APPLICATION OF LITHOGEOCHEMISTRY TO IDENTIFY STRATIGRAPHIC UNITS AND PROVENANCE OF THE KANMANTOO GROUP, KANGAROO ISLAND

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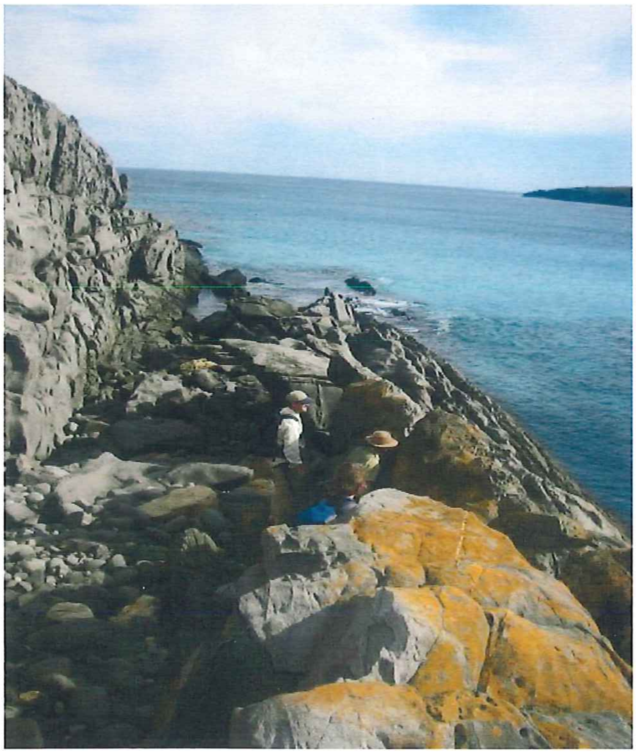

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Abstract

Geochemical data, including Nd isotope ratios, were used to help establish stratigraphic correlations between Kanmantoo Group sedimentary rocks on the mainland and Kangaroo Island, as well as constrain their provenance. Whole-rock Geochemistry of the Kangaroo Island and mainland Kanmantoo Group varied, with little consistency, suggesting a mixed sediment source. The Talisker Formation however has a distinctly higher abundance of mafic detritis compared to other Kanmantoo Group formations.Initial εNd data from the Kangaroo Island Kanmantoo Group is between -12 to -15, compared to those from the mainland which range between -9 and -12 (Turner et.al; 1993). The Nd data are similar to basement of the Gawler Craton and east Antarctica (Prydz Bay), which are two possible source terrains for the sediments. Palaeocurrent data on Kangaroo Island indicate a southern provenance. The εNd values of Prydz Bay Charnockites and felsic gneisses at around 500 Ma are similar to that of the Kangaroo Island Kanmantoo Group. Results from the outcomes of this study suggest that the Kanmantoo Group was derived from a mixture of sources, including the Gawler Craton, west Antarctica (Ross Orogeny) and Adelaidean rocks, however there appears to be a dominance of sediment from the east-Gondwana Orogenic belt in east Antarctica.

Keywords: Kanmantoo Group; Kangaroo Island; Stratigraphy; Geochemistry; Sm/Nd

1. Introduction

The Kanmantoo Group in South Australia (Fig 1.) was formed from the rapid deposition of sediments into the pre-Delamerian Kanmantoo Trough (Jago et al., 2003). The exact mechanisms and tectonic setting for the formation of the Kanmantoo Trough is unknown, as is the provenance of the sedimentary fill. What is known is that the Kanmantoo Group has an initial εNd signature, which is dissimilar to that of the underlying Adelaidean Group suggesting a distinct sediment source (Ireland et al., 1998a). There is also an abundance of Grenvillian to Archaean, as well as Neoproterozoic to Cambrian aged zircons, within the Kanmantoo Group (Ireland et al., 1998a; Preiss, 2000). It is hypothesised that a combination of isotopic and geochemical analyses can be used to distinguish formations within the Kanmantoo Group and determine sedimentary provenance.

The mechanism for the formation of the Kanmantoo Trough is unknown and there has been much debate as to whether the trough formed from west-directed subduction (Foden et al., 2006) or subduction was to the east, beneath an intra-oceanic arc that allowed for extension of the eastern passive margin and the formation of the Kanmantoo Trough (Boger and McMiller, 2004). Geochronological constraints indicate that deposition of the Kanmantoo Group occurred within a 10Ma time period (Haines and Flöttmann, 1998; Jenkins et al., 2002). Paleocurrent indicators such as cross-bedding and flute casts show northerly paleodirections, suggesting a southerly provenance (Jago et al., 2003). Some researches have linked this to sediments derived from the Ross Orogen, where compression and uplift preceded that of the Delamerian Orogen (Foden et al., 2006). Having a Ross Orogen provenance does not fully explain the zircon age spectra in the Kanmantoo Group, which includes a spectrum of Archaean, Mesoproterozoic (Grenvillian), Neoproterozoic and Cambrian ages (Flöttmann et al., 1998).

The Kanmantoo Group is found throughout the Fleurieu Peninsula and Kangaroo Island (Fig 1.). However, formations on Kangaroo Island are poorly exposed and there is little variation in lithology, as well as structural complications hindering correlation between the mainland and Kangaroo Island.

Previous studies by Ireland (1998a) have found an anomalous Nd isotopic composition within the Backstairs Passage Formation, that suggests a change in source for the deposited sediment. This shift in εNd can be used as a stratigraphic marker indicative of the Backstairs Passage Formation. This documented change in the isotopic composition of the Backstairs Passage Formation has the potential to improve correlations within the Kanmantoo Group.

The objectives of this project are to find geochemical and/or isotopic anomalies (Nd) within formations of the Kanmantoo Group, so that the formations on the mainland can be correlated to those on Kangaroo Island.

It is also hoped that the geochemical and isotopic data will help determine the provenance of Kanmantoo Group sediments. Results from this study are of direct benefit to Monax Mining Limited, who hold tenements on Kangaroo Island. Lead/Zinc, Cu and minor Au mineralisation occurs within the Tunkalilla and Tapanappa Formations of the Kanmantoo Group, with past and present mines on the mainland (Kanmantoo Mine- Hillgrove Resources, Angas Zinc Mine- Terramin, former Wheal Ellen Mine, and Scotts Creek Mine) as well as smaller workings on the island such as the Bonaventura Zn/Pb/Cu prospect and the Kohnioor mine.

2. Geological Background

The Kanmantoo Group occurs within the southern Adelaide Fold Belt, stretching from the Fleurieu Peninsula to Kangaroo Island (Fig. 2) which is separated by Investigator Strait. The Kanmantoo Group consists of a thick sequence of deep to shallow marine sediments deposited in the Kanmantoo Trough during the Early Cambrian, at approximately 526 Ma (Jago et al., 2003).This is constrained by dated tuffs within the upper unit of the underlying Adelaidean Group and dating of the Rathjen Gneiss which intrudes the Kanmantoo Group (Foden et al., 1999). The Kanmantoo Group is a package of greenschist-metamorphosed, sedimentary rocks. The Kanmantoo Group overlies the Adelaidean Normanville Shale and is subdivided into eight major formations (Fig. 3). These formations are dominated by sandstones, siltstones and mudstones (Jago et al., 2003) that were deformed and metamorphosed during the Cambrian-Ordovician Delamerian Orogeny (Flöttmann et al., 1994)

The Kanmantoo Group strikes north-south along the Fleurieu Peninsula and terminates structurally in the north. Exposure trends south from the Karinya Syncline until it reaches Investigator Strait where a 90° bend in strike changes the exposure pattern to an east-west trend along the length of Kangaroo Island. On Kangaroo Island, the Kanmantoo Group, though underlying most of the island, is found only in scattered outcrops away from the coastline. The majority of the island is covered by Tertiary and recent sediments (Fig. 3). On the northern coast of Kangaroo Island, the Kanmantoo Group has been thrust to the north over the undeformed Cambrian Kangaroo Island Group, along the Cygnet and Snelling faults.

2.1 Stratigraphy

The Kanmantoo Group consists of eight formations (Fig. 2). The Carrickalinga Head Formation, the oldest consists of turbiditic fine-grained sandstones, mudstones, siltstones and carbonates (Gum, 1998). It overlies the Adelaidean Heatherdale Shale and marks a dramatic change in sedimentation from a shallow, to deep marine setting. It is approximately 900 m thick (Jago et al., 2003). The overlying Backstairs Passage Formation is dominated by tidal sedimentation and Cambrian metamorphism to sandstones and siltstones. It is approximately 1100 m thick and has abundant shallow-water, trough cross-bedding within the unit (Jago et al., 2003).

Overlying the Backstairs Passage Formation, the Talisker Calc-Siltstone is approximately 170 m thick (Jago et al., 2003). It is dominated by mudstones, as well as a large pyritic member, the Nairne Pyrite Member, and underlies the Tapanappa Formation. The Tapanappa Formation forms the thickest unit within the Kanmantoo Group at 3000 m thickness (Gum, 1998). It Consists of greywackes and siltstones. Both the Talisker and Tapanappa Formations contain Zn, Au, Ag and Pb mineralisation (Jago et al., 2003). The Tunkalilla Formation is 170 m in thick (Jago et al., 2003) and lies conformably over the Tapanappa Formation. The Tunkalilla Formation consists of mainly siltstones, but with minor coarse-grained sandstones. There is some evidence of an unconformable type two sequence boundary between the Tapanappa and Tunkalilla Formations (Gum, 1998). The overlying Balquhidder Formation at approximately 1000 m thick (Jago et al., 2003) is similar in composition to the Tapanappa Formation, however shallow-marine, cross-bedding and deep marine flute casts are found within this unit (Preiss, 2000). The Petrel Cove Formation is made up of fine-grained sandstones interbedded with silts and muds (Jago et al., 2003) and is 850 m thick (Jago et al., 2003). The uppermost unit, the Middleton Sandstone consists of a cross-bedded, laminated, shallow-water sandstone with occasional limestone (Jago et al., 2003). The limited exposure of the Middleton Sandstone is in fault contact with the underlying Petrel Cove

Formation, and be a thrust repetition of the Backstairs Passage Formation (Flöttmann et al., 1998). The Middleton Sandstone is approximately 300 m thick (Jago et al., 2003).

Jago et al. (2003) suggest that the Kanmantoo Group can be subdivided into two shoaling upward sequences; the Carrickalinga Formation and Backstairs Passage Formations make up the lower of these successions, the Keynes Subgroup and the Talisker, Tapanappa, Tunkalilla, Balquhidder, Petrel Cove and Middleton Formations comprise the Bollaparuda Subgroup (Fig 2.).

2.2 Provenance

Detrital zircon data, analysed within the Kanmantoo Group, shows a dominance of Grenvillian-Archaean aged and Cambrian to Neoproterozoic aged zircons (Ireland et al., 1998b; Preiss, 2000). Flöttmann et al. (1998) found that the Kanmantoo Group has a Nd isotope signature distinct from the Adelaidean sequence, discounting this as a sole source of sediment for the Kanmantoo Group. Other provenance studies suggest various sources for these sediments; the Gawler Craton (Jenkins and Sandiford, 1992); the Ross Orogeny, (Turner et al., 1994) the Albany-Fraser Belt (Preiss, 2000) or the large east-Gondwana orogenic belts that spanned from south from the west of Australia through to eastern Antarctica and consisted of the Pinjarra Orogen (Collins, 2003; Fitzsimons, 2000).

2.3 Tectonic Setting

The Kanmantoo Trough was at the intersection of areas involved in both the Ross and Delamerian Orogenies (Fig 4.). The infill of Ross Orogen- aged sediments into the Kanmantoo Trough suggests that subsidence of the trough was ongoing when the Delamerian Orogeny started. Foden et al. (2006) suggest that the westward drift of Gondwana, accommodated by subduction at the western margin, delayed the start of the Delamerian Orogeny, and allowed for the continued sedimentation of the Kanmantoo Trough from erosion of the Ross Orogen. In contrast, Boger and Miller (2004) suggest that east-directed subduction beneath an intra-oceanic arc east of Australia, generated crustal extension and the infill of sediments into the Kanmantoo Trough. If in their model, extension was followed by compression, marking the beginning of the Delamerian Orogeny and resulting in the inversion of the Kanmantoo Group. High temperature-low pressure metamorphism of the Kanmantoo Group sediments was a result of rapid exhumation associated with uplift due to the termination of the Delamerian Orogeny.

3. Analytical Methods

Twenty-three Kanmantoo Group outcrop samples (Table 1) were collected from key outcrops across Kangaroo Island (Fig. 3). Another three outcrop samples were collected from the southern Fleurieu Peninsula and five mainland samples were taken from the PIRSA core library (Fig 5a-b.)

Samples were milled using a tungsten-carbide mill. Major and trace element concentrations for 23 samples (Table 2) were determined by Genalysis Laboratory Services using XRF and AT/ICP-MS methods. Additional geochemical data for Kanmantoo Goup formations on the Fleurieu Peninsula were collated from previous studies (Gum, 1998; Turner, 1993).

Fifteen Kanmantoo Group samples were analysed for Sm/Nd isotope compositions; eight Kangaroo Island and seven from the mainland (Fig. 5a-b). The procedure used 0. 7g of sample (approximately), spiked with 0. 3g of Nd/Sm spiked solution with known concentrations of 1.91375 nmol g^{-1} ^{150}Nd and 3.70847 nmol $g^{-1}Sm$. Samples were dissolved in a mixture of HFl and HNO_3 in teflon vials for at 150° C, for 12 hours, then dried and taken up in 6M HCl (Turner, 1993). Neodymium and Sm were separated using cation exchange columns following the procedure of Turner (1993). A procedural blank consisting of a 100x dilution of the Nd/Sm spike and a University of Adelaide in-house standard TASBAS (Tasmanian Basalt with a $^{146}Nd/^{144}Nd$ of 0.511594 ± 10^{-6}) were also run through the digestion and separation procedure. $^{143}Nd/^{144}Nd$ ratios were calculated using a normalizing $^{146}Nd/^{145}Nd$ ratio of 2.8151 (equivalent to a $^{46}Nd/^{144}Nd$ = 0.721903). The Nd-isotope standard (JNdi-1) was run during the analytical sessions. The weighted average of JNdi-1 throughout this study was ($^{143}Nd/^{144}Nd$) 0.51210905. Typical standard errors on individual Sm and Nd isotope analyses are in the ranges of <0.05% for Nd and<0.2% for Sm.

4. Results and Observations

Table 2 contains values for whole rock geochemical data and Table 3 contains Sm-Nd isotope data. All geochemical data from previous studies are found in Appendix 1.

4.1 Palaeocurrent Data

Tectonic tilt-corrected palaeocurrent were collected from tabular and planar cross-bedding in the Middleton Formation on the south-west coast of Kangaroo Island (Fig. 6). The data indicates a dominantly north directed palaeoflow and are consistent with data from Haines et al. (2001) in suggesting a southern provenance.

4.2 Major Element geochemistry

Major element geochemistry shows high SiO_2 levels (60%), reflecting the lithology of the samples collected (Table 2). The Fe_2O_3 values are lower in the sand-dominated samples with values between 1.8-6.95% compared to the shale dominated samples whose values are in the range of 4.63-13.72%. This is also reflected in K_2O and TiO_2 values and is possibly due to a dilution due to increase in Si concentration in sand samples. Concentrations of Na_2O vary from 3.92 to 0.52% for sands and 1.97-1.26% for the Kangaroo Island Kanmantoo Group samples. Concentrations for MgO are more diverse, varying between 0.58 and 5.43% with no consistency between sand samples and shales.

4.3 REE Geochemistry

Rare-earth elements (REEs) were normalised to chondrite using the values of Taylor and McLennan (1985). The sand-dominated samples were separated from the silt-dominated samples to enable comparison without the effect of varying degrees of dilution by quartz. Plots of each sample (Fig. 7a) show a general trend similar to the geochemistry of the standard Post Australian Archaean Shale (PAAS) (ref?). Samples A2220-9 and A2220-20 are markedly depleted and enriched in REEs respectively, relative to PAAS. Kangaroo Island Kanmantoo Group silts and shales are compared with those from the Adelaidean sequence (Fig. 7b) to compare samples of similar chemistries. Data compare relatively well, especially with samples of the Balquhidder Formation (A2220-5) and Tunkalilla Formation (A2220-3, A2220-25) with the Adelaidean shales containing a much greater Eu anomaly and a slightly wider compositional range. Sample A2220-9, from the Tapanappa Formation shares no similarities with the Adelaidean sequence, and A2220-18 (from the Tapanappa Formation also) shows a clear distinction with a severe depletion in HREEs, in comparison to the Adelaidean sequence.

Figure 8 represents Th vs U content for sand-dominated samples from the mainland and Kangaroo Island. Thorium and Uranium are both incompatible elements compared to the mantle. Uranium can be enriched by the addition of sea water into a subducting slab (McLennan et al., 2003), hence making Th/U a good combination to use in identifying Kanmantoo Group formations.

Both locations have similar compositional ranges, with no distinct variation between the two regions. The Th/Sc ratios are used to model the range of sedimentary recycling of the upper crust through time, with an increase in the Th/Sc ratio corresponding to an increase in sedimentary recycling (Taylor and McLennan, 1985). This can be a useful tool for determining a potential provenance. The Kanmantoo Group units may have had a change in their sediment source (Ireland et al., 1998a). The Th/Sc was used to try to find any distinguishing anomalies within the stratigraphy and Figure 9a examines in more detailed Th vs Sc for sand-dominated samples. There are many similarities between the two geographical regions. Figures 9b-d examines the three formations with the majority of data. Within individual formations the Balquhidder, Tapanappa and Talisker Formations show no obvious anomalies, however, the Talisker Formation appears to have a Th/Sc ratio that trends upwards before an independent increase in Sc compared to Th.

Figures 10a-e compare Th/Sc ratios to Cr/Ni. The mainland has a lower Th/Sc component. The Middleton, Balquhidder, Tapanappa and Talisker Formations were examined in more detail. The Balquhidder Formation shows one anomalous sample (A2220-10) with exceptionally high Cr/Ni ratio compared to all of the other samples, however the Talisker Formation shows a trend similar to that in Figure 9d, which shows an increase in the Cr/Ni ratio independent of the Th/Sc ratio.

Figures 10f-g compare the Th/U and Th/Sc ratios to Cr/Ni of the shales and phyllites of the Kanmantoo Group formations in order to determine if the increase of Cr/Ni compared to Th/U and Th/Sc is consistent for the entire Tapanappa and Talisker formations. There is a clear distinction in that the Talisker Formation contains a much greater Cr/Ni ratio than other Kanmantoo Group Formations.

4.4 Transition Metals

Transition metal concentrations, normalised to primitive mantle (McLennan et al., 2003) (Fig.11a,b) show similar patterns between formations of the mainland and those from Kangaroo Island, except for in the case of the Middleton Formation, in which Cu and Zn concentrations in the mainland samples are much lower than on Kangaroo Island.

4.5 Nd-isotope data

The εNd data calculated at 500 Ma (Fig. 12) show a more negative εNd trend up section. There is a sharp change in the εNd values above the Carrickalinga Formation as noted by Turner et al. (1993). The Kangaroo Island Kanmantoo Group has very low εNd values ranging between -12 to -15 (Fig. 13), compared to the εNd values from Turner et al. (1993), the Ross Orogen (Talarico et al., 1995) and the Adelaidean (Barovich and Foden, 2000) but, εNd values are within ranges of those from the Gawler Craton (Barovich, unpublished data (2008; Payne et al., 2006) and East Antarctica (Young et al., 1997).

5. Discussion

5.1 Stratigraphic Correlation

Chondrite normalized REE patterns (Fig. 7b) are generally similar to PAAS. Only 3 samples: A2220-9; A2220-17; and A2220-20, are markedly different, with samples A2220-9 and A2220-20 from the Tapanappa Formation and sample A2220-17 from the Petrel Cove Formation (Table 1). A2220-9, a highly weathered pyritic schist, has a much lower REE abundance and was excluded from further consideration. Sample A2220-17, a meta-sandstone from the Petrel Cove Formation does not have a significant Eu anomaly and, compared to the other samples, is low in the MREEs. The Petrel Cove Formation sample A2220-17 was excluded from further work in this study due to only providing a small sample set. Sample A2220-20, a meta-sandstone of the Tapanappa, has a higher REE abundance. This sample, as well as sample A2220-9, are anomalous within the twenty-three samples and cannot be used as a REE composition specific to any unit. Of the samples used, samples from the Talisker Formation as well as some of the Middleton and Tapanappa formations have the lowest REE contents.

Geochemical data in Figure 8 shows the Th and U ratios of the Kangaroo Island and mainland Kanmantoo Groups. The Kangaroo Island samples associate well with the mainland Kanmantoo Formation. There are, however, no trends and too much variation to suggest a distinction amongst formations of the Kanmantoo Group and this was not studied further..

Figures 9a,d depict Th/Sc ratios. These ratios are the most sensitive to use for determining a distinct sedimentary composition (Taylor and McLennan, 1985). These graphs show extremely good correlation between samples from the two locations. The absence of trends or distinctions within the samples however does not give any indication of an anomaly within any of the individual units allowing for a tool to help when correlating stratigraphy. When the individual units are looked at separately there is still a close association between the units, even considering the low sample numbers. The Balquhidder (b) and Tapanappa (c) formations are very similar with most of the samples falling within Th concentrations of 5-25ppm and most Sc concentrations between 5-10ppm. Samples from the Talisker Formation show a trend that decreases in Sc as Th stays stable at approximately 20 ppm, which is lower than in the other formations.

The Th/Sc vs Cr/Ni (Figure. 10a-f) graphs were compared to show the felsic (Th/Sc) and mafic (Cr/Ni) components of samples. Samples from Kangaroo Island and the mainland compare well. (Figure 10a).However when individual formations are compared there are no significant differences. The Talisker (b) and Tapanappa formations (c) appear to have larger Cr/Ni ratios perhaps indicating a larger mafic component. The Talisker Formation (Figure 10d) was looked at in greater detail to examine if this distinction was consistent throughout the whole unit, or specific to the sand-dominated samples. Figure 10f and 10g compare the Cr/Ni ratios to Th/Sc (a) and Th/U

(b) of the mainland Talisker formation. The Talisker formation appears to have, on average a more mafic component than the other mainland Kanmantoo Group units as discussed previously. This is trend is consistant with REE data (Fig 7b.), for the Talisker Formation, which has amongst the lowest REE concentration for the Kangaroo Island Kanmantoo Group samples. This distinction is again shown in Figures 10f and g. Mainland shales from each Kanmantoo formation were compared to examine if the increase in mafics is continuous throughout the whole of the Talikser Formation. The graphs (fig 10f, g) show that the Talisker Formation has a higher abundance of Cr/Ni compared to the other formations with one high sample from the Tapanappa Formation, due to Cr mineralisation of the sample.

5.2 Provenance

In active margin turbidites, Th/Sc and Zr/Sc ratios both increase with an increase in igneous differentiation (McLennan et al., 2003). However trailing margin turbidites are more likely to see an increase in Zr/Sc (independent of Th/Sc) due to an increase in recycling and Zr concentration. Figure 14 adapted from McLennan et al. (2003) is used to determine the tectonic setting in which the Kanmantoo turbidites were deposited. The diagram shows a small independent increase of Zr/Sc with small, but well-defined trends amongst the Balquhidder, Talisker and Carrickalinga Head formations. This would suggest that the tectonic setting for the deposition of the Kanmantoo turbidites was in a passive tectonic environment, and not an active margin such as a Ross Orogen source. Figure 15 suggests that while the Kanmantoo turbidites were deposited in a passive margin setting, the sediments were sourced from an active continental margin setting and Figure 16 adapted from McLennan et al. (2003), show that the majority of the Kangaroo Island Kanmantoo Group sediments were sourced from older crust with a greater felsic component, than those from the mainland. Figure 16 also shows that the mainland samples from Turner (1993) (circled) have a slightly larger mafic component than those from Kangaroo Island, but this pattern is contradicted by Th/Sc ratios (Fig 9a), which on average are 1.75 compared to the upper continental crust average of 0.97 (Taylor and McLennan, 1985). When examined separately it is the mainland samples that have a slightly higher average Th/Sc ratio of 1.79 to the Kangaroo Island average of 1.6. This is a complete contradiction to the data from Figure 16. There is no εNd data on the Kangaroo Island Talisker Formation.

Highly negative εNd values from Kangaroo Island (compared to the mainland) (Fig.13) are more comparable to an evolved felsic source. Kangaroo Island Kanmantoo Group samples have εNd values that are more negative than those from the mainland. Mainland εNd values, from Turner (1993) and shown as blue triangles, are significantly higher than those measured on Kangaroo Island. Values coincide with those for the Adelaidean sediments (shown as pink boxes). The majority of the Kangaroo Island εNd values correspond with values from the Gawler Craton and East Antarctica. Palaeocurrent data (Fig. 6) from this study and previous work

(Preiss, 2000) shows a NNE directed current. This has, in past work, been linked to a Ross Orogen provenance (Boger and McMiller, 2004), which is thought to have only just preceded the Delamerian Orogeny (510Ma) (Direen et al., 2005) and thus, the deposition of the Kanmantoo Group (at approx. 526Ma (Jago et al., 2003).The εNd data associated with felsic granulites and enderbites of the Ross Orogeny (Rocchi et al., 1998; Talarico et al., 1995) (Fig. 13) show no correlation with any Kangaroo Island Kanmantoo data and only little correlation with mainland Kanmantoo data.

There is little overlap between Adelaidean εNd and Kangaroo Island Kanmantoo samples. Figure 7b compares REE data from Adelaidean shales (Turner, 1993) with siltstones and phyllites from the Kangaroo Island Kanmantoo Group. There is good correlation between the Kanmantoo Group shales and the Adelaidean shales. Further comparison between the two units shows good correlation in Th vs Sc and Th/Sc vs Cr/Ni (Fig 17). There is little apparent association between transition metals (Fig. 18c), but this could be due a result of low sample density for the Adeladiean shales.

The εNd values from the Kanmantoo Group on Kangaroo Island are indistinguishable from those of the of the Gawler Craton and East Antarctica charnockites and orthogneisses (Fig. 13) (Payne et al., 2006; Rameshwar et al., 2000; Young et al., 1997). Fitzsimons (2000) suggests that the extension of the East Gondwana suture, previously thought of as following along the coast of east Antarctica, actually extends further south of Prydz Bay into the central part of the continent (Fig. 19). This allows for a south-south-westerly provenance. Haines et al. (2001) suggest that the small grainsize of sediments that in-filled the Kanmantoo Trough suggest a distal provenance, transported by a large deltaic system. Evidence of the delta however is only found in the south-west of Kangaroo Island and not on the mainland (Haines et al., 2001). This, while allowing for a distal east Antarctic source, also permits for the biased sourcing of Kangaroo Island which explains the difference in εNd values to those from the mainland (Fig. 13). The Prydz Bay region contains felsic orthogneisses, felsic gneisses, charnockites, and metapelites (Kelsey et al., 2007a; Young et al., 1997). Zircon dating has found that the Prydz Bay area contains Grenvillian-Archaen aged orthogneisses and dykes as well as Neoproterozoic-Cambrian aged A-type granites (Kelsey et al., 2007a). Previous studies have found Grenvillian-Archaean and Neo-Proterozoic-Cambrian aged zircons within the Kanmantoo Group (Haines et al., 2001). Orogenic activity gives an explanation for plots which suggest an active continental margin setting (Fig 15) and the extensive felsic-rich gneisses (Hensen and Zhou, 1995; Kelsey et al., 2007b) are a suitable geochemical source. However, geochemical correlation between the Kangaroo Island Kanmantoo Group and the Prydz Bay area (East Antarctica) felsics are weak (Fig. 20a), with east Antarctica slightly less abundant in Th and much more abundant in mafic material (Fig 20b). Yet, Figures 18a and 18b show very good correlation with transition metal concentrations. The east Antarctica model (Fig 18a) can be split into two geochemical types, one whose lower V and Zn concentration samples (highlighted in green) are very similar to the Kangaroo Island Kanmantoo Group sands. εNd correlation with the Gawler Craton (Payne et al., 2006) is restricted to the most negative εNd values, and incorporates all the Kangaroo Island Kanmantoo Group samples. REE data from the Gawler Craton (gneisses, paragneisses and volcanics) (Fig 7a.) shows poor correlation with the upper units of the Kangaroo Island Kanmantoo Group (the Middleton, Petrel Cove and Balquhidder Formations) and most samples from the Tapanappa Formation.

There is weak correlation with geochemical data from felsic granulites and enderbites from west of Antarctica, (associated with the Ross Orogeny) (Rocchi et al., 1998) and the Kangaroo Island Kanmantoo Group (Figs. 18b and 19a,b). Like those of east Antarctica, the west Antarctic samples have higher Th but do not appear to be as mafic as those in the east. West Antarctic samples (Fig. 18b) are much higher in V and Zn than the Kanmantoo Group sand samples.

