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EXECUTIVE SUMMARY

The base metal prospectivities of locations in the Bluebush Project have been considered using the geochemistry of groundwaters from 21 existing water bores and drill holes in the region bounded by Zone 53, AMG co-ordinates: 7800000 - 78 30000 N, and 370000 - 400000 E. The Bluebush Project is based on a zone of significant gravity and magnetic anomalism. Interpretations of a comprehensive suite of major and trace elements in the groundwaters have focused on characterisation of exposed and concealed lithologies including indications of base metal mineral occurrences.

Immediate field measurements of pH and Eh identify four locations where sulfides or magnetite could be being oxidized in the groundwater flow path. These locations form a line oriented WSW through the central zone of the gravity anomaly.

Groundwaters in the study area range from Mg dominated (indicative of mafic rock influence), through Na-Mg and Na-Mg-Ca (mafic rock contribution) to Na dominated (no mafic rock contribution). The eight locations in this last group include the four noted as possibly contacting sulfides or magnetite. The relative contribution of mafic rocks to a groundwater composition can be denoted by normalising groundwater Mg concentrations by total groundwater cation (Na+K+Ca+Mg) levels to produce a parameter NMg. Similar parameters, NK and NSO₄ denote potassic unit contributions and relative S inputs across a study area. Calculation of these parameters from the combined regional groundwater data (NT Government) with data from this study, illustrate a clear NMg anomaly coincident with the central section of the gravity anomaly. Variations in NSO₄ and NK are also evident but are not specific to the gravity anomaly.

Because descriptions of gangue mineralogy of Tennant Creek ores commonly refer to chlorite and muscovite associations with iron-stone host rocks, all Bluebush groundwaters were plotted on muscovite and chlorite stability diagrams, firstly using Si activity as a variable and secondly, assuming the presence of quartz. Comparisons were made with similar plots for groundwaters from mineralised zones at Olympic Dam and mineralised and "not known to be" mineralised locations at Tennant Creek. These indicated dominant Si activities of less than $10^{-3.5}$ for all mineralised samples, and a distribution of mineralised and "not known to be" mineralised locations distributed across the muscovite, phengite and kaolinite stability fields. Application of these observations to Bluebush samples indicated nine locations with Si activity less than $10^{-3.5}$ and a group of five (including three from the group noted as possibly contacting sulfides or magnetite) plotting separately from the rest, in the phengite field. Interestingly, most Olympic Dam groundwaters also plot in the phengite field.

In general, the low regional salinity of groundwaters in the Bluebush Project area means that trace element anomalies will be low in absolute values and only evident by comparison with the very low local background. However, calculations of expected values of Cu in each sample, if each sample were saturated with oxidised or sulfide mineral forms of Cu, illustrate eight locations (including those noted as possibly contacting sulfides or magnetite) where measured Cu concentrations are indicative of Cu mineralisation. The same approach for Pb and Zn identified two locations for Pb and one for Zn, all of which were included in the Cu group. Due to the rarity and low solubility of Au, absolute measurements are adequate indicators. Location of the highest groundwater Au concentration coincided with one of the Cu group, and locations of modestly higher groundwater Au concentrations occurred at locations both north and south of this point.

Although As is a sensitive indicator of certain base metal sulfide deposits (e.g. Dugald River and HYC), groundwater concentrations in this study did not appear related to other base metal or gold indicators.

Relative values of new variables, calculated from multivariate statistical manipulations of major and trace element values which reflect lithological variation, indicate zones where either mafic or felsic(A-type granites) units are dominant, and other zones where both contribute. Most interesting is a correspondence analysis variable, which separates out as lithologically different, the four locations originally identified by field measurements of pH and Eh variable, in the line oriented SE through the central zone of the gravity anomaly.

At one location in the north of the study area, the groundwater contains anomalous concentrations of Mo, Co, Ni, Au, Fe, Mn and P. This combination is similar to that observed in groundwaters from the traditional Tennant Creek style Fe-oxide Cu–Au deposits.

The overall results of this study suggest that in the Bluebush Project area, lithological variations that could have implications with respect to base metal prospectivity, are reflected by groundwater geochemical data, both absolute and derived, and by outcomes from solution chemical models and statistical manipulations.

INTRODUCTION

The base metal prospectivities of locations in the Bluebush Project area have been considered using the geochemistry of groundwaters. Existing water bores and old drill holes provided groundwater data from 21 locations in the region bounded by AMG Zone 53, AMG co-ordinates: 7800000 - 7830000 N, and 370000 - 400000 E (Fig. 1). The study area is in the Tennant Creek Block, south of the region where established Fe-oxide Cu-Au deposits occur. The Bluebush Project is based on a zone of significant gravity and magnetic anomalism. Appropriately spaced groundwater data can generate geochemical characterisation of exposed and concealed lithologies, including indications of economic mineralisation. Sample spacing for this study is adequate to provide broad scale indications, within a boundary defined by outer sample locations.

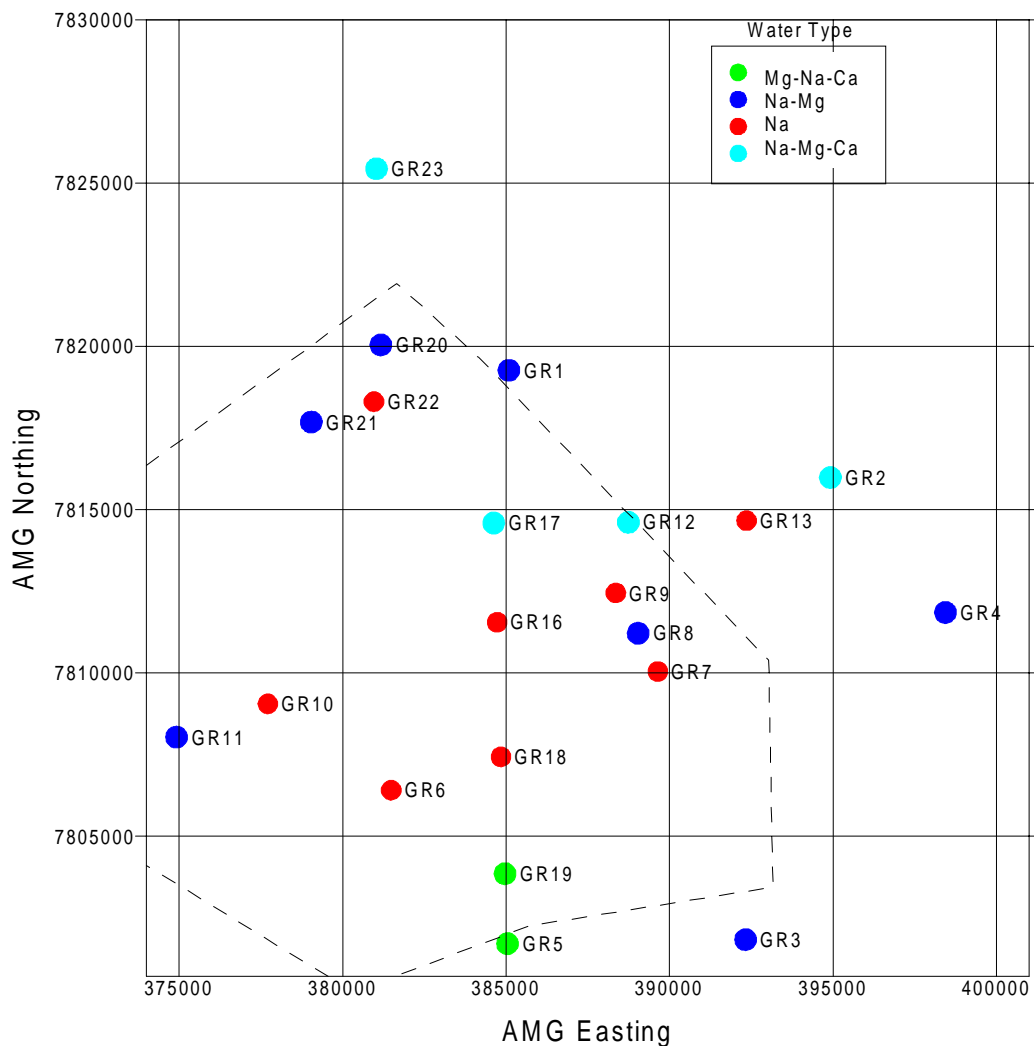


Figure 1. Locations of groundwater samples in the Bluebush Project area. Dashed line delineates the approximate outline of the dominant gravity anomaly

The study required a comprehensive suite of major and trace elements. Sample collection and subsequent field analyses were carried out by Giants Reef Mining personnel following protocols developed by CSIRO Exploration and Mining. Subsequent laboratory analyses followed the protocols described in Appendix 1. Interpretations of groundwater data are based on techniques developed by CSIRO Exploration and Mining.

Data

Groundwater Sources

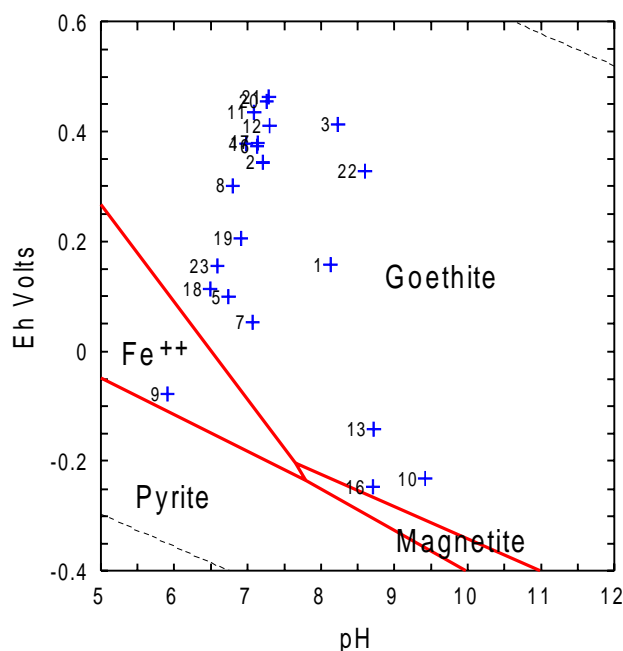
Sample sources were farm bores and old drill-holes, which allowed collection of either a bailed or a pumped sample. This report is based on groundwater geochemistry and at this stage does not consider hydrological effects including aquifer flow rates, which, as is usually the case, are unknown. The groundwaters from each site were field analysed for pH, Eh, temperature and salinity, measured as conductivity. Subsequent laboratory analyses measured a comprehensive suite: Ca, Mg, Na, K, Al, Si, Fe, Mn, Li, P, Ti, B, Ba, Be, V, Sr, Cu, Pb, U, Co, Cr, Cd, Ni, Zn, Mo, Tl, Rb, Cs, Ga, Ge, Sb, Bi, Th, La, Y, Yb, Sc, Cl, SO₄, total carbonate (TCO₃), As and F. Analytical data for all samples are listed in Table 1. Physical observations of sample GR7 indicated colloidal material that could not be separated. High measured concentrations of Al, Ti and Fe indicate that this colloidal material is a clay, and that high element values in this sample should be treated with caution.

pH AND Eh

Measurements of pH and Eh were made on a sub-sample immediately after each sample was collected and are recorded in Table 1.

These measurements reflect the chemical conditions in the groundwater at the point of collection. After being brought to the surface, the measurements will gradually change to reflect earth surface conditions. By initially reflecting sub-surface aquifer conditions, these field measurements provide some immediately useful indicators to minerals that may be either controlling the groundwater pH and Eh, or that will survive while these conditions prevail. Either way, pH and Eh together provide pointers to possible mineral identities in concealed aquifer environments. To determine such mineral identities, diagrams are drawn illustrating how particular mineral stabilities vary with changes in pH and Eh within the ranges relevant to specific field measurements.

An initial application of pH and Eh relates to the importance of magnetite as a significant component of the Fe-stones which host mineral deposits in the Tennant Creek Block. Figure 2



shows that samples GR 16, 10 and 13 are close to the magnetite boundary and that GR 9 is close to the pyrite boundary. All other samples are clearly in the field of oxidised Fe-oxide. Goethite is used for this diagram as haematite does not precipitate out of solution at 25°C.

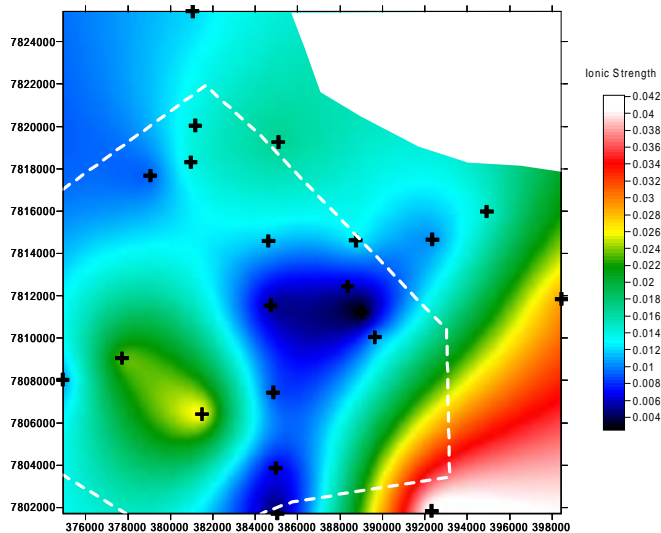
Figure 2. pH – Eh values of Bluebush groundwaters plotted against pH-Eh stability fields of Fe oxide minerals at 25°C.

The pH-Eh fields of GR9, 10, 13 and 16 are clearly much more reducing than those at the earth surface where air dominates Eh values. Because the sam-

ples are brought to the surface before pH and Eh measurements are made, a certain amount of aerial oxidation will have occurred prior to measurements. This suggests that in situ aquifer conditions are even more reducing, implying that in situ groundwaters are feasibly within the sulfide and magnetite fields.

MAJOR ELEMENT COMPOSITION

Salinity



As explained in Appendix 2, Ionic Strength (I) is a calculated parameter that indicates salinity and is derived from the concentrations of all major elements. Figure 3 illustrates that groundwaters within a central zone of the gravity anomaly have the lowest salinities in the study area. This zone includes three of the four locations noted for possible involvement with sulfides or magnetite. Low salinity groundwaters can imply rocks containing minerals resistant to weathering. Quartz, muscovite and K-feldspar are among the least easily weathered minerals.

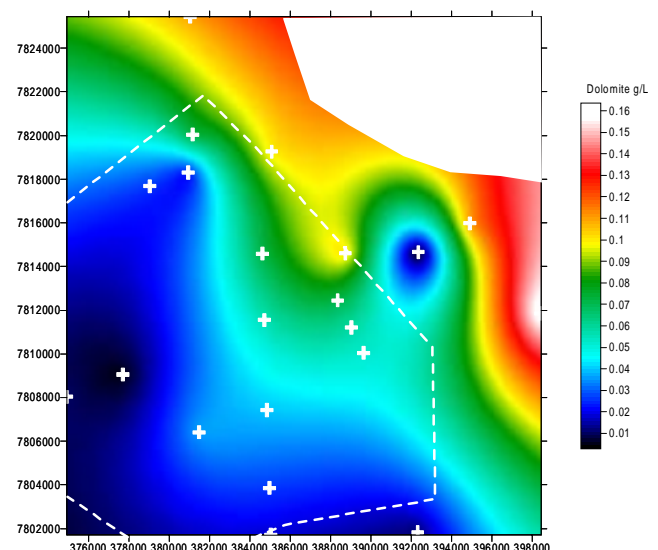
Figure 3 Variations in Ionic Strength

across the study area.

Major Element Variation Related to Water Type

Figure 1 characterises each sample in terms of its dominant and significant cations (water type). Comparing these with Figure 3 demonstrates no simple relationship evident between water type and salinity level. However, cations in groundwaters from the four locations noted for possible involvement with sulfides or magnetite are all dominantly Na with no significant Mg content. This implies no significant mafic mineral constituents at these locations. Water type zoning across the study area suggests that mafic rock units are peripheral to a central non-mafic zone. Rock weathering results in formation of chemically precipitated minerals, in particular carbonates. Because a common weathering product of mafic rocks is dolomite, relative supersaturation of groundwaters with dolomite can reflect distribution of mafic rocks. Figure 4 shows dolomite outside the gravity anomaly at the limited scale of this data set.

Figure 4. Variations in supersaturated dolomite in groundwaters across the study area.



Regional Major Element Variation

The primary control on absolute concentrations of individual major ions is groundwater salinity. If this is ignored, comparisons of major ion concentrations across a set of water samples of varying salinity are of limited use for expressing geochemical variation. This is overcome by translating them into normalised values (e.g. NCa, NMg, etc) by expressing each concentration as a ratio of the total anion or cation concentration, (calculated using milli-equivalents/litre as the concentration units). For this study, normalised Mg (NMg) provides an index for the abundance of ferromagnesian minerals, and hence mafic units, in aquifer lithologies. NMg also can be an indicator of chlorite alteration, and NK, a subtle reflection of varying degrees of potassic alteration. These latter may be hard to observe due to relatively low (compared to other constituents) concentrations of K in groundwaters.

