

APPENDIX 5

EL 8883 BLUEBUSH

Groundwater Geochemistry
CSIRO Report 16.10.02

Exploration Implications from Geochemistry of Groundwaters from Bluebush RC Drill Holes.



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Summary

- Groundwaters from RC drill holes provide information from 2 new locations outside the gravity anomaly and also illustrate groundwater variations at closer spatial densities at 2 previously sampled locations including that sampled by diamond drilled groundwaters GRW 4 and 5.
- Major constituent variation in RC drill hole groundwaters indicates that groundwaters from BBRC7, 8, 9, 12 and 19 have lesser relative concentrations of Mg and Ca, than others in this sample group. The first 3 of these locations indicate a new zone in addition to the previously indicated central zone of rocks that are more felsic/less mafic than those that surround them. The felsic/mafic contrast between BBRC12 and 19 groundwaters and other RC groundwaters in this immediate region support the presence of the sharp geochemical boundary previously illustrated between GR6/GRW3 and GRW4 and 5.
- Statistical clustering of all sampled locations (including the new RC drill holes), on the basis of groundwater concentrations of a suite of major and trace constituents, delineates discrete zones that apart from GR3, GR13 and RC holes 7, 8 and 9, coincide with the general zone of high residual gravity. This clustering may constitute a groundwater geochemical signature for the source of the gravity anomaly. Allocations between clusters, derived from the compositions of groundwaters from RC holes 12 - 18 support the apparent geochemical boundary exhibited between diamond drill holes GRW3 and GRW4,5.
- In this increased data set, although Sc still correlates overall at 95% confidence with NMg, the correlation is not uniform suggesting more than one rock type as the sources of Sc. For example elevated Sc in groundwaters from the new RC holes in the NW is accompanied by low NMg and elevated U, Mo and F, a combination suggesting granites, pegmatites etc rather than rocks high in ferromagnesian minerals. This implies that the statistical cluster reflects more than one felsic rock type.
- Although ore element concentrations are unremarkable in RC drill hole groundwaters, Cu and Pb concentrations in BBRC7 and 13 and Zn concentrations in BBRC13 were sufficiently high to indicate saturation of groundwater from BBRC13 with Cu, Pb and Zn oxidised ore minerals and BBRC7 with Cu and Pb oxidised ore minerals
- All groundwaters from RC drill holes contained modest concentrations of arsenic that are too low to indicate proximity to sulphide minerals, but do not exclude possibly deep or further distant sources.
- Groundwaters from the RC drilling plotted on the relevant mineral stability field diagram, fit the same trend as the groundwaters from previous programs. Groundwaters in the new area of BBRC5 and 6 are equilibrated with kaolinite, in the area of BBRC19 with phengite whilst the rest are equilibrated with muscovite.

Groundwater Analyses

Bluebush RC Drill Holes

Bluebush RC Drill Hole Groundwater Data (page 1)

Sample No.	Type	Water Table	Sample Depth	AMG Zone	Grid East	Grid North	Temp (C)	pH	Eh mV	Ca mg/l	Mg mg/l
BBRC-005	DH	9.1	20	53	368005	7820005	30.4	4.42	592	44	35
BBRC-006	DH	6.2	20	53	368000	7819000	31	5.97	610	31	28
BBRC-007	DH	8	18	53	372200	7824500	27.1	6.80	920	13	18
BBRC-008	DH	7.5	18	53	372200	7825000	29.5	6.92	559	15	22
BBRC-009	DH	7.7	11	53	370900	7824900	30.1	6.84	246	7	8
BBRC-010	DH	4.5	14	53	380960	7819060	30.2	6.34	483	44	38
BBRC-011	DH	8.5	18	53	378500	7812500	31	6.29	1170	53	41
BBRC-012	DH	6	16	53	377000	7805500	31.6	6.67	228	25	21
BBRC-013	DH	5.7	16	53	378150	7805500	30.7	7.31	911	46	39
BBRC-014	DH	5.9	16	53	379000	7805150	30.5	7.05	302	39	29
BBRC-015	DH	5.8	16	53	380025	7805305	31.4	6.54	402	32	17
BBRC-016	DH	5.6	16	53	380225	7805105	31.1	6.75	298	30	23
BBRC-017	DH	5.7	16	53	380025	7804605	32.4	6.62	542	43	24
BBRC-018	DH	5.9	16	53	379825	7805105	32.5	6.76	482	29	22
BBRC-019	DH	8.3	10	53	382900	7806000	30.1	7.64	420	35	98

Sample No.	Na mg/l	K mg/l	Cl mg/l	SO4 mg/l	HCO3 mg/l	Cu ug/l	Pb ug/l	Zn mg/l	F mg/l	U ug/l	Al mg/l
BBRC-005	21	24	20	9	140	0.8	0.05	-0.03	1.0	4.4	0.037
BBRC-006	70	46	50	22	155	1.2	0.04	-0.03	1.8	5.7	0.021
BBRC-007	358	65	235	104	275	4.6	0.39	-0.03	2.2	23.0	0.103
BBRC-008	492	84	275	144	390	4.2	0.32	-0.03	3.7	30.3	0.185
BBRC-009	312	32	195	82	180	1.0	0.01	-0.03	3.6	11.9	0.077
BBRC-010	131	37	140	69	165	0.9	0.29	-0.03	2.2	9.6	0.041
BBRC-011	150	33	155	79	195	2.4	0.11	-0.03	1.7	9.1	0.014
BBRC-012	205	35	130	102	155	1.9	0.21	-0.03	2.2	5.5	0.048
BBRC-013	332	49	240	186	265	3.4	0.34	-0.03	1.7	13.0	0.034
BBRC-014	260	39	205	123	210	2.8	0.32	-0.03	1.3	6.6	0.018
BBRC-015	64	25	20	19	125	0.8	0.04	-0.03	1.1	3.8	0.092
BBRC-016	59	44	30	23	140	1.0	0.03	-0.03	1.0	4.0	0.042
BBRC-017	24	32	15	12	125	0.8	0.06	-0.03	1.0	3.5	0.099
BBRC-018	75	38	40	27	140	0.8	0.01	-0.03	1.5	3.7	0.113
BBRC-019	1571	141	1800	918	435	11.2	1.10	-0.03	3.0	302.8	0.009

Bluebush RC Drill Hole Groundwater Data (page 2)

Sample	Fe	Ti	Mn	B	P	Ag	Ba	Be	Cd	Co	Cr
No.	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	ug/l	ug/l	ug/l
BBRC-005	0.008	-0.002	-0.002	0.151	-0.05	-1	0.227	-0.002	0.03	0.040	1.32
BBRC-006	-0.005	-0.002	0.006	0.313	-0.05	-1	0.081	-0.002	0.04	0.044	4.84
BBRC-007	-0.005	0.004	-0.002	0.931	0.06	-1	0.087	-0.002	-0.01	0.085	8.21
BBRC-008	0.013	0.004	-0.002	1.50	0.09	-1	0.044	-0.002	0.04	-0.066	5.79
BBRC-009	0.007	0.004	-0.002	0.898	0.06	-1	0.046	-0.002	-0.04	-0.033	10.69
BBRC-010	0.011	-0.002	-0.002	0.412	-0.05	-1	0.071	-0.002	-0.06	-0.033	2.20
BBRC-011	-0.005	-0.002	-0.002	0.442	-0.05	-1	0.076	-0.002	0.09	0.059	2.44
BBRC-012	0.032	0.003	-0.002	0.420	0.07	-1	0.114	-0.002	0.04	0.053	5.63
BBRC-013	0.028	-0.002	-0.002	0.567	0.05	-1	0.050	-0.002	0.12	0.095	5.57
BBRC-014	0.010	-0.002	-0.002	0.498	-0.05	-1	0.058	-0.002	0.03	0.068	4.24
BBRC-015	0.034	0.003	-0.002	0.251	-0.05	-1	0.162	-0.002	0.03	0.036	2.60
BBRC-016	0.020	-0.002	-0.002	0.262	0.06	-1	0.344	-0.002	0.01	0.064	4.01
BBRC-017	-0.005	0.002	-0.002	0.160	-0.05	-1	0.257	-0.002	0.01	0.031	1.23
BBRC-018	0.017	0.005	-0.002	0.323	-0.05	-1	0.194	-0.002	0.02	0.035	1.42
BBRC-019	-0.005	-0.002	0.003	5.27	0.23	-1	0.015	-0.002	0.40	0.217	5.24

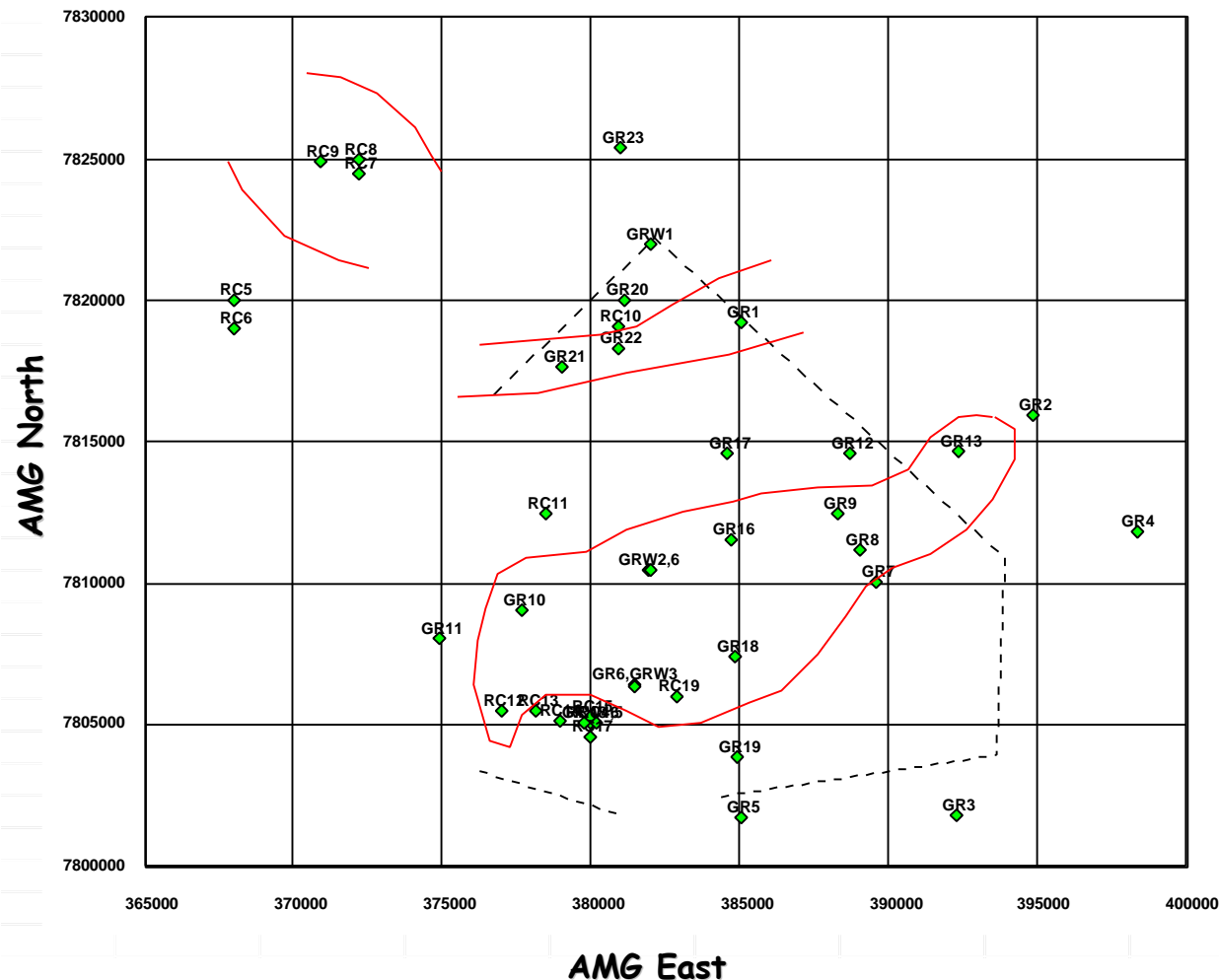
Sample	La	Mo	Sc	Sr	Y	Ni	Yb	As	Li	Si	Au
No.	ug/l	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	mg/l	mg/l	ng/l
BBRC-005	0.042	1.73	14.86	0.677	0.04	0.96	-0.008	0.3	-0.005	38	0.1
BBRC-006	0.007	3.94	9.89	0.483	0.02	1.36	-0.008	0.1	-0.005	29	2.3
BBRC-007	0.085	4.94	11.59	0.351	0.04	0.83	-0.024	1.5	-0.005	33	0.1
BBRC-008	0.067	7.73	11.96	0.470	0.07	0.70	-0.007	2.0	-0.005	30	2.9
BBRC-009	0.008	13.04	10.05	0.127	0.01	0.41	-0.016	1.1	-0.005	25	4.0
BBRC-010	0.014	2.34	14.50	0.626	0.02	0.50	-0.016	1.0	-0.005	38	4.2
BBRC-011	0.014	1.53	14.72	0.773	0.03	0.16	-0.016	1.0	-0.005	34	0.1
BBRC-012	0.026	4.91	11.92	0.391	0.04	0.15	-0.016	0.9	-0.005	29	0.1
BBRC-013	0.035	1.65	13.61	0.705	0.03	0.18	0.006	1.0	-0.005	33	0.1
BBRC-014	0.013	2.77	16.37	0.607	0.12	0.21	-0.016	1.5	-0.005	39	0.1
BBRC-015	0.026	1.39	12.64	0.355	0.04	0.37	-0.008	1.0	-0.005	34	0.1
BBRC-016	0.044	0.80	11.98	0.464	0.01	0.30	-0.008	1.8	-0.005	34	0.1
BBRC-017	0.049	0.35	15.28	0.524	0.02	0.26	-0.008	1.4	-0.005	44	0.1
BBRC-018	0.032	3.62	14.11	0.428	0.02	0.42	-0.008	1.5	-0.005	34	0.1
BBRC-019	-0.038	29.66	15.46	1.44	0.14	1.44	-0.080	1.3	-0.005	36	0.1

