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HYDROGEOCHEMICAL DISPERSION OF GOLD AND OTHER ELEMENTS AT BAXTER, WESTERN AUSTRALIA

D.J. Gray

CRC LEME OPEN FILE REPORT 97

May 2001

(CSIRO Division of Exploration and Mining Report 169R, 1995.
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CRC LEME is an unincorporated joint venture between The Australian National University,
University of Canberra, Australian Geological Survey Organisation and CSIRO Exploration and Mining
Headquarters: CRC LEME c/o CSIRO Exploration and Mining, Private Bag No 5, PO Wembley, Western Australia, 6913.

RESEARCH ARISING FROM CSIRO/AMIRA YILGARN REGOLITH GEOCHEMISTRY PROJECTS 1987-1996

In 1987, CSIRO commenced a series of multi-client research projects in regolith geology and geochemistry which were sponsored by companies in the Australian mining industry, through the Australian Mineral Industries Research Association Limited (AMIRA). The initial research program, "Exploration for concealed gold deposits, Yilgarn Block, Western Australia" had the aim of developing improved geological, geochemical and geophysical methods for mineral exploration that would facilitate the location of blind, buried or deeply weathered gold deposits. The program commenced with the following projects:

P240: Laterite geochemistry for detecting concealed mineral deposits (1987-1991). Leader: Dr R.E. Smith.
Its scope was development of methods for sampling and interpretation of multi-element laterite geochemistry data and application of multi-element techniques to gold and polymetallic mineral exploration in weathered terrain. The project emphasised viewing laterite geochemical dispersion patterns in their regolith-landform context at local and district scales. It was supported by 30 companies.

P241: Gold and associated elements in the regolith - dispersion processes and implications for exploration (1987-1991). Leader: Dr C.R.M. Butt.
The project investigated the distribution of ore and indicator elements in the regolith. It included studies of the mineralogical and geochemical characteristics of weathered ore deposits and wall rocks, and the chemical controls on element dispersion and concentration during regolith evolution. This was to increase the effectiveness of geochemical exploration in weathered terrain through improved understanding of weathering processes. It was supported by 26 companies.

These projects represented 'an opportunity for the mineral industry to participate in a multi-disciplinary program of geoscience research aimed at developing new geological, geochemical and geophysical methods for exploration in deeply weathered Archaean terrains'. This initiative recognised the unique opportunities, created by exploration and open-cut mining, to conduct detailed studies of the weathered zone, with particular emphasis on the near-surface expression of gold mineralisation. The skills of existing and specially recruited research staff from the Floreat Park and North Ryde laboratories (of the then Divisions of Minerals and Geochemistry, and Mineral Physics and Mineralogy, subsequently Exploration Geoscience and later Exploration and Mining) were integrated to form a task force with expertise in geology, mineralogy, geochemistry and geophysics. Several staff participated in more than one project. Following completion of the original projects, two continuation projects were developed.

P240A: Geochemical exploration in complex lateritic environments of the Yilgarn Craton, Western Australia (1991-1993). Leaders: Drs R.E. Smith and R.R. Anand.
The approach of viewing geochemical dispersion within a well-controlled and well-understood regolith-landform and bedrock framework at detailed and district scales continued. In this extension, focus was particularly on areas of transported cover and on more complex lateritic environments typified by the Kalgoorlie regional study. This was supported by 17 companies.

P241A: Gold and associated elements in the regolith - dispersion processes and implications for exploration (1991-1993). Leader: Dr. C.R.M. Butt.
The significance of gold mobilisation under present-day conditions, particularly the important relationship with pedogenic carbonate, was investigated further. In addition, attention was focussed on the recognition of primary lithologies from their weathered equivalents. This project was supported by 14 companies.

Most reports related to the above research projects were published as CRC LEME Open File Reports Series (Nos 1-74), with an index (Report 75), by June 1999. Publication now continues with release of reports from further projects.

P252: Geochemical exploration for platinum group elements in weathered terrain. Leader: Dr C.R.M. Butt.
This project was designed to gather information on the geochemical behaviour of the platinum group elements under weathering conditions using both laboratory and field studies, to determine their dispersion in the regolith and to apply this to concepts for use in exploration. The research was commenced in 1988 by CSIRO Exploration Geoscience and the University of Wales (Cardiff). The Final Report was completed in December 1992. It was supported by 9 companies.

P409: Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, WA.
Leaders: Drs C.R.M. Butt and R.E. Smith.
About 50% or more of prospective terrain in the Yilgarn is obscured by substantial thicknesses of transported overburden that varies in age from Permian to Recent. Some of this cover has undergone substantial weathering. Exploration problems in these covered areas were the focus of Project 409. The research was commenced in June 1993 by CSIRO Exploration and Mining but was subsequently incorporated into the activities of CRC LEME in July 1995 and was concluded in July 1996. It was supported by 22 companies.

Although the confidentiality periods of Projects P252 and P409 expired in 1994 and 1998, respectively, the reports have not been released previously. CRC LEME acknowledges the Australian Mineral Industries Research Association and CSIRO Division of Exploration and Mining for authority to publish these reports. It is intended that publication of the reports will be a substantial additional factor in transferring technology to aid the Australian mineral industry.

This report (CRC LEME Open File Report 97) is a second impression (second printing) of CSIRO, Division of Exploration and Mining Restricted Report 169R, first issued in 1995, which formed part of the CSIRO/AMIRA Project P409.

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Institute of Minerals, Energy and Construction

EXPLORATION AND MINING REPORT 169R

HYDROGEOCHEMICAL DISPERSION OF GOLD AND OTHER ELEMENTS AT BAXTER, WESTERN AUSTRALIA.

D.J. Gray

Prepared for North Ltd and Plutonic Resources Ltd

November 1995

RESTRICTED CIRCULATION

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CSIRO/AMIRA PROJECT 409
(Confidential to the sponsors of the project)

GEOCHEMICAL EXPLORATION IN AREAS OF TRANSPORTED OVERBURDEN,
YILGARN CRATON AND ENVIRONS, W.A.

CSIRO Division of Exploration and Mining
P.O. Wembley, Western Australia, Australia 6014

PREFACE

The CSIRO-AMIRA Project "Exploration in Areas of Transported Overburden, Yilgarn Craton and Environs" (Project 409) has, as its principal objective, development of geochemical methods for mineral exploration in areas with substantial transported overburden, through investigations of the processes of geochemical dispersion from concealed mineralization. The Project has two main themes. One of these, *'Surface and subsurface expression of concealed mineral deposits'* is addressed by this report, which focuses on the hydrogeochemistry of the Harmony Au deposit and the surrounding area. This study complements other geochemical and geophysical investigations of the regolith at this site.

Hydrogeochemistry has long been considered as having considerable potential in exploration, on the premise that groundwaters are a pervasive medium by which ore-associated elements may be widely dispersed and thus present a broader target than the mineralization itself. This target may be relatively localized, indicating mineralization just missed by drilling, or be of district or regional scale. Prospective zones of high reactivity, such as shears and faults, may also have distinct hydrogeochemical signatures, though the rocks themselves may have unremarkable compositions. In addition, hydrogeochemical studies may provide information on currently active processes of weathering. Despite its potential, however, hydrogeochemical exploration has proved difficult to apply, largely due to the complex element interactions and the strong influence of the local environment on salinity, pH, composition and hydrology of the groundwater.

The Baxter study area includes the proposed Harmony pit, a significant Au deposit, as well as several additional drill anomalies, with minor to significant overburden. It therefore represents a field area where the hydrogeochemistry of these different environments can be compared. The groundwaters are neutral and of low salinity. Results from this site and from elsewhere in the northern Yilgarn indicate that such groundwaters have specific characteristics and responses to underlying mineralization, distinct from those for the acid and/or saline groundwaters of the southern Yilgarn Craton. In particular, these groundwaters have extremely low concentrations of dissolved Au, though other elements (namely Mo, W, Sc and possibly Rb) may be useful pathfinders for exploration using groundwater.

C.R.M. Butt and R.E. Smith,
Project Leaders.
November, 1995

ABSTRACT

The hydrogeochemistry of the Baxter study area was investigated, with a view to understanding the interaction of groundwaters with mineralized rocks, and the potential for exploration, particularly in areas of overburden. Groundwaters at Baxter are neutral, with a similar Eh range to other neutral groundwaters from the Yilgarn Craton. However, they differ from groundwaters investigated at sites in the southern Yilgarn in having very low salinities and marked divergence from sea water ratios, suggesting that the major ion concentrations are strongly controlled by local lithological or hydrological factors. The groundwaters at Baxter strongly resemble those at Lawlers, about 300 km to the SE in the north Yilgarn. Elements that appear to be controlled by mineral equilibration in some or all Baxter groundwaters are Ba (barite equilibration), Ca, Mg and HCO_3 (carbonate), Pb and V (chervitite; $Pb_2V_2O_7$).

The Baxter groundwaters have extremely low Au concentrations, similarly to areas of overburden at Lawlers. This suggests that Au is not expected to be extensively chemically redistributed in the regolith under present-day conditions, and therefore that it will not be a useful pathfinder in groundwaters or in soils overlying extensive overburden. However, Sc, Mo, W and, possibly, Rb were observed to have greater groundwater concentrations in areas of Au mineralization and at this site are better pathfinders in groundwater than Au itself. This elemental suite is similar, though more limited, to those observed at other sites. These elements may have scope as target elements for selective extraction of soil or other regolith material. Other elements can be used in groundwaters to indicate underlying rocks or other geochemical features. For example, dissolved Cr concentrations correlate closely with the presence of ultramafic rocks at Baxter and elsewhere, even though the groundwaters are in contact with highly weathered lithologies. Dissolved As and, to a lesser degree, Ni correlate with a zone of As-enriched rocks to the SE of the study area.

Thus, results indicate exploration potential for groundwater in such environments, even where highly weathered rock are overlain by transported material. The elements enriched in mineralized groundwaters may also form part of a suite of elements that may yield a geochemical expression by selective extraction.

TABLE OF CONTENTS

1 INTRODUCTION

Research work in Australia and elsewhere (Morris, 1982; Hamilton *et al.*, 1983; Giblin and Snelling, 1984; Runnells, 1984; Dissanayake and Weerasooriya, 1986; Hall *et al.*, 1986; McHugh, 1988; Bergeron and Choinière, 1989; Dekkers *et al.*, 1989; Cidu and Edmunds, 1990) has suggested that hydrogeochemistry may be useful for exploration for Au and other metals. Although many such investigations have been undertaken in areas with a dominantly residual regolith, it is feasible that groundwater may also provide a useful exploration medium in areas of extensive transported overburden.

