

**The Composition, Development and
Geological Setting of the
Early Permian Boggabri Volcanics,
Gunnedah Basin, NSW**

Appendices

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Appendix 1

**Geochemical Data
Acquisition**

Appendix 1: Geochemical Data Acquisition

INTRODUCTION

Forty five Boggabri rocks have been selected from nearly 800 field samples and have been analysed by conventional XRF techniques for major and common trace elements, by conventional gravimetric techniques for Loss On Ignition and by INAA for 31 major and trace elements. These data are registered as R68601 to R68645 in the Department of Geology and Geophysics (UNE) and are referred to herein as #01 to #45 for brevity (see Petrology for terminology). These data are listed in Tables A1.1, A1.2, A1.3 and A1.4.

SAMPLE SELECTION

The rocks selected for analysis exhibit least petrographic evidence of weathering and alteration amongst the collected rocks and represent a reconnaissance sampling of very diverse volcanic lithologies. Proportionately more of the sparse, more mafic volcanic rocks have been selected for analysis than of the more abundant felsic rocks, in order to define more clearly any fractionation trends among basaltic compositions. Pitchstones have been selected more commonly from amongst the more felsic rocks because these would appear to have suffered least post-emplacement alteration (other than that associated with hydration). Some less than ideal materials were analysed, especially amongst more mafic rocks, in order to establish the affinity of specific isolated outcrops and/or to test whether distinctive geochemical signatures survive alteration and/or weathering. In addition, there has been little opportunity to specifically select rocks for low phenocryst contents.

SAMPLE PREPARATION

Samples were prepared for chemical analysis as follows:

- the best available material was chosen for analysis; typically only small samples of material free from obvious weathering and alteration effects (some samples < 100 g) were available;
- any obvious surface contamination from thin sectioning (e.g. brass from diamond

blade) was removed by briefly touching on a diamond wheel, then the sawn faces were rubbed with emery powder on a glass lap; and then the samples were washed repeatedly in triple distilled water and dried in a drying oven at about 110°C;

- fines from crushing and particles with obvious signs of weathering and/or alteration were discarded; and
- samples of 50 to 100 grams were crushed in a WC lined Tema Mill after thoroughly cleaning the mill with coarsely crushed white vein quartz.

The resulting powders from each sample was stored in separate plastic bags, from which various aliquots were extracted as follows:

- duplicate samples of about 0.3 grams each from which glass beads for XRF major element analysis were made following the method of Norrish and Hutton (1969);
- one sample of about 15 grams from which a pressed power pellet for XRF trace element analysis was made following the method of Norrish and Hutton (1969);
- duplicate samples each of approximately 2 grams for LOI determination; and
- one aliquot of about 10 grams for submission to Becquerel Laboratories (Australian Nuclear Science Technology Organisation, Lucas Heights, Sydney) for encapsulation and NAA analysis. Only about 3 grams was available for SFA09.

ANALYSIS

Samples were analysed as follows:

- the glass beads and pressed powder pellets were analysed for major elements and trace elements respectively in a Phillips X-Ray Fluorescence spectrometer at the Department of Geology and Geophysics, University of New England (J. Bedford analyst) following the method of Norrish and Hutton (1969);
- the NAA analysis was carried out using a spectrometer at Becquerel Laboratories (Lucas Heights Research Laboratories, Lucas Heights Sydney to measure radiation induced by fast neutron irradiation in the HIFAR reactor at Lucas Heights according to the specifications of the commercially available 'gold + 28 elements' package. Tb and Te were also measured in these samples; and
- the samples for LOI determination were analysed gravimetrically at the Department of Geology and Geophysics, University of New England, using laboratory furnaces operating at 1000°C and a Mettler® balance accurate to 0.0001 gm.

DATA ACQUISITION

All XRF and NAA data were acquired in electronic form so as to eliminate the potential for generating errors during data entry. Data acquired include:

- major elements from XRF analysis of glass beads as oxides by weight per cent (namely SiO₂, TiO₂, Al₂O₃, Fe₂O_{3t}, MnO, MgO, CaO, Na₂O, K₂O, P₂O₅);
- other elements from XRF analysis of pressed powder pellets as parts per million by weight (namely Sc, Mn, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Nb, Ba, Th and U);
- selected major elements from NAA analysis (Fe, Na, K) as elements by weight per cent which were then converted to oxides of the same composition as recorded by XRF, and using atomic weights in Emsley (1991);
- other elements from NAA as parts per million by weight (Sb, As, Ba, Br, Ce, Cs, Cr, Co, Eu, Hf, Fe, La, Lu, Mo, K, Rb, Sm, Sc, Se, Ag, Ta, Tb, Th, W, U, Yb, Zn) or parts per billion by weight (Au and Ir); and
- LOI (loss on ignition) as weight percent.

Fe from XRF analysis was recorded as Fe₂O_{3t}, even though most iron in unoxidised rocks occurs as Fe²⁺, because the Fe would have been mostly oxidised during formation of the glass beads, and therefore would have occurred as Fe₂O_{3t} when analysed by XRF (Hughes and Hussey, 1976).

Claimed XRF precision is 0.01% for SiO₂, TiO₂, Al₂O₃, Fe₂O_{3t}, MnO, MgO, CaO, Na₂O, K₂O, and P₂O₅; and detection limits for pressed powder pellets analyses are (J. Bedford pers. comm.): 1 ppm for Ni, Cu, Zn, Ga, Rb, Sr, Y, and Zr; 2 ppm for Sc, V, Cr, As, Pb, Th, U, and Nb; 3 ppm for La, Ce, Nd, and 20 ppm for Ba. Claimed NAA detection limits (Becquerel Laboratory — 'Gold + 28 elements' package description) are 100 ppm for Ba and Zn, 20 ppm for Rb, 5 ppm for Cr, Mo, Se, and Ag, 2 ppm for Br, Ce, W, and U, 1 ppm for As, Cs, Co, Ta, and Tb, 0.5 ppm for Eu, Hf, La, Th and Yb, and 0.2 ppm for Sb, Lu, Sm, 20 ppb for Ir and Au, 0.1 ppm for Sc, 0.05% for Fe, 0.2% for K and 0.01% for Na.