Bluebush RC Drill Hole Groundwater Data (page 3)

No.	V	Sb	Bi	Th	Rb	Cs	Tl	Ga	Ge	Tb
	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
BBRC-005	0.015	0.05	0.004	0.012	17.7	0.20	0.013	0.023	-0.14	0.007
BBRC-006	0.026	0.21	0.009	0.013	20.2	0.32	0.015	0.017	-0.14	0.005
BBRC-007	0.039	0.06	0.031	0.026	23.0	0.25	0.030	-0.027	-0.52	0.008
BBRC-008	0.049	0.05	0.008	0.017	25.1	0.23	0.032	0.052	-0.64	0.010
BBRC-009	0.040	-0.02	-0.006	0.018	13.6	0.13	0.009	-0.018	-0.28	-0.002
BBRC-010	0.036	-0.02	-0.006	-0.006	29.0	0.17	-0.006	-0.018	-0.28	-0.002
BBRC-011	0.020	0.03	-0.006	0.012	29.5	0.15	0.022	-0.018	0.32	0.004
BBRC-012	0.020	-0.02	-0.006	0.011	19.7	0.22	0.010	0.018	-0.28	0.002
BBRC-013	0.026	-0.04	-0.009	-0.009	25.8	0.55	0.009	-0.027	-0.52	-0.003
BBRC-014	0.033	0.02	-0.006	-0.006	21.9	0.44	0.011	-0.018	-0.28	-0.002
BBRC-015	0.024	0.02	-0.003	0.010	15.4	0.34	0.010	0.011	0.14	-0.001
BBRC-016	0.028	0.02	-0.003	0.004	23.1	0.73	0.014	0.016	0.19	-0.001
BBRC-017	0.052	0.03	-0.003	0.011	19.3	0.44	0.007	0.018	-0.14	-0.001
BBRC-018	0.022	0.06	-0.003	0.015	24.4	0.53	0.009	0.023	-0.14	0.003
BBRC-019	0.019	-0.10	0.098	-0.030	104.7	0.78	0.076	0.017	-1.40	0.014

Statistical Clustering

Locations grouped by
groundwater chemical
components.



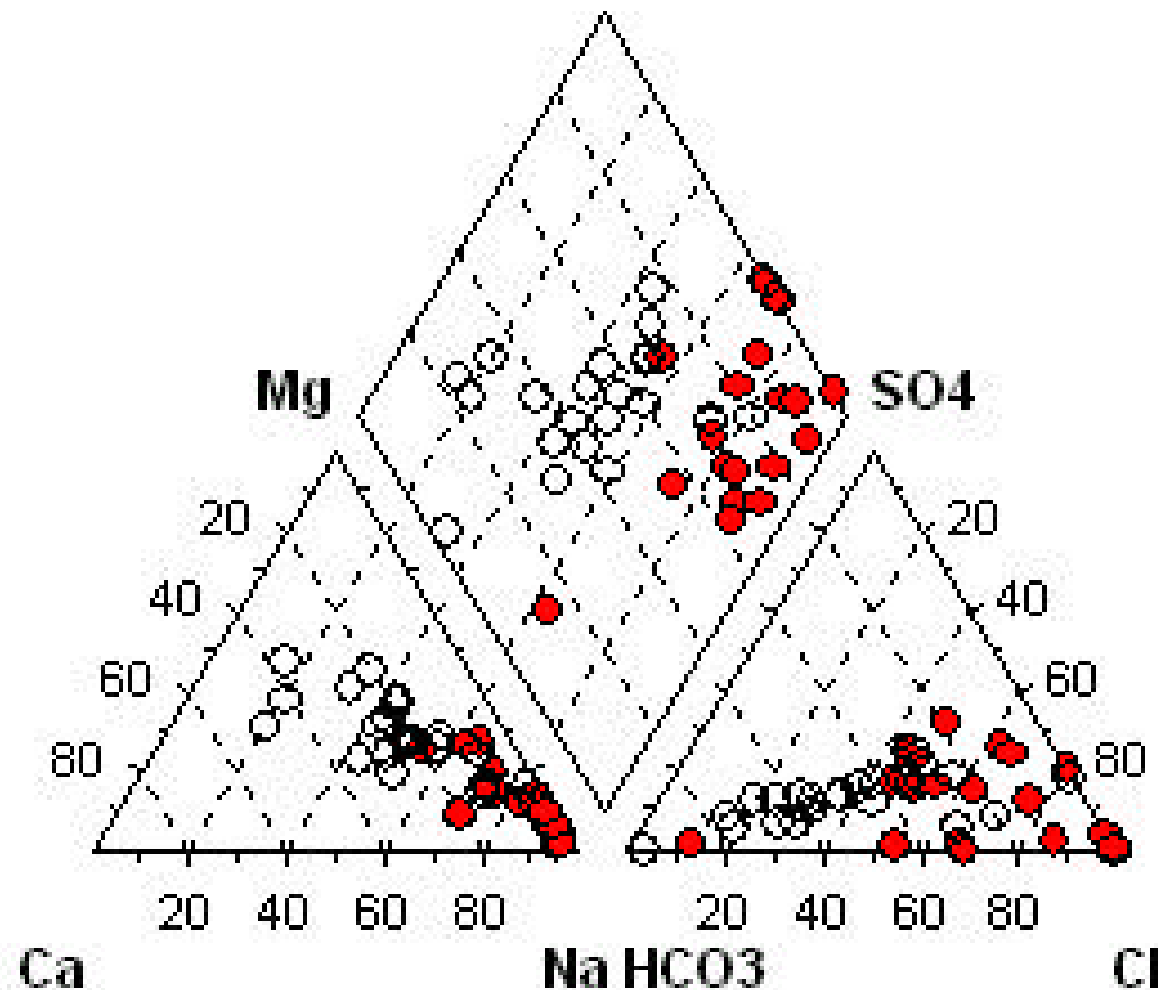
Groundwaters from locations within red lines fit into a statistical cluster (A) that was calculated from concentrations of trace elements and normalised majors. Apart from GR3, GR13 and RC holes 7, 8 and 9, clustered locations all coincide with discrete zones of high residual gravity. This clustering may constitute a groundwater geochemical signature for the source of the gravity anomaly in the Bluebush project region. Note that diamond drill holes represented by GRW1,2 and 6 fit in this cluster but that represented by GRW4 and 5 does not. Composition of groundwaters from RC holes 12 – 18 support this apparent geochemical boundary.

Analysed variables used for clustering - Cu, Pb, Zn, U, Al, Fe, Mn, Ba, Co, Sr, Ni, As, Li, Si, V, Rb, Cs, NCa, NMg, NK, NSO₄, Sc, F, Au, Mo and Ge.

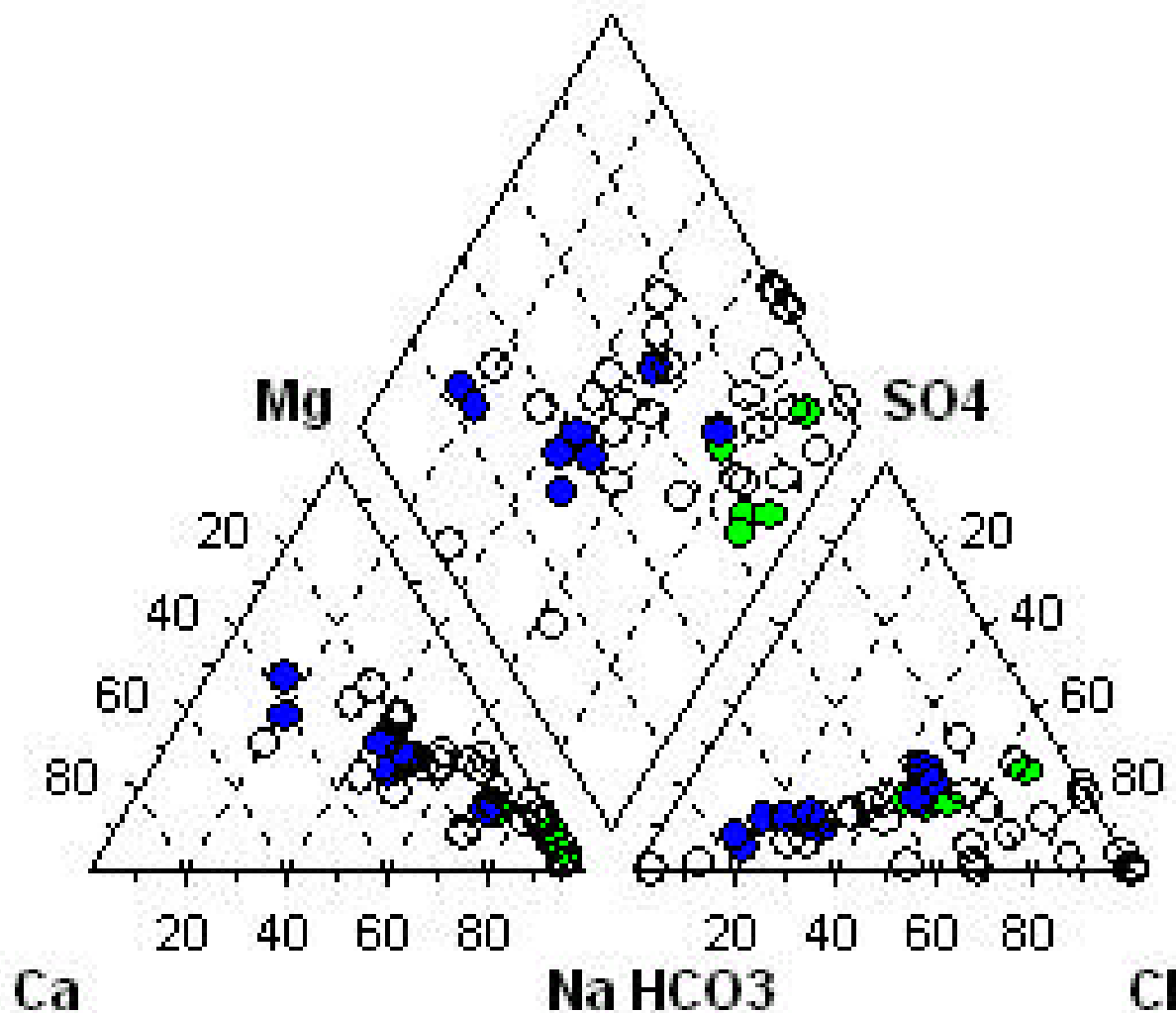
Clustering procedure was k-means clustering of Principal Component scores 1,2,3 and 4.

