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Ground truthing of Western Tasmanian Regional Minerals Program geophysical data in the Balfour–Temma area

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Abstract

Recently acquired aeromagnetic data from the Balfour area indicate some large, strong magnetic anomalies, some closely associated with copper mineralisation. Ground checking of these has failed to reveal the source of most of the anomalies, but some magnetite and ilmenite-bearing siltstones are present in the north of the area. There are no geological, geochemical or petrological indications of near-surface granites or mafic rock under most of the anomaly, and the relationship between mineralisation and magnetic rocks is uncertain.

Introduction

Recently acquired aeromagnetic data from the Balfour area (fig. 1) indicate that most of the known copper deposits are hosted by monotonous sequence of Precambrian siltstone but are associated with high magnetic signatures (fig. 2).

A preliminary magnetic susceptibility survey was undertaken on some of the locations characterised by high aeromagnetic anomalies in the Balfour–Temma area. The purpose of this study was to mainly investigate whether there are any correlations between areas with magnetic high anomalies and the magnetic susceptibility characters of associated rocks cropping out in the area.

The specific aims of the project were:

- Ground checking linear aeromagnetic anomalies associated with copper mineralisation between The Clump and Balfour;
- Ground checking linear aeromagnetic anomalies north of The Clump not obviously associated with mineralisation; and
- Ground checking irregular aeromagnetic anomalies between Temma and the Interview River (mineralisation relationships uncertain).

Unfortunately the attempt to reach the Interview River along the coast route failed because of high river levels.

All locations are on the AGD66 datum.

Local geology

The geology of the Balfour area has been studied in detail by Turner (1994) and Reed *et al*. (unpublished MRT data). The following is basically a summary of the work carried out by Turner (1994) and Everard *et al*. (2001) with minor inputs derived from our field observations. Figures 1 and 3 show a simplified geology of Balfour–Temma area and the associated main structures.

The geology of the Balfour area mainly consists of the Balfour Subgroup and Cowrie Siltstone overlain by some minor Tertiary basalt and younger deposits. The Balfour Subgroup is a sequence of siliceous sandstone and siltstone, carbonaceous pyritic siltstone and shale, quartz arenite and chloritic siltstone that conformably overlies the Lagoon River Quartzite and is conformably overlain by a correlate of the Cowrie Siltstone in the vicinity of Balfour. These rocks are unconformably overlain by the Togari Group which consists of a discontinuous basal, siliceous conglomerate (Forest Conglomerate) overlain by tholeiitic basalt (Spinks Creek Volcanics) and associated volcaniclastic rocks, and variably silicified dolomite (Black River Dolomite).

The local structure of the Balfour area is dominated by a number of faults, including an east-trending fault which separates the Balfour South prospect area from a block containing Balfour. There is also the regionally extensive, NE-trending, steeply-dipping Roger River Fault (fig. 3), that separates the block containing The Clump prospect area from the Balfour area. NNW-trending faults of complex nature occur around Mt Frankland, and form the eastern boundary to the block containing the Balfour and the Balfour South prospects.