A primary justification given for the use of hydrogeochemistry in mineral exploration is that groundwater anomalies may be broader and more regular than the mineralization and secondary dispersion halo in the regolith, thus enhancing the exploration signature. In addition, areas of high reactivity (*e.g.*, faults and shear zones) may have distinct hydrogeochemical signatures even where they are unremarkable in terms of elemental abundances, and where petrographic study is difficult. However, such effects may also be counter-productive, as interpretation may become complicated by the various factors.

Hydrogeochemical studies also provide information on how various materials are weathering. This enhances understanding of active dispersion processes and assists in the development of weathering and geochemical models, which are essential for effective exploration in regolith-dominated terrain.

The aims of this hydrogeochemical study were, therefore:

(i) to provide information on whether groundwater can be used successfully as an exploration medium in this area in particular and, in conjunction with other studies, in the northern Yilgarn and the adjoining Proterozoic belt in general;
(ii) to yield data on geochemical dispersion processes;
(iii) to contribute to a groundwater database on the characteristics of groundwaters at various sites, and to enhance our understanding of groundwater processes in mineralized zones.

The Baxter area holds considerable interest for hydrogeochemical investigations for a number of reasons:

(i) it lies north of the Menzies line, in an area of extensive hardpan;
(ii) groundwater salinity is very low. This is similar to Lawlers and contrasts with Granny Smith, the other sites north of the Menzies line investigated as part of AMIRA Project 409, permitting comparison of the effect of salinity differences on the chemistry of Au and other elements;
(iii) groundwater investigations are complementary to other studies conducted by CSIRO at this site (Butt *et al.*, 1995, Robertson *et al.*, in prep).

The scope of this investigation includes the effect of underlying lithology on the observed water chemistry, thermodynamic modelling, mapping of the data and comparison with results from other Western Australian sites.

2 SITE STUDY AND METHODS

2.1 Site characteristics

Much of this Section is summarized from regolith investigations described in Robertson *et al.* (1996), and the reader is referred to this Report for further discussion.

2.1.1 Regional and local geological setting

The Baxter study area includes the Harmony Deposit (previously known as the Contact Deposit), with a reserve of 2.148 MT at 3.6 g/t Au, and is located approximately 10 km west of Peak Hill and some 90 km north of Meekatharra (Figure 1). The region is arid, characterized by a low, irregular rainfall averaging 200 mm per annum. Vegetation cover is thin and consists largely of mulga and other drought-resistant shrubs and grasses. The deposit is located within a depositional plain bounded to the west by the westerly extent of the Robinson Ranges, to the north by the southerly extension of the Horseshoe Range and to the east and south by rises and low hills. The deposit was discovered in 1991 with mining commencing in mid-1995.

The Peak Hill District, within which the Baxter area is located, comprizes part of a major early Proterozoic orogenic belt, the Capricorn Orogen, that developed on the northern margins of the Yilgarn Craton around 1.8 Ga (Gee, 1987). The District is interpreted to represent part of an early Proterozoic sequence containing thick trough and shelf sediments and mafic and ultramafic volcanics that have been subject to complex folding and thrusting, and moderate metamorphism. The sequence around Peak Hill is regarded as the western part of the Nabberu Basin, but is more properly thought of as a tectonic province rather than a sedimentary basin. The main tectonic features of the region are the fold belt associated with the Bryah, Glengarry and Padbury Groups, two basement highs - referred to as the Marymia and Goodin Domes - and the Bangemall Basin to the north.

The local geology about the deposit is summarized in Figure 2. The Harmony deposit is located at the contact between the Narracoota Volcanics and the Thaduna Greywacke which form part of the Bryah Group. The Narracoota Volcanics comprise a folded sequence of mafic and ultramafic rocks. The Thaduna Greywacke is a thick turbidite sequence of fine-grained lithic, feldspathic and mafic wacke with subordinate interbedded slaty mudstone (Gee, 1987). To the north-west of the deposit, calcareous, manganiferous shales and subgreywackes of the Horseshoe formation outcrop. BIFs of the Padbury Group form prominent ridges south-east of the area.

2.1.2 Mineralization

Primary gold mineralization, associated with quartz veining, is stratabound, hosted within a mafic sequence (albitized dolerite and basalt) at the top of the Narracoota Volcanics, close to the contact with the overlying Thaduna Greywacke. The deposit is sulphide-poor with pyrite >> pyrrhotite. The primary orientation of the mineralization appears to be sub-parallel to the hanging wall contact of the sediments and volcanics associated with sub-vertical structures trending north-south. The detailed structural setting of the deposit is currently under investigation. Mineralization also occurs as a relatively flat-lying supergene deposit close to the surface. This occurs largely within the saprolite of the volcanics but extends into the overlying lateritic residuum and colluvial material. The depth of oxidation over the deposit is variable, averaging approximately 80 m, with a water-table at 30 m. The deposit was found through a shallow RAB drilling program sampling buried "lateritic" material. Anomalous Au concentrations were detected in the vicinity of Harmony and a follow-up drill program located mineralization in what is now the southern part of the Harmony Pit.

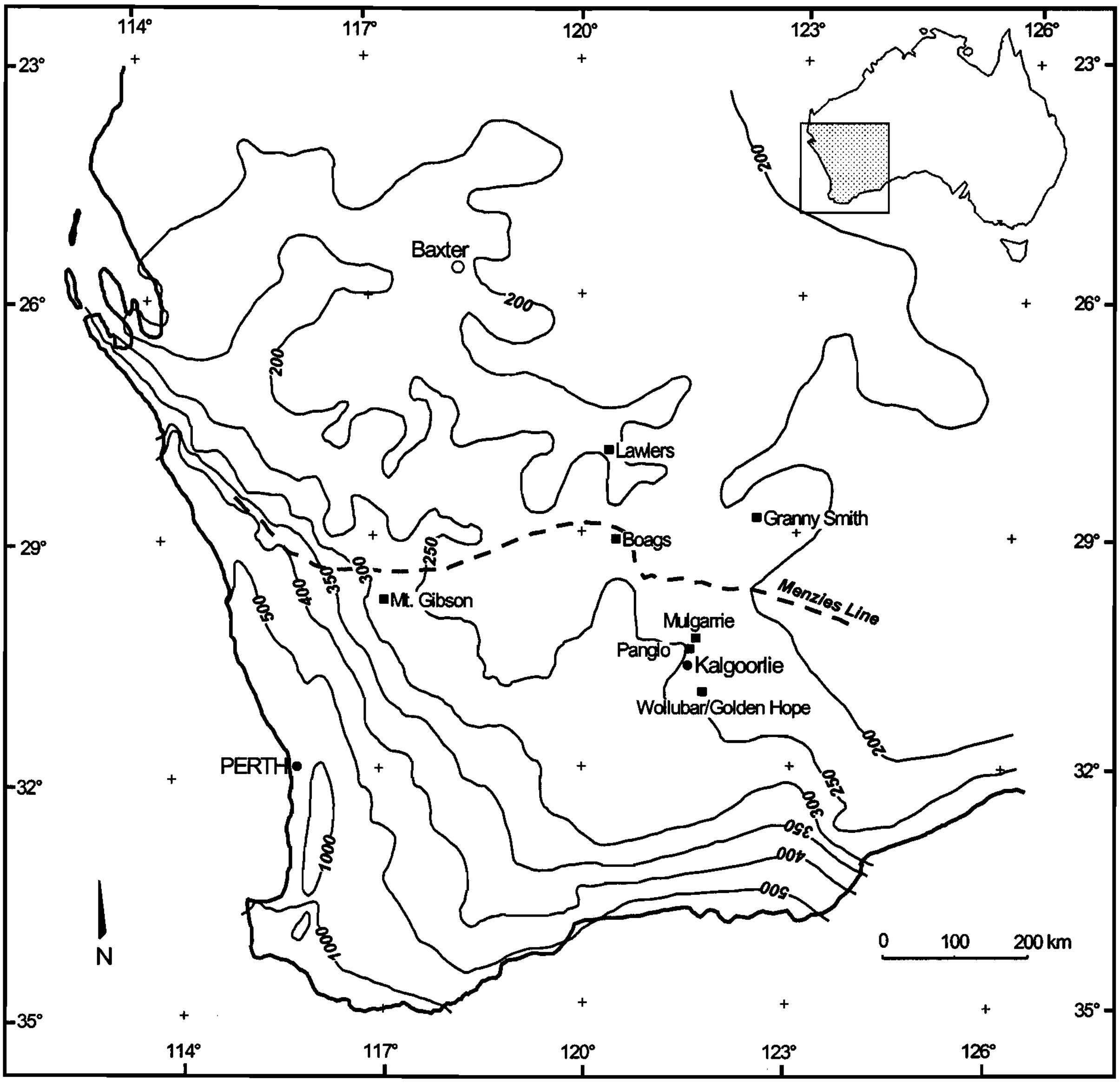

Figure 1 - Regional setting of the Baxter study area, with rainfall contours in mm.

2.1.3 Regolith geology

The deposit is located in a broad depositional plain, surrounded by low hills and ridges. The area is aggraded by infrequently active sheet flow and channelled stream flow, with subordinate wind erosion. To the south of the pit, the colluvium mantles the backslope of a bevelled breakaway. The area south of the breakaway is an erosional plain developed in Thaduna metasediments. The regolith is characterized by a coarse, blocky, quartz-rich polymictic lag developed over ferruginous saprolite. Low rises characterize the landscape to the east and south-east of the deposit. The regolith comprises variably preserved lateritic profiles developed over Narracoota Volcanics, consisting of Fe-rich duricrust, lateritic gravels and ferruginous saprolites. Further east, the regolith is largely composed of saprolite, subcrop and outcrop related to the Peak Hill metamorphics and the Narracoota Volcanics. To the north-east of Harmony, the landscape becomes dominated by low hills developed in the mixed sediments of the Horseshoe Formation. Thick, massive-vermiform, manganiferous duricrusts have developed in places.

