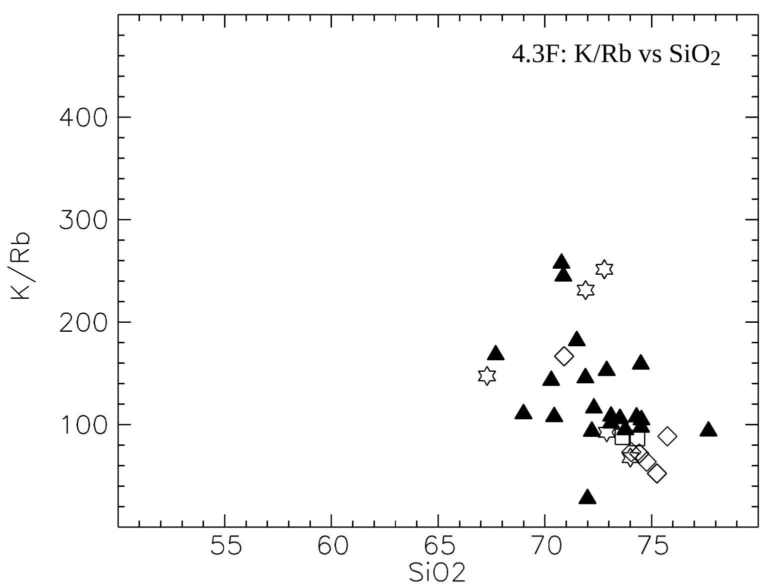

4.3C: Y vs SiO_2
Y
SiO2
100
80
60
40
20
55
60
65
70
75

Legend

- ▲ Warrego Granite
- □ Devils Marbles Grani
- ◇ Elkedra Granite
- ✡ Unnamed granite Dav.

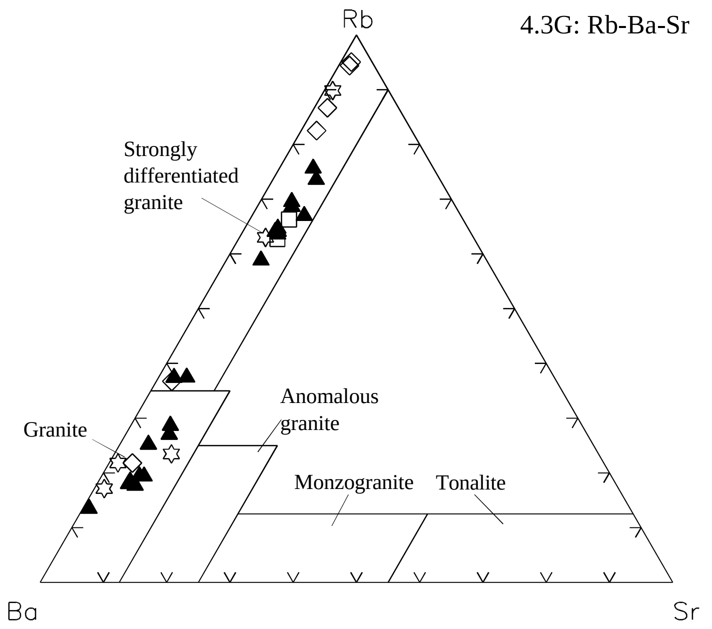


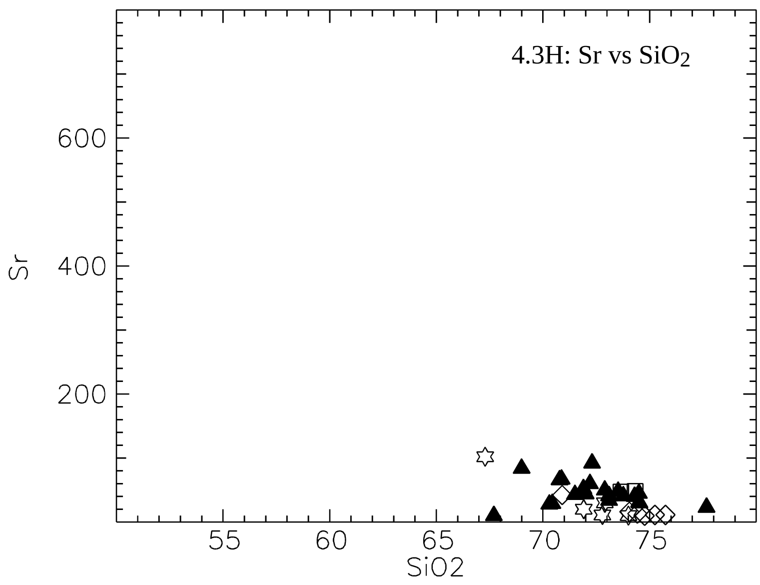


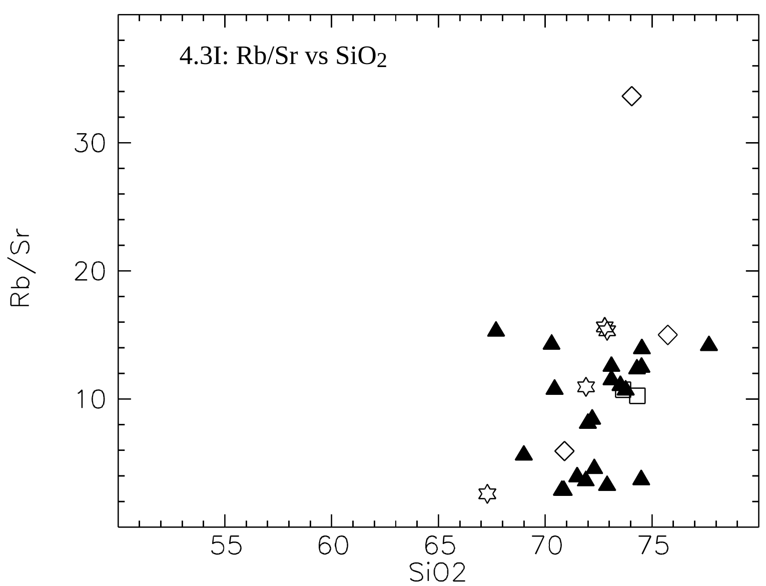


Legend

- ▲ Warrego Granite
- □ Devils Marbles Grani
- ◇ Elkedra Granite
- ✡ Unnamed granite Dav.