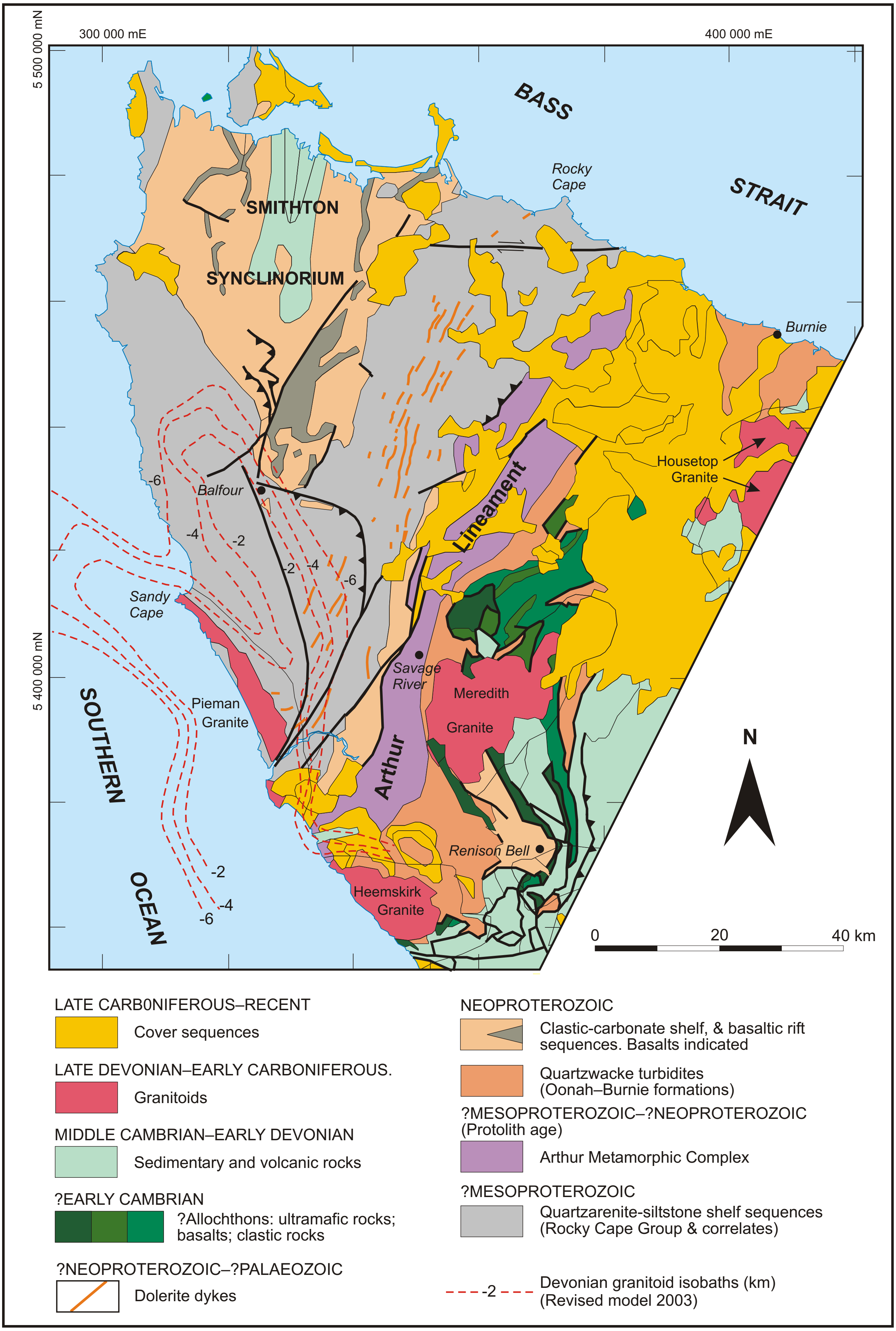

Figure 1

Regional geology map of northwest Tasmania

Turner (1994) subdivided the older rocks of the Balfour area (Rocky Cape Group) on the basis of lithological associations, mainly the character of siltstone, which is the most common rock type in the area. There are lithological sequences where the siltstone is dark grey (carbonaceous), whereas in other sequences it is green or olive (chloritic). The rocks along the Balfour track and west of the Murrays Reward mine consist of a conformable, east-facing sequence ranging from quartz arenite to grey siltstone in the west, changing into green and grey siltstone with interbedded quartz arenite to the east, near Murrays Reward. Similar stratigraphy continues to the south and north of the Murrays Reward mine.

The Neoproterozoic sequences (Togari Group) include units correlated with the Forest Conglomerate and the Spinks Creek Volcanics, both of which are present on Blackwater Road. These formations are laterally offset by some 2.5 km along the Roger River Fault and they reappear to the southwest (around 324 000 mE, 5 436 000 mN). The Black River Dolomite has not been observed within the area.

The Forest Conglomerate and Quartzite consists of siliceous conglomerate and well-sorted quartz arenite. The Spinks Creek Volcanics are basaltic but most exposures are deeply weathered.

Based on a gravity interpretation (Leaman, 1988*a*), the Rocky Cape Group has been overthrust onto the younger sedimentary rocks and basalts (i.e. Togari Group) of the Smithton Synclinorium. The succession has been folded, forming the eastern limb of a southerly extension of the large anticline that occurs south of Marrawah (Seymour and Baillie, 1992). Small scale, NNW-trending folds showing different plunges are also common within the area, including at the Balfour South prospect, on Heemskirk Road, on Blackwater Road and around Specimen Hill. The relationships between these faults and the regional anticline are not yet known.

There are no granitic outcrops known within the Balfour–Temma area. The nearest outcrop of granite (the Pieman Granite) is at Sandy Cape, some 22 km southwest of Balfour. Based on a gravity interpretation (Leaman, 1988*a*; fig. 3), a NNW-trending granite spine shallowly underlies (~2 km) the southern to central parts of the copper belt. Most of the Sn-W prospects, as well as some nearby copper deposits (e.g. Murrays Reward), occur where the interpreted granite surface is about 2 to 4 km deep.

The Balfour and Temma areas are structurally complex, and Everard *et al*. (2001) have recognised at least two extensional and four compressional deformation events.

Mineralisation and associated alteration

Mineralisation in the Balfour–Temma area has been described by Ward (1911) and many exploration geologists (e.g. Parkinson, 1994; Turner, 1995; Dickson, 1983; Perring, 1984). The main deposit in the area is the Murrays Reward mine, described by Yaxley (1981) and Veska (1993).

In general, the primary mineralisation in the Balfour area can be divided into three types:

- Numerous small copper lodes occurring along the 35 km long, NNW-trending Balfour belt. There are also some old copper prospects some 10 km to the south of the Toner River copper prospect, at the southern end of the copper belt (fig. 3); these appear to represent an extension of the copper belt (Taheri and Bottrill, in prep). Copper mineralisation has generally been considered to be economically more significant than other types within the area.
- Vein and stockwork-style tin and tungsten deposits lying in close proximity to the copper lodes, located approximately in the middle of the copper belt (fig. 3).
- Some transgressive magnetite-dominated lodes restricted to the Temma area near the coast, 18 km west of Balfour. These deposits appear to show similar trends to the Balfour Copper Belt (fig. 3) but are distinctly different in mineralisation styles. The bodies are up to 15 m thick and contain varying amounts of hematite, chalcopyrite, tetrahedrite, galena, sphalerite, pyrite, Fe-Mn carbonates, stilpnomelane and grunerite, but relatively little quartz (Taheri and Bottrill, in prep.). They appear to be controlled by structures subparallel to the eastern margin of the Sandy Cape Granite with NNE trends but locally lodes lie in adjacent structures discordant to this trend. Despite the difference in the mineralisation styles, the deposits may be genetically linked to the Balfour deposits, but require more detailed study.

Mineral deposits of secondary nature include alluvial tin, mostly in close proximity to some tin lodes, and coastal sand dune and old strand line deposits containing cassiterite, chromite, zircon and rutile.