DATA PREPARATION

All analyses have been converted to a volatile-free basis. Fe is presented as Fe₂O_{3t} because Fe is largely oxidised during fusion (Hughes and Hussey, 1976). INAA data have been corrected for neutron flux variations during irradiation by the method of Chappell and Hergt (1989).

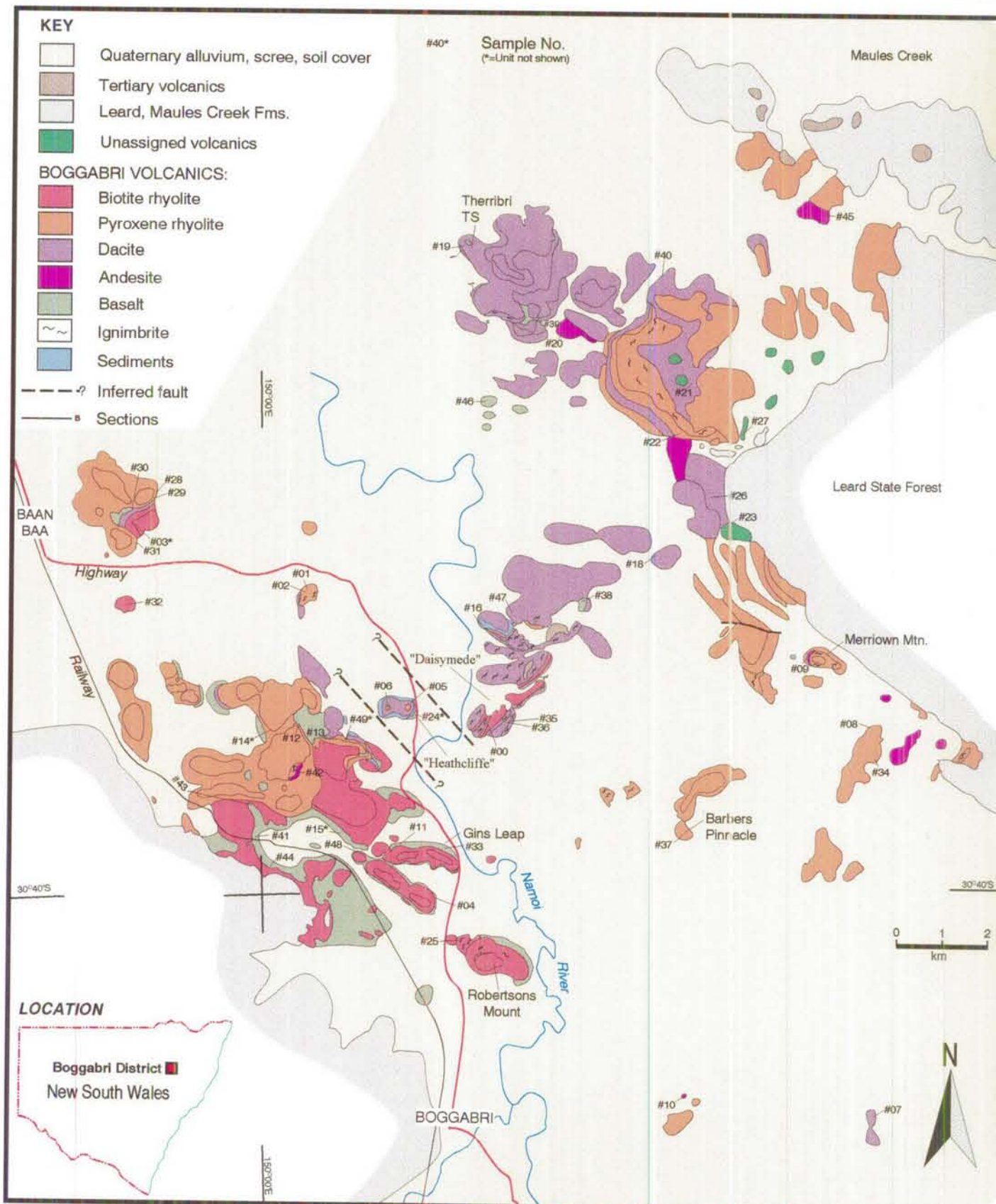


Figure A1.1: Geological Map of Boggabri Volcanics

Table A1.1: Whole Rock Analyses by XRF and Loss On Ignition

Registered No.	Formation	SiO ₂ %	TiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MnO %	MgO %	CaO %	Na ₂ O %	K ₂ O %	P ₂ O ₅ %	LOI %	Total %
R68601	BV	77.68	0.29	12.34	1.26	0.06	0.05	0.20	5.89	1.47	0.03	0.46	99.73
R68602	BV	71.09	0.30	11.64	1.42	0.03	0.59	1.84	0.85	4.12	0.06	7.60	99.54
R68603	BV	50.62	1.12	17.58	5.14	0.28	1.32	11.62	3.28	1.08	0.38	7.18	99.60
R68604*	BV	70.28	0.25	12.98	0.86	0.05	0.15	2.01	2.16	3.74	0.03	7.04	99.55
R68605*	BV	63.04	0.99	15.89	4.77	0.15	1.18	3.24	5.05	2.62	0.29	2.43	99.65
R68606*	BV	67.97	0.38	13.37	1.53	0.05	0.33	2.02	5.01	1.05	0.06	7.83	99.60
R68607	BV	64.45	0.66	14.49	3.28	0.15	0.27	5.26	4.91	2.25	0.16	3.92	99.80
R68608*	BV	70.67	0.26	12.74	0.79	0.01	0.27	1.28	1.55	4.39	0.06	7.52	99.54
R68609*	BV	59.86	1.37	15.91	6.44	0.14	2.32	5.17	4.66	1.59	0.39	2.11	99.96
R68610*	BV	56.04	1.15	16.67	7.94	0.12	1.56	6.53	4.48	1.36	0.31	3.86	100.02
R68611	BV	44.63	1.28	17.34	8.62	0.16	1.25	13.12	3.66	0.54	0.24	8.94	99.78
R68612*	BV	48.81	1.02	17.42	8.62	0.13	8.95	8.97	2.86	0.58	0.26	2.00	99.62
R68613*	BV	68.93	0.33	14.03	1.35	0.07	0.30	1.55	4.92	2.00	0.05	6.36	99.89
R68614	BV	49.55	1.05	18.01	8.07	0.12	7.03	9.64	3.00	0.52	0.27	2.54	99.80
R68615	BV	57.42	1.38	15.99	7.78	0.14	2.72	6.18	4.47	0.82	0.45	1.96	99.31
R68616	BV	59.78	1.11	15.40	5.25	0.11	0.87	4.78	4.29	4.03	0.32	3.81	99.75
R68617	BV	60.99	1.00	15.18	5.67	0.10	0.93	4.19	3.80	2.76	0.29	4.64	99.55
R68618	BV	66.70	0.72	15.39	2.76	0.09	0.93	2.10	5.13	3.12	0.17	2.77	99.88
R68619	BV	63.76	0.90	15.96	4.10	0.07	0.62	3.39	5.22	2.58	0.21	2.99	99.80
R68620	BV	55.08	1.45	16.48	9.85	0.15	2.84	4.05	5.35	0.99	0.31	3.18	99.73
R68621	UV	55.98	1.55	17.46	8.84	0.13	2.40	5.31	5.33	1.01	0.42	1.22	99.65