6. Conclusion

The main focus of this study was to determine a geochemical or isotopic distinction with which to identify units within the Kanmantoo Group and allow for the correlation of mainland Kanmantoo Group to that on Kangaroo Island. The secondary focus was to establish potential provenances for the Kanmantoo Group. There is little geochemical and isotopic distinction, between formations of the Kanmantoo Group on Kangaroo Island with those on the mainland. Small sample sizes of the individual Kangaroo Island formations, as well as a lack of mainland Kanmantoo Group samples may be partly responsible for the inability to show a distinction between formations. It is more likely, however that with a very short deposition time (10Ma) any geochemical changes would be minor and thus any differences indicative of particular units would be subtle. Geochemical plots of Th/Sc and Th/Sc vs Cr/Ni show that the Talisker Formation appears to have a greater Sc and Cr/Ni abundance than the other Kanmantoo Group Formations, in both the sand dominated and shale dominated lithologies. Thus it is concluded that the Talisker Formation's composition consists of a greater mafic component than other Kanmantoo Formations.

Various possible correlations between provenances suggest a mixed sedimentary source for the Kanmantoo Group. Data from Figure 15 suggests that the Kangaroo Island Kanmantoo Group sediments were from an older crustal source and have a greater felsic component than the mainland. The Th/Sc ratios and other graphs presented in this study suggest the mainland has a greater felsic component. There is little sorting of the Kangaroo Island Kanmantoo Group, perhaps due to a mixed and variable sediment source diluting any small trends. Paleocurrent data (Fig. 6) suggests a SSW provenance.

The εNd data strongly correlate with charnockites and orthogneisses from east Antarctica and have poor correlation with west Antarctic felsic granulites and enderbites (Ross Orogeny). This study does not support previous work that suggests a Ross Orogen provenance for the Kanmantoo Group e.g. (Boger and McMiller, 2004). There is more evidence in support of Fitzsimon's (2000) hypothesis of an extended East Gondwana Orogenic Belt, south into central Antarctica (Fig. 16). However a lack of geochemical similarities makes it difficult to confirm this. The Gawler Craton as a dominant provenace for the Kanmantoo Group was not considered in this study due to the suggested tectonic setting of an active margin and palaeocurrents that suggests a SSW provenance for Kangaroo Island. Adelaidean shales provide good similarities with REE patterns, however there is a lack of εNd correlation and other geochemical similarities with the Kanmantoo Group in this study to suggest the Adelaidean sequence as a source. This research suggests that there was a mixed provenance for the sedimentation of the Kanamantoo Group, with east Antarctica acting as a dominant provenance for Kangaroo Island's Kanmantoo Group. This accounts for mixed geochemistry and allows for no particular correlation specific to one source.

There is a noticeable distinction in εNd values between the mainland and Kangaroo Island Kanmantoo Group. While still suggesting a mixed sedimentary source applicable to the whole Kanmantoo Group it is possible that a large deltaic system which extended from east Antarctica to Kangaroo Island (Haines et al., 2001), allowed for the more exclusive transport of sediment to one of the geographical areas (Kangaroo Island) over the other (the mainland). This could perhaps be tested by compiling a data set of regional paleocurrents.

Recommendations for further research into this area include detailed geochemical sample transects across stratigraphy, more isotopic studies of the Kanmantoo Group across all lithologies to allow for a better judgement of values, and more zircon geochronology is needed, for better constraints on sediment ages. With more detail, a better comprehension of any minor geochemical differences can be better attained. This will also provide more details to interpret a more specific provenance.

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FIGURE CAPTIONS

Figure 1.
Geographical map of the Fleurieu Peninsula and Kangaroo Island showing the location of the Kanmantoo Group. Inset, location of the Fleurieu Peninsula and Kangaroo Island in accordance with Australia

Figure 2.
Map of Kangaroo Island showing the regional Geology and the sample sites. (Adapted from SARIG)

Figure 3.
Stratigraphic column of the Kanmantoo Group showing the 8 major Formations.

Figure 4.
Positions of Australia and Antarctica during the Ross-Orogeny/Delamerian Orogeny. Note the Trans-Atlantic mountains, a possible provenance source for the Kanmantoo Group (Ref. This image to whicher paper the positions came from).

Figure 5.
Geological map of (a) Mt Barker area depicting sample sites and south coast Fleurieu Peninsula (b).The shaded orange areas represent Kanmantoo outcrops. Adapted from SARIG.

Figure 6.
Rose diagram showing palaeocurrent data determined from cross-bedding on. Palaeocurrent seen as flowing NNE, indicating a southerly sediment transport direction.

Figure 7a,b.
REE plot of samples taken from the Kanmantoo Group, normalized to chondrite. PAAS shown in bold black. Gawler Craton (Swain et al., 2005) average shown as shaded orange (a) with most similarities occur with the Middleton, Talisker and some Tapanappa Formations. (b) REE plots of the Kanmantoo-Kangaroo Island Shales compared to an average from the Adelaidean shales (Turner et al.; 1993) which can be seen as having a lower LREE abundance.

Figure 8.
Th/U for the Kanmantoo Group on the mainland and Kangaroo Island. There are no obvious anomalies in the graph that suggest a differentiation within the formations.

Figure 9 a-d
Plots of Th vs Sc for the mainland and Kangaroo Island (a) as well as Balquhidder (b), Tapanappa (c) and Talisker (d) formations. The Talisker Formation trends upwards before an independent increase in Sc.

Figure 10 a-e
Plots of Th/Sc vs Cr/Ni for the mainland and Kangaroo Island (a), and formations Middleton (b), Balquhidder (c), Tapanappa (d) and Talisker (e). The Kangaroo Island Tapanappa appears to be more abundant in mafics than its mainland couterpart. There is good correlation between the other formations thought there is a lack of sample size. Figure 10f,g detail of the Th/U and Th/Sc over Cr/Ni ratios of the Kanmantoo Group shales. The graphs show that the increased Cr/Ni ratio of the Talisker Formation is consistent throughout both the sand dominated and shale dominated lithologies.

Figure 11 a-b
Plots of transition metals for the mainland (a) and Kangaroo Island (b). The Balquhidder and Tunkalilla Formations of the mainland (a) appear to have a higher abundance of transition metals. This is not repeated in the Kangaroo Island samples where all of the units have very similar transition metal concentrations.

Figure 12
Graph showing εNd values over the stratigraphy of the Kanmantoo Group. Values from Turner et al. (1993) are shown in pink. The graph shows the sharp change in εNd after the Carrickalinga Head Formation. There is also a decrease in εNd values up the stratigraphy.

Figure 13.
εNd graph which shows that the Kangaroo Island Kanmantoo Group values are significantly lower than those on the mainland (Turner et al. 2003). Note that Kangaroo Island Kanmantoo Group values are within range of the Gawler Craton (shaded lilac) and the East Antarctic orogenic belt (shaded purple).

Figure 14.
Th/Sc vs. Zr/Sc. Kanmantoo Group Formations have a low Zr/Sc ratio suggesting that they are not as well sorted. Trends within the Talisker and Balquhidder formations suggest greater sedimentary sorting

Figure 15.
(a) ($\log K_2O/ Na_2O$ vs. SiO_2) shows the Kanmantoo formations plotting within the active tectonic margin field, as adapted from Rollison (1993).

εNd vs Th/Sc graph shows that the sediments from the mainland and Kangaroo Island (shown in black) were from an older crustal source with a greater felsic component

Figure 16.
εNd vs Th/Sc graph shows that the sediments from the mainland and Kangaroo Island (shown in black) were from an older crustal source with a greater felsic component

Figure 17.
Diagram of Eastern Gondwana showing Australia, Antarctica and India Fitzsimons (2000) suggests the extension of the Pan-African suture further south of Prydz Bay, into central Antarctica, and not along the coast of East Antarctica. (Adapted from Fitzsimmons (2000))

Figure 18.
Th/Sc (a, b) and Th/Sc vs Cr/Ni (c,d) graphs comparing east Antarctica Charnockites, west Antarctica and Kangaroo Island Kanmantoo Group. East Antarctica has more Sc suggesting a mafic component. West Antarctica Th/Sc vs Cr/Ni (d) are more scattered. Th/Sc correlates better, however there is an increase in Th in the West Antarctica samples.

Figure 19
Plots of transition metals comparing KI Kanmantoo Group (a), east Antarctica (b), west Antarctica (c) and the Adelaidean (d)

Figure 20
Th/Sc (a) and Th/Sc vs Cr/Ni (b) data of Adelaidean Shales and the Kangaroo Island Kanmantoo Group Shales. There is good correlation between formations.

TABLES

Table 1
Location and description of samples taken from Kangaroo Island, the southern Fleurieu Penninsula and PIRSA.

Table 2
Table of XRF, ICPMS geochemical data, adapted from Genalysis.

Table 3
Table of εNd data. Mainland data sourced from Turner et al. (1993)

Table 1.

Sample no.	Location	Description	Unit
A2220-1	Cygnet River (KI)	Metasandstone, medium sized grains, fine beds. Interbedded with darker layers, perhaps organic.	Tapanappa
A2220-2	Snellings Beach (KI)	Metasandstone with interbedded with fine silts. More fine grained than the Tapanappa Formation	Tapanappa
A2220-3	Snellings Beach (KI)	Fine laminated shale with soapy texture.	Tunkalilla
A2220-5	Western River (KI)	Black phyllite, slaty looking. Iron stained and chloritic. Finely laminated	Balquhidder
A2220-6	Western River (KI)	Metasandstone interbedded with silty layers. Minor biotite.	Balquhidder
A2220-7	Herveys Return (KI)	Light grey, bitotite and quartz rich metasandstone. Fine biotite laminations.	Balquhidder
A2220-8	Middle River Tributary off of Bowering's property (KI	Dark grey medium-grained metasandstone	Talisker
A2220-9	Middle River Tributary off of Bowering's property (KI	Pyritic Schist. Heavily iron stained. Finely laminated with alternatin dark/light layers.	Tapanappa
A2220-10	Middler River ridge top, Bowering's property (KI)	Light grey, biotite rich metasandstone, interbedded with solely quartz layers.	Balquhidder
A2220-11	Middle River Dam (KI)	Light grey lower-greenschist metasandstone. Non-tabular craossbeds. Quartz rich with minor biotite	Balquhidder
A2220-12	NW of Western Bay (K)	Dark grey metagreywacke. Biotite rich, fine-medium grained. Thickly bedded with finer interbeds. Hummocky corss bedding indicating younging in an upwards direction	Middleton
A2220-13	SE of Western Bay (KI)	Very fine-grained metagreywacke. Plentiful biotite laminations. Thin and moderately defined cleavage. Almost schisty in appearance	Middleton
A2220-14	SE of Western Bay (KI)	Dark coloured, massive bedded metagreywacke. Little structure within. Very fine-grained.	Middleton
A2220-15	Sandy Creek Beach (KI)	Biotite-rich, ironstained metasandstone, medium grained. Crossbedding within and some laminations. Contains a highly weatherd zone of garnet and silimanite	Middleton
A2220-16	Admirals Arch (KI)	Medium-grained biotite and quartz rich metasandstone, well laminated.	Middleton
A2220-17	Creek Bed, unknown location (KI)	Biotite and quartz rich, medium-grained metasandstone. Well laminated	Petrel Cove
A2220-18	Point Morrison	Well metamorphosed phyllite, almost a schist. Had a thicker, sandier bed. Cross bedding indicates a younging	Tapanappa

		direction to the south. Gold colour muscovite and chlorite rich.	
A2220-19	South of Pelican Lagoon (KI)	Light grey quartz rich metasandstone. Some calcareous matter. Little structures	Tapanappa
A2220-20	American River (KI)	Light grey, plagioclase rich metasandstone. Fine-grained with good laminations. Some calcareous material. Similar to above sample	Tapanappa
A2220-21	Western side of Antichamber Bay (KI)	Metagreywacke with some pegmatitic veining. Whole sample shows metasiltstones and mudstones. Perfect turbidite sequence	Tapanappa
A2220-23	Western side of Antichamber Bay (KI)	Muscovite rich siltstone. Similar to sample 18. Gold in colour	Tapanappa
A2220-24	Christmas Cove (KI)	Metagreywacke with crossbedding. Younging to the south. Finely laminated	Tapanappa
A2220-25	Penneshaw (KI)	Shale with high iron staining.	Tunkalilla
A2220-26	South of Strathalbyn (mainland)	Metasandstone (PIRSA sample, cuttings)	Tapanappa
A2220-27	Callington (mainland)	Metasandstone, top of the Tapanappa formation (PIRSA sample, cuttings)	Tapanappa
A2220-28	SE of Callington (mainland)	Metasandstone (PIRSA sample, cuttings)	Balquhidder
A2220-29	NW of Red Creek	Metasandstone, lower Tapanappa (PIRSA sample, cuttings)	Tapanappa
A2220-30	Mt Barker Creek	Metagreywacke (PIRSA sample, core)	Backstairs Passage
A2220-31	Middleton Point (mainland)	Greywacke, beds dipping 60° NE	Middleton
A2220-32	Middleton Quarry (mainland)	Fine-grained greywacke. Little structures within	Middleton
A2220-33	Petrel Cove (mainland)	Metasandstone with more pyritic/biotite rich layers. Steeply dipping to the east.	Petrel Cove

Table 2.

SAMPLE NUMBERS	Al2O3 % 0.01 Fus/XRFm	Ag ppm 0.2 AT/MS	Au ppb 1 FA25/MS	As ppm 2 AT/MS	As ppm 20 Fus/XRFm	Ba ppm 100 Fus/XRFm	CaO % 0.01 Fus/XRFm	Ce ppm 0.01 AT/MS	Cl % 0.002 Fus/XRFm	Co ppm 0.1 AT/MS	Cr ppm 5 AT/OES
A222-001	11.06	X	2	X	X	679	0.26	66.71	0.006	29.4	24
A222-002	13.32	0.2	X	3	X	616	1.65	88.62	X	23.6	41
A222-003	18.76	X	2	6	22	1033	0.47	75.31	0.009	15.9	78
A222-005	15.12	X	8	2	X	782	1.51	95.01	0.110	18.6	77
A222-006	11.57	X	2	3	X	610	1.61	73.05	X	25.6	63
A222-007	10.93	X	X	X	X	865	1.37	91.82	0.015	35.3	47
A222-008	12.57	X	X	X	X	473	2.2	49.12	0.016	21.8	66
A222-009	13.57	X	10	90	100	989	0.4	8.16	0.009	11.4	83
A222-010	10.37	X	2	3	X	390	0.88	94.45	X	24.4	64
A222-011	10.7	X	X	X	X	805	0.33	73.2	0.004	22.7	23
A222-012	13.16	X	X	2	X	617	1.91	31.51	0.044	32.1	53
A222-013	17.32	X	X	3	X	1255	1.27	81.72	0.042	37.4	65
A222-014	11.55	X	X	2	X	311	2.4	79.63	0.092	25.0	59
A222-015	10.09	X	X	2	X	727	1.17	43.36	0.038	30.8	28
A222-016	12.9	X	2	X	X	1178	0.37	41.42	0.064	22.1	58
A222-017	10.06	X	X	X	X	500	1.49	28.91	X	28.6	23
A222-018	16.36	X	5	12	25	945	0.09	63.41	0.105	38.9	155
A222-019	9.55	X	X	X	X	705	0.41	52.12	0.009	28.0	25
A222-020	10.18	X	X	3	X	354	0.38	219.6	0.045	25.1	25
A222-021	13.17	X	X	X	X	612	2.1	73.26	0.042	20.5	40
A222-023	11.53	X	X	X	X	540	1.47	52.02	0.026	28.1	64
A222-024	16.83	X	2	3	X	739	1.65	89.61	0.099	25.6	59
A222-025	18.56	X	2	5	X	629	1.29	66.64	0.068	20.9	81

Table 2 (cont)

	Cu ppm 1 AT/OES	Dy ppm 0.01 AT/MS	Er ppm 0.01 AT/MS	Eu ppm 0.01 AT/MS	Fe2O3 % 0.01 Fus/XRFm	Ga ppm 0.1 AT/MS	Gd ppm 0.01 AT/MS	Hf ppm 0.01 AT/MS	Ho ppm 0.01 AT/MS	K2O % 0.01 Fus/XRFm	LOI % 0.01 /TGA	La ppm 0.01 AT/MS	Lu ppm 0.005 AT/MS
A222-001	3	2.90	1.29	1.07	2.85	12.4	3.87	2.49	0.53	2.65	0.85	35.68	0.164
A222-002	20	4.54	2.26	1.31	5.07	17.7	5.33	3.97	0.85	2.67	1.00	46.46	0.301
A222-003	61	5.87	3.25	1.52	6.60	26.7	6.71	3.06	1.19	5.36	3.07	37.56	0.451
A222-005	42	4.17	2.29	1.22	4.63	20.3	4.98	3.69	0.83	3.69	3.78	49.98	0.322
A222-006	24	3.98	2.00	1.16	3.91	13.8	4.50	2.22	0.75	2.02	0.77	38.62	0.277
A222-007	7	4.05	1.91	1.34	3.13	12.2	5.47	2.42	0.73	3.04	0.43	47.52	0.24
A222-008	7	3.43	2.08	0.80	4.25	15.5	3.23	2.59	0.74	1.73	0.71	23.50	0.321
A222-009	25	2.11	1.45	0.29	6.27	21.0	1.43	4.27	0.48	3.30	4.45	4.72	0.282
A222-010	19	4.38	1.99	1.70	2.65	11.0	5.92	1.98	0.79	1.22	1.27	49.97	0.248
A222-011	3	3.10	1.61	1.10	2.59	11.4	4.02	2.17	0.59	2.67	0.96	37.71	0.221
A222-012	10	2.92	1.32	0.93	5.38	17.7	3.17	3.66	0.53	2.86	1.01	14.04	0.161
A222-013	71	3.32	1.26	1.16	7.53	25.0	4.35	2.71	0.58	4.88	1.80	41.59	0.140
A222-014	11	4.82	2.72	1.19	4.33	13.3	5.22	2.77	0.99	1.97	0.67	42.24	0.391
A222-015	4	2.10	0.99	0.87	1.90	10.5	2.82	1.44	0.39	2.56	0.57	23.07	0.132
A222-016	4	2.63	1.56	0.57	3.61	16.9	2.66	1.78	0.55	6.62	1.40	20.58	0.192
A222-017	2	1.65	0.92	0.61	1.60	10.7	1.82	1.35	0.33	2.02	0.78	15.19	0.142
A222-018	8	2.48	1.12	0.93	13.72	32.6	3.69	1.41	0.45	6.84	2.74	30.73	0.130
A222-019	3	2.07	1.04	0.82	1.93	9.0	2.79	1.48	0.39	2.74	0.93	27.97	0.141
A222-020	3	7.8	3.57	3.18	1.85	9.3	11.66	1.44	1.38	1.26	0.68	122.38	0.399
A222-021	4	3.28	1.55	1.27	4.65	17	4.61	2.96	0.58	2.60	0.63	37.56	0.183
A222-023	33	6.03	3.71	1.12	4.01	12.8	5.37	5.27	1.30	2.15	0.79	22.03	0.507
A222-024	8	3.64	1.59	1.54	6.95	22.1	5.56	3.04	0.61	4.29	1.68	46.85	0.202
A222-025	54	5.46	3.26	1.50	7.42	24.1	6.36	2.81	1.14	4.15	3.73	27.38	0.466

Table 2 (cont)

	MgO % 0.01 Fus/XRFm	MnO % 0.005 Fus/XRFm	Mo ppm 0.1 AT/MS	Na2O % 0.01 Fus/XRFm	Nb Ppm 0.05 AT/MS	Nd ppm 0.01 AT/MS	Ni ppm 1 AT/OES	P2O5 % 0.002 Fus/XRFm	Pb ppm 2 AT/MS	Pd ppb 1 FA25/MS	Pr ppm 0.005 AT/MS	Pt ppb 1 FA25/MS	Rb ppm 0.05 AT/MS
A222-001	0.87	0.135	0.5	3.48	5.69	29.63	16	0.143	20	X	7.746	X	90.07
A222-002	2.39	0.072	0.3	2.47	12.09	38.36	33	0.187	22	X	10.21	X	129.67
A222-003	2.80	0.045	0.6	1.26	16.38	38.32	29	0.027	20	2	9.484	2	239.59
A222-005	1.63	0.036	7.9	1.97	13.73	40.27	13	0.186	45	6	10.889	2	162.87
A222-006	1.69	0.043	0.4	2.33	8.33	32.42	21	0.148	37	3	8.489	X	101.8
A222-007	1.27	0.048	0.4	2.28	5.32	39.71	17	0.176	26	X	10.451	X	108.71
A222-008	1.78	0.066	0.1	3.09	8.82	21.6	25	0.178	18	X	5.884	X	97.66
A222-009	0.81	0.007	20.4	1.43	12.37	3.62	X	0.033	25	4	0.899	2	136.12
A222-010	0.89	0.015	0.4	2.77	5.08	41.78	8	0.044	25	X	11.04	X	64.02
A222-011	0.87	0.04	0.3	2.39	7.43	32.27	13	0.180	8	X	8.487	X	89.46
A222-012	2.64	0.076	0.3	2.00	12.44	14.6	39	0.187	22	3	3.746	X	136.05
A222-013	3.54	0.090	0.4	1.47	15.08	36.52	58	0.174	19	X	9.63	X	208.26
A222-014	1.82	0.068	0.2	2.55	9.78	34.77	23	0.181	16	X	9.167	X	100.89
A222-015	0.77	0.029	0.3	2.45	3.69	19.21	12	0.084	23	X	5.038	X	84.54
A222-016	1.18	0.075	0.3	0.57	6.81	17.08	24	0.132	15	X	4.604	X	210.35
A222-017	0.58	0.027	0.4	2.21	1.88	11.76	9	0.050	10	X	3.177	X	68.79
A222-018	5.43	0.103	0.2	1.48	17.2	27.24	115	0.053	5	3	7.092	X	344.33
A222-019	0.59	0.027	0.4	2.93	2.81	21.55	8	0.072	7	X	5.899	X	80.11
A222-020	0.67	0.011	0.4	3.92	3.11	113.94	10	0.052	15	X	31.24	X	58.40
A222-021	2.33	0.07	X	2.53	11.51	31.94	34	0.147	26	X	8.264	X	127.86
A222-023	1.74	0.055	0.2	3.31	11.59	25.66	22	0.279	16	X	6.503	X	93.57
A222-024	3.54	0.067	0.2	2.22	14.68	39.69	45	0.072	31	X	10.392	X	206.20
A222-025	3.45	0.064	0.3	1.60	12.68	39.46	40	0.120	30	4	9.436	X	188.41

Table 2 (cont)

	S	Sc	SiO2	Sm	Sn	Sr	Ta	Tb	Th	TiO2	Tm	Total	U
	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	%	ppm
	50	1	0.01	0.01	0.1	0.05	0.01	0.005	0.01	0.01	0.01	0.01	0.01
	AT/OES	AT/OES	Fus/XRFm	AT/MS	AT/MS	AT/MS	AT/MS	AT/MS	AT/MS	Fus/XRFm	AT/MS	Fus/XRFm	AT/MS
A222-001	X	6	77.61	5.33	2.0	150.69	0.6	0.556	11.42	0.36	0.18	100.38	2.28
A222-002	X	11	69.97	6.89	3.3	159.19	1.05	0.830	21.81	0.66	0.32	99.58	4.01
A222-003	53	17	60.35	7.56	5.1	104.57	1.19	1.031	18.71	0.79	0.48	99.73	4.19
A222-005	2859	13	66.15	6.94	4.2	207.11	1.15	0.790	19.31	0.69	0.34	99.42	5.13
A222-006	58	8	75.95	5.74	2.5	225.54	0.71	0.714	14.77	0.49	0.29	100.66	2.96
A222-007	X	8	77.61	7.25	2.0	184.46	0.68	0.803	17.48	0.46	0.26	100.89	2.16
A222-008	53	9	73.85	4.04	2.5	205.25	0.62	0.555	17.74	0.6	0.32	101.15	3.10
A222-009	1675	14	69.27	1.07	4.3	93.24	0.87	0.305	21.45	0.78	0.24	100.36	3.39
A222-010	X	6	79.97	7.65	1.6	227.46	0.41	0.901	11.96	0.38	0.28	100.55	2.68
A222-011	X	7	79.81	5.51	2.1	134.41	0.60	0.611	13.36	0.41	0.23	101.07	2.23
A222-012	430	11	71.04	3.2	3.9	189.29	1.09	0.512	15.85	0.68	0.18	101.22	2.32
A222-013	X	16	61.30	6.84	5.6	130.93	1.26	0.658	17.33	0.80	0.16	100.43	1.83
A222-014	395	9	75.00	6.13	2.7	261.01	0.84	0.810	16.43	0.58	0.4	101.4	2.51
A222-015	X	4	80.64	3.52	1.6	218.9	0.53	0.410	7.53	0.22	0.14	100.62	1.57
A222-016	121	8	73.72	3.14	2.8	92.48	0.70	0.450	9.16	0.41	0.22	101.26	0.83
A222-017	X	3	82.18	2.16	1.3	179.51	0.19	0.284	5.90	0.17	0.14	101.25	1.43
A222-018	107	18	51.73	4.87	7.5	102.76	1.09	0.508	6.03	1.40	0.16	100.26	2.09
A222-019	X	4	81.36	3.71	1.3	130.39	0.42	0.405	8.51	0.21	0.15	100.85	2.83
A222-020	108	5	81.79	19.11	1.5	196.41	0.41	1.581	8.76	0.23	0.49	101.15	1.53
A222-021	X	9	71.81	5.79	3.1	224.87	0.92	0.661	12.48	0.57	0.21	100.78	2.51
A222-023	110	10	74.40	5.54	2.7	206.05	1.08	0.940	21.42	0.68	0.55	100.57	3.15
A222-024	148	15	62.31	7.23	4.7	204.02	1.17	0.794	19.76	0.70	0.22	100.59	3.13
A222-025	126	17	59.98	7.80	4.6	133.69	0.71	0.982	18.85	0.73	0.47	101.34	2.91

Table 2 (cont)

	V	W	Y	Yb	Zn	Zr
	ppm	ppm	ppm	ppm	ppm	ppm
	2	0.1	0.05	0.01	1	0.1
	AT/OES	AT/MS	AT/MS	AT/MS	AT/OES	AT/MS
A222-001	38	156.5	11.88	1.12	33	86.0
A222-002	74	94.1	21.87	2.02	89	139.1
A222-003	122	16.9	34.00	3.02	138	113.4
A222-005	138	78.6	20.93	2.11	164	119.7
A222-006	55	143.2	20.09	1.83	116	84.8
A222-007	45	176.4	19.03	1.60	58	73.9
A222-008	63	70.2	18.29	2.07	73	87.2
A222-009	140	43.6	12.66	1.69	11	144
A222-010	39	108.9	19.07	1.67	56	66.9
A222-011	39	150.4	15.26	1.42	41	75.8
A222-012	77	151.3	13.19	1.09	86	124.1
A222-013	111	110	11.51	0.94	120	98.8
A222-014	63	140.9	25.67	2.60	63	94.5
A222-015	29	188.8	10.18	0.85	27	46.3
A222-016	49	90.2	14.44	1.31	56	49.5
A222-017	23	111.7	8.57	0.91	9	44.4
A222-018	152	20.2	12.36	0.94	136	47.0
A222-019	23	154.7	10.72	0.91	12	50.3
A222-020	28	110	33.73	2.84	18	51.4
A222-021	68	60.1	15.04	1.23	79	105.3
A222-023	62	153.4	35.23	3.47	56	185.3
A222-024	101	63.6	16.34	1.33	101	109.5
A222-025	117	22.2	29.37	2.98	132	97.0

Table 3.

