

# Termitaria as regolith landscape attributes and sampling media in northern Australia

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Table 4.14 Summary statistics for TID01 detailed geochemical study at Titania Au-prospect, NT; n=20

Element	Det. limit	Technique	Std. Dev	Mean	Min	Max
<b>Ag_ppm</b>	0.05 ppm	ICP-MS	3.28	0.67	na	15
<b>Al_percent</b>	0.1%	ICP-AES	0.16	2.06	1.64	2.31
<b>As_ppm</b>	0.2 ppm	ICP-MS	0.24	3.17	3.00	3.4
<b>AuAR_ppb</b>	1 ppb	ICP-MS	2.53	12.99	9.00	18
<b>Ba_ppm</b>	0.05 ppm	ICP-MS	34.94	285.28	216.00	359
<b>Bi_ppm</b>	0.02 ppm	ICP-MS	0.01	0.23	0.22	0.26
<b>Ca_percent</b>	0.1%	ICP-AES	0.06	0.34	0.23	0.44
<b>Cd_ppm</b>	0.1 ppm	ICP-MS	0.02	-0.05	na	0.04
<b>Ce_ppm</b>	10 ppb	ICP-MS	2.36	31.52	29.00	36.7
<b>Co_ppm</b>	0.2 ppm	ICP-MS	1.34	11.90	10.00	14
<b>Cr_ppm</b>	5 ppm	ICP-AES	3.39	41.01	40.00	45
<b>Cu_ppm</b>	0.5 ppm	ICP-MS	0.55	13.10	12.00	14.09
<b>Fe_percent</b>	100 ppm	ICP-AES	0.13	3.02	2.81	3.41
<b>Ga_ppm</b>	0.2 ppm	ICP-MS	0.57	9.30	7.80	10.2
<b>In_ppm</b>	5 ppm	ICP-MS	0.00	0.04	0.04	0.045
<b>Kppm</b>	100 ppm	ICP-AES	504.27	4485.71	3700.00	5300
<b>La_ppm</b>	10 ppb	ICP-MS	1.26	15.74	13.80	18.1
<b>Mg_percent</b>	100 ppm	ICP-AES	0.05	0.34	0.28	0.42
<b>Mn_ppm</b>	1 ppm	ICP-AES	15.01	211.29	194.00	246
<b>Mo_ppm</b>	0.1 ppm	ICP-MS	0.06	0.56	0.39	0.6
<b>Na_ppm</b>	100 ppm	ICP-AES	189.79	529.05	200.00	1000
<b>Nd_ppm</b>	10 ppb	ICP-MS	1.78	18.22	15.60	21.7
<b>Ni_ppm</b>	1 ppm	ICP-MS	1.18	13.10	12.00	16
<b>Pb_ppm</b>	1 ppm	ICP-MS	0.52	8.31	8.00	9.53
<b>Pd_ppb</b>	10 ppb	ICP-MS	0.00	-10.00	na	Na
<b>Pr_ppm</b>	5 ppb	ICP-MS	0.40	4.50	3.92	5.21
<b>Pt_ppb</b>	5 ppb	ICP-MS	0.00	-5.00	na	Na
<b>Rb_ppm</b>	0.05 ppm	ICP-MS	2.40	34.45	28.50	37.6
<b>Sppm</b>	50 ppm	ICP-AES	107.96	623.81	400.00	800
<b>Sm_ppm</b>	10 ppb	ICP-MS	0.37	3.51	2.92	4.26
<b>Sn_ppm</b>	0.2 ppm	ICP-MS	0.13	1.80	1.60	1.8
<b>Sr_ppm</b>	0.1 ppm	ICP-MS	2.88	27.09	20.50	30.8
<b>Te_ppm</b>	0.1 ppm	ICP-MS	0.00	-0.10	na	Na
<b>Th_ppm</b>	10 ppb	ICP-MS	0.38	7.37	7.09	8.8
<b>Ti_ppm</b>			8.80	na	na	0.012
<b>Tl_ppm</b>	10 ppb	ICP-MS	0.01	0.22	0.19	0.24
<b>U_ppm</b>	10 ppb	ICP-MS	0.27	3.88	3.48	4.52
<b>V_ppm</b>	2 ppm	ICP-AES	2.56	55.19	52.00	56
<b>Y_ppm</b>	10 ppb	ICP-MS	1.89	12.61	10.70	16.1
<b>Zn_ppm</b>	1 ppm	ICP-MS	0.98	15.81	13	17

**Table 4.15** Correlation values for TID01 termitaria lobe samples. The elements As, Au, Bi, Cd, Ce, Na, Pd, Na, Pd, Pt, Te, Ti, Tl, U, and V did not share any significant correlations within this dataset; n=20

Element	Correlates with:
<b>Ag_ppm</b>	Th (0.86)
<b>Al_percent</b>	Cr (0.78), Rb (0.91), Tl (0.78), Zn (0.76)
<b>Ba_ppm</b>	Sr (0.87)
<b>Ca_percent</b>	Mg (0.76), Sr (0.9)
<b>Co_ppm</b>	Fe (0.87), In (0.8), Rb (0.77), Sn (0.95), Tl (0.8)
<b>Cr_ppm</b>	Al (0.78)
<b>Cu_ppm</b>	Sn (0.79)
<b>Fe_percent</b>	Co (0.87), Sn (0.85), Tl (0.77)
<b>Ga_ppm</b>	K 90.79, Rb (0.94), Tl (0.76)
<b>In_ppm</b>	Co (0.8), Ni (0.75)
<b>K_ppm</b>	Ga (0.79), Mg (0.96), Pr (0.76), Rb (0.9), Sm (0.82), Sn (0.77)
<b>La_ppm</b>	Mg (0.83), Nd (0.96), Ni (0.77), Pr (0.98), Sm (0.97), Y (0.82)
<b>Mg_percent</b>	Ca (0.76), K (0.96), La (0.83), Nd (0.84), Ni (0.76), Pr (0.84), Rb (0.83), Sm (0.9)
<b>Mn_ppm</b>	Pb (0.82)
<b>Mo_ppm</b>	Y (-0.82)
<b>Nd_ppm</b>	La (0.96), Mg (0.84), Pr (0.97), Sn (0.98), Y (0.95)
<b>Ni_ppm</b>	In (0.75), La (0.77), Mg (0.76), Pr (0.76),
<b>Pb_ppm</b>	Mn (0.82)
<b>Pr_ppm</b>	K (0.76), La (0.98), Mg (0.84), Nd (0.97), Ni (0.76), Sm (0.97), Y (0.94)
<b>Rb_ppm</b>	Al (0.91), Co (0.77), Ga (0.94), K (0.9), Mg (0.83), Sn (0.82), Tl (0.91)
<b>S_ppm</b>	Sr (0.78)
<b>Sm_ppm</b>	K (0.82), La (0.97), Mg (0.9), Nd (0.98), Pr (0.97), Y (0.99)
<b>Sn_ppm</b>	Co (0.95), Cu (0.79), Fe (0.85), K (0.77), Rb (0.82), Tl (0.88)
<b>Sr_ppm</b>	Ba (0.87), Ca (0.9), S (0.78)
<b>Th_ppm</b>	Ag (0.86)
<b>Y_ppm</b>	La (0.82), Mo (-0.82), Nd (0.95), Pr (0.94), Sm (0.99)
<b>Zn_ppm</b>	Al (0.76)

### **Detailed survey of TID01: soil geochemical results**

To complement the detailed lobe sampling at TID01 eight samples were collected from the surrounding soils. Figure 4.66 outlines the general configuration of the sampling sites around the *N. triodiae* mound. The soil samples were collected from eight points around the mound, with each point representing a certain distance and orientation from the mound.

The soil samples were collected using a steel shovel, which had been cleaned by rubbing soil from each sample point over the shovel to remove any remaining trace of the last sample. At the sampling site a 15 cm depth of soil was removed and the sample taken from this point. The bagged sample usually weighed approximately 500 g, and was stored in a plastic zip-lock bag. The TID01 soils are loamy sands, orange-brown in

colour as classified by an adapted Munsell chart, and composed of subrounded-to-rounded quartz silty sand. There is little variation in composition between the eight sampling locations at TID01. Only the finest fraction, Fraction 1, was sent to the lab for analysis.

The geochemical results are compared using standard deviation, mean, and maximum values within this data set, as well as the TID01 termitaria samples (Table 4.16). The standard deviations for all the elements are generally small, except for Ba, K, Mn and S, which also have much larger numbers (Ba 359 ppm, K 5300 ppm, Mn 246, Na 1000 ppm).

The soil sample TID01SA, south of the main mounds at TID01, contains the most Ba, Al, Fe, Ga, Rb, Th and Tl. Cesium and S concentrations are highest in the eastern soil sample, TID01SC. Gold content ranges from 3 to 4 ppb within the soil samples. The low variation between soil samples suggests that the TID01 soils are mostly homogeneous.

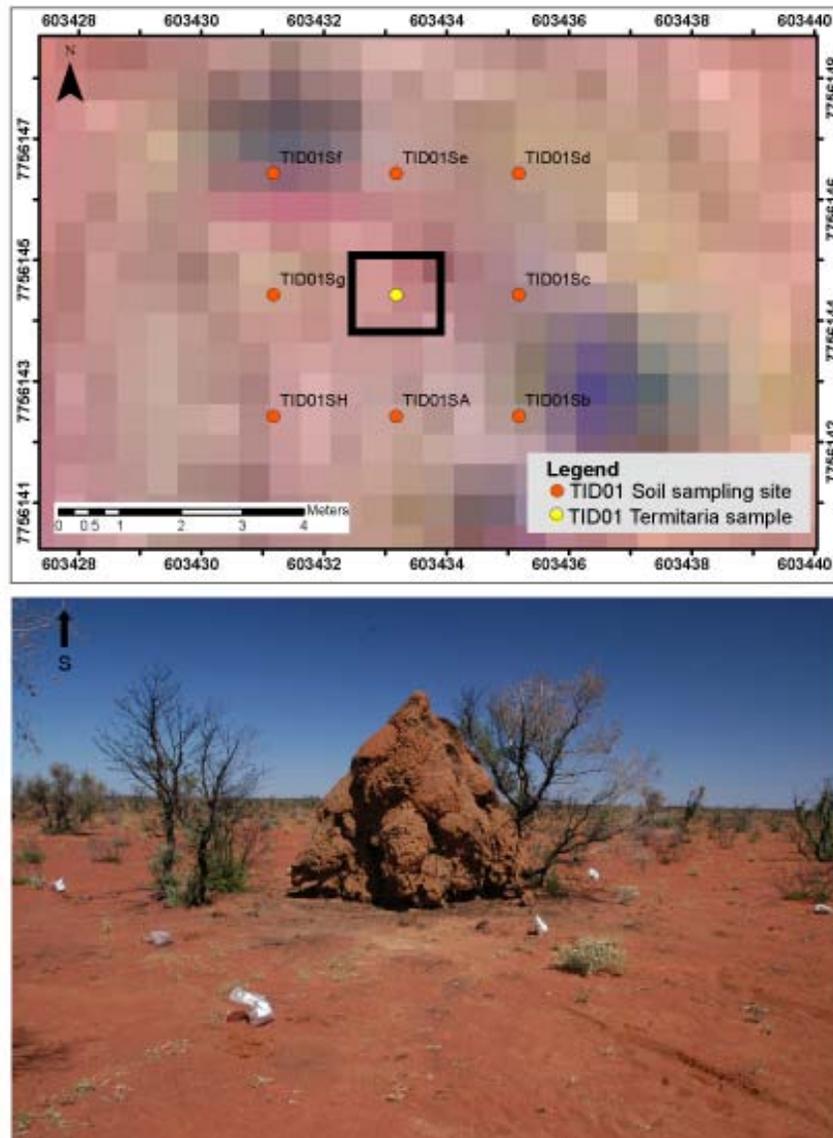


Figure 4.66 TID01 soil sampling locations around the *N. triodiae* mound. The top image displays the ArcGIS image; the black outline represents the area of the photo (inset) which was taken in a southerly direction. (Photo Dr S. Hill)

**Table 4.16 Comparative summary statistics for the TID01 soil and termitaria geochemical results at Titania Au-prospect; n(termitaria)=20 and n(soil)=8**

Element	Det. Limit	F1 TID01 Soil			F1 TID01 Termitaria		
		Std. Dev	Mean	Max	Std. Dev	Mean	Max
<i>Ag_ppm</i>	0.05 ppm	Na	-0.05	Na	3.28	0.67	15
<i>Al_percent</i>	100 ppm	0.09	1.10	1.23	0.16	2.06	2.31
<i>As_ppm</i>	0.2 ppm	0.11	1.70	1.8	0.24	3.17	3.4
<i>AuAR_ppb</i>	1 ppb	0.93	3.00	4	2.53	12.99	18
<i>Ba_ppm</i>	0.05 ppm	13.91	74.05	90.6	34.94	285.28	359
<i>Bi_ppm</i>	0.02 ppm	0.02	0.17	0.18	0.01	0.23	0.26
<i>Ca_percent</i>	100ppm	0.02	0.05	0.08	0.06	0.34	0.44
<i>Cd_ppm</i>	0.1 ppm	0.00	-0.05	Na	0.02	-0.05	0.04
<i>Ce_ppm</i>	10 ppb	1.90	28.99	30.5	2.36	31.52	36.7
<i>Co_ppm</i>	0.2 ppm	0.00	4.00	4	1.34	11.90	14
<i>Cr_ppm</i>	5 ppm	2.59	28.13	30	3.39	41.01	45
<i>Cu_ppm</i>	0.5 ppm	0.83	8.13	9	0.55	13.10	14.09
<i>Fe_percent</i>	100 ppm	0.10	1.92	2.04	0.13	3.02	3.41
<i>Ga_ppm</i>	0.2 ppm	0.41	4.90	5.8	0.57	9.30	10.2
<i>In_ppm</i>	5 ppm	0.00	0.02	0.025	0.00	0.04	0.045
<i>K_ppm</i>	100 ppm	277.42	1437.50	1700	504.27	4485.71	5300
<i>La_ppm</i>	10 ppb	1.03	14.41	15.3	1.26	15.74	18.1
<i>Mg_percent</i>	100 ppm	0.02	0.08	0.1	0.05	0.34	0.42
<i>Mn_ppm</i>	1 ppm	33.46	164.13	212	15.01	211.29	246
<i>Mo_ppm</i>	0.1 ppm	0.05	0.56	0.6	0.06	0.56	0.6
<i>Na_ppm</i>	100 ppm	0.00	-100.00	Na	189.79	529.05	1000
<i>Nd_ppm</i>	10 ppb	1.27	14.48	16.4	1.78	18.22	21.7
<i>Ni_ppm</i>	1 ppm	1.04	6.75	8	1.18	13.10	16
<i>Pb_ppm</i>	1 ppm	0.76	6.00	7	0.52	8.31	9.53
<i>Pd_ppb</i>	10 ppb	0.00	-10.00	Na	0.00	-10.00	na
<i>Pr_ppm</i>	5 ppb	0.26	3.72	4.06	0.40	4.50	5.21
<i>Pt_ppb</i>	5 ppb	0.00	-5.00	Na	0.00	-5.00	na
<i>Rb_ppm</i>	0.05 ppm	1.62	15.23	18.1	2.40	34.45	37.6
<i>S_ppm</i>	50 ppm	26.73	125.00	150	107.96	623.81	800
<i>Sm_ppm</i>	10 ppb	0.25	2.64	3.03	0.37	3.51	4.26
<i>Sn_ppm</i>	0.2 ppm	0.09	1.05	1.2	0.13	1.80	1.8
<i>Sr_ppm</i>	0.1 ppm	1.44	7.46	9	2.88	27.09	30.8
<i>Te_ppm</i>	0.1 ppm	0.00	-0.10	Na	0.00	-0.10	na
<i>Th_ppm</i>	10 ppb	0.30	6.40	6.97	0.38	7.37	8.8
<i>Ti_ppm</i>		17.68	143.75	150	8.80	na	0.012
<i>Tl_ppm</i>	10 ppb	0.01	0.10	0.11	0.01	0.22	0.24
<i>U_ppm</i>	10 ppb	0.21	1.88	2.15	0.27	3.88	4.52
<i>V_ppm</i>	2 ppm	1.67	38.25	40	2.56	55.19	56
<i>Y_ppm</i>	10 ppb	0.99	7.04	8.52	1.89	12.61	16.1
<i>Zn_ppm</i>	1 ppm	0.99	8.88	10	0.98	15.81	17

### **Interpretation of TID01 termitaria and soil geochemical results**

The low variation between the 20 sampled lobes suggests that much of the Fraction 1 material that is mostly used for construction within the mounds is recycled throughout the mound, or sourced from a similar part of the regolith profile. The anomalous Au (generally agreed to be >4 ppb Au amongst mineral explorers in the Tanami) occurring throughout the mound suggests that the termites are able to incorporate material into the mound from a depth close to mineralisation, or at least within its zone of geochemical influence.

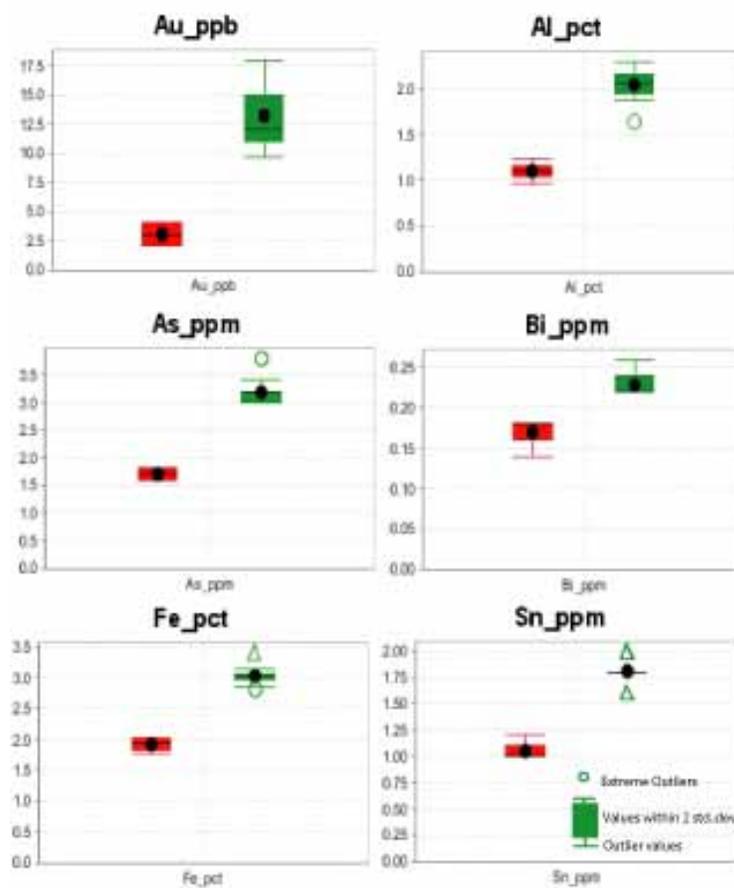
A correlation matrix for the TID01 termitaria lobe samples reveals interesting elemental associations. Many of the elements did not share any significant correlations, including the elements As, Au, Bi, Cd, Ce, Na, Pd, Na, Pd, Pt, Te, Ti, Tl, U, and V. The strong elemental association between Ca and Mg is accounted for by the abundance of carbonate material at surface when construction materials are brought into the mound. The strong association between K and Mg (0.96) and also Ca (0.7) is due to the abundance of both these elements within the mound due to the incorporation of carbonate material and fecal matter within the outer nest lobes. Aluminium is strongly associated with Rb (0.91) and moderately associated with Cr (0.78), Tl (0.78), and Zn (0.76). The small range of values for each of these elements within the mound indicates that these elements are present within minerals common to the regolith profile.

Although K is associated with Mg and Ca due to its presence in carbonates and organic matter, this element is also associated with Ga (0.79), Pr (0.76), Rb (0.9), Sm (0.82) and Sn (0.77). These elements are likely to be sourced from kaolinite and other clays within the regolith profile, or derived from nearby bedrock sources such as the weathering of dolerite.

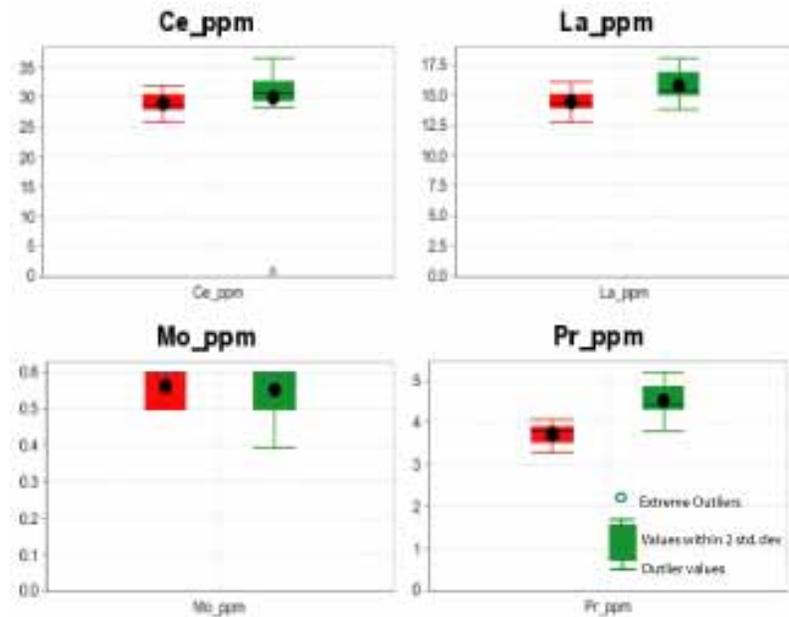
For most of these elements, the standard deviations are less than analytical detection limit and precision, suggesting that more of the variation between samples is likely to be due to the analytical method used. The respective standard deviations for the elements Au, Ba, Ca, Ce, K, N, S, and Sr are larger (Figure 4.67), however, indicating that there is a significant variation in the distribution of these elements between the different lobes. Gold and As do not correlate with any other element, suggesting that it is mostly

sourced from mineralisation. Uranium also does not significantly correlate with any element.

The small sample number ( $n = 20$ ) limits the significance and amount of statistical analyses that may be conducted in the TID01 Fraction 1 soil dataset, including a correlation matrix. When compared to the termitaria results, the soil samples contain lower amounts of most of the elements used for this study, except for Bi, Ce, Fe, In, La, Mo, Pr and Sn. These elements are still more abundant within the termitaria samples, but the datasets appear to overlap for these samples, as shown by the overlapping box-and whisker-plots (Figure 4.68).



**Figure 4.67** Tukey plots of elements within soils (left, orange) and termitaria (right, green) at TID01, which are considerably different in range



**Figure 4.68** Tukey plots of elements within soils (left, orange) and termitaria (right, green) at TID01, with overlapping geochemical results

The soil results reinforce the suggestions by other authors (e.g. Kebede, Gleeson & Poulin) that the soil material surrounding termitaria may either be composed of material eroded from termitaria since the influx of mound-building termites to northern Australia, or that the termitaria are constructed from soil. The former hypothesis may be proved by the inclusion of anomalous levels of pathfinder element and ore mineral concentrations in the termitaria compared to the soils, as measured in this study. That termites take material from the biомantle and contribute material to the mobile zone is well established; whether termites take a large or small percentage of their construction materials from depth is not as well known.

There is also a strong aeolian and transported component within the mounds, exemplified by both composition descriptions and qualitative assessment through geochemical and statistical analysis. The relative paucity of many elements within Fraction 1 soil samples, compared to the TID01 termitaria, is an example of how effective termitaria may be as tools to sample the underlying regolith profile chemistry. The surficial sediments, by comparison, do not represent the underlying regolith profile and are diluted by transported and aeolian material. The ability of the termites to successfully bring to the surface a geochemical signature from deep within their mound should not be underestimated.

**Detailed survey of TID02: termitaria geochemical results**

Four termitaria samples were collected from this mound, TID02, which is located at 603446 mE and 7756228 mN, AGD 66 z52 UTM. The individually sampled lobes were mapped and are presented in Figure 4.69. Each mound tower was treated as a separate sample, allowing the collection of geochemical data in order to compare the geochemical properties between nest segments on a *D. rubriceps* mound. The sample preparation techniques and laboratory analysis procedures of both these termitaria samples and adjacent soil samples are identical with those for the transect samples. Table 4.17 outlines the minimum, maximum, average and standard deviation values for the TID02 samples. Unfortunately, the low sample number for this site does not allow for correlation coefficients to be produced using Excel's ToolPak™ data analysis tool.

The *D. rubriceps* mound has three nests (TID02TMA to TID02TMC, Figure 4.70) which comprise its main above ground portion. A much flatter pavement to the north of the three main mounds comprises the fourth termitaria sample, TID02TMD. The pavement surrounding the nest is approximately 1.5 m in diameter, and the tallest mound is 0.5 m high. It is comprised of poorly-sorted, fine-to-coarse quartz silty sand with minor, very coarse, sub-rounded to sub-angular, polished ferruginous lag. All the nest samples were taken from an active part of the mound, and all contained spinifex chaff.

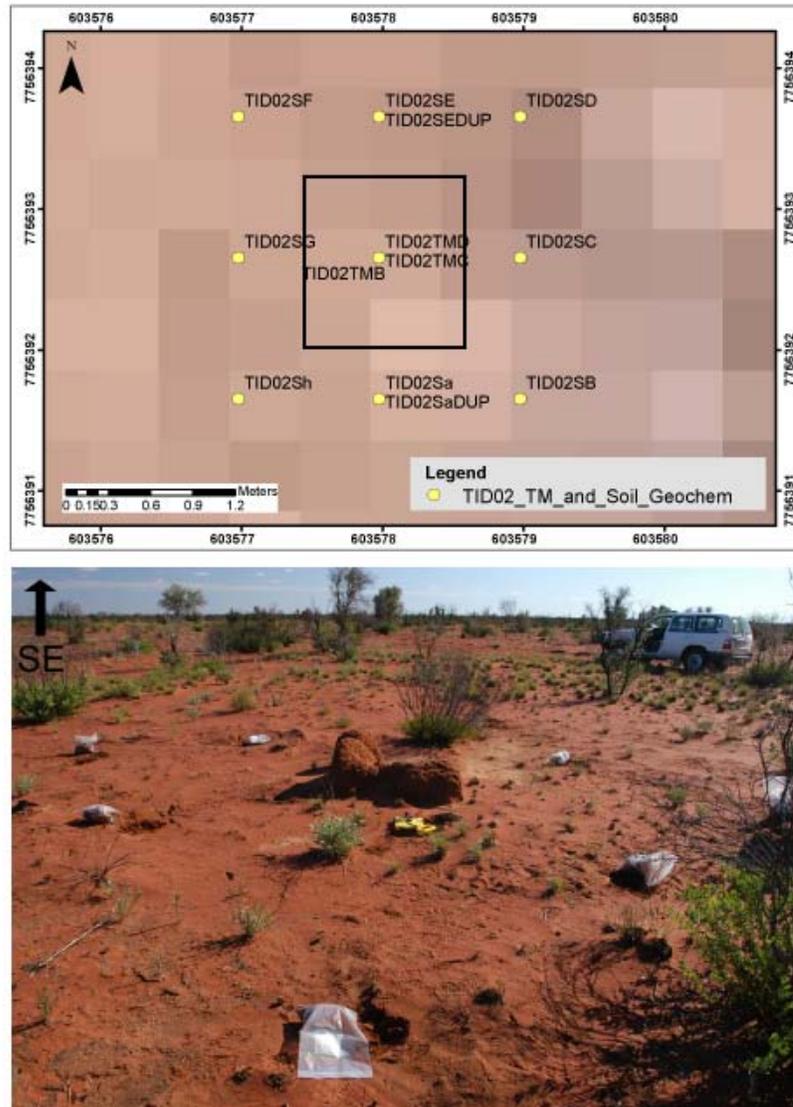


Figure 4.69 TID02 termitaria and soil sampling locations around the *D. rubriceps* mound. The top image displays the ArcGIS image, the black outline representing the area of the inset photo, which was taken in a southerly direction

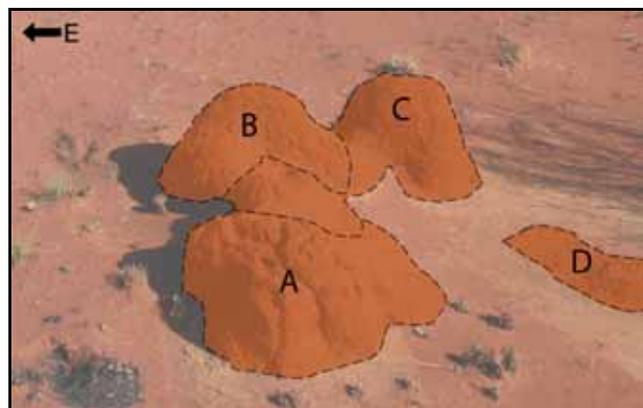


Figure 4.70 Sampling locations for the TID02 mound samples. Actual width of area shown is approx. 1.0 m

**Table 4.17 Comparative summary statistics for the TID02 termitaria and soil geochemical results at Titania Au-prospect; n(termitaria)=4 and n(soil)=8**

Element	TID02 Termitaria			TID02 Soils		
	Mean	Min	Max	Mean	Min	Max
<i>Ag_ppm</i>	-0.05	na	na	-0.05	na	na
<i>Al_percent</i>	1.98	1.86	2.09	1.09	0.92	1.25
<i>As_ppm</i>	16.00	15.00	17	5.38	5.00	5.8
<i>AuAR_ppb</i>	18.25	14.00	22	3.60	3.00	4
<i>Ba_ppm</i>	145.75	119.00	174	59.37	45.00	64.7
<i>Bi_ppm</i>	0.27	0.26	0.28	0.17	0.14	0.18
<i>Ca_percent</i>	0.53	0.25	0.68	0.09	0.06	0.12
<i>Cd_ppm</i>	-0.05	na	na	-0.05	na	na
<i>Ce_ppm</i>	29.78	28.60	30.9	34.04	30.40	38
<i>Co_ppm</i>	10.00	10.00	10	4.40	4.00	6
<i>Cr_ppm</i>	40.00	40.00	40	29.00	25.00	40
<i>Cu_ppm</i>	15.25	14.00	16	8.90	8.00	10
<i>Fe_percent</i>	3.45	3.31	3.55	1.84	1.71	1.92
<i>Ga_ppm</i>	9.30	8.80	9.4	4.68	4.00	5
<i>In_ppm</i>	0.04	0.04	0.045	0.02	0.02	0.02
<i>Kppm</i>	3825.00	3800.00	4200	1370.00	1100.00	1500
<i>La_ppm</i>	14.08	13.60	14.5	16.88	15.30	18.8
<i>Mg_percent</i>	0.28	0.19	0.37	0.07	0.05	0.07
<i>Mn_ppm</i>	252.00	232.00	264	206.50	184.00	255
<i>Mo_ppm</i>	0.68	0.60	0.7	0.45	0.40	0.5
<i>Na_ppm</i>	425.00	100.00	1100	-80.00	na	100
<i>Nd_ppm</i>	14.58	14.30	14.9	15.98	14.10	17.7
<i>Ni_ppm</i>	12.50	12.00	14	7.20	6.00	8
<i>Pb_ppm</i>	8.75	8.00	9	6.10	6.00	7
<i>Pd_ppb</i>	-10.00	na	na	-10.00	na	na
<i>Pr_ppm</i>	3.71	3.61	3.76	4.18	3.43	4.58
<i>Pt_ppb</i>	-5.00	na	na	-5.00	na	na
<i>Rb_ppm</i>	33.78	30.70	36.8	15.41	13.10	16.5
<i>Sppm</i>	437.50	250.00	750	130.00	100.00	150
<i>Sm_ppm</i>	2.77	2.70	2.87	2.86	2.20	3.1
<i>Sn_ppm</i>	1.90	1.80	2	1.00	1.00	1
<i>Sr_ppm</i>	32.38	22.20	44.9	10.92	7.90	16.9
<i>Te_ppm</i>	-0.10	na	na	-0.10	na	na
<i>Th_ppm</i>	7.99	7.79	8.32	7.41	6.00	8.34
<i>Ti_ppm</i>	-12.50	na	100	200.00	150.00	250
<i>Tl_ppm</i>	0.24	0.22	0.25	0.11	0.09	0.12
<i>U_ppm</i>	3.40	3.06	3.64	1.79	1.36	1.93
<i>V_ppm</i>	68.50	68.00	70	38.00	36.00	40
<i>Y_ppm</i>	8.64	8.38	8.8	6.68	5.58	7.3
<i>Zn_ppm</i>	15.00	14	16	9.60	9	11

Geochemical results for the TID02 termitaria samples show associations between elements in the Fraction 1 nest material (Figure 4.71). Gold occurs in the highest concentration (maximum 22 ppb) within the TID02TMA mound sample, as does Ga (9.4 ppm), K (4200 ppm), Ni (14 ppm), Rb (36.8 ppm) and Zn (16 ppm). TID02TMA also contains the lowest amounts of Mn (232 ppm), Na (100 ppm) and Pb (8 ppm).