R68622	BV	78.12	0.26	12.57	0.93	0.03	0.04	0.19	6.91	0.43	0.03	0.63	100.14
R68623	UV	54.37	1.48	17.06	8.00	0.14	1.57	7.87	4.51	1.19	0.39	2.68	99.26
R68624*	BV	61.85	1.00	15.75	5.22	0.10	1.74	4.15	4.91	1.76	0.27	3.02	99.77
R68625*	BV	69.54	0.27	13.51	0.91	0.03	0.21	1.33	2.43	4.67	0.04	6.40	99.34
R68626	BV	64.51	0.95	15.20	4.85	0.09	0.80	2.76	5.30	2.74	0.27	2.39	99.86
R68627	UV	51.49	1.62	17.11	11.02	0.12	3.22	6.08	5.00	1.50	0.58	1.27	99.01
R68628	BV	73.96	0.28	14.56	0.39	0.01	0.07	0.38	2.93	4.54	0.03	2.17	99.32
R68629*	BV	70.70	0.26	12.63	1.02	0.03	0.23	1.12	2.27	4.29	0.02	7.02	99.59
R68630	BV	67.68	0.78	14.93	4.34	0.05	0.49	2.10	4.61	2.70	0.22	1.76	99.66
R68631	BV	73.99	0.30	14.08	0.91	0.01	0.10	0.49	3.33	4.50	0.02	1.90	99.63
R68632	BV	77.88	0.29	12.43	0.30	0.02	0.12	0.19	3.87	3.43	0.02	1.03	99.58
R68633	BV	44.80	1.44	19.12	9.93	0.20	4.81	7.92	4.12	0.83	0.31	6.51	99.99
R68634	BV	79.99	0.24	11.06	0.28	0.01	0.07	0.60	3.05	2.99	0.03	1.21	99.53
R68635	BV	63.71	0.93	15.23	4.71	0.14	1.35	2.55	5.25	3.22	0.25	2.26	99.60
R68636	BV	65.31	0.97	15.56	3.73	0.06	0.94	2.33	4.44	2.94	0.26	2.99	99.53
R68637	BV	78.69	0.16	11.87	0.21	0.01	0.03	0.22	3.01	3.96	0.02	1.28	99.46
R68638	BV	47.46	1.35	18.13	8.12	0.12	5.95	9.27	3.35	0.78	0.45	4.72	99.70
R68639*	BV	48.78	1.58	17.55	9.65	0.17	6.40	8.75	3.68	0.59	0.32	2.14	99.61
R68640	BV	67.84	0.72	16.34	2.53	0.02	0.26	1.43	4.77	2.83	0.16	2.42	99.32
R68641	BV	48.62	1.03	17.30	9.20	0.15	6.03	10.10	2.90	0.49	0.25	3.52	99.59
R68642	BV	59.43	1.34	17.10	7.31	0.08	0.78	5.27	4.26	1.45	0.42	2.25	99.69
R68643	BV	53.91	1.27	16.80	11.19	0.18	0.91	7.07	3.32	0.45	0.26	4.46	99.82
R68644	BV	44.41	1.40	17.51	10.27	0.21	1.62	13.09	3.15	0.47	0.29	7.35	99.77
R68645	BV	51.76	1.15	16.62	7.56	0.12	3.09	6.92	3.42	1.53	0.43	6.79	99.39

* = select analysis (see text for discussion); BV = Boggabri Volcanics; UV = unassigned volcanics
Registered numbers are abbreviated in text as #01 to #45 instead of R68601 to R68645
Negative numbers indicate values below detection limit; the detection limit corresponds to the absolute value of the number indicated; na = not available