Some limitations on the use of normalised concentrations apply to saline waters in which conservative ions (principally Na^+ and Cl^-) reach such a high proportional concentration that normalised variations in other ions are less distinctive. In high salinity waters the non-conservative ions are also affected by the solubilities of chemically precipitated minerals. From the data collected in previous studies it appears that normalised concentrations are useful parameters in waters in which Ionic Strength is less than 0.4. Since all samples in this data set have $I < 0.4$, normalised major ions were used in this study.

To consider major element variation, as a reflection of concealed lithologies, across the gravity anomaly at a more regional scale, groundwater data provided by the Northern Territory Government was accessed. These data, although restricted to major elements and few trace elements, could be used to calculate parameters (Normalised Major Elements) that reflect major element relativities for different lithologies.

In combination with data from the Bluebush study, a clear low NMg anomaly is illustrated coincident with the central section of the gravity anomaly (Figure 5.). White circles in Figure 5 indicate data locations for making the image. Mineral indicators are from NT drill logs. Regional variations are also evident for NSO_4 and NK (Appendix 3), but are not specific to the gravity anomaly.

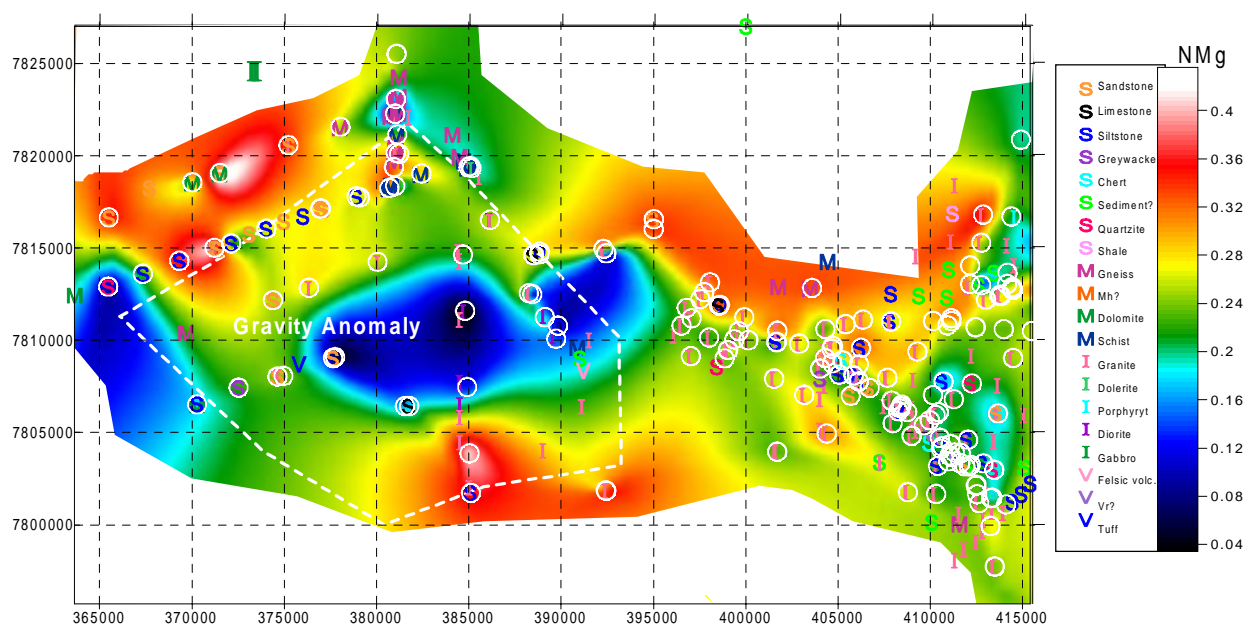


Figure 5. Regional variation of normalised Mg (NMg) in groundwaters indicating low values coincident with central zone of the gravity anomaly.

Schoeller Plots

To demonstrate the range of major element variation, Appendix 2 illustrates the composition of each of the groundwater samples using Schoeller plots drawn as described in Appendix 2. When using Schoeller plots to determine the dominant lithology of aquifer rocks the following relationships apply. Relative abundances of cations Na^+ and K^+ exceed those of Ca^{2+} and Mg^{2+} in waters from aquifers that geochemically match felsic igneous rocks such as granites or rhyolites or, as is more common, chemically equivalent sediments. Conversely, relative abundances of cations Ca^{2+} and Mg^{2+} exceed those of Na^+ and K^+ in waters from aquifers that match mafic igneous rocks such as basalts or chemically equivalent sediments. Waters from aquifers with compositions between these extremes, and more commonly from mixtures of groundwaters from two or more aquifers, show intermediate relationships.

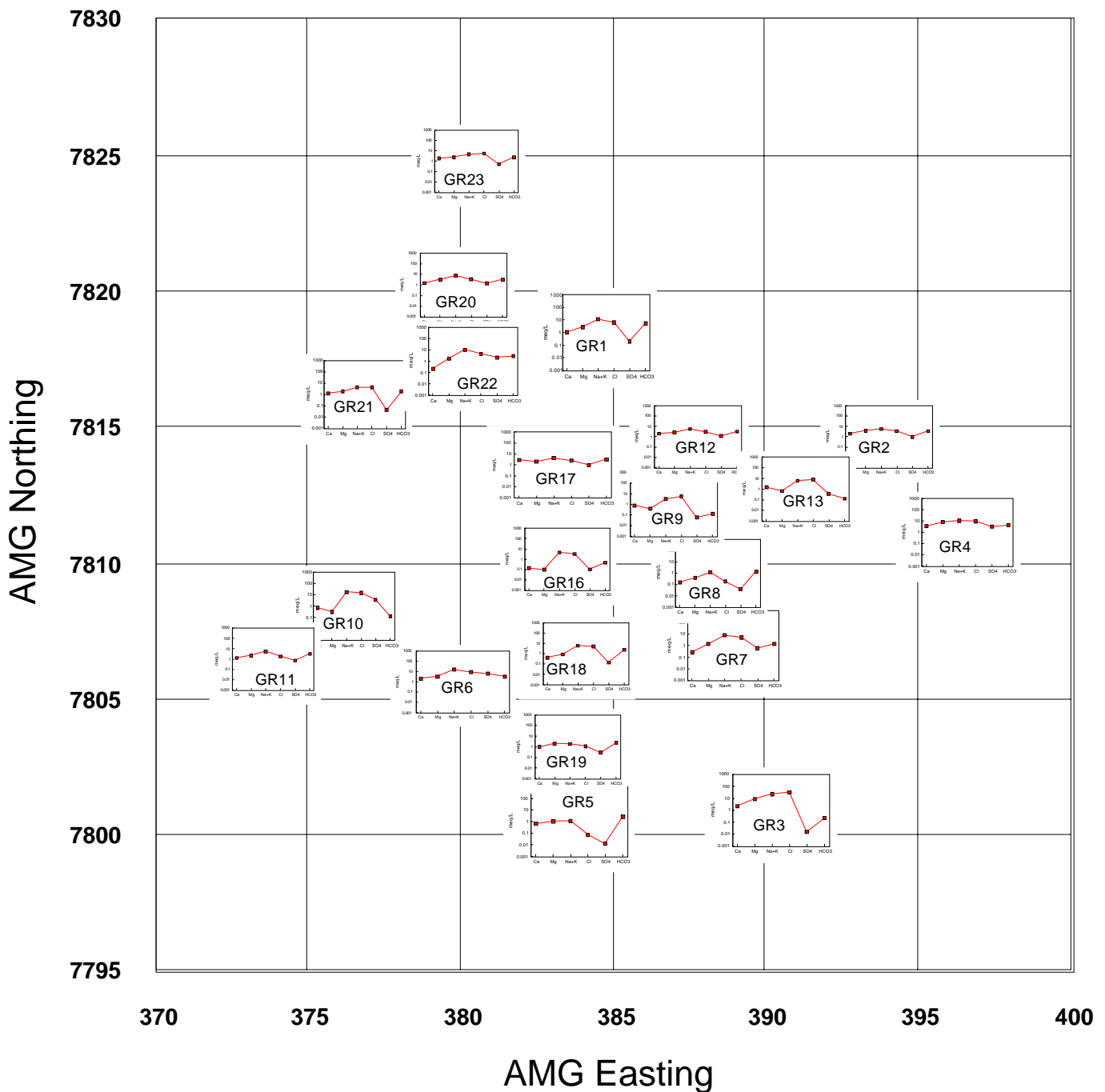
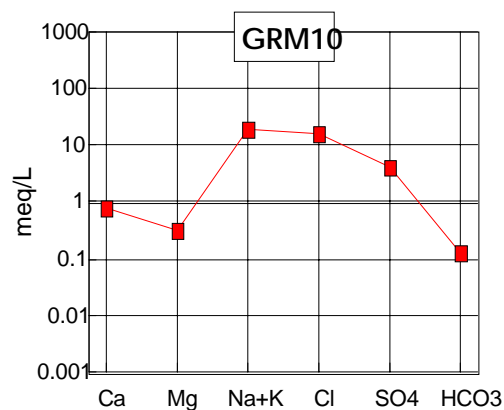


Figure 6 Schoeller plots for each groundwater drawn at approximate sample locations.

Figure 6 illustrates a distinctive major cation shape for the four samples GR9, 10, 13 and 16.(noted for possible involvement with sulfides or magnetite). Their major anions (Cl , SO_4 , HCO_3) are also the same except for GR10 which has higher sulfate content. Groundwater GR10 is clearly contacting a higher source of sulfate that it would be nice to think was an oxidising sulfide! Its Schoeller plot is exactly what would be expected if a groundwater similar to others in this group were locally contacting a discrete source of sulfate.



Silicate Mineral Stabilities from Groundwater Data.

Tennant Creek and Olympic Dam Groundwaters

Because descriptions of gangue mineralogy of Tennant Creek ores commonly refer to chlorite and muscovite associations with iron-stone host rocks, a set of 33 Tennant Creek groundwaters (1988 CSIRO data) were plotted on to muscovite and chlorite stability field diagrams, to look for common features for groundwaters from mineralised locations. Figure 7 (larger copies in Appendix 3) depicts variations in chlorite and muscovite stability fields respectively with variations in Si activity, activities of the relevant cation (Mg^{++} and K^+) and pH. Each Tennant Creek sample's relationships with the minerals considered in each diagram is determined by where each sample is located on the stability field diagram. This is calculated from each sample's concentration of Si, concentration of the relevant cation and pH. Tennant creek samples from mineralised locations are denoted by "m" after the sample number.

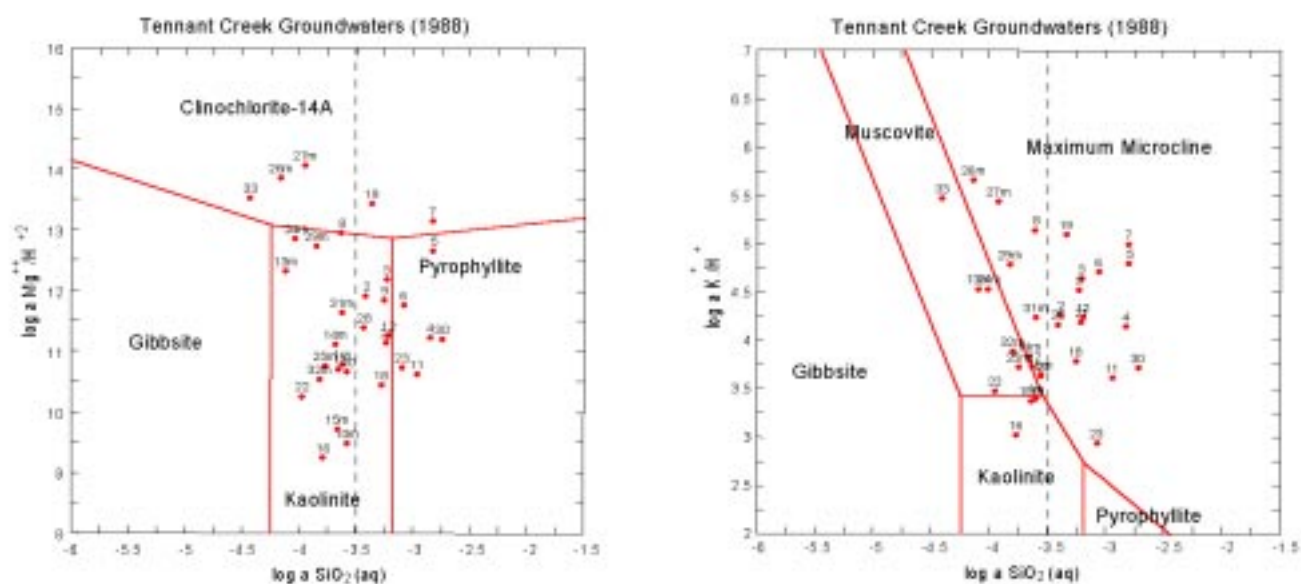


Figure 7. Groundwater samples from the Tennant Creek region in which Fe-oxide Cu-Au deposits have been mined, plotted on muscovite and chlorite stability field diagrams. Samples labelled "m" are from known mineralised locations.

Figure 7 shows that all groundwaters from mineralised locations have activities of $\text{SiO}_2(\text{aq})$ of less than $10^{-3.5}$ which equates to approximately 9mgSi /L. This provides a groundwater feature that hopefully will be useful in further exploration programs in the region. It also increases the prospectivity of other "not known to be mineralised" locations indicated in Figure 7 as having Si contents less than 9 mg/L(viz. TC3, 8, 16, 17, 20, 22 and 33). To add weight to this feature, similar plots were drawn (Figure 8) of groundwaters collected at Olympic Dam before any mining had started, using exploration drill holes to access groundwaters. Sample locations were

within a 3 by 4 km area that subsequently was found to contain the main mineralised zones. All but one Olympic Dam sample appear to confirm that a Si content of less than 9 mg/L is a feature of groundwaters from mineralised environments

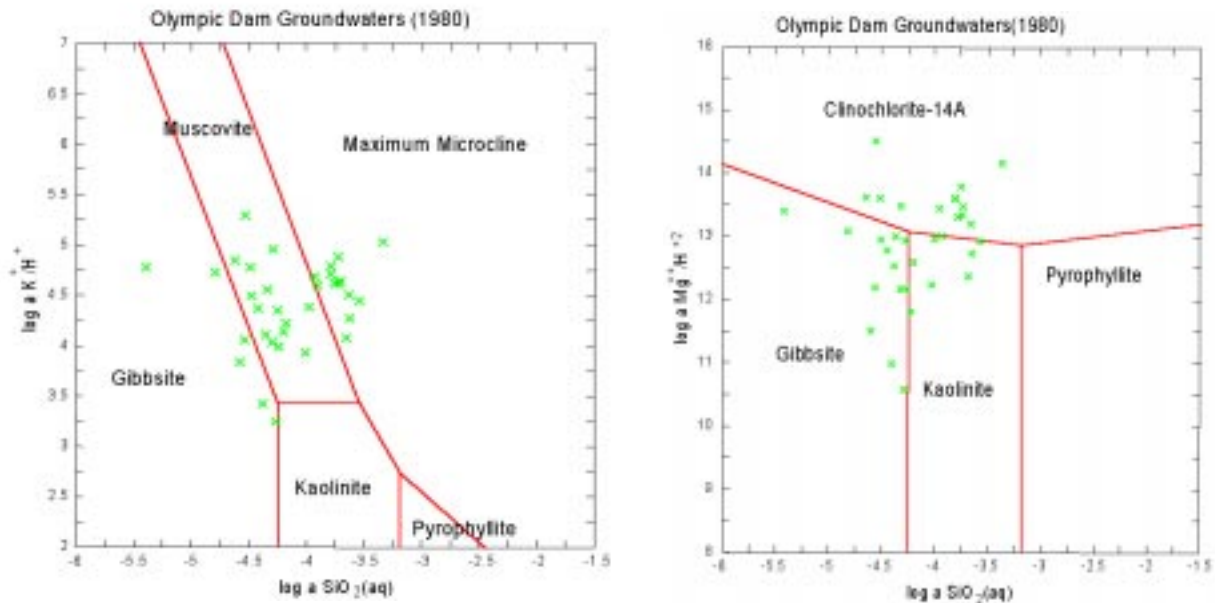


Figure 8 Groundwaters from Olympic dam exploration drill holes plotted on muscovite and chlorite stability field diagrams.

Stability fields occupied by mineralised Tennant Creek groundwaters include muscovite, K-feldspar, chlorite and kaolinite. Olympic Dam groundwaters occupy the same fields but in addition some occupy the gibbsite field.