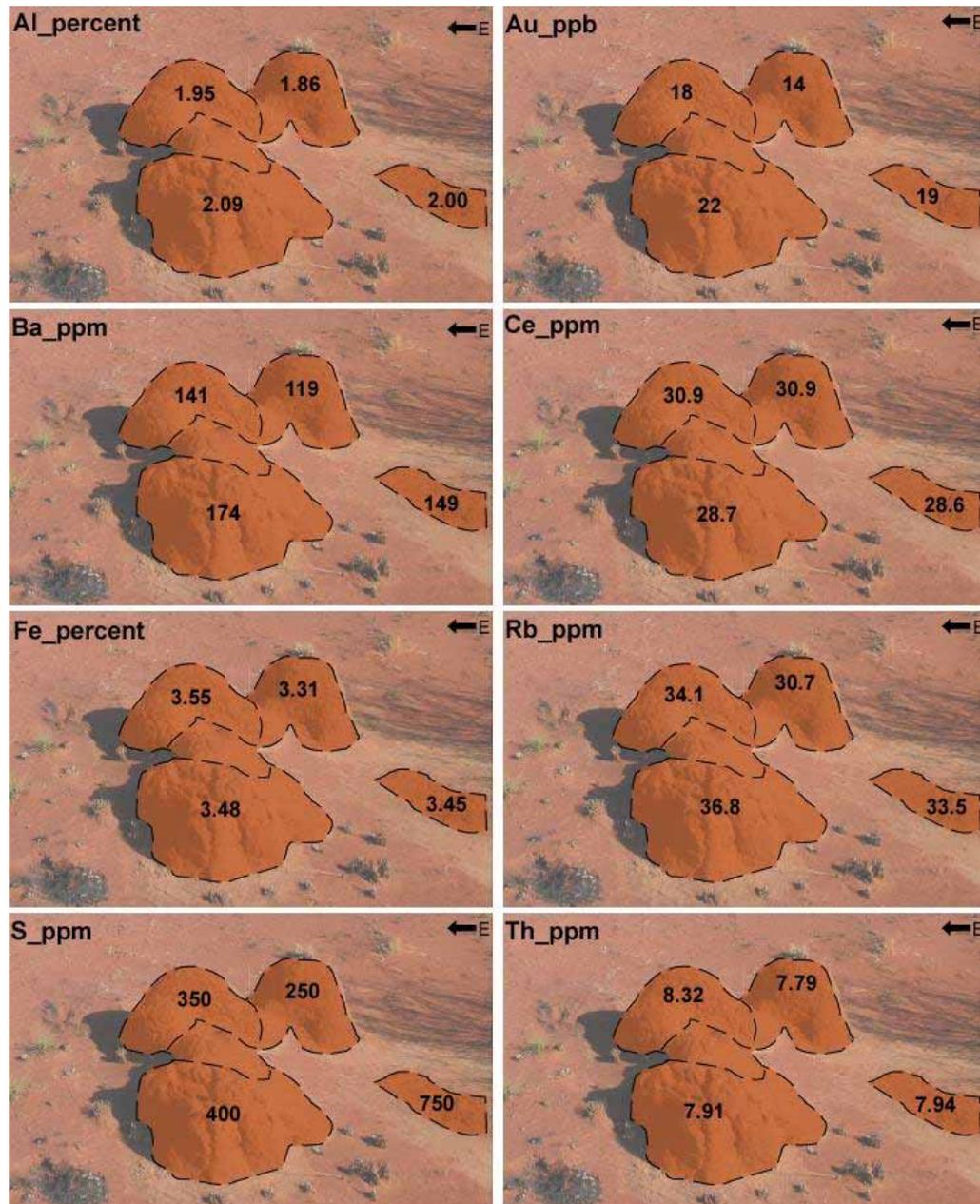


Figure 4.71 TID02TM geochemical assay results, for the elements Al, Au, Ba, Ce, Fe, Rb, S, and Th; n = 4

In comparison, the sample for TID02C contains the lowest amount of Al (1.86 %), As (0.83 ppm), Au (14 ppb), Ga (8.8 ppm), Fe (3.31 %), Mg (0.19 %), Rb (30.7 %), Sr (22.2 ppm), U (3.06 ppm) and Zn (14 ppm). The majority of the standard deviations for these four samples at TID02 are low, indicating little variation across the mounds except for TID02TMA and TID02TMC; and even in these cases the range is small. The variation that does occur within the mound may be explained by the timing of construction, with the higher values of Au-K-Ga-Ni-Rb-Zn present in a recent extension of the main nest. These elements are likely to be bound within clay aluminosilicates (K-Ga-Ni-Rb-Zn) and associated with mineralisation (Au).

With such a small sample number, it is difficult to reach any strong conclusions concerning the source of material within TID02 termitaria, except that the nest geochemistry is relatively homogeneous, with similar construction materials utilised in each section of the mound that constitutes the main above-ground nest.

#### **Detailed survey of TID02: soil geochemical results**

The soil sampling at TID02 aimed to complement the detailed nest sampling, with samples collected proximal to the mound. The sampling locations are shown in Figure 4.72. The soil samples were collected from eight points around the mound, with each point representing a certain distance and orientation from the nest. The soils were sampled approximately one metre from the main mound locations, oriented to the south (TID02Sa), east (TID02Sc), north (TID02Se), and west (TID02Sg). Four samples were also collected two metres from the mound, to the southeast (TID02Sb), northeast (TID02Sd), northwest (TID02Sf), and southwest (TID02Sh). The soil samples were collected using a steel shovel that was cleaned at every sampling site.

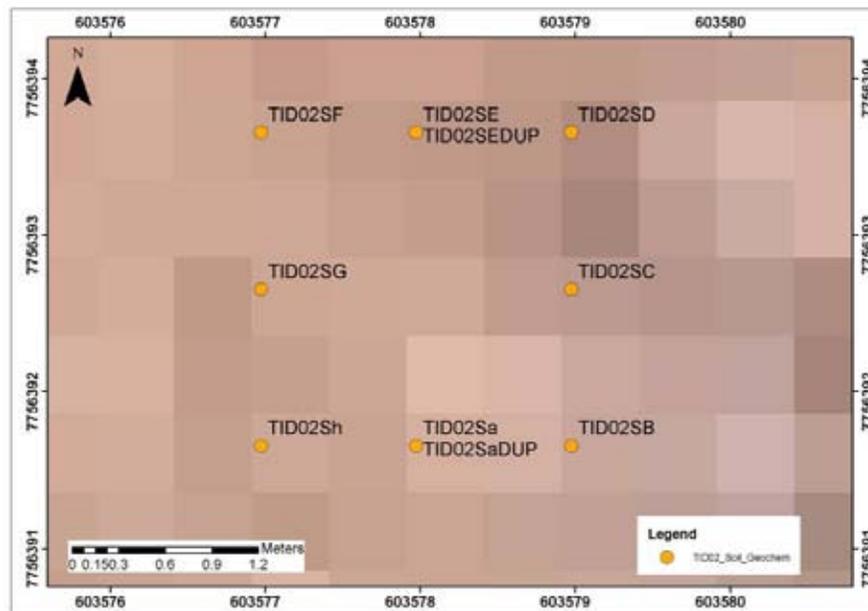


Figure 4.72 Locations for the TID02 soil samples

At least 15 cm of soil was removed and the sample taken from this point. The bagged sample typically weighed approximately 500 g, and was stored in a plastic zip-lock bag. The TID02 soils are loamy sands, orange-brown in colour, and composed of sub-rounded to rounded quartz silty sand. There is little variation in composition between the sampling locations at TID02. Only the silty fraction, Fraction 1, was analysed at the lab as part of this study. Soil samples were taken from approximately 15 cm depth below surface, with the upper portion scraped away using a plastic spoon.

The geochemical results for the soil samples at TID02 are summarised in Table 4.18. The majority of the elements have small standard deviations, with small ranges between minimum and maximum values. The elements Ba, Ce, Cr, K, Mn, Na, S, Sr, Ti and V have standard deviations greater than 1, and in the case of K up to 133.75 ppm (the maximum value for this element is 1500 ppm). Gold ranges from 3 to 4 ppb within the soil samples. Arsenic shows little difference between soil samples (5 to 5.8 ppm).

One sample with results of interest is TID02Sd, which is from northeast of the TID02 termitaria. This sample contains the lowest concentrations of Al, Ba, Ce, Fe, Ga, In, La, Mn, Nd, Pr, Rb, Sm, Th and U. The Sr concentration for this sample is also the maximum for the eight soil samples. The soil samples provide an excellent dataset for comparison with the termitaria samples at TID02, and the general homogeneity of the

results for each element suggests that at a local scale the location of the sampling site is not important unless regolith-landform settings vary greatly at a small scale.

**Table 4.18 Select soil geochemistry results for TID02; n(soil)=8**

Sample ID	TID02S A	TID02S B	TID02S C	TID02S D	TID02S E	TID02S F	TID02S G	TID02S H
<i>As_ppm</i>	5.2	5.4	5.8	5.4	5.8	5.2	5.4	5
<i>Au_ppb</i>	4	3	4	3	3	4	4	3
<i>Co_ppm</i>	4	4	6	4	4	4	4	6
<i>La_ppm</i>	18	18.1	14.9	13.5	18.8	15.3	17.7	16.1
<i>Mg_percent</i>	0.07	0.07	0.07	0.06	0.07	0.05	0.07	0.06
<i>Mo_ppm</i>	0.5	0.5	0.4	0.4	0.5	0.4	0.4	0.5
<i>Sppm</i>	150	100	100	150	150	100	150	100
<i>Th_ppm</i>	7.93	7.39	6.98	6	8.34	6.6	7.75	6.79
<i>U_ppm</i>	1.77	1.86	1.81	1.36	1.92	1.71	1.93	1.83
<i>Zn_ppm</i>	10	11	9	10	10	9	9	9

### **Interpretation of TID02 termitaria and soil geochemical results**

The TID02 termitaria and soil geochemical results show that the soils at Titania Au-prospect, when sampled at a local scale (eg 1: 5000, 1: 10 000), the *D. rubriceps* mounds consist of relatively homogeneous material, with geochemistry showing little variation within the respective sampling media. When the two datasets are compared, however, the abundance of the majority of elements within the termitaria and soils show:

- higher concentration within the TID02 termitaria for Al, As, Au, Ba, Ca, Co, Cu, Fe, Ga, In, K, Mg, Mn, Mo, Na, Ni, Pb, Pr, Sb, S, Sm, Sr, Tl, U, V, Y and Zn
- comparable ranges for Cr, La, Mo and Th
- that the sampled soils contain higher amounts of Ce, Nd, Sm and Ti
- that potassium, Mg and Ca are also abundant within the termitaria samples (often 3 to 4 times the amount), which is due to the high organic content of the mounds.

Some of the elements are abundant within both the termitaria and soil samples, although these are higher within the mound samples, with the range of values overlapping between the two datasets. Tukey plots for Bi, Cr, La, Mo, Nd, Pb, Pr, Sm, and Th (Figure 4.73) show that the relative abundances of these elements are similar for both sampling media. This indicates that the outer nest material and the surface sediments are of similar composition, though with much less weathered minerals within the termitaria.

The termites appear to also incorporate less weathered and more locally derived sediments into the mound, as evident in the much higher concentrations of mineral-forming elements such as Al, As and Zn (Figure 4.74). Termites also readily sample within the upper regolith profile, which includes the geochemical signature for mineralisation at Titania Au-prospect. The values for Au, which are much higher in the TID02 mound samples in particular, support this interpretation.

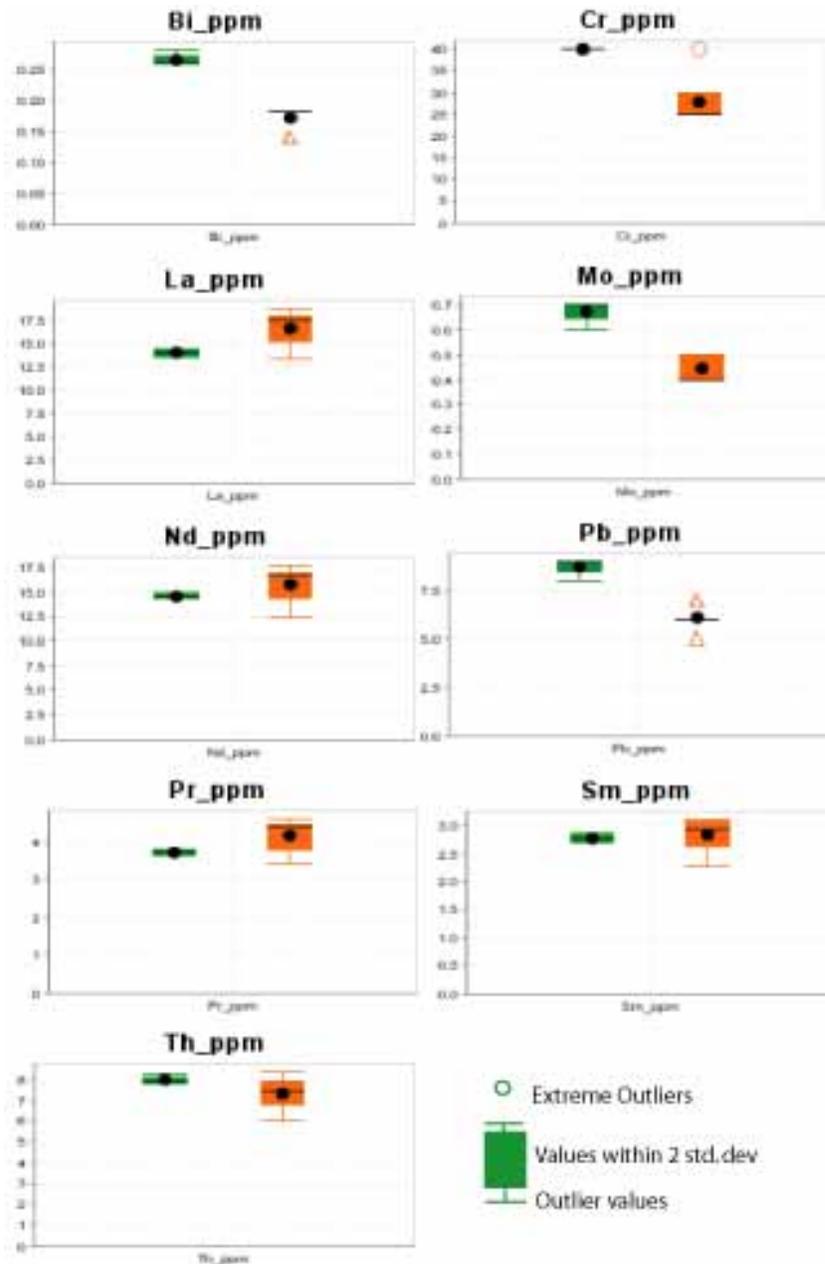


Figure 4.73 Plots of overlapping elements Bi, Cr, La, Mo, Nd, Pb, Pr, Sm, and Th for the termitaria and soil samples at TID02;  $n(\text{termitaria})=4$  and  $n(\text{soil})=8$

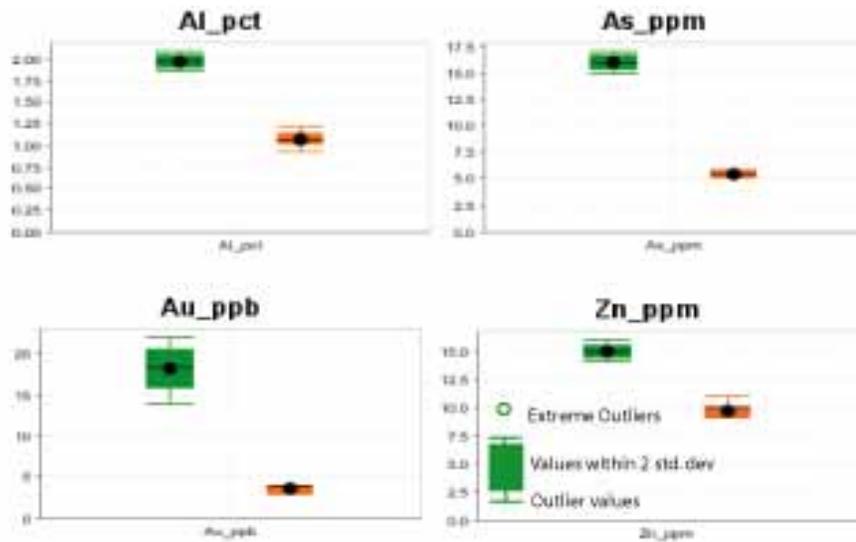


Figure 4.74 Tukey plots of the elements Al, As, Au and Zn for the termitaria (left, green) and soil (right, orange) samples at TID02;  $n(\text{termitaria})=4$  and  $n(\text{soil})=8$

### **Discussion of the variation between soils and termitaria at the detailed survey sites, TID01 and TID02**

At both TID01 and TID02 sites, the termitaria samples typically contained greater concentrations of the majority of the elements than the surrounding soils, excluding Bi, Ce, Fe, In, La, Mo, Pr and Sn for TID01TM, and Cr, La, Th, and Mo for TID02TM. The mean and maximum values for the termitaria samples at TID01 and TID02 are also similar, with the ranges overlapping for elements including Al, Au, Bi, Ca, Ce, Co, Cr, Cu, Fe, Ga, In, K, Mg, Mn, Na, Ni, Pb, Rb, S, Sn, Th, Tl, U, and Zn.

The variation of Au concentration between termitaria and soil samples at TID01 and TID02 is particularly interesting, with the average and maximum value at TID01 calculated to be 12.99 ppb and 18 ppb, respectively, and at TID02 to be 18.25 ppb and 22 ppb, respectively. The concentration of Au within the soil samples, for both TID01 and TID02 averages 3 ppb and 3.06 ppb, respectively, and the maximum concentration of Au is 4 ppb. The low values of Au in the soil profile at both sites suggest that the background value for Au is between 3 to 4 ppb across the prospect. Even with a ‘nuggety’ effect for Au distribution in many surficial sediments and termitaria, as reported in the literature, the strong contrast between Au concentration in termitaria and soils indicates that the material within the nests constructed by termites represents the

underlying regolith profile much more reliably than the surficial sediments, especially for the fine silt-clay fraction (Fraction 1).

#### 4.4.4 Investigation into termite speciation and geochemistry at Titania Au-prospect (from Petts et al., 2008)

Samples from different mound-building species (the thin and pointed *A. vitosus* and the more rounded *D. rubriceps*) were taken at each sample site, where possible. In many cases this was not possible, as the neighbouring mounds were over five metres away from the key study mound; however, ten fieldsites had termitaria from different species in the one field location (within five metres). These coexisting samples are the focus of this part of the study, and are displayed in Figure 4.75.

The paired samples used in this study are the same mounds discussed earlier for the presentation of results from the gridded, termitaria sampling program. Statistical analysis and comparison of the paired mounds is used in this study to investigate any difference between the various nests constructed by the mound-building termite species at Titania Au-prospect. From the 92 gridded and special field sites at Titania, only ten were deemed suitable for inclusion in this study after all criteria were met. Both ArcGIS and Excel™ software were used to construct geochemical maps and graphs of elemental concentration.

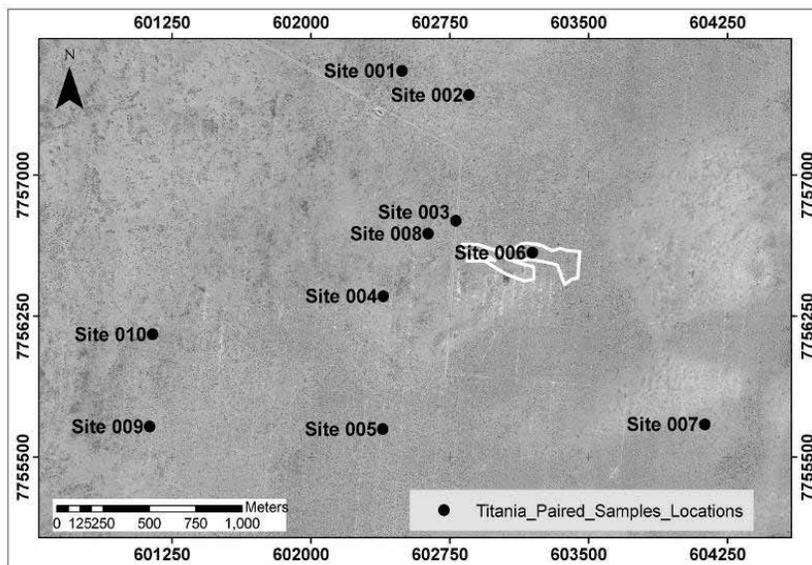


Figure 4.75 Locations of the paired sample study sites, Titania prospect, NT. Grid coordinates conform to AGD GDA 94 z52 UTM. The surface projection of buried mineralisation is outlined in white polygons

### **Termite speciation study results**

The following figures display results derived from the main dataset generated by ICP-MS and ICP-AES, and include 15 major and pathfinder elements— Au, As, Al, Co, Cr, Cu, La, Mg, Mo, Ni, Pb, Sn, Th, U and Zn. Figures 4.76 and 4.77 show comparisons of the geochemical results, separated into termite species and by fraction size. The maximum values displayed here were derived from the original dataset, before being selected for a simplified table showing maximum and minimum values for each fraction, of each element, and divided by species.

The ‘species by species’ fraction comparison for Au in Figure 4.76A reveals all three species have a maximum value of 12 ppb Au in Fraction 1. Values of this element for Fraction 2 and 3 are lower, between 4 and 5 ppb for Au in Fraction 2, and between 3 to 8 ppb Au in Fraction 3. Figure 4.76B shows the As levels for all three mounds, divided by fraction size, and highlights the relatively higher amounts of As in *D. rubriceps* and *N. triodiae* (14 and 3.6 ppm, respectively) in Fraction 1. Fraction 2 maximum values were slightly lower (between 3.8 ppm and 7.6 ppm) and Fraction 3 As results were highest in the *N. triodiae* mound, followed by *D. rubriceps*.

Fraction and species comparisons were also made for Mo and Ni (Figures 4.77A and 4.77B, respectively). Within the silt-clay fraction, Mo values vary between 0.6 ppm for *N. triodiae*, 0.7 ppm within *A. vitiosus* and 0.8 ppm within *D. rubriceps* mounds. The maximum Mo concentration for *N. triodiae* in Fraction 2 is 0.4 ppm, 0.8 ppm for *A. vitiosus* and 0.7 ppm for *D. rubriceps*. Fraction 3 values followed a similar trend to Fraction 2, from 0.4 ppm (*N. triodiae*) to 0.7 ppm for *A. vitiosus* and *D. rubriceps*.

Nickel contents are elevated within the *D. rubriceps* and *N. triodiae* mound material, across all fraction sizes. Maximum concentrations of 12 ppm for Ni in all three species were obtained from Fraction 1. *N. triodiae* and *A. vitiosus* share a maximum Fraction 2 Ni value of 6 ppm, whilst the maximum Fraction 2 result for *D. rubriceps* was 8 ppm. For the coarser, Fraction 3, *A. vitiosus* had a value of 6 ppm, and *N. triodiae* and *D. rubriceps* a value of 10 ppm. The following linear graphs (Figures 4.78 to 4.80) plot the concentration of one species against its paired species, for each of the ten fieldsites, to compare termitaria data from two species of termite, along with correlation coefficients.

Soil samples were also analysed using ICP-MS and ICP-AES. Compared to the termitaria data across the sampling grid, including the paired sample geochemical data that has been discussed here, the soil geochemistry contains less of elements such as Au and Zn. The average Au concentration in the termitaria samples collected across Titania is 4.1 ppb, compared to 1.44 ppb in soils. Average Zn concentration in termitaria at Titania Prospect is 14.8 ppm, but the average amount of Zn in soils is 7.1 ppm.

The levels of Au in termitaria sampled at the Titania prospect are not significant when compared to results normally associated with an Au resource, such as thousands of ppm (Berkman, 2001). Although it was conducted at an already defined prospect, the aim of this study was to determine whether ppb-levels of elements, which are of interest to mineral exploration companies conducting regional exploration, may be detected within mounds built by these common termite species. With Au levels ranging from 4 to 12 ppb, these mounds would typically still warrant follow-up augering, sampling or even regional drilling. The ppb-levels of Au are typically considered anomalous in the regolith of the Tanami region of northern Australia by most local exploration companies.