Table A1.2: Trace Analyses by XRF

Registered No.	Formation	Nb ppm	Zr ppm	Y ppm	Sr ppm	Rb ppm	Th ppm	Pb ppm	As ppm	U ppm	Ga ppm	Zn ppm
R68601	BV	8	286	23	111	18	10	15	na	1	10	29
R68602	BV	8	183	7	2815	46	10	10	na	5	10	28
R68603	BV	6	132	16	1075	15	8	12	na	2	17	82
R68604*	BV	11	230	35	860	95	12	26	na	4	16	60
R68605*	BV	7	327	39	419	70	11	13	na	4	19	67
R68606*	BV	10	301	29	418	25	16	24	na	5	15	40
R68607	BV	6	343	39	265	47	10	23	na	2	17	48
R68608*	BV	7	186	15	590	21	13	20	na	3	13	25
R68609*	BV	7	280	37	513	32	12	11	na	3	17	88
R68610*	BV	5	256	29	653	22	7	7	5	2	18	81
R68611	BV	4	95	18	606	10	2	5	4	3	16	45
R68612*	BV	4	85	15	852	8	4	6	2	4	16	75
R68613*	BV	11	371	43	698	58	11	20	8	4	18	65
R68614	BV	5	89	15	887	6	4	6	2	3	18	69
R68615	BV	7	189	25	908	29	4	10	6	5	19	91
R68616	BV	10	336	34	293	60	9	15	5	4	18	63
R68617	BV	10	354	33	305	65	8	15	6	3	18	52
R68618	BV	8	275	30	270	68	9	19	3	5	17	70
R68619	BV	8	362	37	252	61	13	12	4	3	17	52
R68620	BV	5	211	30	388	15	2	9	10	2	21	112
R68621	UV	6	256	41	526	22	17	21	2	6	20	97
R68622	BV	8	262	24	60	6	10	18	5	4	11	21
R68623	UV	5	210	29	655	31	14	14	5	3	19	89
R68624*	BV	8	237	26	535	44	7	13	7	3	19	68
R68625	BV	11	243	32	771	13	11	16	7	4	17	43
R68626	BV	8	337	40	312	73	9	18	5	3	18	62
R68627	UV	8	260	37	549	29	12	22	3	7	21	79
R68628	BV	9	204	18	97	97	11	20	5	4	16	9
R68629*	BV	9	192	16	663	15	10	19	8	5	13	27
R68630	BV	9	319	29	321	78	9	18	4	2	18	67
R68631	BV	9	210	18	84	84	13	20	3	4	18	18
R68632	BV	10	209	34	61	72	9	13	3	3	16	16
R68633	BV	5	114	19	1827	13	-2	4	5	6	26	88
R68634	BV	7	159	11	84	71	12	17	2	2	10	5
R68635	BV	11	356	35	267	74	11	20	5	3	17	68
R68636	BV	10	362	26	251	64	7	18	11	5	18	107
R68637	BV	10	117	17	47	93	11	16	4	2	13	8
R68638	BV	7	137	16	1425	12	2	8	5	4	18	87
R68639*	BV	5	150	25	735	8	5	7	2	2	18	78
R68640	BV	8	421	31	342	92	22	19	2	6	18	46
R68641	BV	4	82	14	924	11	3	9	1	1	16	75
R68642	BV	7	184	21	743	35	5	12	4	4	19	87
R68643	BV	3	105	15	540	9	3	11	3	3	18	98
R68644	BV	5	110	22	742	7	3	7	2	4	17	74
R68645	BV	11	178	25	784	25	3	8	5	4	18	92

* = select analysis (see text for discussion); BV = Boggabri Volcanics; UV = unassigned volcanics
Registered numbers are abbreviated in text as #01 to #45 instead of R68601 to R68645
Negative numbers indicate values below detection limit; the detection limit corresponds to the absolute value of the number indicated; na = not available

Table A1.2: Trace Analyses by XRF (Cont.)

Registered No.	Formation	Cu ppm	Ni ppm	Mn ppm	Cr ppm	Ce ppm	Nd ppm	Ba ppm	V ppm	La ppm	Sc ppm
R68601	BV	11	9	na	34	45	21	479	5	27	2
R68602	BV	8	8	na	7	32	22	1724	14	24	0
R68603	BV	52	58	na	64	30	21	540	175	22	31
R68604*	BV	4	4	na	2	78	52	1237	8	38	3
R68605*	BV	10	6	na	8	44	35	720	76	26	11
R68606*	BV	3	4	na	8	52	35	934	20	30	4
R68607	BV	10	6	na	9	44	31	562	43	21	9
R68608*	BV	5	4	na	3	34	24	1787	13	21	3
R68609*	BV	29	9	na	17	45	35	456	151	18	17
R68610*	BV	28	45	982	62	40	30	454	131	18	15
R68611	BV	71	59	1291	104	18	15	297	160	13	38
R68612*	BV	61	185	1006	239	19	15	263	183	15	24
R68613*	BV	3	7	524	7	68	48	1431	12	36	4
R68614	BV	84	184	918	235	26	22	283	186	14	24
R68615	BV	43	8	1053	15	45	36	685	208	24	22
R68616	BV	24	10	860	12	48	37	695	106	29	14
R68617	BV	20	7	724	11	55	37	615	75	32	14
R68618	BV	5	5	703	5	48	33	950	47	25	9
R68619	BV	17	9	541	16	49	31	609	85	25	12
R68620	BV	23	8	1098	13	34	31	565	148	17	24
R68621	UV	33	13	954	12	91	58	891	227	51	22
R68622	BV	-2	4	169	2	45	23	161	6	24	1
R68623	UV	31	14	1008	15	71	46	708	225	43	21
R68624*	BV	14	7	769	12	42	27	678	115	26	12
R68625*	BV	2	6	208	10	50	36	2414	10	30	2
R68626	BV	9	7	671	7	48	35	651	59	25	12
R68627	UV	53	26	877	54	101	70	1502	257	53	27
R68628	BV	4	5	9	4	43	25	809	10	26	-1
R68629*	BV	5	4	134	4	-39	22	1781	12	29	2
R68630	BV	7	7	300	4	47	30	715	60	29	8
R68631	BV	5	7	34	4	49	29	759	14	28	3
R68632	BV	5	4	72	1	47	30	802	3	30	2
R68633	BV	24	139	1481	177	26	20	710	234	15	28
R68634	BV	3	4	28	3	34	17	597	7	22	2
R68635	BV	18	9	1047	11	51	34	912	83	32	10
R68636	BV	16	12	420	11	48	33	744	91	27	15
R68637	BV	4	3	16	2	35	21	626	4	20	2
R68638	BV	65	86	927	131	40	30	466	204	22	24
R68639*	BV	54	78	1304	120	38	29	200	216	18	25
R68640	BV	4	6	57	8	69	44	1207	40	35	8
R68641	BV	28	190	1164	217	26	19	274	180	13	25
R68642	BV	65	17	587	17	43	36	574	223	25	19
R68643	BV	56	59	1378	133	17	14	547	94	13	22
R68644	BV	59	108	1632	138	25	21	273	212	14	39
R68645	BV	40	65	967	123	43	35	642	138	25	18