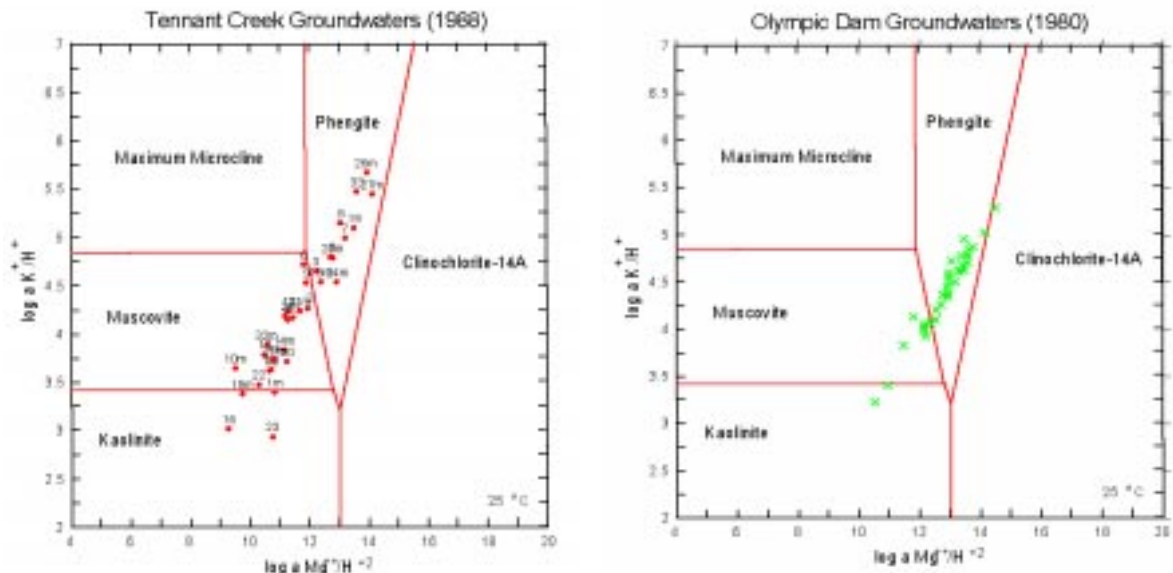


Figure 9 Tennant Creek and Olympic Dam groundwaters plotted against muscovite and chlorite stability fields when quartz is fixed as saturated.

Figure 9 demonstrates that if variation in Si content of groundwaters is removed from consideration, and quartz is assumed to be present and saturated, groundwaters from mineralised locations at Tennant Creek and Olympic Dam plot predominantly in the phengite and muscovite fields. Because phengite is a mineral containing both K and Mg it had no stability field in diagrams in Figure 8. Interestingly, early exploration stage electron microprobe analyses indicated that the “sericite” associated with mineralisation at Olympic dam was in fact

phengite. Figure 9 supports this with the majority of Olympic dam groundwaters plotting in the phengite field. By contrast, Tennant Creek groundwaters from mineralised locations exhibit a distribution between the phengite and muscovite fields. Perhaps this can be related to variations among styles of the relevant ore deposits.

Bluebush Groundwaters.

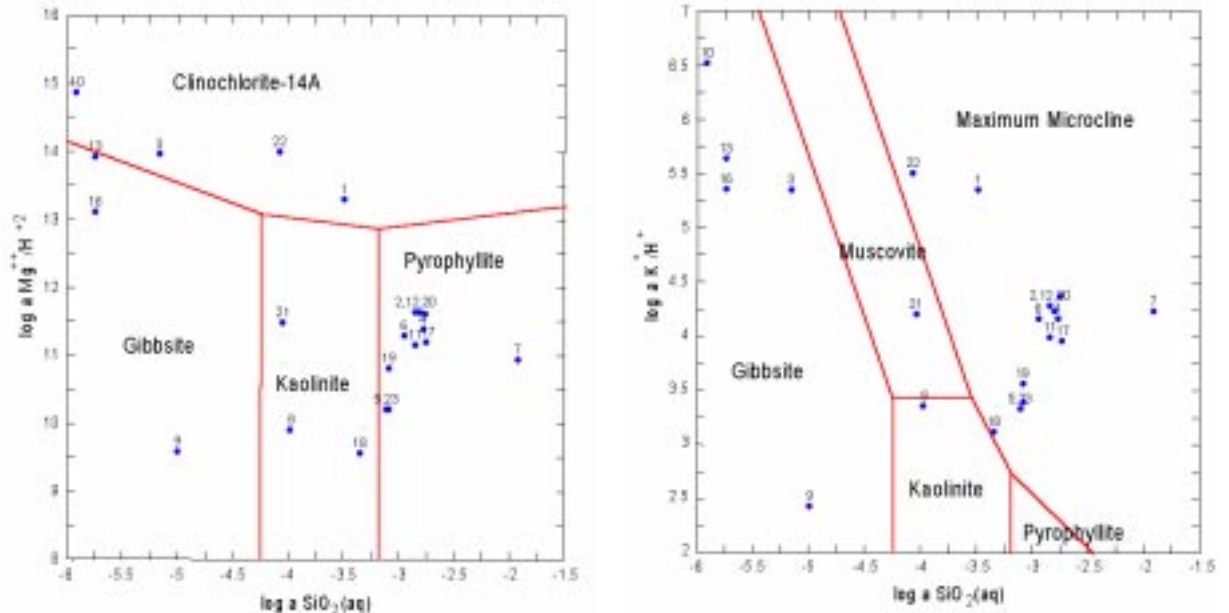


Figure 10. Groundwaters from Bluebush exploration region plotted on muscovite and chlorite stability field diagrams.

Observations from Tennant Creek and Olympic Dam mineralised groundwaters applied to Bluebush samples suggest positive exploration indications for the locations of nine Bluebush

groundwaters (GR1, 3, 8, 9, 19, 13, 16, 21 and 22) in which Si activity is less than $10^{-3.5}$ (Figure 10). In both diagrams in Figure 10 this group of nine appears to be distinctly different to the remaining Bluebush samples, which cluster in groups outside the fields occupied by mineralised groundwaters in Figure 7. In Figure 11 a group of five Bluebush samples plots separately from the rest, in the phengite field. This group is included in the separate group in Figure 10 and includes three from the group noted as possibly contacting sulfides or magnetite

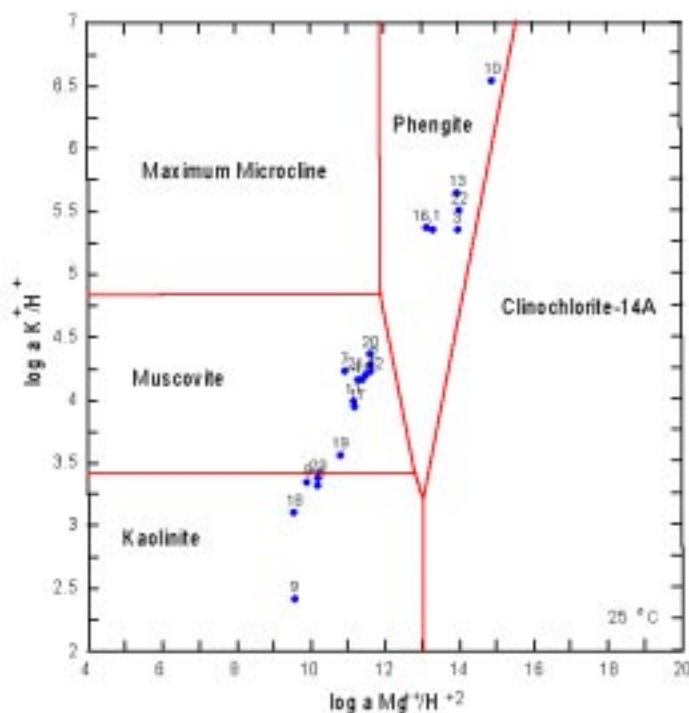


Figure 11. Bluebush groundwaters plotted against muscovite and chlorite stability fields when quartz is fixed as saturated.

TRACE ELEMENTS

Some trace element concentrations in groundwaters reflect lithological variations in aquifers, whilst others can suggest the presence of potentially economic mineralisation. The low regional salinity of groundwaters in the Bluebush Project area means that trace element anomalies will be low in absolute values and only evident by comparison with the very low local background.

Mineralisation Indicators

Enhanced groundwater concentrations of base metals might indicate actual, or down-flow locations of base metal mineralisation. The value of groundwater trace element enrichments to exploration is related to the extent to which they spread beyond the immediate locations of the mineralisation. These enrichments include those directly derived from groundwater interaction with a point source of mineralisation, whether the water is subsequently sampled close to, or away from the deposit, and those derived from groundwater interaction with a weathering or alteration envelope that may surround and geochemically reflect the mineralisation.

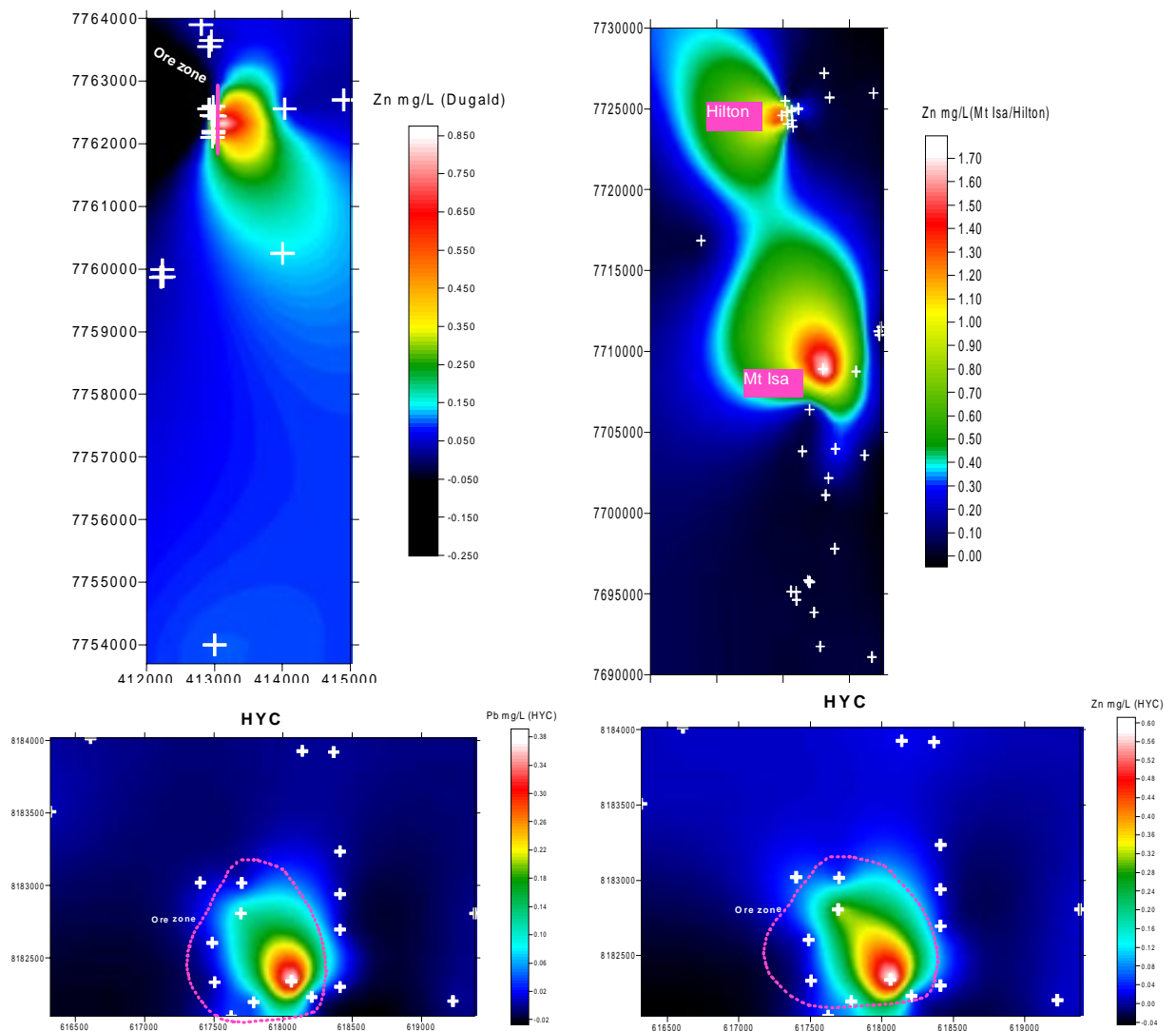


Figure 12 Groundwater concentrations of ore elements in vicinity of some sediment hosted base metal deposits

Previous studies of groundwaters from the vicinity of base metal deposits of the style possible in this region, have shown that groundwater concentrations of target elements such as Cu, Pb and Zn, are not necessarily impressive unless a sample is collected directly from a mineralised zone. Table 2 lists concentration ranges of Cu, Pb and Zn in groundwaters from the vicinity of Dugald River, McArthur River - HYC and Mt. Isa/Hilton deposits. This provides an example of the range of concentrations of base metals that might be expected in groundwaters from the vicinity of major base metal occurrences.

TABLE 2

Deposit	Cu µg/L	Pb µg/L	Zn µg/L
Dugald River	5-70(median 6-20)	<5	10-1450*(median 20-46)
McArthur River HYC	3-25	4-420*	21-652*
Mt. Isa/Hilton	5-30(median 6-9)	7-69(median 0-13)	10-19300* (median 20-50)

*Directly in ore zone

Figure 12 shows imaged contours of Zn at all three deposits and additionally Pb at HYC, demonstrating that regional groundwater anomalies are associated with the mineralisation in each case. Unfortunately, only at HYC, and to some extent Dugald River were samples sufficiently distributed to demonstrate the extent of groundwater haloes in these elements. More details of groundwater concentrations of base metal and gangue mineral indicators at the HYC deposit are shown in Fig. 13 .

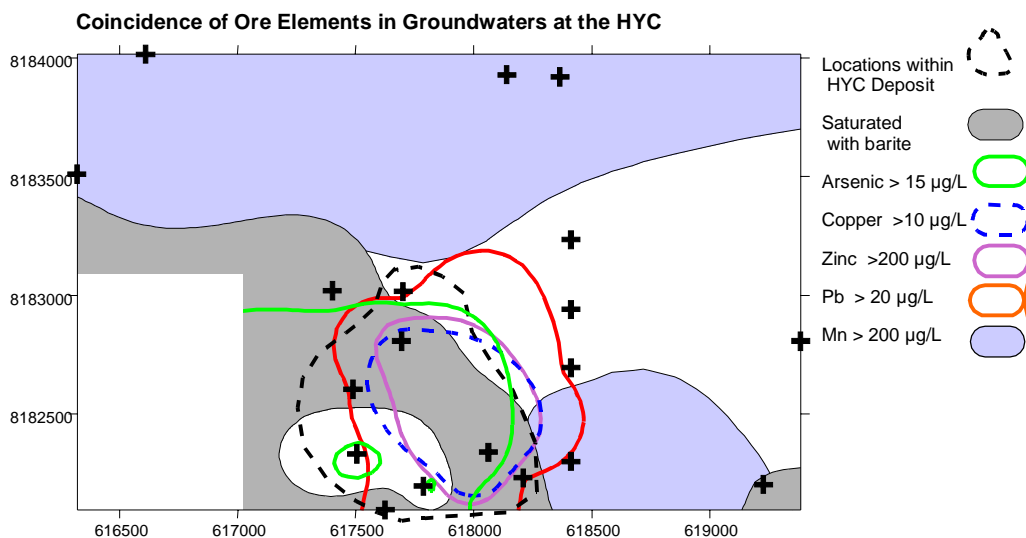


Figure 13 Groundwater concentrations of some ore elements and gangue mineral indicators around the HYC deposit.

Copper

On the basis of absolute Cu values, only GR6 and possibly GR11 are comparable to the examples given from known deposits. However considering the actual groundwater chemistry for each sample, and calculating how much Cu would be in solution if that sample came from an aquifer containing oxidised or sulfide mineral forms of Cu, five locations (including those noted as possibly contacting sulfides or magnetite) are identified where measured Cu concentrations are indicative of Cu mineralisation. Measured values in four other samples, including GR6, are sufficiently close to calculated values, to make it prudent to include them in exploration considerations. There are sufficient degrees of uncertainty in these thermodynamic calculations to always include borderline cases.