Characteristics of Aquifer Rocks

Identified from major groundwater components - Ca, Mg, Na, K, Cl, SO₄ and carbonate

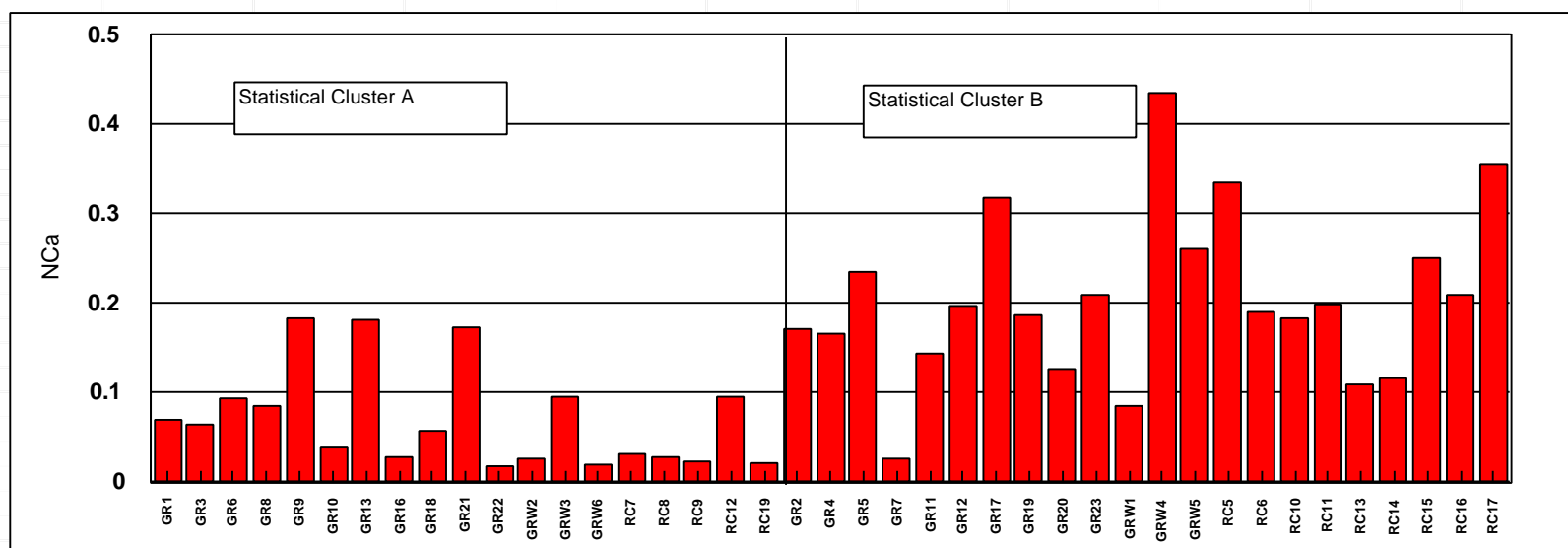
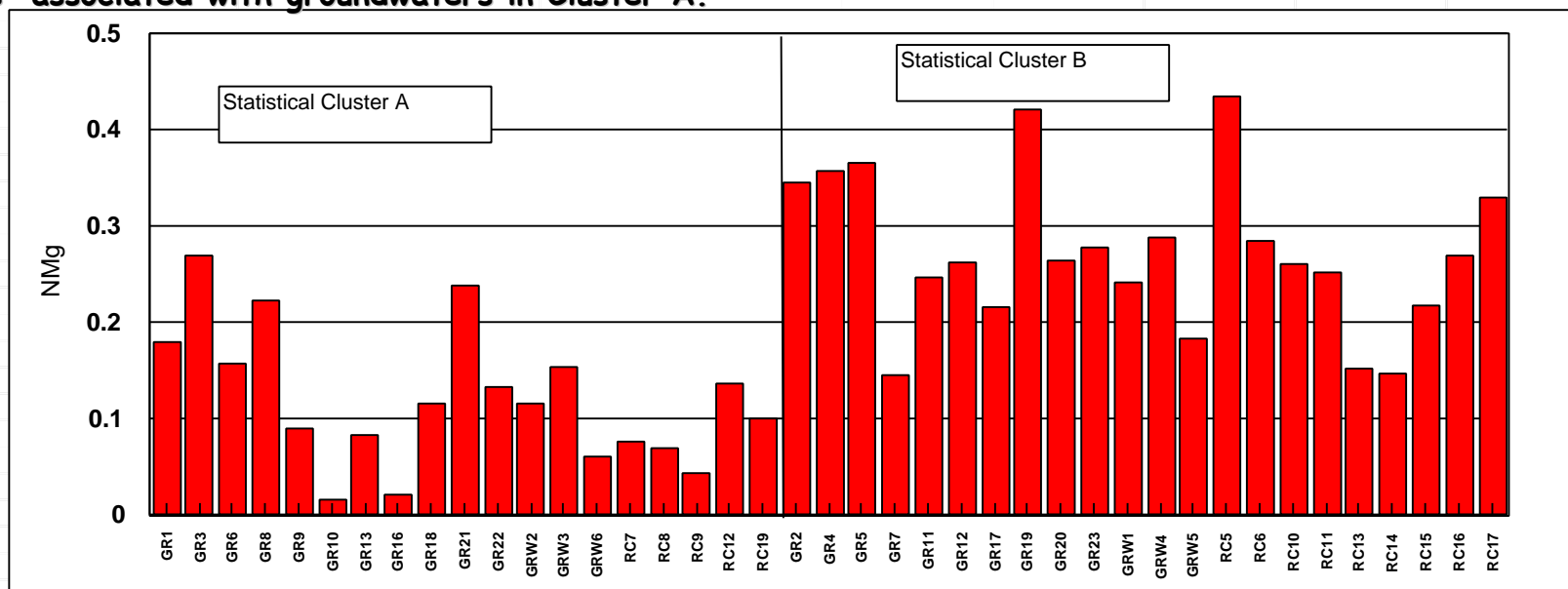


All groundwater samples from Bluebush collections plotted on a major element diagram that illustrates grouping in terms of major element composition, and hence aquifer rock types. Those shown in red are from the statistical cluster (A) that coincides most closely with zones of high residual gravity.

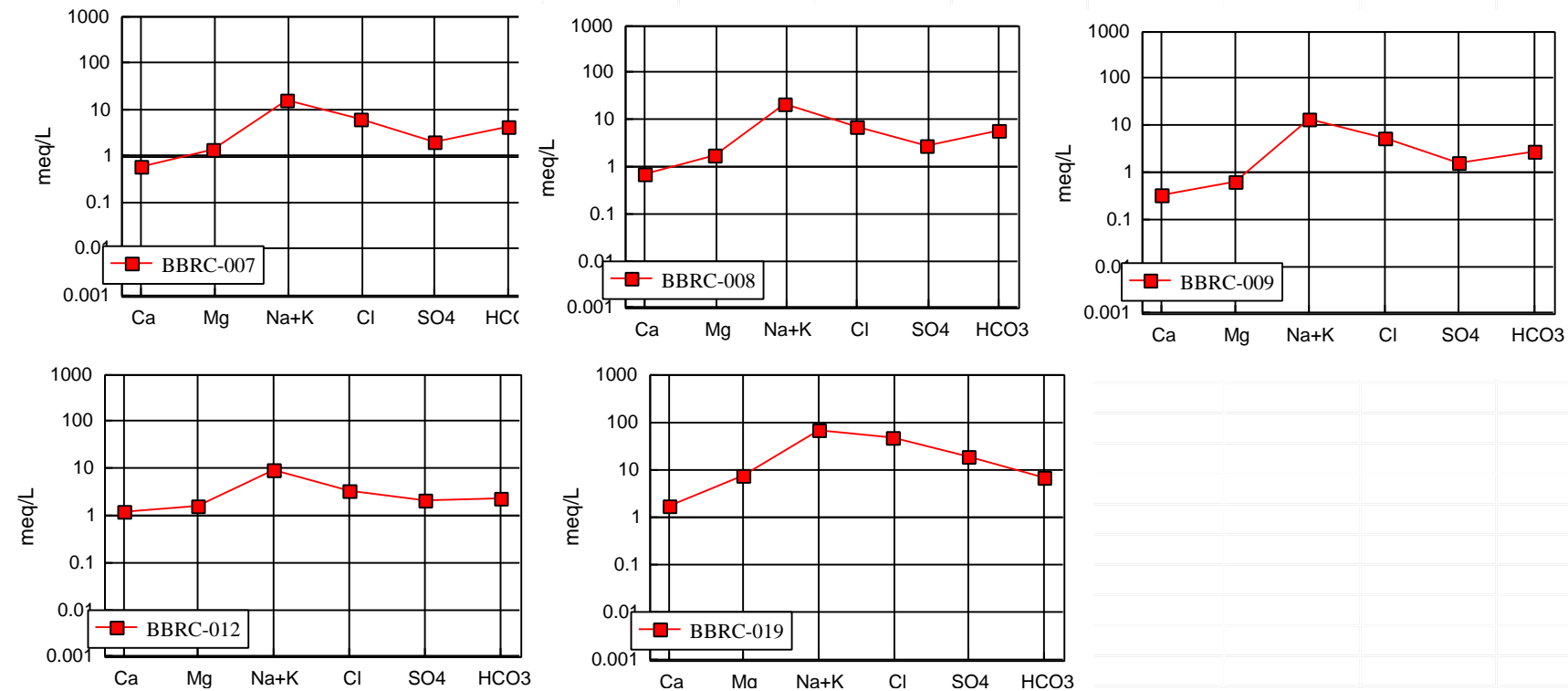


Major element composition of groundwaters from the RC drilling (blue and green) are plotted with samples from previous programs. Those that geochemically fit with samples from the statistical cluster (A) that coincides most closely with zones of high residual gravity are shown in green.

NMg and NCa are the relative proportions of total major cations, (Ca, Mg, Na, K) contributed by Mg and Ca respectively. Because NMg and NCa are higher in groundwaters from mafic rocks than for those from felsic rocks, it is apparent that groundwaters in Cluster B derive from rocks that are more mafic than are the rocks associated with groundwaters in Cluster A.