Sample no.	Bomb no.	Weight of Sample	Spike	Ndppm	Smppm	$^{143}Nd/^{144}Nd$	$^{147}Sm/^{144}Nd$	εNd
1	36	0.07873	0.388929	30.93	5.15	0.511677	0.10053	-13.11
5	40	0.07873	0.37706	38.96	6.73	0.511696	0.10446	-12.82
7	32	0.07148	0.40044	35.31	6.32	0.511628	0.10818	-14.46
9	41	0.07788	0.37939	3.29	1.23	0.512168	0.20697	-16.68
12	39	0.07590	0.38022	13.83	3.14	0.511750	0.13733	-15.11
13	34	0.07588	0.32725	34.5	6.35	0.511696	0.11136	-13.37
15	35	0.07296	0.36103	18.73	3.6	0.511713	0.11464	-13.85
17	31	0.08931	0.38872	13.36	2.5	0.511720	0.11292	-14.11
18	30	0.07647	0.37673	27.85	5.1	0.511731	0.11065	-12.8
21	37	0.08572	0.39288	33.6	6.31	0.511648	0.11349	-14.47
26	38	0.06539	0.33528	32.92	6.18	0.511626	0.11351	-14.91
27	40	0.07311	0.39607	26.74	4.97	0.511626	0.11238	-15.00
28	35	0.07406	0.45607	20.45	3.9	0.511718	0.11520	-13.69
29	13	0.07320	0.39805	31.21	5.76	0.511735	0.11162	-12.69
30	34	0.07570	0.37664	23.17	4.8	0.511760	0.12494	-13.38
31	37	0.07450	0.41070	16.65	3.5	0.511701	0.12671	-15.06
32	30	0.06550	0.3897	30.64	3.16	0.511621	0.06240	-11.63
33	31	0.07500	0.3878	38.86	7.2	0.511695	0.11244	-13.39
TasBas	**33**	**0.0578**	**0.4341**	**15.7**	**3.12**	**0.512949**	**0.11955**	**6.77**

Appendices

Appendix 1.
Middleton Formation

LITHOCODE	SiO2	Al2O3	TiO2	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI
MSLT	60.20	19.10	0.83	5.47	0.01	2.77	0.59	1.08	6.50	0.15	2.70
MSST	66.80	13.60	0.68	5.50	0.07	2.32	1.69	3.56	3.02	0.26	0.81
QTZT	76.60	11.40	0.34	3.08	0.01	1.50	2.75	2.87	1.28	0.08	0.51
SDST	81.60	9.75	0.19	1.61	-0.01	0.28	0.18	3.28	2.32	0.06	0.55

Ni	Pb	Pd	Pt	Rb	Sb	Sc	Se	Sn	Sr	Ta	Th
85.00	6.00	1.00	0.25	0.00	0.00	0.00	0.00	0.00	67.00	0.00	20.00
50.00	10.00	0.00	0.00	0.00	0.00	20.00	0.00	25.00	210.00	25.00	0.00
42.00	6.00	0.25	0.25	0.00	0.00	0.00	0.00	0.00	277.00	0.00	5.00
25.00	25.00	0.00	0.00	0.00	0.00	5.00	0.00	25.00	140.00	25.00	0.00

Tl	U	V	W	Y	Zn	Zr	Ag	As	Au	Ba	Be
1.40	4.09	127.00	6.80	0.00	48.00	176.00	0.05	22.00	0..50	1743.00	0.00
0.00	0.00	90.00	0.00	35.00	55.00	300.00	0.50	25.00	10.00	660.00	5.00
0.70	1.80	44.00	0.50	0.00	16.00	128.00	0.05	16.00	0.50	139.00	0.00
0.00	0.00	-20.00	0.00	10.00	15.00	120.00	0.50	25.00	10.00	760.00	5.00

Bi	Cd	Ce	Co	Cr	Cu	Ga	La	Mn	Mo	Na	Nb	Nd
0.00	0.00	83.00	13.00	125.00	2.50	0.00	44.00	0.00	0.00	0.00	0.00	36.00
0.00	10.00	300.00	40.00	100.00	1.00	0.00	50.00	0.00	10.00	0.00	25.00	0.00
0.00	0.00	58.00	6.00	48.00	2.50	0.00	33.00	0.00	0.00	0.00	0.00	24.00
0.00	10.00	50.00	50.00	20.00	1.00	0.00	25.00	0.00	10.00	0.00	25.00	0.00

Petrel Cove Formation

LITHOCODE	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI
AVER	59.54	18.95	0.77	7.31	0.09	3.79	1.15	1.76	4.10	0.15	2.30
SCHT	59.54	20.99	0.91	3.46	0.05	6.15	1.33	2.69	1.56	0.18	2.30
SCHT	58.21	18.33	0.77	7.31	0.09	3.70	0.89	1.79	4.56	0.16	2.51

Ag	As	Au	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Ga
0.00	0.00	0.00	426.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	426.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

La	Mn	Mo	Na	Nb	Nd	Ni	Pb	Pd	Pt	Rb	Sb
0.00	0.00	0.00	0.00	21.00	0.00	0.00	0.00	0.00	0.00	48.00	0.00
0.00	0.00	0.00	0.00	20.50	0.00	0.00	0.00	0.00	0.00	48.40	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sc	Se	Sn	Sr	Ta	Th	Tl	U	V	W	Y	Zn	Zr
25.00	0.00	0.00	184.00	0.00	25.00	0.00	0.00	0.00	0.00	43.00	0.00	0.00
25.20	0.00	0.00	184.00	0.00	25.10	0.00	0.00	0.00	0.00	43.00	0.00	152.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Balquhidder Formation

LITHOCODE	SiO2	Al2O3	TiO2	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI
PHYL	55.05	20.31	0.79	8.06	0.08	4.15	1.41	1.35	5.82	0.15	2.22
PHYL	55.76	19.61	0.79	8.16	0.07	4.03	1.38	1.78	5.15	0.15	2.47
PHYL	66.26	13.79	0.74	4.88	0.01	0.88	1.37	1.72	3.10	0.07	6.30
QTZT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SDST	76.00	11.60	0.46	3.20	0.04	1.12	1.16	2.88	1.80	0.17	1.53
SDST	71.75	12.10	0.58	6.22	0.15	2.14	4.29	0.80	1.19	0.19	1.15
SDST	72.00	12.50	0.61	4.54	0.09	1.97	1.90	3.02	1.93	0.22	1.15
SLST	55.10	19.45	0.79	8.37	0.08	4.27	0.52	0.72	6.89	0.16	2.26
SLST	58.99	18.33	0.77	7.31	0.09	3.70	0.89	1.79	4.56	0.16	2.51

Ag	As	Au	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Ga
0.00	0.00	0.00	1004.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	513.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00
0.03	2.00	1.00	0.00	0.00	0.25	0.50	0.00	0.10	210.00	24.00	0.00
0.50	0.25	0.10	480.00	0.50	0.00	0.10	50.00	40.00	50.00	20.00	0.00
0.01	21.00	20.00	150.00	0.00	0.00	0.00	0.00	25.00	60.00	115.00	17.50
0.50	0.25	0.10	520.00	0.50	0.00	0.10	50.00	80.00	70.00	16.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

La	Mn	Mo	Na	Nb	Nd	Ni	Pb	Pd	Pt	Rb	Sb
0.00	0.00	0.00	0.00	16.70	0.00	0.00	0.00	0.00	0.00	228.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	16.30	0.00	0.00	0.00	0.00	0.00	109.00	0.00
0.00	30.00	-1.00	0.00	0.00	0.00	0.50	90.00	1.00	2.50	0.00	2.50
0.25	0.00	0.10	0.00	25.00	0.00	25.00	70.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	11.00	0.00	66.00	12.00	0.50	0.25	65.00	0.00
0.25	0.00	10.00	0.00	25.00	0.00	25.00	20.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sc	Se	Sn	Sr	Ta	Th	Tl	U	V	W	Y	Zn	Zr
21.90	0.00	0.00	116.00	0.00	17.60	0.00	0.00	0.00	0.00	33.00	0.00	113.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.20	0.00	0.00	167.00	0.00	25.40	0.00	0.00	0.00	0.00	13.60	0.00	171.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	260.00	0.00	0.00	6.00	0.00
10.00	0.00	25.00	190.00	25.00	0.00	0.00	0.00	50.00	0.00	20.00	200.00	240.00
10.00	1.50	2.00	150.00	0.00	20.00	0.00	4.10	64.00	0.40	38.00	80.00	320.00
10.00	0.00	25.00	210.00	25.00	0.00	0.00	0.00	70.00	0.00	20.00	90.00	330.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Tunkalilla Formation

LITHOCODE	SiO2	Al2O3	TiO2	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI
MDST	81.91	5.45	0.73	3.75	0.01	0.35	0.12	0.29	1.72	0.07	5.62
MDST	55.44	9.04	0.58	13.67	0.01	0.65	0.1	1.28	3.19	0.08	14.64
MDST	53.2	13.6	0.63	14.05	0.01	1.01	0.42	0.89	4.33	0.15	10.94
MGYW	72.05	12.4	0.56	5.08	0.06	2.01	2.19	2.4	1.88	0.12	0.74
MGYW	78.6	10.6	0.58	1.21	0.01	0.45	1.64	1.65	1.32	0.14	3.77
MGYW	68.7	13.7	0.66	4.88	0.08	2.42	2.9	2.28	2.4	0.14	1.22
MSLT	66	15	0.76	4.98	0.03	1.67	0.92	1.78	4.52	0.17	3.74
MSLT	67.6	14.7	0.76	4.34	0.03	1.71	1.19	1.56	4.16	0.22	3.44
MSLT	68.6	15.9	0.76	4.06	0.02	0.85	0.18	1.07	3.88	0.08	4.7
MSLT	60.3	16.1	0.73	8.23	0.06	2.86	1.25	1.3	4.51	0.13	3.69
MSLT	64	15.6	0.77	6.38	0.1	2.98	2.43	2.56	2.99	0.17	1.18
MSLT	56.43	19.92	0.75	7.79	0.1	3.8	0.76	0.88	4.83	0.11	3.9
MSLT	59.38	18.26	0.75	7.17	0.07	3.17	0.18	1.53	3.91	0.08	4.13
PHYL	68.4	15.4	0.77	4.62	0.01	0.63	0.98	1.42	3.1	0.17	4.36
PHYL	61.23	17.03	0.76	7.84	0.07	3.5	0.38	1.31	4.52	0.16	2.9
SDST	71.2	12.5	0.73	5	0.07	2.02	0.39	3.08	2.9	0.24	1.35
SLST	62	19.4	1.64	2	0.01	0.45	2.29	7.7	1.57	0.06	1.99
SLST	67.05	17.85	1.23	2.77	0.01	1.23	0.08	1	5.27	0.04	3.04
SLST	59.52	17.87	0.75	7.47	0.07	3.41	1.37	1.31	4.76	0.1	2.41

Ag	As	Au	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Ga
0.2	107	9	816	0	0	0	42	2.5	60	47	0
0.2	270	6	1092	0	0	0	43	2.5	74	42	0
0.1	343	6	1023	0	0	0	92	5	90	64	0
1.2	47	6	600	0	0	0	100	15	70	15	0
0.2	65	1	314	0	0	0	85	2.5	168	27	0
0.1	32	0.5	648	0	0	0	79	8	114	10	0
0.5	25	10	920	0	0	10	100	10	90	35	0
0.5	25	10	840	0	0	10	100	30	90	25	0
0.5	25	10	1200	0	0	10	250	30	110	25	0
0.1	49	2	1260	0	0	0	68	13	94	42	0
0.1	32	0.5	881	0	0	0	52	18	96	7	0
0	0	0	1088	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
2	25	10	680	0	0	10	150	10	90	20	0
0	0	0	0	0	0	0	0	0	0	0	0
0.5	25	10	820	0	0	10	100	40	90	2	0
0.1	1	0.5	150	0	0	0	200	5	75	5	0
0.1	11	0.5	360	0	0	0	100	2.5	210	5	0
0.1	4	0.5	792	0	0	0	57	22	108	32	0

La	Mn	Mo	Na	Nb	Nd	Ni	Pb	Pd	Pt	Rb	Sb
21	0	0	0	0	13	6	647	0	0	0	0
27	0	0	0	0	11	6	223	0	0	0	0
89	0	0	0	0	23	35	501	4.5	3	0	0
0	0	0	0	0	40	26	54	0	0	0	0
47	0	0	0	0	38	7	79	1.5	1	0	0
42	0	0	0	0	35	22	58	0.5	0.5	0	0
25	0	10	0	25	0	25	35	0	0	0	0
50	0	10	0	25	0	25	20	0	0	0	0
25	0	10	0	25	0	25	65	0	0	0	0
54	0	0	0	0	25	39	52	1.5	0.5	0	0
27	0	0	0	0	22	87	23	0.5	0.5	0	0
0	0	0	0	18.2	0	0	0	0	0	184	0
0	0	0	0	0	0	0	0	0	0	0	0
25	0	10	0	25	0	25	25	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
25	0	10	0	25	0	25	7	0	0	0	0
115	0	0	0	0	60	8	9	0	0	0	0
50	0	0	0	0	40	64	4	0	0	0	0
27	0	0	0	0	26	54	18	0	0	0	0

Sc	Se	Sn	Sr	Ta	Th	Tl	U	V	W	Y	Zn	Zr
0	0	0	70	0	12	0	8.13	120	3	0	75	205
0	0	0	114	0	13	0	6.19	154	2.2	0	109	145
0	0	0	142	0	21	4.3	6.05	271	3.3	0	567	159
0	0	0	295	0	20	0	3.75	68	3	0	160	260
0	0	0	234	0	18	1.6	5.27	57	1.5	0	25	249
0	0	0	249	0	19	2.9	3.63	72	0.6	0	84	213
20	0	25	180	50	0	0	0	110	0	35	155	240
20	0	25	180	50	0	0	0	110	0	55	75	250
25	0	25	70	50	0	0	0	130	0	10	25	280
0	0	0	179	0	18	3.8	3.64	117	5.3	0	202	164
0	0	0	172	0	18	1.2	3.11	88	2.7	0	97	235
22.6	0	0	73	0	16.6	0	0	0	0	24.9	0	117
0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	25	170	50	0	0	0	120	0	5	30	300
0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	25	160	50	0	0	0	80	0	25	90	490
0	0	0	395	0	20	0.5	1.3	28	2.8	0	10	335
0	0	0	30	0	20	0.5	2.6	150	1.5	0	10	185
0	0	0	123	0	19	0	2.88	118	4	0	81	153

Tapanappa Formation

LITHOCODE	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Ag	As
GYWK	66.40	14.35	0.61	6.91	0.05	1.77	0.02	0.10	2.30	0.00	6.62	0.05	7.00
GYWK	70.70	11.50	0.61	5.73	0.04	1.69	0.90	1.25	1.98	0.03	4.71	0.05	2.00
GYWK	72.20	12.70	0.60	4.76	0.06	2.05	1.97	2.25	2.13	0.09	0.90	0.05	1.00
MGYW	50.20	14.30	0.56	11.31	0.26	2.75	8.69	1.20	3.67	0.13	6.61	0.40	71.00
MGYW	61.90	17.30	0.72	6.66	0.09	2.97	1.38	2.01	4.94	0.15	1.95	0.20	2.00
MGYW	62.20	16.90	0.75	6.91	0.08	3.37	1.56	1.87	3.47	0.17	1.99	0.05	19.00
MGYW	64.10	15.00	0.80	7.07	0.08	3.05	3.57	1.56	3.09	0.15	2.38	0.50	45.00
MGYW	65.00	11.70	0.58	9.15	0.25	2.51	4.84	0.85	1.52	0.20	4.21	0.25	8.00
MGYW	65.60	14.25	0.71	5.96	0.12	2.88	5.12	1.35	1.80	0.17	1.02	0.10	4.00
MGYW	66.35	14.05	0.68	6.00	0.08	2.84	3.23	1.90	2.45	0.16	1.46	0.05	6.00
MGYW	66.90	14.40	0.72	6.03	0.10	2.81	5.18	1.34	1.90	0.16	1.33	0.25	12.00
MGYW	67.00	14.00	0.71	5.32	0.07	2.56	2.56	2.35	2.98	0.19	1.19	0.10	4.00
MGYW	67.55	13.65	0.72	5.40	0.11	2.53	4.43	1.15	2.31	0.19	1.31	0.20	2.00
MGYW	68.00	14.40	0.66	6.02	0.07	2.61	0.66	1.70	4.27	0.16	1.84	0.10	1.00
MGYW	68.10	13.90	0.66	5.27	0.05	2.52	0.41	3.01	2.73	0.17	2.55	0.20	13.00
MGYW	68.90	14.20	0.58	4.88	0.05	1.86	0.40	1.66	5.91	0.16	1.95	0.40	5.00
MGYW	68.90	13.90	0.66	5.43	0.08	2.39	2.40	2.54	2.42	0.16	0.66	0.05	53.00
MGYW	69.14	12.92	0.58	5.50	0.06	2.12	1.42	1.85	3.48	0.16	2.16	0.05	5.00
MGYW	69.40	12.90	0.65	5.84	0.16	2.11	3.95	1.25	1.90	0.19	1.21	0.05	56.00
MGYW	69.60	13.00	0.81	5.40	0.05	2.35	0.41	3.01	2.07	0.22	3.02	1.20	23.00
MGYW	69.80	13.60	0.66	5.19	0.06	2.37	1.74	2.12	3.06	0.18	0.79	0.05	76.00
MGYW	70.05	12.84	0.64	5.11	0.07	1.93	2.36	2.84	2.00	0.19	1.52	0.10	6.00
MGYW	70.30	13.60	0.63	5.04	0.07	2.34	2.22	2.87	2.31	0.17	0.42	0.05	39.00
MGYW	70.40	11.30	0.90	5.14	0.02	2.38	1.98	2.47	3.00	0.23	1.15	0.10	140.00
MGYW	70.46	12.24	0.73	5.94	0.11	2.15	2.02	2.31	1.85	0.19	1.65	0.05	2.00

MGYW	70.50	12.81	0.56	5.22	0.06	1.94	1.81	2.20	3.03	0.14	1.53	0.05	4.00
MGYW	70.55	12.75	0.63	5.07	0.06	2.03	1.54	2.60	3.56	0.17	0.64	0.05	9.00
MGYW	70.64	13.13	0.62	5.04	0.05	1.95	1.68	2.05	2.44	0.04	2.12	0.05	7.00
MGYW	70.70	12.30	0.62	4.94	0.08	2.00	2.37	2.80	1.98	0.17	1.21	0.05	2.00
MGYW	70.73	13.36	0.60	5.26	0.07	2.12	1.38	2.17	2.25	0.17	1.43	0.05	2.00
MGYW	70.95	12.00	0.59	5.07	0.07	2.17	2.34	2.70	1.95	0.16	0.97	0.05	2.00
MGYW	71.20	12.90	0.63	4.70	0.05	2.08	1.40	1.72	3.14	0.17	0.96	0.05	16.00
MGYW	71.30	12.30	0.57	4.59	0.08	2.15	4.02	1.00	1.43	0.16	1.46	0.20	3.00
MGYW	71.50	12.80	0.61	4.96	0.06	2.30	1.62	2.17	3.35	0.14	1.29	0.25	5.00
MGYW	71.50	12.80	0.60	5.17	0.06	1.91	0.92	2.70	3.29	0.16	1.35	0.10	3.00
MGYW	71.55	12.18	0.52	4.55	0.06	1.64	2.39	2.07	1.99	0.17	2.34	0.00	0.00
MGYW	71.90	12.30	0.58	4.93	0.07	1.85	1.45	2.80	2.79	0.16	1.01	0.05	0.50
MGYW	72.20	12.60	0.57	4.86	0.04	1.91	1.00	2.40	2.96	0.12	1.33	0.05	2.00
MGYW	72.35	12.10	0.57	4.90	0.11	2.07	4.86	1.20	1.30	0.17	0.89	0.10	8.00
MGYW	72.40	11.80	0.52	4.76	0.12	1.75	3.04	1.00	2.46	0.16	1.20	0.10	7.00
MGYW	72.40	12.10	0.60	4.85	0.07	2.12	2.07	2.56	2.03	0.15	0.50	0.05	32.00
MGYW	72.43	12.64	0.61	4.88	0.03	2.13	2.03	2.00	2.63	0.17	0.99	0.05	0.50
MGYW	72.60	11.73	0.73	5.11	0.08	2.01	1.87	1.98	2.56	0.19	0.80	2.30	3.00
MGYW	72.72	11.32	0.52	4.65	0.06	1.66	1.03	2.20	2.86	0.14	2.60	0.05	4.00
MGYW	72.80	11.50	0.59	4.42	0.06	1.78	1.19	2.29	2.73	0.15	1.08	0.25	3.00
MGYW	72.85	11.15	0.53	5.03	0.15	1.90	5.21	0.60	0.95	0.14	1.11	0.10	5.00
MGYW	72.95	12.05	0.57	4.66	0.07	1.78	1.56	2.60	2.49	0.15	1.03	0.05	2.00
MGYW	72.96	11.82	0.56	5.01	0.08	1.80	1.27	2.35	3.12	0.16	0.93	0.05	3.00
MGYW	73.40	11.50	0.56	5.16	0.06	2.30	1.90	1.97	2.32	0.17	0.75	0.05	13.00
MGYW	73.45	11.50	0.60	4.94	0.07	1.82	1.88	2.35	2.41	0.17	0.40	0.05	8.00
MGYW	73.60	11.60	0.51	4.59	0.06	1.92	1.62	2.45	2.41	0.15	1.10	0.20	21.00
MGYW	74.10	11.40	0.66	6.30	0.07	1.77	0.23	0.29	3.73	0.20	1.50	0.05	18.00
MGYW	74.10	12.90	0.63	1.91	0.02	1.24	1.66	2.02	3.05	0.10	1.98	0.05	67.00
MGYW	74.45	10.95	0.54	4.15	0.05	1.73	2.00	2.65	1.59	0.16	0.85	0.20	11.00
MGYW	74.48	11.36	0.55	4.30	0.07	1.51	1.10	2.91	2.70	0.16	0.84	0.05	1.00
MGYW	74.90	11.20	0.67	4.63	0.05	1.58	1.37	2.52	2.30	0.21	1.07	0.20	4.00
MGYW	75.30	11.20	0.51	4.10	0.03	1.14	0.69	2.79	3.11	0.16	1.15	0.30	10.00

MGYW	77.70	10.20	0.41	3.82	0.06	1.30	2.00	2.47	1.42	0.12	0.73	0.20	11.00
MGYW	78.20	4.44	0.24	6.58	0.16	0.34	0.27	0.06	0.15	0.02	3.59	17.40	8.00
MGYW	80.20	9.23	0.25	3.11	0.03	1.06	1.36	2.53	1.20	0.08	0.68	0.20	2.00
MGYW	68.90	13.75	0.66	5.57	0.07	2.23	1.57	2.15	3.03	0.03	1.56	0.05	4.00
MGYW	68.25	14.35	0.67	5.68	0.08	2.56	2.16	2.25	2.98	0.01	1.15	0.10	1.00
MGYW	66.34	15.55	0.67	5.30	0.03	1.45	0.34	3.35	3.62	0.07	2.82	0.20	5.00
MGYW	68.50	14.05	0.69	5.64	0.08	2.49	2.15	2.40	2.84	0.04	1.16	0.05	3.00
MGYW	68.05	14.50	0.69	5.45	0.07	2.57	2.27	2.40	2.85	0.04	1.22	0.10	3.00
QTZT	78.20	9.75	0.43	3.93	0.05	1.39	1.35	2.10	1.99	0.12	0.70	0.10	3.00
SDST	62.60	8.30	0.67	8.84	0.01	0.06	0.05	0.65	6.77	0.07	10.25	0.80	179.00
SDST	67.95	12.75	0.88	5.13	0.02	0.08	0.31	3.85	3.17	0.14	5.61	1.20	36.00
SDST	68.05	13.25	0.63	5.47	0.07	2.46	4.23	1.15	1.81	0.15	1.83	0.30	5.00
SDST	68.15	11.20	0.50	5.98	0.13	1.83	3.85	2.00	2.03	0.14	2.73	0.20	27.00
SDST	71.50	12.35	0.56	4.93	0.07	2.17	2.30	2.15	2.31	0.15	0.94	0.20	0.50
SDST	74.00	11.20	0.54	4.33	0.06	1.61	1.89	2.50	1.98	0.10	0.98	0.10	3.00
SDST	74.40	10.15	0.64	5.13	0.08	1.71	2.11	2.10	1.66	0.14	0.93	0.10	0.50
SDST	75.10	9.90	0.49	5.99	0.21	0.82	0.17	1.60	2.48	0.22	3.92	0.25	17.00
SDST	76.40	10.70	0.45	4.11	0.05	1.36	1.91	2.70	1.56	0.14	0.66	0.10	3.00
SDST	76.50	11.10	0.38	2.56	0.03	0.93	0.47	3.62	2.66	0.19	0.61	0.50	25.00
SDST	77.60	9.99	0.41	3.50	0.07	0.82	2.94	2.50	0.80	0.12	1.50	0.10	3.00
SDST	77.85	9.65	0.54	3.88	0.05	1.27	2.13	1.85	1.48	0.15	0.74	0.10	9.00
SDST	78.70	8.16	0.20	3.97	0.02	0.73	1.28	1.07	1.40	0.08	2.58	0.25	3.00
SDST	83.15	7.85	0.21	2.11	0.02	0.73	1.12	2.10	0.90	0.06	0.72	0.10	2.00
MSST	53.20	15.00	0.60	11.98	0.16	1.51	6.52	3.43	0.44	0.13	6.35	0.20	52.00
MSLT	53.50	20.20	0.85	9.06	0.09	3.71	0.71	0.88	6.16	0.17	3.64	0.05	37.00
MSLT	55.20	20.10	0.83	8.21	0.08	3.81	1.02	1.63	5.85	0.10	2.65	0.05	39.00
MSLT	55.80	19.60	0.77	8.07	0.10	3.80	0.91	1.98	5.90	0.14	3.08	0.05	3.00
MSLT	56.00	19.30	0.82	8.55	0.09	4.19	0.62	0.91	6.47	0.16	2.28	0.05	23.00
MSLT	56.44	18.93	0.83	8.02	0.05	3.76	1.98	2.13	5.13	0.16	1.97	0.05	13.00
MSLT	56.60	17.60	0.71	6.90	0.04	2.93	0.70	2.29	4.36	0.12	7.52	0.10	24.00
MSLT	56.60	18.70	0.79	8.11	0.08	4.11	0.93	0.89	6.06	0.16	2.60	0.05	9.00
MSLT	57.00	19.00	0.84	7.47	0.05	4.05	0.47	1.04	4.77	0.11	4.97	0.30	25.00

MSLT	57.20	19.73	0.84	7.57	0.06	3.69	0.45	0.76	6.12	0.15	2.51	0.00	0.00
MSLT	57.20	19.50	0.83	7.56	0.10	3.51	1.35	2.21	5.46	0.16	2.22	0.10	11.00
MSLT	57.94	13.39	0.66	10.80	0.06	2.18	1.63	2.12	3.03	0.15	7.05	0.20	24.00
MSLT	58.10	18.60	0.73	7.28	0.09	3.40	1.86	3.27	4.13	0.15	2.23	0.10	8.00
MSLT	58.60	18.25	0.74	7.62	0.07	3.56	1.48	1.65	4.66	0.14	2.99	0.05	12.00
MSLT	58.88	19.52	0.81	13.38	0.19	3.86	0.37	0.20	3.50	0.12	0.75	0.00	0.00
MSLT	60.00	17.13	0.70	8.20	0.06	2.91	0.75	1.80	5.40	0.14	3.16	0.10	9.00
MSLT	60.30	18.10	0.77	7.05	0.08	3.38	1.19	1.58	5.19	0.09	1.95	0.05	63.00
MSLT	60.69	16.66	0.73	7.53	0.08	3.27	2.36	1.99	3.58	0.15	2.39	0.10	8.00
MSLT	60.70	17.30	0.78	7.20	0.09	3.19	1.23	3.13	4.50	0.16	1.61	0.10	2.00
MSLT	60.94	16.35	0.75	7.11	0.06	3.36	1.99	1.57	4.74	0.15	2.11	0.05	5.00
MSLT	62.17	16.35	0.73	7.02	0.12	3.20	2.17	1.73	3.97	0.17	1.39	0.00	0.00
MSLT	63.65	15.88	0.71	6.61	0.07	2.92	1.18	1.67	4.60	0.15	2.21	0.05	6.00
MSLT	67.70	16.50	0.56	3.47	0.01	0.91	0.01	0.21	4.92	0.01	4.42	0.20	0.00
MSLT	67.72	4.02	0.14	19.97	0.01	0.24	0.10	0.10	1.69	0.10	4.75	0.60	97.00
MSLT	55.15	20.85	0.91	7.06	0.10	3.29	0.72	1.30	6.41	0.03	3.54	0.10	4.00
MSLT	59.45	18.05	0.82	7.14	0.09	3.41	1.12	1.35	5.33	0.06	2.73	0.05	7.00
MSLT	76.00	11.10	0.57	3.57	0.05	1.26	1.33	2.30	2.43	0.03	0.89	0.10	2.00
MSLT	67.80	14.35	0.70	5.73	0.08	2.66	1.95	2.25	2.84	0.14	1.52	0.20	2.00
MSLT	60.85	16.6	0.77	7.96	0.1	3.35	1.49	1.75	3.73	0.13	3.24	0.1	7
MSLT	68.5	13.75	0.69	5.78	0.08	2.36	1.75	2.55	2.91	0.16	1.46	0.1	8
MSLT	73.2	10.95	0.62	5.32	0.02	0.58	0.71	2.45	2.79	0.02	3.08	0.1	5
MSLT	57.15	13.05	0.64	18.61	0.01	0.51	0.26	0.15	2.08	0.04	7.35	0.1	443
MSLT	58.8	19.6	0.81	8.01	0.08	3.91	0.67	1.07	5.11	0.05	2.16	0.2	3
SLST	51.82	12.84	0.61	12.60	0.01	0.15	0.92	3.53	3.11	0.06	13.33	0.10	2.00
SLST	55.10	14.40	0.67	11.50	0.01	0.20	0.12	0.90	3.22	0.03	12.80	2.50	140.00
SLST	57.70	2.73	0.65	17.20	0.01	0.04	0.17	0.55	4.09	0.07	17.50	0.25	150.00
SLST	58.30	17.60	0.78	7.71	0.08	3.58	1.38	1.63	5.31	0.15	2.08	0.25	4.00
SLST	58.75	18.45	0.72	9.74	0.02	0.78	0.02	0.10	1.94	0.01	8.92	0.10	31.00
SLST	59.30	19.45	0.88	9.26	0.01	0.67	0.02	-0.05	3.27	0.04	6.96	0.10	250.00
SLST	59.55	17.15	0.73	7.24	0.07	3.36	1.28	1.90	4.98	0.14	2.68	0.10	9.00
SLST	59.90	16.90	0.76	6.77	0.04	3.07	0.86	2.18	5.02	0.10	5.12	0.25	15.00