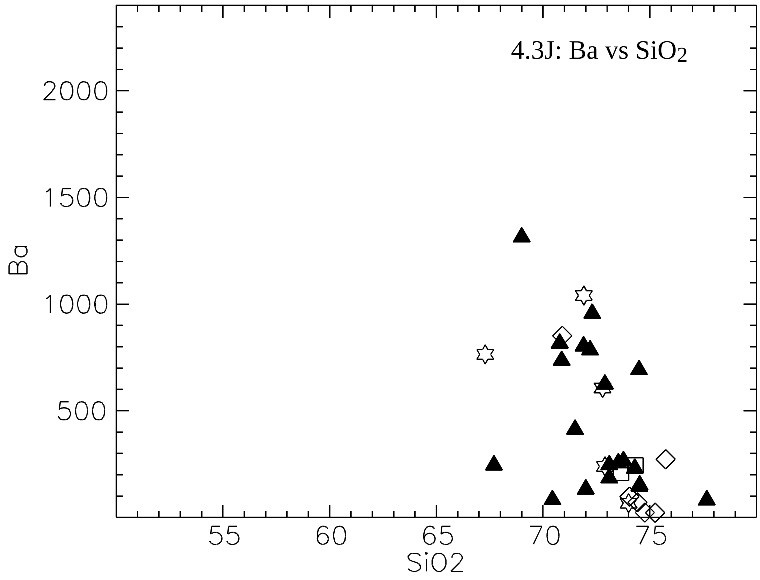






Legend

▲ Warrego Granite
□ Devils Marbles Grani
◇ Elkedra Granite
✡ Unnamed granite Dav.



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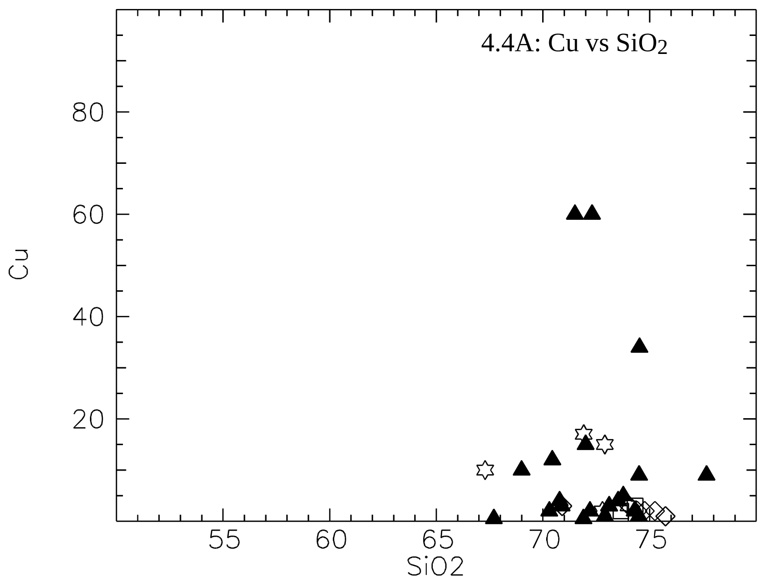
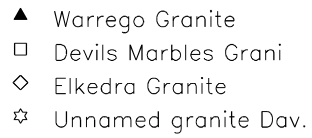
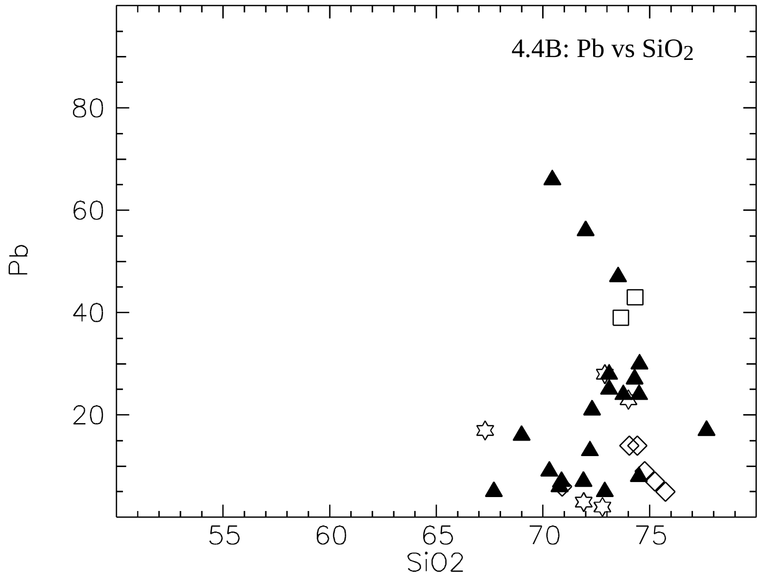
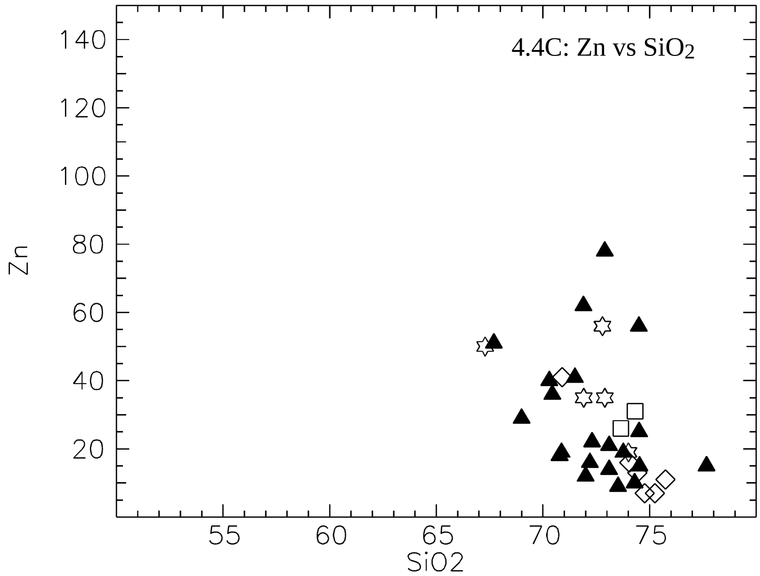
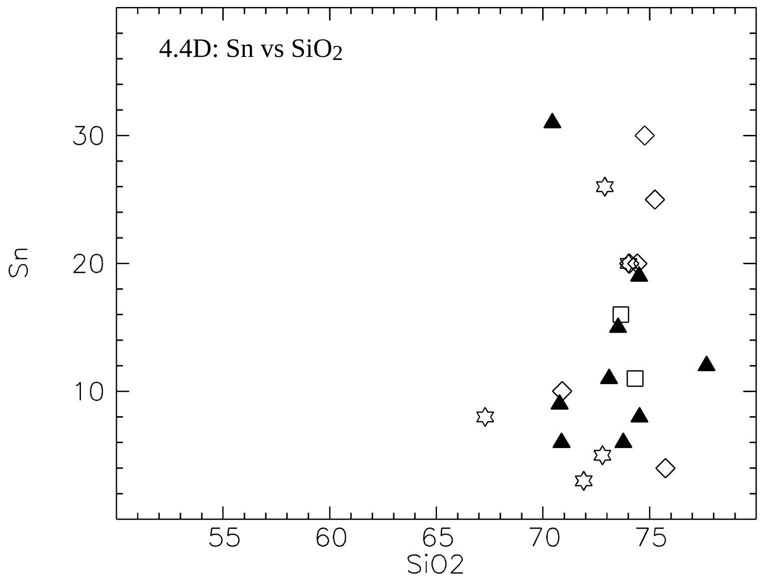