Potential for Broken Hill-style PB-Zn, as evidenced by the occurrence of some Mn-Ca garnet, has been discussed by Bottrill (2004) and Taheri and Bottrill (in prep.).

Magnetic susceptibility results

The magnetic susceptibility (MS) measurements are shown in Table 1. Sample locations are shown in Figure 2. In most cases, similar rock types were measured several times within the same area. Specific areas are discussed below.

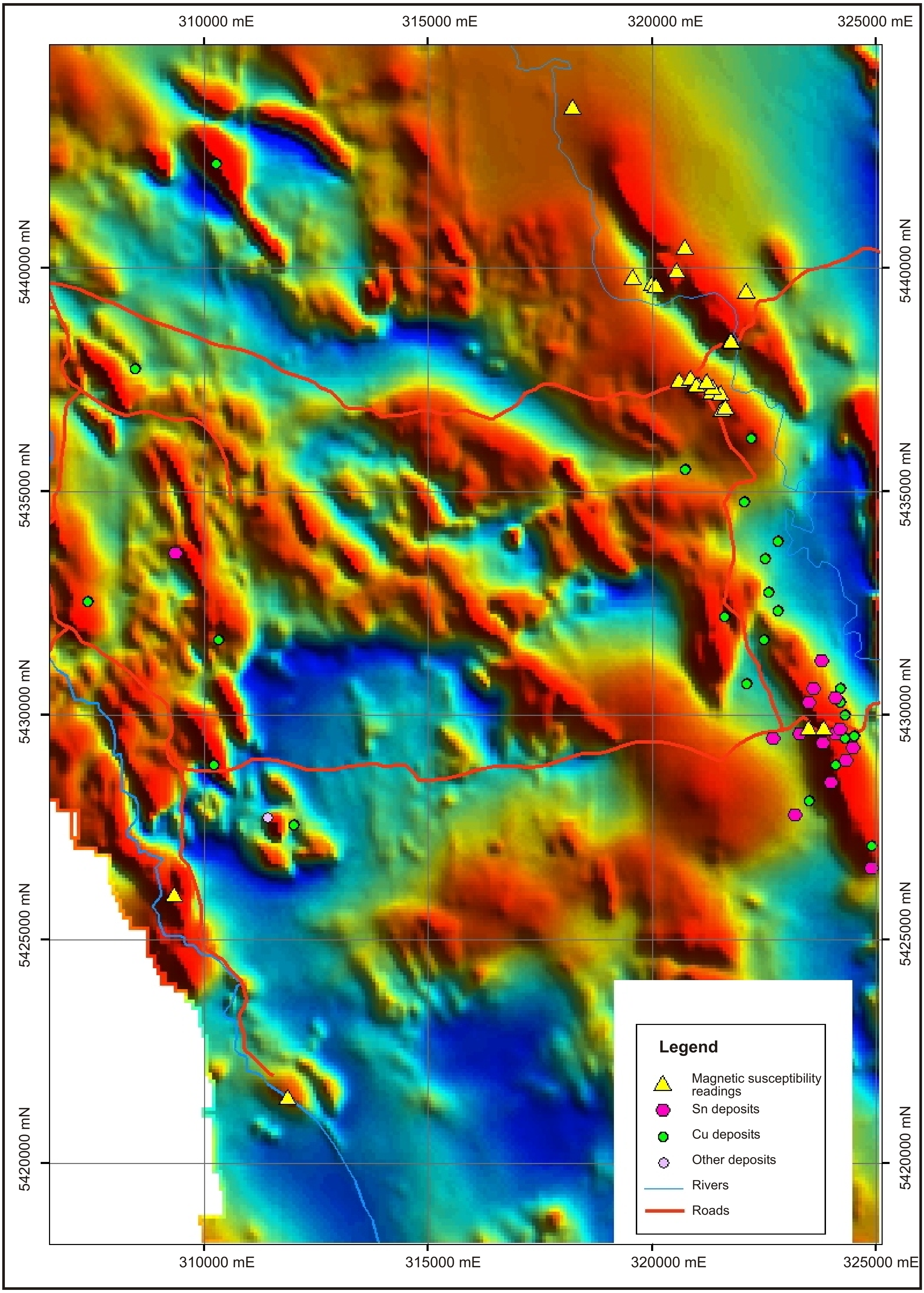

Figure 2

Aeromagnetic image with mineral deposits and magnetic susceptibility reading locations