SLST	60.15	18.85	0.66	5.15	0.03	2.87	0.05	0.10	3.08	0.08	8.57	0.10	23.00
SLST	61.90	14.95	0.75	4.87	0.01	1.53	0.79	1.05	4.83	0.05	6.34	0.10	79.00
SLST	62.60	14.50	0.73	8.06	0.09	2.96	2.77	1.50	3.17	0.13	4.26	0.25	38.00
SLST	63.29	12.70	0.60	9.42	0.04	1.46	0.79	2.36	3.19	0.16	4.08	0.20	6.00
SLST	63.30	13.80	0.68	6.82	0.10	2.78	2.71	2.17	3.16	0.15	5.23	0.25	150.00
SLST	72.15	2.65	0.47	11.58	0.01	0.14	0.09	0.60	1.08	0.08	9.80	0.10	192.00
SLST	75.05	11.35	0.50	4.31	0.06	1.38	1.53	1.30	1.47	0.13	3.27	0.10	19.00
SLST	75.65	11.10	0.44	3.09	0.04	1.24	1.14	2.75	2.70	0.14	0.80	0.10	0.50
SLST	57.28	12.97	0.6	14.17	0.02	1.14	0.3	1.06	4.15	0.17	6.77	0.7	70

LITHOCODE	Au	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Ga	La	Mn	Mo
GYWK	6.00	380.00	0.00	0.00	0.00	60.00	10.00	440.00	55.00	0.00	15.00	0.00	0.00
GYWK	3.00	630.00	0.00	0.00	0.00	200.00	10.00	75.00	20.00	0.00	95.00	0.00	0.00
GYWK	2.00	840.00	0.00	0.00	0.00	100.00	15.00	75.00	15.00	0.00	45.00	0.00	0.00
MGYW	1.00	572.00	0.00	0.00	0.00	72.00	32.00	103.00	79.00	0.00	38.00	0.00	0.00
MGYW	2.00	1126.00	0.00	0.00	0.00	104.00	19.00	111.00	69.00	0.00	63.00	0.00	0.00
MGYW	0.50	555.00	0.00	0.00	0.00	90.00	18.00	107.00	25.00	0.00	54.00	0.00	0.00
MGYW	10.00	160.00	0.00	0.00	0.00	83.00	29.00	100.00	66.00	0.00	45.00	0.00	0.00
MGYW	10.00	100.00	0.00	0.00	0.00	82.00	15.00	50.00	30.00	0.00	43.00	0.00	0.00
MGYW	7.00	260.00	0.00	0.00	0.00	100.00	15.00	245.00	45.00	0.00	55.00	0.00	0.00
MGYW	1.00	340.00	0.00	0.00	0.00	100.00	20.00	95.00	45.00	0.00	55.00	0.00	0.00
MGYW	10.00	20.00	0.00	0.00	0.00	53.00	17.00	100.00	51.00	0.00	46.00	0.00	0.00
MGYW	0.50	520.00	0.00	0.00	0.00	80.00	15.00	175.00	20.00	0.00	40.00	0.00	0.00
MGYW	2.00	480.00	0.00	0.00	0.00	100.00	15.00	220.00	20.00	0.00	55.00	0.00	0.00
MGYW	3.00	936.00	0.00	0.00	0.00	104.00	18.00	109.00	36.00	0.00	57.00	0.00	0.00
MGYW	3.00	594.00	0.00	0.00	0.00	73.00	56.00	92.00	52.00	0.00	37.00	0.00	0.00
MGYW	6.00	797.00	0.00	0.00	0.00	65.00	13.00	79.00	86.00	0.00	36.00	0.00	0.00
MGYW	0.50	572.00	0.00	0.00	0.00	60.00	15.00	115.00	9.00	0.00	31.00	0.00	0.00
MGYW	3.00	697.00	0.00	0.00	0.00	53.00	12.00	75.00	25.00	20.90	47.00	0.00	0.00
MGYW	20.00	330.00	0.00	0.00	0.00	0.00	15.00	65.00	100.00	19.00	0.00	0.00	0.00

MGYW	7.00	386.00	0.00	0.00	0.00	157.00	19.00	93.00	17.00	0.00	88.00	0.00	0.00
MGYW	5.00	699.00	0.00	0.00	0.00	95.00	14.00	118.00	21.00	0.00	54.00	0.00	0.00
MGYW	0.00	330.00	0.00	0.00	0.00	107.00	14.00	80.00	25.00	19.50	68.00	0.00	0.00
MGYW	0.50	463.00	0.00	0.00	0.00	84.00	13.00	114.00	10.00	0.00	47.00	0.00	0.00
MGYW	1.00	564.00	0.00	0.00	0.00	201.00	12.00	137.00	15.00	0.00	127.00	0.00	0.00
MGYW	1.00	572.00	0.00	0.00	0.00	143.00	12.00	82.00	19.00	18.40	89.00	0.00	0.00
MGYW	1.00	543.00	0.00	0.00	0.00	92.00	10.00	75.00	15.00	20.30	60.00	0.00	0.00
MGYW	3.00	820.00	0.00	0.00	0.00	120.00	15.00	75.00	15.00	0.00	0.00	0.00	0.00
MGYW	0.50	704.00	0.00	0.00	0.00	89.00	11.00	84.00	22.00	0.00	32.00	0.00	0.00
MGYW	0.50	410.00	0.00	0.00	0.00	120.00	10.00	70.00	20.00	0.00	60.00	0.00	0.00
MGYW	1.00	592.00	0.00	0.00	0.00	72.00	13.00	85.00	23.00	20.30	51.00	0.00	0.00
MGYW	0.50	420.00	0.00	0.00	0.00	140.00	15.00	80.00	55.00	0.00	75.00	0.00	0.00
MGYW	0.50	1132.00	0.00	0.00	0.00	70.00	13.00	100.00	25.00	0.00	29.00	0.00	0.00
MGYW	3.00	160.00	0.00	0.00	0.00	120.00	25.00	395.00	90.00	0.00	65.00	0.00	0.00
MGYW	10.00	760.00	0.00	0.00	0.00	77.00	10.00	50.00	11.00	0.00	42.00	0.00	0.00
MGYW	3.00	727.00	0.00	0.00	0.00	85.00	13.00	89.00	19.00	0.00	48.00	0.00	0.00
MGYW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MGYW	3.00	711.00	0.00	0.00	0.00	91.00	14.00	79.00	21.00	0.00	52.00	0.00	0.00
MGYW	1.00	1500.00	0.00	0.00	0.00	100.00	10.00	70.00	-5.00	17.00	50.00	0.00	0.00
MGYW	2.00	330.00	0.00	0.00	0.00	100.00	15.00	65.00	60.00	0.00	0.00	0.00	0.00
MGYW	4.00	390.00	0.00	0.00	0.00	80.00	10.00	65.00	30.00	0.00	0.00	0.00	0.00
MGYW	0.50	349.00	0.00	0.00	0.00	93.00	13.00	74.00	9.00	0.00	51.00	0.00	0.00
MGYW	2.00	616.00	0.00	0.00	0.00	71.00	12.00	78.00	19.00	0.00	36.00	0.00	0.00
MGYW	2.00	479.00	0.00	0.00	0.00	103.00	11.00	80.00	41.00	0.00	58.00	0.00	0.00
MGYW	1.00	660.00	0.00	0.00	0.00	44.00	10.00	66.00	7.00	16.90	22.00	0.00	0.00
MGYW	10.00	540.00	0.00	0.00	0.00	57.00	9.00	100.00	10.00	0.00	31.00	0.00	0.00
MGYW	2.00	160.00	0.00	0.00	0.00	120.00	20.00	505.00	70.00	0.00	65.00	0.00	0.00
MGYW	1.00	570.00	0.00	0.00	0.00	100.00	10.00	70.00	5.00	17.00	55.00	0.00	0.00
MGYW	1.00	692.00	0.00	0.00	0.00	78.00	10.00	65.00	7.00	17.20	23.00	0.00	0.00
MGYW	2.00	371.00	0.00	0.00	0.00	100.00	15.00	60.00	31.00	0.00	47.00	0.00	0.00
MGYW	2.00	590.00	0.00	0.00	0.00	100.00	10.00	70.00	15.00	0.00	0.00	0.00	0.00
MGYW	2.00	638.00	0.00	0.00	0.00	74.00	10.00	71.00	18.00	0.00	42.00	0.00	0.00

MGYW	2.00	1360.00	0.00	0.00	0.00	153.00	15.00	63.00	73.00	0.00	88.00	0.00	0.00
MGYW	0.50	1051.00	0.00	0.00	0.00	93.00	5.00	66.00	17.00	0.00	62.00	0.00	0.00
MGYW	0.50	230.00	0.00	0.00	0.00	60.00	10.00	65.00	25.00	0.00	35.00	0.00	0.00
MGYW	1.00	653.00	0.00	0.00	0.00	62.00	10.00	68.00	35.00	16.70	41.00	0.00	0.00
MGYW	19.00	562.00	0.00	0.00	0.00	121.00	10.00	70.00	50.00	0.00	68.00	0.00	0.00
MGYW	3.00	858.00	0.00	0.00	0.00	63.00	13.00	70.00	28.00	0.00	35.00	0.00	0.00
MGYW	1.00	339.00	0.00	0.00	0.00	78.00	9.00	64.00	37.00	0.00	48.00	0.00	0.00
MGYW	457.00	74.00	0.00	0.00	0.00	7.50	5.00	122.00	38750.00	0.00	6.00	0.00	0.00
MGYW	3.00	191.00	0.00	0.00	0.00	47.00	7.00	79.00	78.00	0.00	27.00	0.00	0.00
MGYW	0.50	580.00	0.00	0.00	0.00	80.00	15.00	85.00	10.00	20.50	50.00	0.00	0.00
MGYW	1.00	570.00	0.00	0.00	0.00	20.00	10.00	85.00	20.00	21.00	20.00	0.00	0.00
MGYW	1.00	600.00	0.00	0.00	0.00	140.00	10.00	95.00	80.00	22.50	70.00	0.00	0.00
MGYW	1.00	570.00	0.00	0.00	0.00	60.00	10.00	90.00	10.00	21.00	45.00	0.00	0.00
MGYW	1.00	540.00	0.00	0.00	0.00	40.00	10.00	90.00	15.00	21.50	30.00	0.00	0.00
QTZT	1.00	440.00	0.00	0.00	0.00	0.00	10.00	50.00	25.00	12.50	0.00	0.00	0.00
SDST	11.00	1440.00	0.00	0.00	0.00	60.00	-5.00	25.00	-5.00	10.50	15.00	0.00	0.00
SDST	5.00	500.00	0.00	0.00	0.00	120.00	-5.00	80.00	75.00	22.00	55.00	0.00	0.00
SDST	1.00	140.00	0.00	0.00	0.00	80.00	30.00	85.00	55.00	0.00	35.00	0.00	0.00
SDST	4.00	380.00	0.00	0.00	0.00	60.00	30.00	60.00	25.00	0.00	0.00	0.00	0.00
SDST	2.00	440.00	0.00	0.00	0.00	60.00	15.00	75.00	50.00	0.00	30.00	0.00	0.00
SDST	2.00	520.00	0.00	0.00	0.00	60.00	15.00	65.00	15.00	0.00	35.00	0.00	0.00
SDST	0.50	290.00	0.00	0.00	0.00	100.00	10.00	75.00	30.00	0.00	55.00	0.00	0.00
SDST	10.00	320.00	0.00	0.00	0.00	115.00	62.00	50.00	76.00	0.00	63.00	0.00	0.00
SDST	0.00	350.00	0.00	0.00	0.00	80.00	10.00	60.00	40.00	14.00	45.00	0.00	0.00
SDST	10.00	780.00	5.00	0.00	10.00	200.00	50.00	60.00	9.00	0.00	50.00	0.00	10.00
SDST	0.00	315.00	0.00	0.00	0.00	90.00	5.00	49.00	84.00	12.40	59.00	0.00	0.00
SDST	2.00	390.00	0.00	0.00	0.00	120.00	5.00	65.00	25.00	0.00	0.00	0.00	0.00
SDST	10.00	60.00	0.00	0.00	0.00	32.00	5.00	50.00	20.00	0.00	18.00	0.00	0.00
SDST	1.00	220.00	0.00	0.00	0.00	20.00	-5.00	440.00	20.00	0.00	10.00	0.00	0.00
MSST	3.00	97.00	0.00	0.00	0.00	77.00	14.00	76.00	217.00	0.00	42.00	0.00	0.00
MSLT	1.00	2155.00	0.00	0.00	0.00	87.00	34.00	118.00	83.00	0.00	36.00	0.00	0.00
MSLT	0.50	1269.00	0.00	0.00	0.00	42.00	21.00	115.00	36.00	0.00	24.00	0.00	0.00

MSLT	3.00	1121.00	0.00	0.00	0.00	105.00	25.00	107.00	33.00	0.00	58.00	0.00	0.00
MSLT	0.50	1366.00	0.00	0.00	0.00	91.00	24.00	109.00	50.00	0.00	52.00	0.00	0.00
MSLT	0.50	1155.00	0.00	0.00	0.00	72.00	18.00	110.00	8.00	0.00	42.00	0.00	0.00
MSLT	2.00	717.00	0.00	0.00	0.00	51.00	7.00	94.00	38.00	0.00	39.00	0.00	0.00
MSLT	0.50	1303.00	0.00	0.00	0.00	88.00	24.00	112.00	19.00	0.00	34.00	0.00	0.00
MSLT	3.00	1120.00	0.00	0.00	0.00	94.00	30.00	123.00	43.00	0.00	57.00	0.00	0.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MSLT	4.00	1097.00	0.00	0.00	0.00	69.00	22.00	115.00	47.00	0.00	35.00	0.00	0.00
MSLT	0.00	439.00	0.00	0.00	0.00	7.50	18.00	90.00	24.00	22.40	25.00	0.00	0.00
MSLT	1.00	663.00	0.00	0.00	0.00	77.00	18.00	156.00	33.00	0.00	45.00	0.00	0.00
MSLT	2.00	690.00	0.00	0.00	0.00	0.00	20.00	110.00	55.00	27.00	0.00	0.00	0.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
MSLT	2.00	808.00	0.00	0.00	0.00	82.00	18.00	107.00	79.00	31.70	71.00	0.00	0.00
MSLT	0.50	896.00	0.00	0.00	0.00	63.00	15.00	101.00	29.00	0.00	35.00	0.00	0.00
MSLT	3.00	598.00	0.00	0.00	0.00	35.00	27.00	110.00	32.00	26.10	46.00	0.00	0.00
MSLT	1.00	907.00	0.00	0.00	0.00	99.00	21.00	105.00	20.00	0.00	58.00	0.00	0.00
MSLT	0.50	840.00	0.00	0.00	0.00	85.00	20.00	95.00	10.00	0.00	45.00	0.00	0.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MSLT	0.00	827.00	0.00	0.00	0.00	38.00	13.00	99.00	37.00	24.20	33.00	0.00	0.00
MSLT	35.00	1672.00	0.00	0.00	0.00	-15.00	15.00	84.00	55.00	0.00	7.00	0.00	0.00
MSLT	0.50	318.00	0.00	0.00	0.00	32.00	-5.00	63.00	47.00	0.00	18.00	0.00	0.00
MSLT	0.50	1250.00	0.00	0.00	0.00	60.00	15.00	140.00	40.00	37.00	45.00	0.00	0.00
MSLT	2.00	1120.00	0.00	0.00	0.00	120.00	10.00	115.00	40.00	30.50	60.00	0.00	0.00
MSLT	1.00	440.00	0.00	0.00	0.00	140.00	10.00	60.00	15.00	15.50	65.00	0.00	0.00
MSLT	1.00	530.00	0.00	0.00	0.00	80.00	20.00	90.00	20.00	21.50	50.00	0.00	0.00
MSLT	1	640	0.00	0.00	0.00	60	20	110	65	26	45	0	0.00
MSLT	0	630	0.00	0.00	0.00	80	15	95	25	19.5	55	0	0.00
MSLT	3	760	0.00	0.00	0.00	0	10	65	20	13.5	0	0	0.00
MSLT	1	630	0.00	0.00	0.00	80	-5	130	190	0	0	0	0.00
MSLT	3	915	0.00	0.00	0.00	223	24	130	20	0	112	0	0.00
SLST	3.00	713.00	0.00	0.00	0.00	85.00	114.00	83.00	129.00	0.00	46.00	0.00	0.00
SLST	10.00	600.00	0.00	0.00	0.00	81.00	23.00	100.00	31.00	0.00	46.00	0.00	0.00

SLST	10.00	700.00	0.00	0.00	0.00	54.00	0.50	25.00	29.00	0.00	35.00	0.00	0.00
SLST	10.00	760.00	0.00	0.00	0.00	80.00	15.00	100.00	37.00	0.00	45.00	0.00	0.00
SLST	1.00	470.00	0.00	0.00	0.00	80.00	5.00	420.00	35.00	0.00	20.00	0.00	0.00
SLST	3.00	550.00	0.00	0.00	0.00	80.00	2.50	135.00	55.00	0.00	40.00	0.00	0.00
SLST	2.00	810.00	0.00	0.00	0.00	80.00	20.00	115.00	40.00	0.00	45.00	0.00	0.00
SLST	10.00	1100.00	0.00	0.00	0.00	120.00	13.00	100.00	31.00	0.00	56.00	0.00	0.00
SLST	4.00	1220.00	0.00	0.00	0.00	80.00	2.50	90.00	40.00	0.00	35.00	0.00	0.00
SLST	5.00	680.00	0.00	0.00	0.00	40.00	2.50	185.00	45.00	0.00	25.00	0.00	0.00
SLST	10.00	460.00	0.00	0.00	0.00	76.00	15.00	100.00	29.00	0.00	38.00	0.00	0.00
SLST	4.00	839.00	0.00	0.00	0.00	78.00	67.00	88.00	366.00	0.00	47.00	0.00	0.00
SLST	10.00	340.00	0.00	0.00	0.00	61.00	16.00	100.00	52.00	0.00	33.00	0.00	0.00
SLST	2.00	70.00	0.00	0.00	0.00	40.00	2.50	510.00	105.00	0.00	25.00	0.00	0.00
SLST	2.00	350.00	0.00	0.00	0.00	120.00	10.00	60.00	65.00	0.00	0.00	0.00	0.00
SLST	1.00	690.00	0.00	0.00	0.00	100.00	10.00	290.00	10.00	0.00	50.00	0.00	0.00
SLST	1	739	0.00	0.00	0.00	73	21	99	179	0	46	0	0.00

LITHOCODE	Na	Nb	Nd	Ni	Pb	Pd	Pt	Rb	Sb	Sc	Se	Sn	Sr
GYWK	0.00	0.00	20.00	24.00	32.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
GYWK	0.00	0.00	80.00	26.00	34.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	135.00
GYWK	0.00	0.00	40.00	30.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	380.00
MGYW	0.00	0.00	33.00	29.00	252.00	7.00	2.50	0.00	0.00	0.00	0.00	0.00	300.00
MGYW	0.00	0.00	44.00	49.00	20.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	116.00
MGYW	0.00	0.00	40.00	78.00	22.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	120.00
MGYW	0.00	0.00	35.00	66.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	160.00
MGYW	0.00	0.00	37.00	38.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00
MGYW	0.00	0.00	40.00	42.00	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	195.00
MGYW	0.00	0.00	40.00	54.00	33.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	230.00
MGYW	0.00	0.00	23.00	49.00	36.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	180.00
MGYW	0.00	0.00	30.00	34.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	195.00
MGYW	0.00	0.00	50.00	42.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	190.00
MGYW	0.00	0.00	43.00	49.00	26.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	81.00
MGYW	0.00	0.00	32.00	57.00	86.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	83.00
MGYW	0.00	0.00	31.00	40.00	10.00	1.00	3.00	0.00	0.00	0.00	0.00	0.00	71.00
MGYW	0.00	0.00	26.00	64.00	33.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	178.00
MGYW	0.00	12.00	34.00	36.00	21.00	0.60	0.50	152.00	0.00	8.00	1.50	3.20	228.00
MGYW	0.00	13.00	0.00	26.00	21.00	0.50	0.50	105.00	0.00	11.00	1.50	3.50	200.00
MGYW	0.00	0.00	76.00	39.00	0.00	1.50	0.10	0.00	0.00	0.00	0.00	0.00	120.00
MGYW	0.00	0.00	40.00	49.00	20.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	151.00
MGYW	0.00	13.00	52.00	41.00	34.00	0.00	0.00	110.00	0.00	8.00	1.50	2.10	302.00
MGYW	0.00	0.00	36.00	63.00	31.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	211.00
MGYW	0.00	0.00	76.00	37.00	11.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	167.00
MGYW	0.00	13.00	64.00	31.00	23.00	1.80	0.50	129.00	0.00	9.00	1.50	3.20	219.00
MGYW	0.00	8.00	44.00	28.00	12.00	0.50	0.10	136.00	0.00	8.00	1.50	3.00	171.00
MGYW	0.00	0.00	50.00	32.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	210.00
MGYW	0.00	0.00	32.00	26.00	29.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	228.00
MGYW	0.00	0.00	50.00	30.00	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	240.00
MGYW	0.00	11.00	39.00	36.00	19.00	0.60	0.10	148.00	0.00	9.00	1.50	3.00	177.00
MGYW	0.00	0.00	50.00	34.00	29.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	245.00
MGYW	0.00	0.00	22.00	44.00	30.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	148.00
MGYW	0.00	0.00	50.00	76.00	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	175.00
MGYW	0.00	0.00	32.50	30.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00
MGYW	0.00	0.00	37.00	57.00	30.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	113.00
MGYW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MGYW	0.00	0.00	40.00	31.00	17.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	194.00
MGYW	0.00	13.60	40.00	28.00	1.00	0.10	0.10	110.00	0.00	8.00	1.50	2.50	280.00

MGYW	0.00	0.00	40.00	32.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00
MGYW	0.00	0.00	40.00	28.00	19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	190.00
MGYW	0.00	0.00	39.00	52.00	17.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	179.00
MGYW	0.00	0.00	31.00	29.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.00
MGYW	0.00	0.00	45.00	24.00	466.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	217.00
MGYW	0.00	9.00	17.00	28.00	18.00	0.10	0.10	116.00	0.00	7.00	1.50	2.70	171.00
MGYW	0.00	0.00	26.00	29.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	180.00
MGYW	0.00	0.00	50.00	48.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	180.00
MGYW	0.00	13.20	40.00	30.00	-1.00	2.50	0.10	125.00	0.00	8.00	1.50	2.50	150.00
MGYW	0.00	9.00	18.00	27.00	22.00	0.10	0.10	122.00	0.00	7.00	1.50	2.70	199.00
MGYW	0.00	0.00	36.00	40.00	35.00	2.50	0.10	0.00	0.00	0.00	0.00	0.00	190.00
MGYW	0.00	0.00	40.00	26.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	235.00
MGYW	0.00	0.00	34.00	31.00	21.00	0.50	0.10	0.00	0.00	0.00	0.00	0.00	249.00
MGYW	0.00	0.00	62.00	45.00	6.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	14.00
MGYW	0.00	0.00	47.00	27.00	31.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	259.00
MGYW	0.00	0.00	30.00	24.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00
MGYW	0.00	10.00	34.00	26.00	26.00	0.10	0.10	101.00	0.00	7.00	3.00	2.40	236.00
MGYW	0.00	0.00	50.00	25.00	16.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	146.00
MGYW	0.00	0.00	28.00	72.00	41.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	97.00
MGYW	0.00	0.00	37.00	26.00	22.00	0.50	0.10	0.00	0.00	0.00	0.00	0.00	307.00
MGYW	0.00	0.00	-10.00	12.00	16.00	1.50	1.00	0.00	0.00	0.00	0.00	0.00	7.00
MGYW	0.00	0.00	21.00	26.00	17.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	252.00
MGYW	0.00	14.00	40.00	34.00	12.00	0.10	0.10	140.00	0.00	10.00	1.50	3.00	1755.00
MGYW	0.00	13.00	20.00	22.00	19.00	1.00	0.50	140.00	0.00	9.00	1.50	3.50	210.00
MGYW	0.00	16.60	50.00	28.00	11.00	1.50	2.50	145.00	0.00	11.00	4.00	5.50	80.00
MGYW	0.00	15.40	40.00	32.00	31.00	1.50	0.50	145.00	0.00	10.00	1.50	3.00	235.00
MGYW	0.00	15.00	20.00	24.00	24.00	0.50	0.50	135.00	0.00	10.00	1.50	3.00	235.00
QTZT	0.00	10.00	0.00	20.00	24.00	0.10	0.10	90.00	0.00	7.00	1.50	2.00	250.00
SDST	0.00	16.20	10.00	2.00	410.00	4.00	2.50	185.00	0.00	4.00	3.00	5.00	75.00
SDST	0.00	17.00	30.00	4.00	438.00	3.00	2.50	120.00	0.00	7.00	5.00	3.50	150.00
SDST	0.00	0.00	30.00	76.00	48.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	260.00
SDST	0.00	0.00	20.00	66.00	57.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.00
SDST	0.00	0.00	20.00	30.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	195.00
SDST	0.00	0.00	30.00	26.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	245.00
SDST	0.00	0.00	40.00	20.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	255.00
SDST	0.00	0.00	51.00	92.00	34.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.00
SDST	0.00	10.60	30.00	24.00	12.00	0.00	0.00	90.00	0.00	6.00	1.50	3.00	210.00
SDST	0.00	25.00	0.00	25.00	15.00	0.00	0.00	0.00	0.00	5.00	0.00	254.00	170.00
SDST	0.00	9.00	41.00	18.00	9.00	0.00	0.00	61.00	0.00	5.00	1.50	2.10	216.00

SDST	0.00	0.00	50.00	22.00	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	275.00
SDST	0.00	0.00	14.50	13.00	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	140.00
SDST	0.00	0.00	10.00	14.00	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	255.00
MSST	0.00	0.00	32.00	31.00	19.00	5.00	1.50	0.00	0.00	0.00	0.00	0.00	348.00
MSLT	0.00	0.00	30.00	69.00	27.00	2.00	1.00	0.00	0.00	0.00	0.00	0.00	79.00
MSLT	0.00	0.00	17.00	69.00	27.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	133.00
MSLT	0.00	0.00	44.00	56.00	23.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	124.00
MSLT	0.00	0.00	38.00	99.00	44.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	76.00
MSLT	0.00	0.00	34.00	56.00	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	196.00
MSLT	0.00	0.00	16.00	28.00	57.00	1.50	0.50	0.00	0.00	0.00	0.00	0.00	188.00
MSLT	0.00	0.00	31.00	63.00	24.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	87.00
MSLT	0.00	0.00	47.00	77.00	165.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	60.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MSLT	0.00	0.00	32.00	55.00	16.00	0.50	0.10	0.00	0.00	0.00	0.00	0.00	110.00
MSLT	0.00	12.00	13.00	53.00	209.00	0.00	0.00	124.00	0.00	11.00	1.50	3.50	185.00
MSLT	0.00	0.00	33.00	58.00	20.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	180.00
MSLT	0.00	19.00	0.00	38.00	39.00	2.00	1.00	210.00	0.00	17.00	3.00	5.00	165.00
MSLT	0.00	0.00	0.00	0.00	200.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MSLT	0.00	14.00	57.00	53.00	34.00	1.60	0.90	210.00	0.00	15.00	1.50	5.60	114.00
MSLT	0.00	0.00	26.00	38.00	24.00	1.00	0.10	0.00	0.00	0.00	0.00	0.00	128.00
MSLT	0.00	17.00	33.00	48.00	35.00	2.60	0.90	189.00	0.00	12.00	1.50	4.10	137.00
MSLT	0.00	0.00	42.00	66.00	27.00	3.50	0.10	0.00	0.00	0.00	0.00	0.00	154.00
MSLT	0.00	0.00	36.00	50.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	160.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MSLT	0.00	15.00	27.00	33.00	17.00	0.00	0.00	198.00	0.00	12.00	1.50	4.00	138.00
MSLT	0.00	0.00	5.00	10.00	3.00	1.50	0.50	0.00	0.00	0.00	0.00	0.00	20.00
MSLT	0.00	0.00	17.00	17.00	166.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.00
MSLT	0.00	22.00	30.00	42.00	57.00	0.10	0.10	235.00	0.00	20.00	1.50	8.00	115.00
MSLT	0.00	19.60	60.00	28.00	15.00	1.00	1.50	210.00	0.00	16.00	3.00	7.50	140.00
MSLT	0.00	13.00	50.00	16.00	14.00	0.10	0.50	120.00	0.00	7.00	1.50	2.00	180.00
MSLT	0.00	15.00	30.00	42.00	19.00	0.50	0.50	145.00	0.00	10.00	1.50	4.00	190.00
MSLT	0.00	14	30	54	32	1	1.5	180	0.00	14	1.5	5	160
MSLT	0.00	14.6	40	44	24	0	0	130	0.00	10	1.5	3	150
MSLT	0.00	13	0	16	11	1	2	100	0.00	10	1.5	3	100
MSLT	0.00	0	30	2	98	0	0	0	0.00	0	0	0	45
MSLT	0.00	0	90	55	22	1.5	0.1	0	0.00	0	0	0	119
SLST	0.00	0.00	34.00	41.00	57.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	164.00
SLST	0.00	0.00	36.50	8.00	145.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.00
SLST	0.00	0.00	22.50	2.00	89.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	80.00