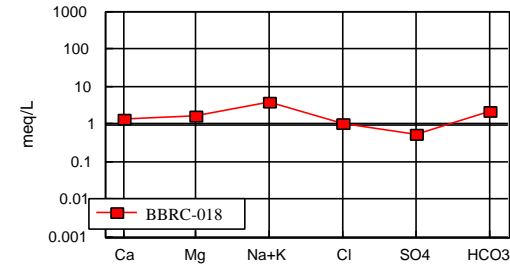
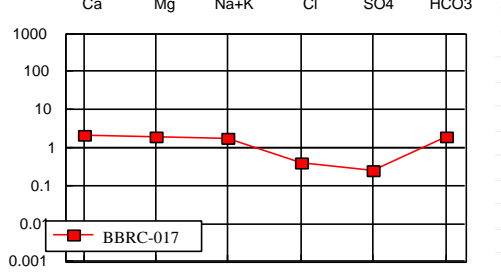
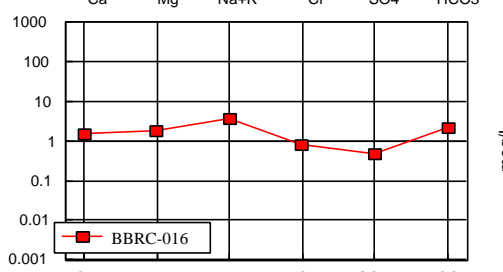
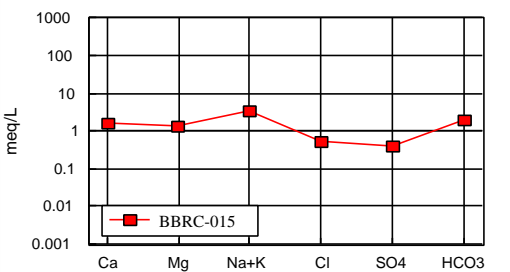
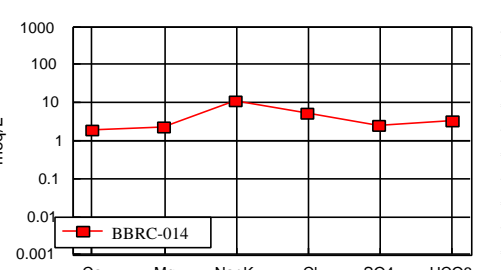
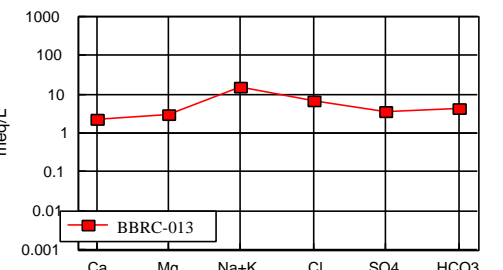
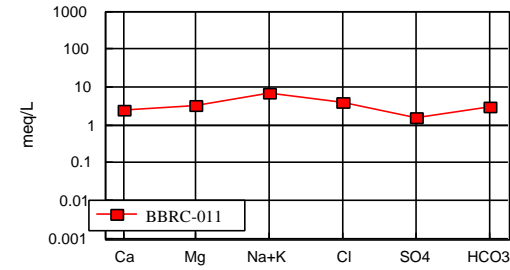
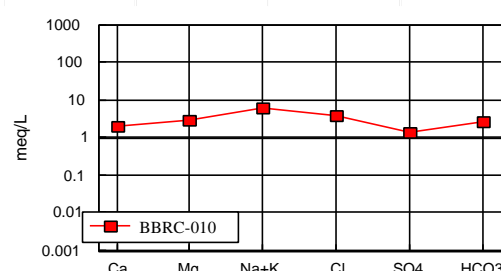
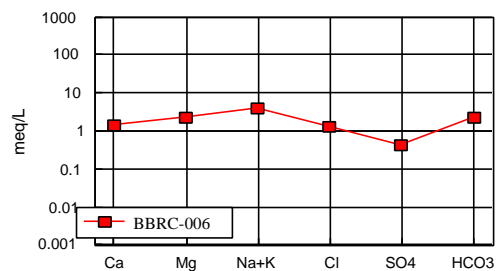
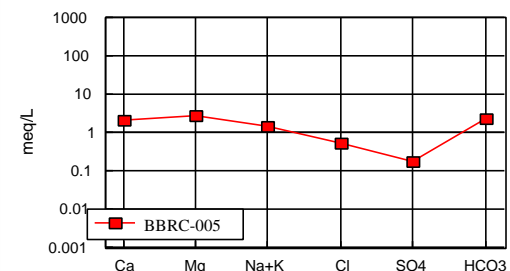
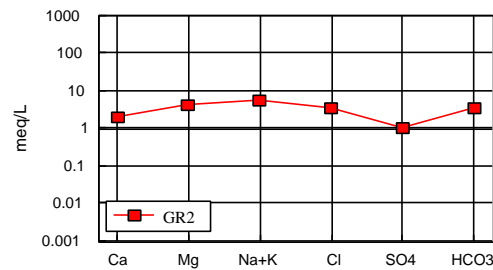
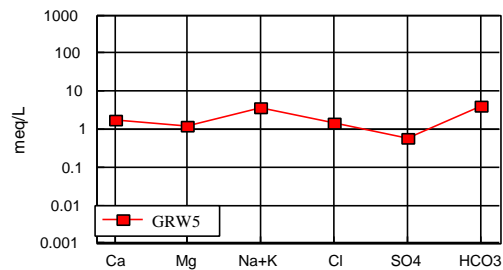
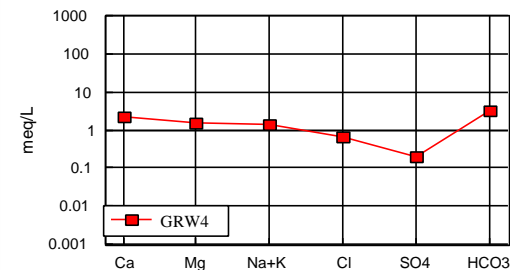


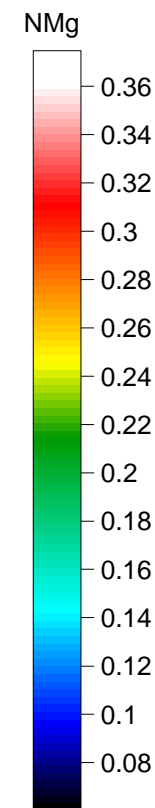
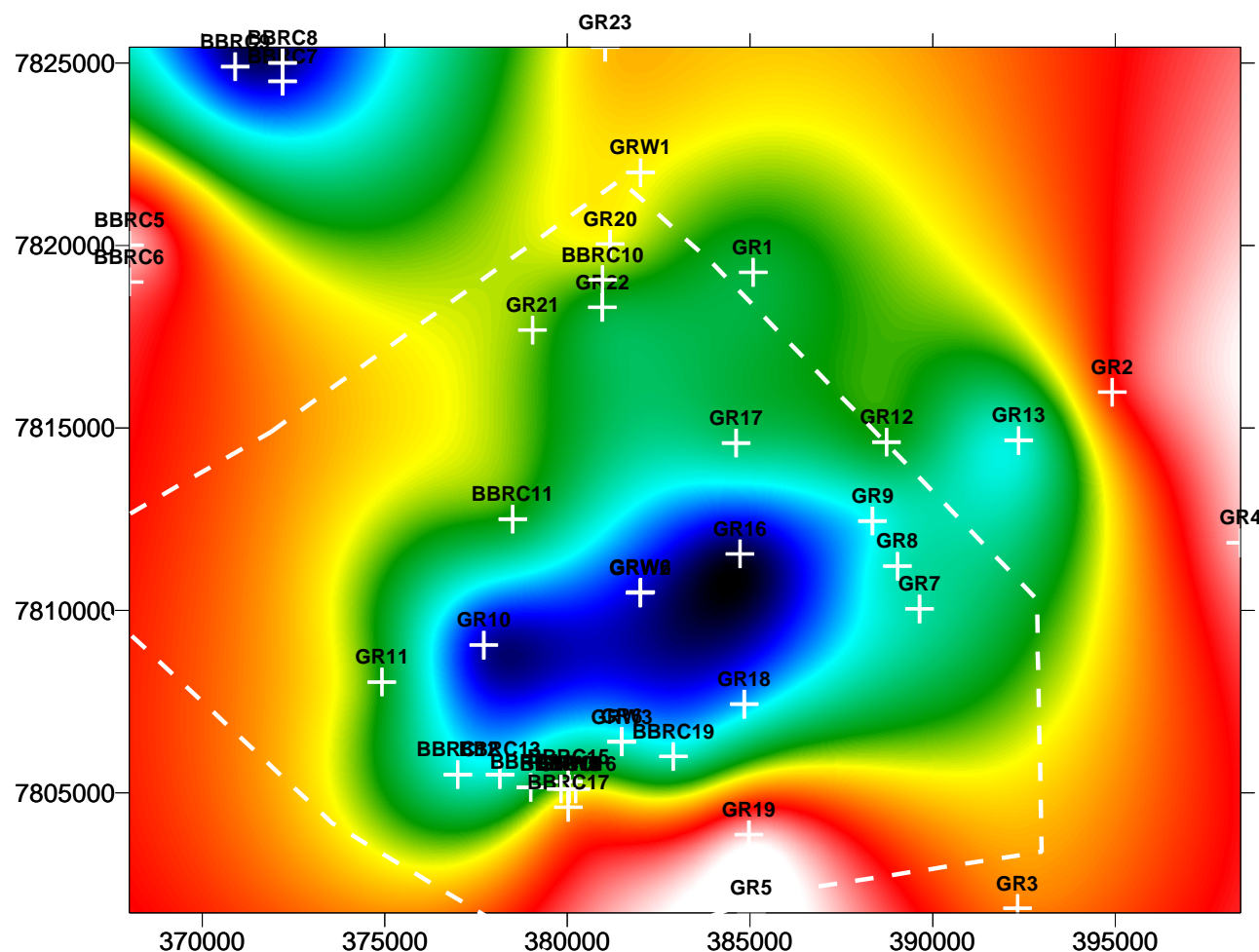
Major element composition plots of groundwaters from RC drill holes that geochemically fit with samples from the statistical cluster (A). Locations of these groundwaters coincide most closely with zones of high residual gravity. In these groundwaters Ca and Mg are less dominant than Na and K.



Major element composition plots of groundwaters from cluster B, i.e. those that do NOT cluster with samples that coincide most closely with zones of high residual gravity.

All patterns reflect significant mafic rock contributions of Ca and Mg to groundwaters

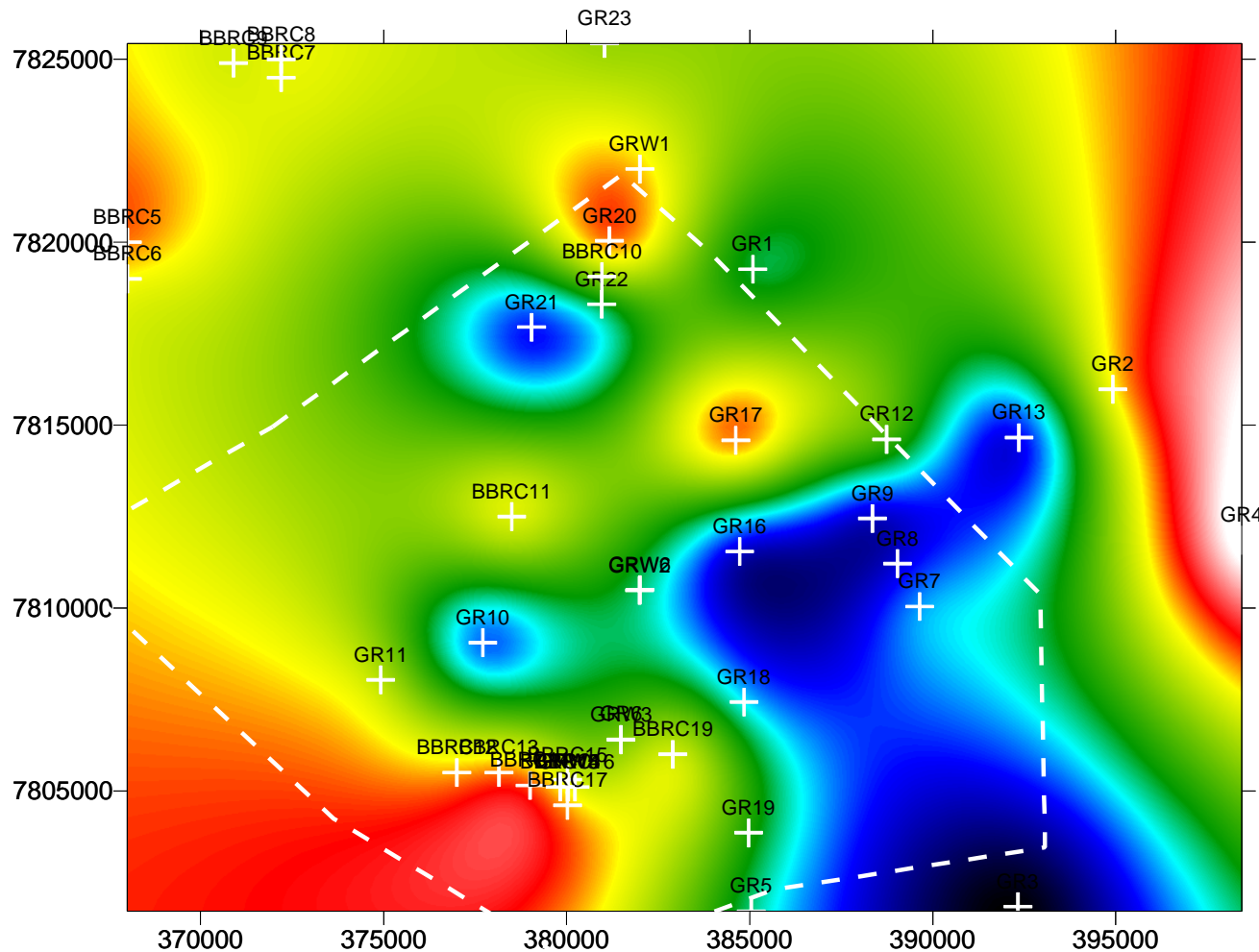




The low NMg anomaly that was previously found to coincide with the general region of anomalous gravity, is confirmed by the samples from RC drill holes. The sharp boundary in NMg previously illustrated between GR6/GRW3 and GRW4 and 5 is confirmed by new data that supports the southern increase in NMg evident in the original bore water data. The RC NMg values also indicate an additional zone in the NW of rocks that are more felsic/less mafic than those that surround them.