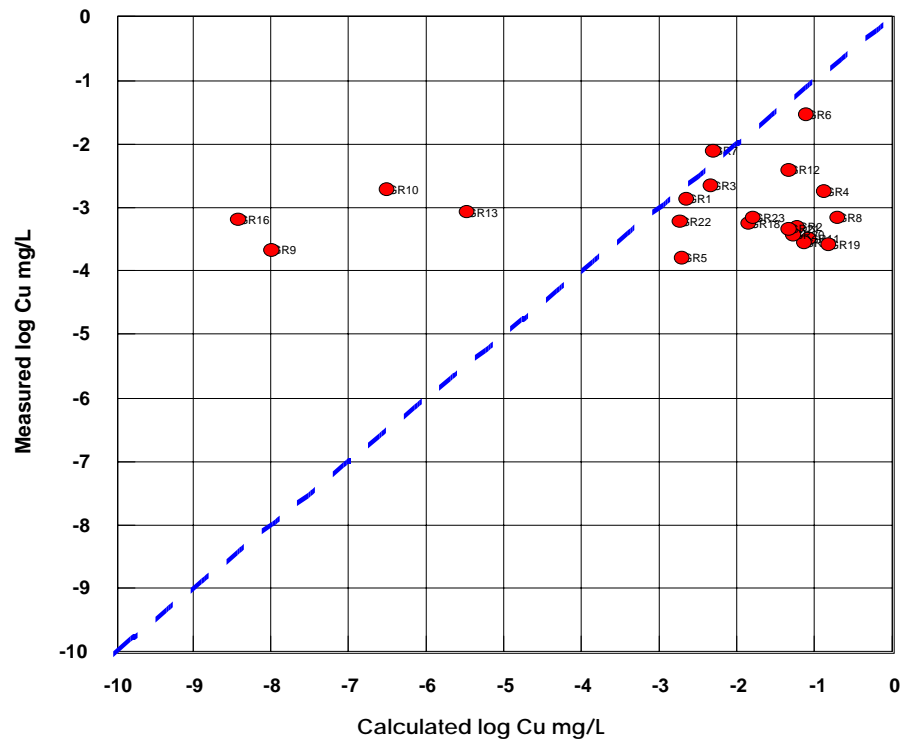
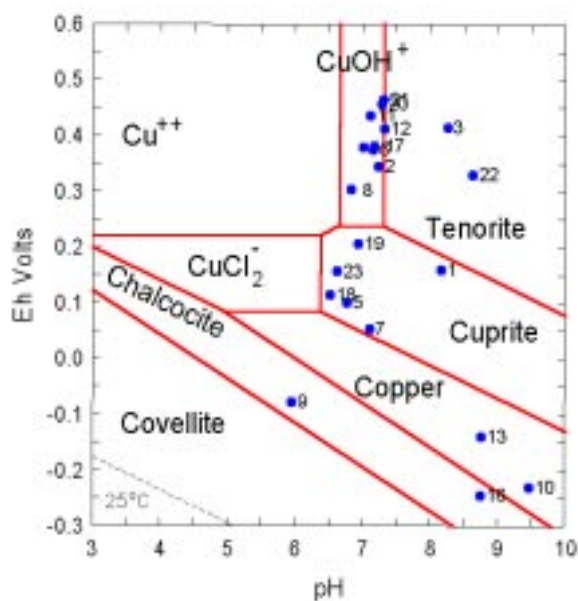


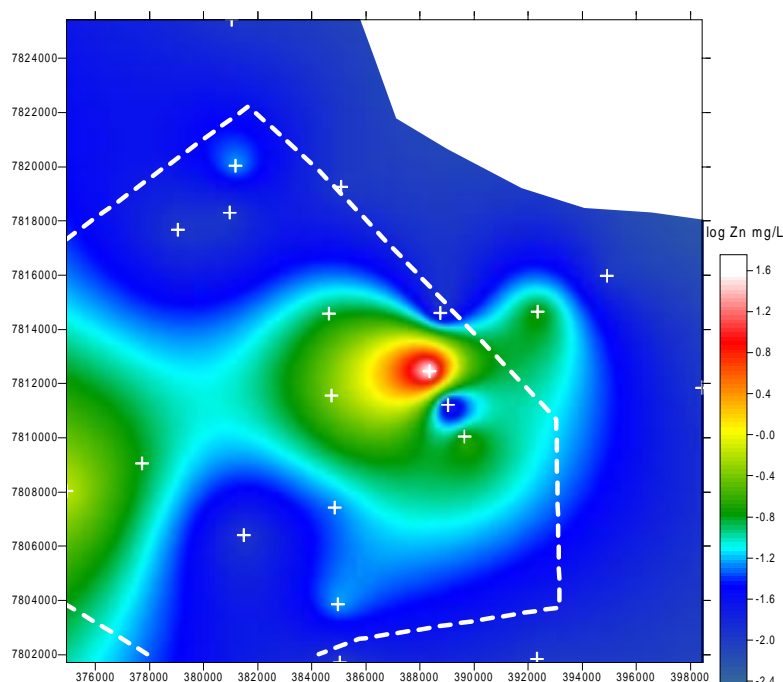
Figure 14 Comparison of calculated Cu concentrations in groundwaters from aquifers containing Cu minerals with those measured in groundwaters across the Bluebush Project area.

The individual sample calculations used to produce Figure 14 can also be used separately to illustrate mineral stability fields of Cu minerals, with respect to pH and Eh. Because anion (Cl , SO_4 , HCO_3) concentrations affect mineral stability field locations with respect to pH and Eh, each diagram will only apply to a particular sample. Figure 15 illustrates relevant Cu mineral stability fields for GR6. Although other samples are shown, this diagram is only valid for GR6.



Boundaries between soluble species (eg Cu^{++}) and insoluble minerals are drawn where Cu concentrations approximate 6 ppb. GR6, plotting in the middle of the soluble CuOH^+ field, is confirmed as being in contact with Cu minerals. To use this diagram approach to assess whether any other samples have Cu concentrations sufficient to conclude the presence of Cu minerals, a separate diagram would be needed for each sample. That is the reason for developing the procedures used to combine each separate set of calculations to produce the diagram in Figure 14.

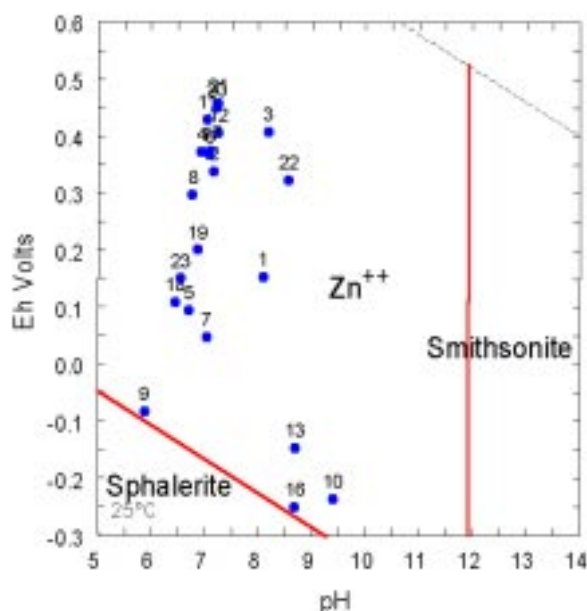
Figure 15. pH-Eh Cu mineral stability fields for anion content of GR6



Zinc

On the basis of absolute Zn values, Figure 16 illustrates an apparently anomalous zone of Zn values that incorporates the linear trend of the four samples previously noted as possibly contacting sulfides or magnetite.

Figure 16. Distribution of Zn values across the Bluebush Project area.



However, Figure 17 illustrates the wide range of pH-Eh values within which Zn is soluble in a groundwater with the composition of GR9. This significant solubility of Zn in groundwaters under common aquifer conditions (boundaries at 6.5 ppb), together with the high incidence of anthropogenic use of Zn in rural areas, eg. galvanised pipes and bore fittings, warrants great caution when interpreting absolute concentrations of Zn in groundwaters in exploration projects.

Figure 17. pH-Eh Zn mineral stability fields for anion content of GR9

As with Cu, the answer is to consider the actual groundwater chemistry for each sample, and calculate how much Zn would be in solution if that sample were from an aquifer containing oxidised or sulfide mineral forms of Zn. This shows that only location GR9, (one of those noted as possibly contacting sulfides or magnetite) was identified where measured Zn concentrations are indicative of Zn mineralisation (Figure 18). When assessing how far all other samples appear to be below their calculated values, the difference in scale between this Zn plot and the previous Cu plot should be noted. Nevertheless it appears that there are some relatively higher Zn values illustrated in Figure 16 that must derive from sources other than oxides, carbonates or sulfides of Zn. Apart from anthropogenic sources, adsorption onto clays and/or Fe and/or Mn oxides could be a source. The grouping of many samples around pH 7 implies a common mineral surface adsorption control for these samples. That is adsorbed Zn is not desorbed from clay and oxide sources until groundwater pH is on the acid side of 7.

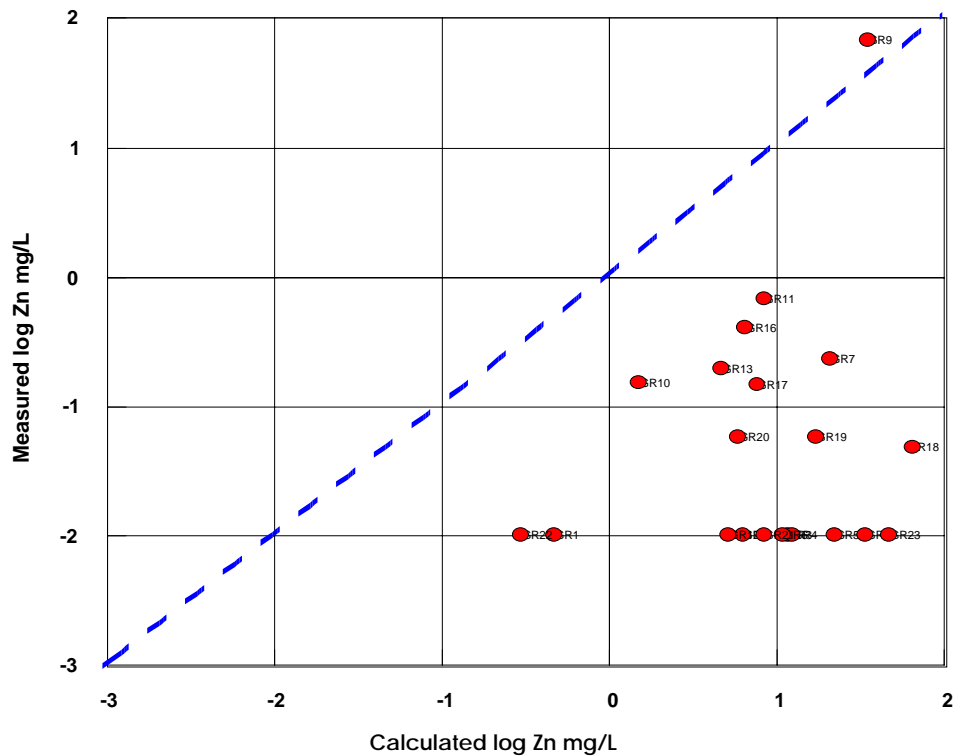
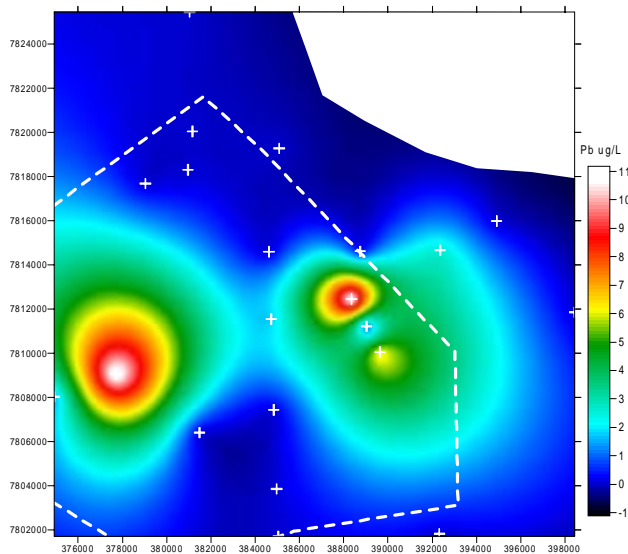


Figure 18. Comparison of calculated Zn concentrations in groundwaters from aquifers containing Zn minerals with those measured in groundwaters across the Bluebush Project area.



Applying the same procedures as used for Cu and Zn, it can be concluded from Figures 20 (boundaries at 2 ppb Pb) and 21, that GR10 and probably GR13, (both among those noted as possibly contacting sulfides or magnetite) contain measured Pb concentrations that are indicative of Pb mineralisation in the groundwater environment.

Figure 20. pH-Eh Pb mineral stability fields for anion content of GR9.

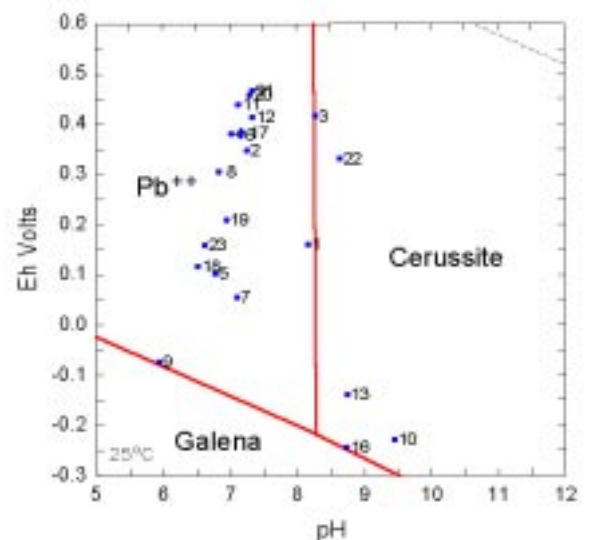
Giants Reef Mining - Bluebush Project

area.

Lead

Although 12 of the 21 Bluebush locations had undetectable Pb in groundwaters, the 9 locations where Pb was detected, similarly to Zn, incorporate the linear trend of the four samples previously noted as possibly contacting sulfides or magnetite (Figure 19.).

Figure 19 Distribution of Pb concentrations in groundwaters across the Bluebush Project area.



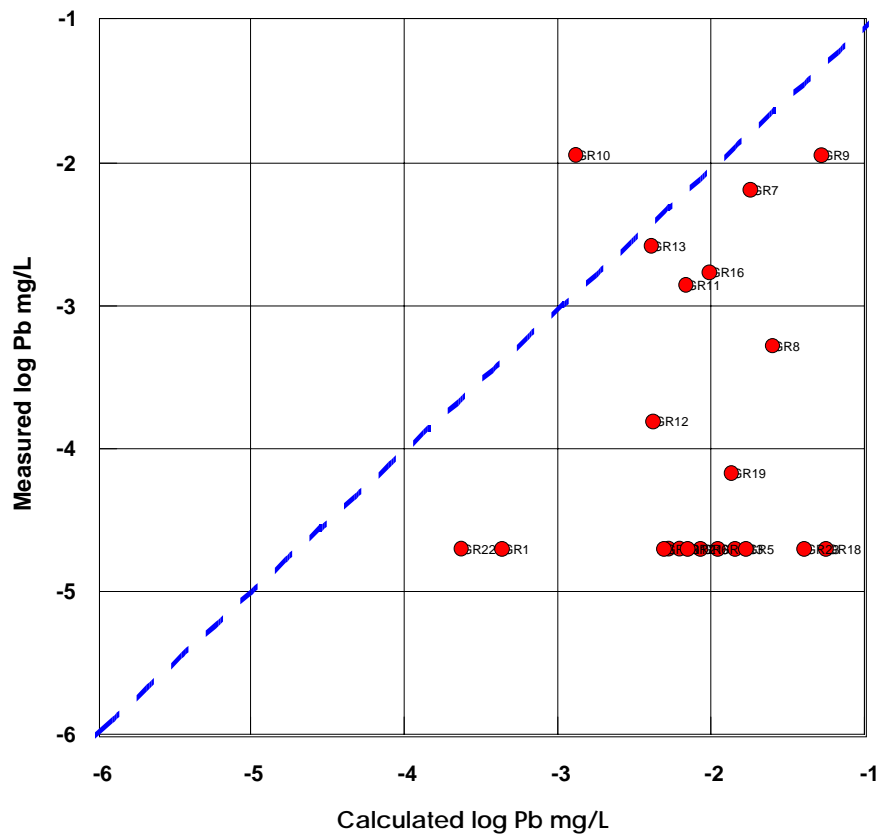


Figure 21. Comparison of calculated Pb concentrations in groundwaters from aquifers containing Pb minerals with those measured in groundwaters across the Bluebush Project area.

Gold

Due to the rarity and low solubility of Au, absolute measurements are adequate indicators. The value of absolute Au in groundwaters, as an exploration indicator has been established from many studies across Australia. These have demonstrated that Au was below or close to detection in the large majority of collected samples. This suggests that Au, detected at 1 ppt (1 ng/L), is a very good groundwater indicator of Au in associated rocks and soils. This may be as Au in its own right, from trace to potentially economic commodity levels, or as a component of

other, e.g. sulfide, mineralisation. The most obviously anomalous groundwater Au concentration in the Bluebush area was in GR16 at 46 ng/L, coinciding with one of the Cu group, and central to a line of locations of modestly higher groundwater Au concentrations both north and south of GR16 (Figure 22). This line intersects at GR16 the line of samples noted as possibly contacting sulfides or magnetite. Gold, Cu and magnetite together enhance the prospectivity of this location.

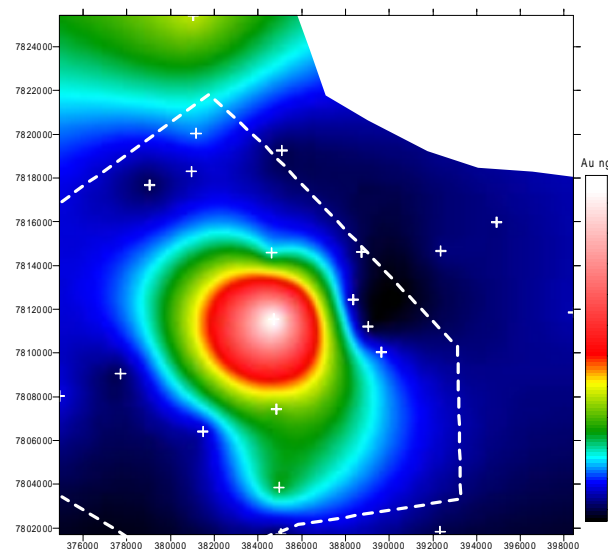
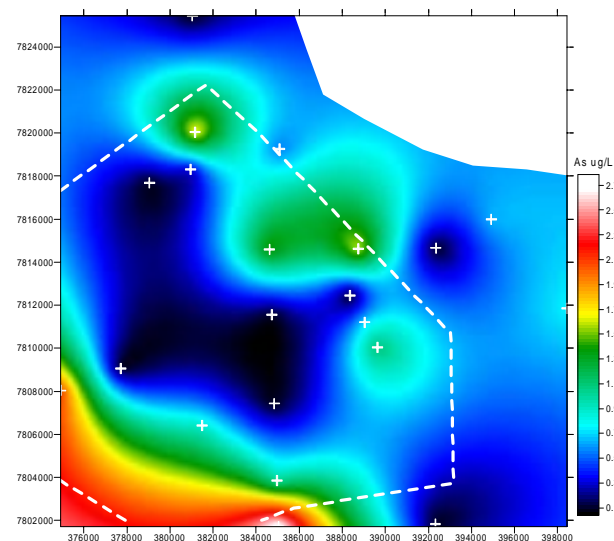


Figure 22. Distribution of Au concentrations in groundwaters across the Bluebush Project area.