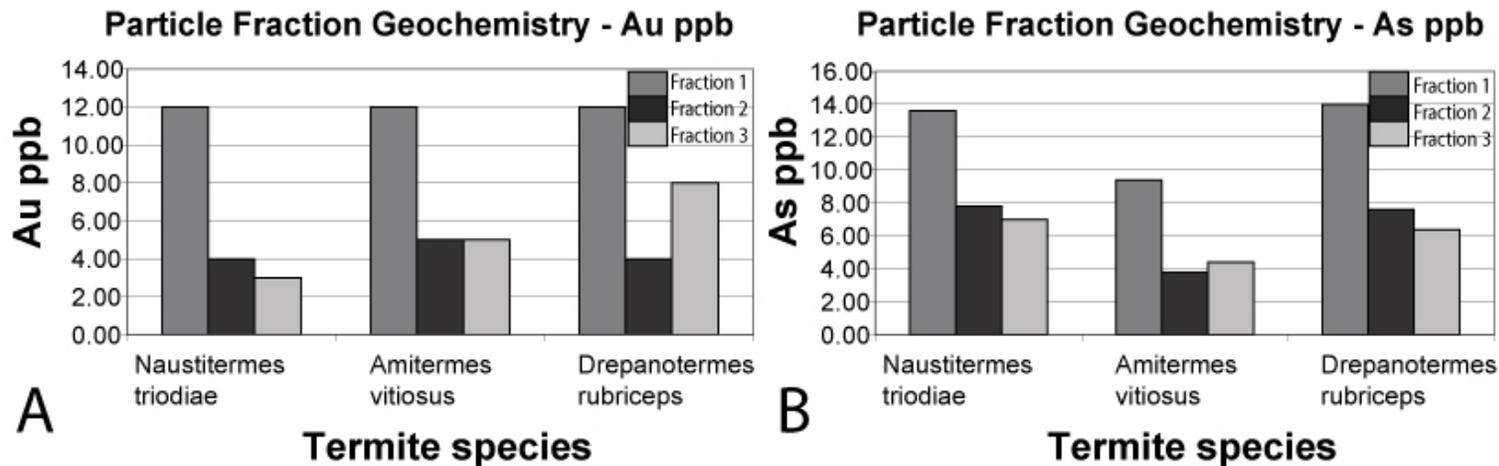


Figure 4.76 Maximum pathfinder and ore element results for each termite species, and further subdivided by particle size (Fraction 1, mid-grey; Fraction 2, dark grey; or Fraction 3, light grey), for Au (A) and As (B); n(total)=10

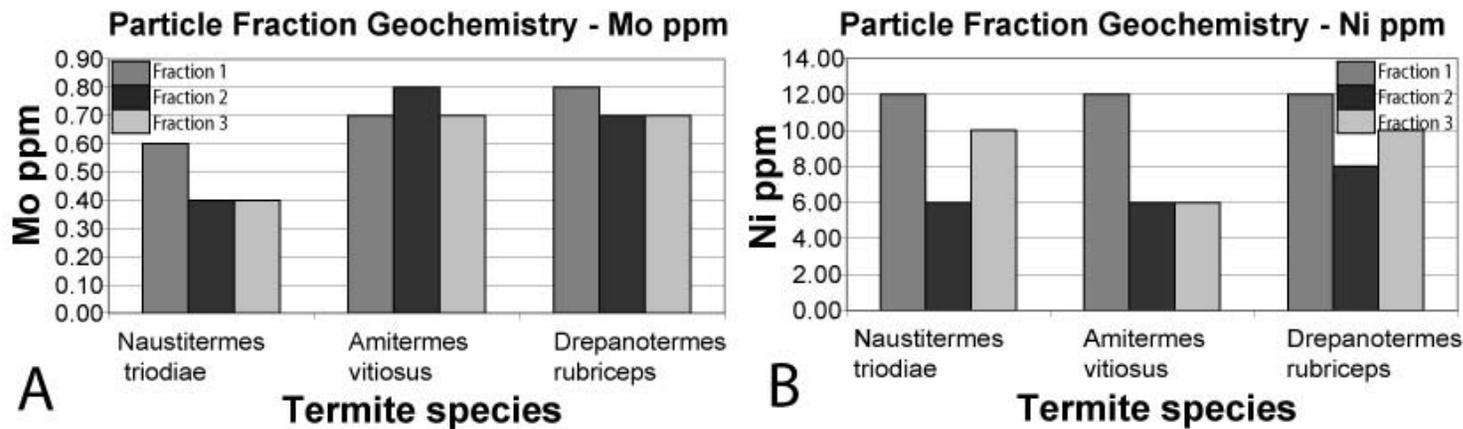


Figure 4.77 Pathfinder and ore element results for termite species, and further subdivided by particle size (Fraction 1, mid-grey; Fraction 2, dark grey; Fraction 3, light grey), Mo values (A) and Ni (B); n(total)=10

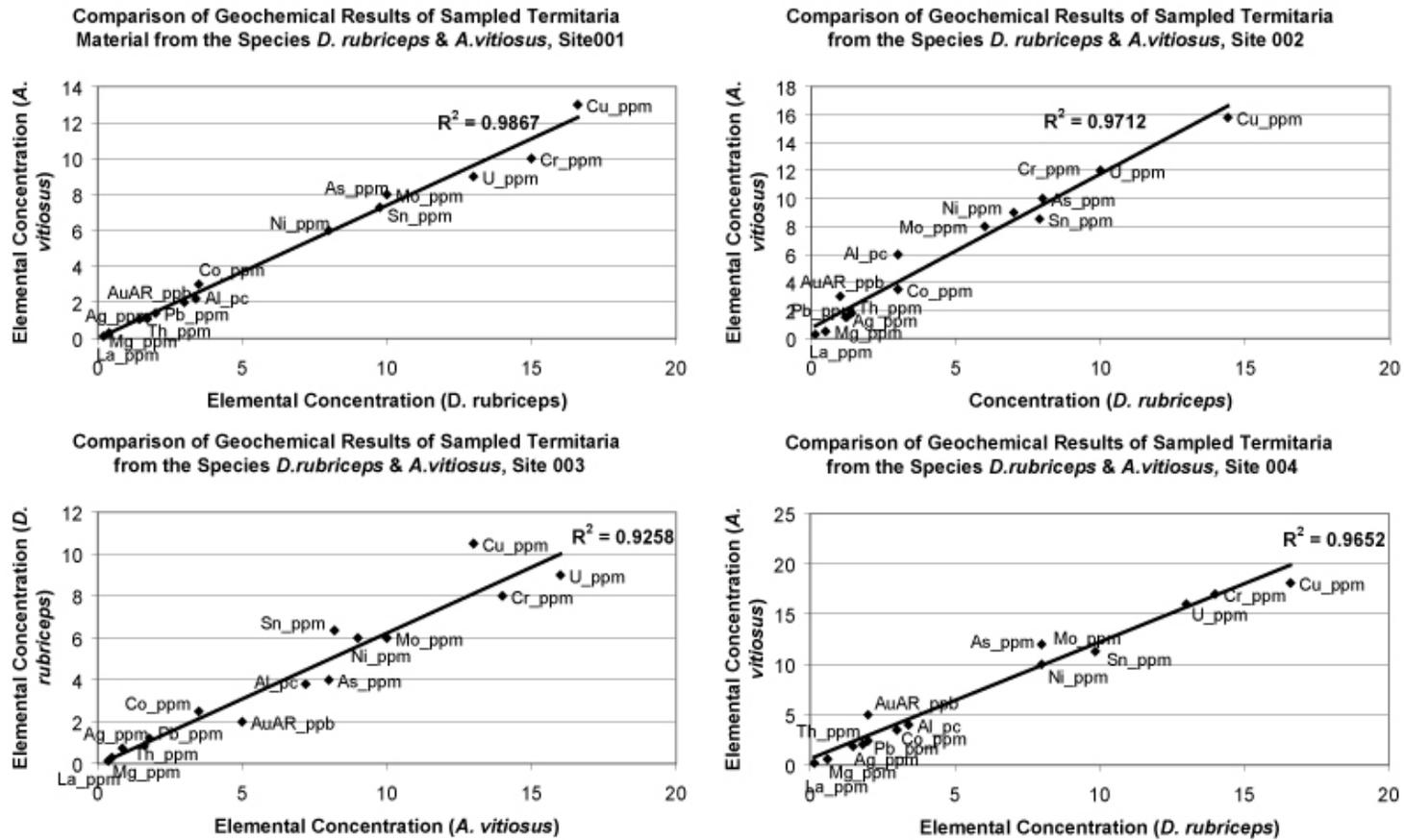


Figure 4.78 Comparison of select geochemical results for termitaria species at Site 001 (602360 7757387, AGD 66 UTM z52) Site 002 (602721 7757259) Site 003 (602651 7756591) and Site 004 (602259 7756190). Elemental concentrations are expressed as either ppb, ppm or %, (shown alongside the element label along the trend line. Fraction 1 ICP-MS/AES geochemical results

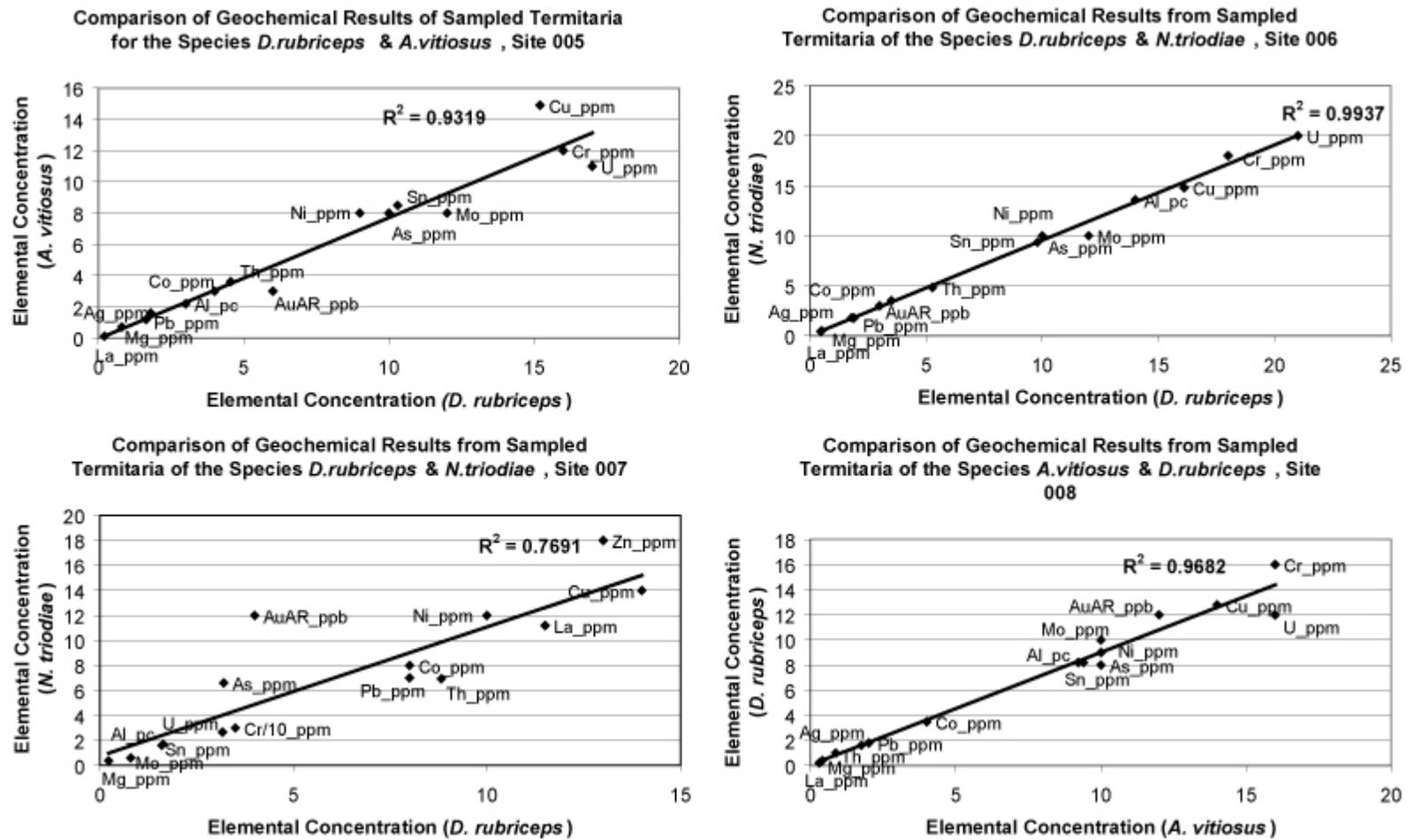
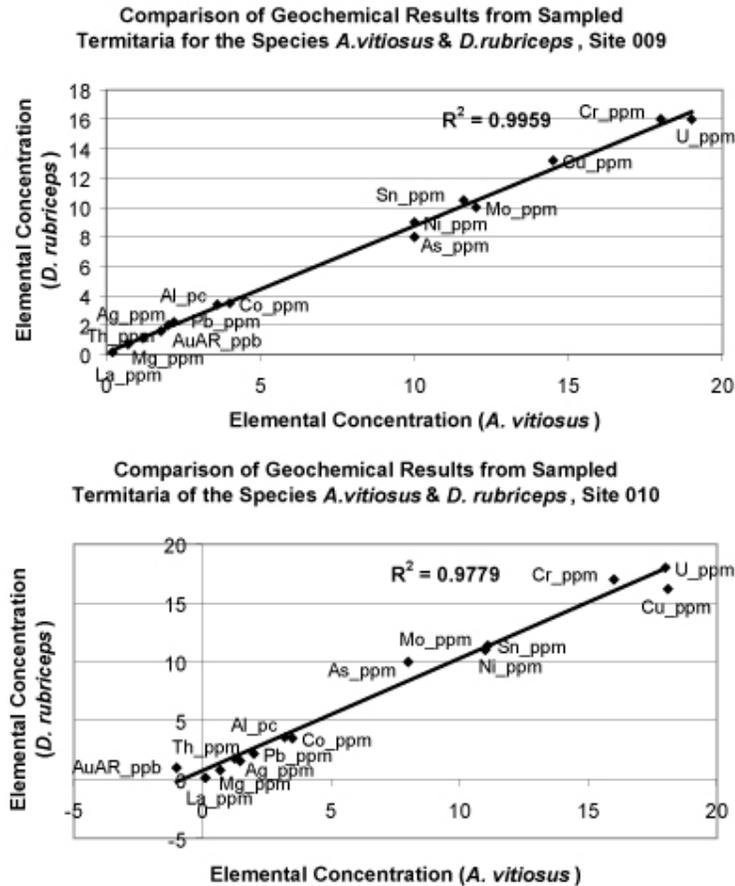


Figure 4.79 Termitaria species comparison for Site 005 (602256 7755484, AGD 66 UTM z52) Site 006 (603064 775642) Site 007 (603995 7755509) and Site 008 (602501 7756522). Elemental concentrations are either in ppb, ppm or % (shown alongside the element label along the trend line). Fraction 1 ICP-MS/AES geochemical results



**Figure 4.80** Termitaria species comparison for Site 009 (600997 7755497 AGD 66 UTM z52) and Site 010 (601013 7755987). Elemental concentrations are either in ppb, ppm or % (shown alongside the element label along the trend line). Fraction 1 ICP-MS/AES geochemical results

### **Interpretation of termite speciation study results**

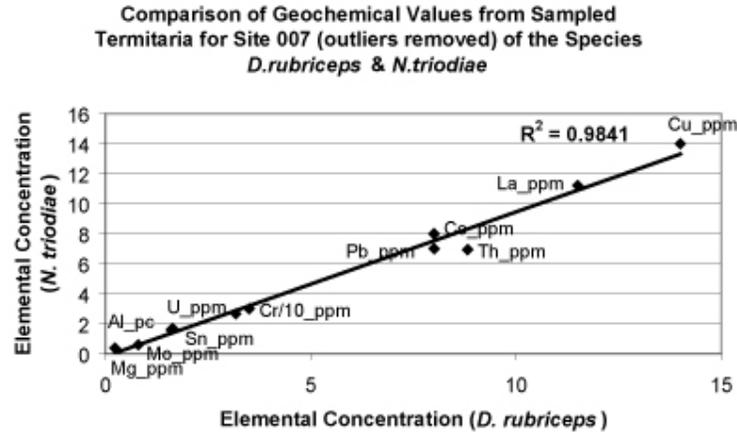
The mineralisation at Titania, which is within a single regolith-landform setting hosting all three species of termite, is expressed in the biogeochemistry of termitaria constructed by all three species. The biogeochemical expression of mineralisation is most apparent in the finer, silty-sand fraction (Fraction 1) of termitaria samples for the main ore and pathfinder elements: Au, As, Cu, Cr, Co, Mn, Mo, Ni, Pb, Sn, Th, U and Zn. At each paired species sampling locality, both species showed concentrations expressing the underlying mineralisation; however, in some results for *D. rubriceps* the coarser fraction (Fraction 3) had elevated concentrations for elements such as Mo and Au. This is likely to be explained by the presence of locally derived (angular) coarse, saprolitic nodules in the outer wall of many *D. rubriceps* nests, as observed during field sampling.

### **Species comparisons**

Termitaria associated with all three of the termite species are equally effective at expressing buried mineralisation. Many of the differences between the maximum values of the species are closely related to the chemical characteristics of the regolith from which they were sampled. For instance, higher results for As coincide with landscape depressions, which directly overlie mineralisation.

Species comparisons reveal insignificant differences in the ability of a particular termite species to preferentially recycle or introduce mineralised material. Values for Al in all three fractions are higher in the *D. rubriceps* samples. *N. triodiae* and *D. rubriceps* have particularly high As concentrations in Fraction 1 (13.5 and 14 ppm, respectively). Fraction 2 and Fraction 3 concentrations of As are also elevated, compared to the As values for *A. vitosus*. The generally elevated levels of As in the termite species, *D. rubriceps* and *N. triodiae*, coincide with the dominance in distribution of these species over mineralisation at Titania. The Au concentrations vary from 1 to 12 ppb, and Au is expressed by all species consistently between samples, except for Site 007 with its finer Fraction 1 materials. These concentration levels are repeated within Fraction 2 and 3 results, but are somewhat lower in value.

Some localities have individual *D. rubriceps* or *A. vitosus* termitaria with higher values for the element suite associated with mineralisation, but it is the response of one *N. triodiae* mound in particular (Site 007) that has major implications for understanding the role of different termite species in bringing geochemical signatures to the surface. This *N. triodiae* mound shows elevated levels of As, Au, Ni and Zn, shown as outliers in Figure 12, with an  $R^2$  value of 0.7691. When these outliers are removed (Figure 4.81), the  $R^2$  value reverts to 0.9841, highlighting the anomalous signature derived from the subsurface. Since there is an absence of similar anomalous values within the *D. rubriceps* mound, it may be argued that *D. rubriceps* termites do not burrow as deep within the regolith profile as *N. triodiae*; the geochemical signature is not present at the surface, but arises instead from lower in the regolith profile. All three sampled species would otherwise incorporate similar geochemical signals from harvested spinifex and other grasses, and have travelled to the groundwater table for moist construction materials or to collect water.



**Figure 4.81** Amended termitaria species comparison for Site 007 (603995 7755509, AGD 66 UTM z52). Elemental concentrations are expressed either in ppb, ppm or % (shown alongside the element label along the trend line). Fraction 1 ICP-MS/AES geochemical results, with outlier values (Au, As, Ni and Zn) removed.

The water table at the Titania prospect is often at the ground surface during the wet season, but otherwise fluctuates around eight metres in depth.

The inclusion of pathfinder elements in the outlier group within the Site 007 *N. triodiae* sample, including Zn, indicates that there is a difference in the use of regolith materials for mound building, between these two termite species. The *N. triodiae* termites may be bringing a deeper chemical signal to the surface, derived from lower within the regolith profile, than the *D. rubriceps* workers; these would normally travel laterally to seek building materials. Another hypothesis may be that *D. rubriceps* incorporates much coarser material from the upper regolith profile than *N. triodiae*, which is reflected in particle size studies of the three termite species sampled at Titania Au-prospect (Table 4.19).

**Table 4.19 Particle size analysis results from 4 study sites at Titania Au-prospect, derived from samples dry-sieved in bulk and weighed before splitting for geochemical analysis. Weight for each fraction is expressed as a percentage (Fraction 3 (F3) > 1 mm; Fraction 2 (F2) 0.075 mm to 1 mm; Fraction 1 (F1) < 0.075 mm)**

Field site	Species	F3%	F2%	F1%
Site 004	<i>D. rubriceps</i>	26.90%	66.04%	7.06%
	<i>A. vitiosus</i>	30.22%	58.71%	11.07%
Site 005	<i>A. vitiosus</i>	26.90%	62.04%	11.06%
	<i>D. rubriceps</i>	29.48%	64.00%	6.51%
Site 006	<i>D. rubriceps</i>	27.18%	57.84%	14.98%
	<i>N. Triodiae</i>	27.02%	56.85%	16.13%
Site007	<i>A. vitiosus</i>	36.44%	54.55%	9.01%
	<i>N. Triodiae</i>	26.34%	65.68%	7.98%

Overall there is not a clear differentiation between elemental concentrations and species in the Fraction 1 results, except for the *N. triodiae* mound at Site 007.

#### **4.1.13 Soil sample collection at Titania Au-prospect**

During the August 2006 fieldwork program soil samples were collected in association with the previous termitaria sampling (Figure 4.82). The samples were collected using a small plastic shovel, which was cleaned at each site by digging up soil from a proximal site within one metre of the sample location. The samples were logged using a Munsell Soil Colour Chart, to determine soil colour, and the CSIRO Soil and Land Survey handbook was used to determine soil type (Gunn *et al.* 1988).

#### **Transect 3 soil geochemical survey results**

Nine soil samples were collected, which were then prepped to three size fractions (Fraction 1, < 75 micron; Fraction 2, between 75 microns and 1 mm; and, Fraction 3; > 1 mm). Locally significant threshold values have been calculated from cumulative frequency plots generated in IoGAS statistical software, where the threshold value is calculated from the concentration value corresponding to the natural break-in-slope along the plot. The elements Ag, Cd, Pd, Pt, and Te all had analytical results less than their analytical detection limits. Appendix E contains summary tables of mean, standard deviation, minimum and maximum values for all three size fractions of the soil geochemical results.

The key elemental patterns for the geochemical results for the nine soil samples, from all three size fractions, are based on the distribution of maximum values within the transect, and displayed in Figure 4.83. The geochemical results are presented in Figures 4.84 to 4.117, with all three fractions for each element presented alongside each other.

Tables 4.20 to 4.22 provide a summary of the maximum, average and threshold values (defined as the 95th percentile), and spatial pattern for each element, for Fraction 1 and Fraction 2 geochemical results, respectively. Only two sample sites contained enough coarse (greater than 1 mm) material for geochemical analysis along Transect 3.

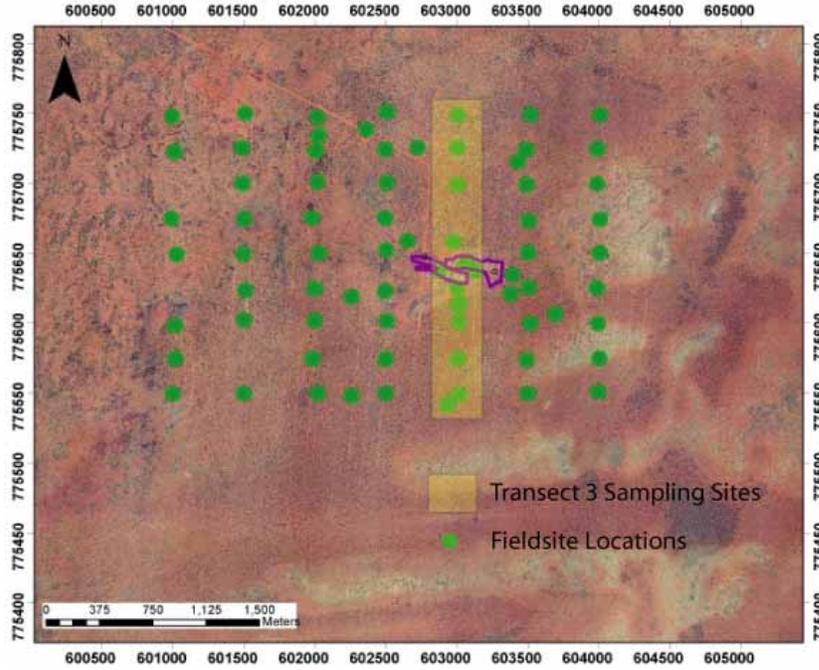


Figure 4.82 Location of site observations made in October 2005. The location of repeat observations and soil sampling sites along Transect 3 is indicated by the orange rectangle.

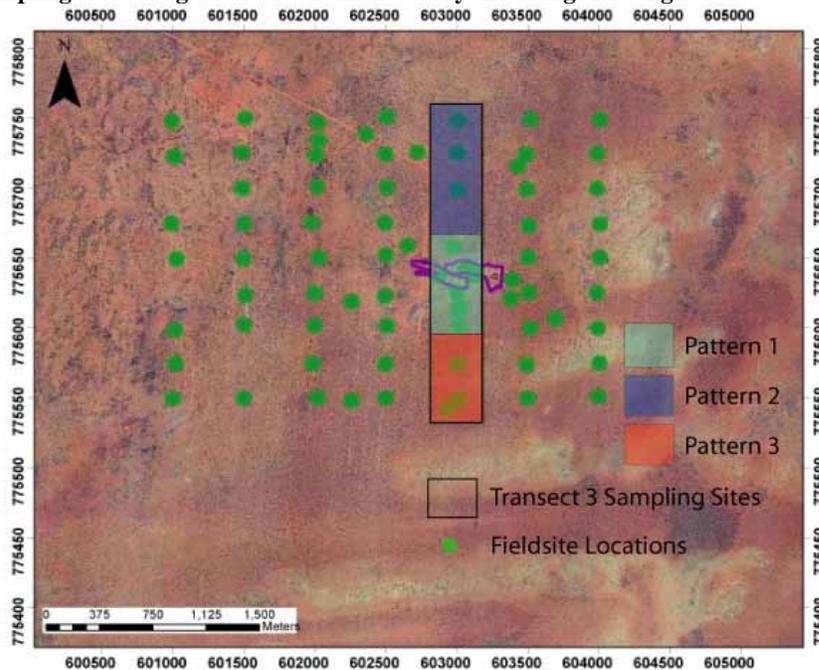


Figure 4.83 Elemental patterns of soil geochemical results based on their distribution within Transect 3 at Titania Au-prospect, NT. Pattern 4, not included in this image, includes elements irregularly distributed.

**Table 4.20 Summary of the mean, minimum and maximum values, anomaly threshold and spatial pattern for Fraction 1 soil geochemical results; n=9**

<b>Element</b>	<b>Mean</b>	<b>Min</b>	<b>Max</b>	<b>Anomaly threshold</b>	<b>Spatial association</b>
<i>Ag_ppm</i>	-0.05	na	na	na	na
<i>Al_percent</i>	0.86	0.61	1.26	1.26	Scattered
<i>As_ppm</i>	2.98	1.20	9.40	9.40	Centre
<i>Au_ppb</i>	1.44	1.00	2.00	2.00	South
<i>Ba_ppm</i>	36.07	23.10	54.80	54.80	Centre
<i>Bi_ppm</i>	0.15	0.12	0.20	0.20	Centre
<i>Ca_percent</i>	0.07	0.03	0.19	0.19	Centre
<i>Cd_ppm</i>	-0.05	na	na	0.00	na
<i>Ce_ppm</i>	22.61	15.30	29.10	29.10	Irregular
<i>Co_ppm</i>	4.22	2.00	6.00	6.00	Centre
<i>Cr_ppm</i>	35.00	25.00	55.00	55.00	Centre
<i>Cu_ppm</i>	6.44	5.00	9.00	9.00	Centre
<i>Fe_percent</i>	1.88	1.53	2.57	2.57	Centre
<i>Ga_ppm</i>	3.87	3.00	5.40	5.40	Centre
<i>In_ppm</i>	0.02	0.02	0.03	0.03	Centre
<i>K_ppm</i>	1155.56	600.00	2300.00	2300.00	Centre
<i>La_ppm</i>	10.95	7.84	15.20	15.20	Irregular
<i>Mg_percent</i>	0.06	0.03	0.16	0.16	Centre
<i>Mn_ppm</i>	139.89	93.00	219.00	219.00	Centre
<i>Mo_ppm</i>	0.37	0.20	0.50	0.50	South
<i>Na_ppm</i>	-22.22	0.00	300.00	300.00	Centre
<i>Nd_ppm</i>	11.03	8.17	15.00	15.00	North
<i>Ni_ppm</i>	5.33	4.00	8.00	8.00	Centre
<i>Pb_ppm</i>	4.89	4.00	7.00	7.00	Centre
<i>Pd_ppb</i>	-10.00	na	na	na	na
<i>Pr_ppm</i>	3.04	2.17	4.18	4.18	Centre
<i>Pt_ppb</i>	-5.00	na	na	na	na
<i>Rb_ppm</i>	13.31	9.60	23.20	23.20	Centre
<i>S_ppm</i>	100.00	50.00	300.00	300.00	Centre
<i>Sm_ppm</i>	2.11	1.60	2.81	2.44	North
<i>Sn_ppm</i>	1.04	0.80	1.40	1.40	North
<i>Sr_ppm</i>	6.01	3.30	10.40	10.40	Centre
<i>Te_ppm</i>	-0.10	na	na	na	na
<i>Th_ppm</i>	5.64	4.64	7.36	7.36	North
<i>Tl_ppm</i>	0.09	0.07	0.15	0.15	Centre
<i>U_ppm</i>	1.52	0.69	3.08	3.08	South
<i>V_ppm</i>	37.56	30.00	54.00	54.00	Centre
<i>Y_ppm</i>	5.99	4.54	7.74	7.74	North
<i>Zn_ppm</i>	7.11	5.00	12.00	12.00	Centre

**Table 4.21 Summary of the mean, minimum and maximum values, anomaly threshold and spatial pattern for Fraction 2 soil geochemical results, where n=9**

<b>Element</b>	<b>Mean</b>	<b>Min</b>	<b>Max</b>	<b>Anomaly threshold</b>	<b>Spatial association</b>
<i>Ag_ppm</i>	-0.05	-0.05	-0.05	na	na
<i>Al_percent</i>	0.52	0.43	0.64	0.64	Irregular
<i>As_ppm</i>	1.87	1	4.4	4.4	Centre
<i>Au_ppb</i>	-0.78	na	1	1	South
<i>Ba_ppm</i>	54.90	20.5	107	107	Centre
<i>Bi_ppm</i>	0.10	0.08	0.1	0.1	Irregular
<i>Ca_percent</i>	0.03	0.01	0.06	0.06	Centre
<i>Cd_ppm</i>	-0.05	na	na	na	na
<i>Ce_ppm</i>	6.42	5.29	8.16	8.16	Centre
<i>Co_ppm</i>	0.22	na	2	2	Irregular
<i>Cr_ppm</i>	56.11	50	60	60	Irregular
<i>Cu_ppm</i>	2.78	2	4	4	Centre
<i>Fe_percent</i>	1.09	0.97	1.27	1.27	Centre
<i>Ga_ppm</i>	1.96	1.6	2.4	2.4	Centre
<i>In_ppm</i>	na	na	na	na	na
<i>K_ppm</i>	600.00	400	1000	1000	Centre
<i>La_ppm</i>	3.23	2.76	3.98	3.98	Centre
<i>Mg_percent</i>	0.03	0.01	0.06	0.06	Centre
<i>Mn_ppm</i>	64.44	48	85	85	Centre
<i>Mo_ppm</i>	0.23	0.2	0.3	0.3	Centre
<i>Na_ppm</i>	-55.56	na	100	100	Centre
<i>Nd_ppm</i>	2.98	2.37	3.72	3.72	Centre
<i>Ni_ppm</i>	3.78	2	4	4	Irregular
<i>Pb_ppm</i>	2.33	2	3	3	Centre
<i>Pd_ppb</i>	-10.00	na	na	na	na
<i>Pr_ppm</i>	0.79	0.64	0.99	0.99	Centre
<i>Pt_ppb</i>	-5.00	na	na	na	na
<i>Rb_ppm</i>	7.20	5.55	10.7	10.7	Centre
<i>S_ppm</i>	50.00	na	100	100	Centre
<i>Sm_ppm</i>	0.57	0.44	0.73	0.73	Centre
<i>Sn_ppm</i>	0.56	0.4	0.6	0.6	Irregular
<i>Sr_ppm</i>	2.90	1.8	5	5	Irregular
<i>Te_ppm</i>	-0.10	na	na	na	na
<i>Th_ppm</i>	1.87	1.49	2.44	2.44	Centre
<i>Tl_ppm</i>	0.05	0.04	0.07	0.07	Centre
<i>U_ppm</i>	0.51	0.3	1.24	1.24	South
<i>V_ppm</i>	20.67	18	26	26	Centre
<i>Y_ppm</i>	1.56	1.15	2.23	2.23	Centre
<i>Zn_ppm</i>	3.89	3	5	5	Centre