Characteristics of Aquifer Rocks

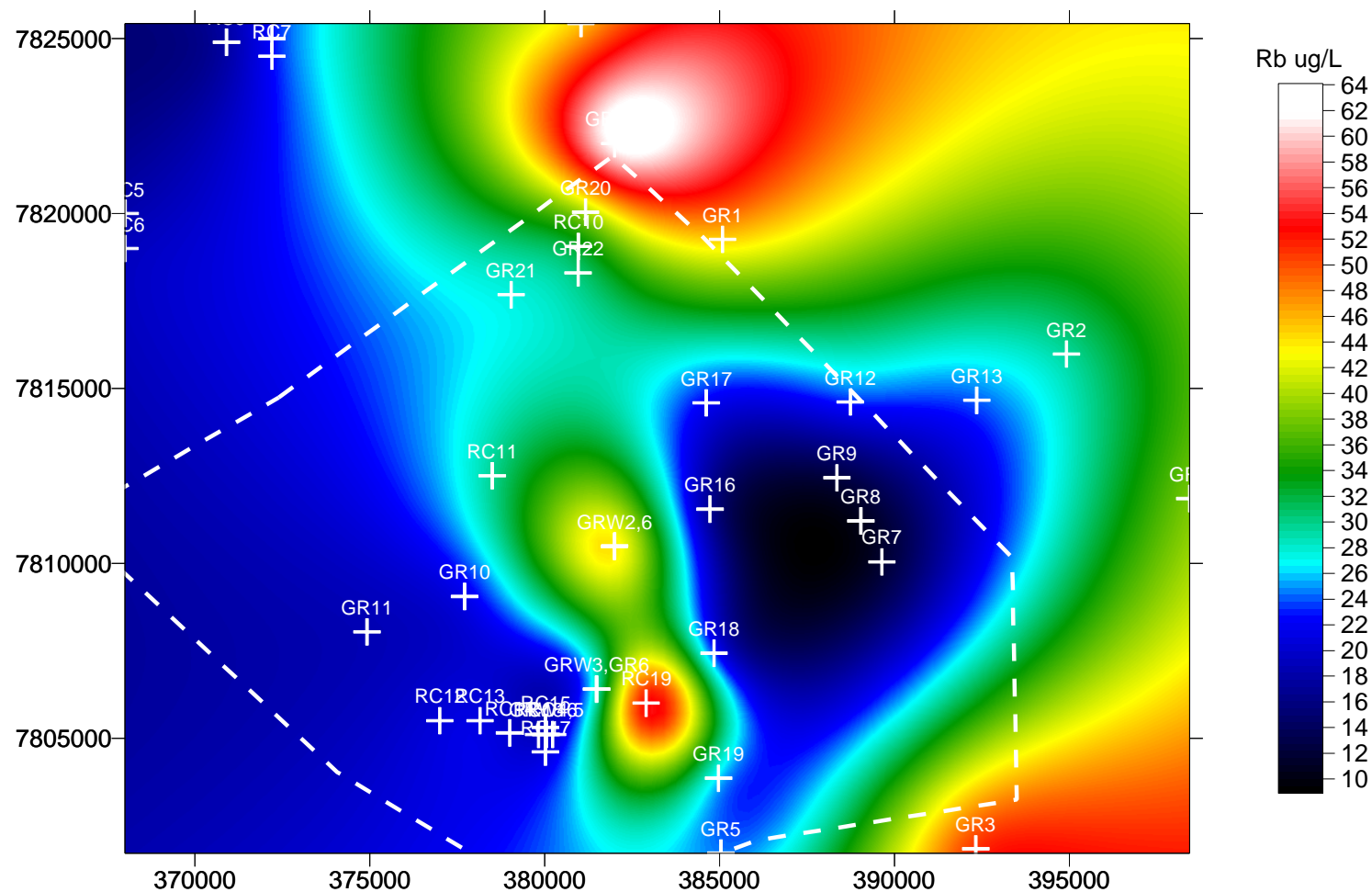
Indications from trace
components.



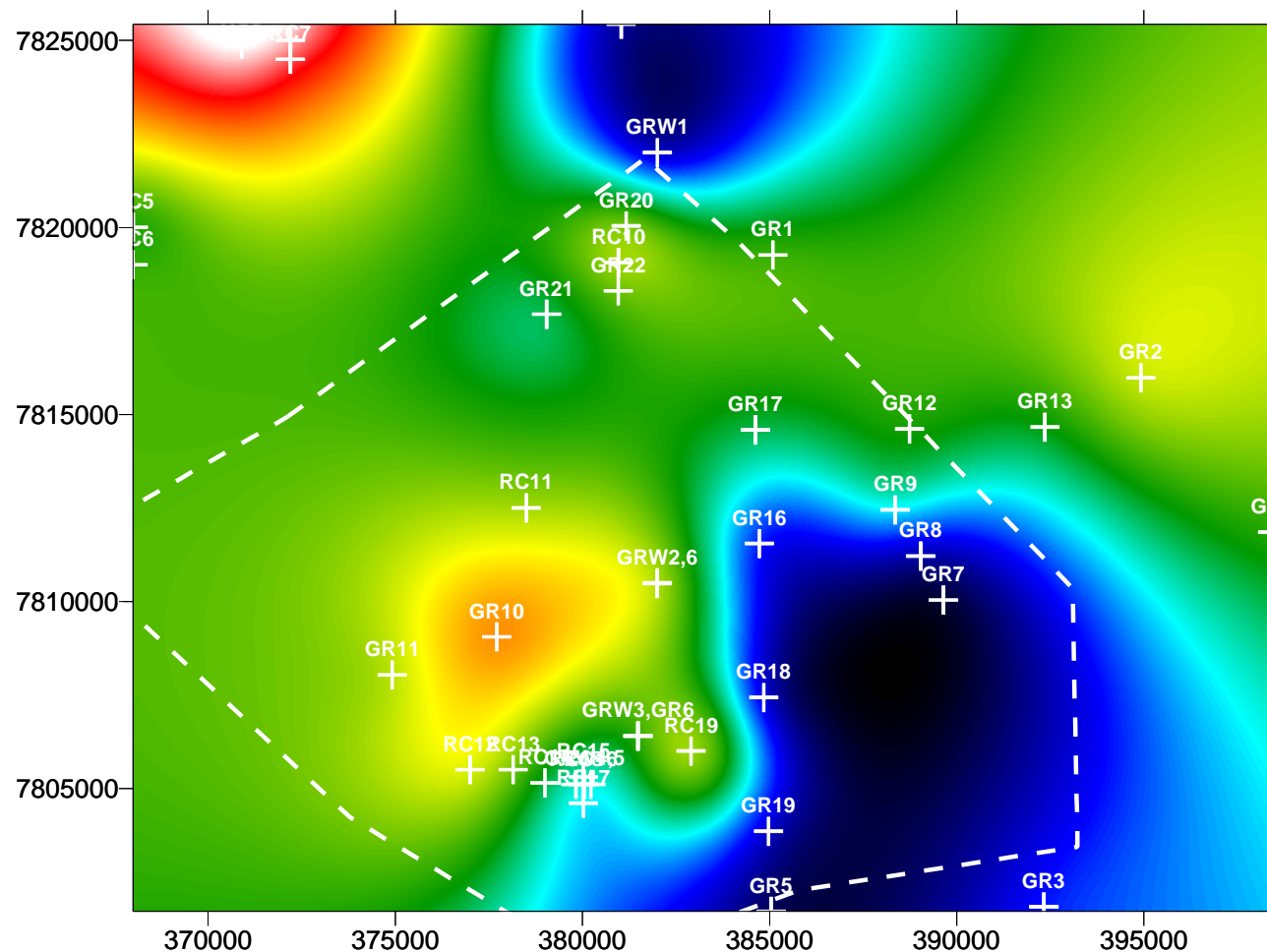
Sc ug/L



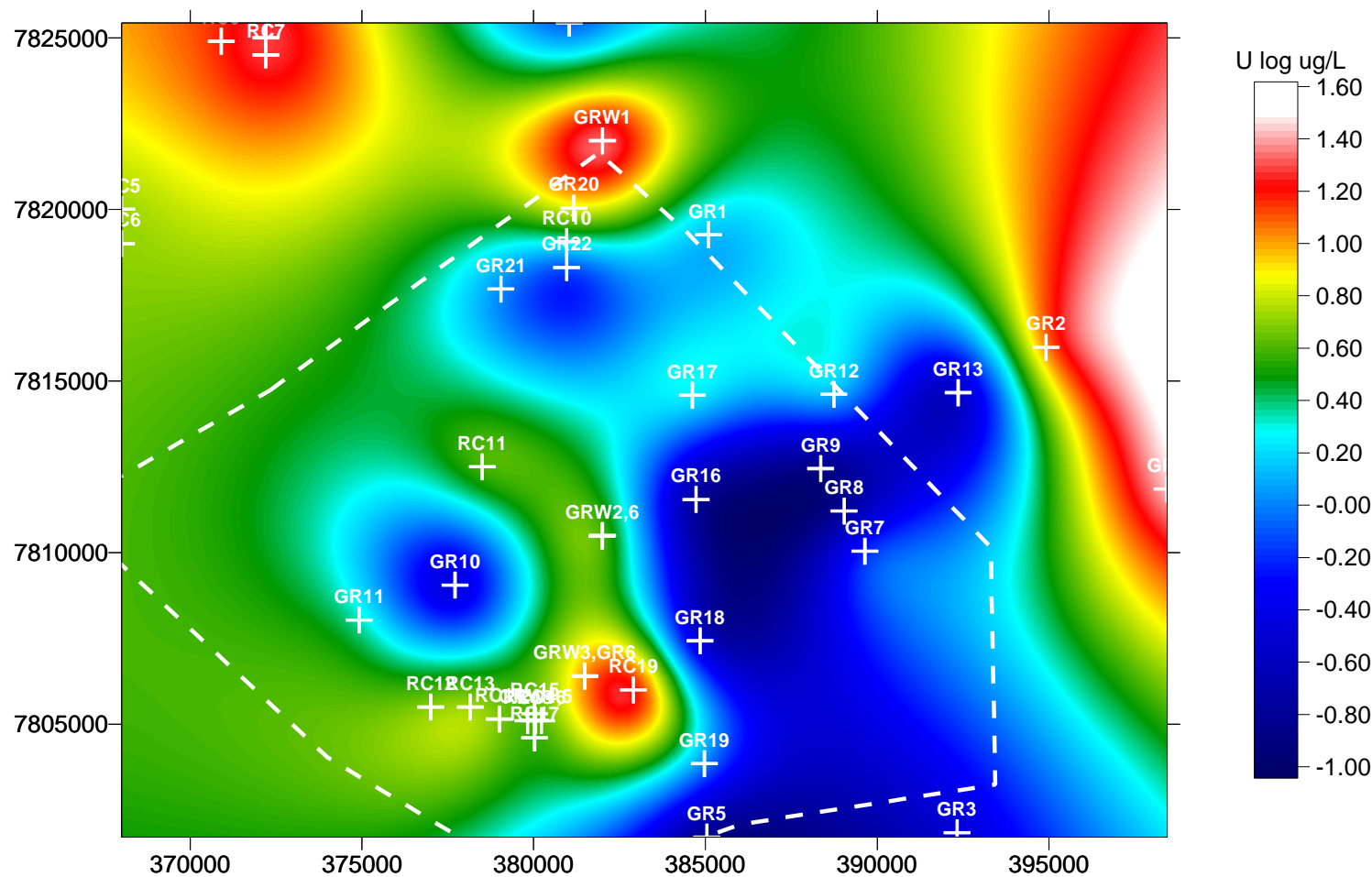
Scandium in groundwaters can be a good indicator to ferro-magnesian minerals in aquifer rocks. In this increased data set, although Sc still correlates overall at 95% confidence with NMg, the correlation is not uniform, suggesting more than one rock type in the sources of Sc. For example elevated Sc in groundwaters from the new RC holes in the NW is accompanied by low NMg and elevated U, Mo and F, a combination suggesting granites, pegmatites etc rather than rocks high in ferromagnesian minerals.



Rubidium content of groundwaters from the additional RC drill-hole samples suggests that a north-south belt of rocks, that are locally more potassic, extends through the middle of the gravity anomaly. This belt has some locations where groundwaters also have elevated Mo.