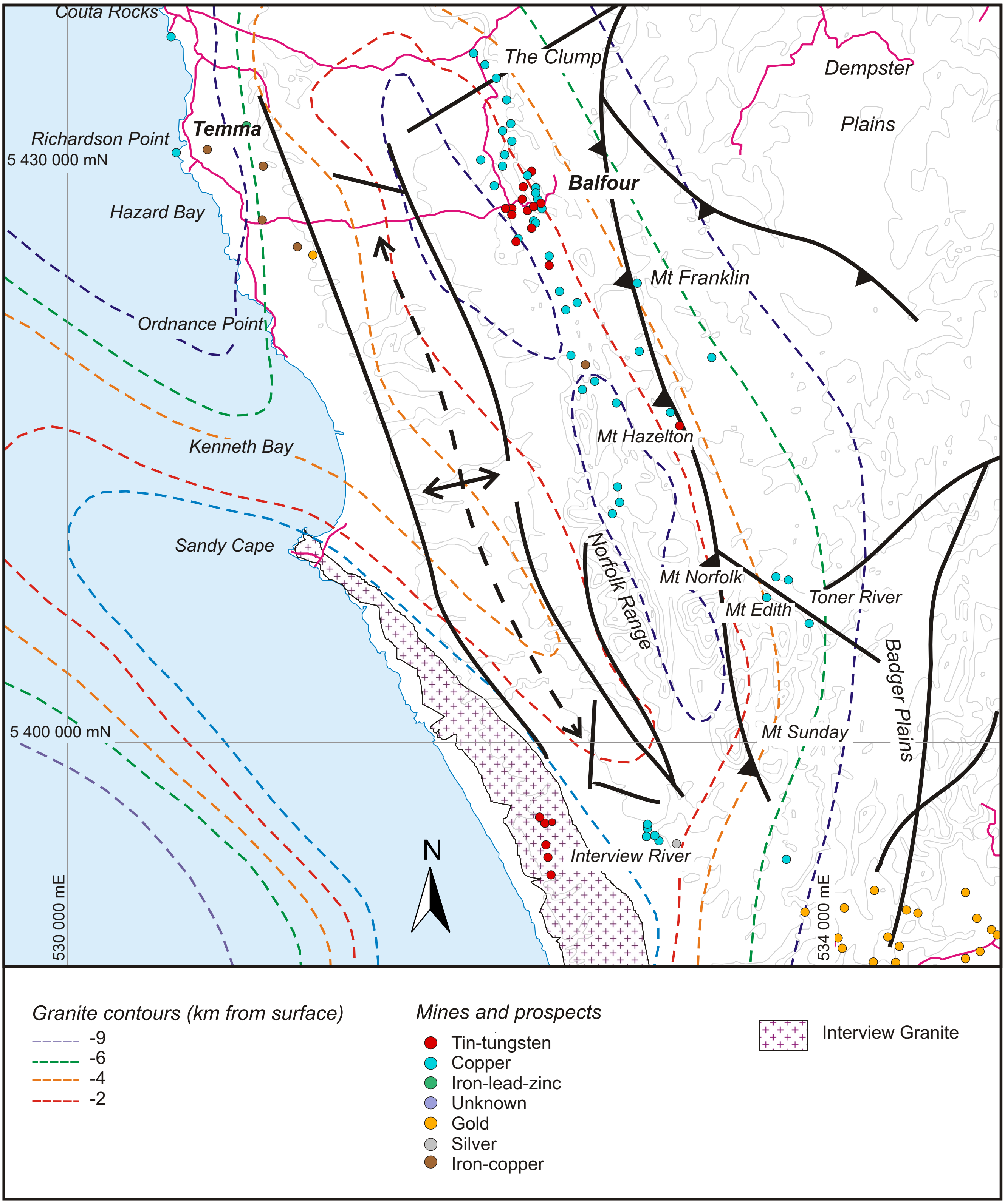

Figure 3

Granite contours, structure, topography and mineral deposits, Balfour district

The Clump-Balfour area

Ground-checking the striking aeromagnetic anomaly running from north of The Clump to south of Balfour, through the middle of the 'Copper Belt', failed to locate many rocks that could explain these magnetic anomalies. MS readings were mostly near zero, with some exceptions noted below.

In some of the most northerly of the copper workings (321 050 mE, 5 437 390 mN), a highly chloritic siltstone (sample C108436) has an MS of 1.1 × 10^{-3} SI. This siltstone, hosting some copper vein mineralisation, has relatively abundant ilmenite and may represent a highly altered mafic rock, or a metasedimentary rock derived from such rocks. This sample was relatively unweathered and was exposed in a deep creek bed; the lack of magnetic rocks elsewhere may reflect more pervasive weathering of most outcrops.

Some MS readings up to about 0.1 × 10^{-3} SI occur in weathered siltstone near Specimen Hill (sample C108522; 323 830 mE, 5 429 723 mN). Despite the subdued MS response, some geochemical anomalies were also recorded in this zone (see *Geochemistry* section).

Frankland River — north of Temma Road

Some aeromagnetic anomalies were noted in this area, and some were confirmed on the ground. The most prominent anomalies were near the Frankland River bridge (~321 800 mE, 5 438 350 mN) and an area some two kilometres to the northeast (~320 080 mE, 5 439 609 mN). These contain trace disseminated magnetite in chloritic siltstone (samples C108496–C108499 and C108503–C108510, see *Petrology* section).

Sandy Cape–Temma

A large zone with numerous small but strong, spotty to lenticular, aeromagnetic anomalies (up to a few kilometres in length) was noted in this area, but numerous magnetic susceptibility measurements of the Precambrian siltstone revealed only low to moderate values (<0.8 × 10^{-3} SI). Abundant basalt cobbles with high MS values occur in some areas (e.g.