SLST	0.00	0.00	34.00	43.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	120.00
SLST	0.00	0.00	10.00	24.00	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00
SLST	0.00	0.00	20.00	2.00	166.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.00
SLST	0.00	0.00	40.00	48.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	150.00
SLST	0.00	0.00	40.00	48.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	140.00
SLST	0.00	0.00	30.00	8.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	355.00
SLST	0.00	0.00	20.00	4.00	125.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	125.00
SLST	0.00	0.00	30.00	49.00	28.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00
SLST	0.00	0.00	33.00	44.00	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	182.00
SLST	0.00	0.00	27.50	40.00	73.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200.00
SLST	0.00	0.00	20.00	8.00	668.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	55.00
SLST	0.00	0.00	50.00	38.00	41.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	165.00
SLST	0.00	0.00	40.00	22.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	240.00
SLST	0.00	0	28	21	2000	0	0	0	0.00	0	0	0	190

LITHOCODE	Ta	Th	Tl	U	V	W	Y	Zn	Zr
GYWK	0.00	20.00	0.00	3.65	106.00	1.10	0.00	120.00	195.00
GYWK	0.00	20.00	0.00	4.30	68.00	1.30	0.00	40.00	320.00
GYWK	0.00	20.00	1.00	2.80	64.00	1.60	0.00	115.00	245.00
MGYW	0.00	15.00	2.70	3.45	89.00	4.00	0.00	411.00	110.00
MGYW	0.00	22.00	1.40	2.54	101.00	8.80	0.00	80.00	183.00
MGYW	0.00	20.00	1.50	2.99	92.00	3.50	0.00	111.00	185.00
MGYW	0.00	14.50	0.00	4.50	110.00	1.50	0.00	145.00	240.00
MGYW	0.00	11.00	0.00	5.50	76.00	1.50	0.00	165.00	200.00
MGYW	0.00	20.00	0.00	4.10	90.00	1.30	0.00	100.00	205.00
MGYW	0.00	20.00	0.00	3.35	88.00	0.90	0.00	105.00	190.00
MGYW	0.00	10.00	0.00	4.00	97.00	1.50	0.00	91.00	200.00
MGYW	0.00	20.00	0.00	4.25	86.00	1.20	0.00	85.00	265.00
MGYW	0.00	20.00	0.00	4.20	88.00	1.50	0.00	85.00	255.00
MGYW	0.00	22.00	1.10	2.48	77.00	9.50	0.00	69.00	226.00
MGYW	0.00	16.00	1.30	1.93	73.00	1.90	0.00	86.00	194.00
MGYW	0.00	16.00	1.00	2.14	65.00	3.20	0.00	52.00	200.00
MGYW	0.00	15.00	1.20	2.59	71.00	1.70	0.00	90.00	221.00
MGYW	0.00	15.00	0.00	2.93	65.00	2.00	27.00	81.00	201.00
MGYW	0.00	20.00	0.00	2.95	74.00	2.00	43.00	70.00	320.00
MGYW	0.00	32.00	1.50	3.04	77.00	1.50	0.00	89.00	471.00
MGYW	0.00	19.00	1.30	3.10	72.00	3.10	0.00	82.00	234.00
MGYW	0.00	22.00	0.00	3.21	63.00	0.70	30.00	73.00	282.00
MGYW	0.00	18.00	1.20	2.69	66.00	1.20	0.00	86.00	219.00

MGYW	0.00	43.00	0.70	5.23	78.00	0.30	0.00	35.00	567.00
MGYW	0.00	28.00	0.00	4.41	71.00	1.30	35.00	71.00	380.00
MGYW	0.00	16.00	0.00	2.93	64.00	1.60	25.00	65.00	179.00
MGYW	0.00	20.00	0.00	4.10	70.00	4.30	0.00	65.00	285.00
MGYW	0.00	13.00	0.00	1.62	63.00	2.10	0.00	80.00	267.00
MGYW	0.00	20.00	0.00	4.20	70.00	1.10	0.00	65.00	305.00
MGYW	0.00	15.00	0.00	5.55	68.00	1.90	25.00	88.00	186.00
MGYW	0.00	20.00	0.00	4.15	68.00	0.90	0.00	65.00	285.00
MGYW	0.00	16.00	1.50	2.43	64.00	3.30	0.00	77.00	247.00
MGYW	0.00	10.00	0.00	3.20	80.00	1.90	0.00	75.00	205.00
MGYW	0.00	11.50	0.00	3.50	48.00	1.50	0.00	60.00	240.00
MGYW	0.00	23.00	0.80	2.44	61.00	3.60	0.00	51.00	279.00
MGYW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MGYW	0.00	19.00	0.90	2.54	60.00	2.00	0.00	68.00	270.00
MGYW	0.00	20.00	0.00	2.55	60.00	1.50	24.00	20.00	220.00
MGYW	0.00	20.00	0.00	3.55	62.00	0.90	0.00	70.00	265.00
MGYW	0.00	10.00	0.00	3.10	58.00	1.30	0.00	70.00	215.00
MGYW	0.00	16.00	1.10	2.37	58.00	0.60	0.00	72.00	239.00
MGYW	0.00	15.00	0.00	2.41	66.00	3.20	0.00	33.00	258.00
MGYW	0.00	30.00	0.00	5.06	67.00	1.60	0.00	84.00	377.00
MGYW	0.00	15.00	0.00	2.31	52.00	1.40	25.00	48.00	242.00
MGYW	0.00	9.00	0.00	3.50	43.00	1.50	0.00	58.00	280.00
MGYW	0.00	20.00	0.00	3.20	76.00	2.50	0.00	70.00	245.00
MGYW	0.00	10.00	0.00	2.85	58.00	1.10	27.00	60.00	225.00
MGYW	0.00	17.00	0.00	2.84	56.00	1.50	26.00	60.00	231.00
MGYW	0.00	17.00	1.10	2.33	56.00	1.10	0.00	94.00	245.00
MGYW	0.00	20.00	0.00	4.00	64.00	5.80	0.00	60.00	345.00
MGYW	0.00	15.00	0.70	2.40	53.00	2.10	0.00	54.00	257.00
MGYW	0.00	29.00	1.60	4.13	56.00	10.40	0.00	50.00	410.00
MGYW	0.00	21.00	3.10	3.68	65.00	2.10	0.00	26.00	266.00
MGYW	0.00	20.00	0.00	3.15	56.00	1.40	0.00	50.00	340.00
MGYW	0.00	19.00	0.00	2.95	56.00	1.70	26.00	61.00	270.00
MGYW	0.00	27.00	0.70	3.39	60.00	2.20	0.00	60.00	501.00
MGYW	0.00	23.00	0.70	2.46	46.00	3.90	0.00	29.00	255.00
MGYW	0.00	14.00	0.60	2.32	41.00	2.00	0.00	46.00	227.00
MGYW	0.00	5.00	-0.50	2.30	25.00	16.00	0.00	18.00	64.00
MGYW	0.00	5.00	0.50	1.38	27.00	0.60	0.00	42.00	138.00
MGYW	0.00	20.00	0.00	2.60	76.00	1.30	30.00	70.00	205.00
MGYW	0.00	20.00	0.00	2.15	76.00	1.00	18.00	90.00	180.00

MGYW	0.00	20.00	0.00	3.85	84.00	2.50	30.00	100.00	215.00
MGYW	0.00	20.00	0.00	2.30	74.00	1.60	25.00	110.00	205.00
MGYW	0.00	20.00	0.00	2.15	76.00	1.50	22.00	70.00	220.00
QTZT	0.00	20.00	0.00	2.10	44.00	0.50	22.00	45.00	240.00
SDST	0.00	5.00	0.00	2.40	36.00	3.10	5.00	35.00	160.00
SDST	0.00	20.00	0.00	7.35	66.00	2.70	9.00	75.00	240.00
SDST	0.00	20.00	0.00	4.65	84.00	0.90	0.00	190.00	225.00
SDST	0.00	20.00	0.00	3.25	64.00	2.10	0.00	355.00	220.00
SDST	0.00	20.00	0.00	3.30	68.00	1.50	0.00	95.00	225.00
SDST	0.00	20.00	0.00	2.80	60.00	0.90	0.00	65.00	275.00
SDST	0.00	30.00	0.00	4.00	66.00	1.00	0.00	60.00	390.00
SDST	0.00	10.50	0.00	7.50	20.00	4.00	0.00	62.00	180.00
SDST	0.00	20.00	0.00	2.75	46.00	1.30	19.00	55.00	205.00
SDST	25.00	0.00	0.00	0.00	50.00	0.00	25.00	85.00	210.00
SDST	0.00	13.00	0.00	2.43	39.00	1.60	25.00	40.00	181.00
SDST	0.00	20.00	0.00	3.20	54.00	0.80	0.00	50.00	320.00
SDST	0.00	5.50	0.00	2.00	20.00	1.50	0.00	135.00	80.00
SDST	0.00	5.00	0.00	1.75	40.00	0.50	0.00	30.00	115.00
MSST	0.00	21.00	-0.50	3.82	95.00	2.10	0.00	215.00	138.00
MSLT	0.00	23.00	2.50	6.74	124.00	6.60	0.00	144.00	153.00
MSLT	0.00	18.00	2.10	3.43	129.00	4.80	0.00	133.00	132.00
MSLT	0.00	28.00	1.70	2.29	116.00	6.10	0.00	113.00	127.00
MSLT	0.00	21.00	2.40	3.29	112.00	4.50	0.00	140.00	125.00
MSLT	0.00	18.00	0.00	3.17	122.00	5.20	0.00	57.00	172.00
MSLT	0.00	17.00	2.50	3.26	102.00	2.30	0.00	121.00	135.00
MSLT	0.00	18.00	2.10	2.04	112.00	6.20	0.00	141.00	143.00
MSLT	0.00	23.00	1.30	2.45	122.00	4.70	0.00	121.00	174.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MSLT	0.00	27.00	1.60	2.33	118.00	5.80	0.00	114.00	165.00
MSLT	0.00	15.00	0.00	4.25	82.00	2.70	29.00	371.00	160.00
MSLT	0.00	23.00	1.30	2.67	107.00	4.70	0.00	92.00	143.00
MSLT	0.00	20.00	0.00	4.30	118.00	3.40	31.00	125.00	140.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1000.00	0.00
MSLT	0.00	21.00	0.00	4.13	108.00	4.20	35.00	116.00	132.00
MSLT	0.00	19.00	1.70	2.92	103.00	3.50	0.00	117.00	148.00
MSLT	0.00	13.00	0.00	3.17	99.00	2.50	28.00	117.00	141.00
MSLT	0.00	25.00	1.30	2.32	101.00	7.10	0.00	86.00	188.00
MSLT	0.00	22.00	0.00	2.66	100.00	3.60	0.00	82.00	182.00
MSLT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MSLT	0.00	16.00	0.00	3.25	88.00	2.20	25.00	105.00	161.00
MSLT	0.00	5.00	0.60	3.86	79.00	62.20	0.00	16.00	244.00
MSLT	0.00	5.00	0.00	1.63	64.00	1.90	0.00	303.00	55.00
MSLT	0.00	20.00	0.00	3.25	126.00	4.80	41.00	140.00	140.00
MSLT	0.00	20.00	0.00	2.65	122.00	4.50	29.00	115.00	135.00
MSLT	0.00	20.00	0.00	2.70	52.00	0.70	44.00	60.00	310.00
MSLT	0.00	10.00	0.00	2.20	78.00	1.50	27.00	100.00	185.00
MSLT	0.00	20	0.00	2.5	108	3.2	23	125	155
MSLT	0.00	20	0.00	3	80	1.5	26	115	215
MSLT	0.00	20	0.00	5.15	70	1.4	37	25	430
MSLT	0.00	30	0.00	4.65	186	2.2	0	25	230
MSLT	0.00	27	1.5	3.23	115	1.6	0	108	138
SLST	0.00	18.00	0.00	5.38	105.00	1.60	0.00	8.00	157.00
SLST	0.00	9.00	0.00	5.00	22.00	6.00	0.00	13.00	180.00
SLST	0.00	9.50	0.00	4.00	13.00	4.00	0.00	7.00	200.00
SLST	0.00	12.50	0.00	3.50	71.00	4.00	0.00	125.00	140.00
SLST	0.00	30.00	0.00	4.60	134.00	2.10	0.00	75.00	230.00
SLST	0.00	30.00	1.50	3.70	136.00	4.50	0.00	15.00	235.00
SLST	0.00	20.00	0.00	5.35	112.00	3.10	0.00	120.00	150.00
SLST	0.00	13.50	0.00	4.00	59.00	4.00	0.00	65.00	160.00
SLST	0.00	10.00	4.00	4.85	134.00	1.90	0.00	160.00	155.00
SLST	0.00	20.00	0.00	4.35	114.00	3.70	0.00	25.00	165.00
SLST	0.00	12.50	0.00	4.50	69.00	1.50	0.00	160.00	220.00
SLST	0.00	18.00	0.00	5.80	105.00	1.70	0.00	87.00	181.00
SLST	0.00	11.00	0.00	5.00	77.00	1.50	0.00	130.00	200.00
SLST	0.00	10.00	0.00	19.60	40.00	2.00	0.00	20.00	195.00
SLST	0.00	10.00	0.00	3.50	58.00	1.70	0.00	105.00	210.00
SLST	0.00	20.00	0.00	2.75	52.00	1.10	0.00	45.00	295.00
SLST	0.00	19	0.00	4.02	126	3.2	0	1203	203

Talisker Formation

LITHOCODE	SiO2	Al2O3	TiO2	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI	Ag	As
MDST	52.60	16.70	0.57	14.03	0.19	3.11	1.56	1.85	3.63	0.11	4.63	2.50	149.00
MDST	62.60	14.60	0.67	8.28	0.01	0.84	0.30	0.23	3.97	0.13	7.66	0.20	839.00
MDST	56.00	4.60	0.64	15.54	0.01	0.22	0.03	1.35	2.60	0.06	17.25	0.50	224.00
MDST	65.05	16.20	0.69	5.77	0.01	0.33	0.13	0.65	3.34	0.04	7.82	1.50	46.00
MGYW	74.1	12.8	0.76	1.28	0.005	0.46	0.07	0.2	2.49	0.08	2.57	1.2	3810
MGYW	83.20	7.75	0.33	3.22	0.03	1.07	0.75	1.00	1.54	0.03	1.23	0.50	20.00
MGYW	74.6	12.1	0.42	5.5	0.02	1.74	0.38	3.1	1.41	0.16	0.78	0.005	19
MGYW	72.70	12.05	0.52	4.81	0.05	1.68	0.81	3.20	2.73	0.17	0.80	0.05	8.00
MGYW	69.20	13.65	0.72	5.23	0.06	1.84	1.43	2.20	3.66	0.21	1.35	0.20	53.00
MGYW	57.1	11	0.54	20.9	0.02	0.48	0.07	0.42	3.77	0.5	5.08	0.005	274
MGYW	65.10	15.90	0.69	6.31	0.05	2.19	1.06	1.95	3.87	0.06	2.76	0.05	4.00
MGYW	59.1	18.85	0.74	6.99	0.03	2.49	0.17	0.8	5.64	0.13	4.64	0.05	14.00
MGYW	50.55	14.25	0.55	17.17	0.08	2.58	1.79	1.45	3.04	0.12	7.11	7.00	271.00
MGYW	76	11.8	0.91	3.21	0.005	0.69	0.05	1.78	3.61	0.07	1.74	0.2	13
MGYW	77.30	10.70	0.45	4.47	0.05	1.70	0.48	3.36	1.42	0.14	0.77	0.05	9.00
MSLT	66.40	11.80	0.50	7.33	0.04	1.70	0.85	2.50	3.00	0.13	5.44	0.05	28.00
MSLT	69.55	13.05	0.61	4.98	0.06	2.18	0.76	1.25	4.04	0.09	3.83	0.05	1.00
MSLT	57.70	18.85	0.67	8.48	0.05	2.31	0.69	0.95	4.02	0.07	5.91	0.05	38.00
MSLT	62.00	17.65	0.79	6.70	0.07	2.49	0.52	1.10	4.02	0.04	4.25	0.05	13.00
MSLT	67.50	14.00	0.82	5.13	0.01	2.51	0.06	2.01	3.81	0.05	4.01	0.20	11.00
MSLT	61.35	8.60	0.62	14.37	0.06	0.25	0.22	1.15	2.95	0.10	9.68	0.10	76.00
MSLT	59.05	18.55	0.72	9.50	0.01	0.51	0.56	1.05	2.74	0.05	7.34	0.50	100.00
SDST	79.25	9.65	0.35	3.07	0.02	0.57	1.45	2.75	0.85	0.06	1.37	0.10	9.00
SDST	63.45	15.50	0.77	6.51	0.14	2.93	3.91	2.20	2.50	0.19	1.01	0.10	4.00
SDST	81.65	8.55	0.42	3.06	0.01	0.37	1.15	1.50	0.58	0.05	2.50	0.50	11.00
SDST	68.65	14.30	0.62	5.01	0.08	2.10	1.87	3.30	2.40	0.10	1.48	0.50	3.00
SDST	68.65	14.30	0.62	5.01	0.08	2.10	1.87	3.30	2.40	0.10	1.48	0.05	3.00
SLST	66.10	14.40	0.58	6.26	0.03	1.94	0.23	1.55	3.04	0.10	5.81	0.05	2.00
SLST	65.05	7.20	0.71	10.42	0.01	0.24	0.01	0.70	2.30	0.05	13.12	0.50	224.00

Au	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Ga	La	Mn	Mo	Na
8.00	570.00	0.00	0.00	0.00	80.00	45.00	90.00	120.00	0.00	0.00	0.00	0.00	0.00
27	1170.00	0.00	0.00	0.00	97.00	14.00	89.00	835.00	0.00	55.00	0.00	0.00	0.00
6.00	3390.00	0.00	0.00	0.00	80.00	2.50	45.00	20.00	0.00	0.00	0.00	0.00	0.00
4.00	620.00	0.00	0.00	0.00	80.00	2.50	95.00	60.00	0.00	0.00	0.00	0.00	0.00
54	0	0.00	0.00	0.00	460	9	0	24865	0	262	0	0.00	0.00
3.00	390.00	0.00	0.00	0.00	80.00	5.00	40.00	15.00	0.00	0.00	0.00	0.00	0.00
1	264	0.00	0.00	0.00	55	8	49	2.5	0	33	0	0.00	0.00
2.00	610.00	0.00	0.00	0.00	40.00	10.00	65.00	2.50	0.00	0.00	0.00	0.00	0.00
12.00	650.00	0.00	0.00	0.00	100.00	10.00	70.00	35.00	0.00	0.00	0.00	0.00	0.00
4	1577	0.00	0.00	0.00	73	13	79	277	0	45	0	0.00	0.00
0.00	750.00	0.00	0.00	0.00	60.00	10.00	95.00	15.00	25.00	50.00	0.00	0.00	0.00
0.00	930.00	0.00	0.00	0.00	140.00	30.00	110.00	40.00	30.00	80.00	0.00	0.00	0.00
22.00	1470.00	0.00	0.00	0.00	80.00	30.00	80.00	90.00	0.00	0.00	0.00	0.00	0.00
2	831	0.00	0.00	0.00	182	2.5	89	16	0	110	0	0.00	0.00
0.50	232.00	0.00	0.00	0.00	74.00	10.00	108.00	10.00	0.00	42.00	0.00	0.00	0.00
0.00	480.00	0.00	0.00	0.00	100.00	2.50	55.00	15.00	17.00	55.00	0.00	0.00	0.00
0.00	740.00	0.00	0.00	0.00	120.00	2.50	75.00	20.00	19.50	85.00	0.00	0.00	0.00
2.00	770.00	0.00	0.00	0.00	0.00	10.00	95.00	85.00	29.00	0.00	0.00	0.00	0.00
0.50	570.00	0.00	0.00	0.00	200.00	15.00	120.00	25.00	29.00	75.00	0.00	0.00	0.00
2	646.00	0.00	0.00	0.00	102.00	11.00	86.00	23.00	0.00	56.00	0.00	0.00	0.00
3.00	870.00	0.00	0.00	0.00	0.00	15.00	60.00	120.00	19.00	0.00	0.00	0.00	0.00
2.00	830.00	0.00	0.00	0.00	0.00	2.50	105.00	75.00	28.50	0.00	0.00	0.00	0.00
0.00	110.00	0.00	0.00	0.00	20.00	2.50	40.00	10.00	9.50	15.00	0.00	0.00	0.00
11.00	290.00	0.00	0.00	0.00	80.00	20.00	100.00	80.00	0.00	45.00	0.00	0.00	0.00
2.00	100.00	0.00	0.00	0.00	0.00	2.50	30.00	45.00	11.00	0.00	0.00	0.00	0.00
0.50	350.00	0.00	0.00	0.00	100.00	10.00	85.00	15.00	21.00	55.00	0.00	0.00	0.00
0.50	350.00	0.00	0.00	0.00	100.00	10.00	85.00	15.00	21.00	55.00	0.00	0.00	0.00
0.00	370.00	0.00	0.00	0.00	160.00	15.00	70.00	60.00	20.00	80.00	0.00	0.00	0.00
8.00	1000.00	0.00	0.00	0.00	0.00	10.00	60.00	50.00	22.00	0.00	0.00	0.00	0.00

Nb	Nd	Ni	Pb	Pd	Pt	Rb	Sb	Sc	Se	Sn	Sr	Ta	Th
0.00	30.00	82.00	376.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	125.00	0.00	20.00
0.00	44.00	66.00	39.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.00	0.00	23.00
0.00	30.00	2.00	66.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	80.00	0.00	5.00
0.00	20.00	4.00	44.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.00	0.00	10.00
0	216	26	65	1	2	0	0.00	0	0	0	0	0.00	144
0.00	30.00	16.00	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	320	0.00	10

0	24	23	4	0.025	0.025	0	0.00	0	0	0	78	0.00	16
0.00	20.00	22.00	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	195.00	0.00	5.00
0.00	40.00	18.00	45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	235.00	0.00	20.00
0	31	70	385	0.5	0.5	0	0.00	0	0	0	61	0.00	17
15.80	30.00	38.00	23.00	0	0.00	175.00	0.00	12.00	1.50	4.00	190.00	0.00	20.00
18.40	70.00	68.00	23.00	0	0.00	235.00	0.00	17.00	1.50	5.50	55.00	0.00	20.00
0.00	30.00	56.00	1394.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	10.00
0	83	15	61	1	0.025	0	0.00	0	0	0	101	0.00	24
0.00	27.00	45.00	2.00	0.25	0.25	0.00	0.00	0.00	0.00	0.00	57.00	0.00	11.00
8.20	40.00	12.00	28.00	0	0.00	125.00	0.00	8.00	3.00	3.00	200.00	0.00	10.00
12.00	40.00	6.00	20.00	0	0.00	165.00	0.00	9.00	1.50	3.50	185.00	0.00	10.00
15.00	0.00	10.00	45	2.00	1.50	195.00	0.00	18.00	1.50	5.00	120.00	0.00	20.00
17.60	70.00	36.00	37.00	0	0.00	190.00	0.00	17.00	1.50	6.50	85.00	0.00	20.00
0.00	46.00	33.00	44.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.00	0.00	22.00
12.00	0.00	30.00	126.00	6.50	2.50	80.00	0.00	10.00	3.00	3.00	130.00	0.00	20.00
17.00	0.00	8.00	68.00	4.00	3.00	95.00	0.00	18.00	-3.00	4.00	110.00	0.00	30.00
8.00	10.00	8.00	44.00	0	0.00	45.00	0.00	3.00	1.50	1.00	260.00	0.00	5.00
0.00	40.00	44.00	29.00	0	0.00	0.00	0.00	0.00	0.00	0.00	280.00	0.00	20.00
9.00	0.00	1.00	165.00	1.50	1.00	35.00	0.00	5.00	-3.00	1.50	170.00	0.00	10.00
12.00	40.00	26.00	17.00	0.00	0.00	120.00	0.00	10.00	1.50	2.50	140.00	0.00	20.00
12.00	40.00	26.00	17.00	0.00	0.00	120.00	0.00	10.00	1.50	2.50	140.00	0.00	20.00
10.00	60.00	44.00	18.00	0	0.00	155.00	0.00	11.00	1.50	3.00	130.00	0.00	20.00
14.00	0.00	4.00	88.00	6.00	4.00	55.00	0.00	11.00	-3.00	3.00	85.00	0.00	10.00

Tl	U	V	W	Y	Zn	Zr
0.00	3.70	108.00	3.90	0.00	885.00	95.00
0.00	6.84	161.00	2.10	0.00	126.00	200.00
0.00	3.25	60.00	2.30	0.00	15.00	155.00
0.00	2.40	152.00	2.50	0.00	20.00	180.00
0.9	16.6	64	1.6	0	33	0
0	2.05	46	1.3	0	60	145
0.1	2.52	35	1	0	7	249
0	2.65	62	2	0	45	200
0	3.6	80	4.1	0	95	290
1.1	5.82	63	1.5	0	139	272
0.00	3.35	92.00	2.60	21	70.00	165.00
0.00	5.05	110.00	3.20	37	115.00	130.00
0.00	4.85	94.00	2.40	0.00	605.00	110.00
1.1	2.35	70	1.2	0	45	619

0.00	1.92	38.00	0.80	0.00	5.00	162.00
0.00	3.60	62.00	1.90	18	105.00	165.00
0.00	3.85	64.00	2.30	21	75.00	190.00
0	4.3	120	2.5	33	140	135
0	3.95	110	3.7	79	160	150
0.00	2.24	75.00	2.30	0.00	147.00	267.00
0.00	5.15	78.00	2.40	29.00	165.00	150.00
0.00	4.85	108.00	2.10	26.00	15.00	160.00
0.00	2.30	22.00	0.70	9	35.00	205.00
0	5.65	98	1.5	0	110	185
0.00	2.85	28.00	0.60	26.00	35.00	235.00
0.00	3.35	74.00	1.30	26.00	115.00	195.00
0.00	3.35	74.00	1.30	26.00	115.00	195.00
0.00	3.90	74.00	1.70	28	120.00	170.00
0.00	2.30	84.00	2.40	27.00	10.00	170.00

Backstairs Passage Formation

LITHOCODE	SiO2	Al2O3	TiO2	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	LOI	Ag	As
MSLT	71.15	11.40	0.46	6.63	0.02	1.02	0.33	2.20	3.03	0.10	3.10	0.10	44.00
MSST	73.00	12.40	0.63	5.00	0.02	1.05	0.09	2.45	3.86	0.05	1.74	0.20	18.00
SDST	51.85	5.00	0.17	2.82	0.15	6.35	9.23	0.40	2.74	0.05	15.22	0.10	3.00
SDST	78.35	10.85	0.23	2.62	0.02	0.50	0.36	2.70	3.21	0.03	0.92	0.10	9.00
SDST	81.05	9.05	0.30	3.43	0.04	0.67	0.70	2.50	1.25	0.03	0.74	0.20	63.00
SDST	76.85	11.35	0.31	2.94	0.05	0.54	0.82	2.55	3.56	0.08	0.92	0.10	2.00
SDST	73.35	12.20	0.43	4.23	0.05	1.48	1.10	3.50	2.11	0.15	1.35	0.10	4.00
SDST	57.85	10.60	0.47	4.65	0.08	1.75	10.70	1.80	2.48	0.14	9.33	0.10	14.00
SDST	71.05	12.75	0.55	4.85	0.05	1.85	0.93	3.05	2.95	0.16	3.10	0.10	3.00
SDST	71.10	11.10	0.62	3.92	0.08	1.49	1.45	2.50	3.43	0.28	3.30	0.10	1.50
SDST	82.90	7.46	0.26	4.60	0.01	0.63	0.15	2.04	1.17	0.06	0.89	0.10	15.00