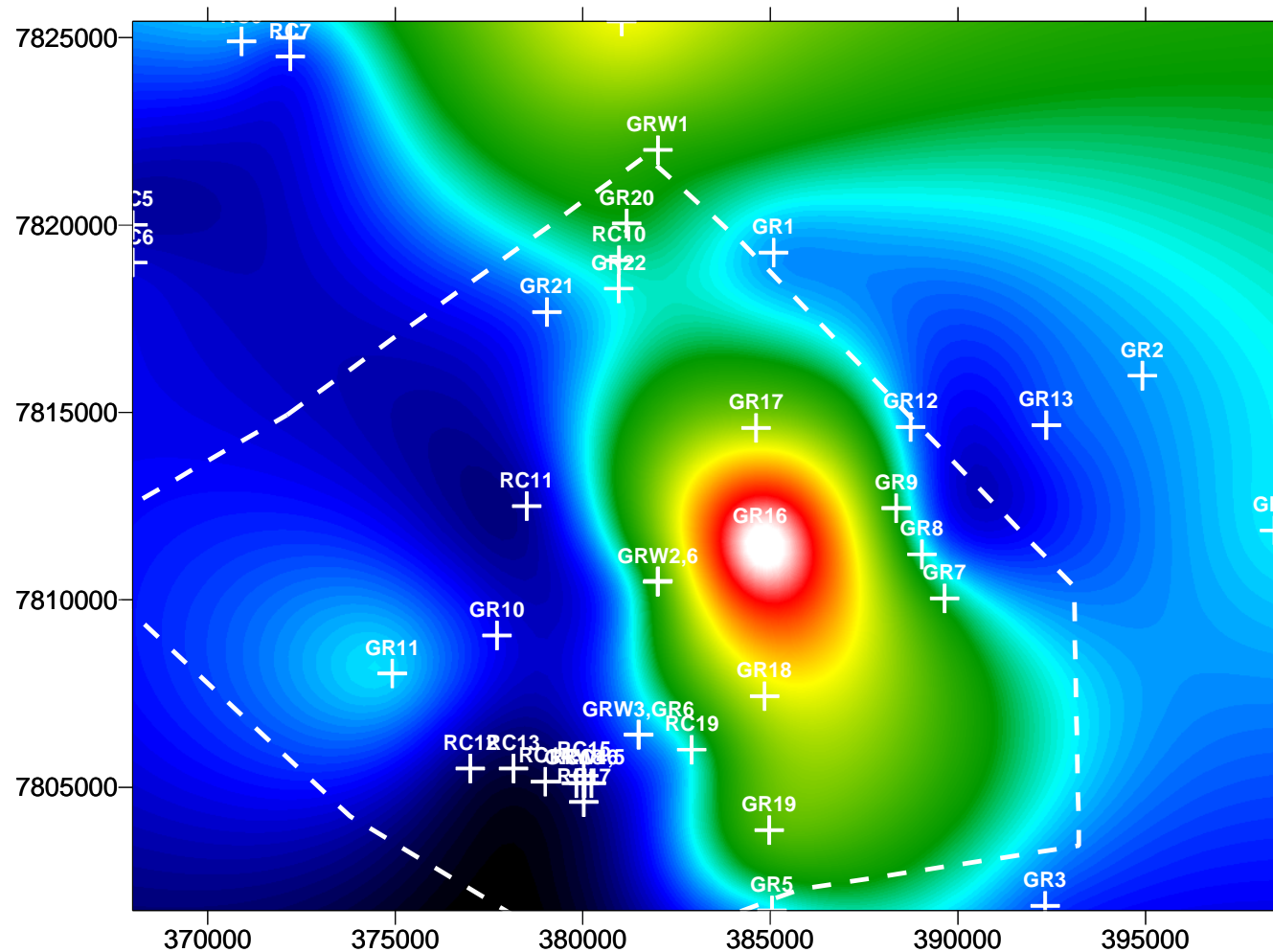
The new data do not change the previous conclusion that in general concentrations of F in groundwaters accord with locations of mapped sediments such as sandstones. A geochemically significant lithological boundary in the vicinity of GRW4 and 5 is supported by variations in F concentrations in groundwaters from the RC drill holes. Also, elevated F in groundwaters from the new RC drill holes in the NW suggest the possibility of local felsic igneous rocks.



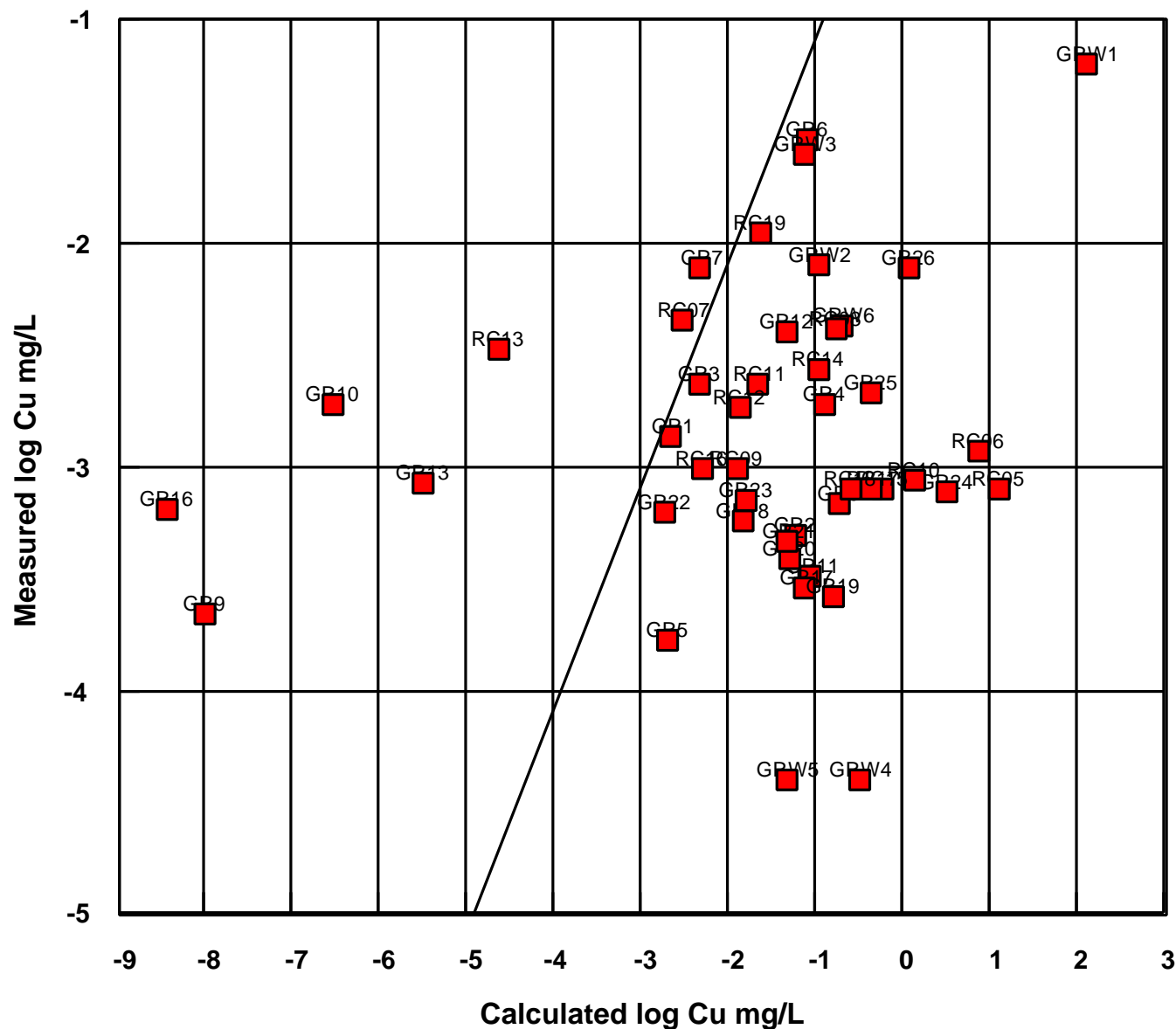
Concentration levels of uranium in Bluebush groundwaters suggest lithological boundaries within the gravity anomaly. Locations of groundwaters with elevated uranium, imply felsic igneous rocks. These zones can be further characterised by considering coincidentally elevated F or Mo or Rb. Groundwaters from the new RC drill holes in the NW with co-leached fluorine suggest local granites or felsic volcanics, whereas the absence of fluorine in groundwater from GRW1 is similar to that observed in extremely uranium enriched groundwaters in the Short Range region north of Warrego.