**Table 4.22 Summary of the standard deviation, mean, minimum and maximum values for Pattern 3 elements within Fraction 3 soil sample geochemical results; n=2**

<b>Element</b>	<b>TIT304S</b>	<b>TIT305S</b>
<i>Ag_ppm</i>	-0.05	-0.05
<i>Al_percent</i>	0.82	0.96
<i>As_ppm</i>	5.4	5.40
<i>Au_ppb</i>	1	-1.00
<i>Ba_ppm</i>	204	85.20
<i>Bi_ppm</i>	0.12	0.14
<i>Ca_percent</i>	0.03	0.16
<i>Cd_ppm</i>	-0.05	-0.05
<i>Ce_ppm</i>	11.6	11.30
<i>Co_ppm</i>	4	2.00
<i>Cr_ppm</i>	140	95.00
<i>Cu_ppm</i>	6	5.00
<i>Fe_percent</i>	1.98	1.87
<i>Ga_ppm</i>	2.6	3.40
<i>In_ppm</i>	0.01	0.02
<i>K_ppm</i>	1100	1400.00
<i>La_ppm</i>	5.61	5.77
<i>Mg_percent</i>	0.05	0.10
<i>Mn_ppm</i>	199	128.00
<i>Mo_ppm</i>	0.4	0.30
<i>Na_ppm</i>	200	100.00
<i>Nd_ppm</i>	5.26	5.13
<i>Ni_ppm</i>	8	6.00
<i>Pb_ppm</i>	4	4.00
<i>Pd_ppb</i>	-10	-10.00
<i>Pr_ppm</i>	1.39	1.39
<i>Pt_ppb</i>	-5	-5.00
<i>Rb_ppm</i>	9.45	14.00
<i>S_ppm</i>	150	150.00
<i>Sm_ppm</i>	0.98	0.96
<i>Sn_ppm</i>	1	0.80
<i>Sr_ppm</i>	7.3	6.70
<i>Te_ppm</i>	-0.1	-0.10
<i>Th_ppm</i>	3.37	3.61
<i>Tl_ppm</i>	0.07	0.08
<i>U_ppm</i>	1.38	0.62
<i>V_ppm</i>	26	36.00
<i>Y_ppm</i>	2.7	2.81
<i>Zn_ppm</i>	6	7.00

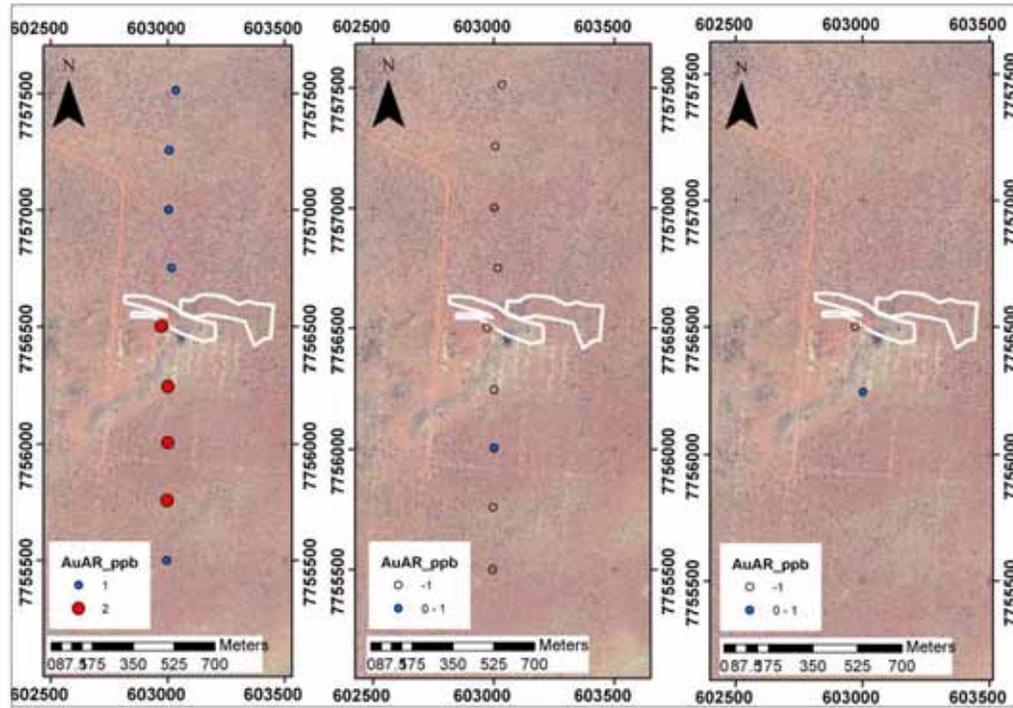


Figure 4.84 Elemental concentrations of Au within soils at Titania prospect, NT. in: L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 ( $1\text{mm}$  to  $75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1\text{mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

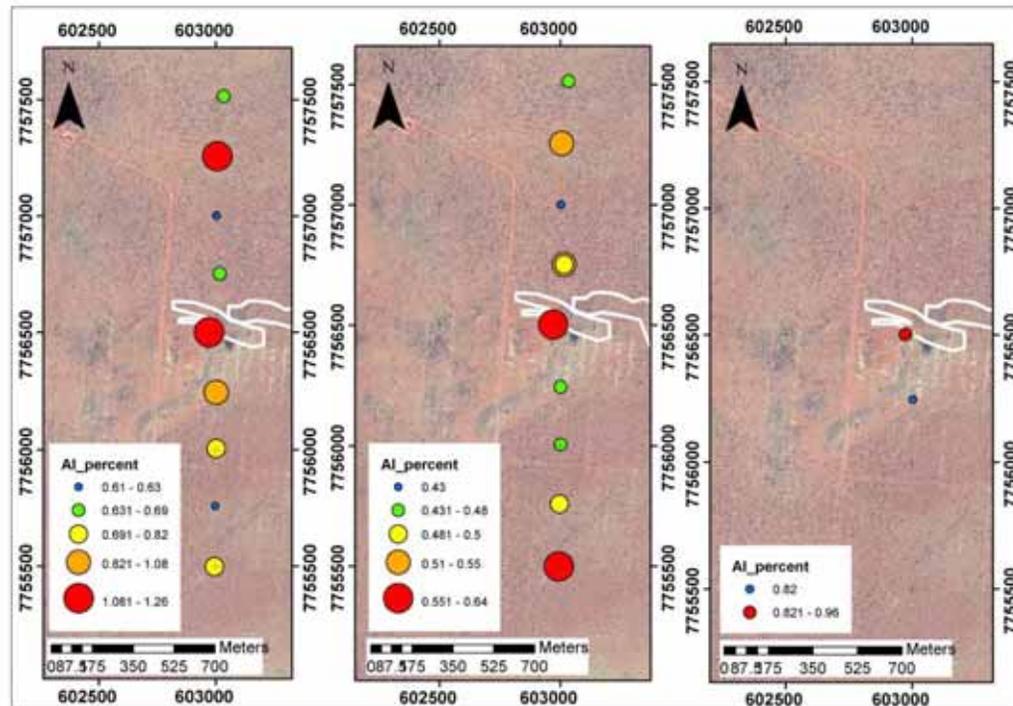


Figure 4.85 Elemental concentrations of Al within soils at Titania Prospect, NT in L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 ( $1\text{mm}$  to  $75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1\text{mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

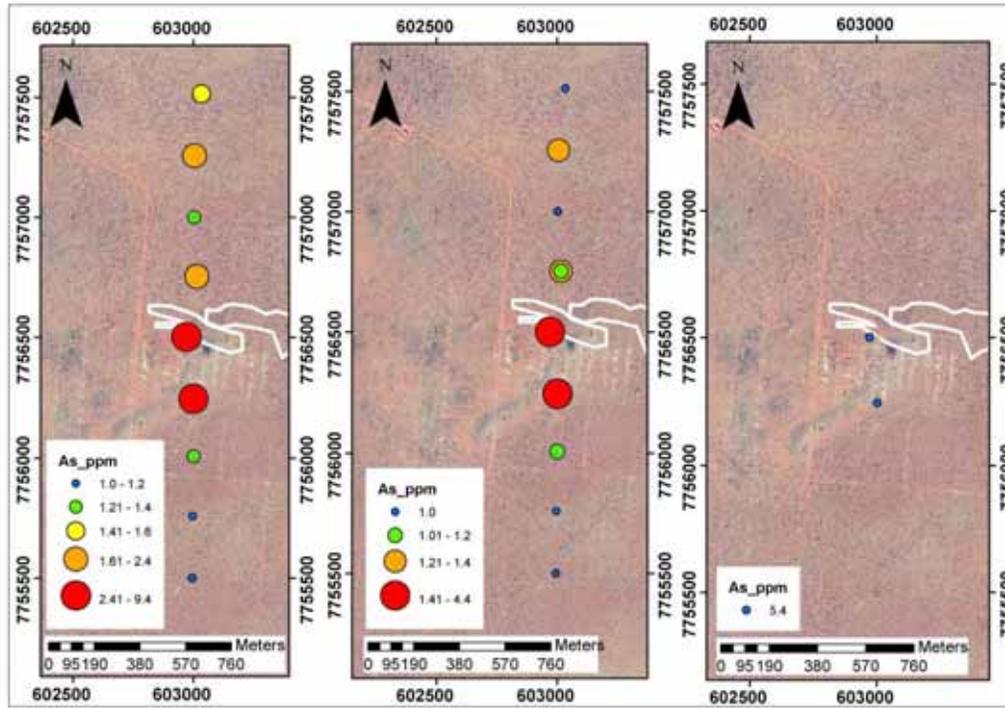


Figure 4.86 Elemental concentrations of As in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1mm to 75 μm); and R (Right) Fraction 3 (> 1mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

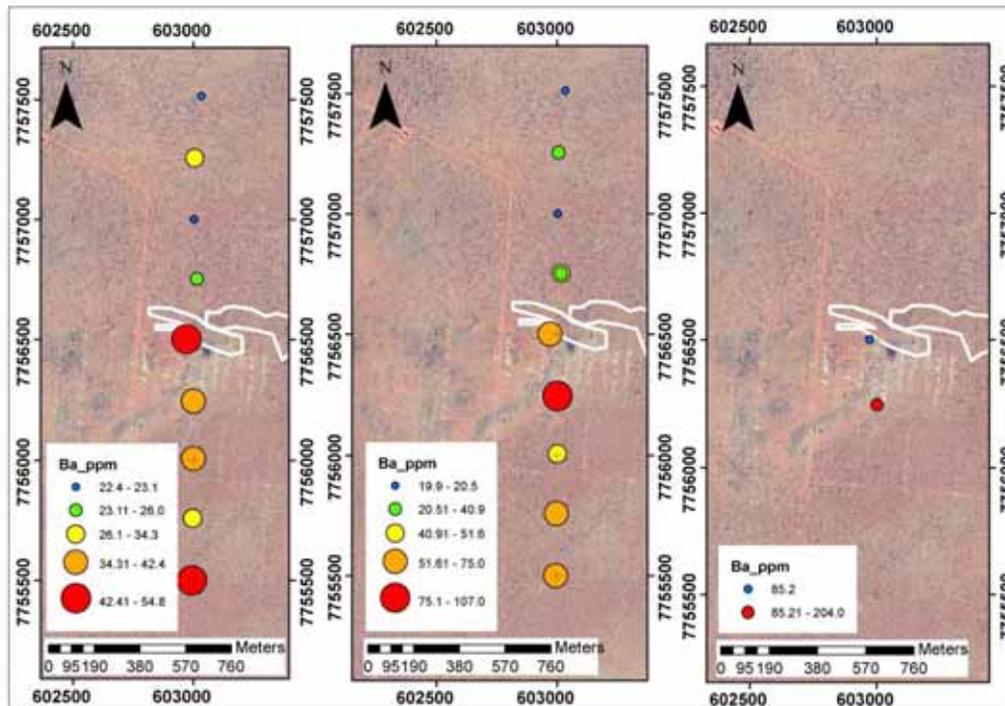


Figure 4.87 Elemental concentrations of Ba within soils at Titania Prospect, NT in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1mm to 75 μm); and R (Right) Fraction 3 (> 1mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

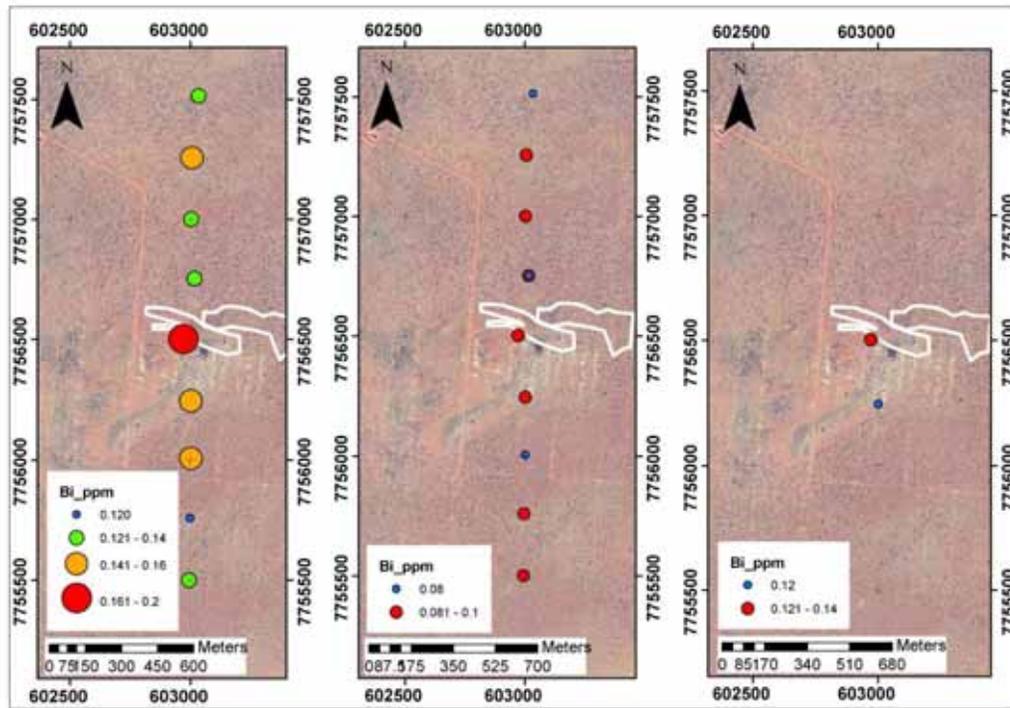


Figure 4.88 Elemental concentrations of Bi in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

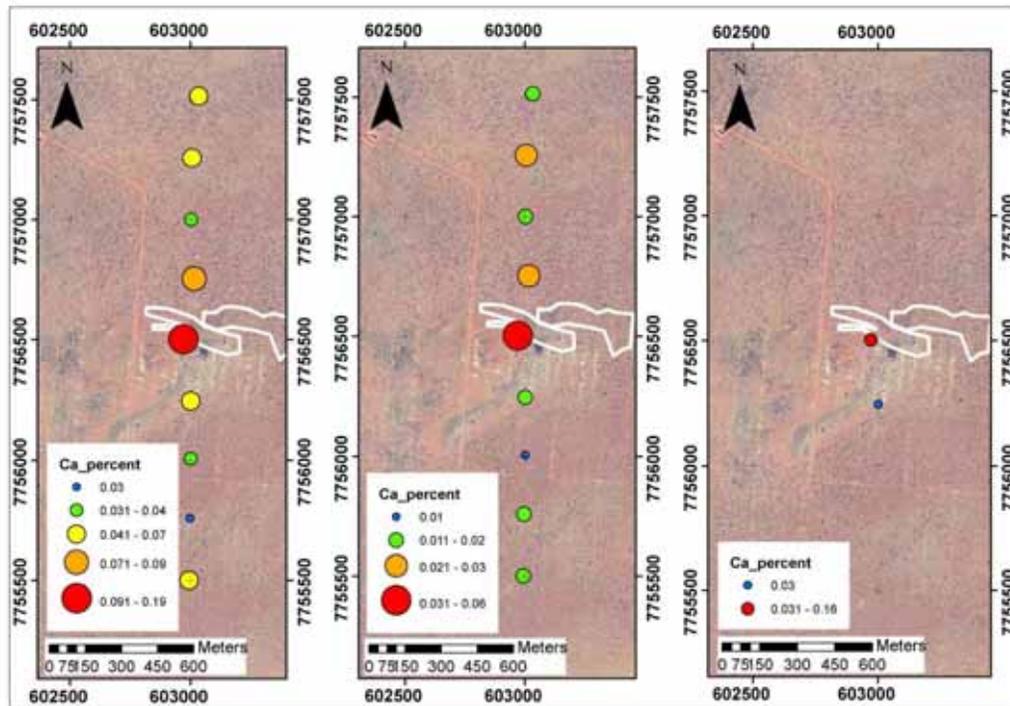


Figure 4.89 Elemental concentrations of Ca in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

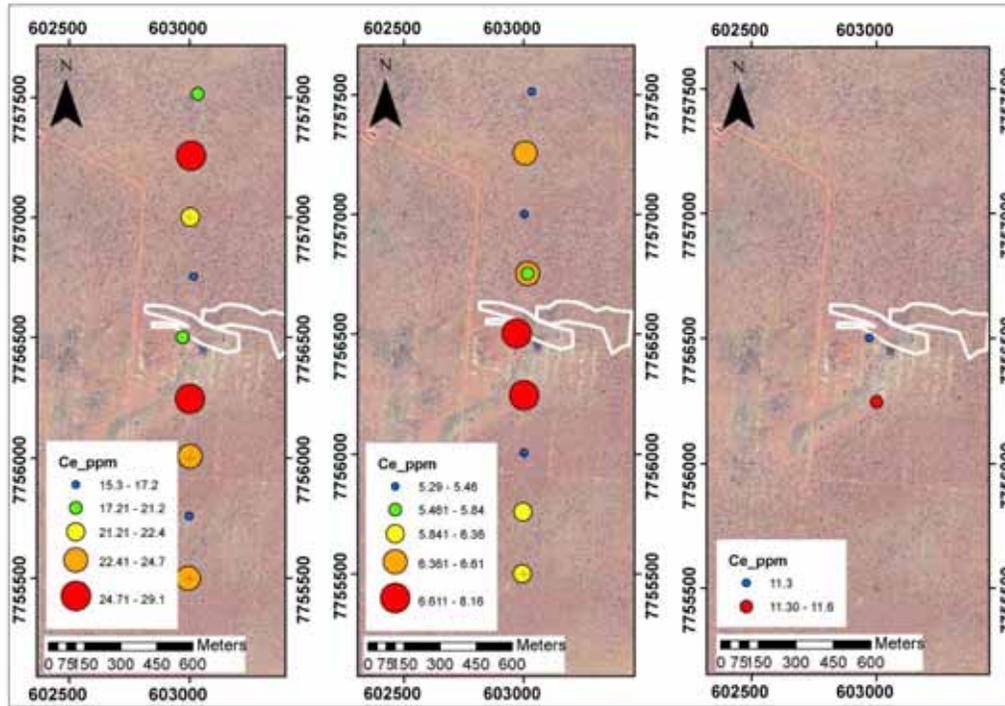


Figure 4.90 Elemental concentrations of Ce in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

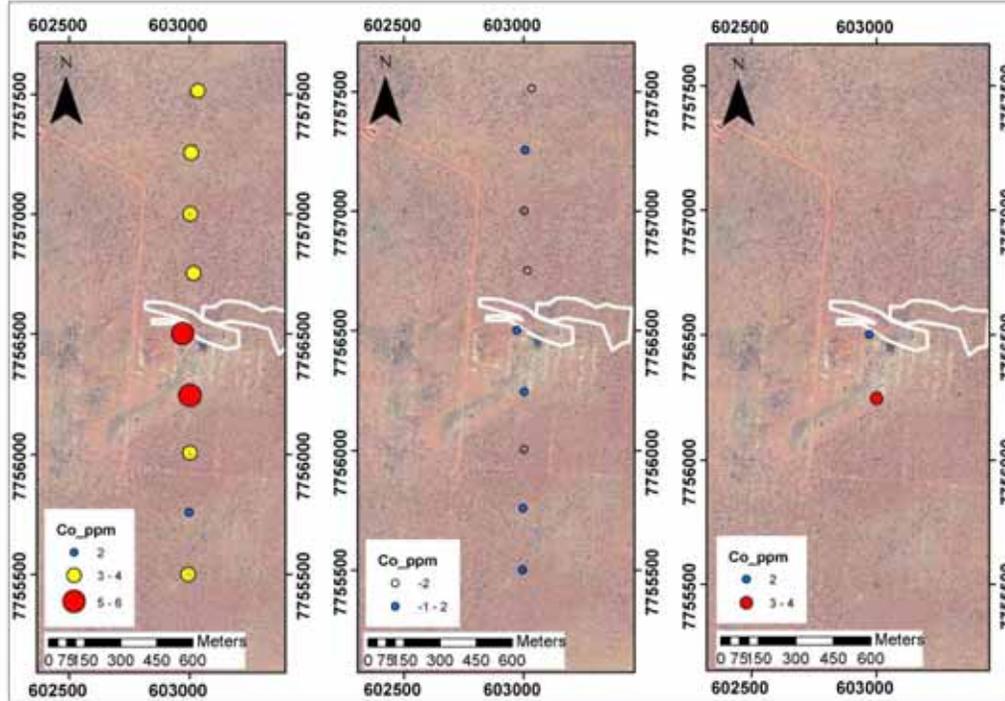


Figure 4.91 Elemental concentrations of Co in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

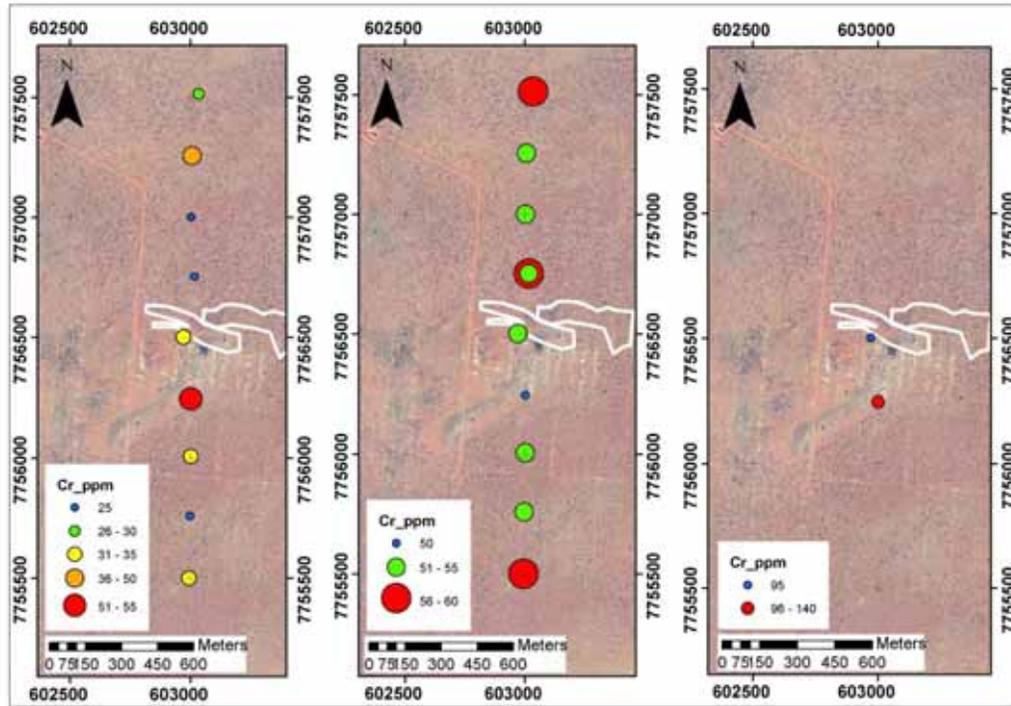


Figure 4.92 Elemental concentrations of Cr in L (Left) Fraction 1 (<0.075mm); M (Middle) Fraction 2 (1 mm to 0.075 mm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

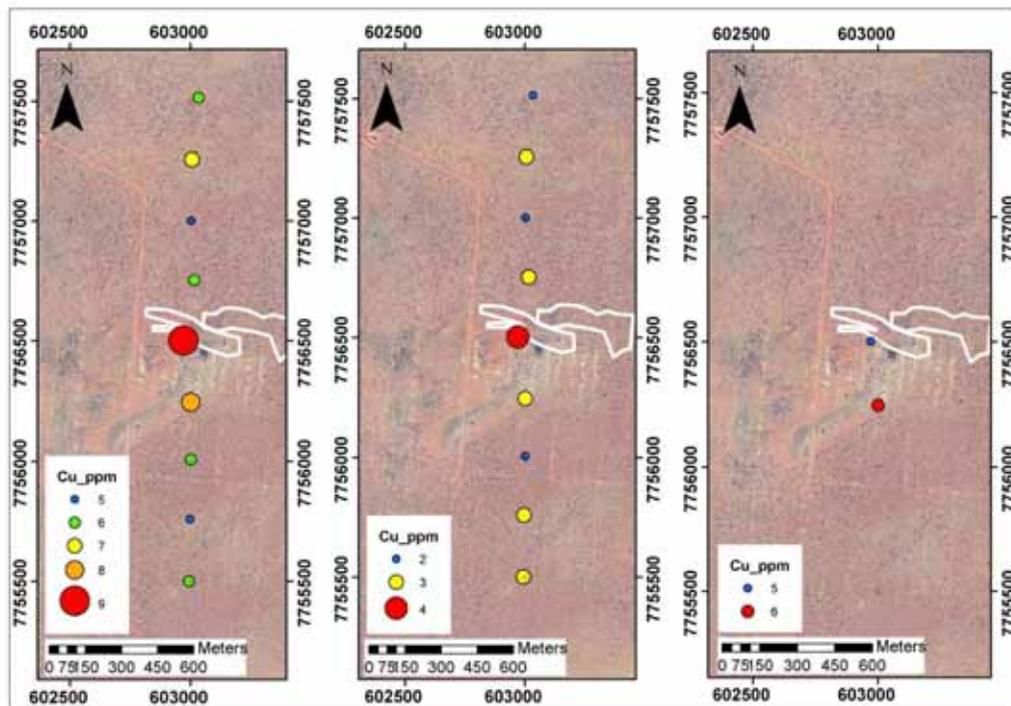


Figure 4.93 Elemental concentrations of Cu in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

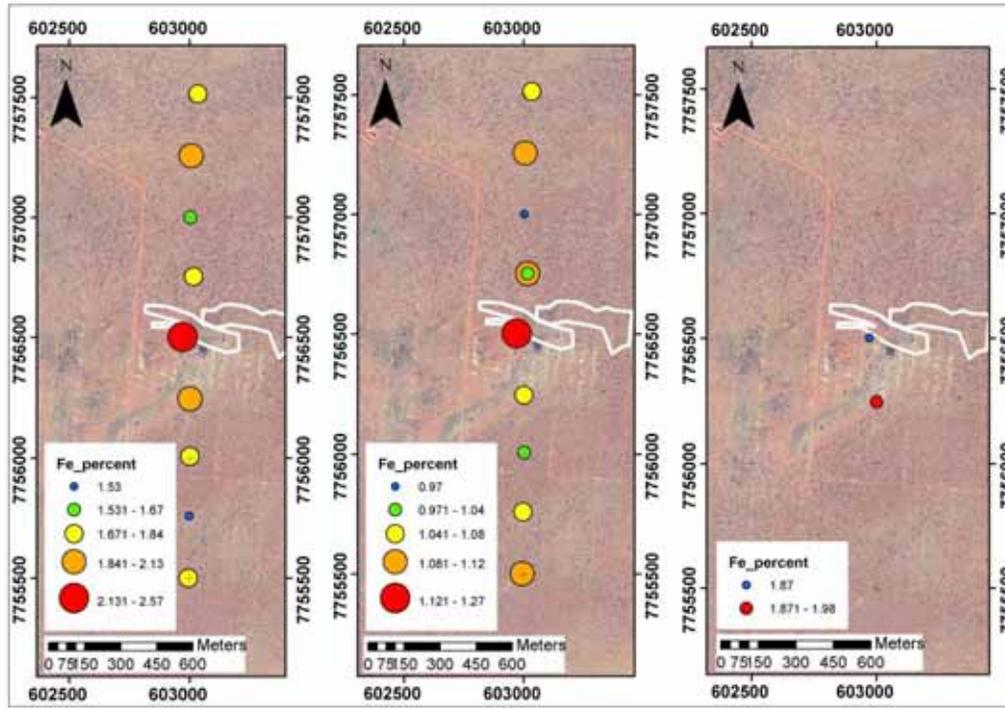


Figure 4.94 Elemental concentrations of Fe in L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 ( $1 \text{ mm to } 75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1 \text{ mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