Arsenic

Arsenic is highly soluble and mobile in groundwaters and is hence a good groundwater indicator to economic mineral occurrences with which it is often associated. These are principally gold deposits, but economic mineral occurrences associated with As also include base metal deposits, including both the Dugald River and HYC (Figure 13). Arsenic is generally rare in the absence of some mineral source, so the locations in the Bluebush area where As was detected in groundwaters, albeit at modest concentrations, should not be ignored. Figure 23 shows a degree of focus for these locations, in two zones outside of those suggested as prospective by either major elements or Au and base metals.

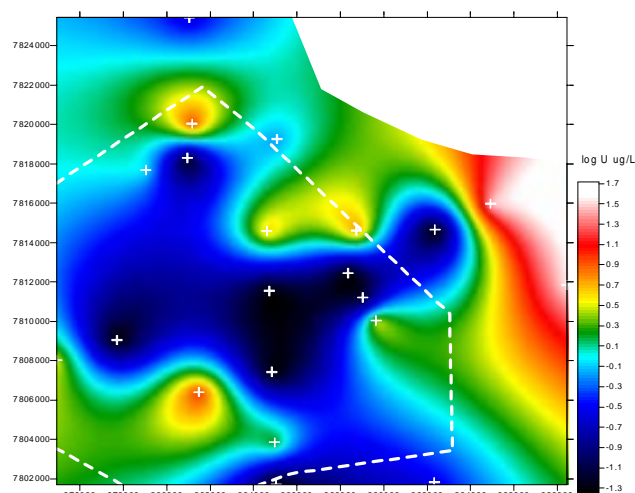
Figure 23. Distribution of As concentrations in groundwaters across the Bluebush Project area



Uranium

Apart from U mineralised rocks, U is acquired by groundwater leaching of micaceous sediments and certain felsic igneous rocks. Figure 24 indicates that low values of U generally correspond with locations within the gravity anomaly, suggesting that whatever is the source of the gravity anomaly, U is probably not a constituent.

Figure 24. Distribution of U concentrations in groundwaters across the Bluebush Project area

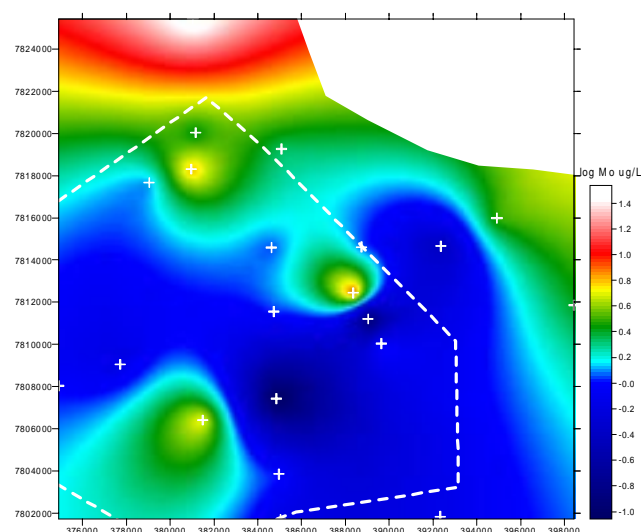


Lithological Indicators

Molybdenum

Molybdenum is slightly enriched in felsic igneous rocks and is an accessory element in many metal ores, including traditional Tennant Creek deposits, and particularly those that accumulate in quartz veins. Molybdenum is relatively easily leached by natural waters from rock sources. At the same time it is rare in groundwaters making it a potent exploration associated indicator of deposits with which elevated Mo is associated. For example, anomalous Mo in groundwaters is leached from porphyry Cu deposits in the USA.

Figure 25 Distribution of Mo concentrations in groundwaters across the Bluebush Project area.



An Australian example of this is seen in the vicinity of the Northparkes porphyry Cu-Au deposits. Near these deposits, Mo is detected in groundwaters, but is otherwise rare in the region.

Figure 25 illustrates the distribution of Mo concentrations in groundwaters across the study area illustrating location GR23 as potentially very interesting. At this location groundwaters also carry anomalous values of Co, Ni, Au, Fe and P, a combination with Mo as similar to that observed in rocks associated with traditional Tennant Creek style Fe-oxide Cu-Au deposits.

Rubidium.

Rubidium is geochemically very similar to K but because it occurs at much lower abundances, and is among the most mobile of the alkali metals, its groundwater concentrations are very useful for tracking K rich lithologies. Unfortunately in spite of significant concentrations measured in groundwaters across the Bluebush area, variation in concentrations of Rb across the sample set is insufficient to identify zones that are significantly different in terms of potassic enrichment.

Fluorine

Fluorine in groundwaters (concentrations of the order of 1 – 5 mg/L) is normally a good indicator of felsic igneous and mica rich rocks. Also, correlation between F and U in groundwaters can point to a common felsic igneous or micaceous mineral source for these elements. In the Bluebush data set, U and F are only weakly correlated as are Rb and F.

Because the NT government groundwater data included F, the present data set, incorporated with the NT government data, provides an indication of how these F source rocks are distributed regionally with respect to the gravity anomaly and mapped mineral types (Figure 26). It appears from the mapped mineral indicators that F in groundwaters derives from sedimentary units.

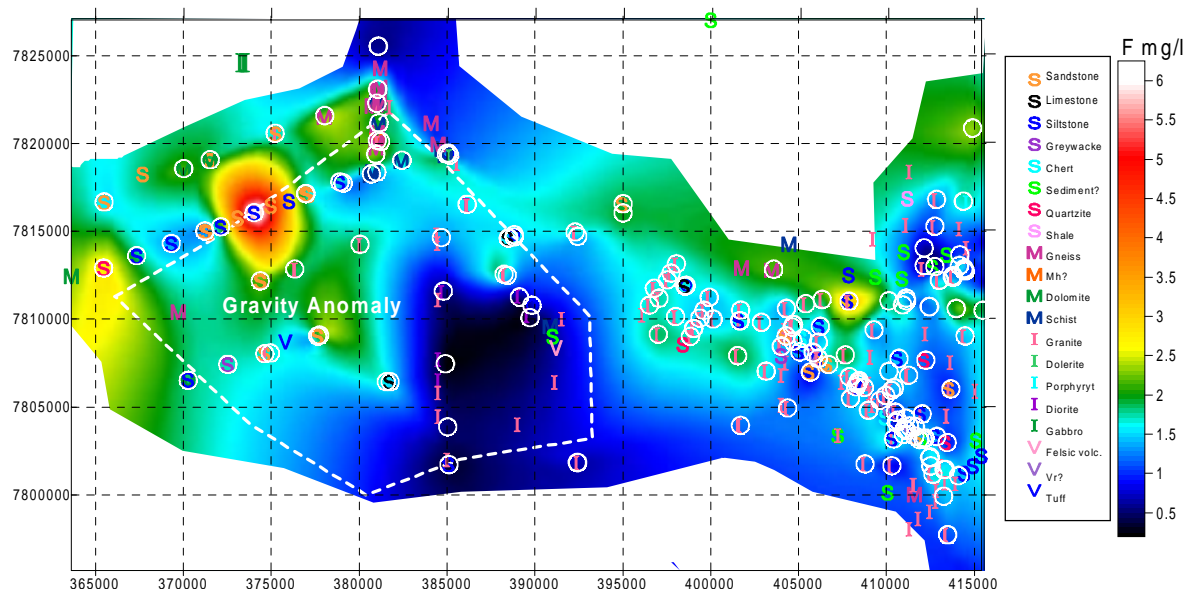


Figure 26. Regional variation of F in groundwaters indicating coincidence of higher F concentrations with mapped sedimentary units.

Boron

Boron is a conservative element concentrations of which need to be normalised by groundwater salinity to identify anomalous locations. Boron can be an indicator of hot spring derived sediments, but more often as an indicator of marine derived sediments. It is considered here because its concentrations in Bluebush groundwaters are closely correlated with those of F ($r =$

0.68 after normalising both for salinity) suggesting that the sedimentary units hosting F are marine in origin.

Another interpretation may be that this variously correlated combination of F, U, B and Rb could be indicating a specific type of granite. For example, Davidson and Large, (AGSO Journal 17(4), 105-113) refer to some granite suites associated with mineralisation in the Tennant Creek Block as having an unusual A-type granite chemistry characterised by high K, HFSE (Nb, Ta, Zr, Y etc), F, B, U and Li. Leaving out Li, and the rare and insoluble HFSEs, and using Rb to proxy for K, the correlated combination of F, U, B and Rb may constitute a groundwater signature for this style of granite. The present data set is a bit small to unequivocally test such a signature.

Silicon, Scandium and Chromium

Another strongly mutually correlated group of trace element concentrations in Bluebush groundwaters, Si, Sc, Cr also correlate strongly with NMg. Since Sc is closely related to Mg and Fe in ferromagnesian silicates as is Cr, this grouping suggests that locations where these are jointly elevated are where mafic units are influencing groundwater compositions. Silicon may seem an unlikely indicator to mafic rocks, as by contrast, felsic rocks have higher Si content. However, when considered from a groundwater perspective, because mafic rock minerals (eg olivine, pyroxene, amphibole) are in general more easily changed by groundwater interaction, than Si containing minerals in felsic rocks (eg quartz, K-feldspar, muscovite), more Si will be released into groundwaters from mafic than from felsic rock minerals.

Iron, Manganese, Cobalt and Phosphorus

These elements are among those commonly enhanced in iron-stone Cu-Au deposits (eg. Olympic dam and probably Tennant Creek). Therefore, observed correlations amongst groundwater concentrations of Fe, Mn, Co and P in the Bluebush data set suggests that locations, GR5, 7 and 23, where these are jointly elevated, are locations where iron-stones are influencing groundwater compositions.

LITHOLOGY VARIATION FROM GROUNDWATER GEOCHEMISTRY

Derived from Multivariate Statistical Manipulations

Various multivariate manipulations of the Bluebush groundwater data were tried to search for location groupings that might be indicative of concealed lithological zones. Because there were only 21 samples the number of original variables (elements) that could be used for a rational result, in each calculation, was limited. The purpose of multivariate manipulations is to calculate combinations of original variables, which compress the original data variation into progressively fewer new variables. The technique therefore incorporates into one or more new variables those original elements that have a degree of correlation (positive and negative) with each other. Unlike the input variables, the new variables do not correlate with one another in an overall sense. Hence by plotting 2 of the new variables against each other, new clustering of samples can be observed in the new variable XY space. Furthermore, if a Correspondence Analysis is used, the position of samples can also be seen with respect to the original data variables.

Figure 27 illustrates such a plot. It is a scatter plot of calculated values for the first 2 Correspondence Analysis variable scores derived from original variables Sc, Si, Cr, NMg, B (normalised by salinity), F(normalised by salinity) and Rb(normalised by salinity). Elements whose concentrations were normalised by salinity were those for which concentrations correlated with

salinity. The intention was to exclude salinity as an input variable. Figure 27 illustrates four sample groups with GR3 on its own. The locations of samples, with respect to the original variables suggest that the X axis ranges from generally mafic (2 groups separating in a Y axis direction by influence of NMg), through groundwaters possibly from micaceous sediments, to the group set apart throughout this study, originally by their possibly contacting sulfides or magnetite. Because this analysis is based on only 21 samples, its apparent simplicity may be illusory. However, at this stage of our information, Figure 27 implies that for the sample group GR9, 10, 13 16, whilst deriving from the least mafic locations of all the samples in the study,

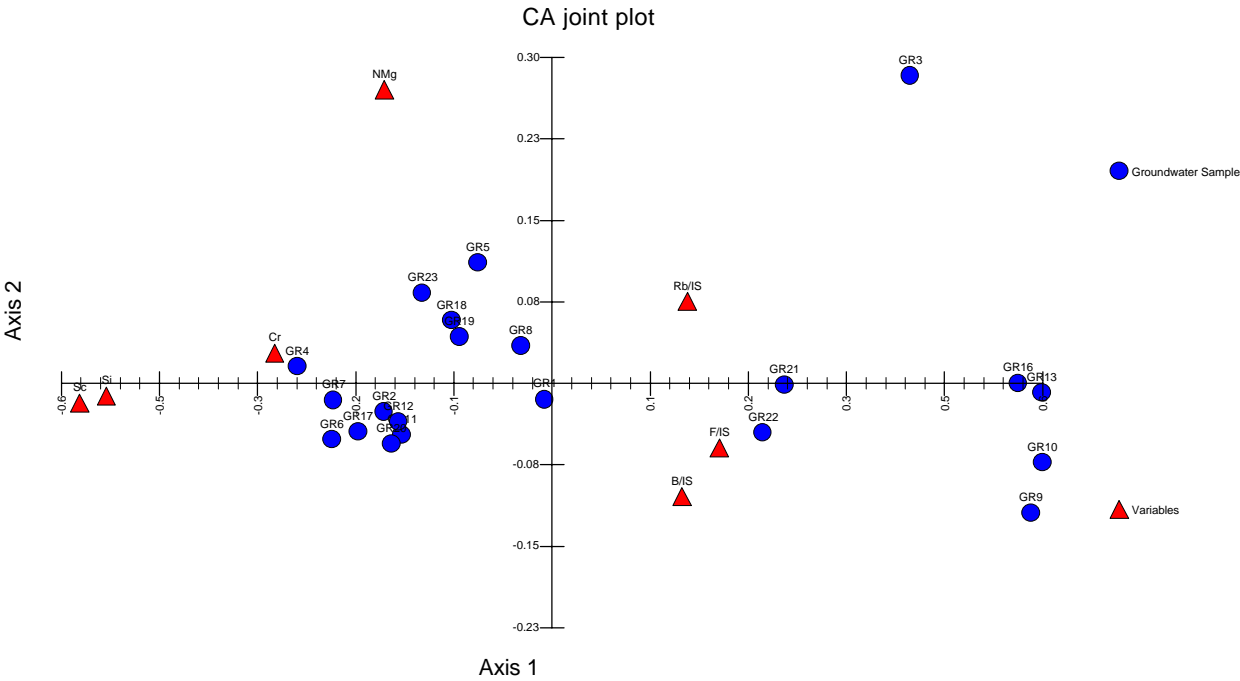
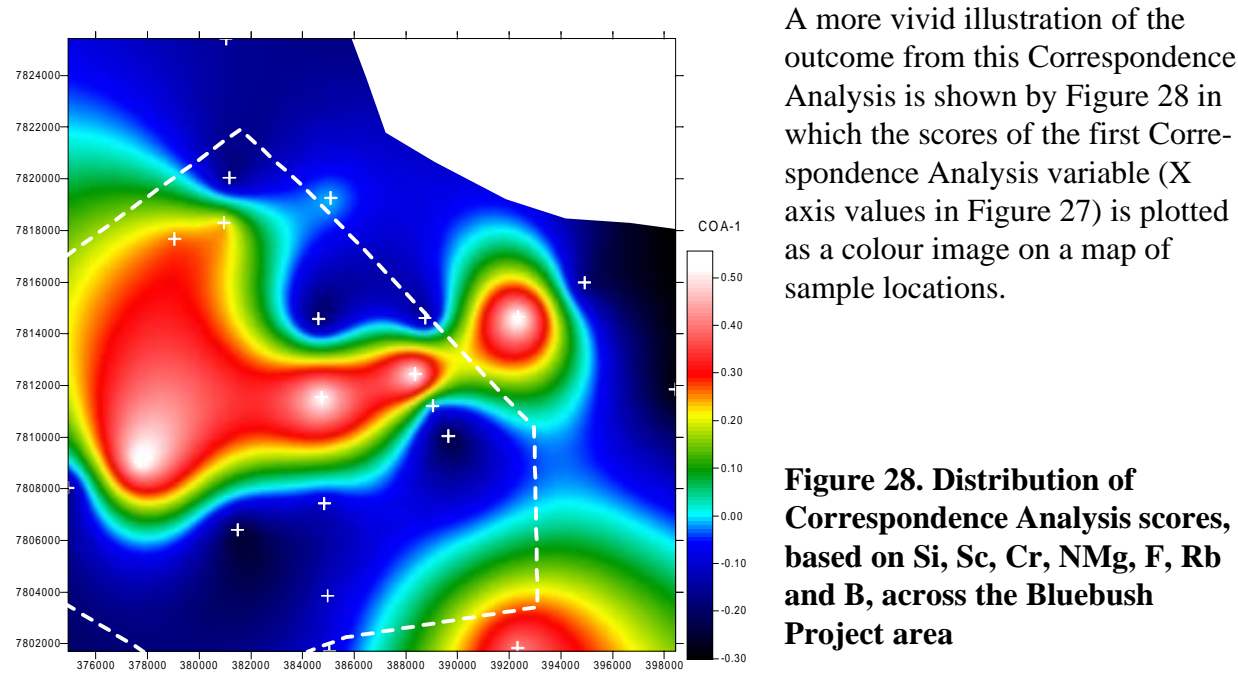


Figure 27. Scatter plot of calculated values for the first 2 Correspondence Analysis variable scores derived from original variables Sc, Si, Cr, NMg, B (normalised by salinity), F(normalised by salinity) and Rb(normalised by salinity) in Bluebush data set.