Economic Mineral Indicators

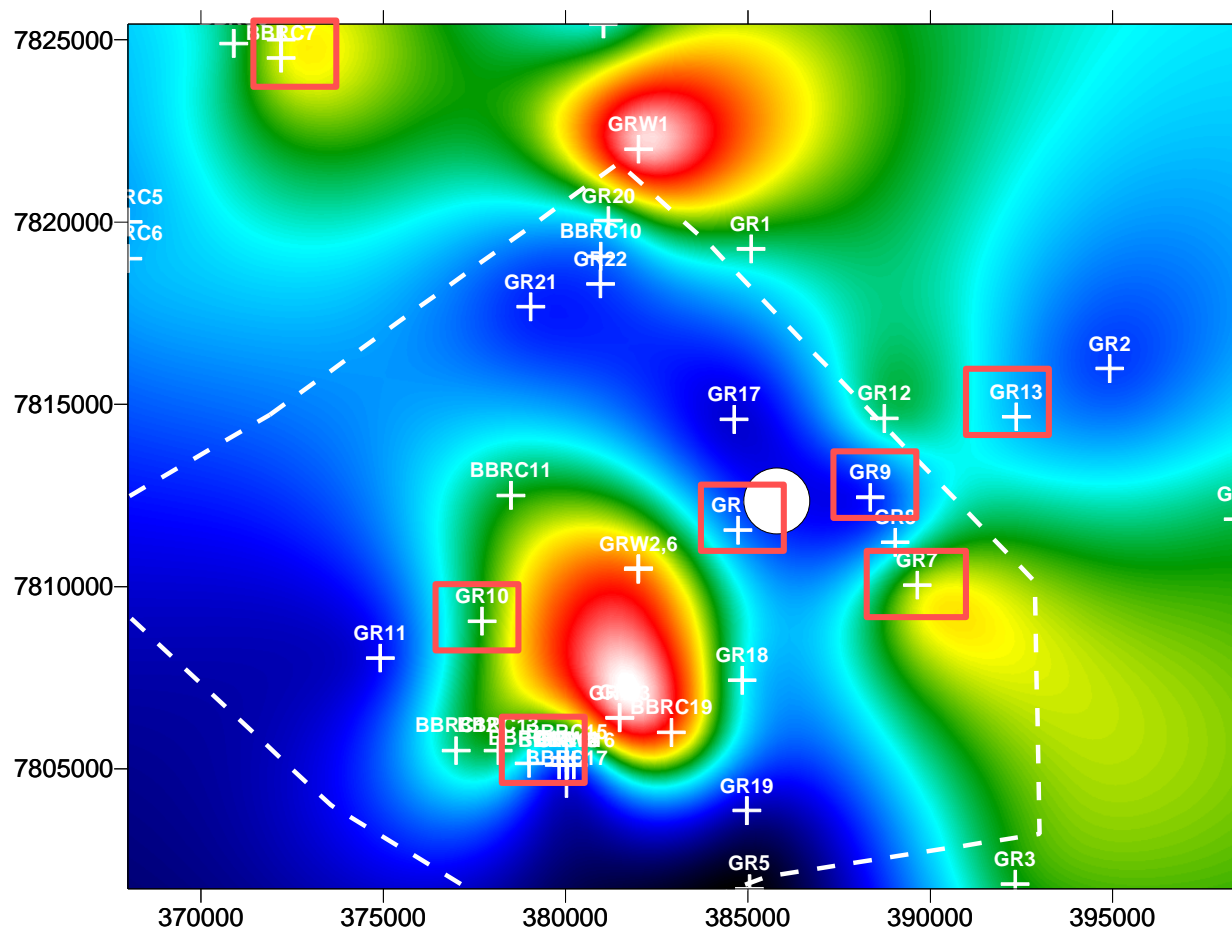
Gold, Lead, Zinc, Copper,
Arsenic



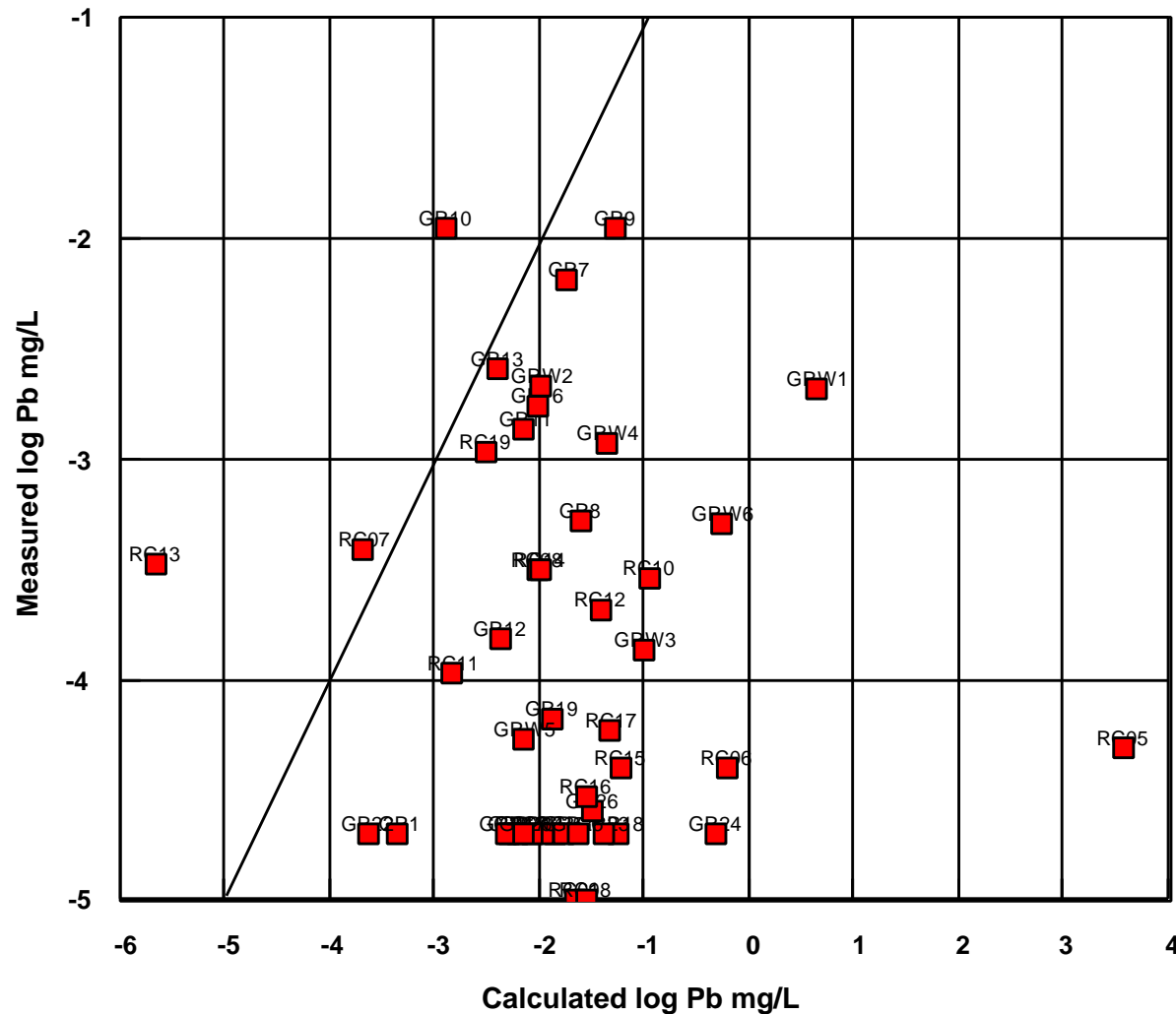
Gold values in groundwaters from RC drill holes confirm the western boundary of the groundwater gold anomaly, evident from the previous study. Modest gold contents in BBRC6, 8, 9 and 10 support previous observations. Apart from GR16, gold values accord with sulphide sources rather than gold as a separate commodity.



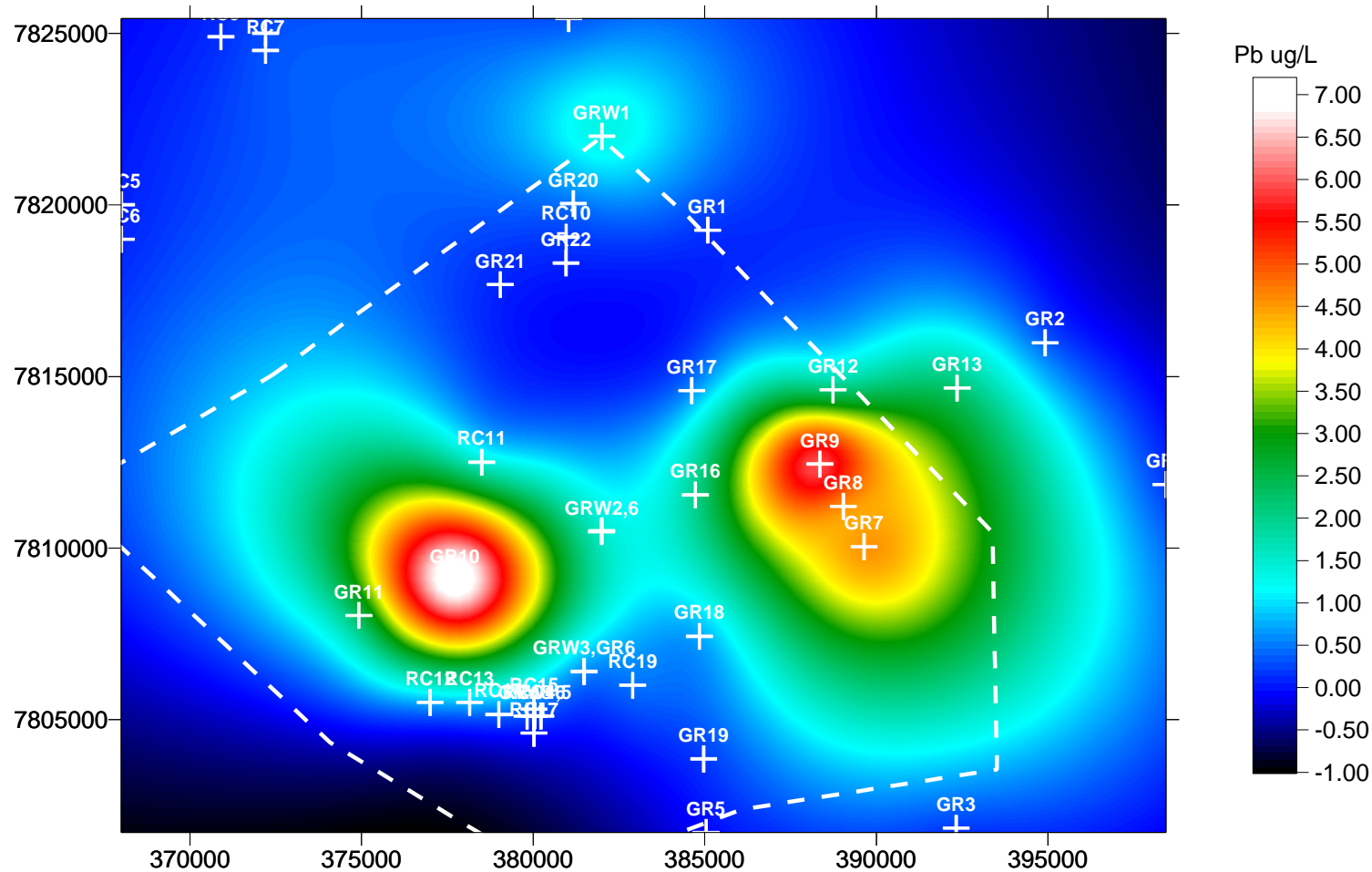
This plot compares measured concentrations of Cu in groundwaters with those calculated for a groundwater-rock system that includes oxidised Cu minerals. Illustrated are 7 samples in which the Cu content is high enough for the conclusion that Cu minerals are present. Two of these, BBRC7 and 13 are groundwaters from RC drilling.



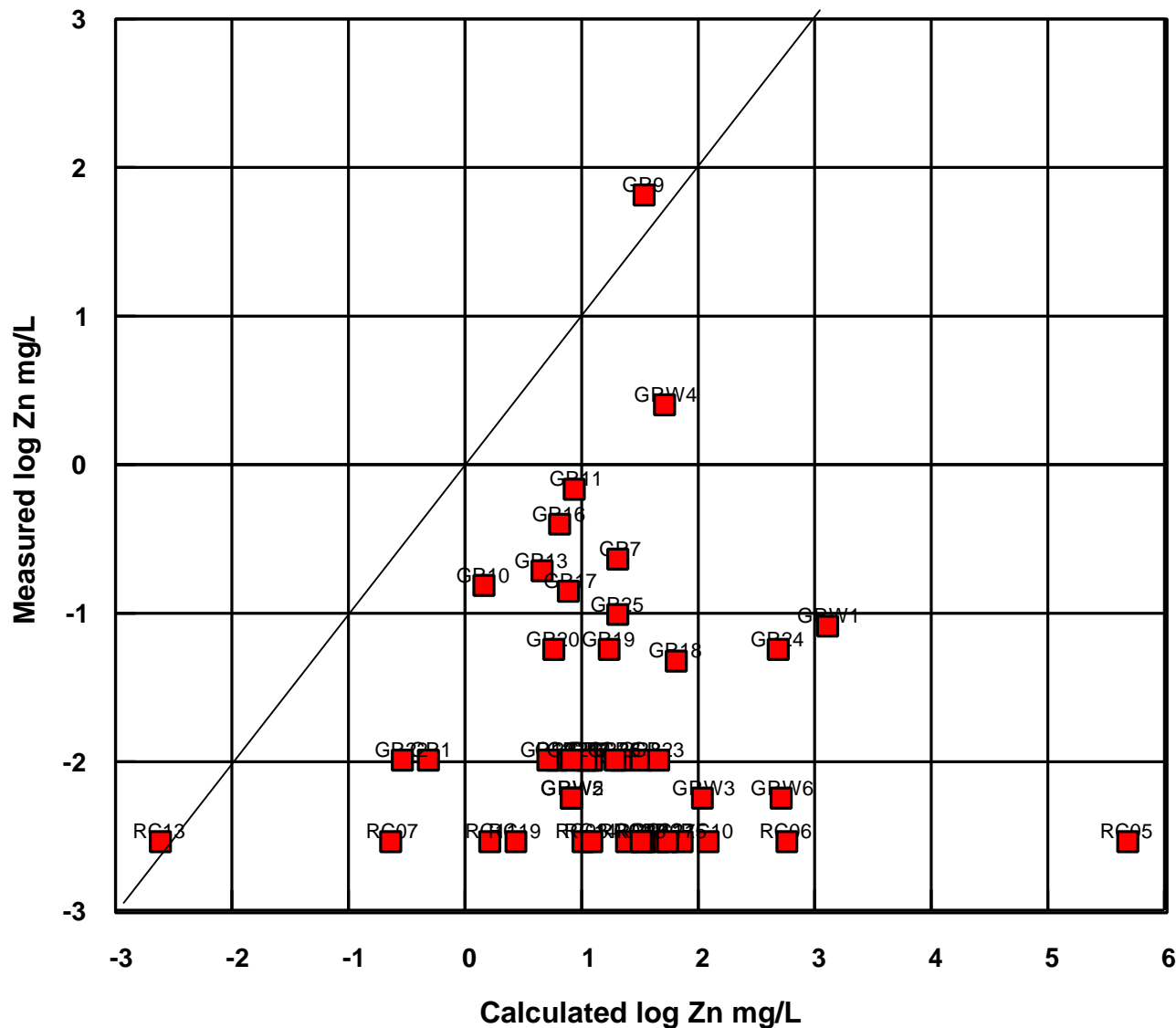
Copper values in groundwaters from RC drill holes support the possibility of a Cu source within the area bounded by GR10, GR6 and GRW2,6. Weight is added to this suggestion by the very modest values in GR10 and BBRC13 being actually higher than predicted if they were in contact with oxidised Cu minerals (indicated by red squares). Other locations where modest Cu concentrations in groundwaters exceed that predicted for contact with Cu minerals suggest additional locations of Cu mineralisation that might not be evident from raw Cu data. Included is BBRC7 which may relate to elevated Cu in groundwater from GRW1.