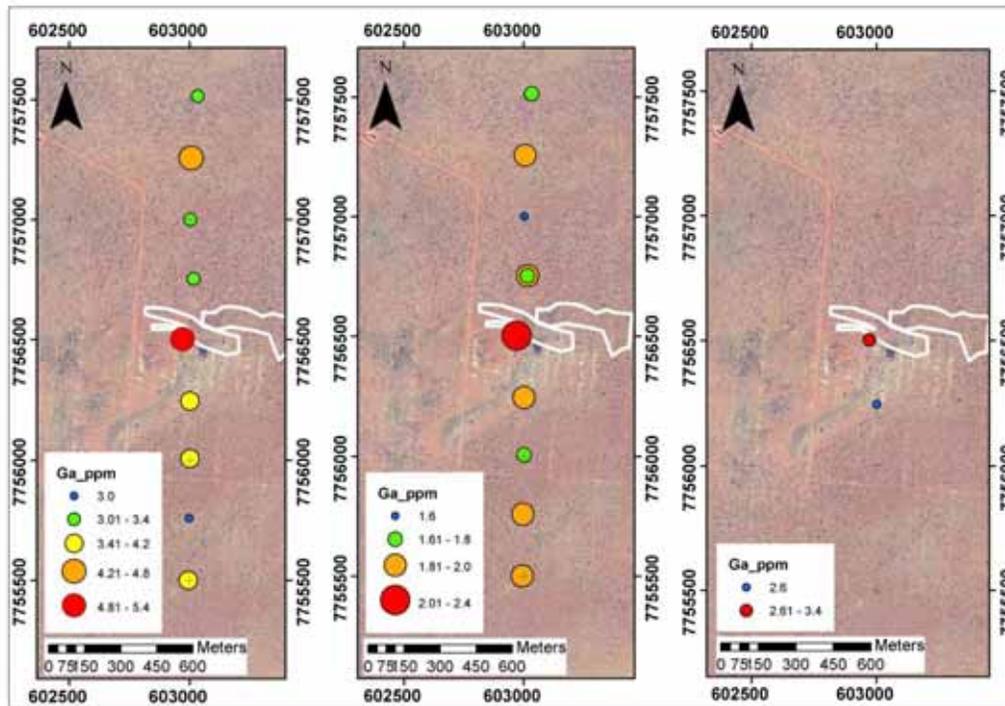


Figure 4.95 Elemental concentrations of Ga in L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 ( $1 \text{ mm to } 75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1 \text{ mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

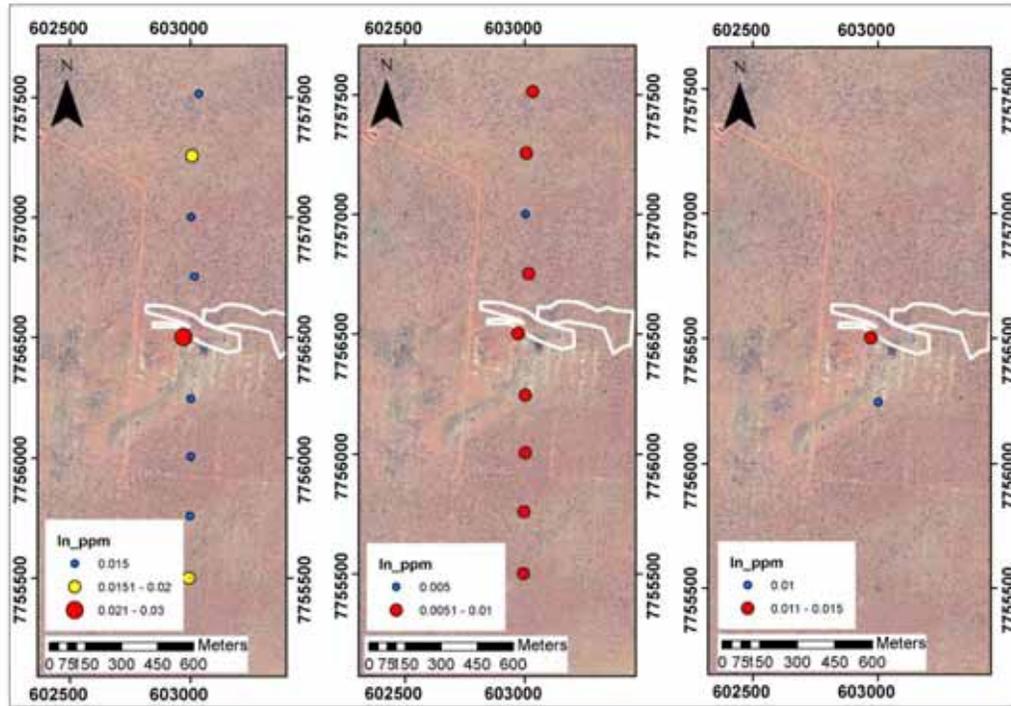


Figure 4.96 Elemental concentrations of In within soils at Titania Prospect, NT in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

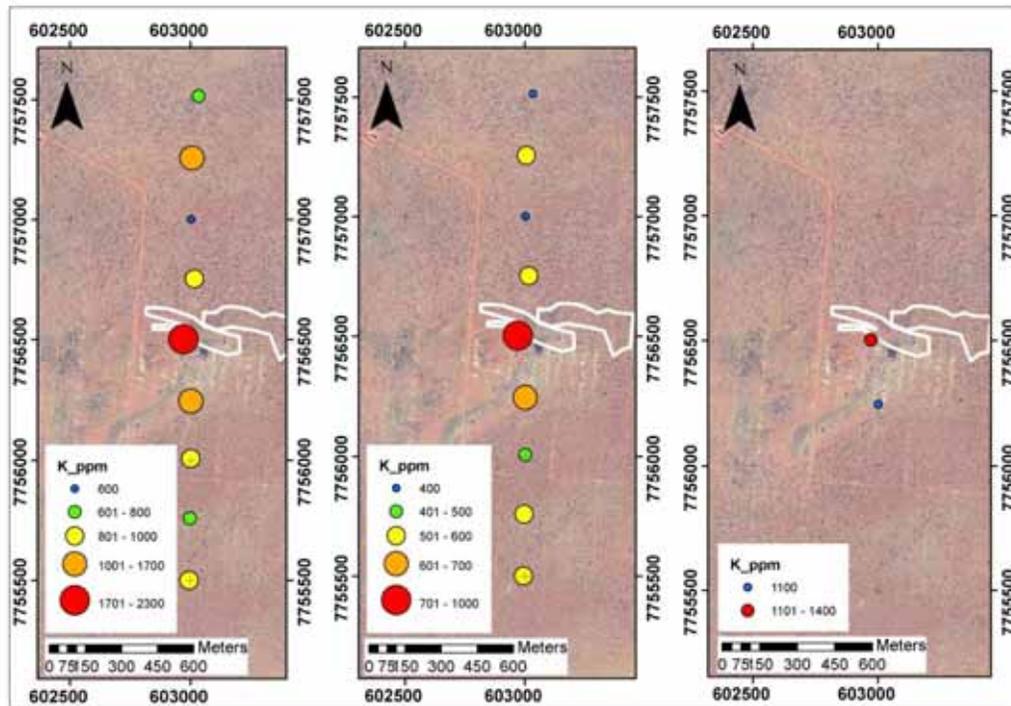


Figure 4.97 Concentrations of K in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

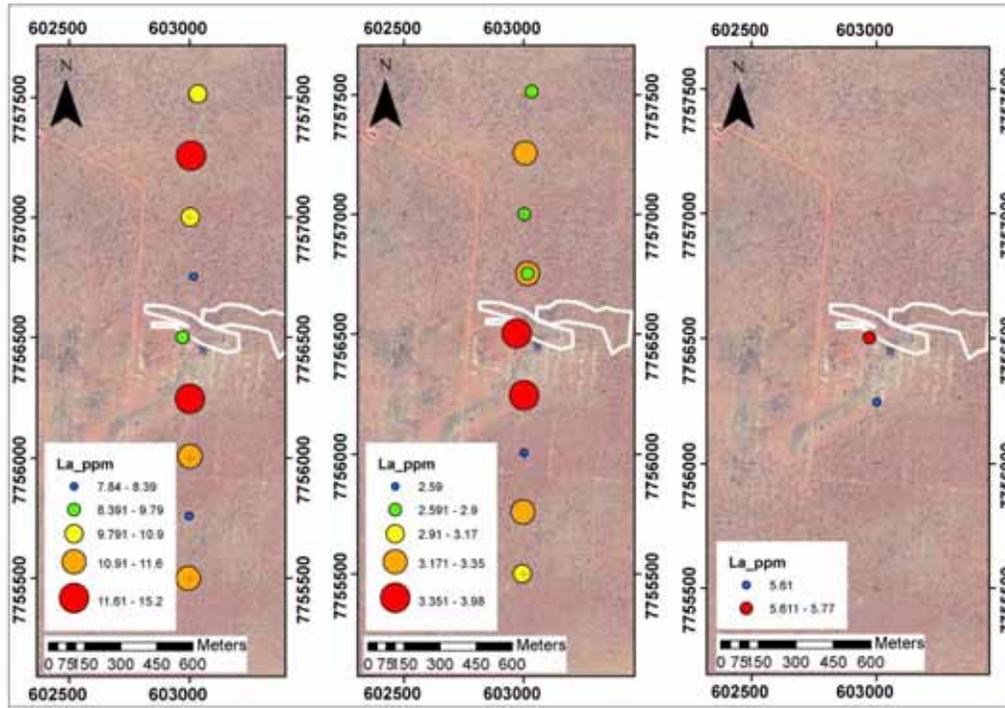


Figure 4.98 Elemental concentrations of La in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

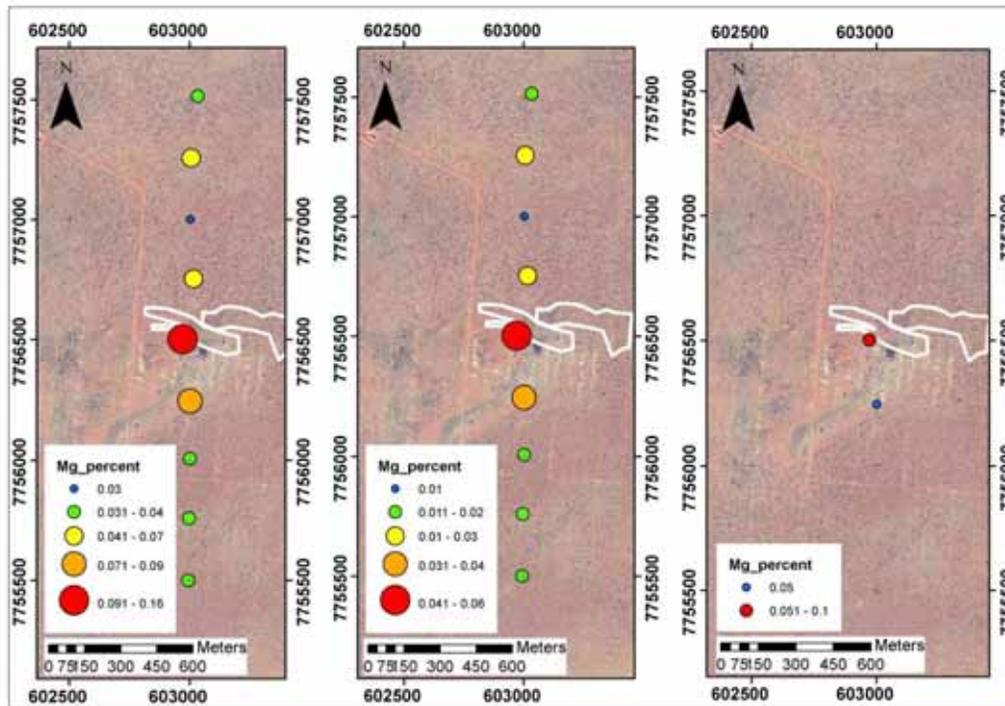


Figure 4.99 Elemental concentrations of Mg within soils at Titania Prospect, NT in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm); n(F1)=9, n(F2)=9, and n(F3)=2

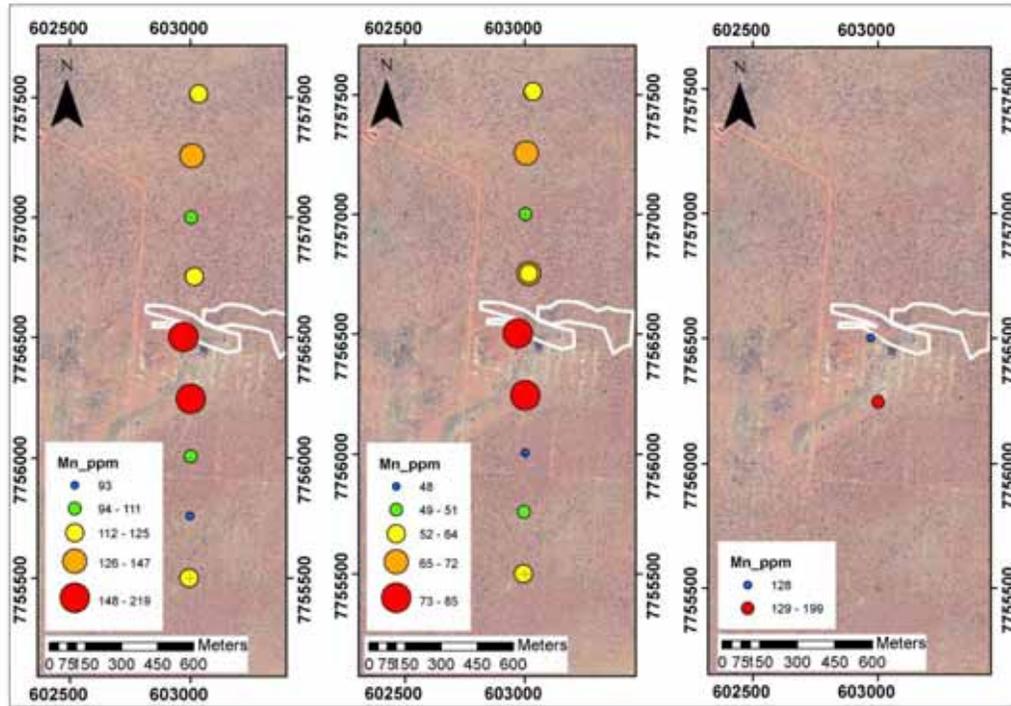


Figure 4.100 Elemental concentrations of Mn in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

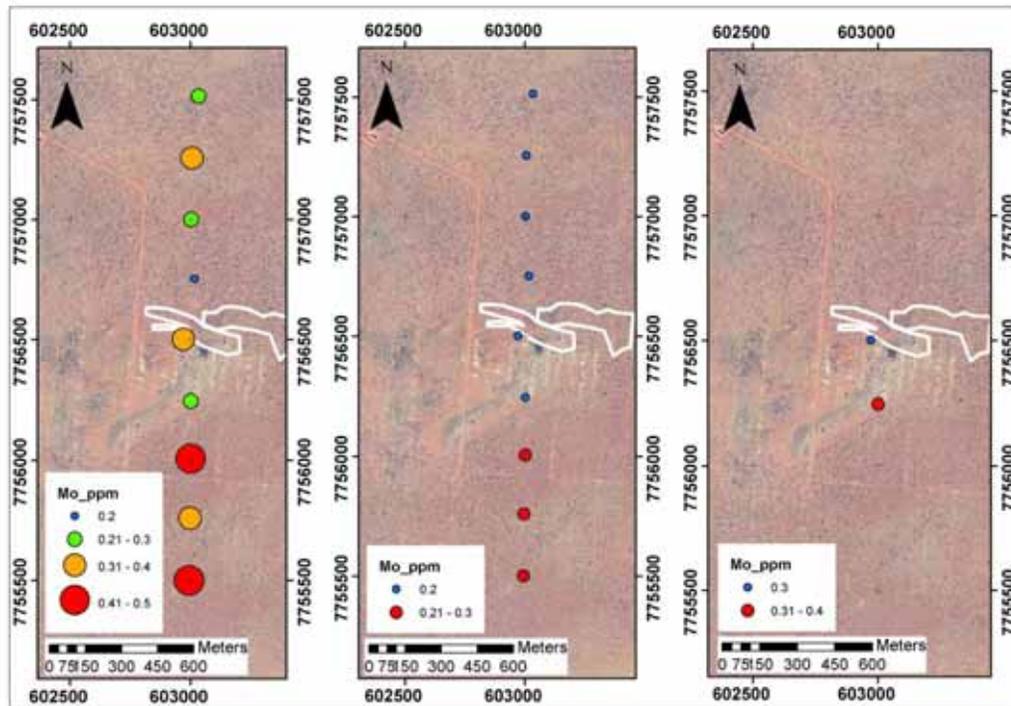


Figure 4.101 Elemental concentrations of Mo in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

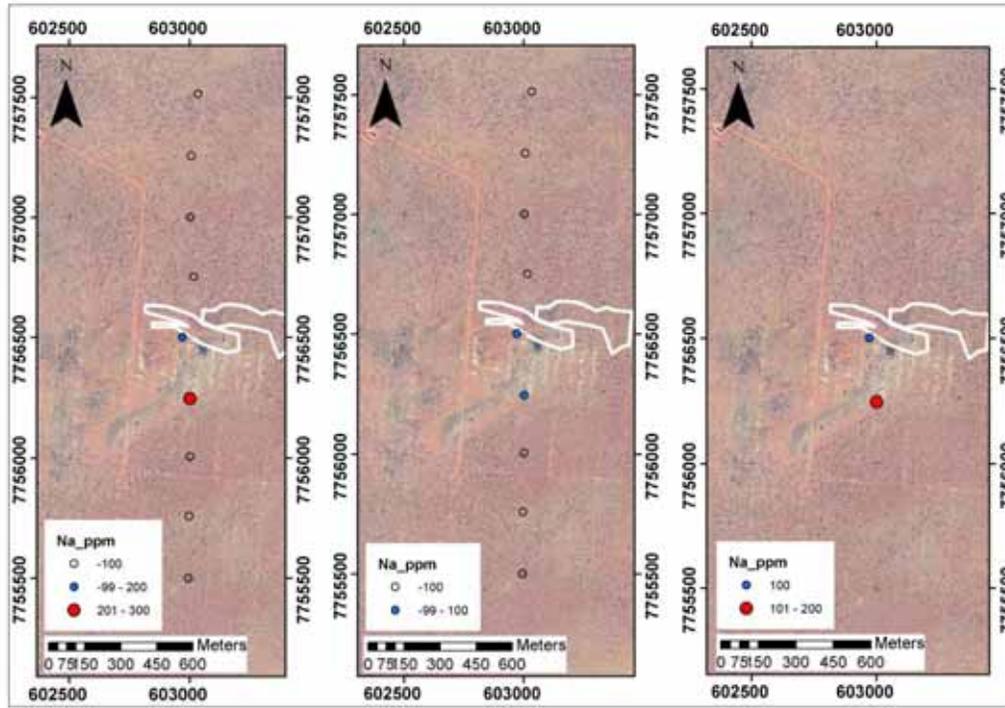


Figure 4.102 Elemental concentrations of Na in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

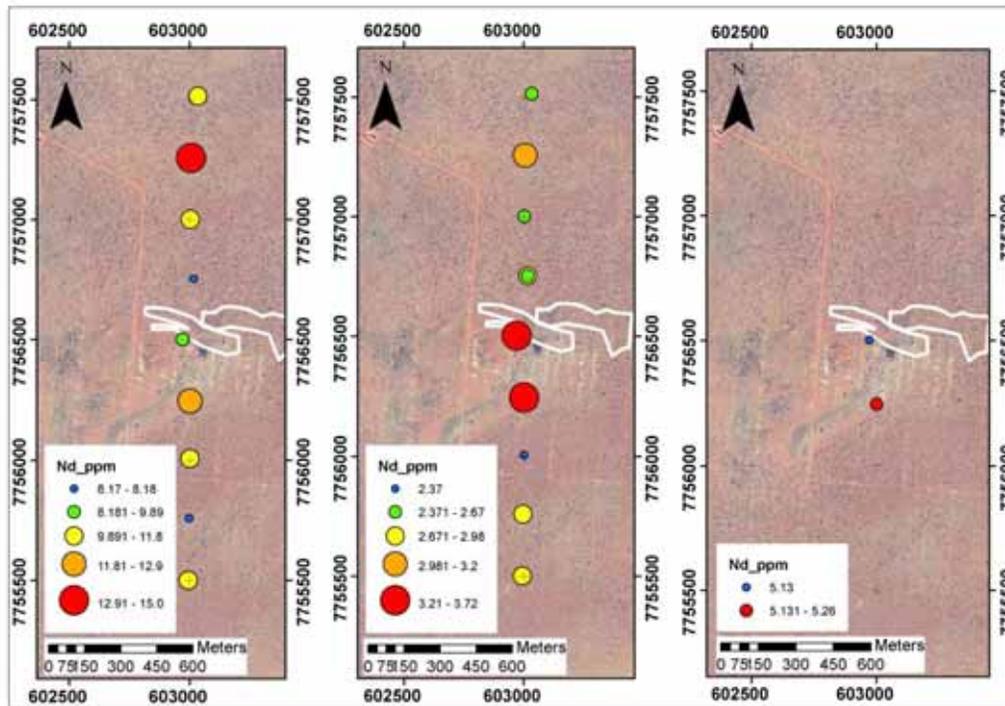


Figure 4.103 Elemental concentrations of Nd in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

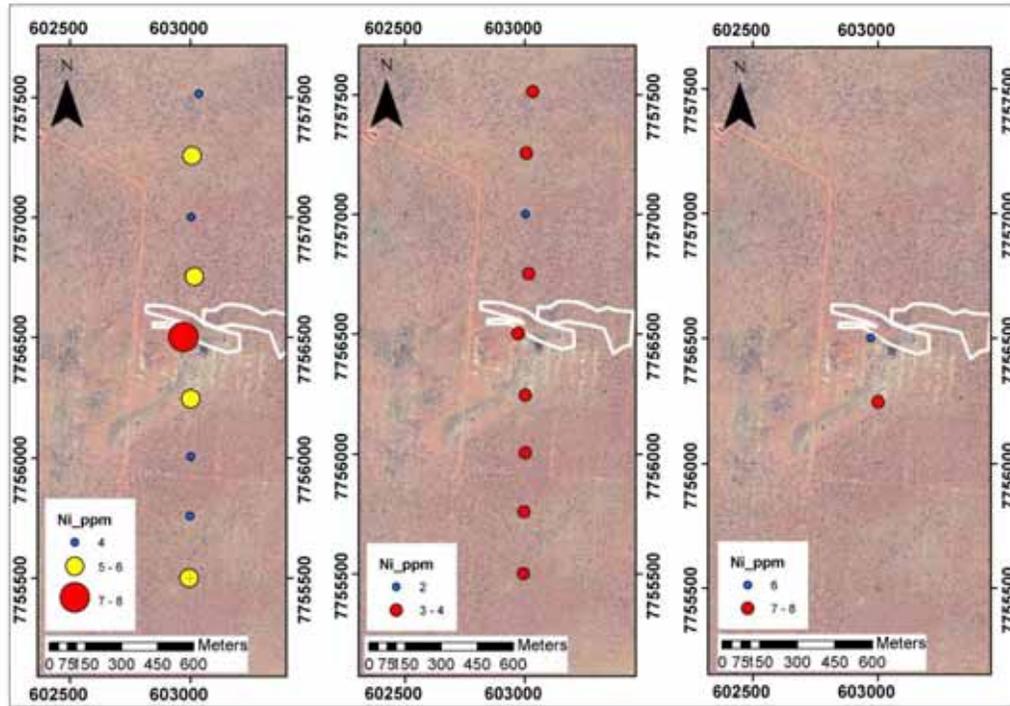


Figure 4.104 Elemental concentrations of Ni in L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 (1 mm to  $75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1 \text{mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

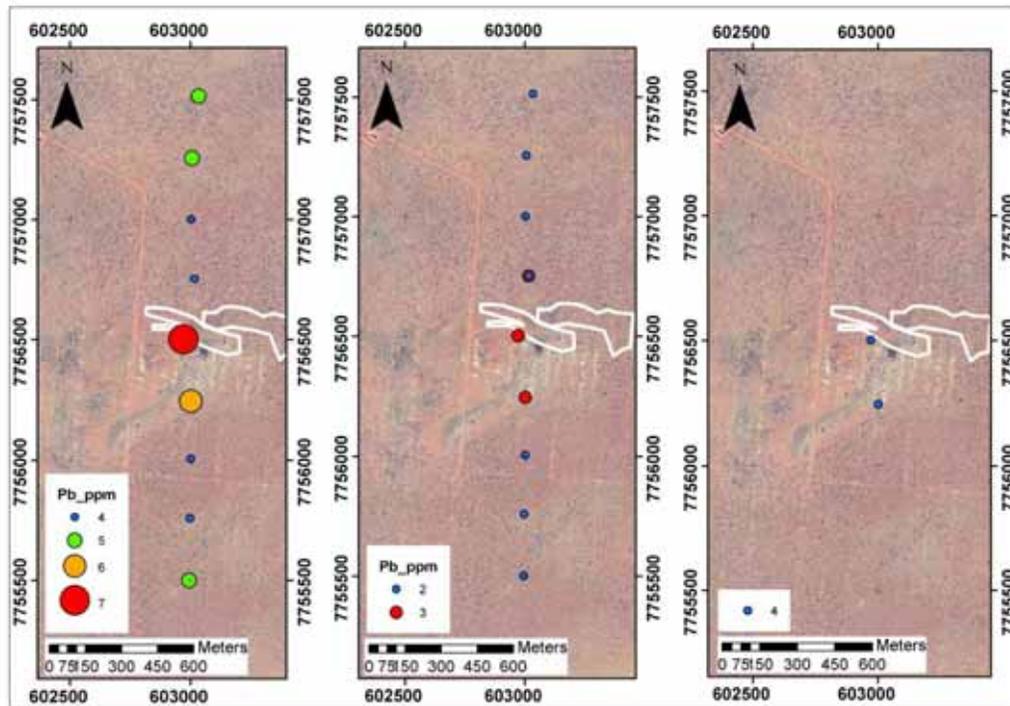


Figure 4.105 Elemental concentrations of Pb within soils at Titania Prospect, NT in L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 (1 mm to  $75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1 \text{mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

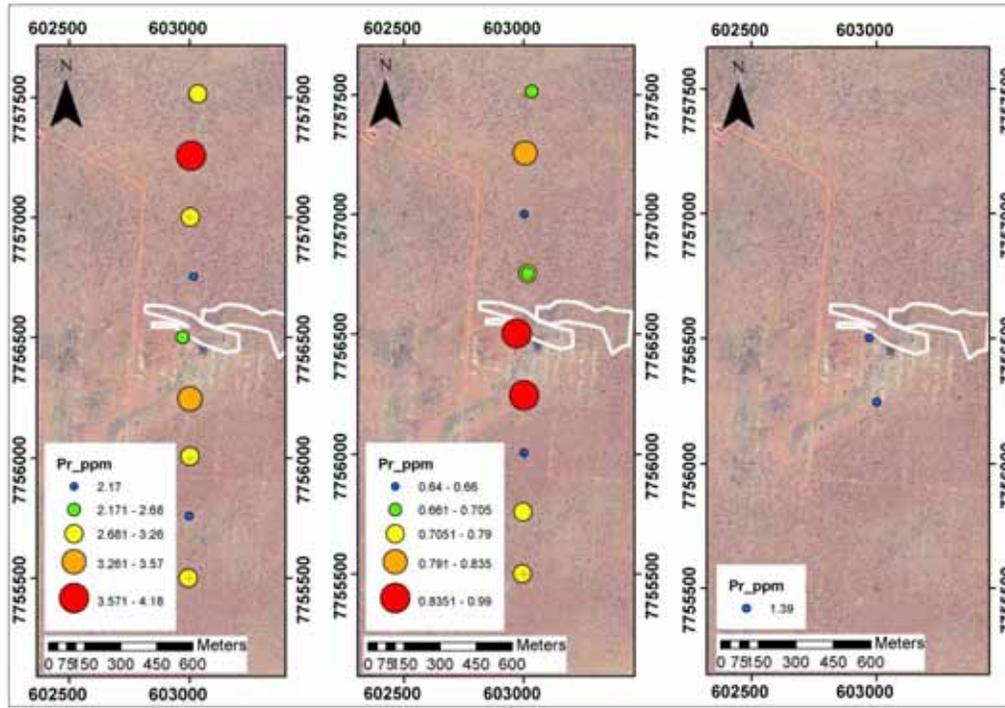


Figure 4.106 Elemental concentrations of Pr in L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 (1 mm to  $75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1 \text{mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