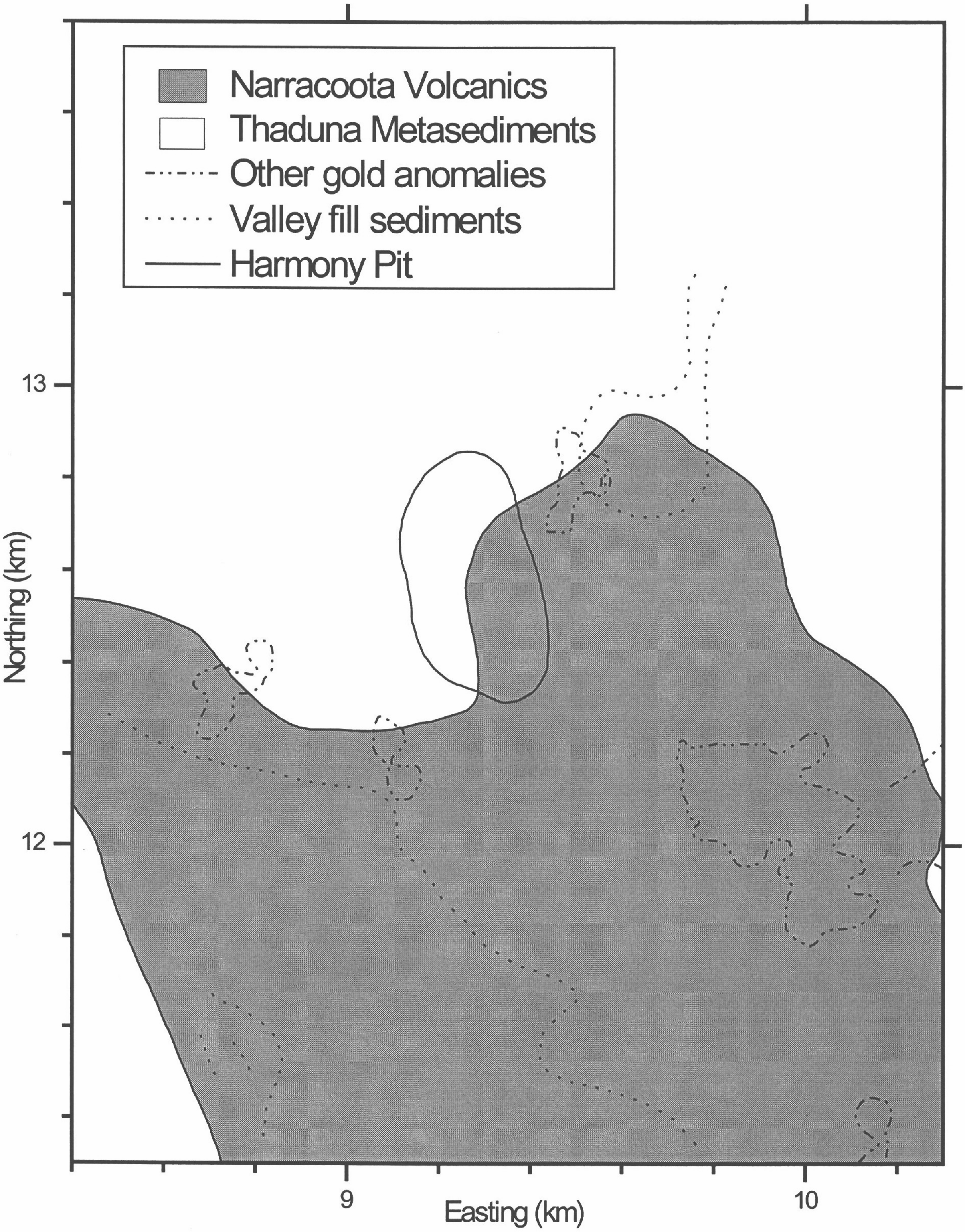

Figure 2: Geology of the Baxter study area, showing the Harmony Pit, other Au anomalies and valley fill sediments. (Based on information supplied by AFMECO.)

In the immediate vicinity of the deposit, the regolith is characterized by a variably thick, hardpanized, red-brown, colluvial-alluvial blanket, beneath which the degree of complexity varies considerably. In places, particularly close to the Harmony Deposit, the colluvium directly overlies a basement of ferruginous saprolite, saprolite and saprock. Elsewhere, notably to the southwest and northeast of Harmony, the colluvium is underlain by various mottled clay sediments which appear to infill palaeochannels cut into the basement. Parts of the basement (residual saprolitic material) are mantled by buried duricrust, complete with nodules and pisoliths, coated with pale brown, clay-rich cutans.

Intercalated within the palaeochannel-fill sediments there are horizons containing lateritic nodules and pisoliths with cutans. There are two possible origins. Firstly, the channel sediments had an intermittent depositional history, with periods of exposure and further weathering of lower units and the development of a lateritic duricrust, followed by the continued deposition of transported materials. Secondly, and a more probably, these horizons may relate to local erosion, transport and deposition of *in situ* lateritic debris from adjacent slopes of a palaeo-valley, which was being progressively infilled with finer sediments.

2.1.4 Regolith stratigraphy

Because of the complexity of the sub-surface regolith and the very extensive drilling around the Harmony deposit, a 3-D regolith model of regolith stratigraphy has been developed for the site (Butt *et al.*, 1995, Robertson *et al.*, 1996). Contour and isopach maps of the various surfaces and regolith units were produced to provide some indication of palaeotopography and the spatial disposition of regolith materials in three dimensions (Figures 3A-D).

The contour map of the top of the residual profile on the basement (Figure 3D) shows the Harmony Deposit lying on a palaeohigh which trends in a north-westerly direction. Cut into the basement are two palaeochannels. A major, deep palaeochannel, which appears to parallel the trend of the palaeohigh, lies to the west of Harmony. The flow direction appears to be towards the north-west (from the volcanics into the metasediments). A smaller, shallower palaeochannel drains north-east from the margins of the Harmony deposit. The regolith of the palaeohigh largely consists of ferruginous saprolite. Thick, mottled zones and clay-rich saprolites underlie the palaeochannels.

Extensive colluvial deposits have infilled many of the palaeovalleys, with the thickest colluvium developed over the palaeochannels. The topography, prior to the deposition of the colluvium, is shown in Figure 3B. The upper part of the colluvium is hardpanized. An isopach map of the palaeochannel sediments (Figure 3C) fits the palaeochannels cut in the basement (Figure 3D). Some of these sediments may be subdivided into an upper unit of dark, puggy clays and a lower unit of pallid clays with silica. The present topography consists of a gently inclined surface which is being incised by a southwest-flowing drainage system (Figure 3A).

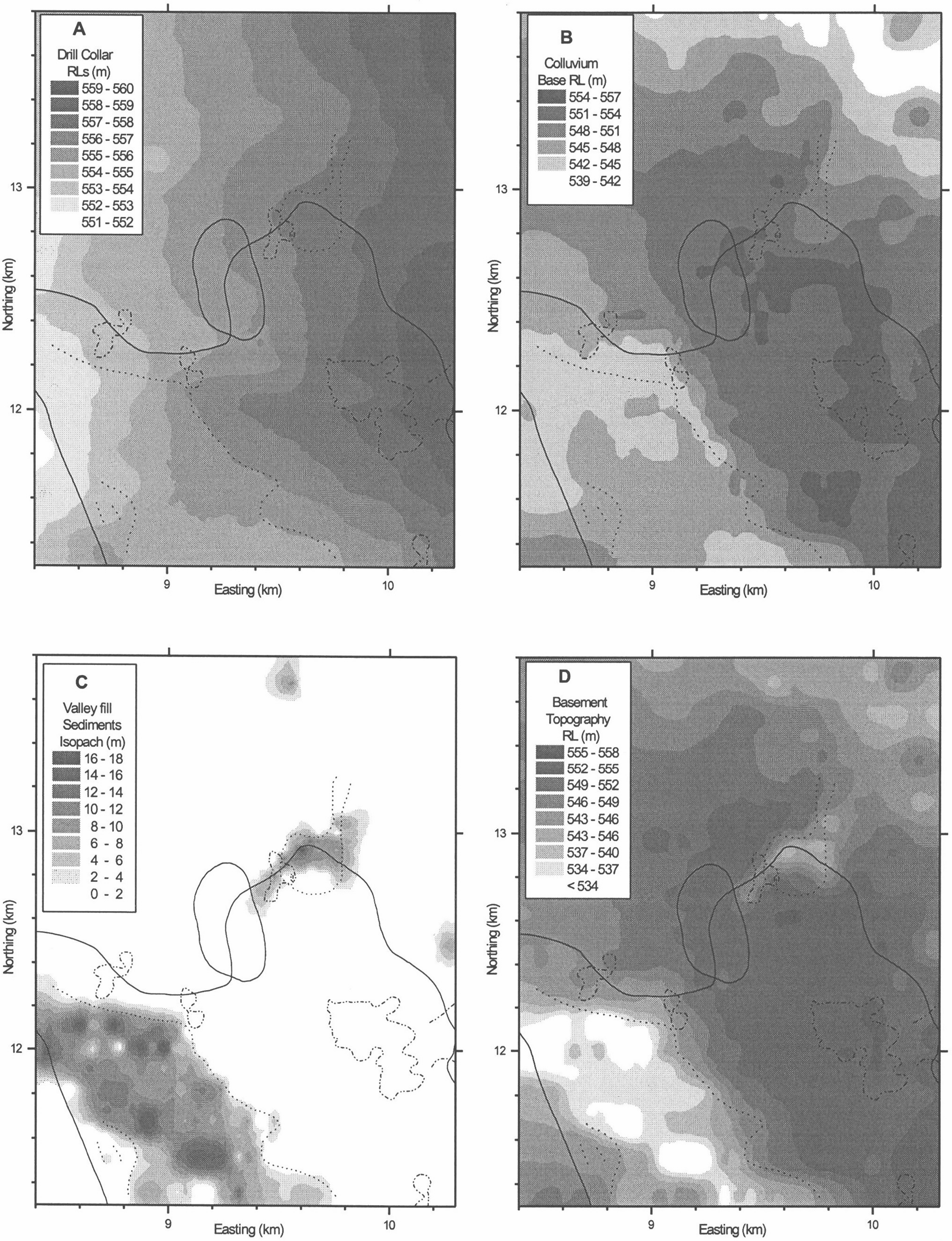

Figure 3: Contours of the palaeotopography and isopach maps of some regolith units at Baxter. (see Butt *et al.*, 1995, Robertson *et al.*, in prep).

2.2 Sample collection, treatment and analysis

Groundwaters samples were collected by bailing in 1994 and in 1995, from cased and uncased drill holes. At a number of the sites, the base of the drill holes were just above the water table, and/or the drill holes lacked casing, and/or were in local depressions, thus allowing flow-in of surface run-off (often including leaves and other material). Analytical results indicated that most of these samples were unrepresentative (low oxidation potential, low pH, low salinities and/or anomalous in Mn or P) and they were not included in data analysis.