Table 1

Magnetic susceptibility measurements of various samples

Sample No.	Lithology	Magnetic Susceptibility (× 10^{-3}) Average	Minimum	Maximum	Locality
C108436	siltstone	1.10	1.0	1.2	North-most Balfour workings
C108492	siltstone	0.45	0.40	0.50	Sandy Cape beach
C108493	siltstone	0.45	0.40	0.50	Sandy Cape beach
C108494	basalt	6.00	1.50	10.00	Sandy Cape beach
C108495	siltstone	0.22	0.50	0.80	Gannet Point
C108496	siltstone	10.00	6.00	15.00	Frankland River
C108497	siltstone	0.40	0.40	0.40	Frankland River
C108498	siltstone	3.00	3.00	3.00	Frankland River
C108499	siltstone	0.01	0.01	0.01	Frankland River
C108501	vein	0.10	0.00	0.20	Temma/Corinna Road junction
C108502	slate	0.10	0.00	0.20	Temma/Corinna Road junction
C108503	siltstone	0.10	0.00	0.20	Frankland Road
C108504	siltstone	0.10	0.00	0.20	Frankland Road
C108505	siltstone	0.01	0.01	0.01	Frankland Road
C108506	siltstone	3.00	3.00	3.00	Frankland Road
C108507	siltstone	10.00	9.00	10.00	Frankland Road
C108508	siltstone	0.10	0.10	0.10	Frankland Road
C108509	siltstone	0.03	0.00	0.06	Frankland Road
C108510	pelite	0.11	0.09	0.12	Frankland Road
C108511	siltstone	0.00	0.00	0.00	Old Balfour Road
C108512	siltstone	0.00	0.00	0.00	Old Balfour Road
C108513	siltstone	0.25	0.20	0.30	Old Balfour Road
C108514	slate	0.00	0.00	0.00	Drill track north of The Clump
C108515	siltstone	0.00	0.00	0.00	Drill track north of The Clump
C108516	gossan	0.00	0.00	0.00	Drill track north of The Clump
C108517	gossan	0.00	0.00	0.00	North of The Clump
C108518	siltstone	0.00	0.00	0.00	North of The Clump
C108519	siltstone	0.00	0.00	0.00	Creek through The Clump
C108520	siltstone	0.00	0.00	0.00	Creek through The Clump
C108521	siltstone	0.00	0.00	0.00	Balfour Road
C108522	siltstone	0.055	0.02	0.09	Balfour Road

sample C108494; 311 860 mE, 5 421 475 mN, fig. 4) , and some small Tertiary mafic intrusive rocks or alluvial concentrations of Tertiary clasts may account for the anomalies. Others may represent magnetite-ironstone bodies, noted near Temma (Taheri and Bottrill, in prep.).

Summary of magnetic susceptibility

In general, magnetic susceptibilities are relatively low with the exception of a few samples measured from the Frankland River and Frankland Road (Table 1), and basalt cobbles from south of Temma. Values range from 0.0 to 0.9, with rocks in The Clump prospect area and Balfour Road having almost zero magnetic susceptibilities. The results do not indicate any correlations between the magnetic anomalies and the magnetic susceptibility values measured in these areas (fig. 2). Preliminary petrographical studies show that rocks with high susceptibilities contain fine-grained disseminated magnetite (see below).

Petrology

Some low and high magnetic siltstone units, related to aeromagnetic anomalies near the Frankland River, were studied microscopically. This study indicated the presence of small magnetite porphyroblasts (<0.3 mm), variably altered or retrogressed to hematite, in a phyllitic quartz-muscovite-chlorite matrix (e.g. C108498) (fig. 6). It is not clear whether the magnetite is of hydrothermal origin. Tourmaline is a rare accessory, and may be a primary clastic component.

One pyritic siltstone from near the Frankland River (C108510) contains abundant altered porphyroblasts (chloritoid?, <1 mm; see Bottrill, 2004; fig. 5), altered to quartz-chlorite ± rutile aggregates. Magnetic susceptibility readings are only slightly elevated (~0.1 × 10^{-3} SI).

Sample C108436 from north of The Clump contains some small pyrite-chalcopyrite-quartz veinlets and relatively abundant ilmenite, as disseminated small poikiloblastic grains (<0.1 mm). The rock may represent a highly altered dolerite or basalt, or a metasedimentary rock derived from such rocks. The ilmenite is partly altered to leucoxene.

Geochemistry

Twenty-eight samples collected in the district were analysed for base metals, gold and other trace elements; the results are presented in Appendix 2. Few significant anomalies were identified, except:

- Quartz-chalcopyrite veining (striking 180°, in black slate) near the road junction (up to 480 ppm Cu; sample C108501). Anomalous Cu also occurs in a massive gossan horizon north of The Clump (<1400 ppm Cu; sample C108516). These examples of copper mineralisation were previously unreported, and both are near the aeromagnetic anomaly described earlier.
- Anomalous Sn in a laminated siltstone near Balfour (<90 ppm; C108521). This is probably related to the Specimen Hill mineralisation (due to disseminated cassiterite?).
- Anomalous Zn in a laminated siltstone near Balfour (<90 ppm; C108521). The source is unknown.

The latter two samples are not obviously mineralised but are near the Specimen Hill Sn-W deposits, and close to the main aeromagnetic anomaly.

Summary and discussion

In general, magnetic susceptibilities are very low with the exception of a few siltstones with minor disseminated magnetite in the Frankland River and Frankland Road (Table 1) areas, an ilmenite-rich siltstone near The Clump, and some basalt south of Temma. The results do not indicate any correlations between the magnetic anomalies and the general magnetic susceptibility values measured in these areas (fig. 2).

There are few geochemical anomalies, except for some minor copper mineralisation (some previously unreported) and weak Sn and Zn anomalies near Specimen Hill.

This preliminary study indicates that the magnetic contribution of outcropping Precambrian rocks in areas characterised by high aeromagnetic anomalies, including those associated with copper and tin deposits, is nil. The source for the anomalies is presumably at some depth, or is in deeply weathered rock.

Webster's (2002) modelling of the area suggests that the main Balfour aeromagnetic anomaly is due to contact metamorphic effects in a (Devonian?) granite aureole, with some deep basaltic rocks also being inferred to underlie the area. A granite body is interpreted to form a shallow NNW-trending ridge parallelling the main copper belt. Some of the Balfour deposits are granite related (Sn-W-polymetallic deposits), but most of the copper deposits give no geochemical, petrological or other indication of a granitic link. No evidence for a granite aureole or mafic rocks can be seen in any of the rocks in the Balfour area.