Au	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Ga	La	Mn	Mo	Na
0.00	740.00	0.00	0.00	0.00	80.00	5.00	55.00	35.00	16.00	50.00	0.00	0.00	0.00
2.00	1136.00	0.00	0.00	0.00	92.00	10.00	77.00	9.00	0.00	55.00	0.00	0.00	0.00
0.00	400.00	0.00	0.00	0.00	10.00	2.50	10.00	10.00	5.50	15.00	0.00	0.00	0.00
3.00	850.00	0.00	0.00	0.00	40.00	2.50	35.00	20.00	0.00	0.00	0.00	0.00	0.00
35.00	320.00	0.00	0.00	0.00	40.00	2.50	35.00	15.00	0.00	0.00	0.00	0.00	0.00
0.50	710.00	0.00	0.00	0.00	140.00	5.00	40.00	20.00	14.50	65.00	0.00	0.00	0.00
0.00	470.00	0.00	0.00	0.00	80.00	10.00	50.00	2.50	17.00	40.00	0.00	0.00	0.00
0.00	510.00	0.00	0.00	0.00	60.00	10.00	55.00	15.00	16.50	55.00	0.00	0.00	0.00
0.00	600.00	0.00	0.00	0.00	80.00	10.00	60.00	5.00	18.50	40.00	0.00	0.00	0.00
1.00	800.00	0.00	2.50	2.50	120.00	8.00	67.00	3.00	0.00	74.00	460.00	1.50	1.88
0.50	205.00	0.00	0.00	0.00	78.00	6.00	101.00	25.00	0.00	45.00	0.00	0.00	0.00

Nb	Nd	Ni	Pb	Pd	Pt	Rb	Sb	Sc	Se	Sn	Sr	Ta	Th
8.60	30.00	20.00	80.00	0.00	0.00	110.00	0.00	8.00	3.00	2.50	245.00	0.00	10.00
0.00	39.00	22.00	53.00	0.50	0.25	0.00	0.00	0.00	0.00	0.00	147.00	0.00	17.00
6.40	10.00	10.00	1.00	0.00	0.00	65.00	0.00	2.00	3.00	0.50	70.00	0.00	5.00
0.00	10.00	14.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	225.00	0.00	5.00
0.00	20.00	10.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	185.00	0.00	5.00
7.40	50.00	14.00	8.00	0.00	0.00	130.00	0.00	5.00	3.00	1.50	135.00	0.00	5.00
7.00	30.00	24.00	12.00	0.00	0.00	100.00	0.00	6.00	3.00	3.00	190.00	0.00	10.00
10.60	50.00	34.00	16.00	0.00	0.00	120.00	0.00	7.00	3.00	2.50	470.00	0.00	20.00
13.00	30.00	26.00	12.00	0.00	0.00	135.00	0.00	7.00	3.00	3.50	170.00	0.00	10.00
15.00	55.00	18.00	15.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	145.00	0.00	24.00
0.00	30.00	16.00	4.00	<0.5	<0.5	0.00	0.00	0.00	0.00	0.00	32.00	0.00	12.00

Tl	U	V	W	Y	Zn	Zr
0.00	3.70	56.00	1.60	16.00	55.00	180.00
5.00	1.76	65.00	0.40	0.00	61.00	384.00
0.00	1.30	14.00	3.00	13.00	15.00	110.00
0.00	1.30	28.00	1.00	0.00	25.00	135.00
0.00	1.75	34.00	6.20	0.00	30.00	170.00
0.00	1.80	34.00	0.60	25.00	15.00	125.00
0.00	1.90	48.00	1.20	23.00	50.00	180.00
0.00	3.05	54.00	1.70	29.00	70.00	165.00
0.00	2.95	58.00	1.70	29.00	60.00	225.00
0.70	3.60	55.00	0.90	10.00	87.00	400.00
5.00	2.09	32.00	5.30	0.00	10.00	141.00

Carrickalinga Head Formation

LITHOCODE	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Ag	As
MGYW	65.78	14.96	0.71	6.05	0.09	2.82	1.43	2.50	3.26	0.17	1.33	0.00	0.00
SDST	75.72	10.74	0.41	3.58	0.04	1.19	1.64	3.29	1.44	0.16	1.23	0.05	4.00
MSLT	60.29	17.20	0.91	7.09	0.11	3.08	2.35	2.69	3.03	0.18	2.29	0.00	0.00
MSLT	64.46	15.49	0.79	6.44	0.10	2.84	1.73	2.02	3.51	0.20	1.49	0.00	0.00
MSLT	67.65	13.63	0.63	5.57	0.07	1.87	1.62	2.22	3.10	0.19	3.08	0.05	9.00
MSLT	63.61	15.89	0.75	6.91	0.08	2.87	1.46	1.73	3.78	0.17	2.38	0.05	6.00
PHYL	57.10	19.33	0.77	7.91	0.09	3.46	0.63	1.60	4.76	0.19	2.74	0.00	0.00

Au	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Ga	La	Mn	Mo	Na
0.00	895.00	0.00	0.00	0.00	85.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.50	325.00	0.00	0.00	0.00	24.00	7.00	44.00	10.00	13.40	29.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.50	538.00	0.00	0.00	0.00	36.00	13.00	81.00	16.00	20.80	42.00	0.00	0.00	0.00
0.50	642.00	0.00	0.00	0.00	29.00	17.00	93.00	25.00	26.80	40.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Nb	Nd	Ni	Pb	Pd	Pt	Rb	Sb	Sc	Se	Sn	Sr	Ta	Th
15.70	0.00	0.00	0.00	0.00	0.00	174.00	0.00	14.10	0.00	0.00	179.00	0.00	15.00
9.00	25.00	16.00	17.00	0.25	0.25	78.00	0.00	5.00	1.50	2.10	317.00	0.00	12.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.00	35.00	33.00	17.00	0.25	0.25	163.00	0.00	9.00	1.50	4.30	178.00	0.00	14.00
14.00	38.00	44.00	27.00	0.25	0.25	185.00	0.00	13.00	1.50	5.20	189.00	0.00	16.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

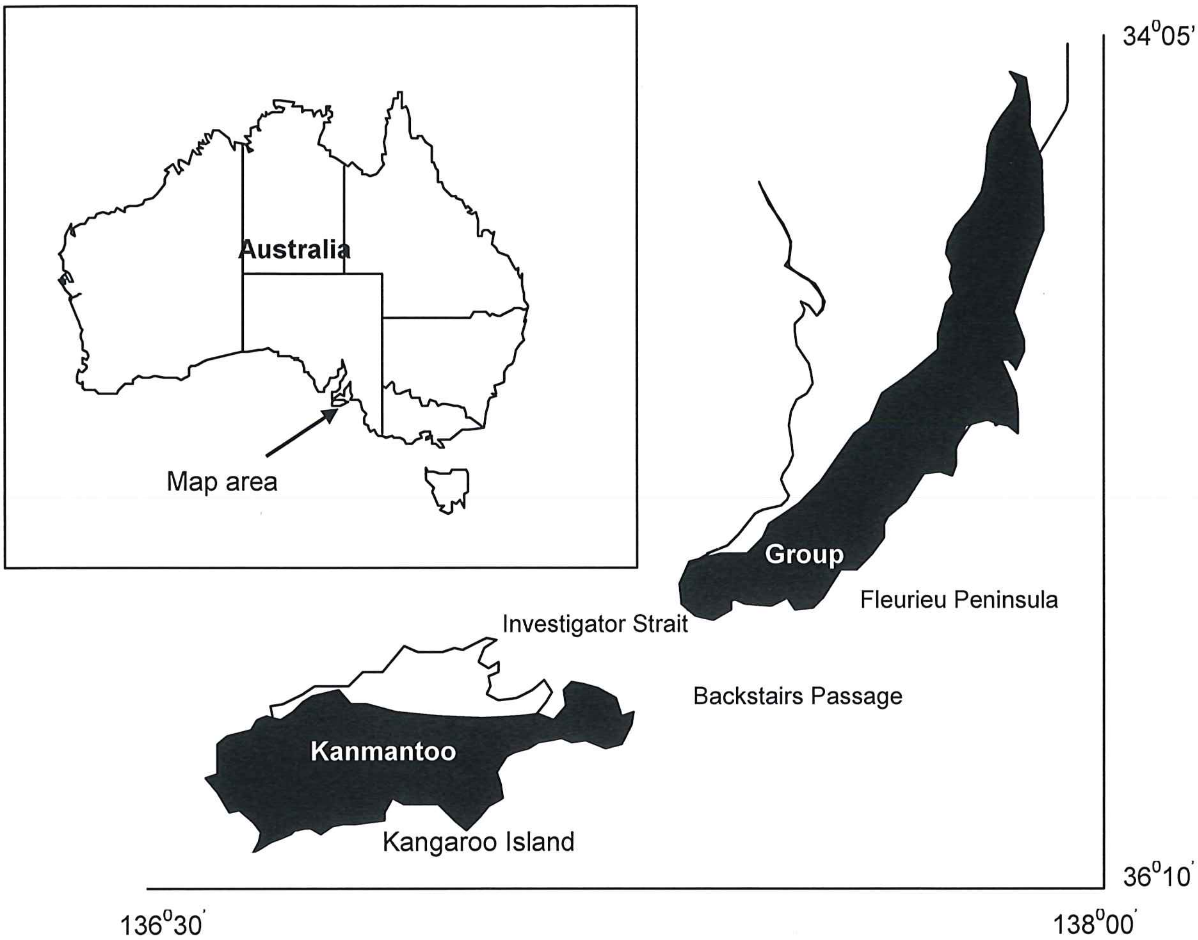
Tl	U	V	W	Y	Zn	Zr
0.00	0.00	0.00	0.00	29.50	0.00	161.00
0.00	2.30	38.00	0.80	24.00	49.00	225.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	2.54	73.00	2.10	29.00	74.00	193.00
0.00	3.55	94.00	3.00	32.00	115.00	187.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 2.

Cross-bedding

Stop	Easting	Northing	Altitude	Bedding		Clevage	Fold Plunge	
1				4/320		76/140		
2				20/356				
							10-->	
Sandy Creek Bay				54/300		68/316	030	
				69/322				
				66/326				
				65/320				
				63/324				
				68/304				
				70/320				
				64/313				
				72/316				
				64/313				
Pt Morrison				58/162				
				54/154				
to the N				48/170				
American River				70/357	70/083d/dd	68/232S	(68/142d/dd)	
Antechamber Bay				30/104				
				30/086		72/288		
Frenchmans Rock				59/169		72/130		

Figure 1.



Australia
Map area
34°05'
Group
Fleurieu Peninsula
Investigator Strait
Backstairs Passage
Kanmantoo
Kangaroo Island
36°10'
136°30'
138°00'

Figure 2.

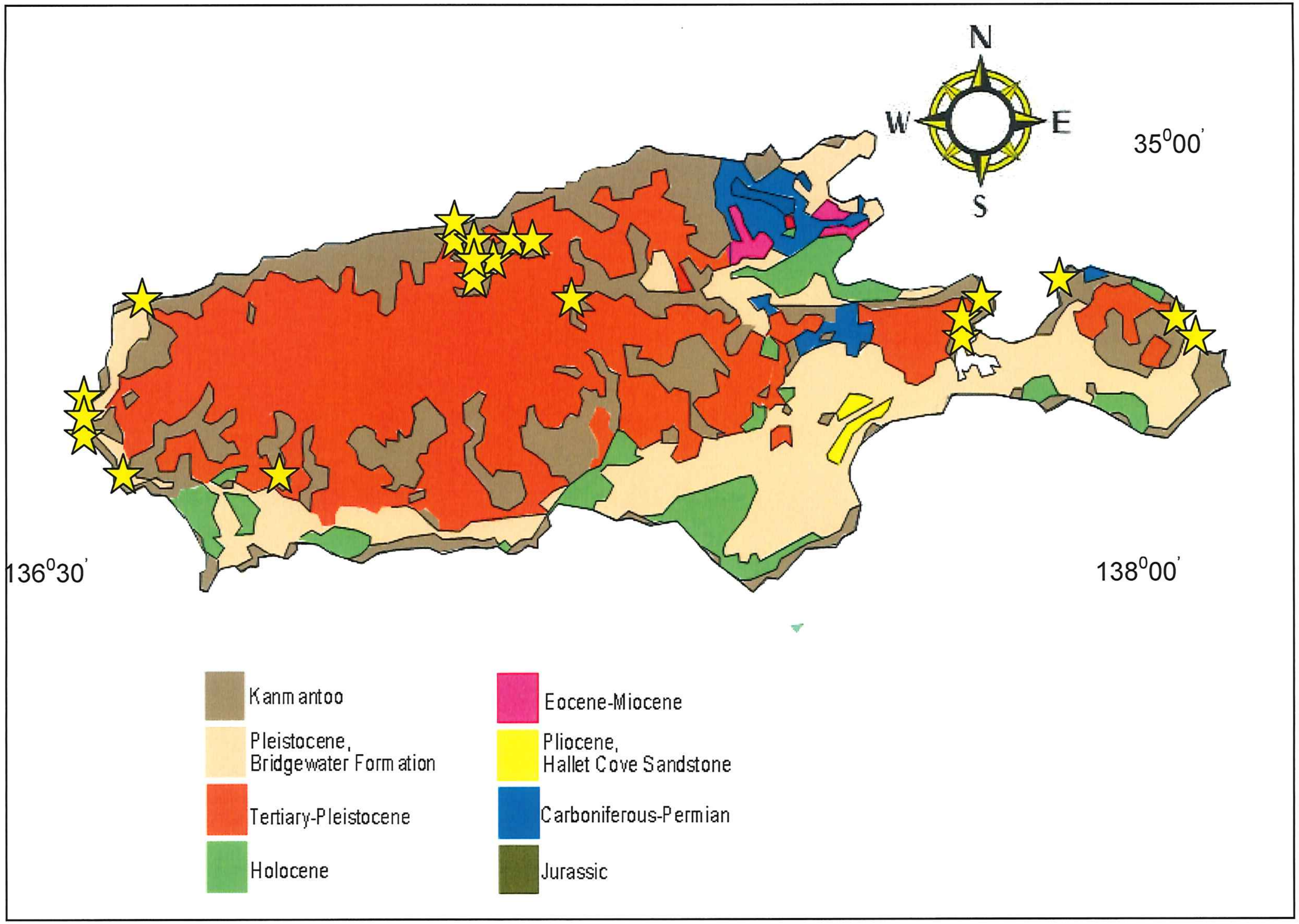
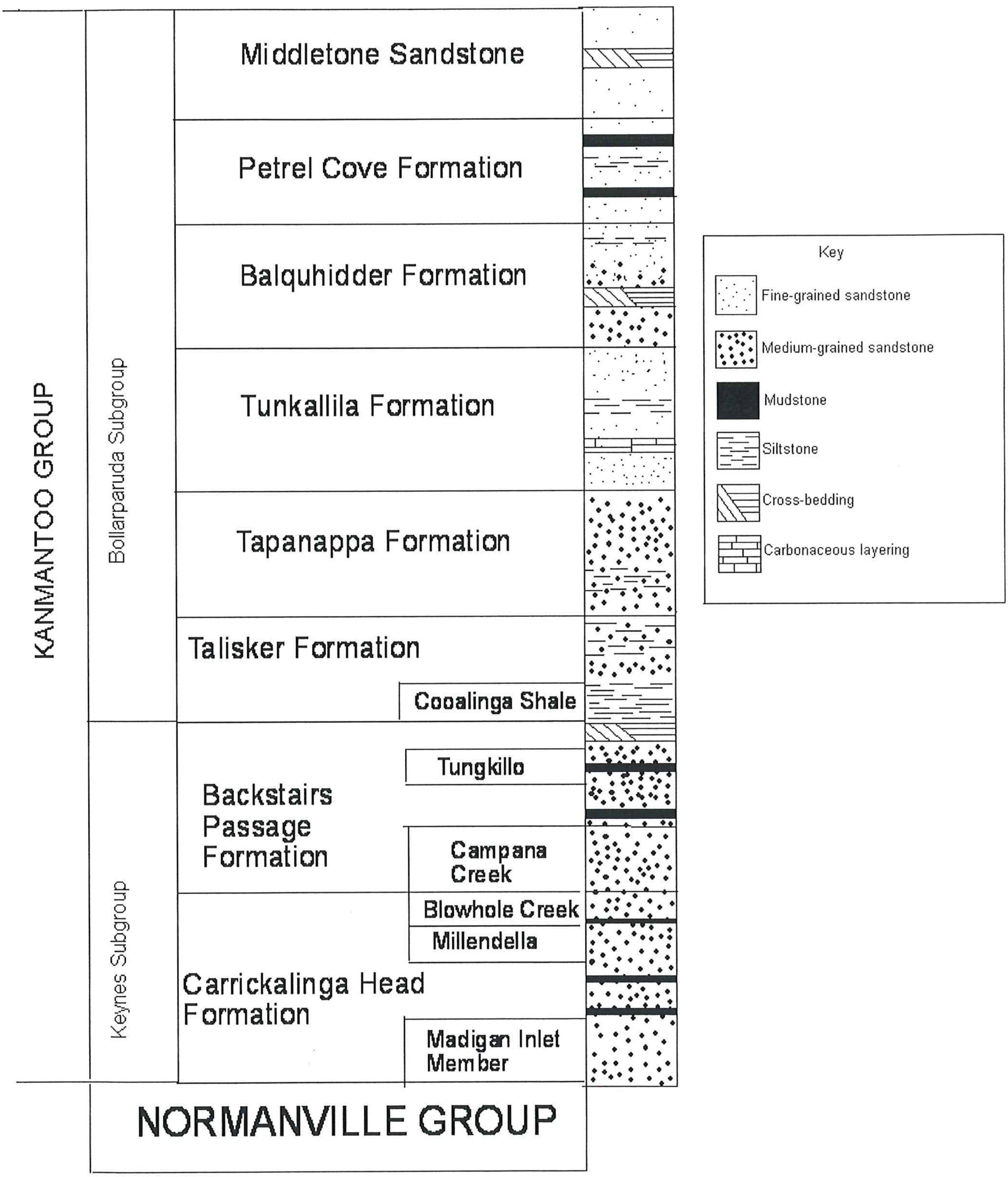
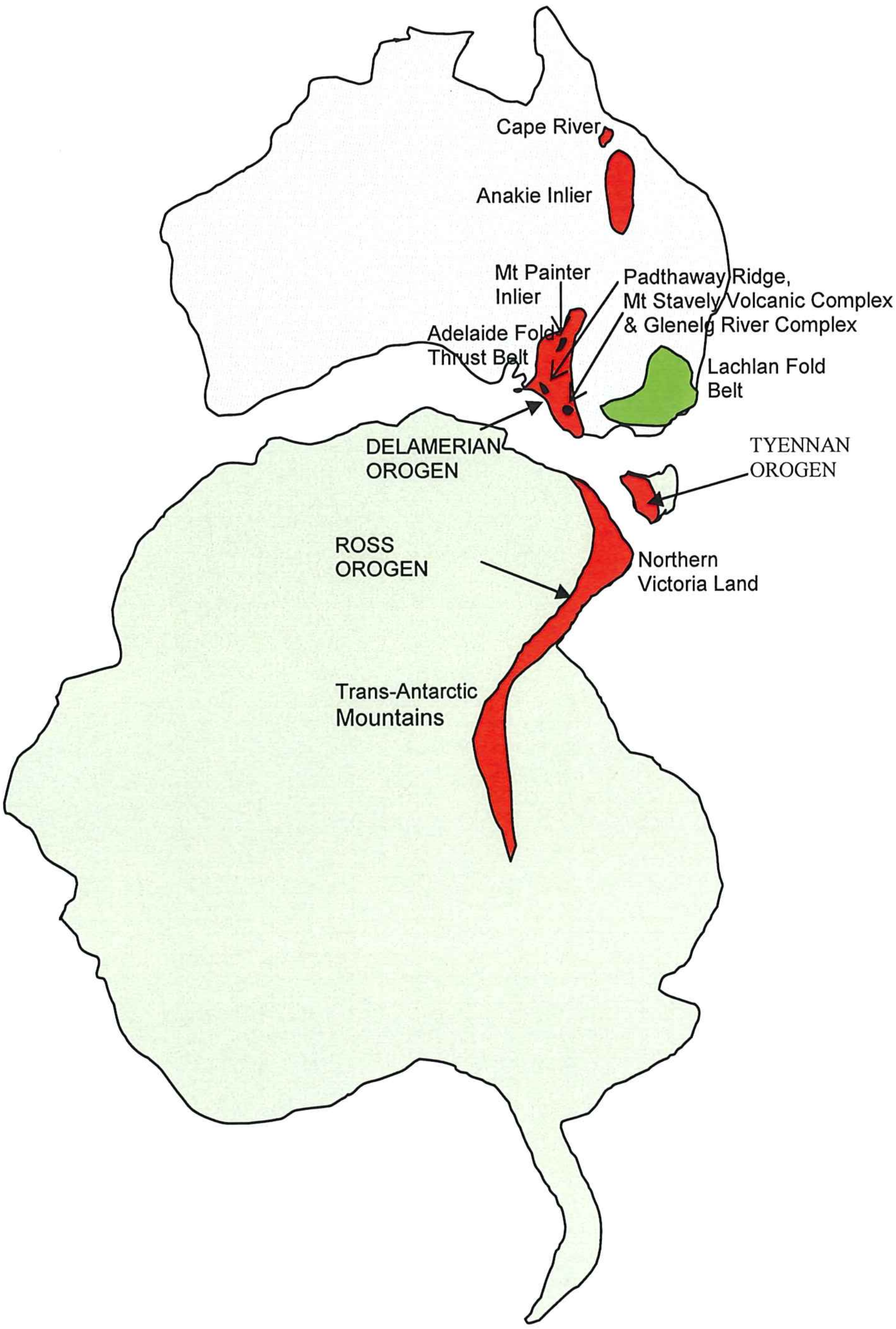

N
W
E
S
35°00'
136°30'
138°00'
Kanmantoo
Pleistocene,
Bridgewater Formation
Tertiary-Pleistocene
Holocene
Eocene-Miocene
Pliocene,
Hallet Cove Sandstone
Carboniferous-Permian
Jurassic

Figure 3.



KANMANTOO GROUP
Bollarparuda Subgroup
Middletone Sandstone
Petrel Cove Formation
Balquhidder Formation
Tunkallila Formation
Tapanappa Formation
Talisker Formation
Coaalinga Shale
Keynes Subgroup
Backstairs Passage Formation
Tungkillo
Campana Creek
Blowhole Creek
Millendella
Carrickalinga Head Formation
Madigan Inlet Member
NORMANVILLE GROUP
Key
Fine-grained sandstone
Medium-grained sandstone
Mudstone
Siltstone
Cross-bedding
Carbonaceous layering

Figure 4.



Cape River
Anakie Inlier
Mt Painter Inlier
Padthaway Ridge, Mt Stavely Volcanic Complex & Glenelg River Complex
Adelaide Fold Thrust Belt
Lachlan Fold Belt
DELAMERIAN OROGEN
TYENNAN OROGEN
ROSS OROGEN
Northern Victoria Land
Trans-Antarctic Mountains

Figure 5.

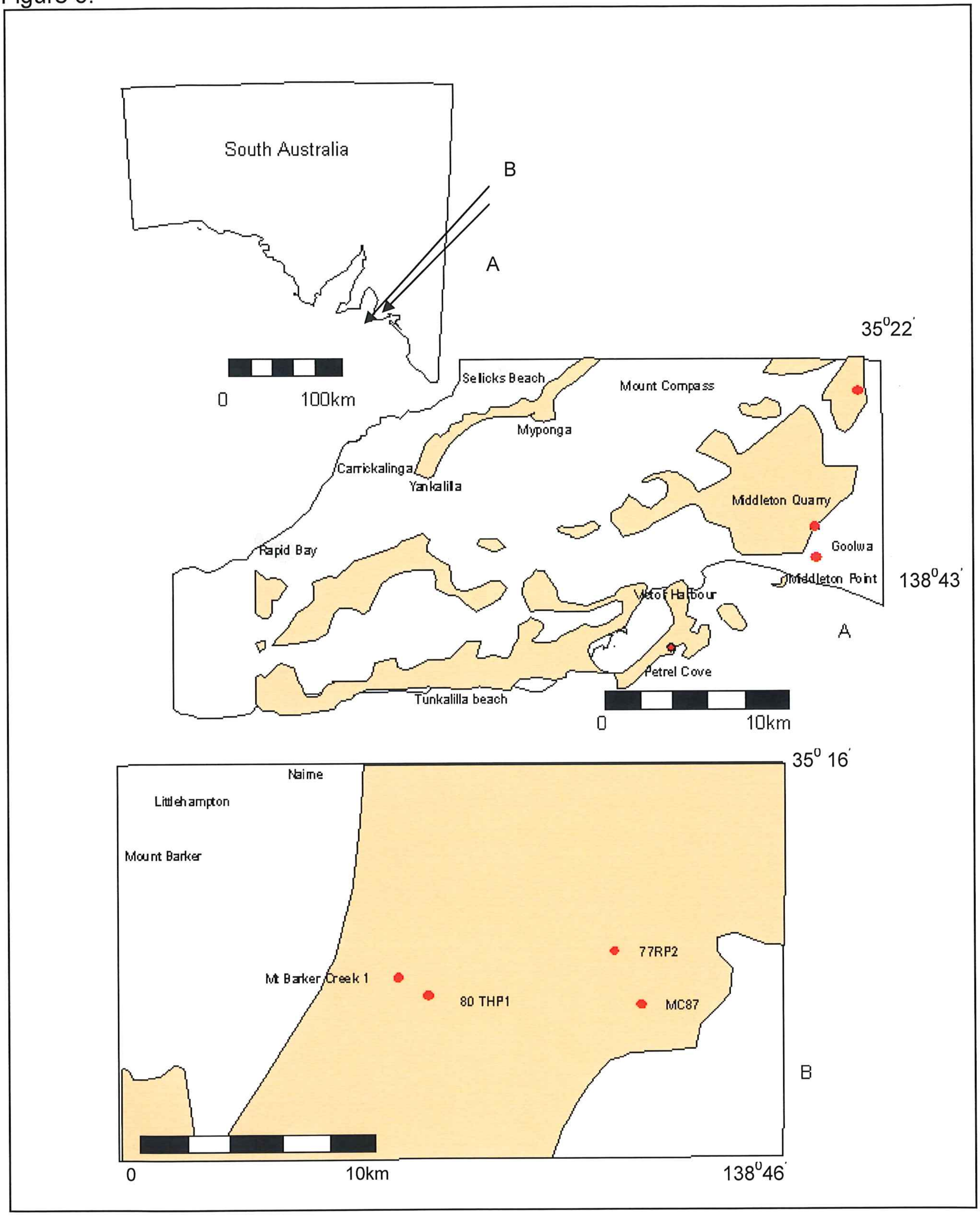

South Australia
B
A
0
100km
35°22′
Sellicks Beach
Mount Compass
Myponga
Carrickalinga
Yankalilla
Middleton Quarry
Goolwa
Rapid Bay
Middleton Point
138°43′
Victor Harbour
A
Petrel Cove
Tunkalilla beach
0
10km
35° 16′
Nairne
Littlehampton
Mount Barker
77RP2
Mt Barker Creek 1
80 THP1
MC87
B
0
10km
138°46′

Figure 6.