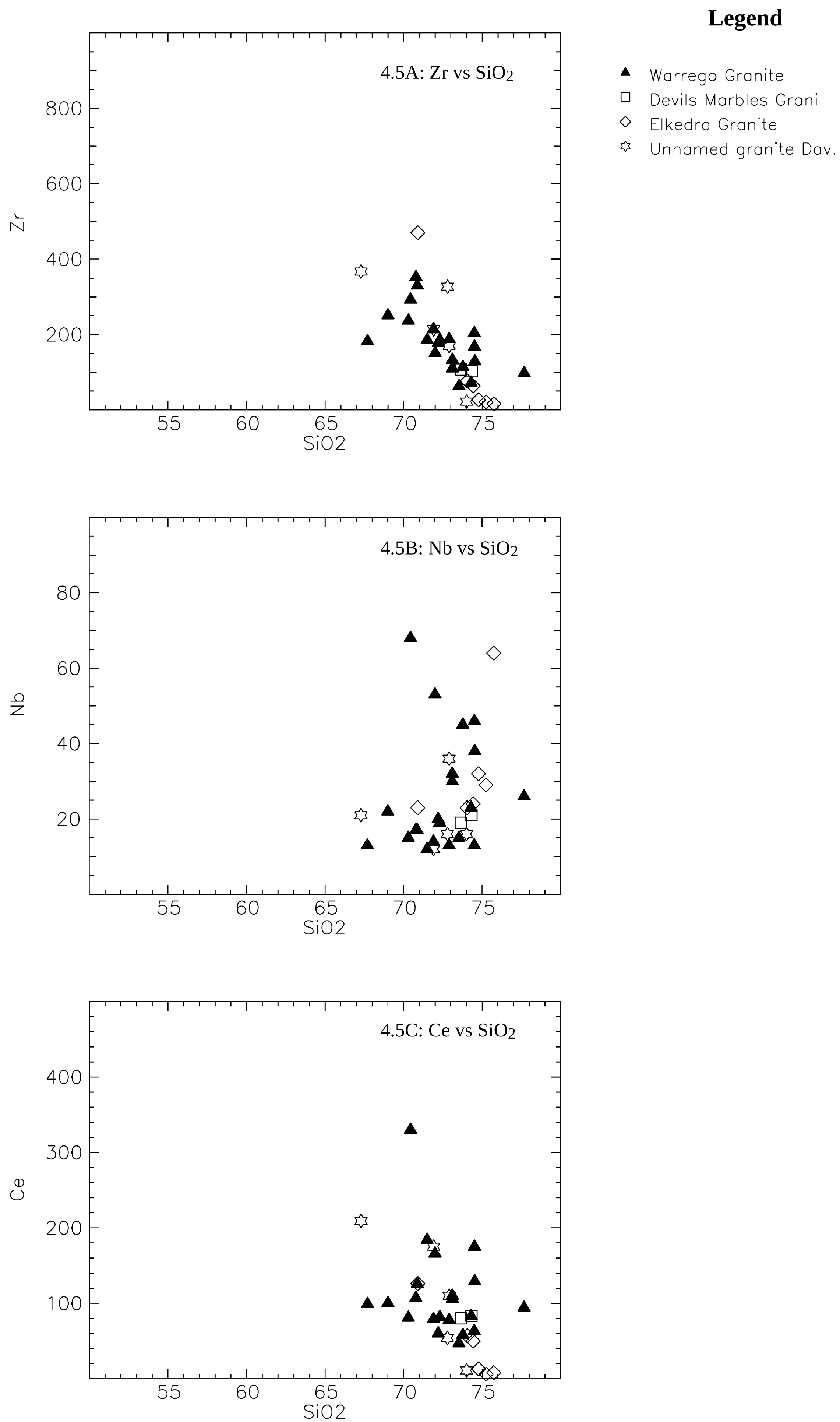
Legend


Warrego Granite
Devils Marbles Grani
Elkedra Granite
Unnamed granite Dav.