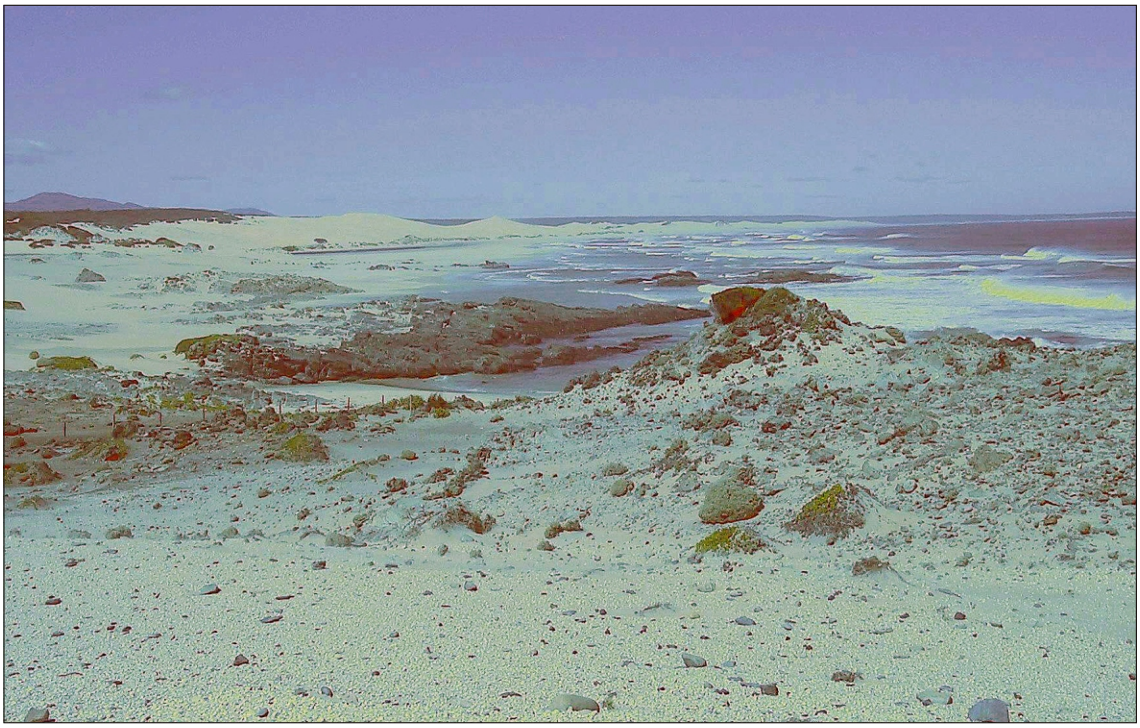

Figure 4
Basalt (RHS) and siltstone (LHS), Sandy Cape Beach.

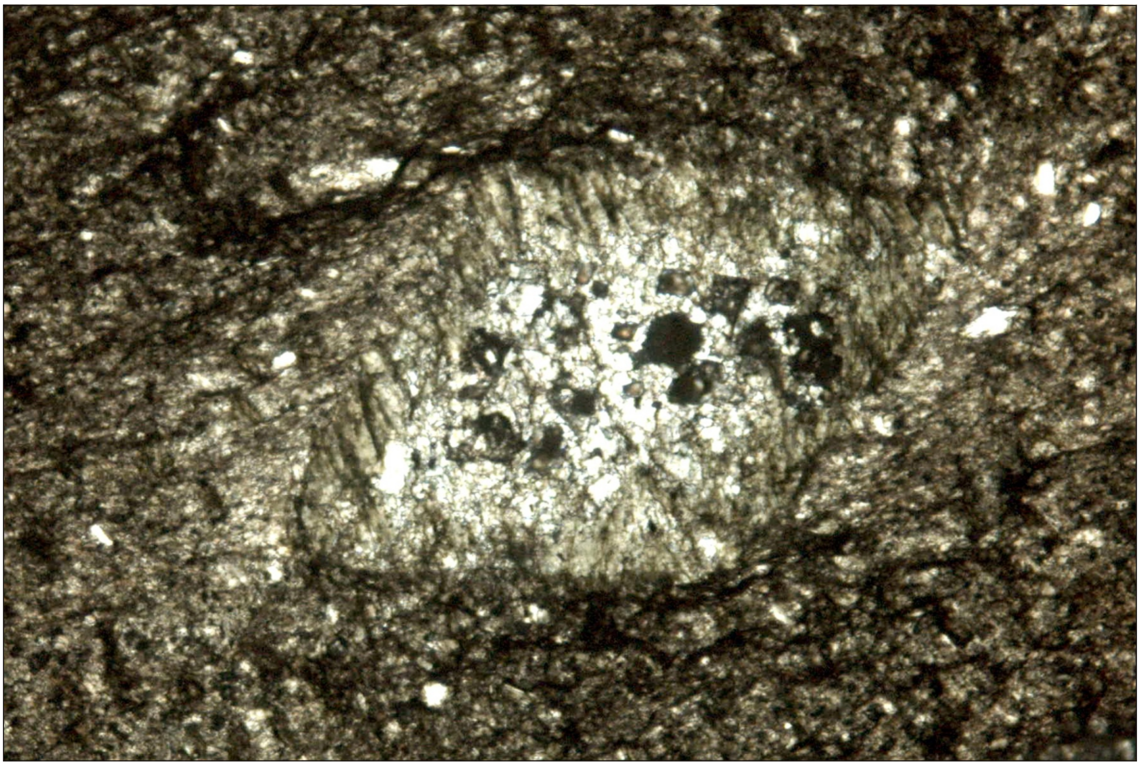

Figure 5
Retrogressed porphyroblasts, containing chlorite, quartz and Ti-oxides, in sample C108510.
Cross-polarised light. Field of view; ~1 × 0.7 mm.