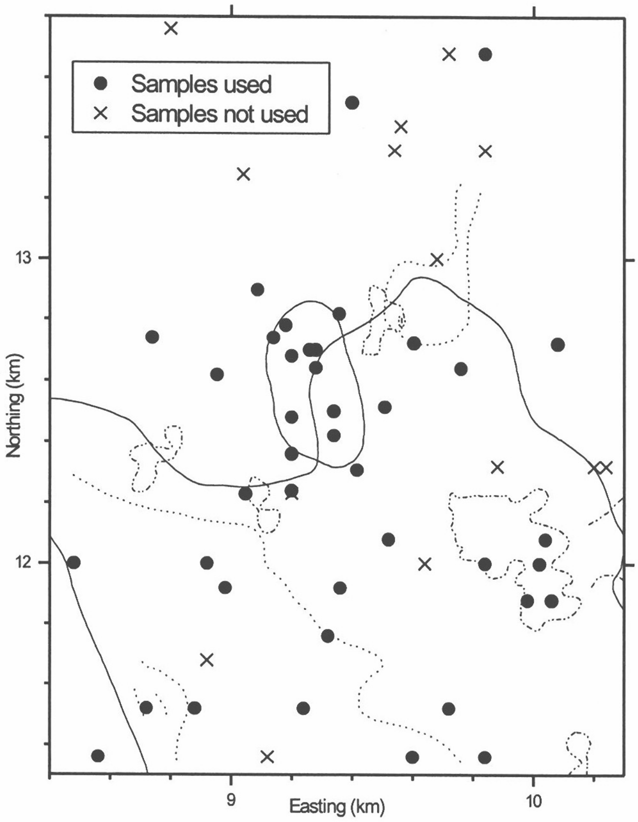

Figure 4: Water sample locations at Baxter. Samples used are marked as filled circles; those contaminated, and therefore not used, as crosses.

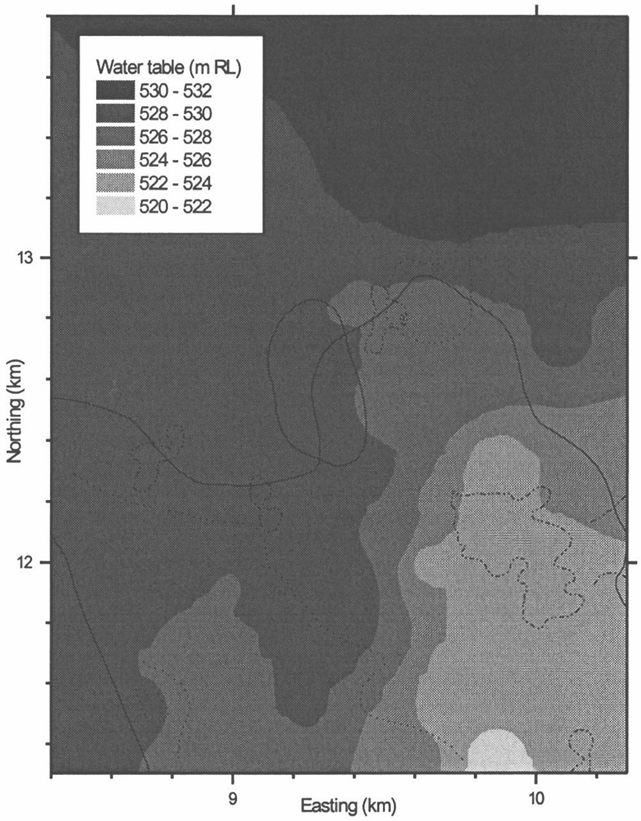

Figure 5: Variation in piezometric head at Baxter.

Waters were analysed for pH, temperature, conductivity and oxidation potential (Eh) at the time of sampling. A 125 mL water sample was collected in a polyethylene bottle (with overfilling to remove all air) for later HCO_3^- analysis by alkalinity titration in the laboratory. Following this, about 1.5 L of water was filtered through a 0.2 μm membrane filter in the field. About 100 mL of the filtered solution was acidified [0.1 mL 15 moles/litre (M) nitric acid (HNO_3)], and analysed for Al, B, Ba, Be, Ca, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P+I (distinction between P and I is difficult due to spectral overlap), SO_4 (measured as S), Si, Sr, Ti, V and Zn by Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES), and for Ag, As, Bi, Cd, Ce, Cr, Co, Cs, Dy, Er, Eu, Ga, Gd, Ge, Hg, Ho, La, Mo, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Sm, Sn, Tb, Th, Tl, Tm, U, W, Y, Yb and Zr by Inductively Coupled Plasma - Mass Spectroscopy (ICP-MS) at CSIRO Laboratories in Sydney. Four elements are analysed by both methods: for Cr the ICP-AES and ICP-MS results were averaged, whereas for Co, Mo and Ni the ICP-MS results were used (with the ICP-AES results used as a check where concentrations were high). There were no significant discrepancies between analytical methods for these elements. Total phosphate (as P) was measured in acidified waters by the molybdenum blue colorimetric method (Murphy and Riley, 1962). Iodine was determined by subtraction of P from P+I concentration.

One litre sub-samples of the filtered water were acidified with 1 mL 15 M HNO_3 and one gram sachet of activated carbon and 25 - 30g of AR grade NaCl added. The bottles were rolled for eight days in the laboratory and the solution discarded. The carbon was analysed for Au by Neutron Activation (NAA). Laboratory investigations by the author have indicated that this pre-concentration system permits successful analysis of waters for Au to < 0.005 µg/L. Calibration of the method was obtained by shaking Au standards of varying concentrations, and in varying salinities, with activated carbon (Gray, unpublished data).

About 50 mL of filtered water was collected separately, and analysed for Cl by the Technicon Industrial method (Zall *et al.*, 1956) at CSIRO Division of Water Resources Floreat Park Laboratories.

2.3 Speciation analysis

Speciation analysis involves computing the solution species and degree of mineral saturation from the solution compositions, based on thermodynamic data. This is commonly done using the program PHREEQE (Parkhurst *et al.*, 1980; described in detail in Gray, 1990 and Gray, 1991), which determines the chemical speciation of many of the major and trace elements. To obtain highly accurate speciation data on a limited suite of the major elements (Na, K, Mg, Ca, Cl, HCO_3, SO_4, Sr and Ba), the specific ion interaction model known as the Pitzer equations was applied, using the program PHRQPITZ (courtesy USGS).

These programs calculate the solubility indices (SI) for a number of mineral phases for each water sample. If the SI for a mineral equals zero (empirically from -0.2 to 0.2 for the major elements, and -1 to 1 for the minor elements which did not have Pitzer corrections), the water is in equilibrium with that particular solid phase, under the conditions specified. Where the SI is less than zero, the solution is under-saturated with respect to the phase, so that, if present, the phase may dissolve. If the SI is greater than zero the solution is over-saturated with respect to this phase and the phase can precipitate. Note that this analysis only specifies possible reactions, as kinetic constraints may rule out reactions that are thermodynamically allowed. Thus, for example, waters are commonly in equilibrium with calcite, but may become over-saturated with respect to dolomite, due to the slow rate of solution equilibration with the latter mineral (Drever, 1982).

The determinations are important in understanding solution processes at the site. They have particular value in determining whether the spatial distribution of an element is correlated with geological and/or mineralization phenomena or whether they are related to weathering or environmental effects. Thus, if Ca distribution is controlled by equilibrium with gypsum in all samples, then the spatial distribution of dissolved Ca will reflect SO_4 concentration alone and have no direct exploration significance.

3 RESULTS

3.1 Compilation of results

Analytical results are compiled in Appendix 1. As discussed in Section 2.2, certain samples were discarded, due to suspected contamination from rain-water or organic material. The total dissolved solids (TDS), a measure of groundwater salinity, were calculated from the major element contents.

3.2 Comparison with results from other Yilgarn waters.

The groundwaters at Baxter were neutral (pH range 6 - 8). An important comparison for these data is with other neutral groundwaters. Data for acid (pH < 6) groundwaters are not included as the solubility of many metals and pathfinder elements is enhanced in acid conditions, thus complicating any comparison between neutral and acid groundwaters. Table 1 shows the averaged elemental data for Baxter groundwater, along with data for sea water (taken from Weast, 1983) and the averaged data for five other gold deposits having neutral groundwater (for Mt. Gibson and Mulgarrie, acid groundwaters samples were disregarded before averaging data):

(i) Lawlers: fresh/neutral groundwaters, about 300 km north of Kalgoorlie, with ultramafic and mafic rocks, granitoids and sediments (northern Yilgarn; Gray, 1994)
(ii) Mt. Gibson: fresh to saline / acid to neutral groundwaters, about 100 km north-east of Dalwallinu (central-west Yilgarn; Gray, 1991);
(ii) Boags: saline/neutral groundwaters from a deposit at Bottle Creek, located 210 km north north-west of Kalgoorlie (central Yilgarn; Gray, 1992a);
(iii) Golden Hope: saline/neutral groundwaters from a deposit at New Celebration some 40 km southeast of Kalgoorlie (south Yilgarn; Gray, 1993b);
(iv) Granny Smith: saline/neutral groundwaters, about 25 km south of Laverton (central Yilgarn; Gray 1993a);
(v) Mulgarrie: saline/neutral groundwaters, about 40 km north of Kalgoorlie (south Yilgarn; Gray 1992b).

Mt. Gibson, Boags and Golden Hope are designated as primarily residual sites in relict and erosional landform regimes. The Granny Smith groundwaters are divided into two groups: those from the north part of the study area (Goanna and Granny pits) which are primarily in residual landform regimes; and samples from the southern part of the study area (Windich) that have appreciable overburden (Gray, 1993a). Lawlers groundwaters can also be split in two groups, in a similar manner. The Mulgarrie groundwaters are from a palaeodrainage overlying a gold deposit.

Comparisons with other sites may be useful in indicating the degree of any particular element anomaly, and whether the groundwater composition is affected by particular lithological interactions.

The concentrations of various ions at Baxter and at other sites are plotted *versus* TDS or *versus* pH in Appendix 2, Figures A2.1 - A2.40. The sea water data are used to derive the line of possible values if sea water were diluted with freshwater or concentrated by evaporation, hereafter denoted as the sea water line, and shown as the dotted line. Where the dotted line is not shown, this is because the sea water concentration is too low, relative to the concentration of the element in groundwaters, to be observed on the graph.