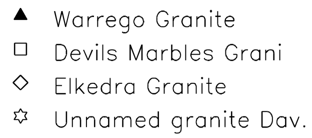

4.4B: Pb vs SiO2
Pb
80
60
40
20
55
60
65
70
75
SiO2

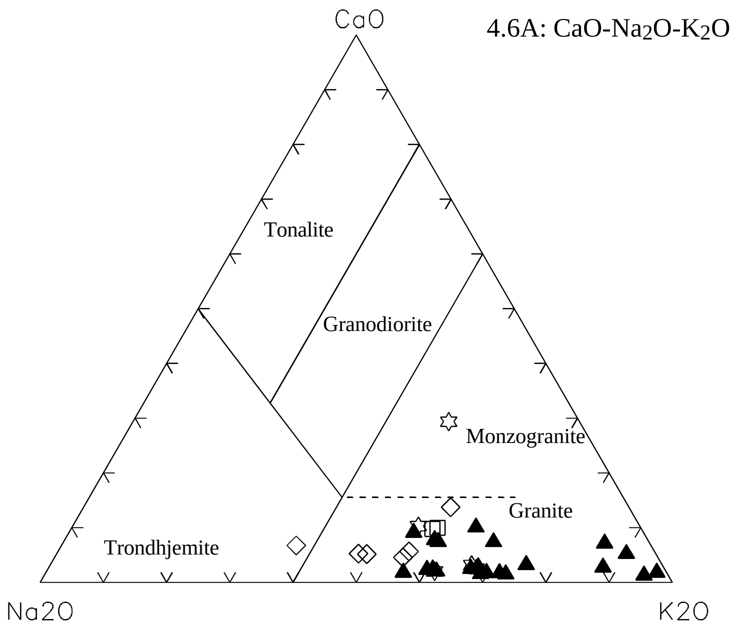

4.4C: Zn vs SiO2
Zn
140
120
100
80
60
40
20
55
60
65
70
75
SiO2

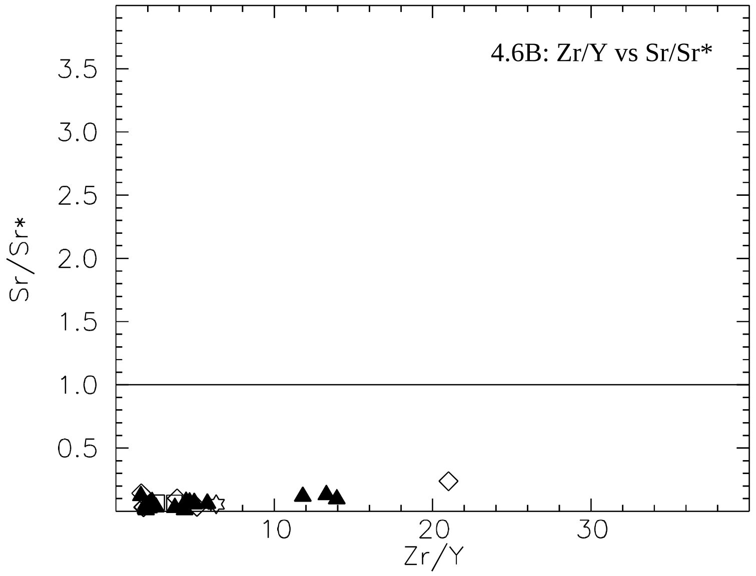

4.4D: Sn vs SiO2
Sn
30
20
10
55
60
65
70
75
SiO2

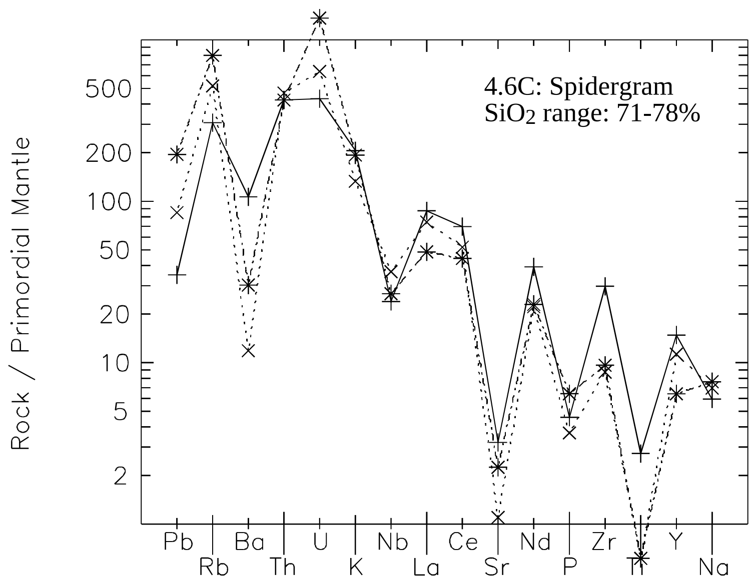

Legend
Warrego Granite
Devils Marbles Grani
Elkedra Granite
Unnamed granite Dav.
4.5A: Zr vs SiO2
Zr
800
600
400
200
55
60
65
70
75
SiO2
4.5B: Nb vs SiO2
Nb
80
60
40
20
55
60
65
70
75
SiO2
4.5C: Ce vs SiO2
Ce
400
300
200
100
55
60
65
70
75
SiO2

Legend


Warrego Granite
Devils Marbles Grani
Elkedra Granite
Unnamed granite Dav.