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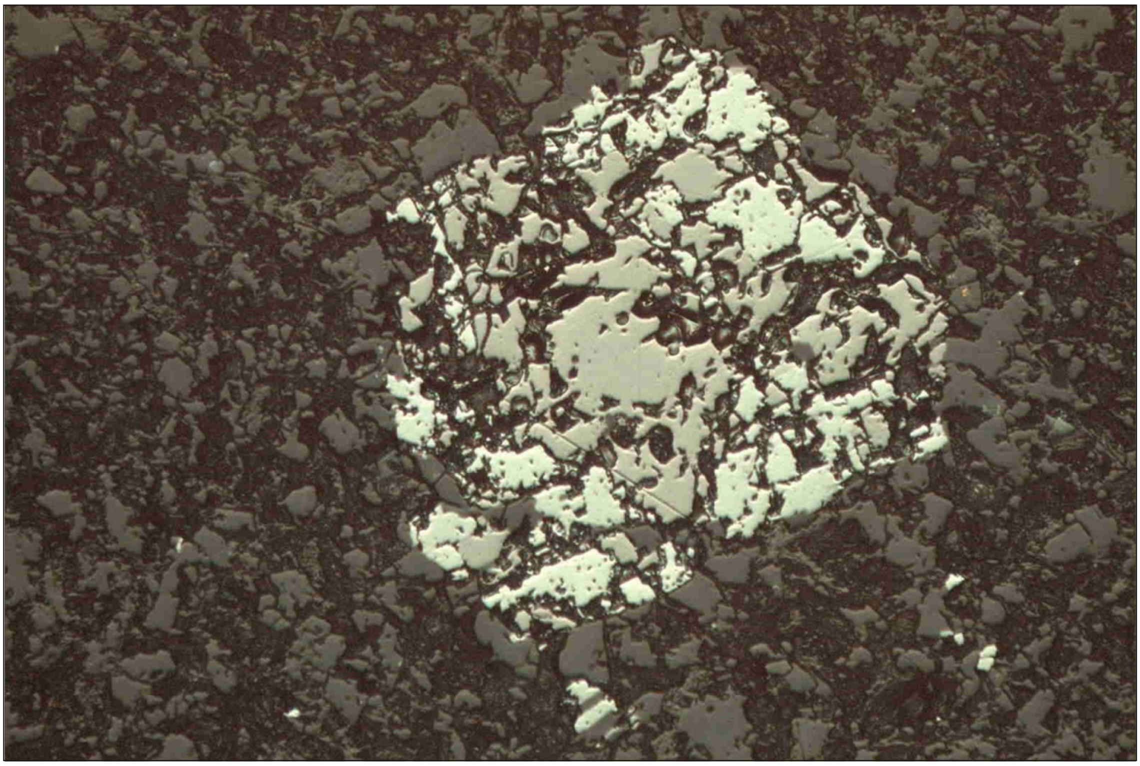

Figure 6

Magnetite porphyroblast (~0.3 mm diameter), partly altered to hematite. Reflected light, plain polarised light, sample C108498.

APPENDIX 1
Sample details

Tasrock Reg. no.	*Date collected*	*Lithology*	*Minerals*	*Modifiers*	*Treatments*	*Sample description*	*Age*	*Locality*	*AMG mE*	*AMG mN*	*Site type*	*Site description*
C108436	13/03/2000	siltstone	py	veins	PT		PRP	N-most Balfour workings	321050	5437390	outcrop	River bed
C108492	05/03/2002	siltstone		bndd	CA		PRP	Sandy Cape Beach	311860	5421475	outcrop	Coastal outcrop
C108493	05/03/2002	siltstone		mass	CA		PRP	Sandy Cape Beach	311860	5421475	outcrop	Coastal outcrop
C108494	05/03/2002	basalt	ze	vesi	CA		T	Sandy Cape Beach	311860	5421475	float	Cobble
C108495	05/03/2002	siltstone		bndd	CA		PRP	Gannet Point	309328	5426010	outcrop	Coastal outcrop
C108496	06/03/2002	siltstone	mt, chl, hem	lami	CA, PT		PRP	Frankland River	321800	5438350	outcrop	Outcrop in river
C108497	06/03/2002	siltstone	mt	lami	CA, PT		PRP	Frankland River	321800	5438350	outcrop	Outcrop in river
C108498	06/03/2002	siltstone	mt, hem	lami	CA, PT		PRP	Frankland River	321737	5438375	outcrop	Outcrop in river
C108499	06/03/2002	siltstone	hm	lami	CA, PT		PRP	Frankland River	321763	5438371	outcrop	Outcrop in river
C108501	06/03/2002	vein	qtz, cpy, py, chl		CA			Temma/Corinna Road jct	320590	5437475	outcrop	10 cm lodes in roadcut
C108502	06/03/2002	slate		black	CA, PT		PRP	Temma/Corinna Road jct	320590	5437475	outcrop	Road cut
C108503	06/03/2002	siltstone	grt	spot	CA		PRP	Frankland Road	322108	5439475	outcrop	Road cut
C108504	06/03/2002	siltstone		lami, green, sili	CA		PRP	Frankland Road	320736	5440447	outcrop	Road cut
C108505	06/03/2002	siltstone		spot, green	CA		PRP	Frankland Road	320550	5439940	outcrop	Road cut
C108506	06/03/2002	siltstone	mt, chl	lami, green, spot	CA, PT		PRP	Frankland Road	320016	5439646	outcrop	Road cut
C108507	06/03/2002	siltstone	mt, chl	lami, green, spot	CA, PT		PRP	Frankland Road	320084	5439609	outcrop	Road cut
C108508	06/03/2002	siltstone	chl	lami, green, spot	CA, PT		PRP	Frankland Road	320088	5439604	outcrop	Road cut
C108509	06/03/2002	siltstone		lami, black, spot	CA		PRP	Frankland Road	319570	5439790	outcrop	Road cut
C108510	06/03/2002	pelite	py, chl, ctd	black, spot	CA, PT		PRP	Frankland Road	318230	5443580	outcrop	
C108511	06/03/2002	siltstone		mass, black	CA, PT		PRP	Old Balfour Road	320860	5437534	outcrop	
C108512	06/03/2002	siltstone		grey	CA		PRP	Old Balfour Road	320990	5437380	outcrop	
C108513	06/03/2002	siltstone		grey, mass	CA		PRP	Old Balfour Road	321320	5437220	outcrop	
C108514	06/03/2002	slate		grey	CA		PRP	Drill track north of The Clump	321537	5437194	outcrop	
C108515	06/03/2002	siltstone		grey, mass	CA		PRP	Drill track north of The Clump	321340	5437340	outcrop	
C108516	06/03/2002	gossan	lim		CA			Drill track north of The Clump	321340	5437340	outcrop	30 cm lode
C108517	06/03/2002	gossan	lim		CA			North of The Clump	321230	5437470	outcrop	
C108518	06/03/2002	siltstone		mass, black	CA		PRP	North of The Clump	321194	4537365	outcrop	
C108519	06/03/2002	siltstone	cpy	grey, vein	CA	cpy vein	PRP	Clump Creek	321569	5436850	outcrop	Stream bed
C108520	06/03/2002	siltstone		grey	CA	chl-py veins	PRP	Clump Creek	321638	5436883	outcrop	Stream bed
C108521	06/03/2002	siltstone		mass, black, carb	CA		PRP	Balfour Road	323487	5429726	outcrop	Road cut
C108522	06/03/2002	siltstone		lami, grey	CA		PRP	Balfour Road	323830	5429723	outcrop	Road cut