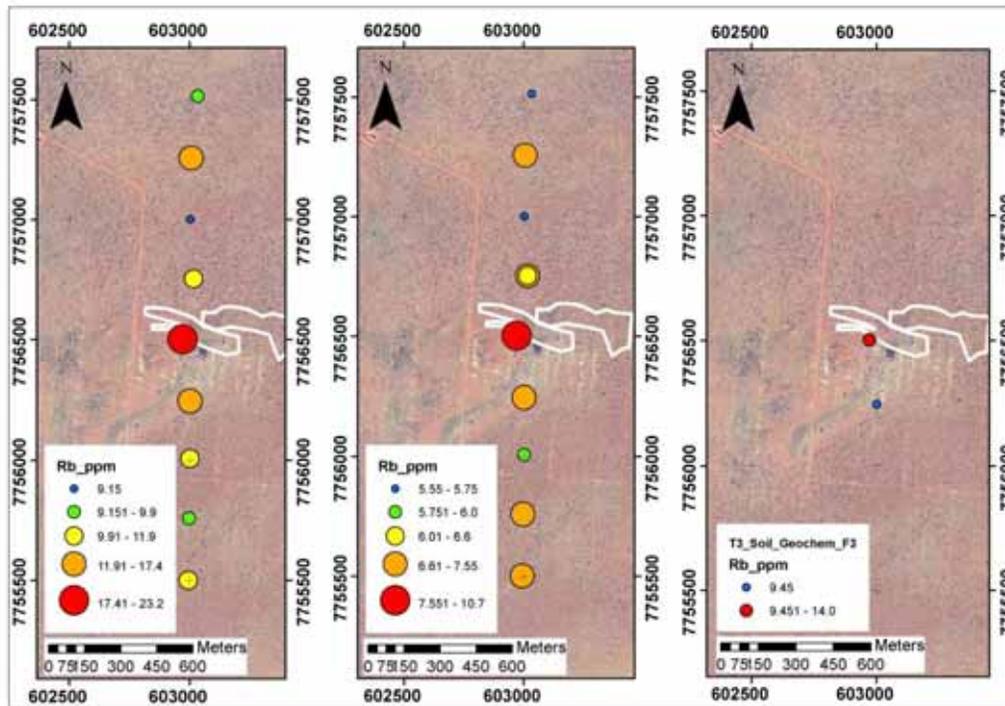


Figure 4.107 Elemental concentrations of Rb in L (Left) Fraction 1 ( $< 75 \mu\text{m}$ ); M (Middle) Fraction 2 (1 mm to  $75 \mu\text{m}$ ); and R (Right) Fraction 3 ( $> 1 \text{mm}$ ) within soils at Titania Au-prospect, NT;  $n(\text{F1})=9$ ,  $n(\text{F2})=9$ , and  $n(\text{F3})=2$

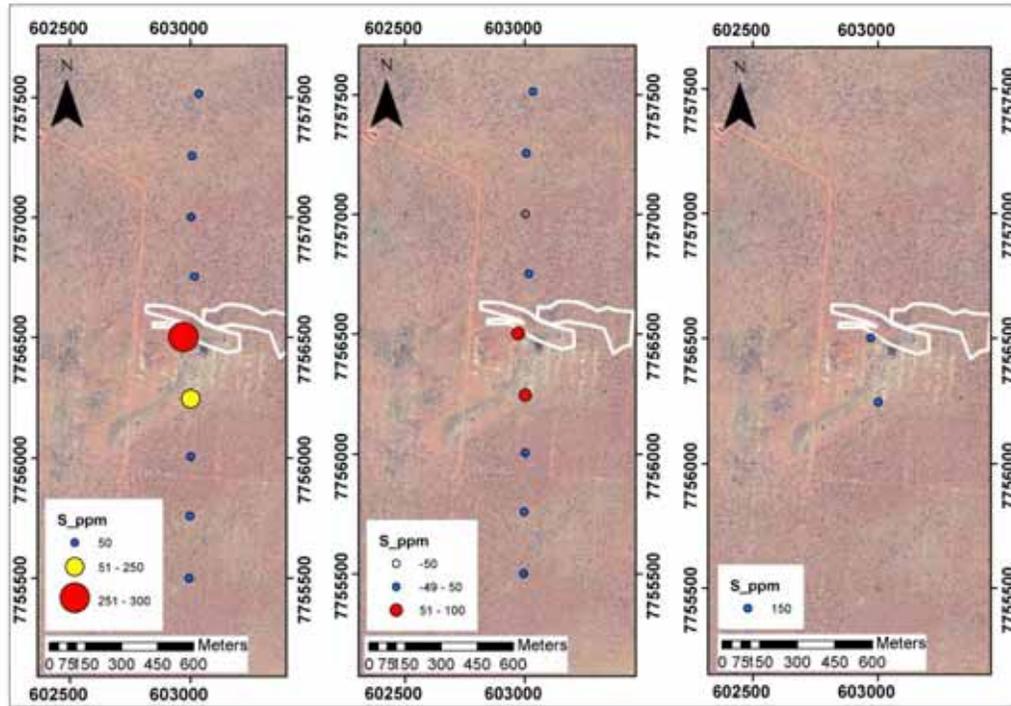


Figure 4.108 Elemental concentrations of S in L (Left) Fraction 1 (< 75  $\mu\text{m}$ ); M (Middle) Fraction 2 (1 mm to 75  $\mu\text{m}$ ); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

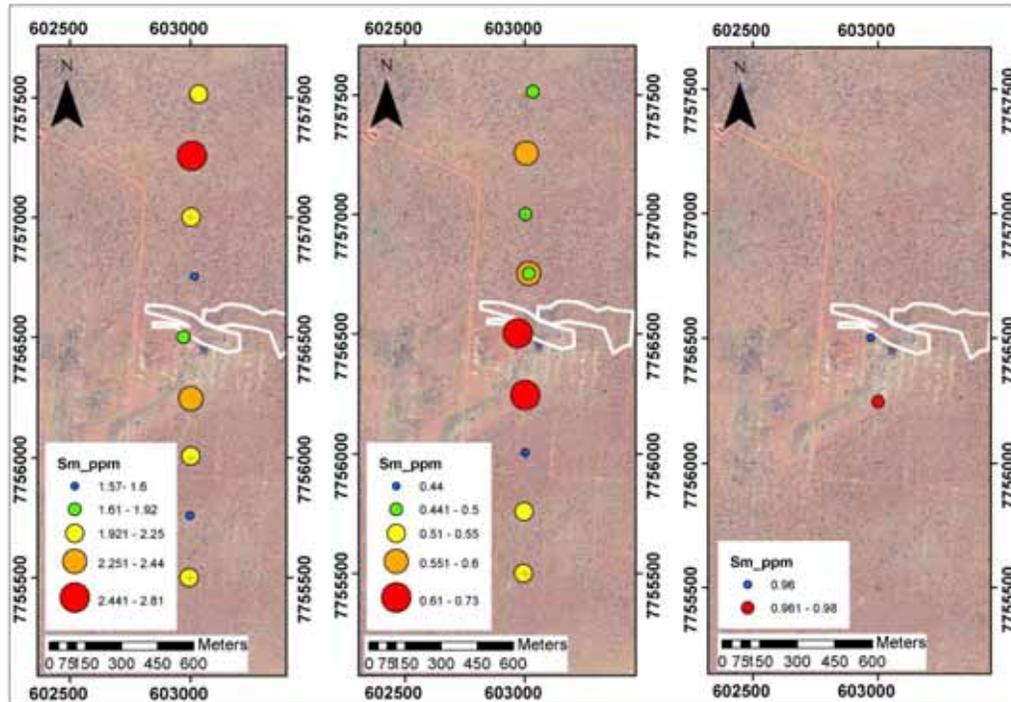


Figure 4.109 Elemental concentrations of Sm in L (Left) Fraction 1 (< 75  $\mu\text{m}$ ); M (Middle) Fraction 2 (1 mm to 75  $\mu\text{m}$ ); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

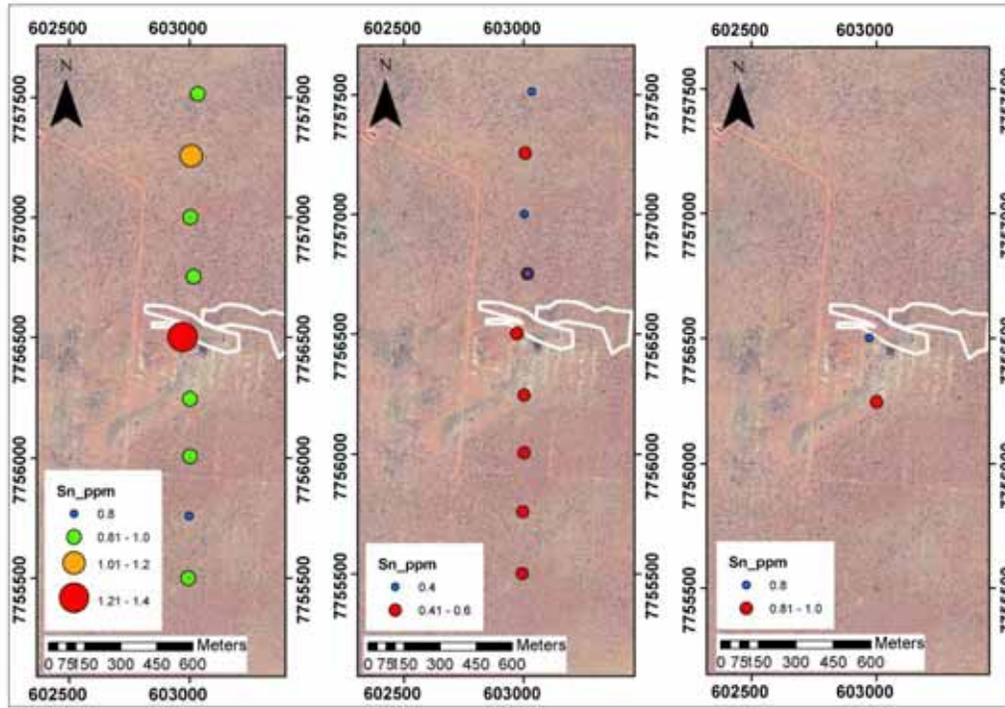


Figure 4.110 Elemental concentrations of Sn in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

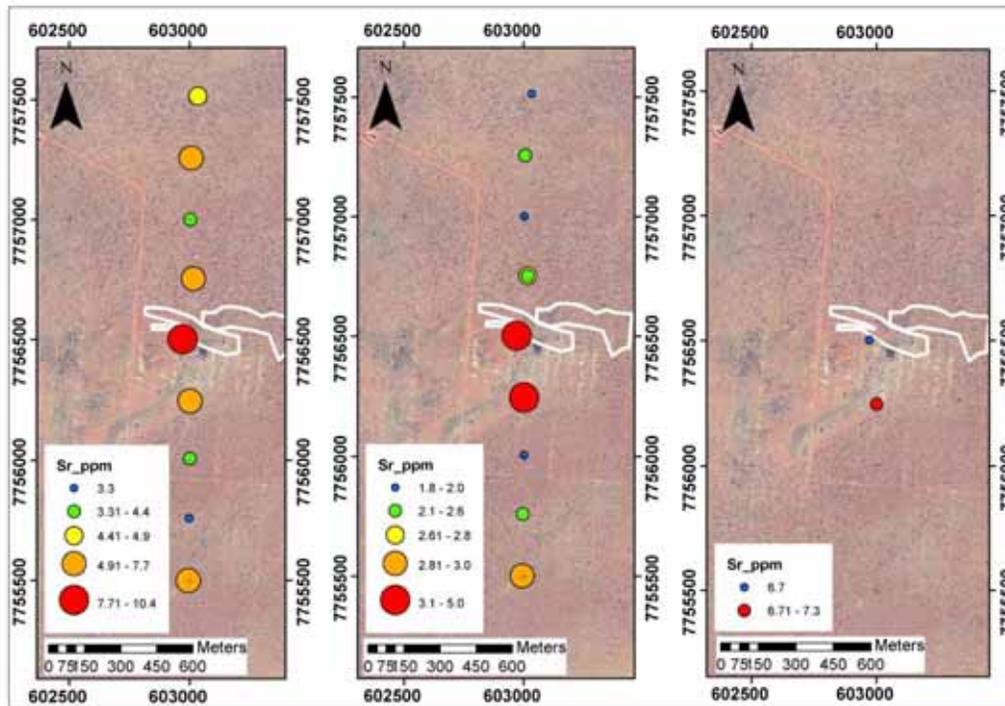


Figure 4.111 Elemental concentrations of Sr in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

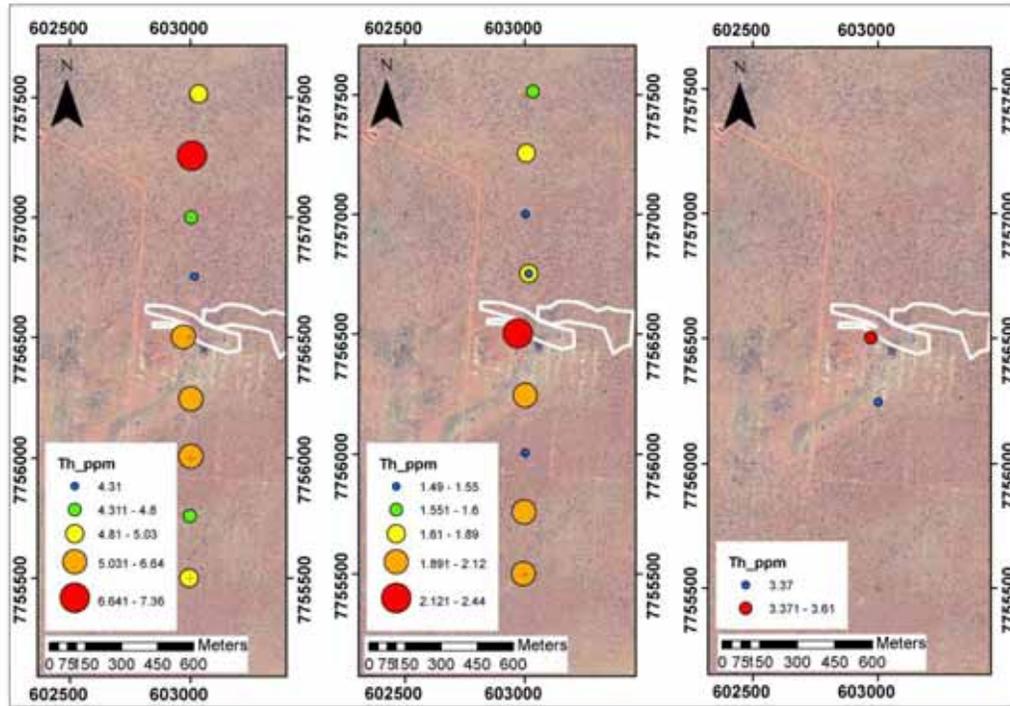


Figure 4.112 Elemental concentrations of Th in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

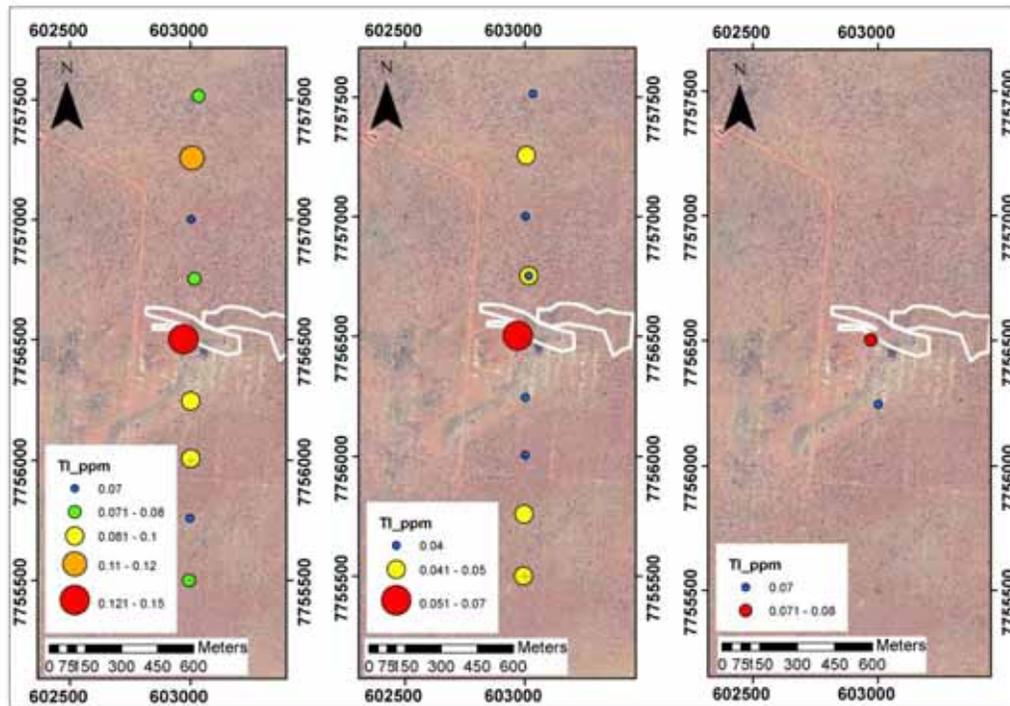


Figure 4.113 Elemental concentrations of Tl in L (Left) Fraction 1 (< 75 μm); M (Middle) Fraction 2 (1 mm to 75 μm); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

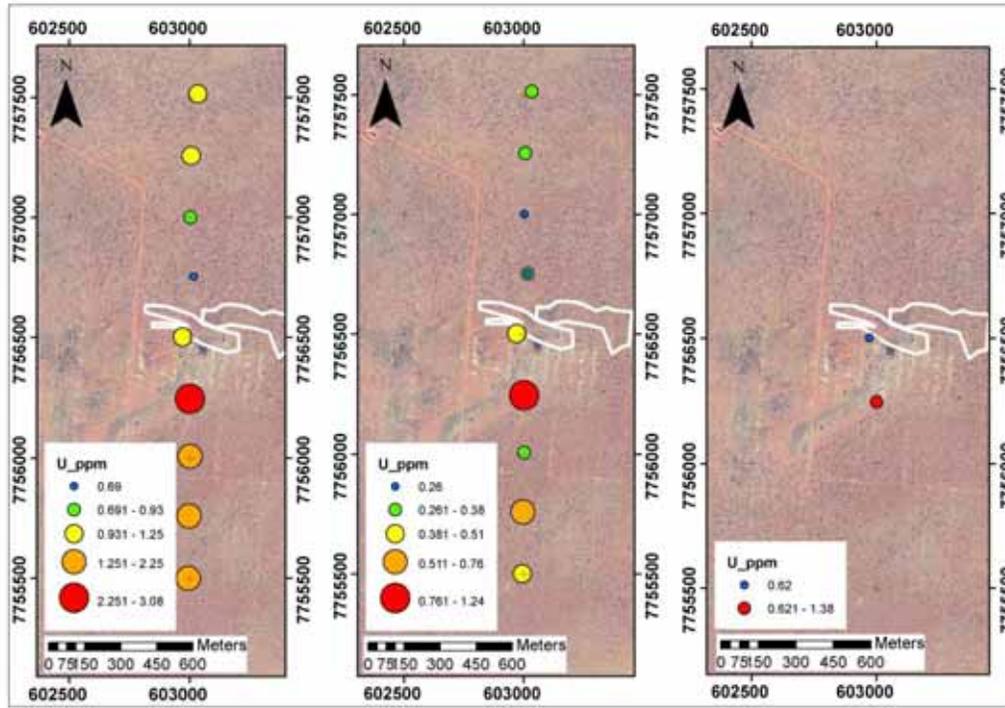


Figure 4.114 Elemental concentrations of U within soils at Titania Prospect, NT in L (Left) Fraction 1 (< 75  $\mu$ m); M (Middle) Fraction 2 (1 mm to 75  $\mu$ m); and R (Right) Fraction 3 (> 1 mm) within soils at Titania Au-prospect, NT; n(F1)=9, n(F2)=9, and n(F3)=2

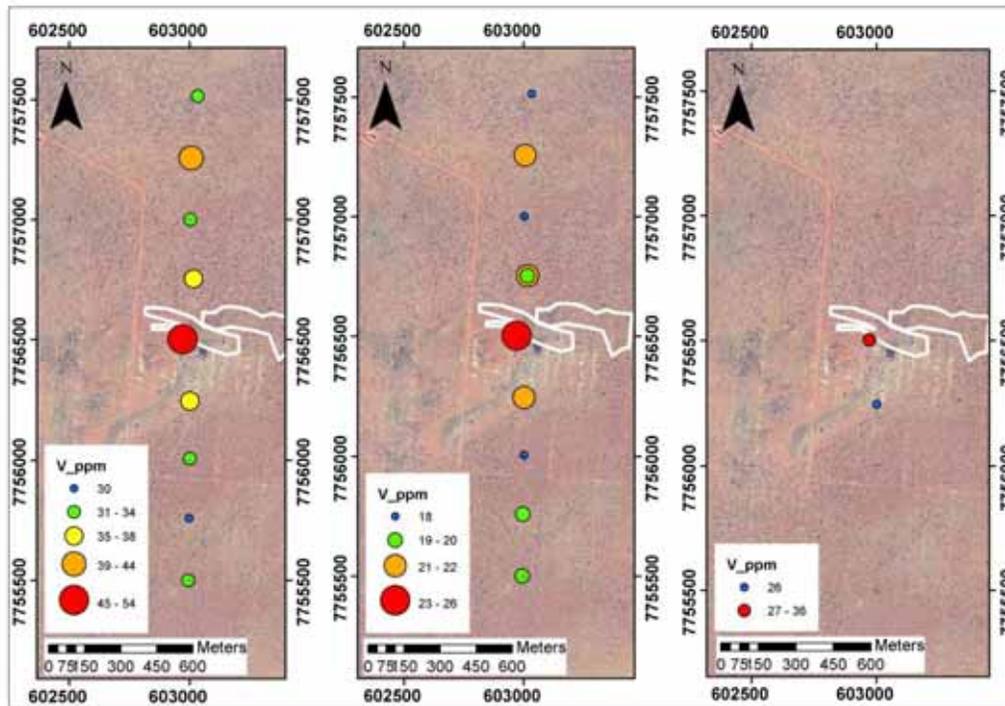


Figure 4.115 Elemental concentrations of V within soils at Titania Prospect, NT in L (Left) Fraction 1 (< 75  $\mu$ m); M (Middle) Fraction 2 (1 mm to 75  $\mu$ m); and R (Right) Fraction 3 (> 1 mm); n(F1)=9, n(F2)=9, and n(F3)=2

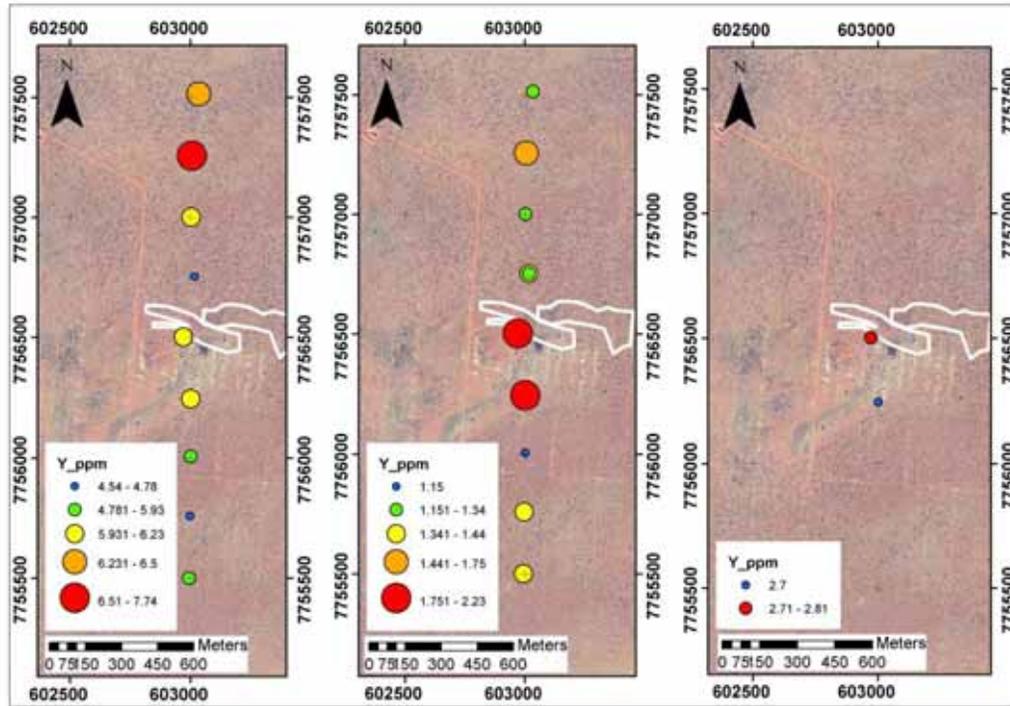


Figure 4.116 Elemental concentrations of Y within soils at Titania Prospect, NT; in L (Left) Fraction 1 (< 75  $\mu$ m); M (Middle) Fraction 2 (1 mm to 75  $\mu$ m); and R (Right) Fraction 3 (> 1 mm); n(F1)=9, n(F2)=9, and n(F3)=2

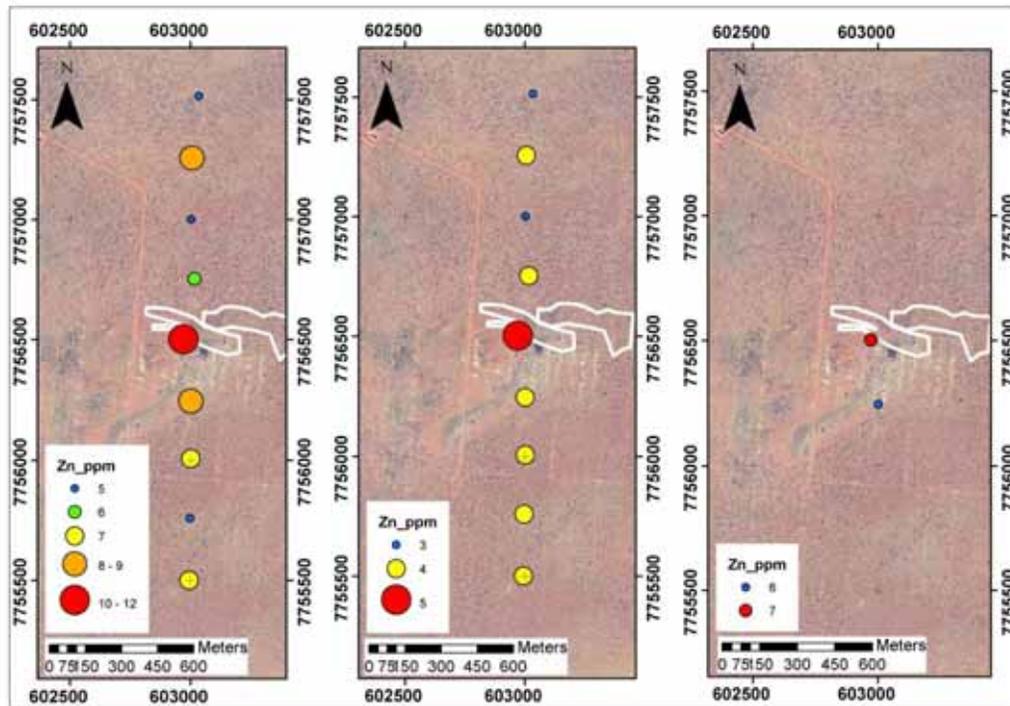


Figure 4.117 Elemental concentrations of Zn within soils at Titania Prospect, NT; in L (Left) Fraction 1 (< 75  $\mu$ m); M (Middle) Fraction 2 (1 mm to 75  $\mu$ m); and R (Right) Fraction 3 (> 1 mm); n(F1)=9, n(F2)=9, and n(F3)=2

### **Interpretation of Titania soil transect 3 results**

The number of soil samples limits the geochemical interpretation as compared to termitaria geochemistry. Specific soil samples from all three fractions contain elevated values of most of the analysed elements, over or adjacent to mineralisation. The higher Cr content in the soil fractions however, including up to four times more Cr in the Fraction 3 soil samples, may suggest a locally derived colluvial source of the coarser-grained sediments in the surrounding soil profile (such as a mafic intrusion). The maximum values for Au and Mo are offset from the surface projection of mineralisation, implying dispersion of these elements from the zone of mineralisation. The geochemical results for the soil samples, collected along Transect 3, suggest a trend for elements such as:

- centre of transect: As, Ba, Ca, Ce, Cu, Fe, Ga, In, K, La, Mg, Mn, Mo, Nd, Pb, Pr, Rb, S, Sm, Th, Tl, V, Zn
- southern half of the transect: Au, Mo, U.

From the 39 analytes listed in the table, almost all of the concentrations are higher in the Fraction 1 samples, than for Fraction 2. This suggests that the Fraction 1 samples have more iron, and therefore may be best able to host trace elements. For example, Cu and other elements are proportional to Fe content. The elements Au, In, Mo, Pb, and Tl share similar maximum values, for both Fraction 2 and Fraction 3 samples.

### **Interpretation of Transect 3 soil and termitaria geochemistry results**

The soil samples were collected to compare the background chemistry with the termitaria geochemistry and both Transect 3 termitaria and soil results for all three fractions are presented in Table 4.23 for interpretation. Within all three fractions, the termitaria sample results had much higher maximum concentrations (twice to three times as much concentration, for some elements) than the soil results. Within the Fraction 1 soil and termitaria data, only the elements Ag, Ba and Cr were elevated within the soil samples; for the Fraction 2 results only Cr is elevated within the soil results, compared to the termitaria data, and for the Fraction 3 soil results only the elements Cr, Mn, and Pr contained higher maximum values than the termitaria results. There is some variation in the distribution of elements along the sampling transect within each grain-size fraction (which has been discussed in the results section). This may be summarised as shown:

- Fraction 1: highest concentration of the elements Al, Au, As, Bi, Ca, Ce, Co, Cu, Fe, Ga, In, K, La, Mg, Mn, Mo, Na, Nd, Pb, Pr, Rb, S, Sm, Sn, Sr, Tl, U, V, Y, Zn
- Fraction 3: highest for Ba, Cr, Th
- Fraction 1 and Fraction 2 results for Ni are equal in value.

The termitaria fraction geochemistry for Transect 3 also exhibits some general trends, such as:

- Fraction 1: elevated for Al, Au, As, and Ca
- Fraction 3: higher Ba and Cr
- Fraction 2: Mo is elevated.

The elements Ba, Bi, In, La, Mo, Pb, Pr and Sn, despite being of higher concentration in the termitaria samples, are still within comparable range between the two sampling media. These elements are commonly hosted in iron oxide minerals, and suggest that there is still some surficial material incorporated into the mounds by the termites. Generally, the elevated concentration of most of the analytes, especially Au, in all three of the grain-size fractions within the termitaria samples, supports the argument that termites accommodate the subsurface regolith profile and host this in their mounds.