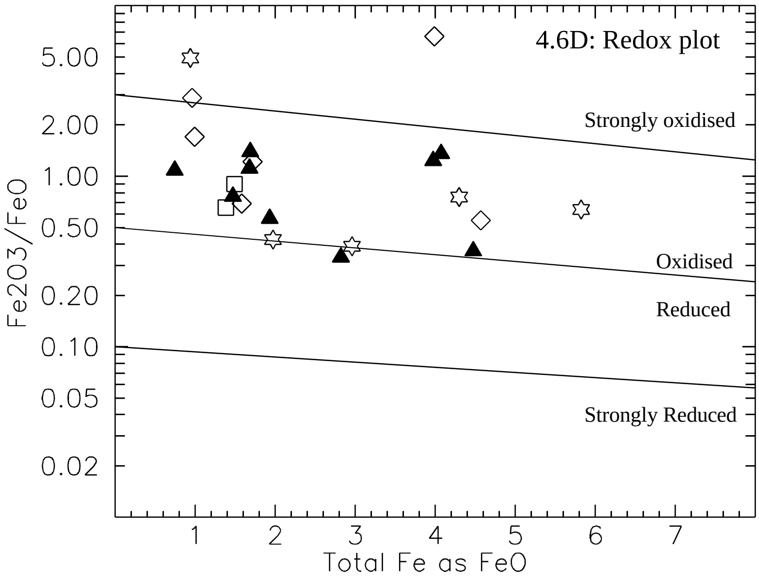

CaO
4.6A: CaO-Na2O-K2O
Tonalite
Granodiorite
Monzogranite
Granite
Trondhjemite
Na2O
K2O

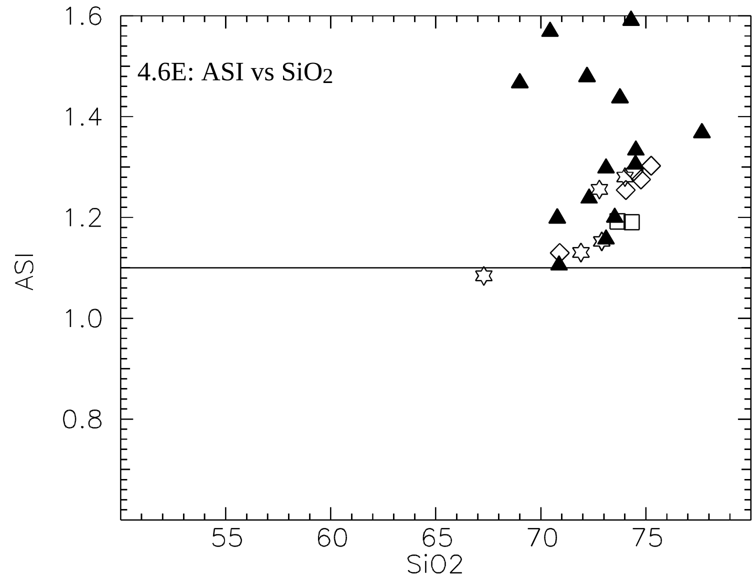

4.6B: Zr/Y vs Sr/Sr*
Sr/Sr*
3.5
3.0
2.5
2.0
1.5
1.0
0.5
10
20
30
Zr/Y

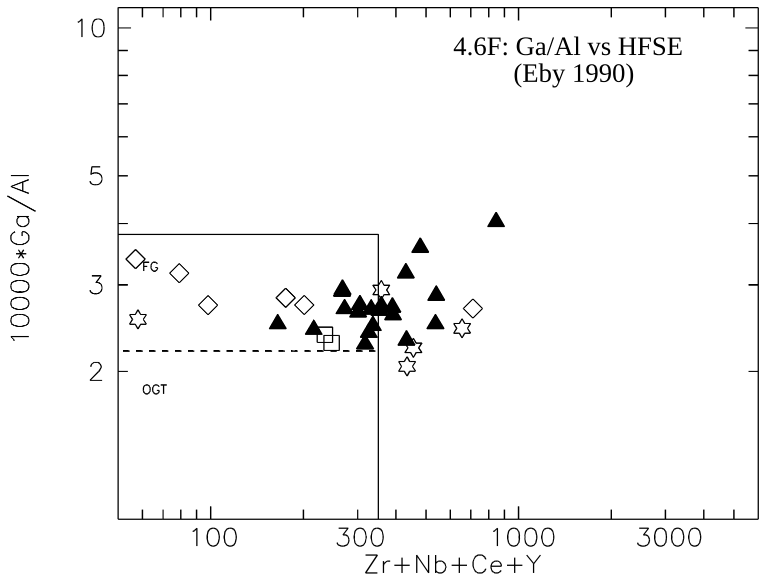

4.6C: Spidergram
SiO2 range: 71-78%
Rock / Primordial Mantle
500
200
100
50
20
10
5
2
Pb
Rb
Ba
Th
U
K
Nb
La
Ce
Sr
Nd
P
Zr
Ti
Y
Na