A more vivid illustration of the outcome from this Correspondence Analysis is shown by Figure 28 in which the scores of the first Correspondence Analysis variable (X axis values in Figure 27) is plotted as a colour image on a map of sample locations.

Figure 28. Distribution of Correspondence Analysis scores, based on Si, Sc, Cr, NMg, F, Rb and B, across the Bluebush Project area

Saturated Minerals

Most groundwater samples are normally supersaturated with several minerals that can form as chemical precipitates. This supersaturation results from slow rates at which many chemical precipitations of minerals occur at earth surface temperatures. A good example of this is seawater, which is supersaturated with at least 13 minerals. Distribution of relative levels of supersaturated dolomite in each groundwater (Figure 4) as an indicator to locations of mafic rocks, has already been demonstrated. Other indications to zoning in concealed lithologies could be evident by noting the saturation status of other minerals that can form as chemical precipitates. For example -

- 1 In this study, groundwaters with Si derived from mafic silicates would probably be supersaturated with respect to slowly precipitating quartz. Conversely, samples that are not supersaturated with quartz could be derived from aquifers containing Si in minerals such as quartz, muscovite and K-Feldspar that react very slowly with groundwaters. The only samples not saturated with quartz are GR3, 8, 9, 10, 13, 16, 21 and 22, a group that further suggests a central zone in the gravity anomaly that may not be dominated by mafic rocks.
- 2 Calculations of which minerals are still saturated, after notional (calculated) precipitation of supersaturated minerals provides further criteria for characterising aquifer mineralogy:
 - Muscovite is saturated in GR11, 17 and 20
 - All Bluebush Project groundwaters except GR9 are saturated with Witherite (BaCO_3).
 - GR 9 is saturated with siderite.
 - GR3, 8 and 22 are saturated with Mn minerals.
 - GR10 and 22 are saturated with antigorite
 - The only groundwater in the set to be saturated with talc is GR1
 - The only groundwater in the set to be saturated with chlorite is GR3
 - The only groundwater in the set to be saturated with magnesite is GR22

CONCLUSIONS

Groundwater geochemical data from the Bluebush Project area has been studied to find interpretation procedures which identify variations in concealed lithologies that may relate to aquifer prospectivity for base metal mineralisation. Potentially useful outcomes that can now be applied to further groundwater data from the area include the following.

1. Four Bluebush groundwaters (GR9, 10, 13 and 16) exhibited pH-Eh values which when plotted on an appropriate Fe mineral stability field diagram, were indicative of an aquifer environment in which magnetite or sulfide minerals could exist. Locations from which all were collected are within a zone that passes through the centre of the gravity anomaly.
2. Silicate mineral stability fields occupied by groundwaters from mineralised locations at both Olympic Dam and Tennant Creek, were also occupied by a group of Bluebush groundwaters (GR1, 3, 8, 9, 10, 13, 16, 21 and 22) from locations which included those noted for possible magnetite or sulfide association.
3. Solution chemical models of expected commodity element concentrations in groundwaters from aquifers containing ore minerals, indicated that measured values in

this study were comparable with expected Cu contents of GR1, 3, 6, 7, 9, 10, 13, 16, Zn content of GR9 and the Pb contents of GR10 and 13. Once again these potentially mineralised locations included those noted for possible magnetite or sulfide association.

4. Anomalous Au in groundwater from GR16 was flanked north and south by locations in which groundwaters were modestly enhanced with Au.

5. Multivariate statistical manipulations of a series of combined major and trace elements in Bluebush groundwaters define a zone statistically different from locations designated as either mafic or felsic by groundwater indicator elements. Coincidentally, and therefore hopefully significantly, this group is the same as that noted for possible magnetite or sulfide association.

6. At location GR23, in the north of the study area, the groundwater contains anomalous concentrations of Mo, Co, Ni, Au, Fe, Mn and P. This combination is similar to that observed in groundwaters from the traditional Tennant Creek style Fe-oxide Cu–Au deposits

ACKNOWLEDGEMENTS

All laboratory analytical data used was coordinated, compiled and verified within the CSIRO Exploration and Mining North Ryde Groundwater Pathfinders project. ICP-AES and MS, Cl, F and carbonate analyses were performed by Lesley Dotter, As by AGAL and NAA determinations by Bequerel Laboratories.

APPENDIX 1

SAMPLE COLLECTION AND ANALYSES

Recommended Methods

If a pump (wind or diesel powered) is fitted to a bore or well that is to be sampled, flowing water is collected after that flow has replaced stagnant water in pipe systems. Where no pump is available, groundwater samples are usually collected with a chemically inert tube sampler which has one-way flow valves. One-way valves allow water to flow through the tube as it is lowered down a sampling hole, but prevent water leaving the tube during the return of the sample to the ground surface. The water collected is a sample from the lowest depth reached by the tube. Calibrated survey cable ("polychain") wound onto a hand held reel is used to suspend the sampler and to measure the depth to standing water and the sample depth. A standard sample depth of 5m below the water table provides samples unaffected by atmospheric contact. At all sites sufficient water is collected to provide for rinsing and filling two 500mL and one 1L sample bottles; one 500mL bottle for immediate field measurements, the other for subsequent laboratory analyses and the 1L bottle for laboratory gold analysis. The laboratory sample bottles are labelled with a relevant sample number and stored (after treatment of the 1L sample as detailed below), preferably in a field freezer. It is recommended that multiple labels are used on each bottle as subsequent transport and general handling can cause label erasure.

Field pre-treatment of gold sample

The procedure for pre-concentrating Au in groundwater samples devised in the CSIRO, Exploration and Mining laboratories at North Ryde, uses 1 gram sachets of activated carbon to pre-concentrate Au from 1 litre water samples to which appropriate amounts of lime and cyanide have been added. Adsorption of the cyanide complexed Au onto activated carbon provides a 1000 times pre-concentration on a matrix that is amenable to Neutron Activation Analysis such that Au in the original sample is determined at 1ng/L. Explicit and detailed instructions for this field pre-treatment are included at the end of this report. It is essential that these are followed precisely.

Chemical analysis of water samples

1. Field Analyses

Some properties of natural waters change rapidly after a sample has been removed from the water body it represents. Unstable properties of interest in exploration programs are pH, Eh, reduced iron (Fe^{2+}) and temperature. Equipment for measuring pH, Eh and temperature consists of a hand held digital read-out meter, to which separate probes for each parameter are attached. Insertion of each probe into a water sample produces a digital reading for each parameter, which is recorded. The meter is calibrated using standard pH buffer solutions, but requires no calibration for Eh or temperature. All probes, including those for pH and Eh are reasonably robust if handled and stored with care according to supplier's recommendations.

Salinity measured as "conductivity", although not an unstable water property is useful to know in the field, as it provides a field classification of groundwaters into those that may have the

same source, compared with others that are completely different. A conductivity meter and probe allow this parameter to be easily determined and recorded.

Field measurement of Fe^{2+} is performed on a 10 mL sample of water to which is added 3 drops of 0.2% aqueous solution of 2-2' Biquinolyl. This reagent promotes a distinctive red colouration to the water if Fe^{2+} is present. The depth of colour is directly related to the solution concentration of Fe^{2+} using a field colorimeter or visual comparison with prepared standards. Concentrations of Fe^{2+} in groundwaters, particularly if associated with low (acid) pH values, may be immediate field indications that sulfides are being oxidised in the groundwater flow path.

2. Laboratory Analyses

Samples (500ml) for analyses of major and trace constituents are returned to the CSIRO Division of Exploration and Mining laboratory at North Ryde where a portion of each sample is centrifuged if necessary to obtain a clear extract and acidified (10ml/L) with high purity concentrated HNO_3 . The acidified samples are analyzed by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) for major elements Ca, Mg, Na, K and S, and trace elements Al, Si, Fe, Mn, Cu, Li, P, Ti, B, Ba, Be, Sc, V and Sr. ICP coupled with mass spectrometry (ICP-MS) is used to determine trace concentrations of Pb, U, La, Y, Yb, Co, Cr, Cd, Ni, Zn, Mo, Tl, Th, Rb, Cs, Ga, Ge, Zr, Sb and Bi.

The unacidified portions of the samples are analyzed for Cl by ion chromatography, total carbonate (TCO_3) with a thermal conductivity analyzer, for As with a hydride generator coupled with quartz tube ICPMS, and for F with an ion selective electrode. If necessary, Cu and Pb values are checked by voltammetry.

In all analytical procedures a protocol is adhered to of analysing a separate standard, followed by a sample spiked with standard additions of relevant analytes, followed by a blank in between every 5 samples.

The charcoal sachets are removed from the 1 litre sample bottles, washed in distilled water, dried and then sent to Bequerel Laboratories for Neutron Activation Analysis for Au.

APPENDIX 2.

MAJOR ELEMENT CONCENTRATIONS

Major elements in their ionic solute form in a groundwater are - Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Cl^- , SO_4^{2-} and TCO_3 (the total of all carbonate species). These constitute the major part of the water's salinity. Salinity can be described as Total Dissolved Solids (TDS), the sum of the concentrations of these major solutes, or as Ionic Strength (I), a measure of salinity that takes account of the greater contributions of polyvalent ions to solution properties related to salinity. $I = \sum(m_i z_i^2 / 2)$ where m_i is the concentration of a particular ion in moles/Litre and z_i is the charge on that ion. On the "T" scale, drinking water would have a value of 0.002 and sea-water of 0.8.

Graphical Depictions.

A useful means of depicting the major solute composition of a groundwater is by a Schoeller Plot. Schoeller plots are drawn by plotting logarithmic concentrations of major solutes (in milli-equivalents/litre (me/L)) in a water, in the order Ca^{2+} , Mg^{2+} , $(\text{Na}^+ + \text{K}^+)$, Cl^- , SO_4^{2-} and TCO_3 . The slope of each line joining the points represents the concentration ratios Ca/Mg , $\text{Mg}/(\text{Na} + \text{K})$, $(\text{Na} + \text{K})/\text{Cl}$, Cl/SO_4 , SO_4/TCO_3 respectively, and the resultant shape that derives from these ratios constitutes a signature for the aquifer in terms of the major solute content of the water. For waters with **low** salinities, Schoeller plots provide a convenient means for sorting waters into groups, as a first step in identifying the presence of different lithologies. For example, Fig. A2.1 shows Schoeller Plot signatures for a range of waters, each known to be equilibrated with a specific rock type. Although waters from all aquifers of these types do not conform exactly to these shapes, specific aquifer lithologies are often identifiable from the ratios of major ion concentrations. Consistent relative abundances of cations include: Na^+ and $\text{K}^+ > \text{Ca}^{2+}$ and Mg^{2+} in waters from aquifers that geochemically match felsic igneous rocks such as granites or rhyolites; Ca^{2+} and $\text{Mg}^{2+} > \text{Na}^+$ and K^+ in waters from aquifers that match mafic igneous rocks such as basalts. Intermediate relationships are shown by waters from aquifers with compositions between these extremes. Waters from ultramafic aquifers show $\text{Mg}^{2+} > \text{Ca}^{2+}$, Na^+ and K^+ .

For each igneous group there are groups of sedimentary and metamorphic rocks that are equivalent in terms of bulk chemistry. Major solute relativities in groundwaters from aquifers in chemically equivalent rocks should be indistinguishable from each other. Some sedimentary rocks such as sandstones have no igneous equivalent, nor an immutable composition. The compositions of groundwaters from these reflect the more soluble minor constituents, such as cementing clays and lithic fragments. Groundwaters from sandstone aquifers therefore vary widely in composition.

Figure A2.2 illustrates Schoeller plots of major element composition of all Bluebush Project samples.

Normalised Major Elements

The initial control on absolute concentrations of individual major ions is groundwater salinity. If this is ignored, comparisons of major ion concentrations within a set of water samples are of little use for expressing geochemical variation. This is overcome by translating them into normalised values (e.g. NCa , NMg , etc) by expressing each concentration as a ratio of the total anion or cation concentration, (calculated using milli-equivalents/Litre as the concentration units). An example of the value of normalised major ions was given in Table 3 where high values were listed of NSO_4 in groundwaters that are known to leach sulfide minerals in the

Broken Hill and Mount Isa regions. Normalised Mg (NMg) provides an index for the abundance of ferromagnesian minerals, and hence mafic units, in aquifer lithologies. NMg also can be an indicator of chlorite alteration, and NK, a subtle reflection of varying degrees of potassic alteration. These latter may be hard to observe due to relatively low (compared to other constituents) concentrations of K in groundwaters.

Some limitations on the use of normalised concentrations apply to saline waters in which conservative ions (principally Na⁺ and Cl⁻) reach such a high proportional concentration that normalised variations in other ions are less distinctive. In high salinity waters the non-conservative ions are also affected by the solubilities of chemically precipitated minerals. From the data collected in previous studies it appears that normalised concentrations are useful parameters in waters in which Ionic Strength is less than 0.4. Since most samples in this data set have I < 0.4, normalised major ions were used in this study.

TABLE 3

Examples of groundwater properties that indicate oxidising sulphides in the flow path.

SAMPLE No.	pH	Fell mg/l	NSO₄
H16	6.5	38	0.6511
H19	6.3	100	0.6237
PYH5	3.6	100	0.8784
PYH6	5.4	100	0.7431
PYH7	6.0	350	0.8203
PYH9	6.3	1	0.6282
PYH10	3.6	45	0.8394
PYH12	5.4		0.7234
PYH13	5.1	500	0.5989

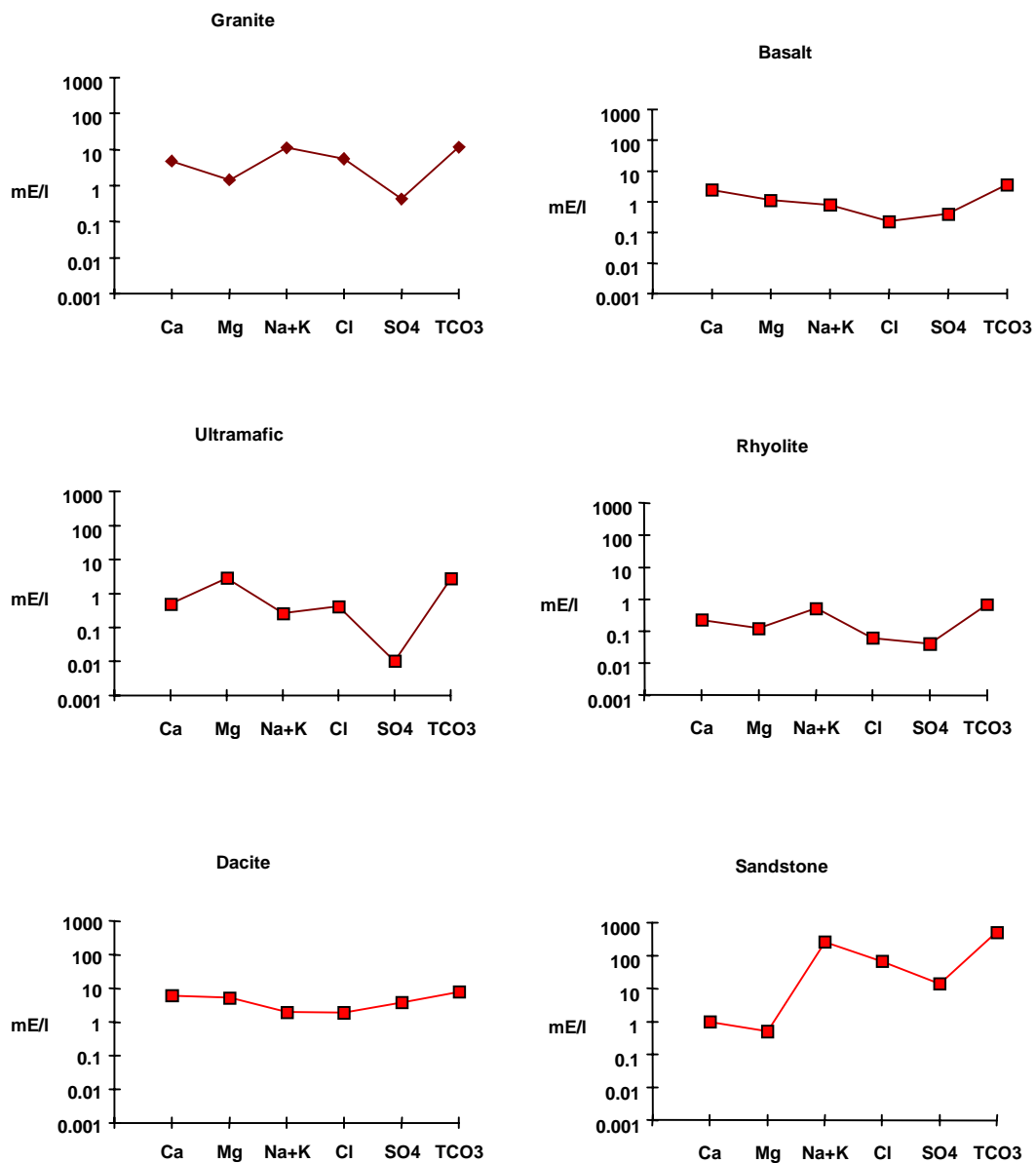


Figure A2.1. Schoeller plot signatures for a range of groundwaters, each known to be equilibrated with a specific rock type.