**Table 4.23 Comparative study of Transect 3 soil and termitaria geochemical results. The elements Cd, Pd, Pt and Te contained concentrations below their respective detection limits; n(F1soil)=9, n(F2soil)=9, n(F3)=2 and n(AllTermitaria)=9)**

Soil				Termitaria			
elements	F1 Max	F2 Max	F3 Max	elements	F1 Max	F2 Max	F3 Max
<i>Ag_ppm</i>	na	-0.05	na	<i>Au(AR) ppb</i>	10	5	4
<i>Al_percent</i>	1.26	0.64	0.96	<i>Ag ppm</i>	na	na	na
<i>As_ppm</i>	9.4	1.4	5.4	<i>Al %</i>	1.95	1.39	1.24
<i>AuAR_ppb</i>	2	1	1	<i>As ppm</i>	20.6	4.4	10
<i>Ba_ppm</i>	54.8	75	204	<i>Ba ppm</i>	139	108	243
<i>Bi_ppm</i>	0.2	0.1	0.14	<i>Bi ppm</i>	0.28	0.18	0.16
<i>Ca_percent</i>	0.19	0.06	0.16	<i>Ca %</i>	1.04	0.23	0.66
<i>Ce_ppm</i>	29.1	8.16	11.6	<i>Ce ppm</i>	36.7	14.1	15.5
<i>Co_ppm</i>	6	2	4	<i>Co ppm</i>	14	6	6
<i>Cr_ppm</i>	55	60	140	<i>Cr ppm</i>	35	30	45
<i>Cu_ppm</i>	9	4	6	<i>Cu ppm</i>	18	11	10
<i>Fe_percent</i>	2.57	1.27	1.98	<i>Fe %</i>	3.18	2.42	2.76
<i>Ga_ppm</i>	5.4	2.4	3.4	<i>Ga ppm</i>	8.4	6	4.6
<i>In_ppm</i>	0.03	0.01	0.015	<i>In ppm</i>	0.04	0.025	0.025
<i>K_ppm</i>	2300	1000	1400	<i>K ppm</i>	5600	3000	2800
<i>La_ppm</i>	15.2	3.98	5.77	<i>La ppm</i>	17.2	7.01	5.84
<i>Mg_percent</i>	0.16	0.06	0.1	<i>Mg ppm</i>	0.66	0.33	0.32
<i>Mn_ppm</i>	219	85	199	<i>Mn ppm</i>	323	224	198
<i>Mo_ppm</i>	0.5	0.3	0.4	<i>Mo ppm</i>	0.8	0.9	0.5
<i>Na_ppm</i>	300	100	200	<i>Na ppm</i>	400	300	400
<i>Nd_ppm</i>	12.9	3.72	5.26	<i>Nd ppm</i>	18.4	6.77	5.79
<i>Ni_ppm</i>	8	4	8	<i>Ni ppm</i>	12	8	8
<i>Pb_ppm</i>	7	3	4	<i>Pb ppm</i>	10	5	5
<i>Pr_ppm</i>	4.18	0.99	1.39	<i>Pr ppm</i>	4.78	1.76	1.16
<i>Rb_ppm</i>	23.2	10.7	14	<i>Rb ppm</i>	35.6	25	20
<i>S_ppm</i>	300	100	150	<i>S ppm</i>	600	350	450
<i>Sm_ppm</i>	2.44	0.73	0.98	<i>Sm ppm</i>	3.78	1.28	1.24
<i>Sn_ppm</i>	1.4	0.6	1	<i>Sn ppm</i>	2	1.2	1
<i>Sr_ppm</i>	10.4	5	7.3	<i>Sr ppm</i>	36.1	17.4	19.5
<i>Th_ppm</i>	1.36	2.44	3.61	<i>Th ppm</i>	9.9	5.63	4.91
<i>Tl_ppm</i>	0.15	0.07	0.08	<i>Tl ppm</i>	0.25	0.16	0.13
<i>U_ppm</i>	3.08	1.24	1.38	<i>U ppm</i>	5.27	2.9	2.29
<i>V_ppm</i>	54	26	36	<i>V ppm</i>	74	38	48
<i>Y_ppm</i>	7.74	2.23	2.81	<i>Y ppm</i>	10.5	5.04	5.05
<i>Zn_ppm</i>	12	5	7	<i>Zn ppm</i>	20	12	11

#### 4.1.14 Chaff geochemical sampling at Titania Au-prospect

Fourteen spinifex chaff samples were collected from termitaria within the sample grid, at Titania Au-prospect. The full Excel™ worksheet of data is in Appendix 4, on the digital data disc. The elements In, Re, Ta, Te, and W returned results below their analytical detection limits. Table 4.24 provides summary statistics for the geochemical

results, including mean, minimum and maximum values as well as anomaly threshold (defined as the 95th percentile) and spatial distribution pattern for each element. Gold, Sb and Se did not correlate closely with other elements.

The spinifex chaff geochemical results are distributed across the prospect, and have been summarised into four main patterns:

- Pattern 1: centrally elevated —Al, As, B, Bi, Cr, Cs, Fe, Ga, K, Li, Mg, Na, Sc, Tl, U and V
- Pattern 2: north-east elevated— Au, Se
- Pattern 3: west and south-west elevated —Ag, Ba, Mo, Ni and Y
- Pattern 4: irregular distribution — Ca, Cd, Ce, Co, Cu, Ge, Hf, Hg, La, Mn, Nb, P, Pd, Pb, Pt, Rb, S, Sb, Sn, Sr, Th, Tl, Zn and Zr.

Geochemical maps of the results for each element have been grouped into the distribution patterns (Figures 4.118 to 4.123).

**Table 4.24 Summary statistics for Titania Au-prospect spinifex chaff samples analysed at ACME Analytical Labs, Vancouver; n=14. The elements In, Re, Ta, Te and W were all below detection limit**

Element	Mean	Min	Max	Anomaly threshold	Spatial pattern
<i>Ag_ppb</i>	2.39	0.5	4	19.00	West
<i>Al_%</i>	0.09	0.07	0.17	0.17	Centre
<i>As_ppm</i>	0.41	0	2.1	2.10	Centre
<i>Au_ppm</i>	0.58	0	2.2	2.20	Northeast
<i>B_ppm</i>	2.14	1	7	19.00	Centre
<i>Ba_ppm</i>	22.91	8.9	39.3	39.30	West
<i>Be_ppm</i>	0.10	0	0.1	na	Irregular
<i>Bi_ppm</i>	0.02	0	0.02	0.02	Centre
<i>Ca_%</i>	0.20	0.1	0.36	0.58	Irregular
<i>Cd_ppm</i>	0.01	0.005	0.03	0.07	Irregular
<i>Ce_ppm</i>	1.50	1.03	2.84	2.84	Irregular
<i>Co_ppm</i>	0.47	0.32	0.96	0.96	Irregular
<i>Cr_ppm</i>	2.69	2.1	3.9	3.90	Centre
<i>Cs_ppm</i>	0.08	0.058	0.158	0.16	Centre
<i>Cu_ppm</i>	2.39	1.63	3.23	3.23	Irregular
<i>Fe_%</i>	0.09	0.057	0.209	0.21	Centre
<i>Ga_ppm</i>	0.27	0.2	0.6	0.60	Centre
<i>Ge_ppm</i>	0.04	0.005	0.06	0.06	Irregular
<i>Hf_ppm</i>	0.02	0.01	0.048	0.05	Irregular
<i>Hg_ppb</i>	15.14	10	20	53.00	Irregular
<i>K_%</i>	0.02	0.01	0.06	0.56	Centre
<i>La_ppm</i>	0.72	0.5	1.36	1.36	Irregular
<i>Li_ppm</i>	0.38	0.26	0.72	0.72	Centre
<i>Mg_%</i>	0.03	0.014	0.079	0.08	Centre
<i>Mn_ppm</i>	36.50	21	89	1886.00	Irregular
<i>Mo_ppm</i>	0.15	0.04	0.51	0.51	West
<i>Na_%</i>	0.01	0.005	0.012	0.02	Centre
<i>Nb_ppm</i>	0.03	0.005	0.06	0.06	Irregular
<i>Ni_ppm</i>	3.53	0.6	9.8	9.80	West
<i>P_%</i>	0.01	0.003	0.011	0.13	Irregular
<i>Pb_ppm</i>	0.68	0.51	1.04	1.18	Irregular
<i>Pd_ppb</i>	2.50	0	4	4.00	Irregular
<i>Pt_ppb</i>	1.00	0	1	1.00	Irregular
<i>Rb_ppm</i>	1.38	0.8	2.8	2.80	Irregular
<i>S_%</i>	0.02	0.005	0.04	0.06	Irregular
<i>Sb_ppm</i>	0.10	0.05	0.22	0.22	Irregular
<i>Sc_ppm</i>	0.29	0.2	0.4	0.50	Centre
<i>Se_ppm</i>	0.29	0.2	0.5	0.50	Northeast
<i>Sn_ppm</i>	0.06	0.04	0.11	0.11	Irregular
<i>Sr_ppm</i>	10.39	5.3	16.1	17.70	Irregular
<i>Th_ppm</i>	0.15	0.06	0.35	0.35	Irregular
<i>Ti_ppm</i>	11.43	7	21	21.00	Irregular
<i>Tl_ppm</i>	0.01	0.01	0.01	0.02	Centre
<i>U_ppm</i>	0.09	0.02	0.46	0.46	Centre
<i>V_ppm</i>	2.71	2	5	5.00	Centre
<i>Y_ppm</i>	0.46	0.281	0.99	0.99	West
<i>Zn_ppm</i>	31.70	14.8	50.7	50.70	Irregular
<i>Zr_ppm</i>	0.66	0.37	1.31	1.31	Irregular

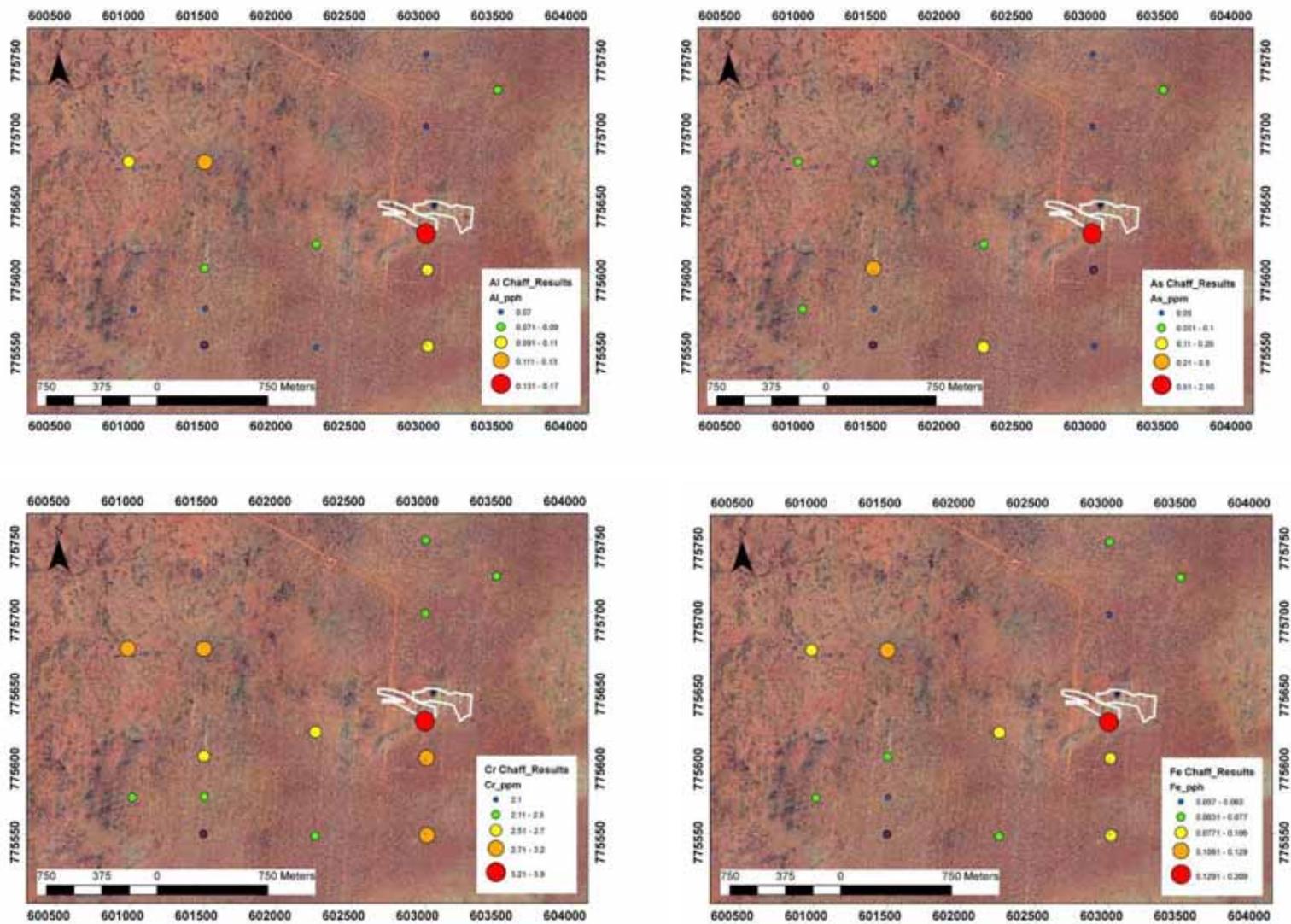


Figure 4.118 Distribution for Pattern 1 elements, including Al, As, Cr and Fe, for spinifex chaff samples at Titania Au-prospect, NT; n=14

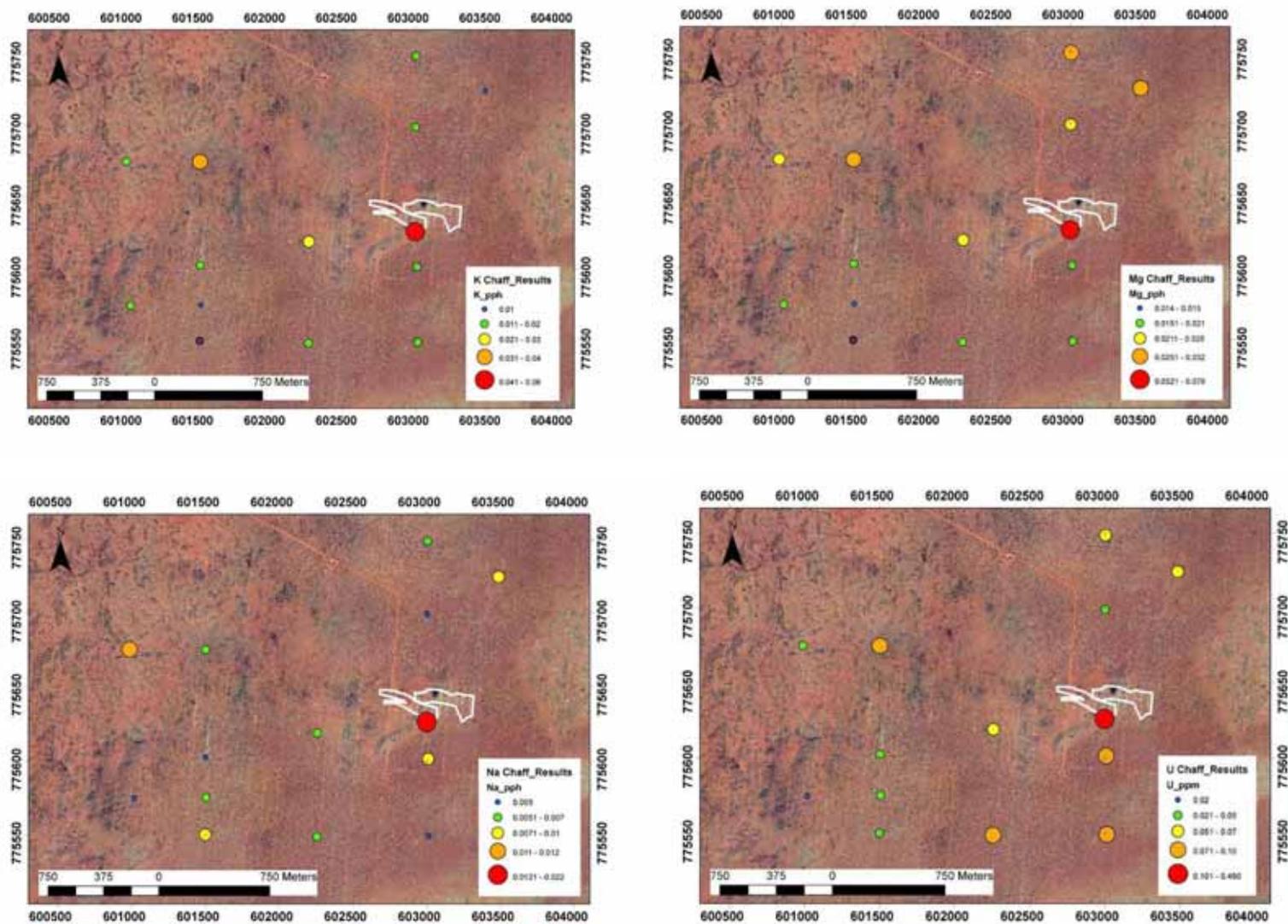


Figure 4.119 Distribution for Pattern 1 elements, including K, Mg, Na and U, for spinifex chaff samples at Titania Au-prospect, NT; n=14

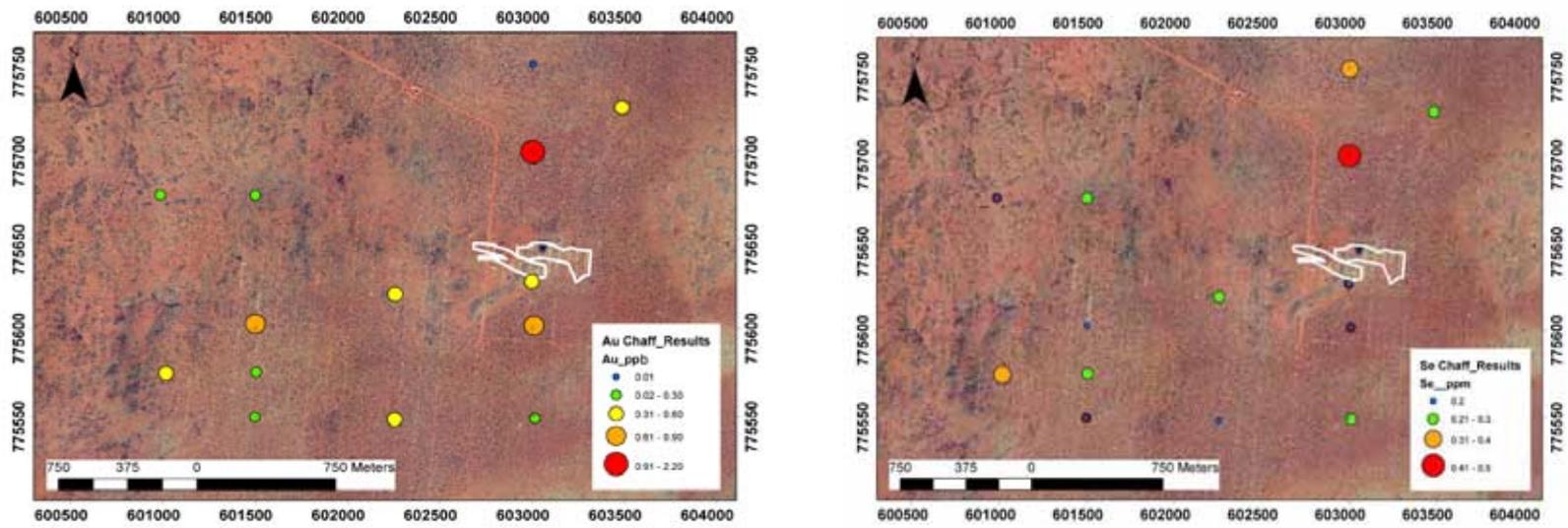


Figure 4.120 Distribution for Pattern 2 elements, including Au and Se, for spinifex chaff samples at Titania Au-prospect, NT; n=14

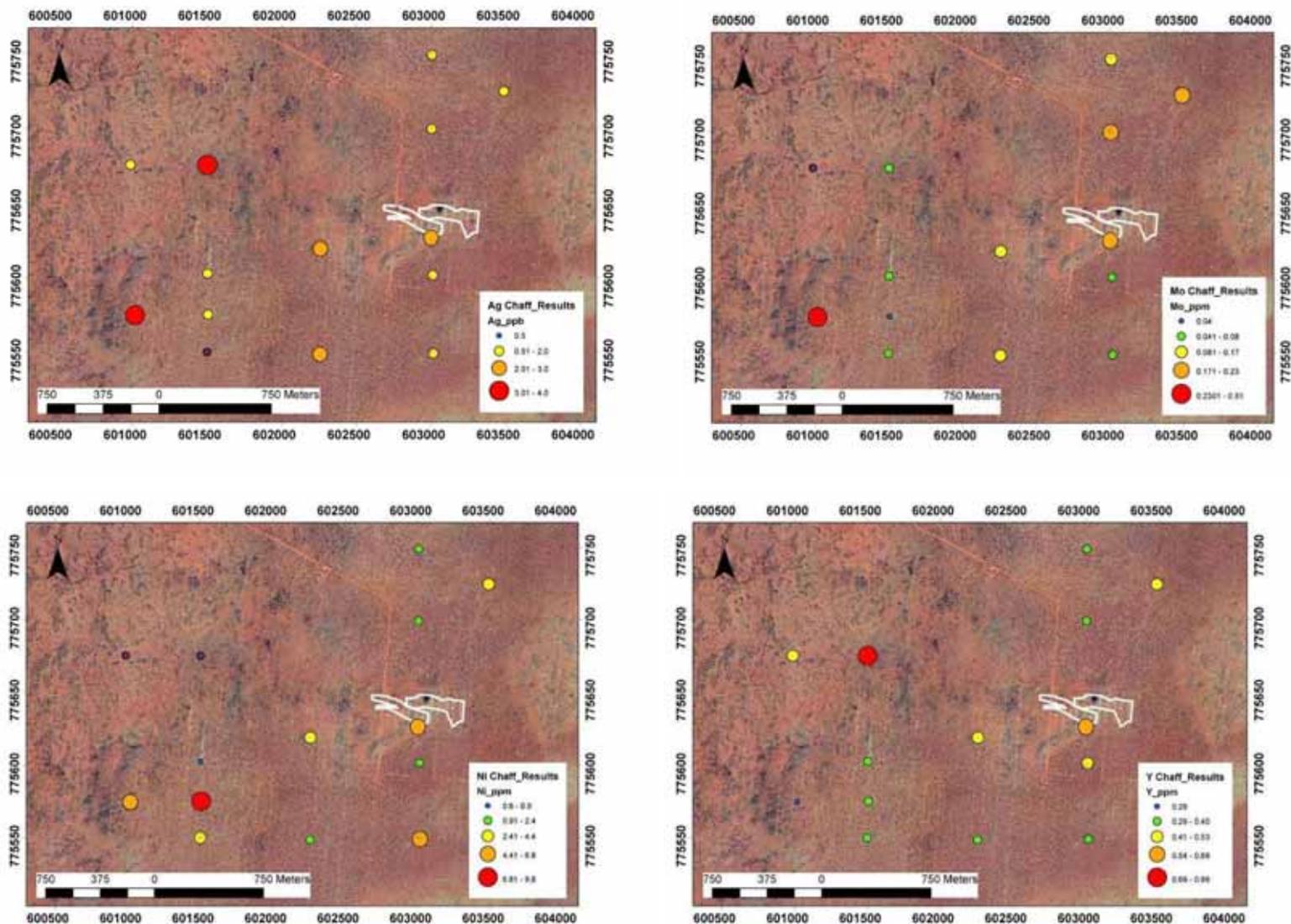


Figure 4.121 Distribution for Pattern 3 elements, including Ag, Mo, Ni and Y, for spinifex chaff samples at Titania Au-prospect, NT; n=14

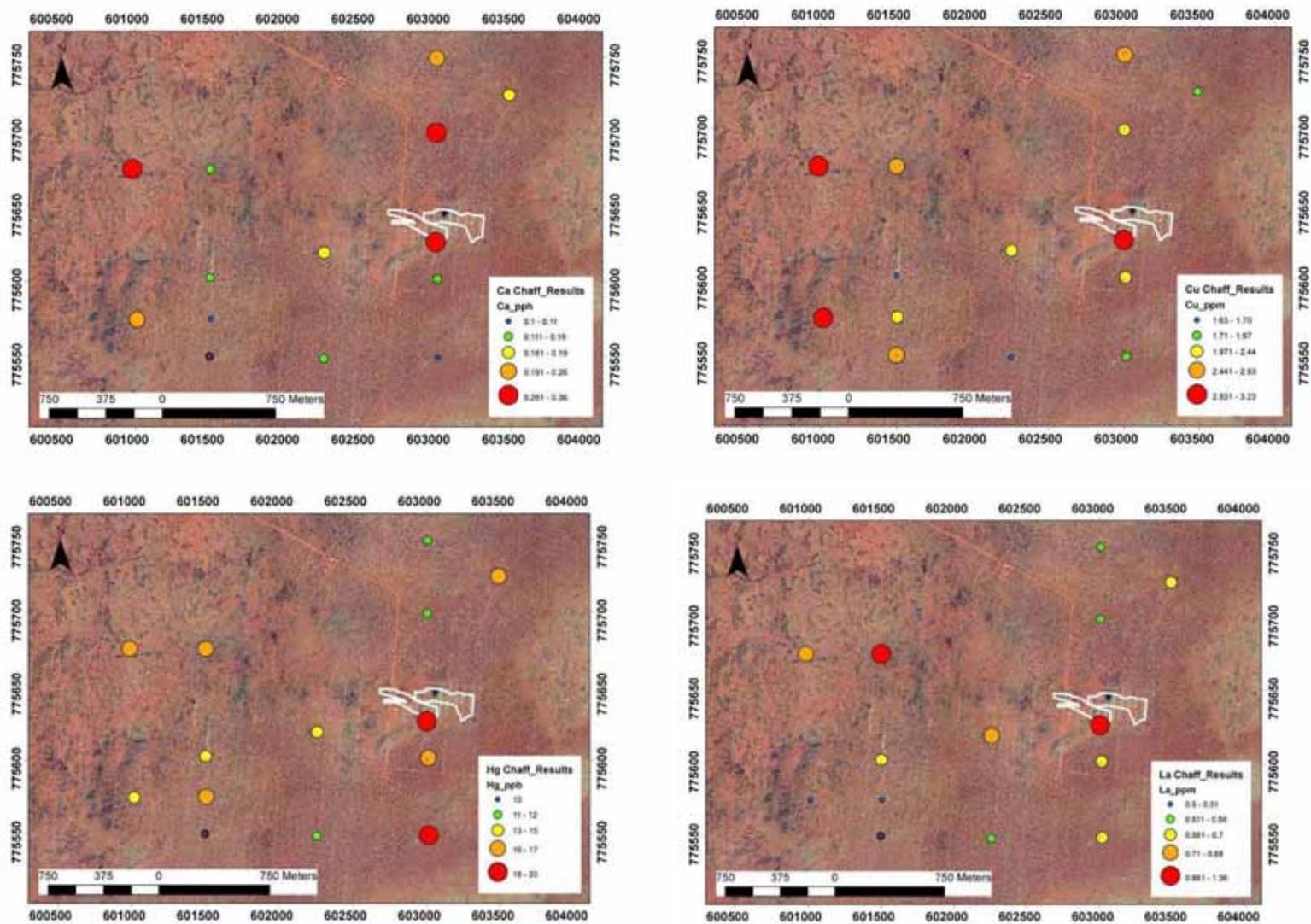


Figure 4.122 Distribution for Pattern 4 elements, including Ca, Cu, Hg and La, for spinifex chaff samples at Titania Au-prospect, NT; n=14

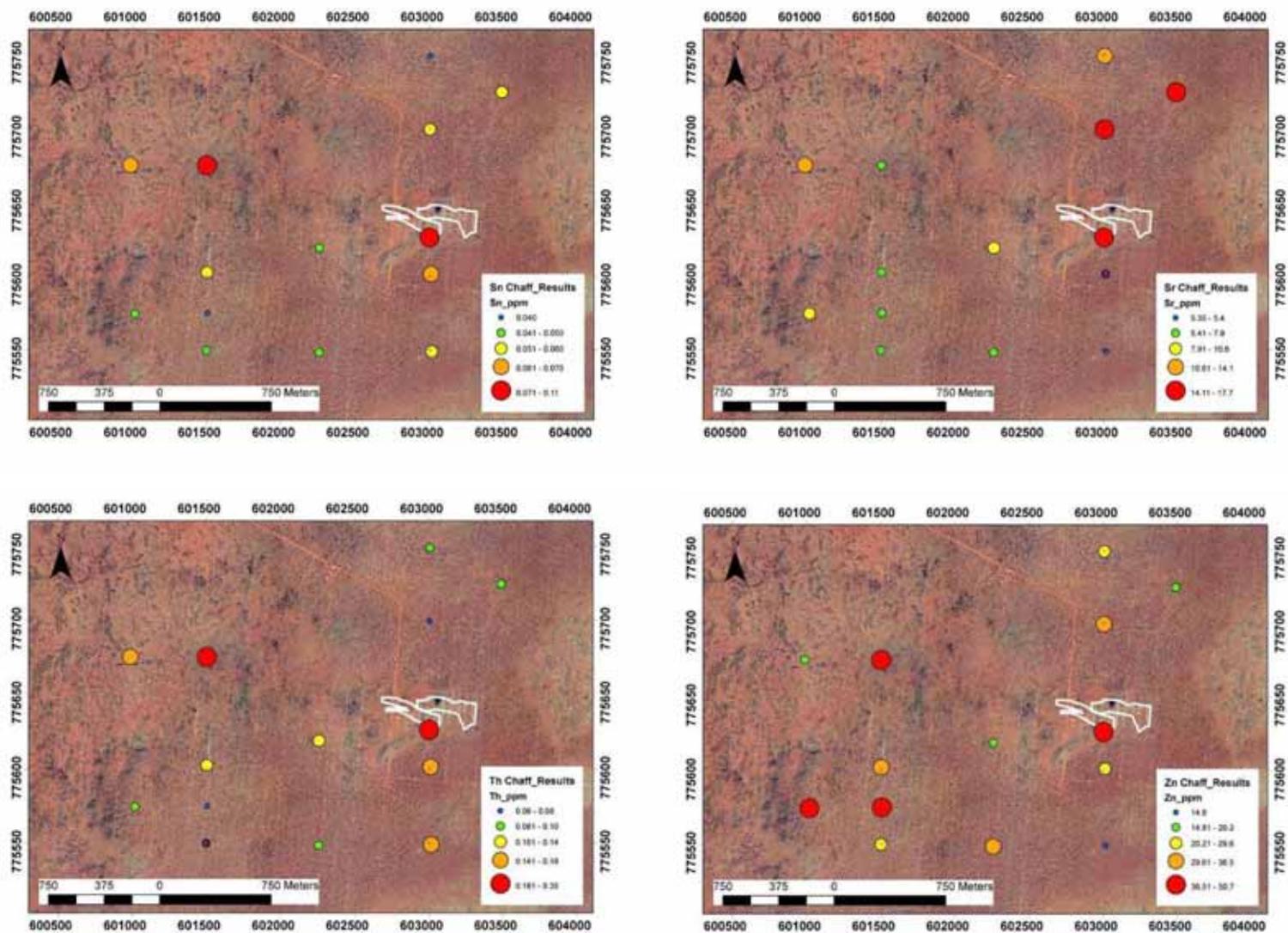


Figure 4.123 Distribution for Pattern 4 elements, including Sn, Sr, Th and Zn, for spinifex chaff samples at Titania Au-prospect, NT; n=14

### **Interpretation of chaff geochemistry results at Titania Au-prospect**

The spatial patterns for elements within the spinifex chaff may be summarised into the following elemental associations:

- Pattern 1: Al, As, B, Bi, Cr, Cs, Fe, Ga, K, Li, Mg, Na, Sc, Tl, U and V — mineralised bedrock and development of salt crusts within the soil profile, as well as vegetation types
- Pattern 2: Au, Se — Lamaque mineralisation
- Pattern 4: Ca, Cd, Ce, Co, Cu, Ge, Hf, Hg, La, Mn, Nb, P, Pd, Pb, Pt, Rb, S, Sb, Sn, Sr, Th, Tl, Zn and Zr — plant nutrients and trace element values within groundwater and vegetative matter.