APPENDIX 2
Geochemistry

Reg No.	*TASROCK No.*	*Co ppm*	*As ppm*	*Bi ppm*	*Ga ppm*	*Zn ppm*	*W ppm*	*Cu ppm*	*Ni ppm*	*Sn ppm*	*Pb ppm*	*S %*	*Ag g/t*	*Au g/t*
20020682	C108501	22	27	<5	14	38	<10	480	10	<9	<10	2.5	6	<0.01
20020683	C108502	<8	<20	<5	22	8	<10	9	11	<9	<10	0.0	<1	<0.01
20020684	C108503	<8	<20	<5	16	8	<10	7	13	<9	<10	0.0	2	<0.01
20020685	C108504	<8	<20	<5	17	25	<10	8	7	<9	<10	0.0	1	<0.01
20020686	C108505	<8	<20	<5	14	41	<10	6	7	<9	<10	0.0	2	<0.01
20020687	C108506	14	<20	<5	22	80	<10	17	21	<9	<10	0.0	3	<0.01
20020688	C108507	15	<20	<5	21	84	<10	10	22	<9	<10	0.0	2	<0.01
20020689	C108508	17	<20	<5	21	97	<10	6	26	<9	19	0.0	1	<0.01
20020690	C108509	<8	<20	<5	24	84	<10	16	19	<9	<10	0.0	2	<0.01
20020691	C108510	<8	<20	<5	21	52	<10	13	11	<9	11	0.9	2	<0.01
20020692	C108511	<8	<20	<5	27	10	<10	7	17	<9	<10	0.0	1	<0.01
20020693	C108512	<8	<20	<5	25	25	<10	<5	27	<9	<10	0.0	2	<0.01
20020694	C108513	<8	<20	<5	17	<5	<10	<5	<5	<9	<10	0.0	<1	<0.01
20020695	C108514	<8	<20	<5	23	11	<10	10	17	<9	<10	0.0	1	<0.01
20020696	C108515	<8	<20	<5	22	43	<10	14	13	<9	<10	0.0	1	<0.01
20020697	C108516	57	52	<5	7	35	23	1400	<5	<9	36	0.4	8	<0.01
20020698	C108517	33	<20	<5	20	155	<10	67	15	<9	<10	0.1	5	<0.01
20020699	C108518	<8	<20	<5	21	12	<10	6	18	<9	<10	0.0	1	<0.01
20020700	C108519	11	<20	<5	16	10	<10	71	15	<9	<10	0.4	2	<0.01
20020701	C108520	<8	<20	<5	17	12	<10	70	13	<9	<10	0.0	2	<0.01
20020702	C108521	<8	<20	<5	23	19	12	9	10	90	10	0.0	1	<0.01
20020703	C108522	<8	56	<5	24	440	<10	46	8	12	37	0.2	1	<0.01
20020704	C108492	12	<20	<5	20	77	<10	19	26	<9	20	0.0	1	<0.01
20020705	C108493	<8	<20	<5	21	58	<10	6	18	<9	34	0.0	1	<0.01
20020706	C108494A	41	<20	<5	22	110	<10	7	39	<9	<10	0.1	3	<0.01
20020707	108494B	36	<20	<5	22	105	<10	15	64	<9	10	0.0	3	<0.01
20020708	108495	<8	<20	<5	20	33	<10	<5	7	<9	13	0.0	<1	<0.01