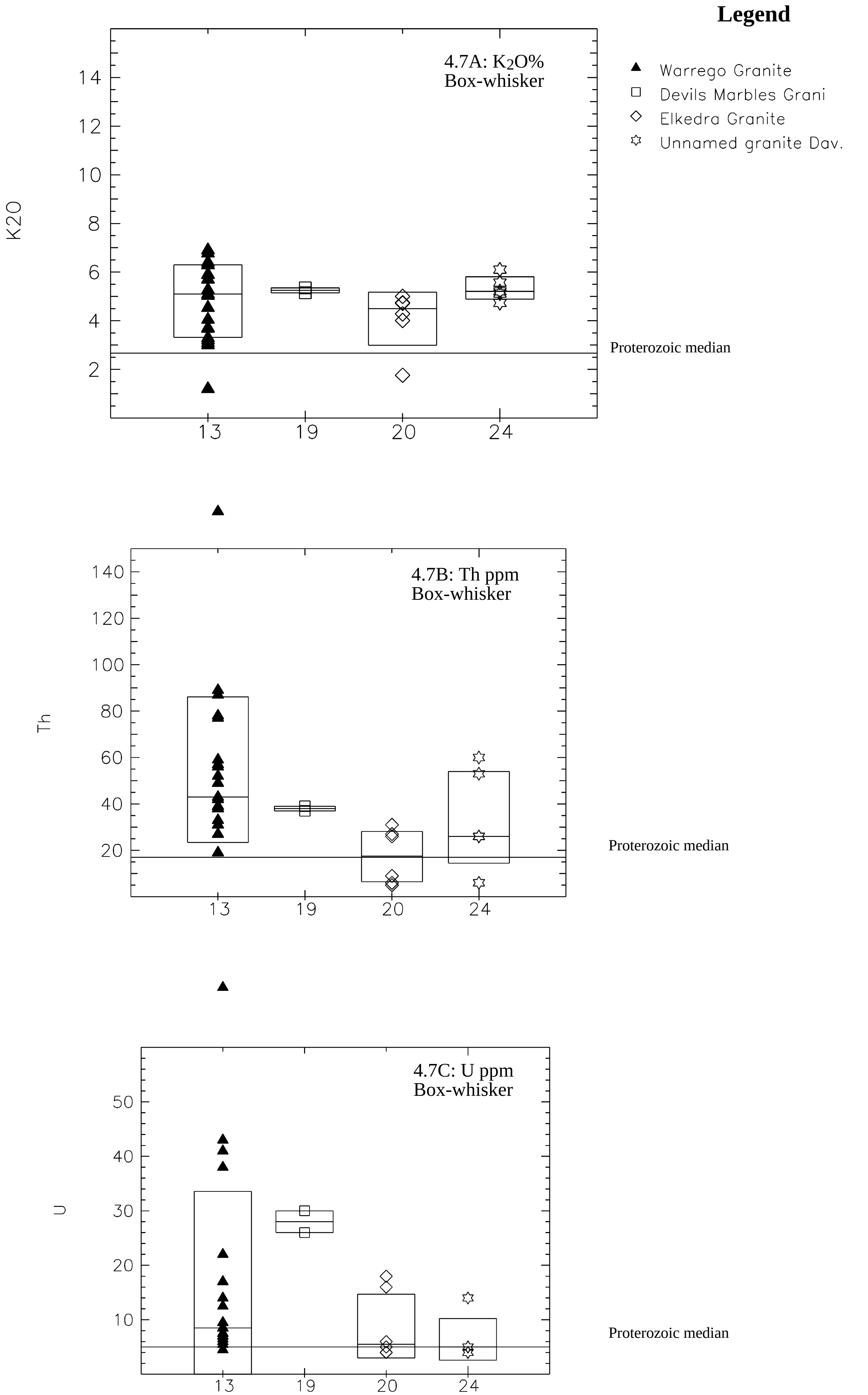
Legend

▲ Warrego Granite
□ Devils Marbles Grani
◇ Elkedra Granite
✡ Unnamed granite Dav.








Legend
Warrego Granite
Devils Marbles Grani
Elkedra Granite
Unnamed granite Dav.
4.7A: K2O%
Box-whisker
K2O
14
12
10
8
6
4
2
13
19
20
24
Proterozoic median
4.7B: Th ppm
Box-whisker
Th
140
120
100
80
60
40
20
13
19
20
24
Proterozoic median
4.7C: U ppm
Box-whisker
U
50
40
30
20
10
13
19
20
24
Proterozoic median

Warrego Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	72.42	72.3	2.21	67.7	77.67	21
TiO2	0.29	0.24	0.16	0.07	0.6	21
Al2O3	13.5	13.3	1.05	11.58	15.5	21
Fe2O3	2.31	2.36	1.51	0.39	6.5	21
FeO	1.43	1.24	0.91	0.36	3.29	9
MnO	0.03	0.03	0.02	0.01	0.07	9
MgO	1.4	1.11	0.91	0.2	4	21
CaO	0.26	0.18	0.21	0.05	0.9	21
Na2O	1.83	2.13	0.98	0.1	3.2	21
K2O	4.81	5.1	1.53	1.2	6.9	21
P2O5	0.1	0.1	0.03	0.03	0.16	21
H2O+	1.38	1.18	0.55	0.76	2.22	5
H2O-	0.1	0.09	0.02	0.08	0.13	5
CO2	0.17	0.18	0.1	0.06	0.27	5
LOI	2.09	1.6	1.32	0.85	6.5	21
Ba	557	266	568.26	82	2530	21
Li	13.52	13	4.53	6	23	21
Rb	342.43	387	134.19	153	531	21
Sr	45.62	43	19.76	10	92	21
Pb	50.71	21	132.43	5	624	21
Th	54.76	43	32.17	19	166	21
U	16.71	8.5	17.26	4.5	71	21
Zr	182.71	182	78.15	63	352	21
Nb	26.24	20	15.51	12	68	21
Y	53.05	50	29.23	14	154	21
La	64.43	52	41.98	23	180	21
Ce	112.24	99	62.44	47	330	21
Pr	10.25	10	3.28	4	17	16
Nd	39.81	35	18.45	15	104	21
Sc	8.38	8	3.8	2	18	21
V	19.33	24	10.99	3	37	21
Cr	39.78	14	82.67		287	18
Mn	268.63	303	127.88	64	565	16
Co	15.84	5	25.23		73	19
Ni	6.33	6	3.97	2	20	21
Cu	11.43	4	17.81		60	21
Zn	28.95	21	19.11	9	78	21
Sn	13	11	7.97	6	31	9
W	46.88	7	155.01	1	628	16
Mo	2.29		2.99		14	21
Ga	19.62	19	3.01	16	28	21
As	1.74	0.5	3.09	50	13	21
S	68.95	17	152.25	d	500	10
F	-	-	-	-	-	-
Cl	112.4	119	16.71	93	128	5
Be	6.86	6	4.37	2	17	21
Ag	1.44	1	0.51	1	2	16
Bi	3.83	2	4.31		18	20
Hf	5.25	5	2.57		9	16
Ta	2.94	2	2.24		8	16
Cs	14.09	14	8.09		35	16
Ge	2.19	1.5	1.94	0.5	7.5	16
Se	0.7	50	1.11		4	16