The abundance of elements included in Pattern 4 indicates that many of these elements are present in plant tissue such as spinifex, as well as being related to a possible transported groundwater anomaly. This is supported by the dominant surficial (and groundwater) flow direction from NW to SE, and the dominant palaeochannel flow direction from north to south (as reported by Wilford, 2001). The spinifex chaff geochemical results reveal some different correlations to those at Coyote, using a cut-off of +0.5 and -0.5 to determine significant correlations. Gold does not correlate closely with other elements at the prospect, as was the case at Coyote. Elements such as Al, Fe, Ga, As, Bi, Ce, Co, Hg, Li, K, La, Rb, Sn, Ti, I, U, V and Zr share close correlations with each other.

The lack of elements related to iron-oxides, such as Fe, Ga, and Al, indicates that the chaff samples are relatively uncontaminated, as termitaria samples in this area contained a high percentage of these metals. To test whether the chaff samples were contaminated by silty material, from sampling in the field, scatter-plot matrices were created in IoGas to compare results from the two sampling media, termitaria and spinifex chaff. Scatter-plots relating to this discussion are included as Figure 4.124, below. Using the map attributes function, chaff samples have been coloured green, whilst termitaria samples are an orange-brown. The elements Fe, Al, As, and Au were selected for comparison. Unfortunately, the analytical suite used for the termitaria geochemical analysis did not include the elements Ti and Zr which, alongside Al and Fe, are common elements in surface minerals.

The scatter-plots show a definite grouping of values for all four featured elements, with the chaff and the termitaria analytical results plotting in two distinct groups for the Fe and Al n-score plots. The As and Au n-score plots show a similar distinction between the sample media, although the values are much closer; in the case of the Au results, one of the chaff samples contains higher Au than four of the termitaria samples from the site.

Plotting each of the featured elements, such as Fe:Al, Fe:Au and Al:Au, provides a means of testing the potential contamination of spinifex chaff by soil material. Figure 4.125 shows the degree of correlation between the elements Fe, Al and Au for both the termitaria and spinifex chaff samples. For all three plots, the separate grouping of spinifex chaff and termitaria results shows that there is insignificant inorganic material in the chaff samples when separated using flotation in the sample preparation procedures. It can therefore be concluded that contamination of the spinifex chaff samples by nest material, from initial sample collection in the field, is not a significant concern in this study.

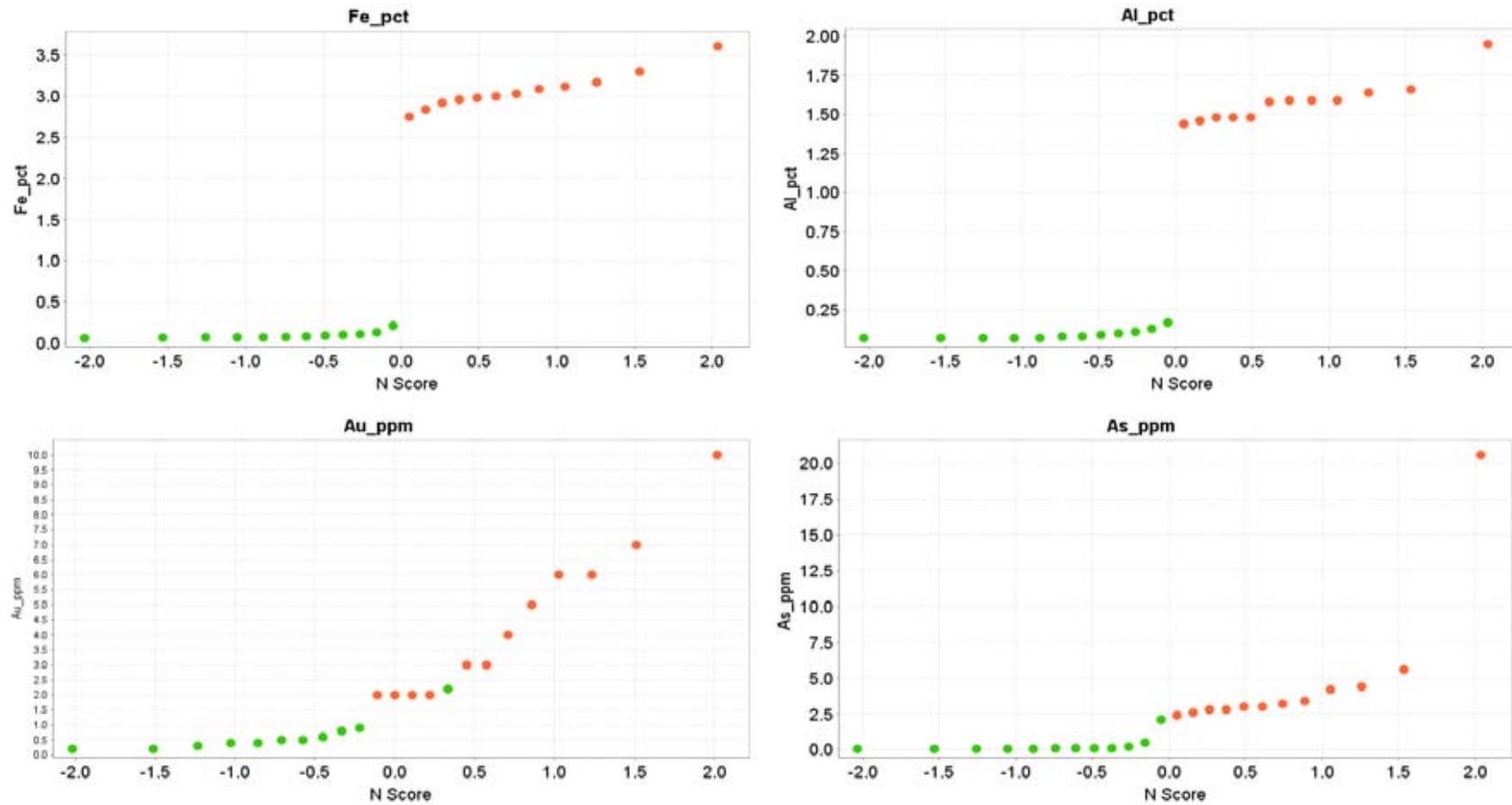


Figure 4.124 N-score plots, generated in IoGas, of geochemical results for Titania Au-prospect, with termitaria samples highlighted as orange-brown and spinifex chaff samples as green, for the elements Fe, Al, Au and As; n(termitaria)=93 and n(spinifex)=14

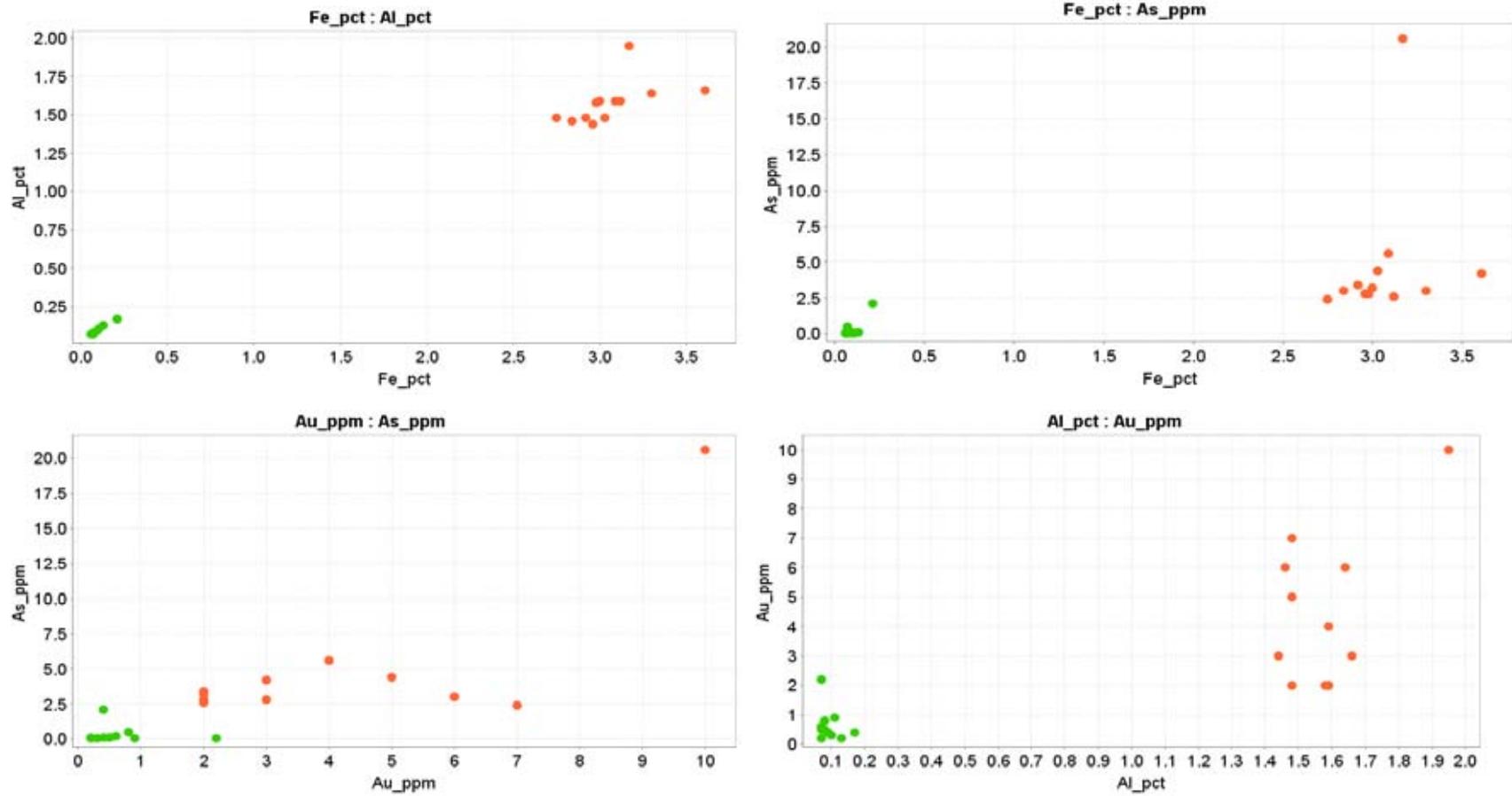


Figure 4.125 Scatterplot, generated in IoGas, of geochemical results for Titania Au-prospect, with termitaria samples highlighted as orange-brown and spinifex chaff samples as green, for the elements Fe, Al, Au and As; n(termitaria)=93 and n(spinifex)=14

#### 4.1.15 Discussion of Titania Au-prospect geochemical sampling program

Analytical concentrations from this study were typically much higher in the finer, silt-clay fraction (Fraction 1) than in the coarser-grained fractions; the higher elemental concentrations also brought out much sharper contrasts between the soil results for the region and the surface projection of the Oberon lode of the Titania Au-prospect (Gibbons *et al.*1997).

Elements such as Hg, K, Mg, Na, Pb, Te, S, Th and Zn, are abundant within the Fraction 1 termitaria. The Fraction 2 and 3 results showed a mixed geochemical signature, containing transported lag material from the west, as well as aeolian-derived sediment. The higher concentrations for Ca, K, Mg, S and Zn within the Fraction 1 sediments also suggest the incorporation of organic material, derived from the harvested spinifex chaff, into the nest walls, as well as groundwater.

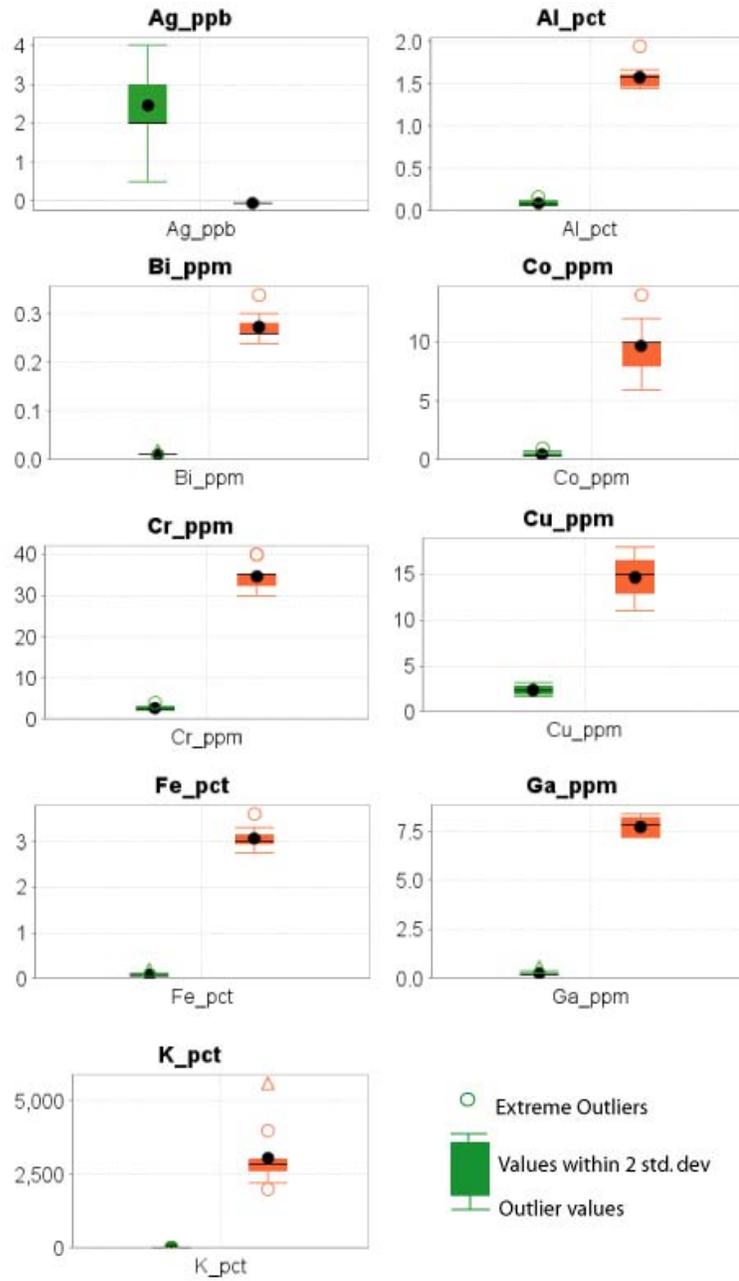
To define the origin of the dominant geochemical signatures within the termitaria across the prospect, Tukey plots of the Fraction 1 termitaria and the spinifex chaff samples were generated in IoGas. Two patterns emerge from the Tukey plots: one group of elements was relatively high in the termitaria samples compared to the chaff samples; and, the group of elements displayed similar box plots for each element, though usually with the termitaria samples having higher concentration. These groups may be summarised as:

- bedrock and Au-mineralisation (Al, Bi, Cd, Ce, Co, Cr, Cu, Fe, Ga, In, K, La, Mn, Ni, Pb, Rb, S, Sn, Th, Tl, U, V, Y)
- vegetation and groundwater (As, Au, Ba, Ca, Mg, Mo, Na, Sr, and Zn).

Within the first group of elements the termitaria samples are generally much higher in elemental concentration than the spinifex chaff samples, with no overlap in either Tukey plot. These elements include Al, Bi, Cd, Ce, Co, Cr, Cu, Fe, Ga, In, K, La, Mn, Ni, Pb, Rb, S, Sn, Th, Tl, U, V and Y. Figures 4.126 and 4.127 display Tukey plots from a selection of elements from this group. Most of these elements are abundant in the weathered bedrock within the regolith profile, as well as in the clay, silt and fine sand-rich substrate. This material is utilised by the termites as building materials for the outer walls of their mounds.

The elements Ag, Pd, and Pt are more abundant in the spinifex chaff samples, relative to the termitaria sample results, but the dataset for these elements within the Fraction 1 samples reveals that most of the results were below detection limit. The analytical techniques for both sampling media, therefore, had some impact on the results across the Titania Au-prospect and this should be considered when comparing the results.

The second group of elements includes those where Tukey plots show overlapping spinifex chaff and termitaria sample results at either the outliers or quartile boxes and medians. Elements such as As, Au, Ba, Ca, Mg, Mo, Na, Sr, and Zn are included within this group (Figure 4.128). The incorporation of harvested spinifex grass, and the indirect sampling of the groundwater by using saturated materials from within the regolith, are implied by the similarity in range for many of the elements shown. The spinifex grasses, which are harvested by the termites, provide possible information of both the groundwater and the regolith chemistry; however, this is still limited by uptake inhibitors within the plant (Hulme 2005, Dunn 2007). The spinifex chaff results express the general presence of mineralisation in the substrate by tapping into Au and other trace element-bearing groundwater with its roots (Reid *et al.*, 2006).



**Figure 4.126** Tukey plots displaying the geochemical results for spinifex chaff samples (green, on left for each element) and termitaria samples (orange, on right for each element) for the elements Ag, Al, Bi, Co, Cr, Cu, Fe, Ga, and K;  $n(\text{termitaria})=93$  and  $n(\text{spinifex})=14$

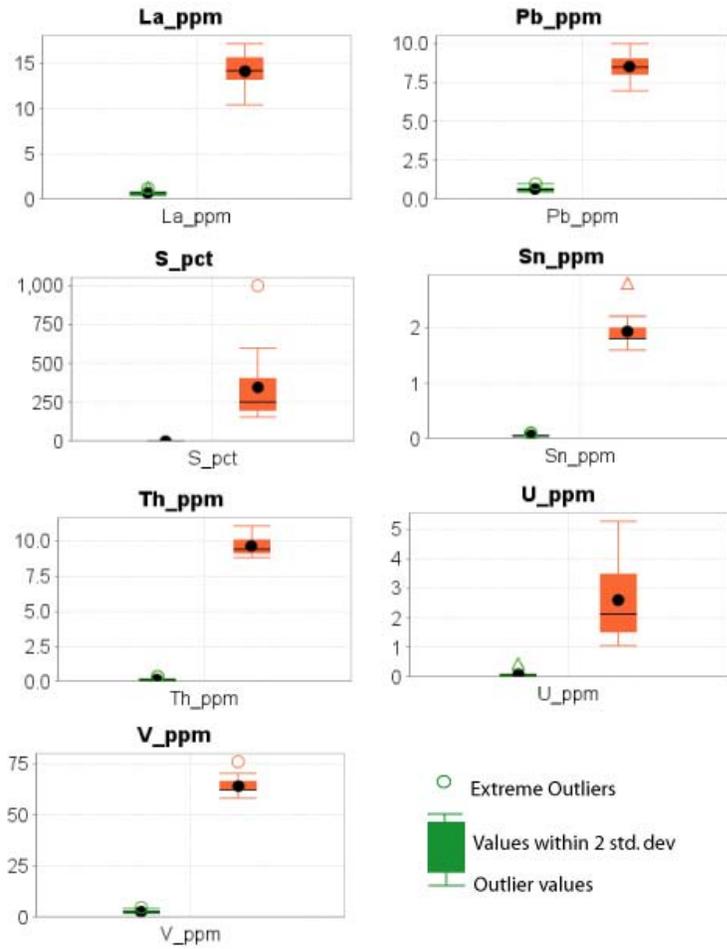


Figure 4.127 Tukey Plots displaying the geochemical results for spinifex chaff samples (green, on left for each element) and termitaria samples (orange, on right for each element) for the elements La, Pb, S, Sn, Th, U, and V; n(termitaria)=93 and n(spinfex)=14

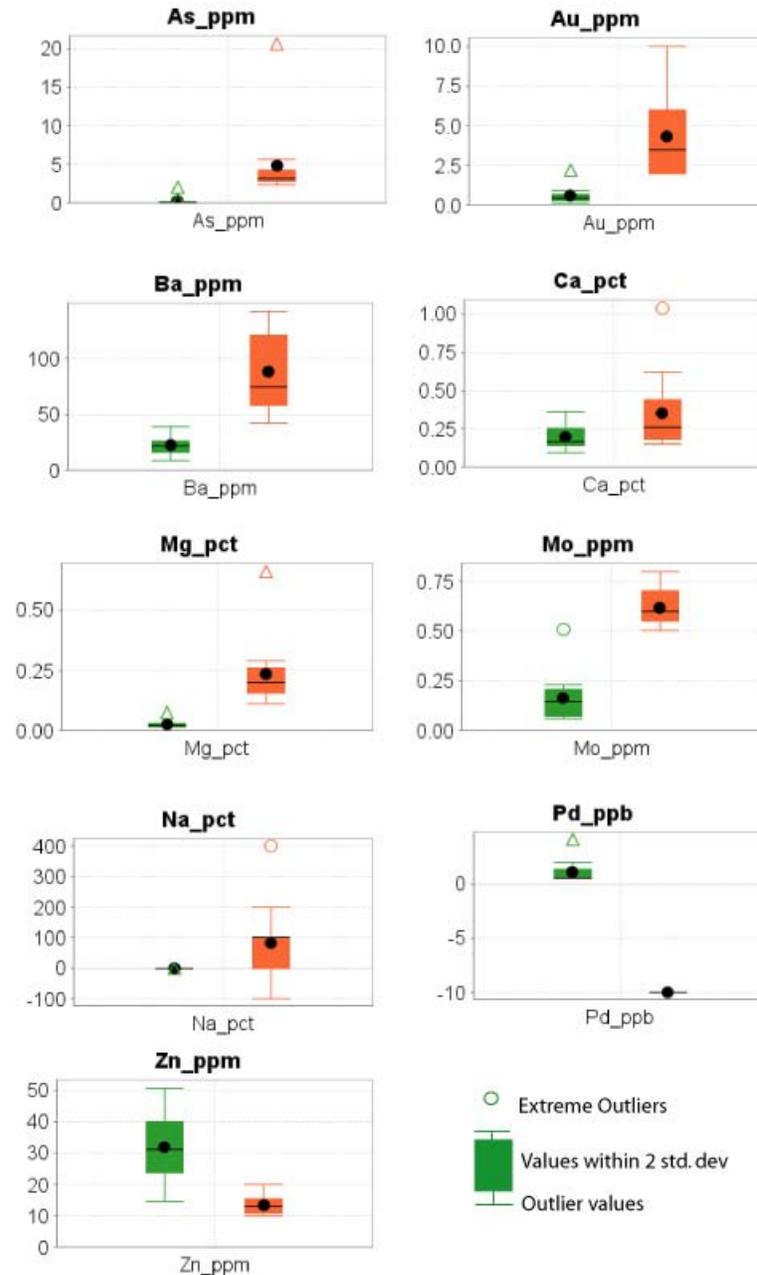


Figure 4.128 Tukey Plots displaying the geochemical results for spinifex chaff samples (green, on left for each element) and termitaria samples (orange, on right for each element) for the elements As, Au, Ba, Ca, Mg, Mo, Na, Pd, and Zn;  $n(\text{termitaria})=93$  and  $n(\text{spinifex})=14$

The comparable Ca and Sr within the chaff samples may be an expression of high Ca and Sr content in the groundwaters, whilst the termitaria show a geochemical response to groundwater carbonates. Zinc<sup>+</sup> is highly mobile in groundwater when Cl<sup>-</sup> is present, and the high values of this element within the spinifex chaff results suggests that this

element is also an essential plant nutrient and is present in high concentrations within the spinifex at Titania Au-prospect.

A number of conclusions may be drawn from the interpretation of the termitaria and spinifex chaff sampling results at Titania Au-prospect. These are based on the transect-based sampling program, the detailed sampling program, the soil sampling program and the spinifex chaff sampling program. These conclusions may be summarised as follows:

- The fine sand/silt/clay fraction (<75 µm mesh) is ideal for delineating zones of mineralisation and separating transported geochemical signatures.
- There is little difference in geochemistry between the three main mound-building termite species at Titania Au-prospect, and composite samples of individual mounds provide the best homogenised sample, especially from bigger mounds.
- Traditional soil sampling methods display an anomaly for As, Ni, Zn and Bi over the deposit (Fraction 1 sediments).
- Spinifex chaff is a viable sampling media, providing insight into the mechanisms of elemental dispersion within the upper regolith by both plants and termites.

The termitaria that were sampled at Titania Au-prospect, therefore, contained a homogenised geochemical signature derived from plants, regolith and groundwater.

#### Discussion of Titania Au-prospect regolith-landform mapping and geochemical results

Elemental concentrations were typically much higher in the finer, silt-clay fraction (Fraction 1) than the coarser-grained fractions. The higher concentrations also showed greater contrasts with the soil results for the region, and outlined the surface projection of the Oberon anomaly at the Titania Au-deposit.

The deeper geochemical signal of the *N. triodiae* mound at Site 007 shows great potential for mineral explorers and warrants further study by regolith scientists, but as *N. triodiae* has limited distribution in the Tanami (due to its alluvial plain landscape setting preferences) this may limit widespread regional sampling. At a tenement scale, however, *N. triodiae* should prove extremely useful in delineating possible mineralisation, especially in regolith-dominated landscapes, where traditional

techniques such as soil sampling have proven inconclusive because of significant transported sediment cover.

Generally, paired mounds at the sampling site showed a similar pattern of elemental concentration (e.g. Au, As, Mo, Ni) using first-pass evaluation methods. *D. rubriceps*, a species which builds mounds that are low and very well cemented (otherwise known as 'pavement mounds'), collects and uses slightly coarser building materials from the regolith profile. This is reflected in the geochemical results from the coarse-grained, > 1 mm fraction, where such material forms a much higher percentage of the total outer nest wall volume than for other termites (Lee & Wood, 1971). Within the scope of this study, large angular flecks of bedrock clasts and coarse gravel material were consistently observed in the outer nest of *D. rubriceps* mounds.

As a sampling medium for mineral exploration, however, termitaria from all three termite species provide a homogenised vegetation-regolith sample with distinct geochemical responses in the finer, silty-clay fraction. The silty-clay material from the outer wall of these nests, described here as Fraction 1, contained the best geochemical signature of the underlying regolith profile.

Conclusions from the detailed termitaria and soil surveys include:

- Within *N. triodiae* and *D. rubriceps* mound outer walls, there is minor geochemical variation.
- The termitaria contained much higher concentrations of pathfinder elements than the surrounding soils.
- The *N. triodiae* mound lobes contained significant amounts of material from the deeper regolith profile, rather than from the surrounding soils, as shown by the abundance of aluminosilicate-mineral forming elements.

The importance of mineral hosts and landscape setting in controlling chemistry cannot be underestimated, as evident in the pattern groupings. For instance, the Fraction 1 results may be grouped into three main patterns:

- Pattern 1: mineralisation
- Pattern 2: clays/alluvial system

- Pattern 3: Fe-oxides/proximal sheetwash and ferricrete.
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The soils at the Titania prospect are essentially derived from eroded termitaria, eroded and dispersed during the intensive flooding events which are common seasonal occurrences in northern Australia. This diminishes the potential for soils to accurately represent occurrences of mineralisation in the underlying regolith profiles in areas with thick (> 2 m) cover. Similar conclusions have been made in Niger by Gleeson & Poulin (1989), whilst Kebede (2004) describes termitaria in North Ethiopia as containing similar values of metals, such as Au, Ag, Cu, Zn and Co, as the bedrock parent material.