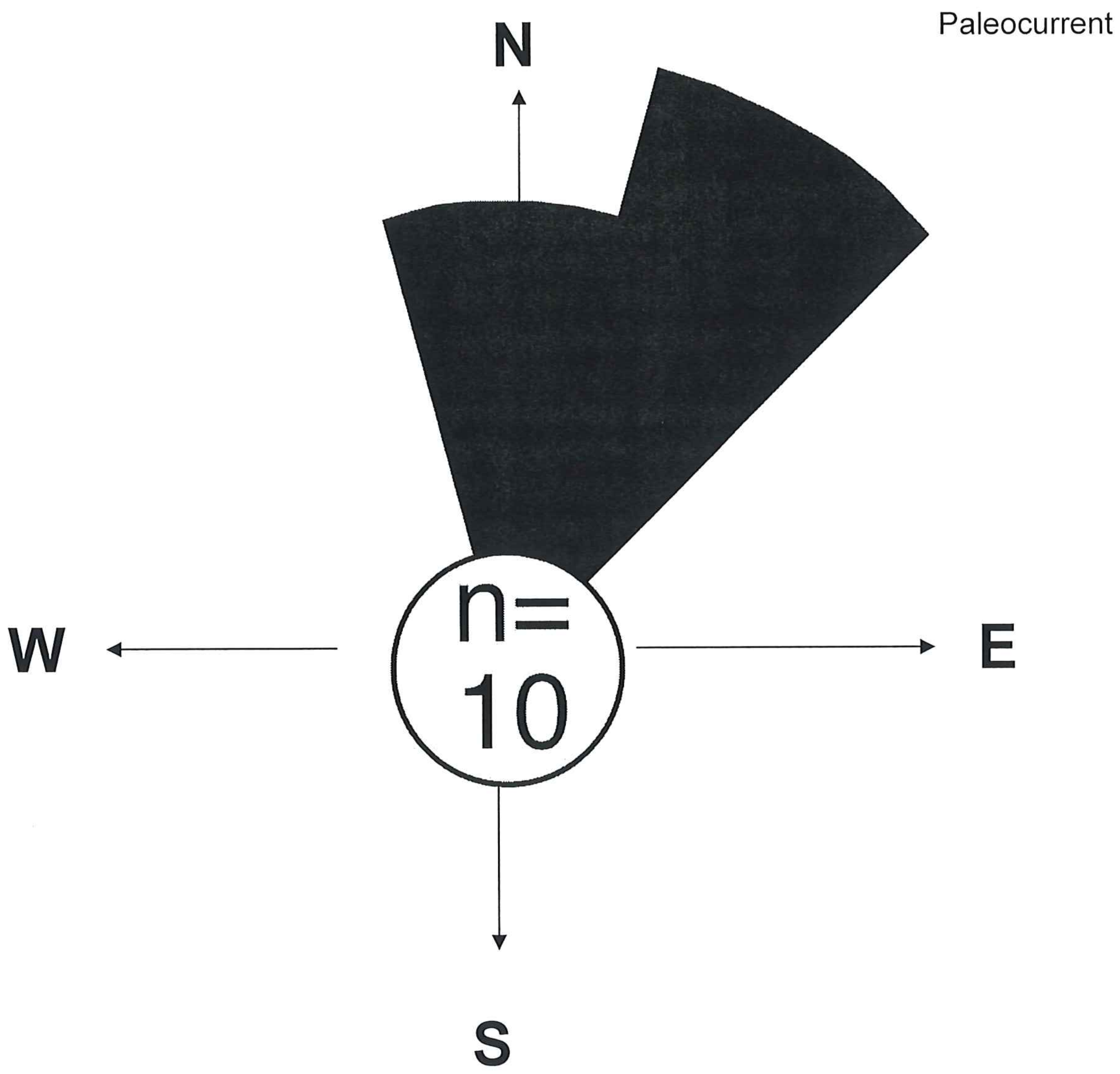
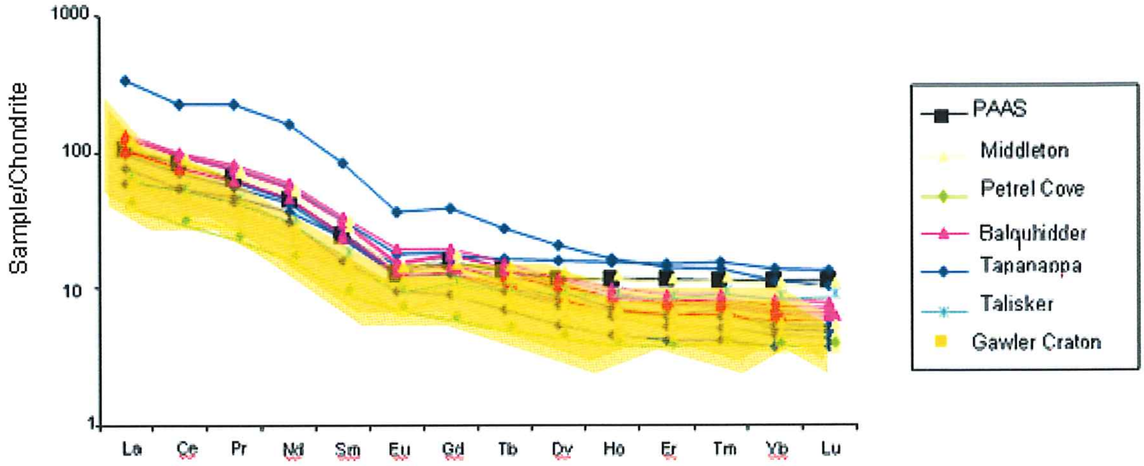
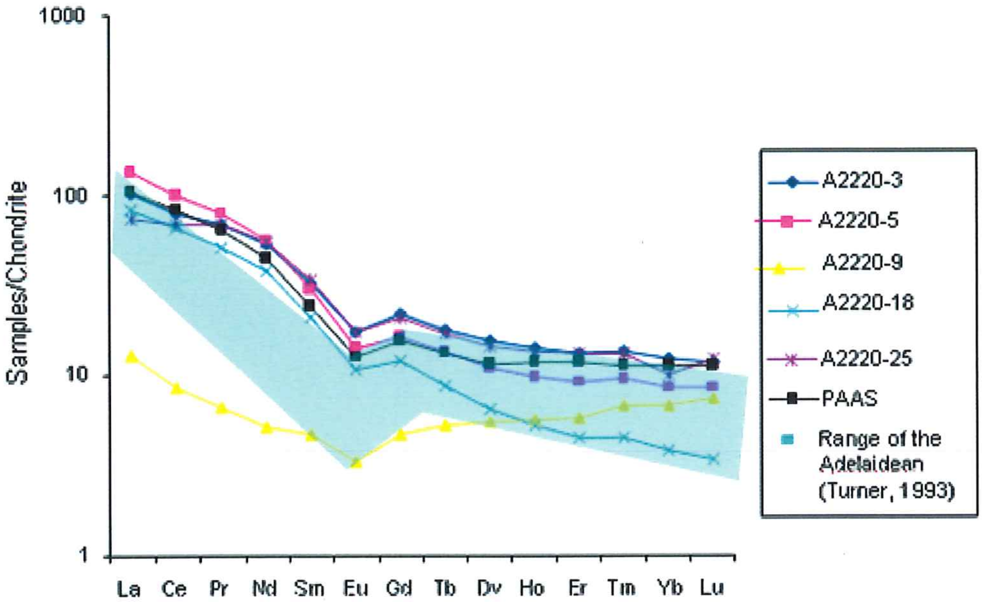


Figure 7.

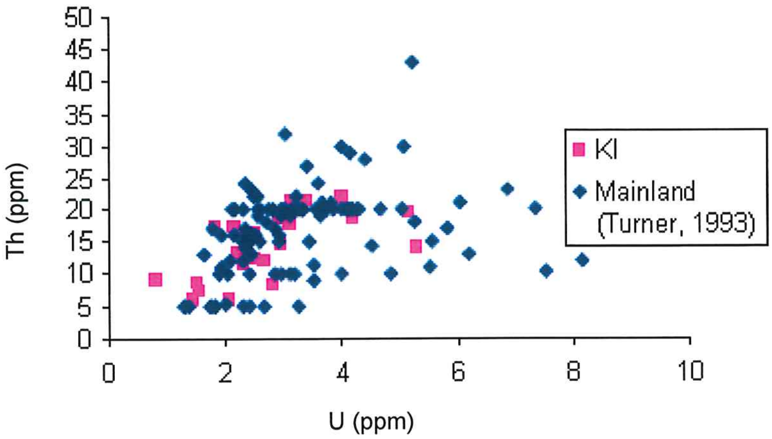

1000
100
10
1
Sample/Chondrite
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
PAAS
Middleton
Petrel Cove
Balquhidder
Tapanappa
Talisker
Gawler Craton

a)


1000
100
10
1
Samples/Chondrite
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
A2220-3
A2220-5
A2220-9
A2220-18
A2220-25
PAAS
Range of the Adelaidean (Turner, 1993)

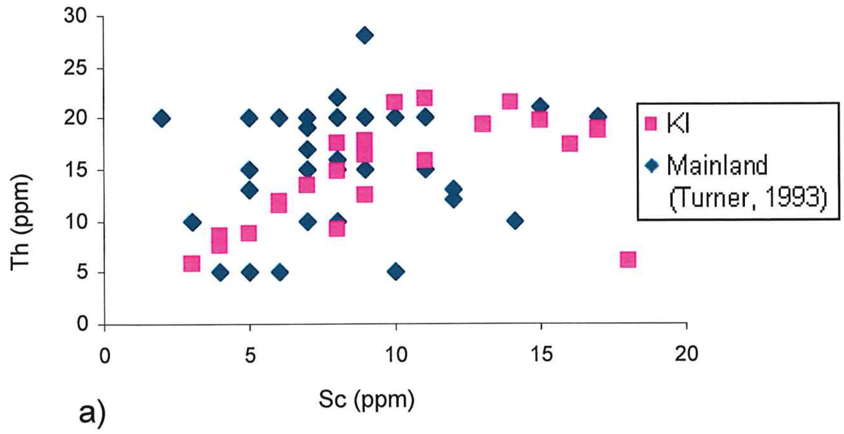
b)

Figure 8



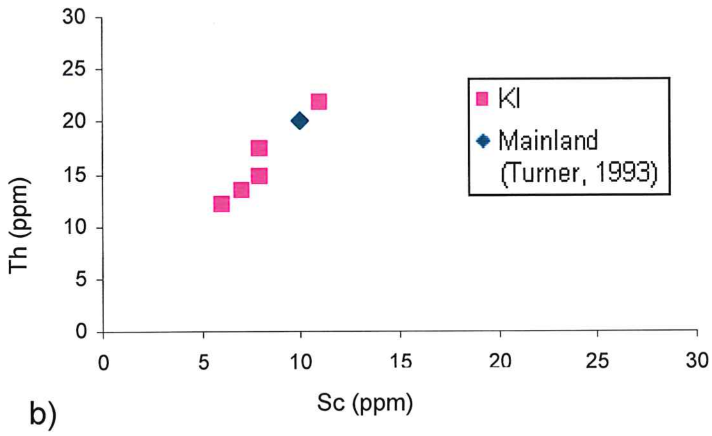
50
45
40
35
30
25
20
15
10
5
0
Th (ppm)
0
2
4
6
8
10
U (ppm)
KI
Mainland
(Turner, 1993)

Figure 9



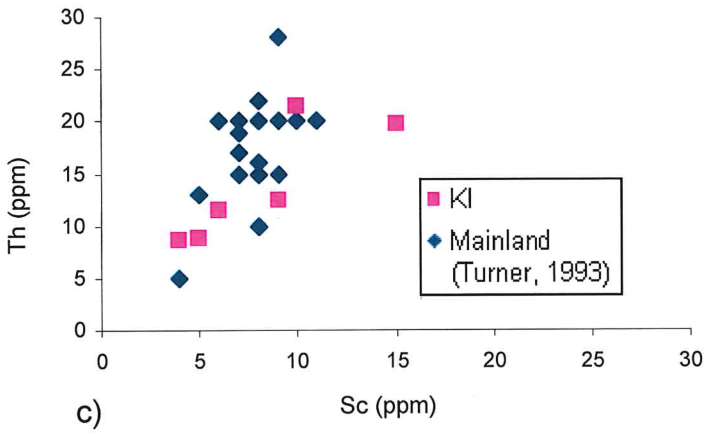
30
25
20
15
10
5
0
Th (ppm)
0
5
10
15
20
Sc (ppm)
KI
Mainland (Turner, 1993)

a)



30
25
20
15
10
5
0
Th (ppm)
0
5
10
15
20
25
30
Sc (ppm)
KI
Mainland (Turner, 1993)

b)


Th (ppm)
Sc (ppm)
0
5
10
15
20
25
30
KI
Mainland
(Turner, 1993)
c)

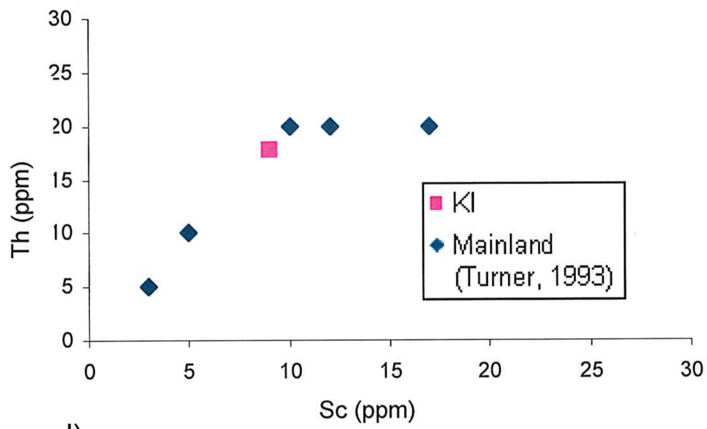
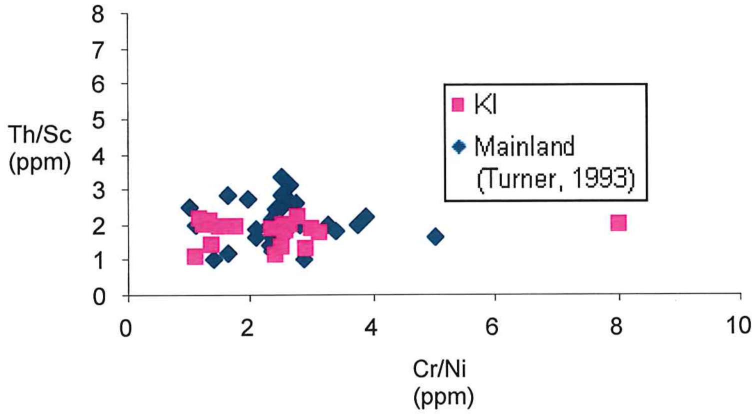
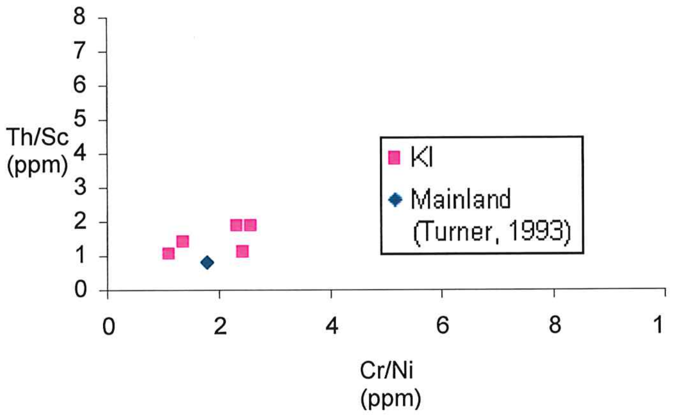

Th (ppm)
Sc (ppm)
0
5
10
15
20
25
30
KI
Mainland
(Turner, 1993)
d)

Figure 10



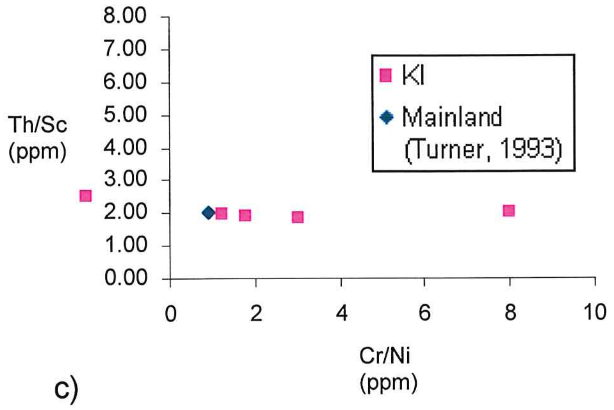
Th/Sc
(ppm)
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
Cr/Ni
(ppm)
KI
Mainland
(Turner, 1993)

a)

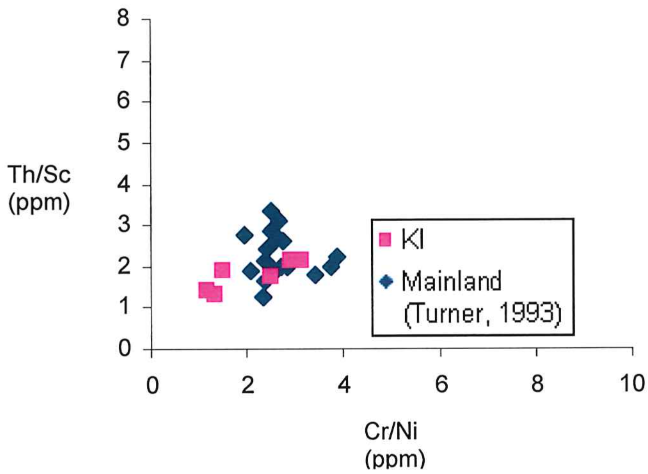


Th/Sc
(ppm)
8
7
6
5
4
3
2
1
0
0
2
4
6
8
1
Cr/Ni
(ppm)
KI
Mainland
(Turner, 1993)

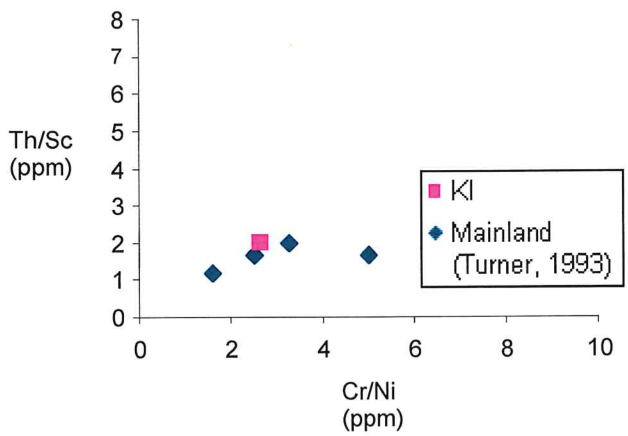
b)


8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Th/Sc
(ppm)
KI
Mainland
(Turner, 1993)
0
2
4
6
8
10
Cr/Ni
(ppm)

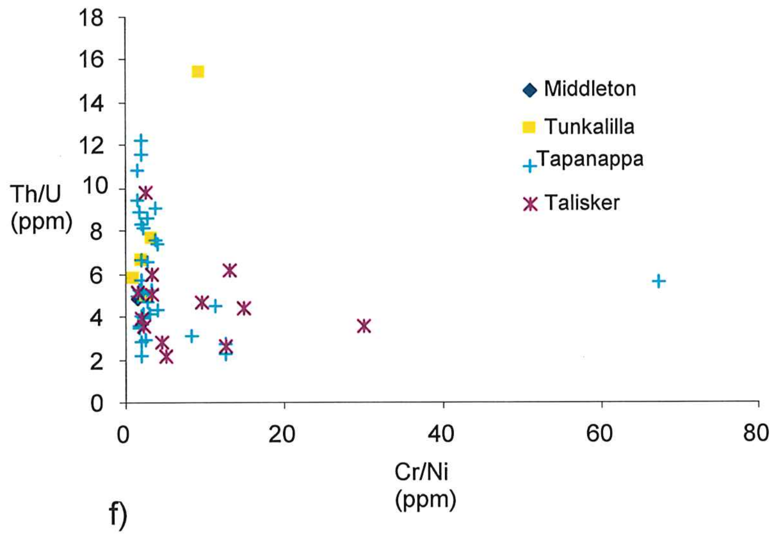
c)


8
7
6
5
4
3
2
1
0
Th/Sc
(ppm)
KI
Mainland
(Turner, 1993)
0
2
4
6
8
10
Cr/Ni
(ppm)

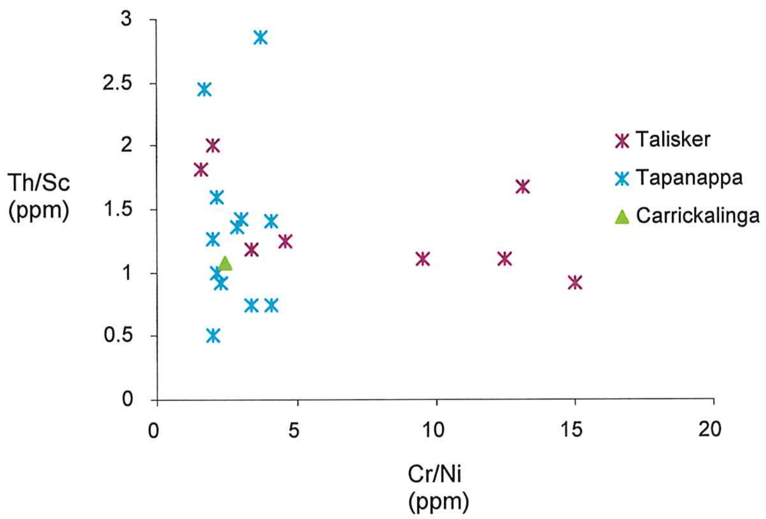
d)


8
7
6
5
4
3
2
1
0
Th/Sc
(ppm)
KI
Mainland
(Turner, 1993)
0
2
4
6
8
10
Cr/Ni
(ppm)

e)


18
16
14
12
10
8
6
4
2
0
Th/U
(ppm)
0
20
40
60
80
Cr/Ni
(ppm)
Middleton
Tunkalilla
Tapanappa
Talisker

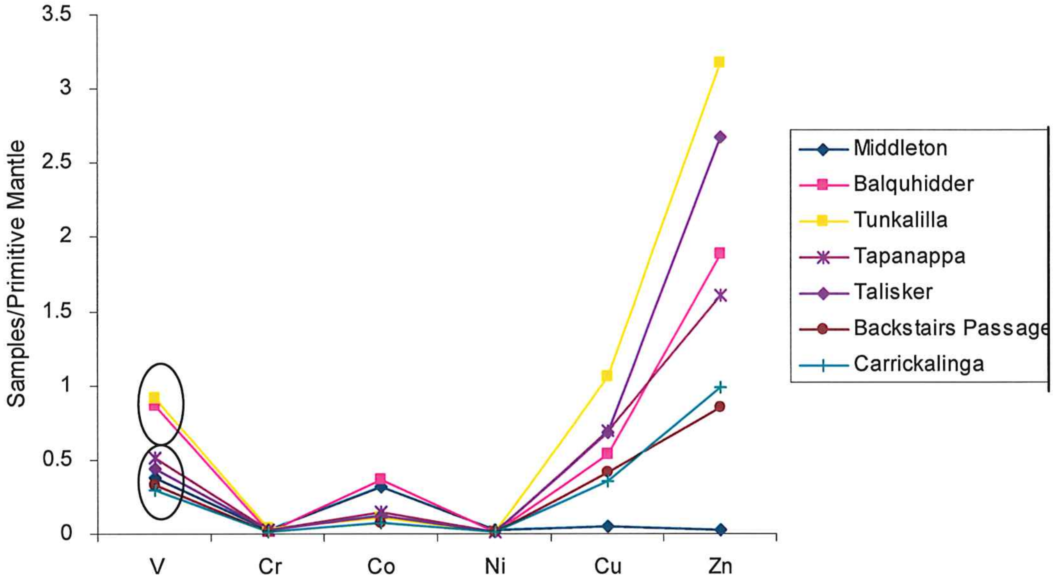
f)


3
2.5
2
1.5
1
0.5
0
Th/Sc
(ppm)
0
5
10
15
20
Cr/Ni
(ppm)
Talisker
Tapanappa
Carrickalinga

g)

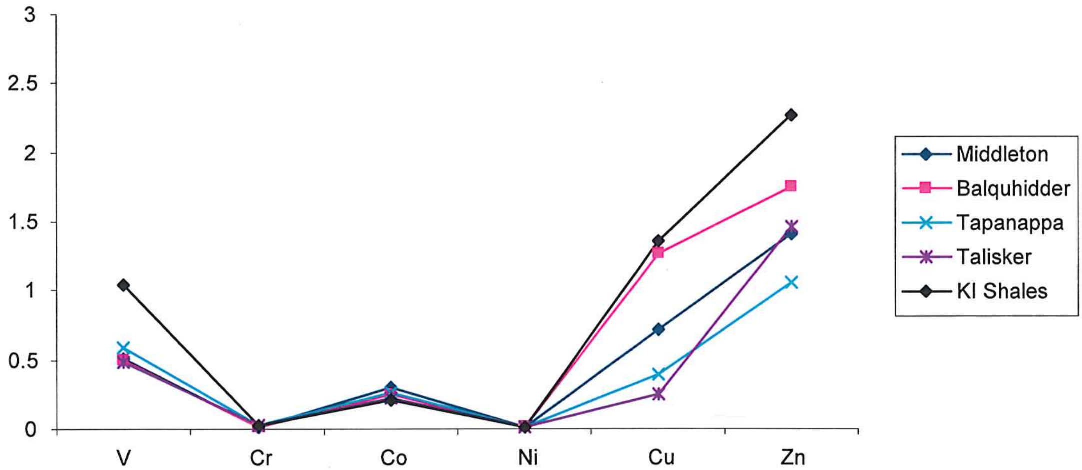
Figure 11

a)



3.5
3
2.5
2
1.5
1
0.5
0
Samples/Primitive Mantle
V
Cr
Co
Ni
Cu
Zn
Middleton
Balquhidder
Tunkalilla
Tapanappa
Talisker
Backstairs Passage
Carrickalinga

b)



3
2.5
2
1.5
1
0.5
0
V
Cr
Co
Ni
Cu
Zn
Middleton
Balquhidder
Tapanappa
Talisker
KI Shales

Figure 12.

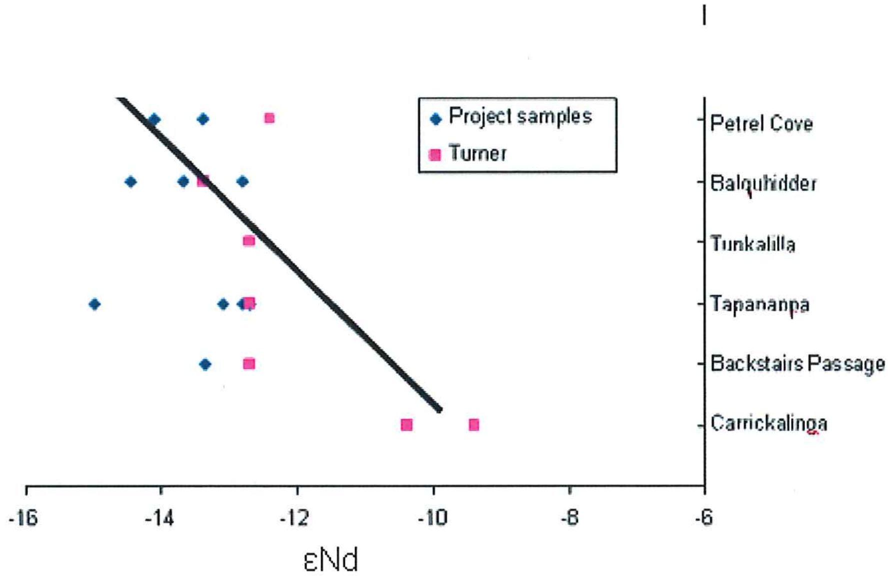

Project samples
Turner
Petrel Cove
Balquhidder
Tunkalilla
Tapananpa
Backstairs Passage
Carrickalinga
-16
-14
-12
-10
-8
-6
εNd

Figure 13.

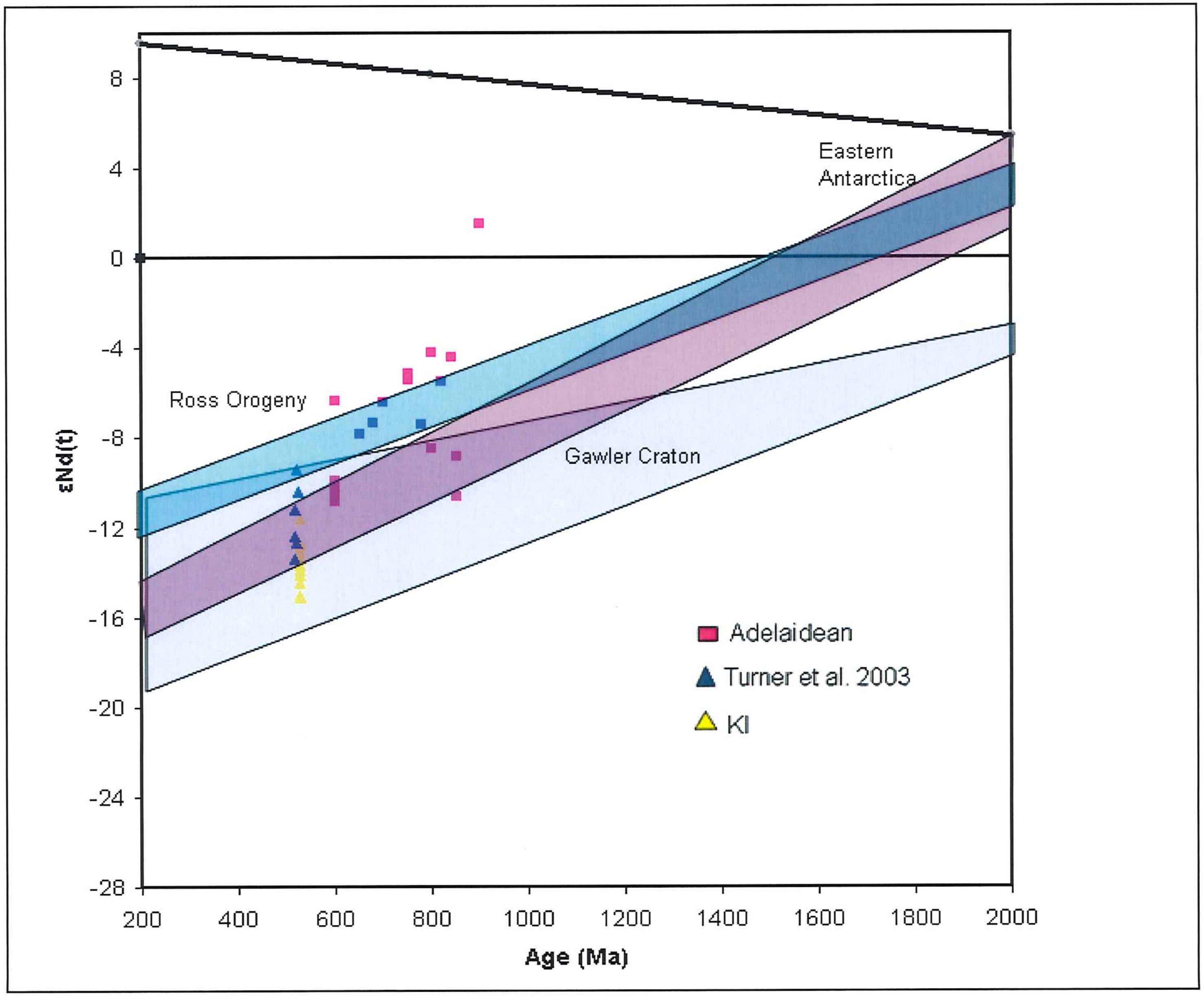

εNd(t)
8
4
0
-4
-8
-12
-16
-20
-24
-28
200
400
600
800
1000
1200
1400
1600
1800
2000
Age (Ma)
Eastern Antarctica
Ross Orogeny
Gawler Craton
Adelaidean
Turner et al. 2003
KI

Figure 14.