* = select analysis (see text for discussion); BV = Boggabri Volcanics; UV = unassigned volcanics
Registered numbers are abbreviated in text as #01 to #45 instead of R68601 to R68645
Negative numbers indicate values below detection limit; the detection limit corresponds to the absolute value of the number indicated; na = not available

Table A1.3: Trace Elements by INAA

Registered No.	Formation	Sb ppm	As ppm	Ba ppm	Br ppm	Ce ppm	Cs ppm	Cr ppm	Co ppm	Eu ppm	Au ppb
R68601	BV	0.4	-1	510	-2	55	-1	-5	55.1	0.91	13.4
R68602	BV	1.36	17.5	1610	-2	37.3	2.23	-5	35.8	-0.5	7.5
R68603	BV	0.35	7.01	498	-2	38.1	-1	51.7	43.9	1.37	33.6
R68604*	BV	0.72	5.18	1310	-2	97.4	31.6	-5	65	2.05	-5
R68605*	BV	1.09	1.6	664	-2	54.7	2.41	-5	36	2.02	-5
R68606*	BV	1.2	6.61	890	-2	60.8	12.7	-5	71.2	1.1	8.4
R68607	BV	0.35	-1	506	-2	50.6	-1	-5	48.8	1.22	-5
R68608*	BV	0.63	5.17	1910	-2	44.5	19	-5	61.9	-0.5	-5
R68609*	BV	0.56	2.4	421	-2	50.2	4.06	10.6	34.1	2.11	19.8
R68610*	BV	-0.2	3.07	566	-2	42.6	-1	39	51.5	1.6	24.1
R68611	BV	-0.2	2.31	183	-2	21.7	2.2	81.1	50.6	0.9	13.1
R68612*	BV	-0.2	-1	211	-2	24.9	-1	206	91.6	1.09	23.1
R68613*	BV	0.84	3.64	1390	-2	74.6	32.4	-5	71.7	1.6	-5
R68614	BV	-0.2	-1	394	-2	22.7	-1	199	56.9	1.18	12.3
R68615	BV	-0.2	-1	811	-2	43.8	9.56	-5	134	1.73	67.3
R68616	BV	0.64	4.2	708	-2	64.8	-1	-5	26.3	1.88	-5
R68617	BV	0.6	2.52	654	-2	60.5	3.88	-5	190	1.75	40.2
R68618	BV	-0.2	1.75	995	-2	59.1	-1	-5	22.8	1.51	12.6
R68619	BV	-0.2	-1	582	-2	56.8	2.01	11.3	66	1.44	-5
R68620	BV	1.09	9.15	458	-2	33.4	1.47	-5	33.5	1.75	-5
R68621	UV	-0.2	-1	1080	-2	110	-1	-5	33.8	2.63	19.5
R68622	BV	0.94	4.97	336	-2	47.7	-1	-5	79.9	0.5	25
R68623	UV	0.4	-1	763	-2	88.7	-1	-5	46.2	2.07	-5
R68624*	BV	-0.2	3.05	719	-2	49.6	2.83	-5	55.1	1.52	47.6
R68625*	BV	0.79	4.77	2360	-2	68.8	37.5	-5	27.4	0.99	-5
R68626	BV	-0.2	-1	703	-2	54.5	1.22	-5	40.8	1.78	-5
R68627	UV	-0.2	-2	1530	2.46	122	-1	32.4	127	2.61	-10
R68628	BV	0.53	1.5	671	-2	54	-1	-5	48.4	0.71	-5
R68629*	BV	0.71	5.97	1670	2.59	51.1	29.8	-5	63.6	-0.5	26.5
R68630	BV	0.51	-1	544	-2	55.8	2.97	-5	57.5	1.37	57.7
R68631	BV	0.83	-2	628	-2	54.2	-1	-5	186	0.61	68.4
R68632	BV	0.38	-1	736	-2	54.9	1.2	-5	61.5	0.74	35.3
R68633	BV	-0.2	2.85	690	-2	27.4	1.28	158	59	1.67	-5
R68634	BV	0.46	-1	586	-2	36.5	-1	-5	130	0.82	-5
R68635	BV	0.43	3.81	957	2.48	58.4	1.13	-5	67.6	1.05	33.4
R68636	BV	0.7	7.52	751	-2	57.6	-1	-5	47.7	1.5	-5
R68637	BV	0.53	-2	554	-2	42.9	-1	-5	93.7	0.67	11.5
R68638	BV	-0.2	2.7	286	-2	46.4	4.35	107	46	1.67	-5
R68639*	BV	-0.2	2.35	176	2.85	38	2.22	100	71	1.72	-5
R68640	BV	-0.2	-1	1170	-2	81.9	3.44	-5	46.5	1.41	32.6
R68641	BV	0.5	2.24	227	2.45	24.1	2.38	204	68.1	1	-5
R68642	BV	-0.2	-1	425	-2	48.3	1.47	-5	46.1	1.49	14.7
R68643	BV	-0.2	-1	524	-2	21.3	1.87	113	59.8	1.11	15.6
R68644	BV	-0.2	-1	240	-2	28	-1	111	52.8	1.13	-5
R68645	BV	-0.2	3.25	787	-2	49	-1	81.4	69.6	1.8	-5