Devils Marbles Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	73.99	73.99	0.47	73.65	74.32	2
TiO2	0.13	0.13	0.01	0.13	0.14	2
Al2O3	14.19	14.19	0.18	14.06	14.32	2
Fe2O3	0.63	0.63	0.11	0.55	0.71	2
FeO	0.81	0.81	0.04	0.79	0.84	2
MnO	0.05	0.05	0.01	0.05	0.06	2
MgO	0.31	0.31	0.02	0.3	0.33	2
CaO	0.9	0.9	0.03	0.88	0.92	2
Na2O	2.97	2.97	0.01	2.97	2.98	2
K2O	5.25	5.25	0.14	5.15	5.35	2
P2O5	0.13	0.13	0.02	0.11	0.14	2
H2O+	0.75	0.75	0.2	0.61	0.89	2
H2O-	0.09	0.09	-	0.09	0.09	1
CO2	0.1	0.1	-	0.1	0.1	1
LOI	-	-	-	-	-	-
Ba	226.5	226.5	24.75	209	244	2
Li	107	107	4.24	104	110	2
Rb	498	498	8.49	492	504	2
Sr	47.5	47.5	0.71	47	48	2
Pb	41	41	2.83	39	43	2
Th	38	38	1.41	37	39	2
U	28	28	2.83	26	30	2
Zr	105	105	2.83	103	107	2
Nb	20	20	1.41	19	21	2
Y	34.5	34.5	7.78	29	40	2
La	39	39	7.07	34	44	2
Ce	81.5	81.5	2.12	80	83	2
Pr	-	-	-	-	-	-
Nd	29	29	2.83	27	31	2
Sc	5	5	2.83	3	7	2
V	9	9	1.41	8	10	2
Cr	2.5	2.5	2.12		4	2
Mn	-	-	-	-	-	-
Co	3	3	-	3	3	1
Ni	1.5	1.5	0.71		2	2
Cu	2.5	2.5	0.71	2	3	2
Zn	28.5	28.5	3.54	26	31	2
Sn	13.5	13.5	3.54	11	16	2
W	10	10	-	10	10	1
Mo	1.5		-			2
Ga	17.5	17.5	0.71	17	18	2
As	1	1	-	1	1	2
S	-	01	-	01	01	1
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Elkedra Granite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	74.19	74.6	1.72	70.9	75.74	6
TiO2	0.14	0.07	0.2	0.03	0.55	6
Al2O3	13.67	13.91	0.62	12.67	14.31	6
Fe2O3	1.35	0.84	1.12	0.63	3.5	6
FeO	0.97	0.65	1.01	0.25	2.96	6
MnO	0.04	0.04	0.01	0.03	0.05	6
MgO	0.35	0.27	0.29	0.14	0.92	6
CaO	0.54	0.44	0.32	0.32	1.18	6
Na2O	3.3	3.38	0.65	2.43	3.99	6
K2O	4.09	4.5	1.19	1.76	5	6
P2O5	0.25	0.22	0.09	0.14	0.38	6
H2O+	0.84	0.85	0.11	0.68	0.99	6
H2O-	0.09	0.09	0.04	0.03	0.13	4
CO2	0.08	0.08	0.01	0.06	0.09	4
LOI	-	-	-	-	-	-
Ba	223	84.5	321.25	22	851	6
Li	27.17	24	17.49	3	52	6
Rb	448.5	542.5	192.06	165	635	6
Sr	17.17	12	12.35	10	42	6
Pb	9.17	8	3.97	5	14	6
Th	17.33	17.5	11.88	5	31	6
U	8.83	5.5	6.4	4	18	6
Zr	112.5	45.5	176.87	16	470	6
Nb	32.5	26.5	15.86	23	64	6
Y	31.83	23.5	34.17	1	92	6
La	22	16.5	25.35		66	6
Ce	43.33	31.5	46.1	6	126	6
Pr	-	-	-	-	-	-
Nd	17.42	10	22.56		61	6
Sc	4.83	5	3.06		9	6
V	6.5	3	9.12	2	25	6
Cr	3.33	2.5	3.39		10	6
Mn	-	-	-	-	-	-
Co	3.5	2	3.7		9	4
Ni	2.33	2	1.86		6	6
Cu	2.17	2	0.75		3	6
Zn	15.83	12	12.81	7	41	6
Sn	18.17	20	9.6	4	30	6
W	18.5	12.5	19.09	3	46	4
Mo	1.75		0.61		3	6
Ga	21.17	20.5	2.79	18	25	6
As	1.75	1	1.67	0.5	5	6
S	-	01	-	01	01	2
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

Late unnamed granites from the Davenport Province

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	71.78	72.79	2.62	67.29	74.01	5
TiO2	0.37	0.44	0.27	0.03	0.7	5
Al2O3	13.54	13.9	1.17	11.85	14.82	5
Fe2O3	1.27	0.83	0.75	0.59	2.28	5
FeO	1.94	2.14	1.27	0.16	3.57	5
MnO	0.04	0.04	0.02	0.02	0.08	5
MgO	0.63	0.63	0.42	0.04	1.05	5
CaO	0.88	0.29	1.11	0.18	2.78	5
Na2O	2.72	2.76	0.6	1.96	3.32	5
K2O	5.35	5.21	0.52	4.73	6.1	5
P2O5	0.14	0.13	0.06	0.1	0.24	5
H2O+	1.02	1.03	0.23	0.78	1.37	5
H2O-	0.14	0.1	0.15	10	0.39	5
CO2	0.14	0.15	0.09	10	0.25	5
LOI	-	-	-	-	-	-
Ba	543.6	606	393.27	67	1040	5
Li	23.75	21	19.4	7	46	4
Rb	359.8	266	210.8	172	682	5
Sr	34.6	20	38.53	10	102	5
Pb	14.6	17	11.72	2	28	5
Th	34.2	26	22.07	6	60	5
U	6.4	5	4.28	4	14	5
Zr	220	214	136.75	22	367	5
Nb	20.2	16	9.39	12	36	5
Y	40	42	20.38	9	58	5
La	57.6	50	47.86		118	5
Ce	111.8	110	82.08	11	209	5
Pr	-	-	-	-	-	-
Nd	80	80	-	80	80	1
Sc	8	8	4.16	3	13	4
V	20.3	12	18.5		50	5
Cr	2.9		2.13		6	5
Mn	-	-	-	-	-	-
Co	12.2	8	10.01	6	30	5
Ni	1.3		0.67		2	5
Cu	9.4	10	6.8	2	17	5
Zn	39	35	14.51	19	56	5
Sn	12.4	8	10.06	3	26	5
W	5.8	4	3.56		12	5
Mo	1.5		-			4
Ga	17.6	18	3.58	14	22	5
As	0.63		0.25		1	4
S	-	-	-	-	-	-
F	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Be	-	-	-	-	-	-
Ag	-	-	-	-	-	-
Bi	-	-	-	-	-	-
Hf	-	-	-	-	-	-
Ta	-	-	-	-	-	-
Cs	-	-	-	-	-	-
Ge	-	-	-	-	-	-
Se	-	-	-	-	-	-

5 OTHER UNITS/SUITES

5.1 Introduction

This section contains brief descriptions of other units not included in the previous chapters. The two units described are of limited size, but as they are of similar age to the 1720-1680 Ma Devils suite, and have been implicated in the Au mineralisation they will be briefly considered here.