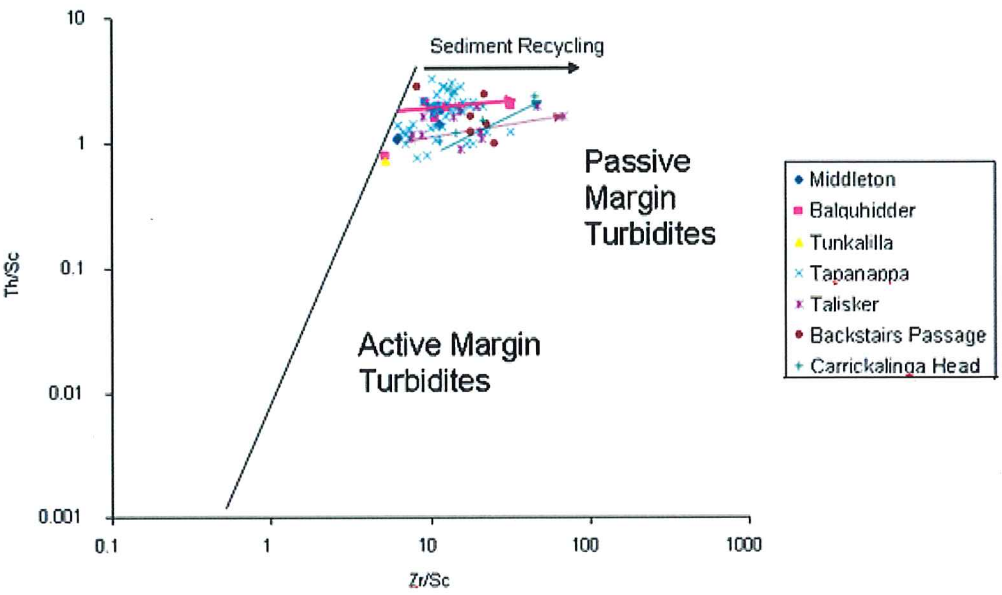
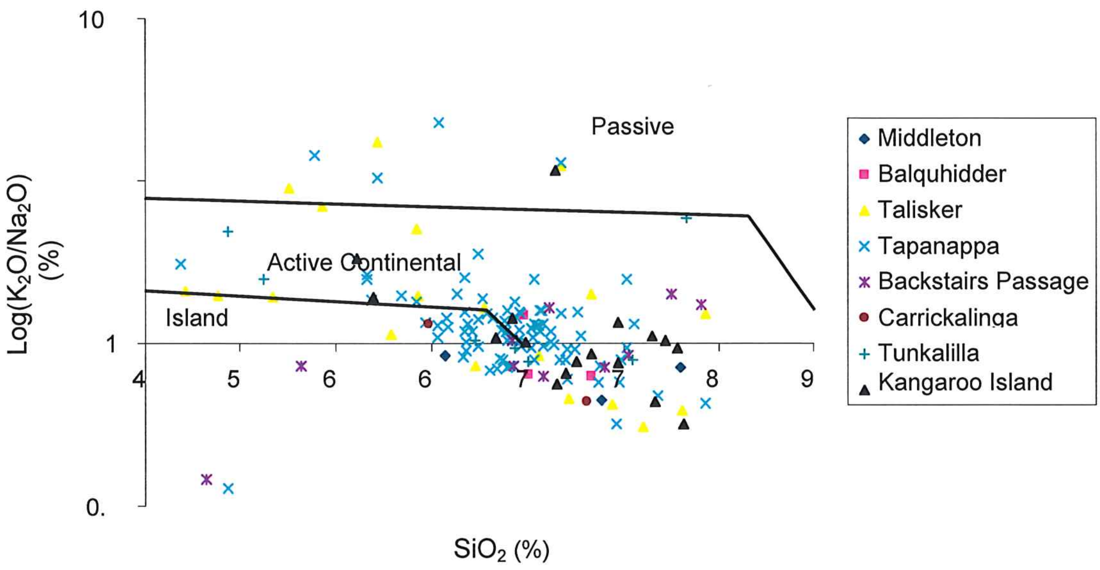
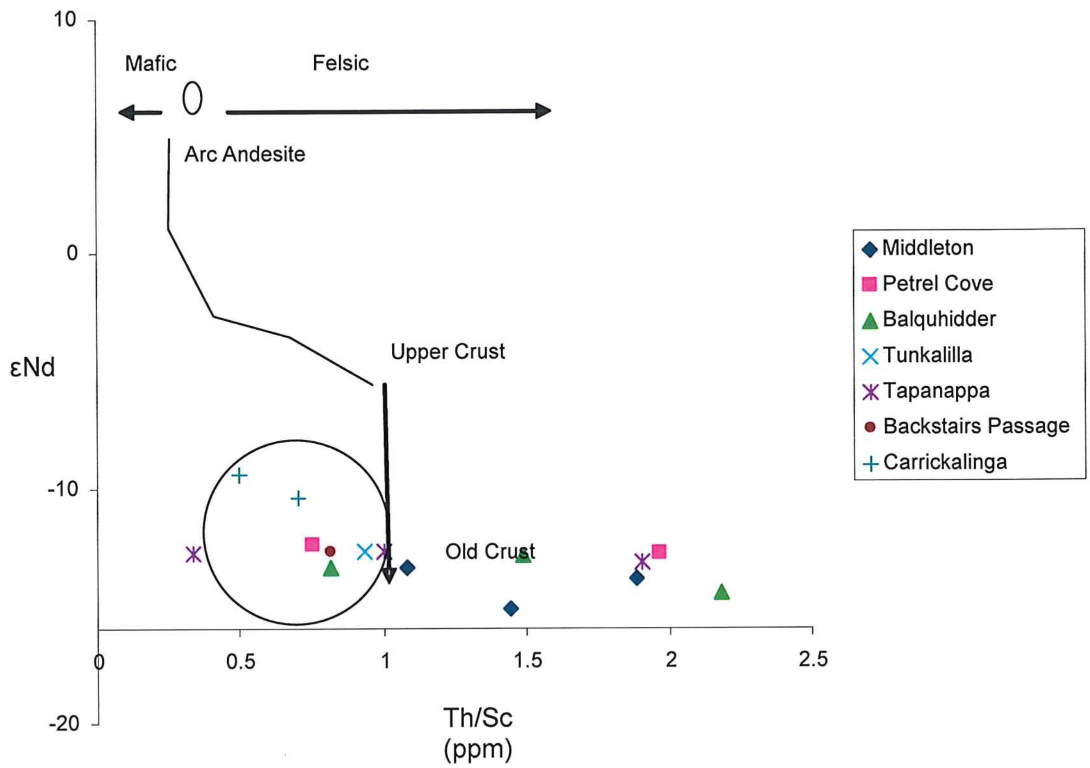

10
1
0.1
0.01
0.001
Th/Sc
0.1
1
10
100
1000
Zr/Sc
Sediment Recycling
Passive Margin Turbidites
Active Margin Turbidites
Middleton
Balquhidder
Tunkalilla
Tapanappa
Talisker
Backstairs Passage
Carrickalinga Head

Figure 15.



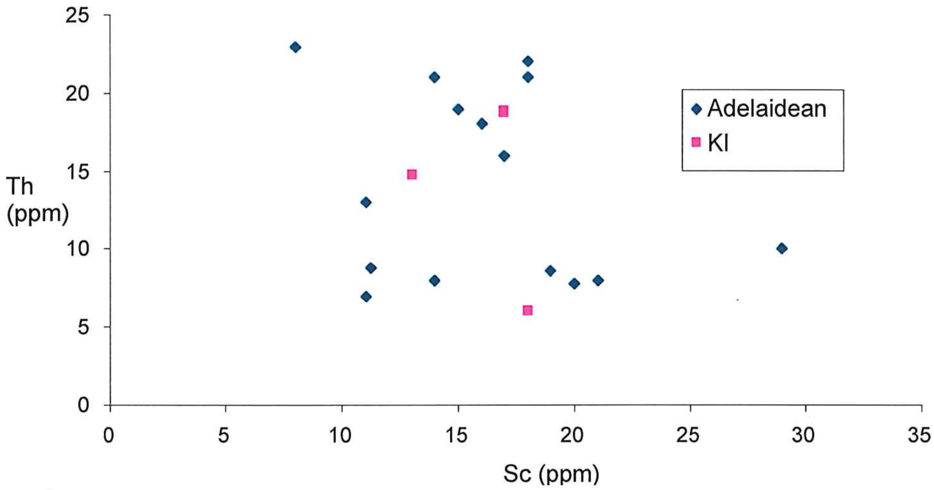
10
1
0.
Log(K2O/Na2O) (%)
4
5
6
6
7
7
8
9
SiO2 (%)
Passive
Active Continental
Island
Middleton
Balquhidder
Talisker
Tapanappa
Backstairs Passage
Carrickalinga
Tunkalilla
Kangaroo Island

Figure 16.



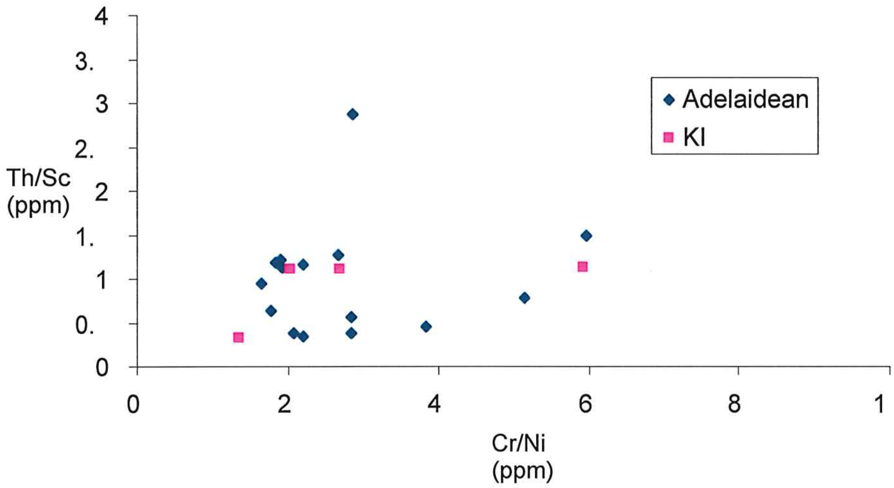
10
0
-10
-20
εNd
Mafic
Felsic
Arc Andesite
Upper Crust
Old Crust
0
0.5
1
1.5
2
2.5
Th/Sc
(ppm)
Middleton
Petrel Cove
Balquhidder
Tunkalilla
Tapanappa
Backstairs Passage
Carrickalinga

Figure 17.



Th (ppm)
25
20
15
10
5
0
Adelaidean
KI
0
5
10
15
20
25
30
35
Sc (ppm)

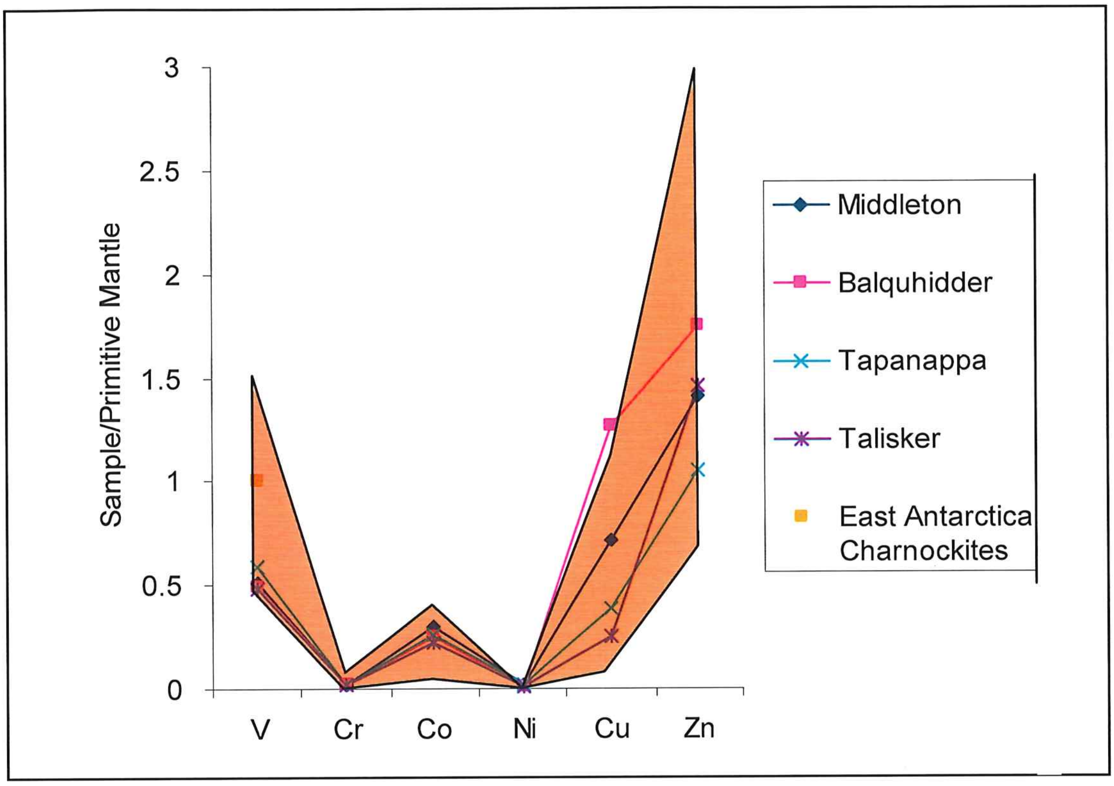
a)



Th/Sc (ppm)
4
3.
3
2.
2
1.
1
0.
0
Adelaidean
KI
0
2
4
6
8
1
Cr/Ni (ppm)

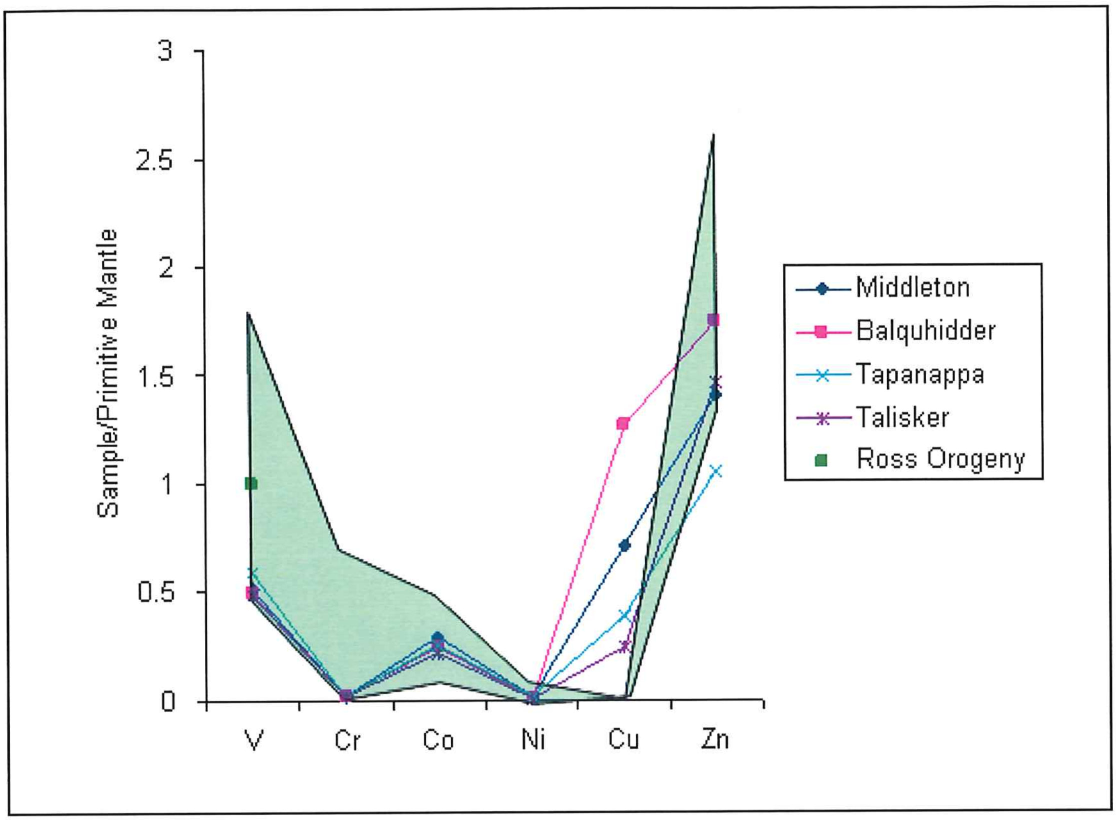
b)

Figure 18.



3
2.5
2
1.5
1
0.5
0
Sample/Primitive Mantle
V
Cr
Co
Ni
Cu
Zn
Middleton
Balquhidder
Tapanappa
Talisker
East Antarctica Charnockites

a)


3
2.5
2
1.5
1
0.5
0
Sample/Primitive Mantle
V
Cr
Co
Ni
Cu
Zn
Middleton
Balquhidder
Tapanappa
Talisker
Ross Orogeny

b)

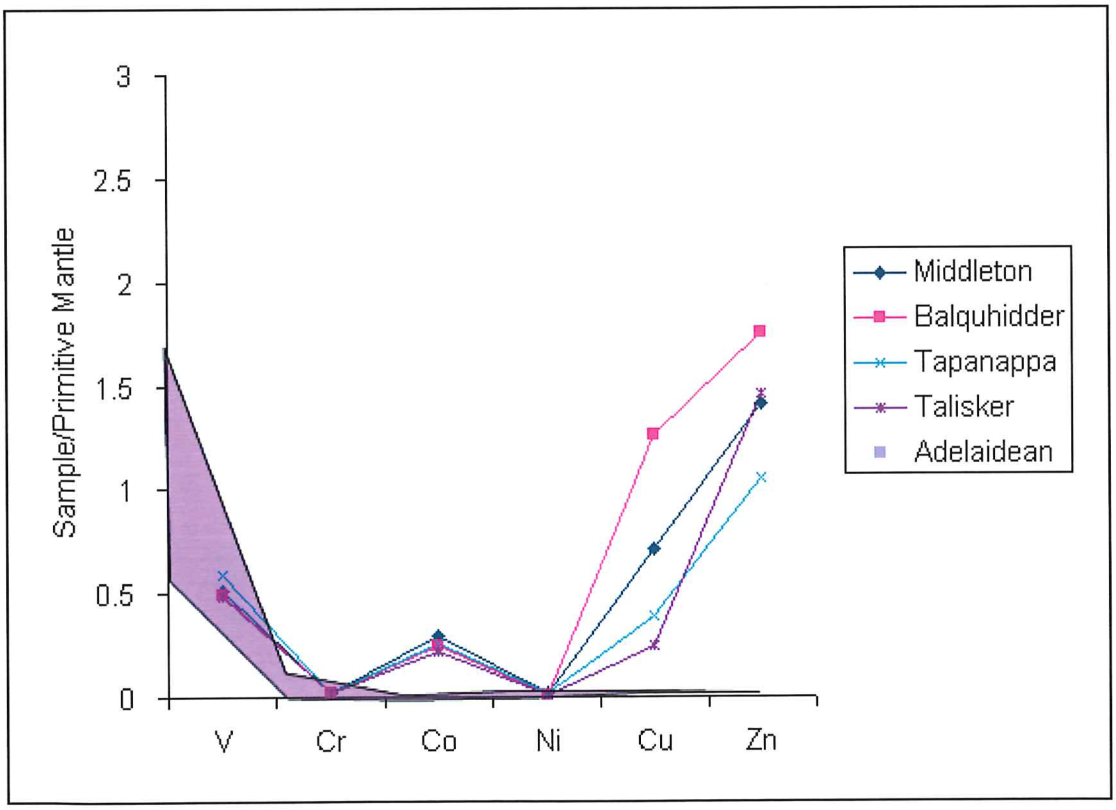
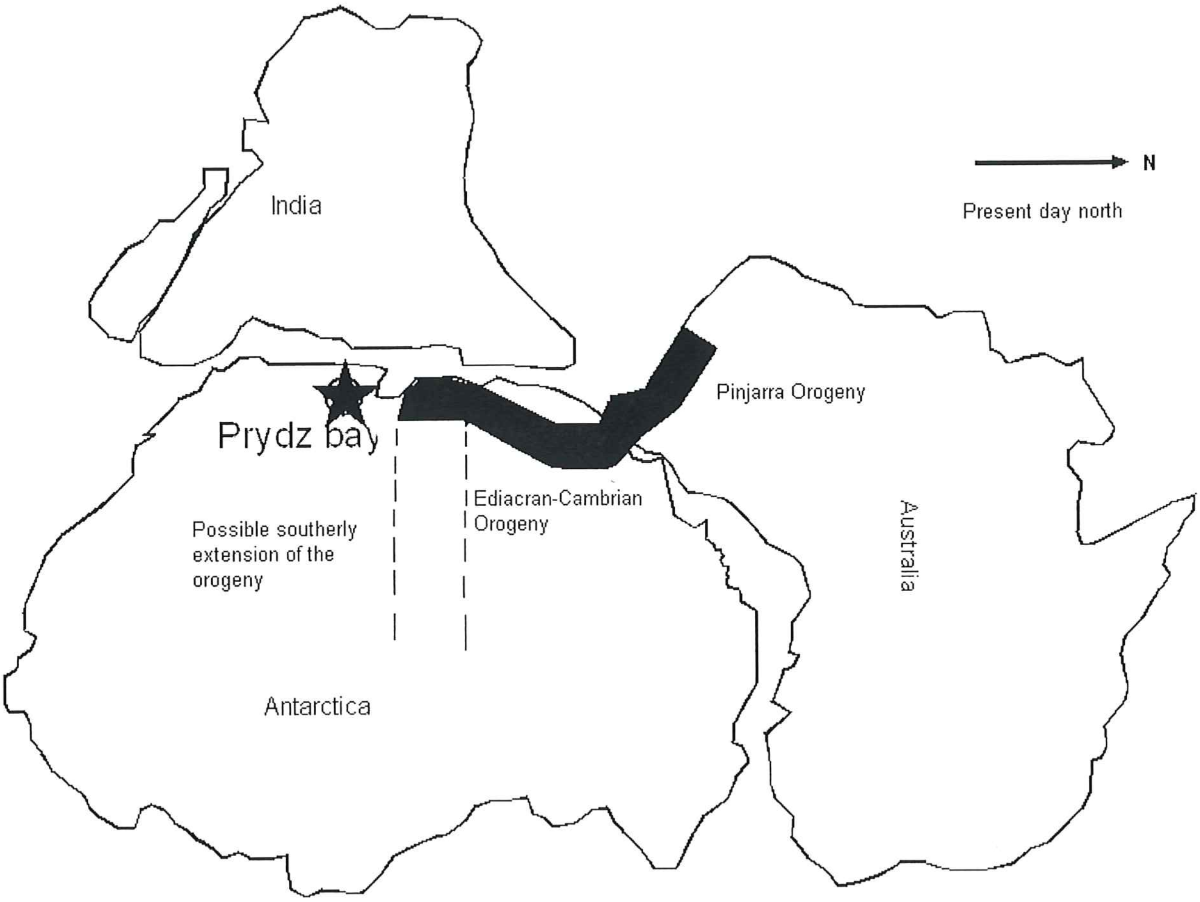
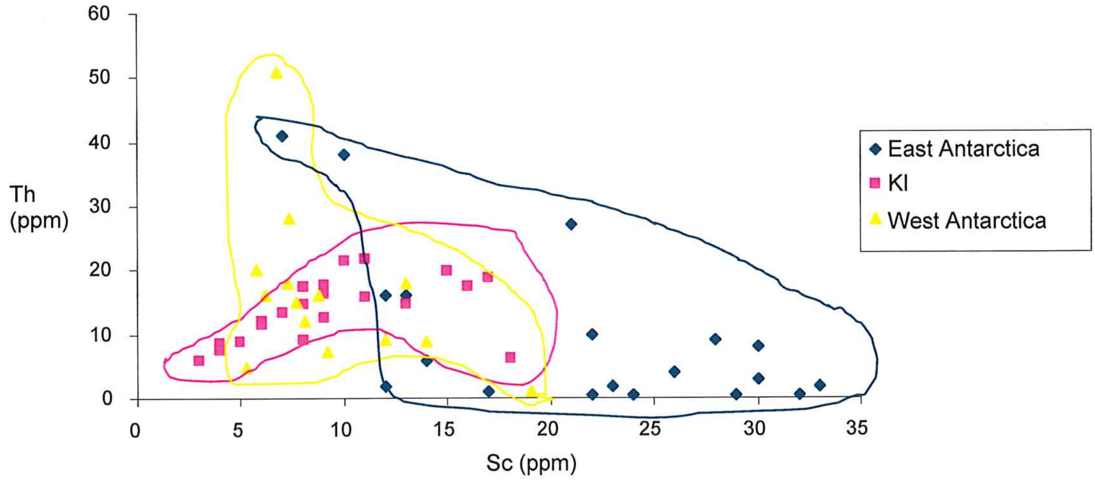

3
2.5
2
1.5
1
0.5
0
Sample/Primitive Mantle
V
Cr
Co
Ni
Cu
Zn
Middleton
Balquhidder
Tapanappa
Talisker
Adelaidean

Figure 19.



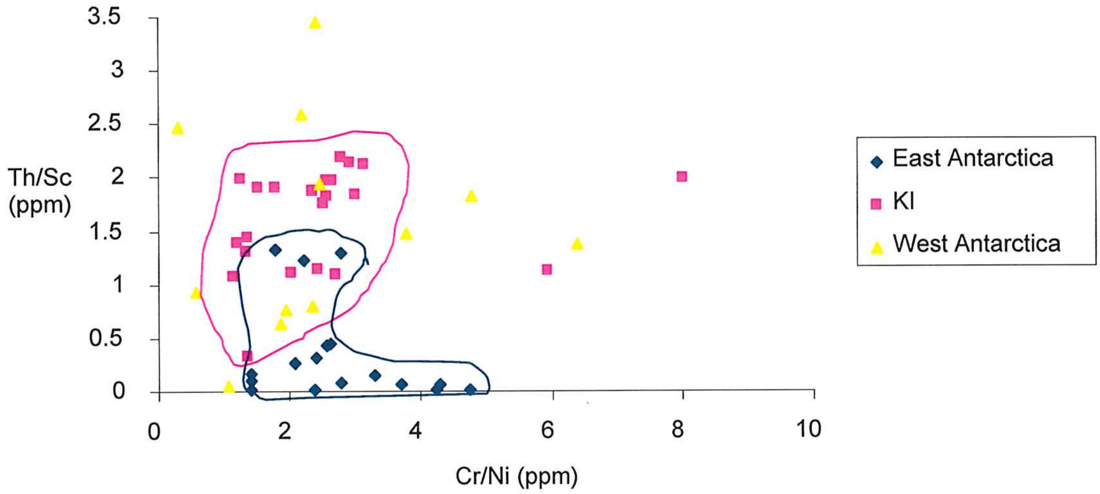
India
N
Present day north
Pinjarra Orogeny
Prydz bay
Ediacran-Cambrian
Orogeny
Possible southerly
extension of the
orogeny
Australia
Antarctica

Figure 20



60
50
40
30
20
10
0
Th
(ppm)
0
5
10
15
20
25
30
35
Sc (ppm)
East Antarctica
KI
West Antarctica

a)



3.5
3
2.5
2
1.5
1
0.5
0
Th/Sc
(ppm)
0
2
4
6
8
10
Cr/Ni (ppm)
East Antarctica
KI
West Antarctica

b)