* = select analysis (see text for discussion); BV = Boggabri Volcanics; UV = unassigned volcanics
Registered numbers are abbreviated in text as #01 to #45 instead of R68601 to R68645
Negative numbers indicate values below detection limit; the detection limit corresponds to the absolute value of the number indicated; na = not available

Table A1.3: Trace Elements by INAA (Cont.)

Registered No.	Formation	Hf ppm	Ir ppb	Fe ₂ O ₃ %	La ppm	Lu ppm	Mo ppm	K ₂ O %	Rb ppm	Sm ppm	Sc ppm
R68601	BV	6.69	-20	1.2	26.9	0.37	-5	1.72	-20	4.21	1.99
R68602	BV	4.57	-20	1.32	21.7	0.24	-5	3.7	52	2.67	2.68
R68603	BV	3.23	-20	4.96	18.8	0.21	-5	1.77	-20	4.74	17.3
R68604*	BV	6.83	-20	0.86	41.5	0.64	-5	3.89	112	9.79	2.76
R68605*	BV	7.13	-20	4.66	27	0.47	-5	2.24	65.5	7.47	11.6
R68606*	BV	7.13	-20	1.4	31.1	0.43	-5	2.17	107	5.55	4.34
R68607	BV	7.64	-20	3.09	23.7	0.56	-5	3.29	42.9	5.88	7.24
R68608*	BV	4.91	-20	0.73	25.1	0.25	-5	4.83	111	3.04	2.31
R68609*	BV	6.31	-20	6.33	23.2	0.51	-5	0.65	29.1	7.03	17.6
R68610*	BV	5.92	-20	7.15	18.5	0.34	-5	1.65	-20	5.87	15.5
R68611	BV	1.83	-20	7.63	8.45	-0.2	-5	-0.24	-20	3.56	23.8
R68612*	BV	1.46	-20	7.71	10.2	0.21	-5	-0.24	-20	3.42	23
R68613*	BV	7.96	-20	1.09	34.7	0.66	-5	1.52	50.9	8.06	4.65
R68614	BV	1.77	-20	7.19	10.4	-0.2	-5	0.86	34.7	3.49	23.9
R68615	BV	4.59	-20	6.99	21.9	0.34	-5	1.13	24.7	5.88	19.4
R68616	BV	7.54	-20	4.72	29	0.53	-5	3.73	35	7.19	13.3
R68617	BV	7.63	-20	5	29.2	0.49	-5	2.12	78.1	6.74	11.5
R68618	BV	6.43	-20	2.5	27.7	0.39	-5	2.37	84.8	5.8	9.8
R68619	BV	8.94	-20	3.52	24.7	0.44	-5	1.2	63.2	6.31	11.2
R68620	BV	4.54	-20	8.86	15.5	0.39	-5	-0.24	-20	5.65	20
R68621	UV	5.42	-20	7.89	55.3	0.51	-5	-0.24	-20	9.38	21.4
R68622	BV	6.45	-20	0.81	23.8	0.38	-5	-0.24	-20	3.86	2.32
R68623	UV	4.94	-20	7.22	43.6	0.33	-5	-0.24	-20	7.84	21.8
R68624*	BV	5.28	-20	4.72	23.4	0.36	-5	1.22	45.2	5.24	12.6
R68625*	BV	6.55	-20	0.79	31.4	0.55	-5	3.89	106	6.09	2.85
R68626	BV	7.16	-20	4.22	24.5	0.48	-5	2.94	45.6	6.53	10.4
R68627	UV	5.81	-20	9.82	59.7	0.41	-5	2.71	-20	10.8	24.1
R68628	BV	5.24	-20	0.31	28.5	0.28	-5	4.52	84.9	3.56	2.65
R68629*	BV	4.31	-20	0.89	23.6	0.23	-5	3.16	89.9	3.41	2.42
R68630	BV	7.24	-20	3.83	25.2	0.4	-5	2.83	104	5.71	8.02
R68631	BV	5.58	-20	0.71	29.1	0.25	-5	4.78	59.5	3.81	2.44
R68632	BV	5.96	-20	0.29	30.3	0.56	-5	2.95	82	5.85	2.13
R68633	BV	3.05	-20	8.76	11.5	0.26	-5	-0.24	-20	4.33	26.7
R68634	BV	3.87	-20	0.2	19	-0.2	-5	3.82	36.3	2.3	1.44
R68635	BV	7.93	-20	4.27	31.2	0.41	-5	1.45	71.9	6.54	10.7
R68636	BV	8.47	-20	3.33	27.4	0.3	-5	2.42	53.8	6.03	11.1
R68637	BV	3.6	-20	0.16	24.2	0.24	-5	4.59	83.5	3.22	1.25
R68638	BV	3.1	-20	7.26	19.5	0.24	-5	-0.24	-20	5.09	22.5
R68639*	BV	2.99	-20	8.55	15.6	0.37	-5	-0.24	-20	5.28	25.5
R68640	BV	8.9	-20	2.2	38.4	0.49	-5	3.04	75.5	7.93	6.81
R68641	BV	1.99	-20	8.16	9.78	0.22	-5	-0.24	-20	3.17	23
R68642	BV	3.93	-20	6.65	22.8	0.21	-5	1.45	50.2	5.9	20.5
R68643	BV	1.8	-20	10.04	10.7	-0.2	-5	1.2	30.6	3.19	14.8
R68644	BV	2.51	-20	9.26	11.4	0.32	-5	-0.24	-20	4.14	24.8
R68645	BV	3.79	-20	6.68	22.1	0.29	-5	1.33	34.5	6.36	15.9