The salinities of the Baxter groundwaters are appreciably less than that of the other sites studied, so that when a scale where most of the Baxter data can be resolved is used, only some of the groundwaters from the previous sites are depicted.

Table 1: Averaged compositions of Baxter groundwaters, with averaged results from other sites and sea water given for comparison.

	Baxter (42) [#]		Lawlers (40)	Mt Gibson (39)	Boags (2)	Golden Hope (3)	Granny Smith - Residual (7)	Granny Smith - Covered (11)	Mulgarrie (6)	Sea Water
	mean	std dv [@]								
pH	7.11	0.27	7.26	6.41	6.61	6.35	7.38	7.25	6.83	
Eh (mV)	300	40	270	330	160	200	270	240	180	
Na *	0.18	0.03	0.21	0.33	0.25	0.27	0.32	0.33	0.29	0.30
Mg *	0.063	0.007	0.070	0.031	0.052	0.062	0.026	0.023	0.052	0.039
Ca *	0.12	0.02	0.07	0.01	0.03	0.01	0.02	0.03	0.01	0.01
K *	0.039	0.009	0.020	0.011	0.009	0.006	0.010	0.010	0.004	0.011
Cl *	0.29	0.03	0.30	0.54	0.47	0.52	0.47	0.46	0.54	0.55
SO_4 *	0.13	0.04	0.18	0.08	0.17	0.13	0.14	0.12	0.10	0.08
HCO_3	80	30	120	220	620	690	210	170	400	140
TDS	410	130	800	19000	21000	45000	21000	7000	41900	34400
Li	<0.005	-	<0.005	0.08	nd	nd	nd	nd	nd	0.18
Rb	0.018	0.005	0.009	nd	nd	nd	nd	nd	nd	0.12
Sr	0.28	0.08	0.37	2.0	5.9	6.7	2.3	1.4	8.4	8.1
Cs	<0.0002	-	<0.0002	nd	nd	0.05	0.005	0.002	nd	0.0005
Ba	0.05	0.03	0.05	0.04	0.01	0.04	0.03	0.03	0.05	0.03
B	0.5	0.2	0.9	nd	nd	nd	nd	nd	nd	4.6
Al	0.004	0.003	0.005	0.03	<0.01	0.04	0.005	0.011	0.04	0.01
Si	22	9	24	29	7.2	8	8.5	22	12	3
P	0.02	0.01	0.04	nd	nd	0.05	0.01	0.02	nd	0.06
I	0.2	0.1	0.5	0.4[$]	2.1[$]	2.8[$]	1.3	0.6	0.5[$]	0.06
Sc	0.012	0.006	0.010	nd	nd	nd	nd	nd	nd	nd
Ti	<0.002	-	<0.002	nd	nd	nd	<0.002	<0.002	nd	0.001
V	0.009	0.009	0.011	nd	nd	nd	nd	nd	nd	0.002
Cr	0.03	0.02	0.03	<0.02	0.002	0.002	<0.005	<0.005	0.03	0.00005
Mn	0.02	0.04	0.06	0.6	0.03	0.32	0.6	0.19	4	0.002
Fe	0.003	0.002	0.008	3	0.07	3	0.2	0.5	0.04	0.01
Co	0.0004	0.0006	0.02	<0.05	<0.005	0.004	0.03	0.005	0.06	0.00027
Ni	0.003	0.008	0.007	<0.1	<0.01	0.03	0.06	0.013	0.14	0.005
Cu	0.003	0.003	0.002	<0.03	0.008	0.040	0.003	0.03	0.021	0.003
Zn	0.007	0.006	0.009	<0.2	0.015	0.014	0.10	0.05	0.03	0.01
Ga	0.002	0.002	0.002	nd	nd	0.009	0.001	0.001	nd	0.00003
Ge	<0.0005	-	<0.0005	nd	nd	nd	nd	nd	nd	0.00007
As	0.001	0.005	0.04	nd	0.11	<0.02	0.06	0.03	<0.02	0.003
Y	<0.0002	-	<0.0002	nd	nd	0.004	<0.0001	0.0002	nd	0.0003
Zr	<0.0002	-	<0.001	nd	nd	nd	nd	nd	nd	0.00002
Mo	0.001	0.002	0.003	nd	nd	0.019	0.03	0.025	nd	0.01
Ag	<0.0002	-	<0.001	nd	nd	0.0041	0.0003	0.0001	nd	0.0003
Cd	<0.0005	-	<0.002	nd	0.009	0.001	0.002	<0.002	nd	0.00011
Sn	<0.0002	-	<0.0002	nd	nd	0.003	0.001	0.0005	nd	0.003
Sb	<0.0002	-	0.0003	nd	0.17	<0.0003	0.007	0.002	<0.0003	0.0003
La[$]	<0.0002	-	<0.0002	nd	nd	0.0010	0.0001	0.0003	nd	0.00000
W	0.0004	0.0012	0.001	nd	nd	0.056	<0.0001	0.001	nd	0.0001
Au	0.003	0.002	3	0.16	0.5	0.004	0.03	0.006	0.05	0.011
Hg	<0.0002	-	<0.0002	nd	nd	0.0039	0.0002	0.0004	nd	0.00003
Tl	<0.0002	-	<0.0002	nd	nd	0.0006	0.0003	<0.0002	nd	0.00000
Pb	0.0005	0.0010	0.001	0.11	0.008	0.03	0.019	0.003	0.007	0.00005
Bi	<0.0002	-	<0.0003	nd	<0.002	<0.0001	<0.0003	<0.0003	<0.002	0.00002
Th	<0.0002	-	<0.0005	nd	nd	<0.0005	<0.0005	<0.0005	nd	0.00005
U	0.0003	0.0010	0.001	nd	<0.002	0.010	0.004	0.012	<0.002	0.003

All concentrations in mg/L (ppm), except Au in µg/L (ppb). Eh is measured in mV.

\# Bracketed numbers denote the number of samples.

@ Standard Deviation or detection limit (whichever is the larger).

* For the elements Na, Mg, Ca, K, Cl and SO_4, the ratio of the element concentration to TDS is used rather than the concentration. (See Section 3.4 for details.)

$ All other REE were < 0.0002 at Baxter

nd not determined - not applicable

3.3 Acidity and oxidation potential

An Eh-pH plot of waters from Baxter and other sites is shown in Figure 6. For simplicity, the Mt. Gibson, Boags, and Granny Smith groundwaters are combined into the Central Yilgarn group, whereas the Southern Yilgarn group includes Mulgarrie and Golden Hope, as well as acid groundwaters at Panglo, Wollubar, Argo and Steinway (Gray, 1990, 1993b; Lintern and Gray, 1995a, b). The Baxter groundwaters are neutral ($6.2 < pH < 7.6$) and have a similar Eh range to neutral waters from other sites.

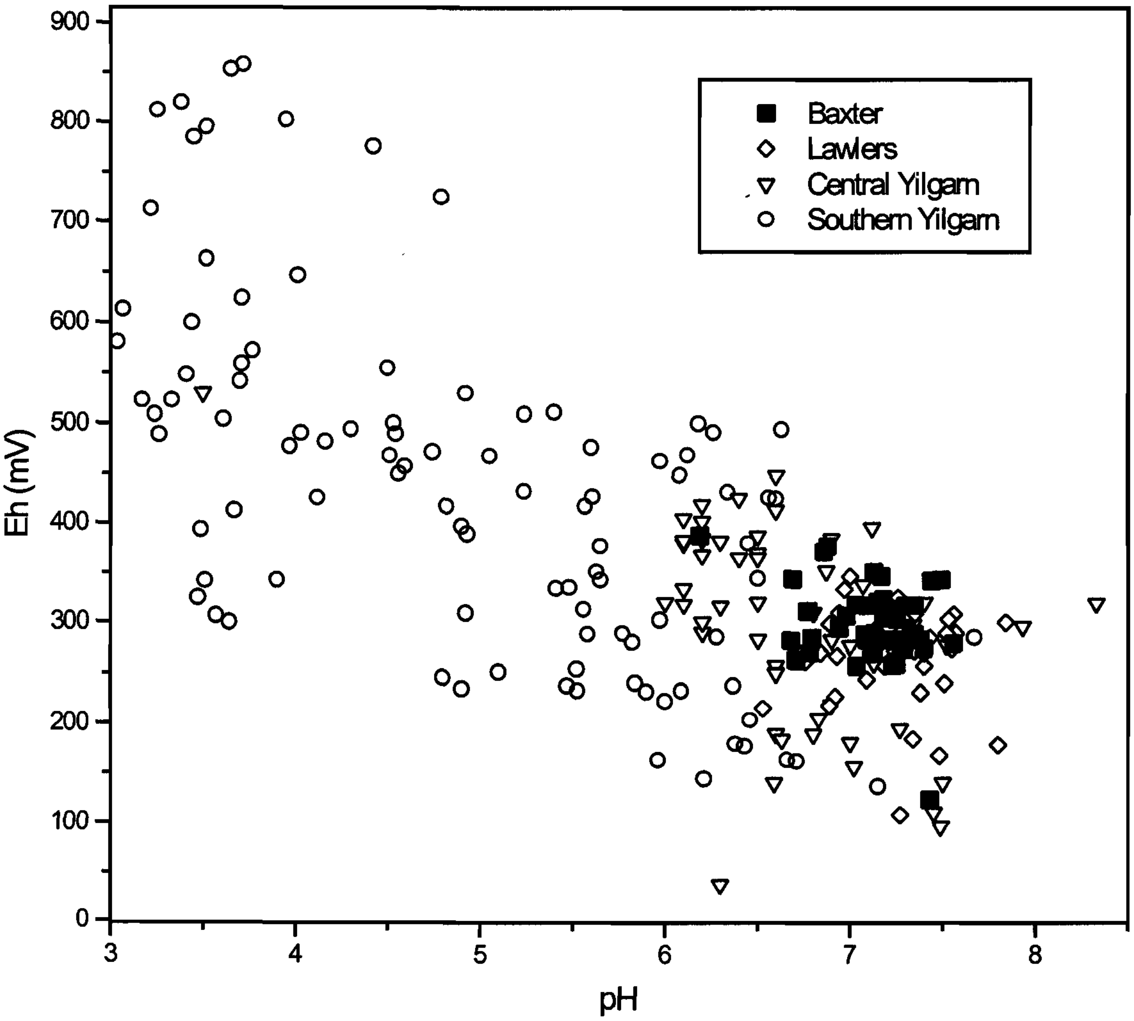

Figure 6: Eh vs. pH for groundwaters from Baxter and other sites.