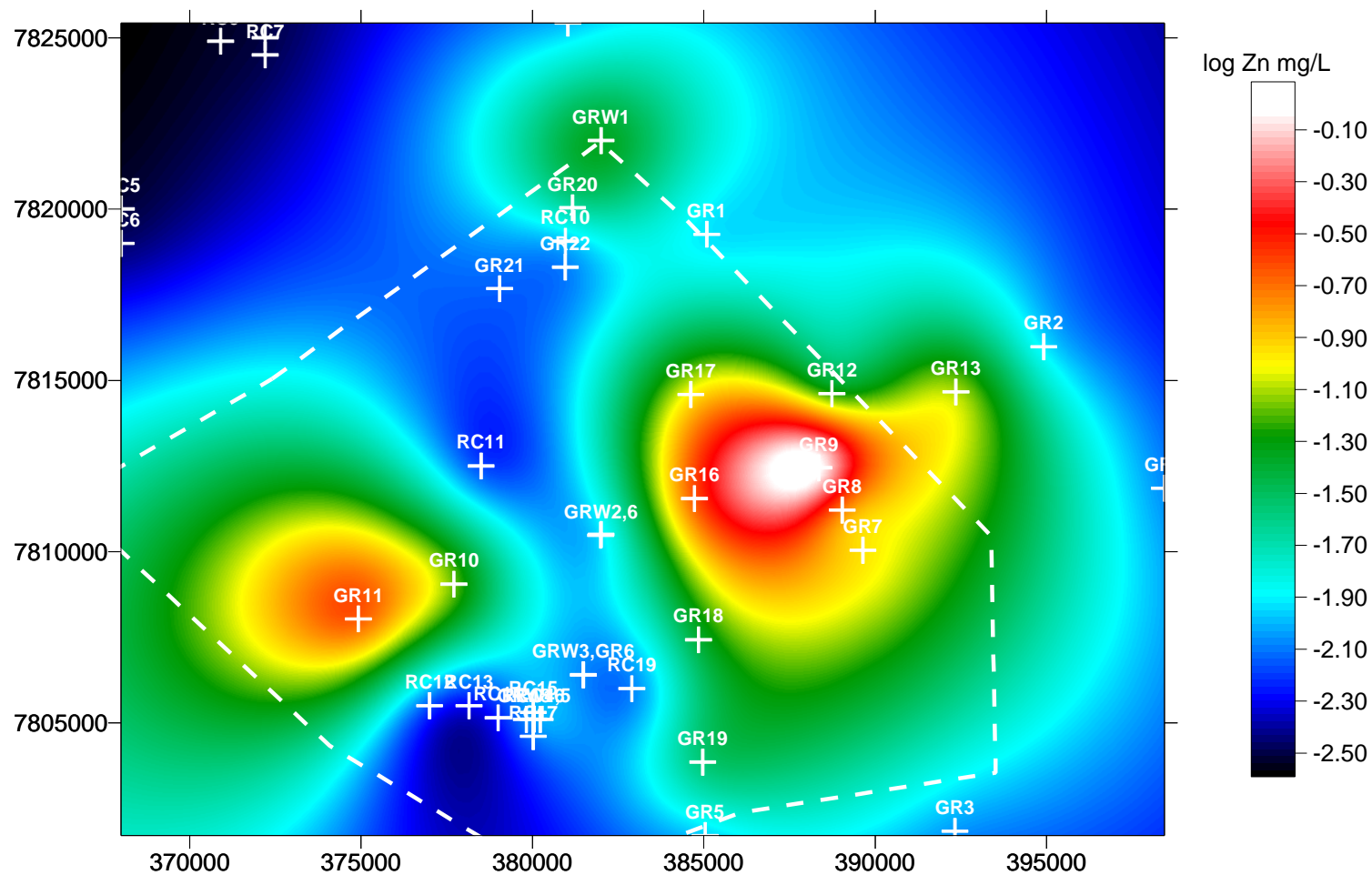
This plot compares measured concentrations of Pb in groundwaters with that calculated for a groundwater-rock system that includes oxidised Pb minerals. Illustrated are 3 samples in which the Pb content is high enough for the conclusion that Pb minerals are present. Two of these, BBRC7 and 13 are groundwaters from RC drilling.



Although groundwaters in RC drill holes did not contain elevated concentrations of lead, 2 groundwaters, BBRC7 and 13, contained lead at concentrations indicative of oxidised lead ore minerals.

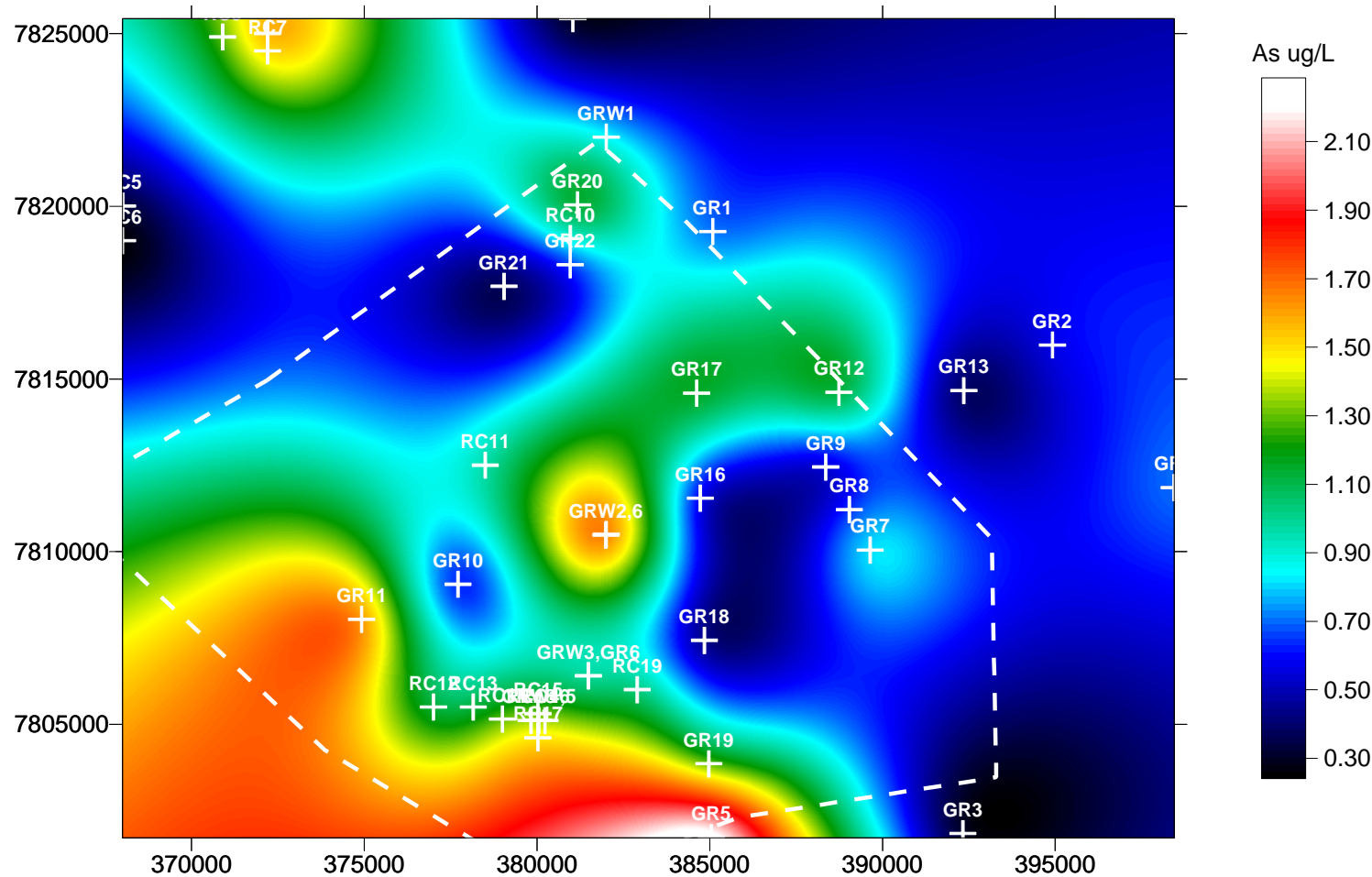


This plot compares measured concentrations of Zn in groundwaters with that calculated for a groundwater-rock system that includes oxidised Zn minerals. Illustrated are 2 samples in which the Zn content is high enough for the conclusion that Zn minerals are present. One of these, BBRC13 is a groundwater from RC drilling.



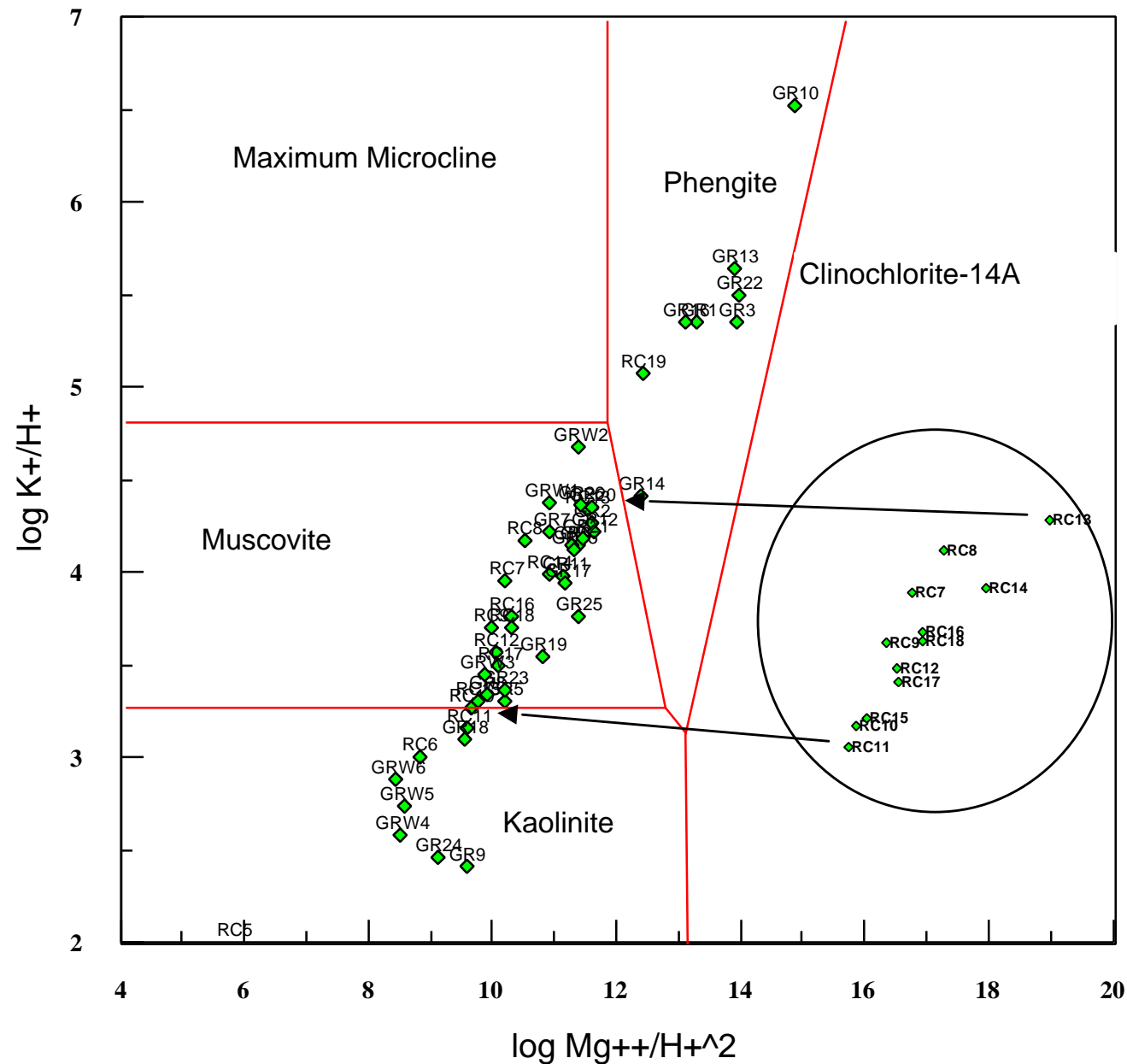
Although groundwaters in RC drill holes did not contain elevated concentrations of Zn, 1 groundwater, BBRC13, contained Zn at concentrations indicative of oxidised Zn ore minerals. This location is not close to any zones where groundwaters contain more obviously elevated Zn. These latter zones appear to flank the north-south belt of potassic rocks suggested by elevated Rb in groundwaters.

Apart from BBRC5 and 6, all groundwaters from RC drill holes contained modest concentrations of As that contribute to a regional pattern. However the values are too low to conclude their source to be significant quantities of nearby sulphide minerals. They might however be indicating deeper sources of As.



Silicate Mineral Stabilities

Indicated by compositions of
groundwaters in RC drill holes.



Groundwaters from the RC drilling plotted on the relevant mineral stability field diagram, fit the same trend as the groundwaters from previous programs. Most new groundwaters plot in the Muscovite field. Groundwaters BBRC5 and 6 plot in the Kaolinite field whilst the most saline of the RC waters BBRC19 plots in the Phengite field.