* = select analysis (see text for discussion); BV = Boggabri Volcanics; UV = unassigned volcanics
Registered numbers are abbreviated in text as #01 to #45 instead of R68601 to R68645
Negative numbers indicate values below detection limit; the detection limit corresponds to the absolute value of the number indicated; na = not available

Table A1.3: Trace Elements by INAA (Cont.)

Registered No.	Formation	Se ppm	Ag ppm	Na ₂ O %	Ta ppm	Tb ppm	Th ppm	W ppm	U ppm	Yb ppm	Zn ppm	Field No.
R68601	BV	-5	-5	6.24	1.81	-1	4.69	522	-2	2.57	-100	91/B002
R68602	BV	-5	-5	1.13	-1	-1	6.69	265	-2	1.61	-100	91/B003
R68603	BV	-5	-5	3.68	-1	-1	1.93	189	-2	1.5	166	91/B021
R68604*	BV	-5	-5	2.67	2.09	1.66	7.05	329	-2	4.37	118	91/B067
R68605*	BV	-5	-5	5.42	-1	1.18	7.33	281	-2	3.68	154	91/B071
R68606*	BV	-5	-5	5.11	1.96	1	10.8	535	-2	2.89	-100	91/B075
R68607	BV	-5	-5	5.07	-1	1.05	4.97	396	-2	3.97	108	90/B005
R68608*	BV	-5	-5	1.83	1.16	-1	9.33	452	-2	1.73	-100	90/B065B
R68609*	BV	-5	-5	4.84	1.32	1.22	6.19	134	-2	3.76	245	90/B098
R68610*	BV	-5	-5	4.34	1.46	1.06	2.7	215	-2	2.76	159	90/B031
R68611	BV	-5	-5	3.65	1.49	-1	-0.5	228	-2	1.4	134	91/B062
R68612*	BV	-5	-5	2.92	1.59	-1	1.08	379	-2	1.47	150	91/B135
R68613*	BV	-5	-5	4.66	2.56	1.3	6.4	509	-2	4.46	158	91/B138A
R68614	BV	-5	-5	3.05	-1	-1	1.14	130	-2	1.31	161	91/B144
R68615	BV	-5	-5	4.27	1.8	1.01	3.02	929	-2	2.55	162	91/B164
R68616	BV	-5	-5	4.19	2.33	1.2	4.54	132	-2	3.52	153	90/F001
R68617	BV	-5	-5	3.68	-1	1.16	5.66	1530	-2	3.38	-100	90/F028
R68618	BV	-5	-5	5	1.94	1	6.4	186	-2	2.89	104	90/F056
R68619	BV	-5	-5	4.92	1.83	-1	8.2	497	-2	3.25	114	90/F113
R68620	BV	-5	-5	5.22	-1	1.01	2.39	102	-2	2.92	179	90/F127
R68621	UV	-5	-5	5.09	-1	1.35	13.8	120	-2	3.7	203	90/F225
R68622	BV	-5	-5	6.69	-1	-1	7.13	699	2.69	2.86	113	90/F229
R68623	UV	-5	-5	4.35	-1	1.12	10.1	185	-2	2.77	191	90/F239
R68624*	BV	-5	-5	4.66	-1	-1	4.07	334	-2	2.55	157	90/F282
R68625*	BV	-5	-5	2.47	-1	1.01	6.84	170	-2	3.76	108	90/F288
R68626	BV	-5	-5	5.04	1.56	1.1	7.67	298	-2	3.68	113	90/F297
R68627	UV	-5	-10	4.83	2.84	1.5	9.7	795	-2	3.29	143	90/F300
R68628	BV	-5	-5	3.06	-1	-1	10.2	357	-2	2.01	-100	91/B013A
R68629*	BV	-5	-5	2.39	2.31	-1	8.85	422	-2	1.71	-100	91/B014A
R68630	BV	-5	-5	4.57	2.06	-1	5.18	422	-2	3.07	150	91/B016
R68631	BV	-5	-5	3.48	-1	-1	9.79	1480	-2	1.79	-100	91/B029
R68632	BV	-5	-5	4.04	-1	1.02	6.74	480	-2	3.69	-100	91/B038
R68633	BV	-5	-5	4.04	-1	-1	-0.5	168	-2	2.02	168	91/B044A
R68634	BV	-5	-5	3.09	1.14	-1	8.05	1130	-2	1.26	-100	90/B056
R68635	BV	-5	-5	5.11	1.8	-1	7.44	452	3.76	2.85	141	90/E063
R68636	BV	-5	-5	4.42	1.42	-1	6.7	319	-2	2.34	162	90/E069
R68637	BV	-5	-5	3.22	1.46	-1	9.1	751	2.27	1.7	-100	90/E090
R68638	BV	-5	-5	3.37	-1	-1	1.06	116	-2	1.76	161	90/F045
R68639*	BV	-5	-5	3.65	-1	-1	1.33	225	-2	2.58	162	90/F081B
R68640	BV	-5	-5	4.73	1.59	1.17	18.3	346	-2	3.27	-100	90/F182
R68641	BV	-5	-5	2.91	-1	-1	-0.5	192	2.57	1.68	141	90/B177
R68642	BV	-5	-5	4.33	-1	-1	3.5	159	-2	1.8	148	91/B187
R68643	BV	-5	-5	3.25	-1	-1	0.55	215	-2	1.36	174	91/B179
R68644	BV	-5	-5	3.09	1.73	-1	0.99	113	-2	2.29	145	91/B203
R68645	BV	-5	-5	3.4	2.19	1.01	1.25	345	-2	2.2	154	91/B233