5.2 Lamprophyres

Location: Occur throughout the Tennant Creek Province, and have been mapped in the adjacent Davenport Province.

Timing & Relationships: Using Rb-Sr techniques, Black (1977) dated one dyke at 1664 ± 16 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.701 ± 0.002. Compston (1994) and Compston and McDougall (1994) report a K-Ar age of 1690 ± 35 Ma and a zircon age of 1685 ± 15 Ma on a single zircon grain. Dallwitz in Sullivan (1952) reported an unusual biotite-sericite rock in the contact aureole of the Devils Marbles Granite, and suggested it may be a contact metamorphosed minette. The lamprophyres are known to intrude the Warramunga Formation, Wundirgi Formation and the Yungkulungu Formation (Donnellan *et al.*, in prep.) as well as some of the granites and porphyries. The lamprophyres have been postulated to be a source of the Au mineralisation (e.g., Rock *et al.* 1987), a theory discounted by Duggan and Jaques (1996), in part on the known late timing of the lamprophyres relative to the mineralisation. Blake *et al.* (1987) also suggested that the lamprophyres may be related to the W mineralisation at the Mosquito Tungsten Field, which is within the Hill of Leaders Granite.

Description: Phlogopite bearing minettes: some amphibole and pyroxene varieties noted by Crohn and Oldershaw (1965). They have been classified as shoshonitic by Duggan and Jaques (1996).

Country Rocks: Intrude mainly quartzofeldspathic sediments and felsic igneous rocks.

References: Black 1977; Blake *et al.* 1987; Compston 1994; Compston and McDougall 1994; Donnellan *et al.* 1995, in prep.; Duggan and Jaques 1996; Jaques *et al.* 1985, Rock *et al.* 1987; Sullivan 1952.

5.3 Gosse River East syenite

Location: The intrusion is located in the southeastern part of the Tennant Creek Province and occurs as scattered outcrops 20 km east-southeast of the junction of the Gosse River and Channingum Creek.

Timing & Relationships: Dated at 1712 ± 12 Ma by U-Pb zircon (Compston 1994, 1995). Black (1977) records a Rb-Sr age determination of 1330 ± 100 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.703 ± 0.002: this has probably been reset by later deformation(s). The Gosse River East syenite is known to intrude the Warramunga Formation (Mendum and Tonkin 1976).

Description: Exposures are highly ferruginised and weathered. The samples analysed come from drill core and the dated sample was described as having plagioclase (40%), microcline (35%), quartz (10%) and chlorite (10%) and probably altered biotite or hornblende.

Country Rocks: Intrudes typical Warramunga Formation rock types.

References**:** Black 1977; Compston 1994, 1995.

5.4 References

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Gosse River East syenite

MEANS AND STANDARD DEVIATIONS

Element	Mean	Median	Standard Deviation	Minimum	Maximum	Number of Items
SiO2	61.55	61.28	0.49	61.26	62.39	5
TiO2	0.74	0.69	0.14	0.61	0.96	5
Al2O3	16.8	16.9	0.23	16.39	16.92	5
Fe2O3	2.31	2.3	0.48	1.76	3.08	5
FeO	1.31	1.3	0.18	1.05	1.51	5
MnO	0.03	0.03	0.01	0.02	0.03	5
MgO	1.92	1.99	0.26	1.52	2.21	5
CaO	0.4	0.41	0.05	0.32	0.45	5
Na2O	1.23	1.3	0.15	1.05	1.36	5
K2O	11.17	11.21	0.81	9.89	11.96	5
P2O5	0.23	0.25	0.04	0.18	0.26	5
H2O+	1.4	1.38	0.23	1.14	1.69	4
H2O-	0.16	0.16	0.04	0.11	0.19	4
CO2	0.2	0.2	0.18	05	0.35	4
LOI	1.63	1.6	0.25	1.34	2.02	5
Ba	3873.6	3975	357.58	3258	4133	5
Li	16	14	3.08	14	21	5
Rb	425.4	421	12.78	414	445	5
Sr	720.4	763	74	613	779	5
Pb	17.6	18	1.67	15	19	5
Th	75.8	82	13.94	60	91	5
U	17.1	16	2.61	14	20.5	5
Zr	893.2	866	115.43	801	1094	5
Nb	19.6	16	11.59	11	40	5
Y	41.6	41	9.04	33	56	5
La	81.6	78	17.07	60	103	5
Ce	182.8	162	45.87	134	238	5
Pr	30	30	-	30	30	1
Nd	83.4	74	30.59	52	129	5
Sc	7	6	3.54	4	13	5
V	48.4	46	11.1	40	67	5
Cr	18.6	18	2.3	16	21	5
Mn	225	225	-	225	225	1
Co	37.25	38	1.5	35	38	4
Ni	11.6	12	0.55	11	12	5
Cu	23	20	4.24	20	29	5
Zn	31	31	4.42	26	38	5
Sn	6.4	6	2.07	5	10	5
W	-	-	-	-	-	-
Mo	1.4		0.22			5
Ga	18.4	18	2.7	15	22	5
As	1.45	2	0.8	50	2	5
S	480.2	500	153.23	240	668	5
F	-	-	-	-	-	-
Cl	144	142.5	3.37	142	149	4
Be	4.4	4	0.55	4	5	5
Ag	1	1	-	1	1	1
Bi	1.2		0.45		2	5
Hf	29	29	-	29	29	1
Ta	1		-			1
Cs	17	17	-	17	17	1
Ge	3	3	-	3	3	1
Se	0.5		-			1