3.4 Major ion chemistry

For the ions Na, Mg, Ca, K, Cl and SO_4, the ratio of the concentration divided by TDS (hereafter called the TDS ratio) is used in Table 1 rather than the concentration. This is because the chemistries of these ions are commonly controlled by salinity effects and therefore better understood by using the TDS ratio. Additional information may also be obtained from concentration vs. TDS plots (Figures A2.1 - A2.6). The TDS ratios for most of the major elements diverge markedly from those of sea water. In particular, the major ions Na and Cl are depleted, relative to sea water, whereas the other ions are proportionally enriched at Baxter. This is also demonstrated by plotting the groundwater data on a Piper-Stiff diagram (Figure 7), which is a ternary plot of the ionic equivalences of the major ions. The southern Yilgarn groundwaters and, to a lesser degree, the central Yilgarn groundwaters have very similar ion proportions to sea water, suggesting a sea water origin, either due to an earlier marine transgression, or a salt aerosol originating from sea water and subsequently concentrated by evaporation. In contrast, both Baxter and Lawlers have very similar ion proportions, and differ markedly from sea water. The divergences are sufficiently great to suggest that the Baxter groundwaters do not predominantly derive from sea water (albeit with minor depletions or enrichments), but is, instead, a groundwater in which the major ion abundances are controlled by lithological and hydrological factors. The similarity between Baxter and Lawlers is of interest, as it suggests that these factors are regional rather than local. Further sampling in the northern Yilgarn will demonstrate whether this is coincidental or represents a groundwater trend for this entire region.

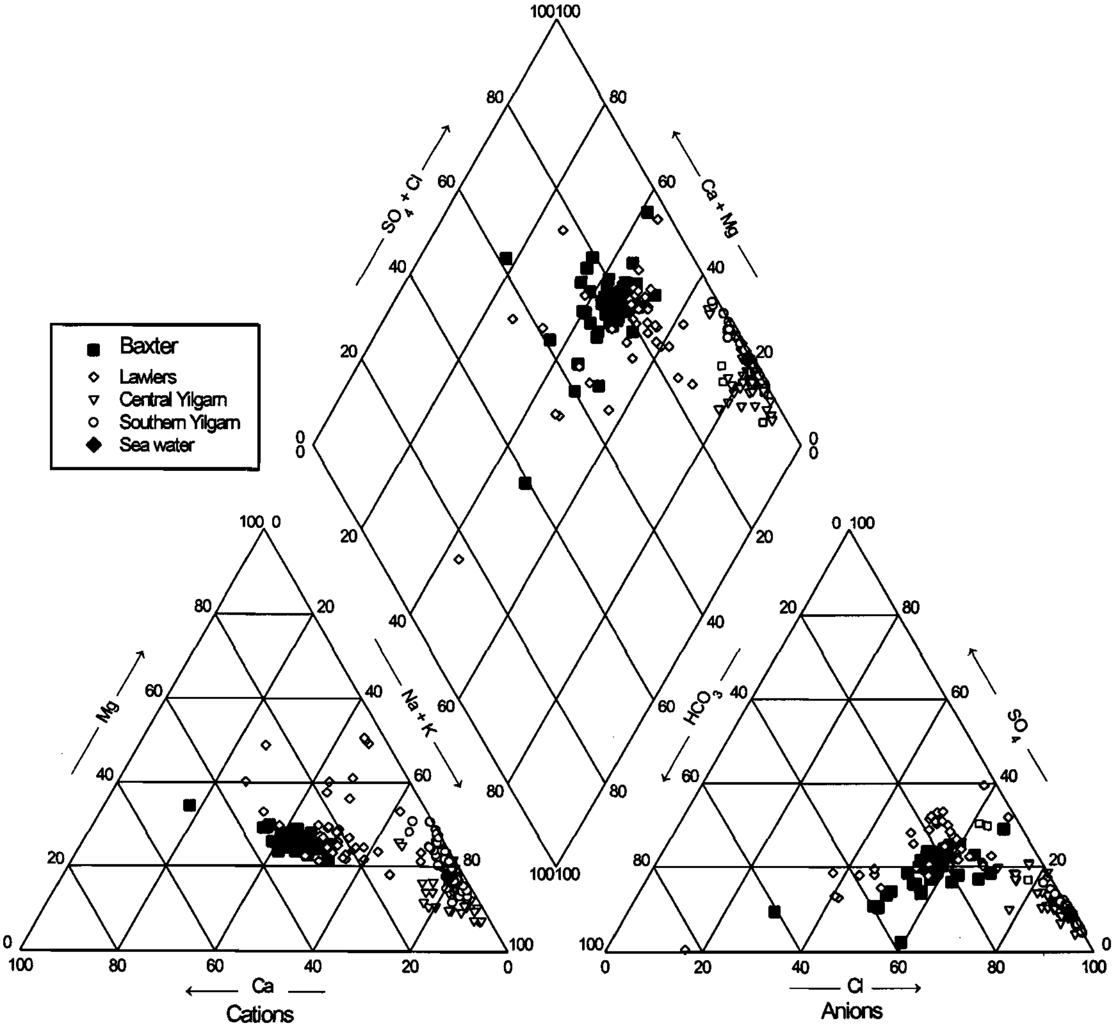

Figure 7: Piper-Stiff diagram for groundwaters from Baxter and other sites

The potential for dissolution or precipitation of minerals such as gypsum from the Baxter groundwaters is tested by speciation analysis (Section 2.3). The range, average and standard deviation of the SI values of the water samples for a number of relevant solid phases are given in Table 2, with SI values plotted in Appendix 3. As discussed in detail in Section 2.3, a SI of zero indicates the solution is saturated with respect to that mineral, a SI less than zero indicates under-saturation and a SI greater than zero indicates the solution is over-saturated with respect to the mineral phase and has the potential to precipitate.

Table 2: SI Values for the Baxter groundwaters, for a number of relevant solid phases. Saturation is indicated by italics and over-saturation by bold font.

Mineral	Formula	Lower	Upper	Mean	Standard Deviation
Halite	$NaCl$	-7.7	-6.2	-6.7	0.4
Gypsum	$CaSO_4.2H_2O$	-3.1	-1.6	-2.1	0.4
Celestine	$SrSO_4$	-3.9	-2.3	-2.7	0.4
Barite	$BaSO_4$	-1.4	*0.0*	-0.6	0.4
Calcite	$CaCO_3$	-2.6	*-0.1*	-0.9	0.5
Dolomite	$CaMg(CO_3)_2$	-5.0	*0.1*	-1.6	1.0
Magnesite	$MgCO_3$	-3.3	-0.7	-1.5	0.5
Quartz	SiO_2	*0.3*	**1.1**	0.8	0.2
Amorphous Silica	"	-1.0	*-0.1*	-0.4	0.2
Gibbsite	$Al(OH)_3$	*0.0*	**1.3**	0.6	0.4
Amorphous Alumina	"	-2.3	-0.9	-1.6	0.4
Kaolinite	$Al_2Si_2O_5(OH)_4$	**1.8**	**5.2**	3.7	0.9
Siderite	$FeCO_3$	-3.6	-1.9	-2.9	0.5
Ferrihydrite	$Fe_2O_3.nH_2O$	*0.5*	**1.4**	0.9	0.4
Goethite	$FeOOH$	**5.5**	**6.4**	5.9	0.4
Rhodochrosite	$MnCO_3$	-2.9	*-0.2*	-2.0	0.6
Tenorite	$Cu(OH)_2.H_2O$	-1	-1	-1	-
Smithsonite	$ZnCO_3$	-4.4	-2.5	-3.2	0.4
Cerussite	$PbCO_3$	-2.2	-1.0	-1.6	0.4
Theophrasite	$Ni(OH)_2$	-6.1	-2.1	-4.3	0.7
Sphaerocobaltite	$CoCO_3$	-5.4	-3.1	-4.6	0.4
Eskolaite	Cr_2O_3	**3.3**	**9.5**	7.5	1.4
Au Metal	Au	**3.1**	**6.9**	4.5	0.7
$Sb(OH)_3$	$Sb(OH)_3$	-1.6	-1.0	-1.3	0.2
Chervitite	$Pb_2V_2O_7$	-0.6	*0.1*	-0.2	0.3
Carnotite	$K_2(UO_2)_2(VO_4)_2.3H_2O$	-3.9	-2.6	-3.3	0.5

Groundwaters at Baxter are undersaturated with respect to halite, gypsum and celestine (Figures A3.1 - A3.3), in contrast with the majority of sites in the south Yilgarn in which waters are saline to hypersaline and saturated with these salts. However, similarly to other sites, Baxter groundwaters reach barite saturation (Figure A3.4). Baxter groundwaters are undersaturated to saturated with respect to calcite, dolomite and magnesite (Figures A3.5 to A3.7), as previously observed at the other, more saline, sites. At those sites, the great excess of Mg and Ca relative to bicarbonate means that carbonate equilibration will control bicarbonate concentrations, but have little direct effect on those of Mg and Ca. In contrast, the Baxter groundwaters are fresher and Mg and Ca concentrations are less than that of bicarbonate so that, for the higher pH samples, equilibration with carbonate minerals will therefore have a strong effect on the Mg and Ca concentration.

The upper limit for HCO_3 concentration is less than most other sites (though, as for many other species, it is similar to that for Lawlers; Figure A2.8), with some groundwaters having particularly low HCO_3 contents. Aluminium concentrations are low in the Baxter groundwaters, approximating that of sea water (Figure A2.15), again consistent with the neutral pH. All waters are saturated or oversaturated with respect to gibbsite, but are undersaturated with respect to amorphous alumina

(Figure A3.9). Similarly, the groundwaters are oversaturated with respect to quartz but undersaturated with respect to amorphous silica (Figure A3.8), perhaps reflecting the presence of phases such as opaline silica. Dissolved Si concentrations are above that for sea water but approximately match other sites (Figure A2.16).

Dissolved Fe concentrations (Figure A2.21) are very low. The groundwaters are undersaturated with respect to siderite ($FeCO_3$; Figure A3.11), a Fe^{II} carbonate, and moderately oversaturated with respect to ferrihydrite (Figure A3.12), a highly soluble Fe^{III} oxide. Manganese concentrations are similar to other sites (Figure A2.20) and Baxter groundwaters are unsaturated with respect to rhodochrosite ($MnCO_3$; Figure A3.13). These results are also similar to those observed for Lawlers.