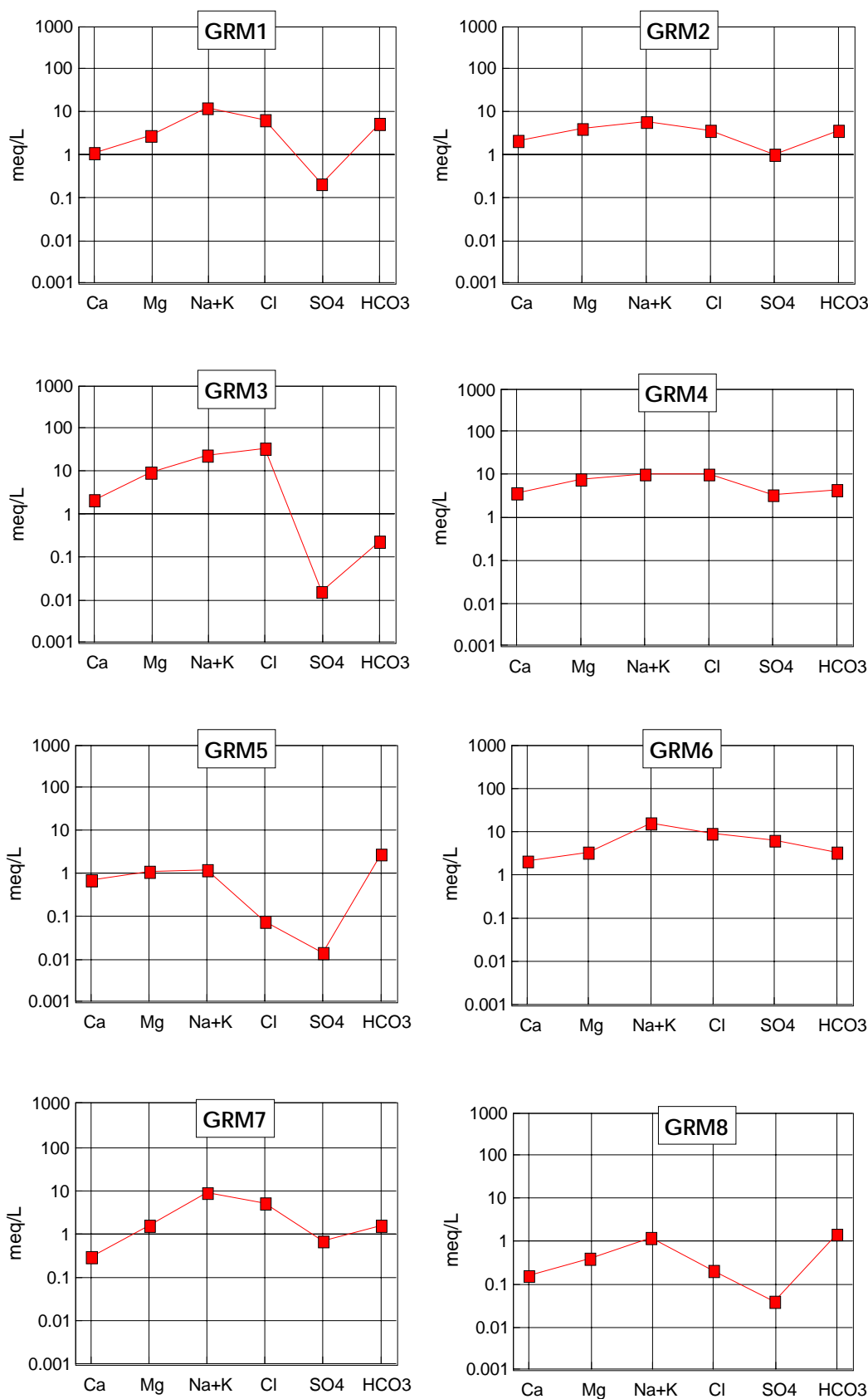


Fig. A2.2(a). Schoeller plots of major element compositions of groundwaters from the Bluebush Project area.

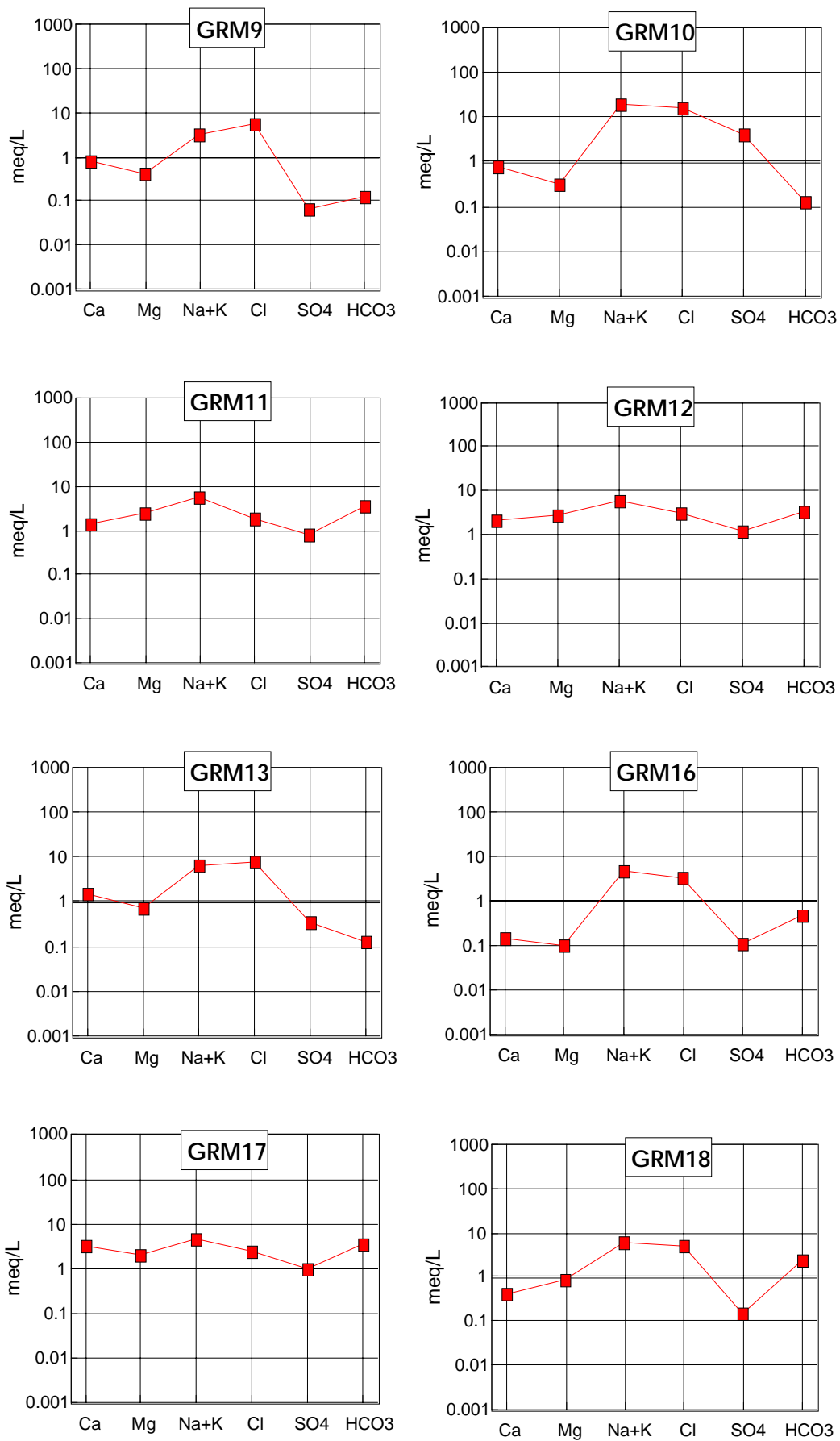


Fig. A2.2(b). Schoeller plots of major element compositions of groundwaters from the Bluebush Project area.

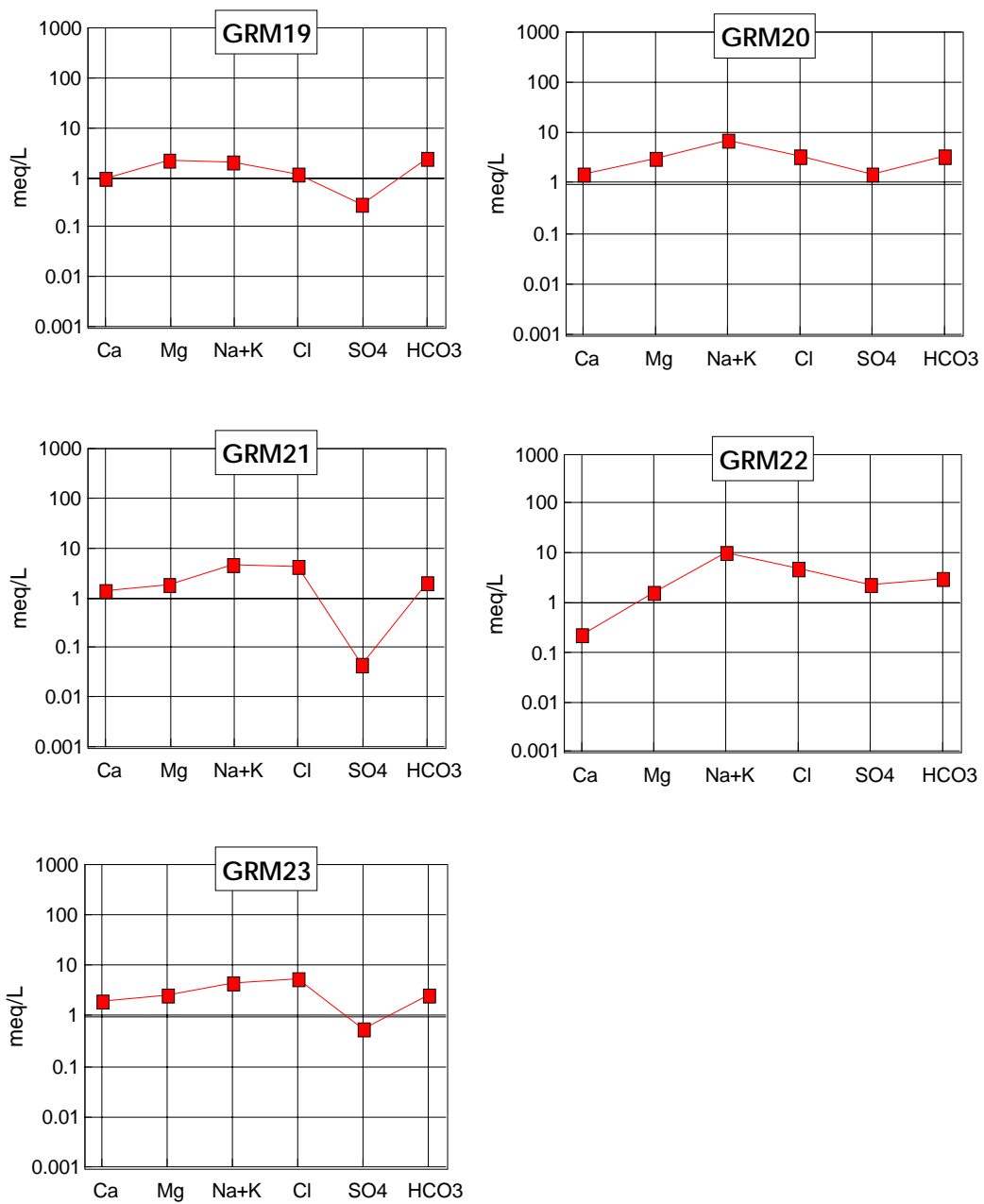


Fig. A2.2(c). Schoeller plots of major element compositions of groundwaters from the Bluebush Project area.

APPENDIX 3

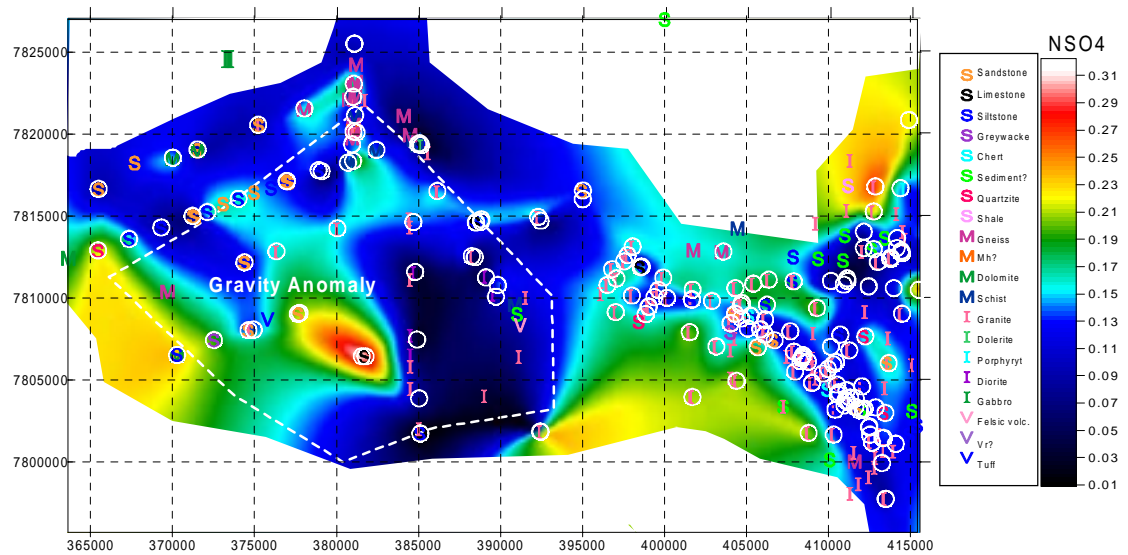


Figure A3.1 Regional variation of NSO4 in groundwaters around the Bluebush Project

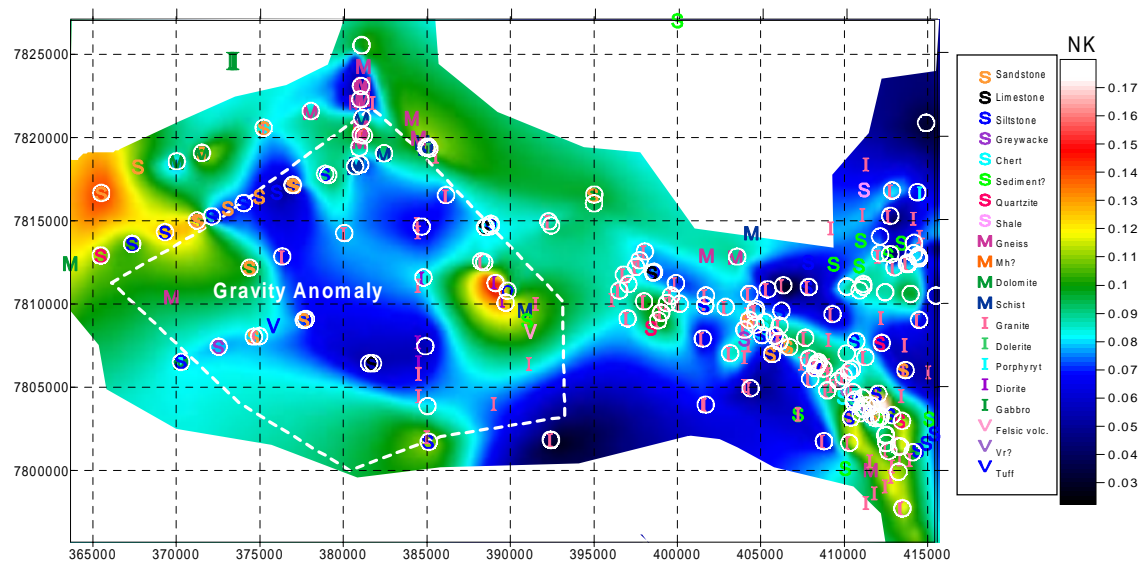


Figure A3.2 Regional variation of NK in groundwaters around the Bluebush Project

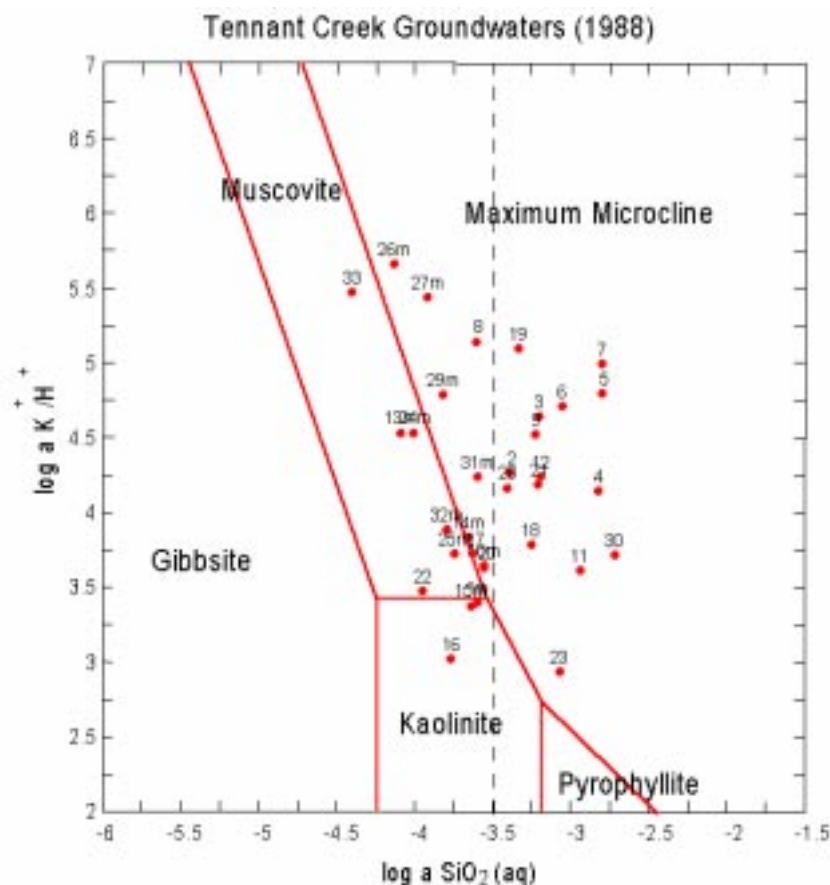


Figure A3.3
Groundwater samples from the Tennant Creek region in which Fe-oxide Cu-Au deposits have been mined, plotted on muscovite and chlorite stability field diagrams. Samples labelled “m” are from known mineralised locations.