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Registered numbers are abbreviated in text as #01 to #45 instead of R68601 to R68645
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Table 1.4 — Registered Samples and Sampling Locations

Reg. No.	Field No.	Grid mE	Ref.* mN	Lithology	Rock Unit	Rock Anal.?	Probe Data?
68600	90/E098	217250	6607450	Quartz-biotite rhyolite lava (spherulitic)	BV		
68601	91/B002	213450	6610050	Leucocratic pyroxene rhyolite lava (silicified)	BV	Y	
68602	91/B003	213350	6609950	Leucocratic pyroxene rhyolite ignimbrite (silicified)	BV	Y	
68603	91/B021	785020	6611400	Basaltic andesite lava (carbonated)	BV	Y	
68604*	91/B067	216100	6603450	Biotite rhyolite lava (pitchstone)	BV	Y	
68605*	91/B071A	215550	6607700	Enstatite dacite lava (perlitic)	BV	Y	Y
68606*	91/B075A	215000	6607550	Melanocratic enstatite rhyolite (pitchstone)	BV	Y	Y
68607	90/B005	225500	6599050	Enstatite dacite lava (carbonated)	BV	Y	
68608*	90/B065A	225250	6607400	Leucocratic pyroxene rhyolite lava (pitchstone)	BV	Y	
68609*	90/B098	223950	6608950	Olivine-free andesite lava	BV	Y	Y
68610*	90/B031	221470	6599230	Olivine andesite lava	BV	Y	Y
68611	91/B062	215500	6604550	Olivine-poor basalt lava (carbonated)	BV	Y	
68612*	91/B135	213250	6607250	Olivine basalt lava	BV	Y	Y
68613*	91/B138A	213600	6606850	Leucocratic pyroxene rhyolite ignimbrite (vitrophyre)	BV	Y	Y
68614	91/B144	212450	6607000	Olivine basalt lava	BV	Y	
68615	91/B164	214140	6604170	Olivine-free andesite lava	BV	Y	Y
68616	90/F001	216930	6609450	Dacite lava (altered)	BV	Y	
68617	90/F028	217650	6608950	Dacite lava (altered)	BV	Y	
68618	90/F056	220640	6610840	Enstatite dacite lava (silicified)	BV	Y	
68619	90/F113	216350	6617550	Dacite lava?	BV	Y	
68620	90/F127	218600	6615730	Olivine-free andesite lava (ferruginised)	BV	Y	
68621	90/F225	221270	6614500	Benmoreite lava (altered)	UV	Y	
68622	90/F229	221050	6613550	Leucocratic pyroxene rhyolite ignimbrite? (silicified)	BV	Y	
68623	90/F239	222300	6611550	Mugearite lava (altered)	UV	Y	
68624*	90/F282	215650	6707300	Augite dacite lava (vitrophyre)	BV	Y	Y
68625*	90/F288	216700	6602600	Biotite rhyolite ignimbrite vitrophyre (pitchstone)	BV	Y	
68626	90/F297	221800	6612100	Enstatite? dacite lava (altered)	BV	Y	
68627	90/F300	222450	6613700	Hawaiite lava (altered)	UV	Y	
68628	91/B013A	785120	6611700	Leucocratic pyroxene rhyolite lava (white)	BV	Y	
68629*	91/B014A	785220	6611740	Leucocratic pyroxene rhyolite lava (pitchstone)	BV	Y	Y
68630	91/B016	784980	6611700	Augite? dacite lava (silicified)	BV	Y	
68631	91/B029	785000	6611100	Leucocratic pyroxene rhyolite lava (silicified)	BV	Y	
68632	91/B038	784720	6608800	Biotite rhyolite lava (white)	BV	Y	
68633	91/B044A	216300	6604500	Olivine-poor basalt lava (zeolitised)	BV	Y	
68634	90/B056	225400	6609900	Leucocratic pyroxene rhyolite lava (white)	BV	Y	
68635	90/E063	217580	6607450	Augite dacite lava (altered)	BV	Y	
68636	90/E069	217480	6707300	Augite? dacite lava (altered)	BV	Y	
68637	90/E090	221350	6605050	Leucocratic pyroxene rhyolite lava (white)	BV	Y	
68638	90/F045	221960	6609950	Olivine-poor basalt lava (carbonated)	BV	Y	
68639*	90/F081E	217900	6615900	Olivine-poor basalt lava	BV	Y	Y
68640	90/F182	220000	6617250	Enstatite? dacite lava (leached)	BV	Y	
68641	91/B177	787500	6604750	Olivine basalt lava (altered)	BV	Y	
68642	91/B187	213150	6606220	Olivine-free andesite lava (altered)	BV	Y	
68643	91/B179	787150	6605450	Olivine-poor basalt lava (silicified)	BV	Y	
68644	91/B203	212500	6704150	Olivine-poor basalt lava (carbonated)	BV	Y	
68645	91/B223	223900	6618600	Basaltic andesite lava (silicified)	BV	Y	
68646	90/F059	216900	6614040	Olivine basalt lava	BV		Y
68647	90/F032	217550	6609600	Augite dacite lava	BV		Y
68648	91/B061	214940	6604650	Biotite rhyolite lava (white)	BV		Y
68649	91/B105	214180	6606900	Olivine-free andesite lava	BV		Y

BV = Boggabri Volcanics; UV = unassigned volcanics; * = Australian Map Grid References for Zones 55 and 56.
 * = select analysis (see text for discussion);