3.5 Minor element chemistry

Most of the minor elements have concentrations similar to those at other sites (Table 2; Figures A2.17 - A2.40). As discussed previously, Fe concentrations are significantly lower at Baxter than elsewhere. Chromium (Figure A2.19) is high at Baxter (and at Lawlers and Mulgarrie), specifically due to the presence of ultramafic rocks. However, Ni concentrations are low at Baxter (Figure A2.23), consistent with observations at Panglo (Gray, 1990), suggesting that Cr is readily dissolved during neutral weathering of ultramafic rocks, whereas most of the Ni is included in more resistant minerals and will only be released during acid weathering.

Most minor elements are undersaturated with respect to the least soluble mineral phase (Table 2; also see Figures A3.14 - A3.27), indicating little dissolution of these elements and/or removal from solution via mechanisms such as sorption. Exceptions are Pb, V, REE and Cr, with groundwaters at equilibrium with respect to solid chervitite ($Pb_2V_2O_7$; Figure A3.22) and with monazite minerals ($LaPO_4$ and $CePO_4$; Figures A3.25 and A3.26), and being strongly oversaturated with respect to eskolaite (Cr_2O_3; Figure A3.19). This is consistent with the above suggestion that Cr is being released from weathering minerals and the groundwaters are not equilibrating with less soluble Cr minerals.

3.6 Gold chemistry

The low salinity of the Baxter groundwaters means that the dominant mechanism for the mobilization of Au in the southern Yilgarn, namely as the chloride complex ($AuCl_2^-$):

$$2Au_{(S)} + 4Cl^- + \tfrac{1}{2}O_2 + 2H^+ \rightleftharpoons 2AuCl_2^- + H_2O \qquad \text{...(1)}$$

is not expected to be significant at this site. Two other mechanisms for Au solubilization are as an organic complex, which is not expected to be important in the organic-poor groundwaters occurring at this site, and as the thiosulphate complex [$Au(S_2O_3)_2^{3-}$]:

$$2Au_{(S)} + 4S_2O_3^{2-} + \tfrac{1}{2}O_2 + 2H^+ \Rightarrow 2Au(S_2O_3)_2^{3-} + H_2O \qquad \text{...(2)}$$

Generation of this later complex is controlled by the production of thiosulphate:

$$FeS_2 + 3O_2 \Rightarrow Fe^{2+} + S_2O_3^{2-} \qquad \text{...(3)}$$

which primarily occurs during oxidation of sulphides, when acid production is buffered by minerals such as carbonates. Previous investigations (Butt *et al.*, 1993; Gray, 1994) have indicated that this is only significant for groundwaters sampled at the weathering interface, and will have little effect on Au solubility for shallower groundwaters such as those analysed at Baxter. Therefore, dissolved Au concentrations are expected to be very low, as is observed (Figure A2.36). A histogram of dissolved Au data for all sites (Figure 8) also demonstrates the comparatively low Au concentrations at Baxter. This is similar to groundwaters sampled at Lawlers from partially or wholly intact regolith and areas of overburden (*i.e.*, crossed diamonds in Figure A2.36) which also had very low Au contents (0.001 - 0.027 μg/L), but (consistent with the thiosulphate mechanism) not with Lawlers groundwaters sampled at the weathering interface, which had extremely high Au concentrations (up to 41 µg/L; Gray, 1994).

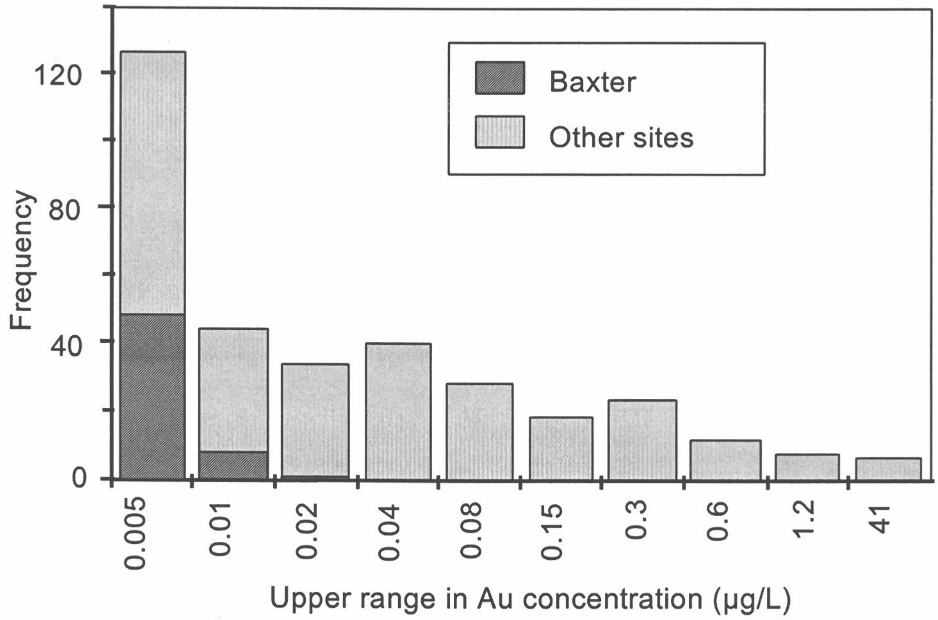

Figure 8: Histogram of dissolved Au concentrations for groundwaters from Baxter and other sites.

This suggests that Au is not expected to be actively dispersed in the regolith, and therefore will not be a useful pathfinder in groundwater or in juvenile soils overlying extensive overburden. However, other elements can be associated with Au mineralization and, at this site, may be better pathfinders for Au mineralization than dissolved Au (Section 4).

4 MAPPING OF THE DATA

4.1 Description of the mapping

Element distributions determined by groundwater sampling are given in Appendix 4, with the key for the different map features given in Figure 2 and Figure A4.1. The highest assays for Au, As, Cr, Pb, Cu and Ni in each hole (courtesy AFMECO) have been contoured (Figures A4.2 - A4.7) for comparison. Some of the more critical distribution maps have been reproduced in the text.

4.2 Total dissolved solids and salinity-related elements

Total dissolved solids (Figures A4.8): The groundwaters vary from 140 to 650 mg/L TDS. Lowest salinities appear to occur in the region of the main palaeovalley in the southwest of the study area, possibly as a consequence of enhanced flow. Although the ion/TDS ratio has been mapped at other sites (*e.g.*, Gray, 1993a, 1994), this has not been done at Baxter, because Na, K, Mg, Ca, Cl and SO_4 appears to be linearly correlated with TDS (Figures A2.1 - A2.6) and, with the low salinities at this site, any deviation from linearity is probably less than analytical error. For example, SO_4/TDS (Figure A4.9) shows no clear spatial distribution.

Rubidium (Figures 13 and A4.9): Rubidium concentrations are poorly correlated with K (Figure 9) and TDS, and are higher than expected if the groundwaters had the same ion ratios as sea water. Mineralized groundwaters tend to be Rb-rich (Figure 13).

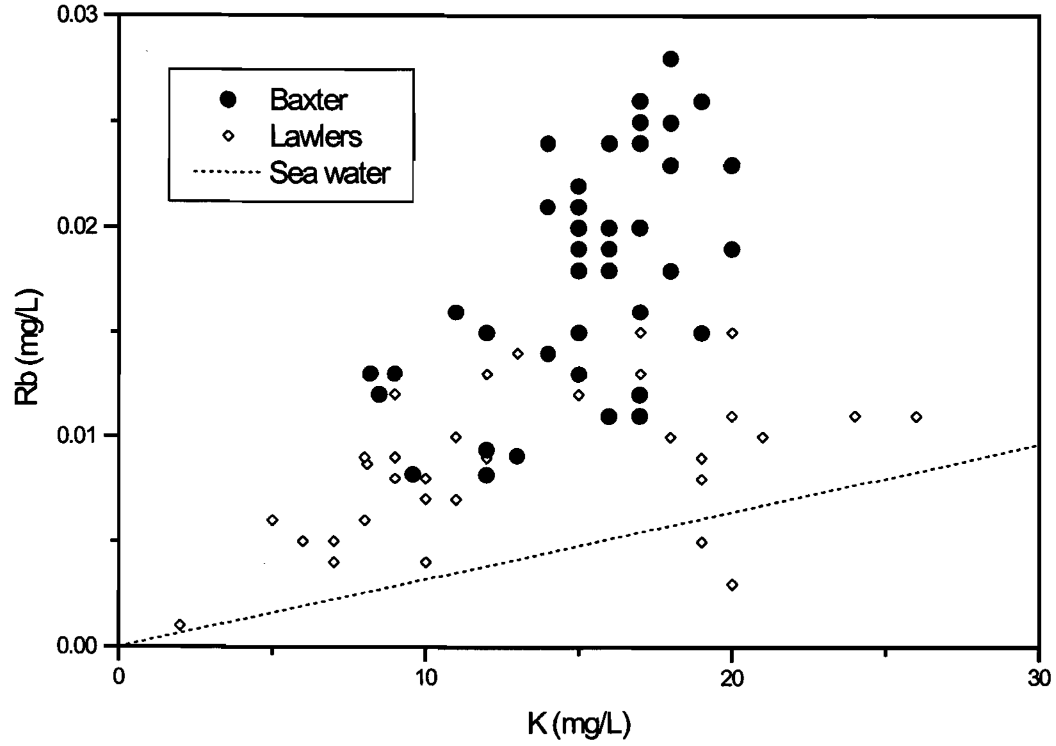

Figure 9: Rb vs. K for groundwaters from Baxter and Lawlers

Strontium (Figures A4.10): Strontium concentrations show no clear spatial distribution.

Barium (Figures A4.11): Although an alkaline earth, Ba commonly shows different behaviour from Sr and Ca, partially because of a major solubility control by equilibration with barite (*i.e.*, an increase in salinity will lower the Ba concentration because higher SO_4 concentration will enhance the precipitation of barite). Barium concentrations are greatest in groundwaters from the southwest of the study area, possibly because of the decreased salinity of the palaeo-valley waters.

Boron (Figure A4.12): Boron concentrations are highly correlated with TDS for both Baxter and Lawlers (though the B/TDS ratio is considerably greater than that for sea water; Figure 10) and the B distribution closely matches that of TDS (Figure A4.8).