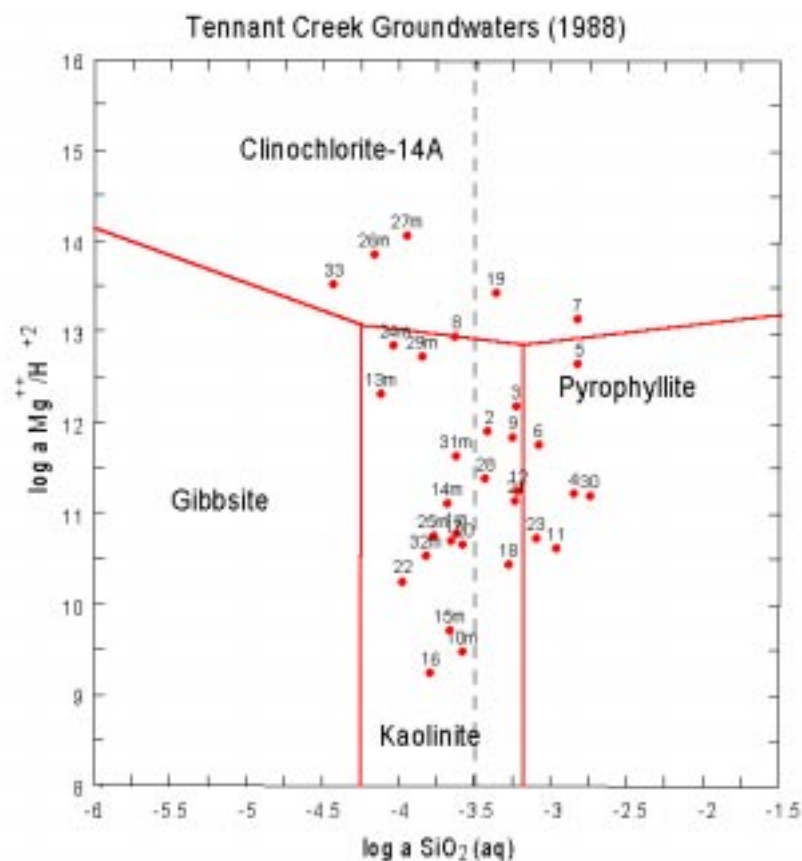


TABLE 1. Analytical Data for Bluebush Project groundwaters.

Sample No.	DH/Bore Name	Type	Water Table (m)	Sample Depth (m)	AMG Zone	Grid East (m)	Grid North (m)	Temp (C)	pH	Eh mV
GR1	10760	B	6	11	53	385086	7819262	29.7	8.15	158
GR2		B			53	394917	7815981	28.9	7.23	344
GR3	7446	B	11	16	53	392325	7801835	30.2	8.25	413
GR4	1669	B			53	398438	7811851	29.7	7	378
GR5	14515	DH	11.5	16.5	53	385041	7801710	29.9	6.76	100
GR6	13204	B			53	381485	7806410	31.8	7.15	374
GR7	KL13	DH	4	11	53	389640	7810042	32.4	7.09	53
GR8	KL12	DH	5.5	11.5	53	389036	7811213	32.1	6.82	302
GR9	11641	DH	6.5	11.5	53	388355	7812447	33.6	5.93	-77
GR10	12130	B	4.5	9.5	53	377710	7809053	31.4	9.44	-231
GR11	12132	B	7.0	12.0	53	374921	7808035	31.4	7.11	435
GR12	10933	B			53	388740	7814612	29.3	7.32	411
GR13	12138	B	6.5	11.0	53	392353	7814660	30.5	8.74	-141
GR16	11688	B	13	18	53	384728	7811548	24.8	8.73	-246
GR17	KL4	DH	8.5	13.5	53	384620	7814587	29.6	7.16	380
GR18	KL6	DH	16	21	53	384842	7807430	31.3	6.51	114
GR19	KL9	DH	8.5	13.5	53	384968	7803854	31.5	6.93	206
GR20	11558	DH	4.5	7.5	53	381168	7820041	30.4	7.28	455
GR21	11603	B	6	11	53	379042	7817678	31.3	7.31	463
GR22	11597	B	6.5	11.5	53	380956	7818303	32.1	8.62	328
GR23	10928	DH	7	10	53	381035	7825434	29.9	6.61	156

**TABLE 1. ANALYTICAL DATA FOR BLUEBUSH PROJECT
GROUNDWATERS**

TABLE 1. Analytical Data for Bluebush Project groundwaters.

Sample No.	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	SO4 mg/l	HCO3 mg/l	Cu ug/l	Pb ug/l	Zn mg/l
GR1	23	36	249	67	239	10.2	345	1.4	-0.1	-0.03
GR2	43	52	113	46	135	51	235	0.5	-0.1	-0.03
GR3	46	117	521	57	1280	0.78	15	2.4	-0.1	-0.03
GR4	79	101	222	62	374	174	275	1.9	-0.1	-0.03
GR5	15	14	21	14	2.8	0.69	180	0.2	-0.1	-0.03
GR6	42	42	358	44	330	303	220	29.9	-0.1	-0.03
GR7	6	19	175	56	191	33	95	8.0	6.5	0.24
GR8	3.2	5	22	13	7.4	1.92	95	0.7	0.5	-0.03
GR9	17	5	69	14	211	3.3	-15	0.2	11.4	69
GR10	16	4	421	53	583	207	-15	2.0	11.5	0.16
GR11	28	29	118	31	70	39	220	0.3	1.4	0.71
GR12	44	35	118	33	111	63	220	4.1	0.2	-0.03
GR13	33	9	134	33	296	18	-15	0.9	2.6	0.2
GR16	3	1.3	105	17	128	5.4	30	0.7	1.7	0.42
GR17	64	26	93	25	91.3	48	220	0.3	-0.1	0.15
GR18	9	11	139	16	191	7.5	155	0.6	-0.1	0.05
GR19	20	27	38	17	44.6	15	155	0.3	0.1	0.06
GR20	32	40	146	50	130	75	220	0.4	-0.1	0.06
GR21	28	23	91	31	161	2.25	125	0.5	-0.1	-0.03
GR22	4.8	21	235	32	174	120	195	0.6	-0.1	-0.03
GR23	40	32	99	24	210	27	165	0.7	-0.1	-0.03

TABLE 1. Analytical Data for Bluebush Project groundwaters.

Sample No.	F mg/l	U ug/l	Al mg/l	Fe mg/l	Ti mg/l	Mn mg/l	B mg/l	P mg/l	Ag ug/l	Ba mg/l
GR1	1.7	0.7	-0.002	0.086	-0.002	0.08	0.659	0.53	-1	0.053
GR2	2.0	30.3	-0.002	-0.005	-0.002	0.002	0.441	0.05	-1	0.105
GR3	0.9	0.3	-0.002	0.015	-0.002	0.123	0.175	0.15	-1	0.046
GR4	1.5	36.8	-0.002	-0.005	-0.002	-0.002	0.556	0.12	-1	0.061
GR5	0.3	-0.1	1.11	0.591	0.035	1.43	0.047	0.67	-1	0.22
GR6	1.7	10.0	-0.002	0.05	-0.002	0.006	0.502	0.1	-1	0.047
GR7	0.3	3.0	196	79	8.2	0.596	0.267	1.2	-1	0.271
GR8	0.3	0.1	10.8	3.3	0.221	0.014	0.039	1.4	-1	0.038
GR9	1.5	-0.1	-0.002	0.403	-0.002	0.08	0.298	0.15	-1	0.044
GR10	2.6	-0.1	-0.002	0.071	-0.002	-0.002	0.426	0.19	-1	0.018
GR11	1.7	3.3	0.009	0.031	-0.002	-0.002	0.314	0.06	-1	0.058
GR12	1.5	6.0	-0.002	-0.005	-0.002	-0.002	0.397	0.05	-1	0.078
GR13	1.3	-0.1	-0.002	0.07	-0.002	-0.002	0.224	0.11	-1	0.208
GR16	0.4	-0.1	0.007	0.045	-0.002	-0.002	0.101	-0.05	-1	0.004
GR17	1.3	4.5	0.067	0.029	0.004	-0.002	0.307	0.07	-1	0.42
GR18	0.2	-0.1	0.162	2.7	0.005	0.525	0.078	0.18	-1	0.142
GR19	0.5	1.8	0.046	0.305	-0.002	0.545	0.118	0.15	-1	0.295
GR20	2.2	9.0	0.014	0.006	-0.002	-0.002	0.557	0.07	-1	0.064
GR21	1.1	0.9	0.003	1.4	-0.002	0.005	0.32	0.09	-1	0.024
GR22	1.4	0.1	0.003	0.17	-0.002	0.066	0.672	0.11	-1	-0.002
GR23	0.4	0.3	0.031	24	-0.002	1.28	0.182	0.24	-1	0.096

TABLE 1. Analytical Data for Bluebush Project groundwaters.

Sample No.	Be mg/l	Cd ug/l	Co ug/l	Cr ug/l	La ug/l	Mo ug/l	Sc ug/l	Sr mg/l	Y ug/l	Ni ug/l
GR1	-0.002	-0.1	0.1	5.4	-0.1	2.2	4.4	0.525	-0.1	0.2
GR2	-0.002	-0.1	-0.1	4.7	-0.1	3.2	13.4	0.908	-0.1	0.4
GR3	-0.002	-0.1	0.1	1.1	-0.1	0.7	0.2	0.764	-0.1	0.9
GR4	-0.002	-0.1	0.1	4.8	-0.1	2.6	17.9	1.8	-0.1	11.8
GR5	-0.002	-0.1	1.2	2.2	0.1	0.7	5.9	0.158	0.1	0.9
GR6	-0.002	-0.1	-0.1	6.7	-0.1	5.5	8.8	0.865	-0.1	0.2
GR7	0.006	-0.1	1.8	3.0	2.1	1.1	6.8	0.24	2.7	1.1
GR8	-0.002	-0.1	0.3	1.5	0.2	0.1	3.8	0.094	0.2	0.6
GR9	-0.002	3.6	0.1	0.1	-0.1	9.2	0.0	0.284	-0.1	0.5
GR10	-0.002	-0.1	-0.1	0.2	-0.0	0.7	-0.1	0.338	-0.1	0.2
GR11	-0.002	-0.1	-0.1	3.6	-0.1	1.0	11.7	0.529	-0.1	0.4
GR12	-0.002	-0.1	-0.1	2.8	-0.1	1.1	11.4	0.528	-0.1	0.5
GR13	-0.002	-0.1	-0.1	0.1	-0.1	0.4	-0.1	0.681	-0.1	0.5
GR16	-0.002	0.8	-0.1	0.6	-0.1	1.1	0.0	0.084	-0.1	0.1
GR17	-0.002	0.1	0.1	2.4	-0.1	1.1	17.5	0.474	0.1	0.8
GR18	-0.002	-0.1	0.1	1.4	-0.1	0.1	4.4	0.181	-0.1	0.3
GR19	-0.002	-0.1	0.2	1.5	-0.1	1.0	7.5	0.411	-0.1	0.5
GR20	-0.002	-0.1	-0.1	2.6	-0.1	2.6	16.5	0.656	-0.1	0.4
GR21	-0.002	-0.1	0.1	1.2	-0.1	1.3	0.9	0.812	-0.1	1.4
GR22	-0.002	-0.1	-0.1	1.8	-0.1	6.8	1.0	0.047	-0.1	0.2
GR23	-0.002	0.8	3.3	1.5	-0.1	35.7	9.3	0.474	-0.1	105.4

TABLE 1. Analytical Data for Bluebush Project groundwaters.

Sample No.	Yb ug/l	As ug/l	Li mg/l	Si mg/l	Au ng/l	V mg/l	Sb ug/l	Bi ug/l	Th ug/l	Rb ug/l
GR1	-0.1	0.55	-0.005	9.0	2	-0.002	0.1	-0.1	-0.1	45.9
GR2	-0.1	0.64	-0.005	38	3	0.015	-0.1	-0.1	-0.1	28.4
GR3	-0.1	-0.2	0.063	0.2	2	-0.002	-0.1	-0.1	-0.1	56.1
GR4	-0.1	0.75	-0.005	45	4	0.021	-0.1	-0.1	-0.1	38.8
GR5	-0.1	2.8	-0.005	21	2	-0.002	-0.1	-0.1	-0.1	23.3
GR6	-0.1	0.88	-0.005	30	4	0.009	0.1	-0.1	0.1	12.7
GR7	0.3	1.1	0.106	317	6	0.294	-0.1	0.1	0.5	9.9
GR8	-0.1	0.71	-0.005	28	-1	0.013	-0.1	-0.1	-0.1	10.1
GR9	-0.1	-0.2	0.029	0.27	3	-0.002	-0.1	-0.1	-0.1	10.6
GR10	-0.1	-0.2	-0.005	-0.1	2	-0.002	-0.1	-0.1	-0.1	18.6
GR11	-0.1	2.1	-0.005	38	5	0.055	-0.1	-0.1	-0.1	18.5
GR12	-0.1	1.6	-0.005	42	2	0.029	-0.1	-0.1	-0.1	26.0
GR13	-0.1	-0.2	-0.005	-0.1	3	-0.002	-0.1	-0.1	-0.1	23.1
GR16	-0.1	-0.2	-0.005	-0.1	46	-0.002	0.1	-0.1	-0.1	9.5
GR17	-0.1	1.4	-0.005	48	9	0.032	-0.1	-0.1	-0.1	20.0
GR18	-0.1	-0.2	0.005	12	14	0.002	-0.1	-0.1	-0.1	7.1
GR19	-0.1	0.99	-0.005	22	12	0.003	-0.1	-0.1	-0.1	16.3
GR20	-0.1	1.7	-0.005	47	7	0.041	-0.1	-0.1	-0.1	33.1
GR21	-0.1	-0.2	0.011	2.5	2	-0.002	0.1	-0.1	-0.1	26.9
GR22	-0.1	0.26	0.011	2.5	4	-0.002	-0.1	-0.1	-0.1	31.3
GR23	-0.1	-0.2	-0.005	22	17	-0.002	-0.1	-0.1	-0.1	41.2

TABLE 1. Analytical Data for Bluebush Project groundwaters.

Sample No.	Cs ug/l	Tl ug/l	Ga ug/l	Ge ug/l	Tb ug/l
GR1	0.5	-0.1	-0.1	0.2	-0.5
GR2	0.3	-0.1	-0.1	0.1	-0.5
GR3	0.4	-0.1	-0.1	0.2	-0.5
GR4	0.5	-0.1	-0.1	0.2	-0.5
GR5	0.7	-0.1	0.2	0.1	-0.5
GR6	0.4	-0.1	-0.1	0.1	-0.5
GR7	0.1	-0.1	0.6	0.4	-0.5
GR8	0.1	-0.1	0.1	0.3	-0.5
GR9	0.1	-0.1	-0.1	0.2	-0.5
GR10	0.6	-0.1	-0.1	0.1	-0.5
GR11	0.2	-0.1	-0.1	0.2	-0.5
GR12	0.3	-0.1	-0.1	0.2	-0.5
GR13	0.2	0.1	-0.1	0.1	-0.5
GR16	-0.1	-0.1	-0.1	0.1	-0.5
GR17	0.2	-0.1	-0.1	0.2	-0.5
GR18	-0.1	-0.1	-0.1	0.2	-0.5
GR19	0.3	-0.1	-0.1	-0.1	-0.5
GR20	0.3	-0.1	-0.1	0.2	-0.5
GR21	0.1	-0.1	-0.1	0.3	-0.5
GR22	0.1	-0.1	-0.1	0.1	-0.5
GR23	0.4	-0.1	-0.1	0.4	-0.5