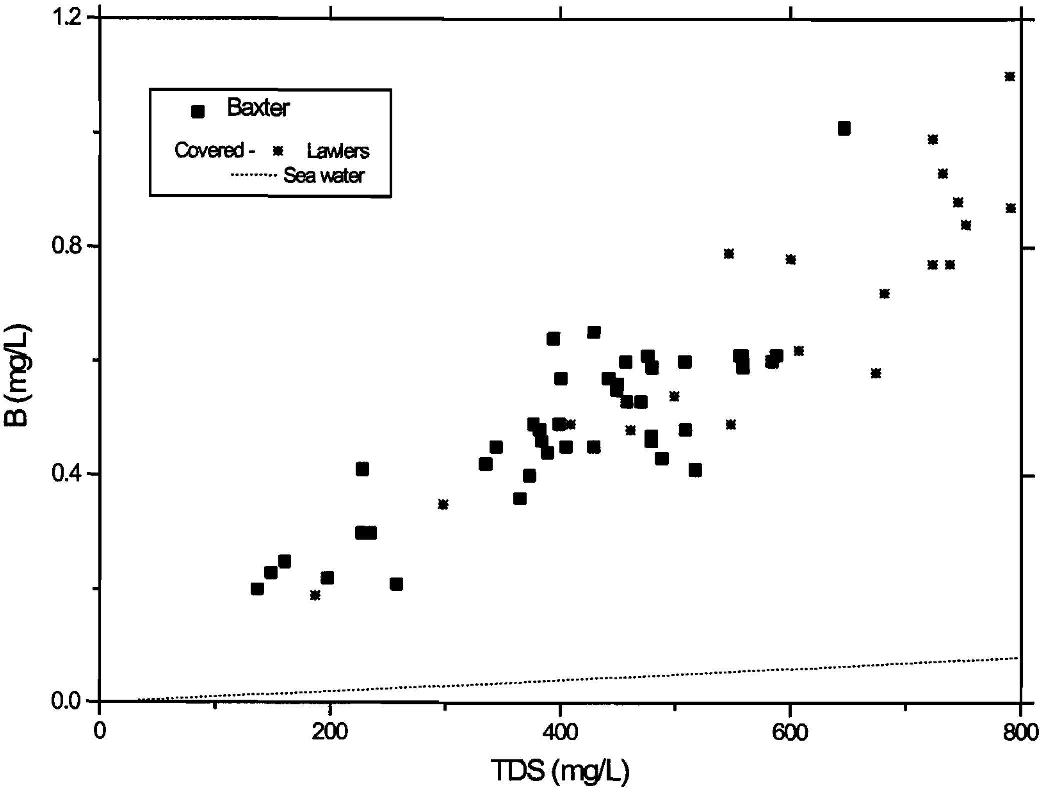

Figure 10: B vs. TDS for groundwaters from Baxter and Lawlers.

Phosphorus (Figures A4.13): Contaminated groundwaters are P-rich (Section 2.2) and P is therefore expected to be unreliable at this site.

4.3 pH, alkalinity and oxidation potential

pH, alkalinity and oxidation potential (Figures A4.14 - A4.16): None of these parameters show any clear spatial distribution.

4.4 Aluminium, gallium and silicon

Aluminium (Figure A4.17): Aluminium concentration is strongly controlled by pH and is generally very low under neutral conditions. The greatest Al concentrations at Baxter are observed in the major palaeo-valley to the southwest and in the Thaduna Formation. In contrast, groundwaters from within the Narracoota Volcanics generally have less than 0.005 mg/L dissolved Al.

Gallium (Figure A4.18): Gallium has a similar ionic radius to Al (Ga^{3+} - 0.62 Å, Al^{3+} - 0.51 Å) and therefore is almost always found substituted in Al minerals (Goldschmidt, 1954). The distribution of Ga in groundwater is similar to that of Al (Figure A4.17), although the lithological differences are even more marked.

Silicon (Figure A4.19): Silicon concentrations show no explainable spatial distribution.

4.5 First row transition metals

Scandium (Figures 14 and A4.20): Scandium is often linked with Y and REE, though by virtue of its smaller ionic radius (0.75 Å, compared with 0.86 - 1.05 Å for Y and REE), it is commonly associated with Fe^{3+} or Al minerals and has a different geochemical behaviour than REE (Frondel, 1978). Previous investigations (Giblin, 1990, page 88; Gray, 1993b, 1994) have suggested that dissolved Sc may be a useful indicator element in Au exploration. This is supported by the observed groundwater enhancement of Sc in the mineralized zone at Baxter.

Vanadium (Figure A4.21): Results suggest a highly variable V distribution.

Chromium (Figures 18 and A4.22): Groundwater Cr concentrations at Baxter are primarily related to lithology, with greatest concentrations above Cr-rich ultramafic rocks. Gray (1990, 1992b, 1994), has shown that dissolved Cr is a very specific indicator for ultramafic rocks, regardless of pH.

Manganese and iron (Figures A4.23 and A4.24): Manganese and Fe concentrations in the uncontaminated groundwaters are very low, relative to other sites (Figures A2.20 and A2.21). Manganese concentrations are very high (up to 2.7 mg/L; Section 2.2) in contaminated groundwaters, so dissolved Mn is expected to be a very unreliable groundwater parameter at Baxter.

Cobalt (Figure A4.25): Cobalt concentrations show no explainable spatial distribution.

Nickel (Figures 19 and A4.26): Although the geochemical database is incomplete, it appears that the Ni distribution (Figure A4.6) in the solids closely matches that of Cr (Figure A4.4), presumably mapping the ultramafic occurrence in the Narracoota volcanics. However, unlike Cr, dissolved Ni correlates very poorly with the ultramafic distribution (Figure 19), and instead appears to be enriched with dissolved As (Figure 11), suggesting that both of these elements are dissolved from the same mineral.

Copper and zinc (Figures A4.27): Copper (not shown) was close to or below detection at Baxter, and Zn concentrations show no explainable spatial distribution.

4.6 Yttrium and rare earth elements

Concentrations of these elements are close to or below detection at Baxter.

4.7 Second and third row transition elements, metalloids, iodine and uranium

Molybdenum and tungsten (Figures 15, 16, A4.28 and A4.29): These elements have similar co-ordination chemistry, but differ in that Mo mostly occurs as a sulphide (*e.g.*, MoS_2), whereas W may be found as oxygen compounds (*e.g.*, $FeWO_4$; Goldschmidt, 1954; Evans *et al.*, 1978; Evans and Krauskopf, 1978). Both elements have similar enrichments for groundwaters from the Harmony deposit, though Mo has the clearer anomaly at Harmony, and is also enriched in groundwaters from the area of enriched Au to the SE of the study area.

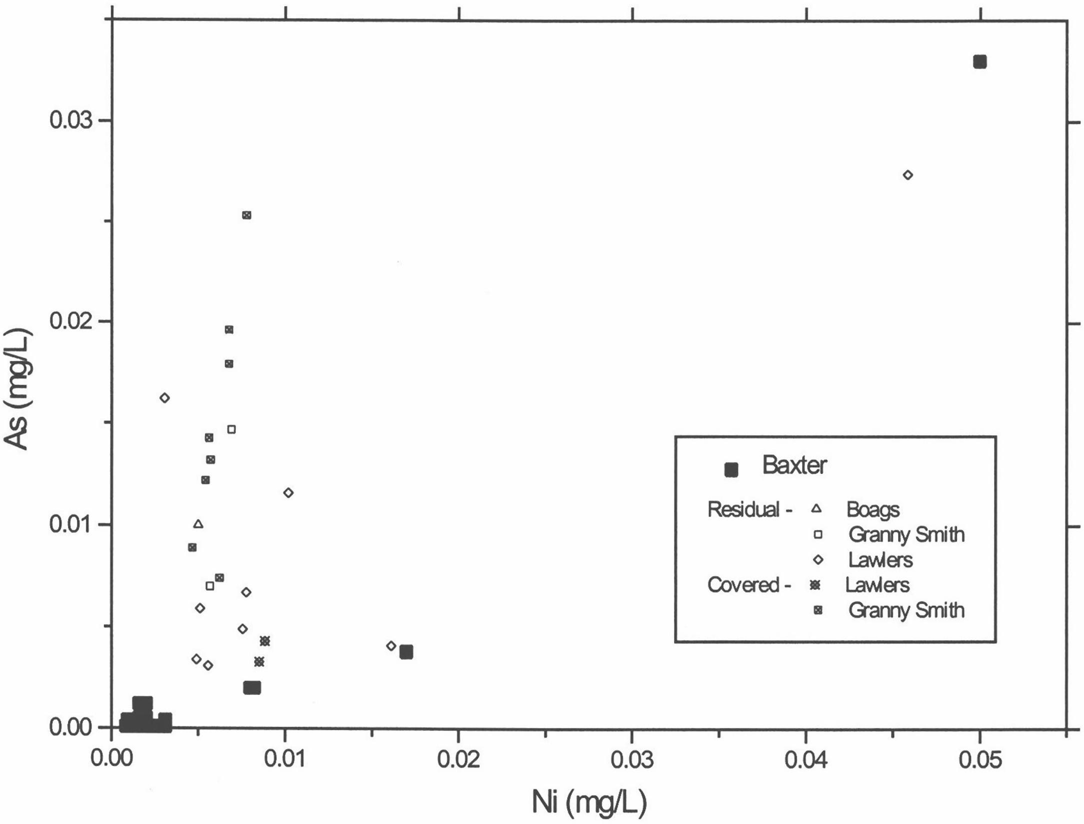

Figure 11: As vs. Ni for groundwaters from Baxter and Lawlers.

Cadmium, mercury, thallium, germanium, tin, antimony, bismuth and uranium: These elements were close to or below detection for Baxter groundwaters.

Arsenic (Figures 17 and A4.30): Dissolved As shows a strong enrichment in groundwaters in the SE of the study area, correlated with an "As corridor", *i.e.*, a band of As-rich rocks to the south-east of the study area. As discussed above (Section 4.5), dissolved Ni also appears to be enriched in this area, but the correlation is not as clearly defined, possibly because of the higher detection limit for Ni.

Lead (Figures 20 and A4.31): Dissolved Pb did not correlate with Pb in the solid, or with any other known geochemical factor. The highest Pb concentrations (up to 0.005 mg/L) were observed at or close to the interface between the Narracoota Volcanics and the Thaduna Formation, and may reflect alteration at the contact.

Iodine (Figure A4.32): Iodine concentrations show no explainable spatial distribution.

4.8 Gold

As discussed previously (Section 3.6), dissolved Au concentrations (Figures 12 and A4.33) are very low at Baxter. There is no discernible spatial distribution for the dissolved Au data, with the greater number of high dissolved Au samples in the region of Harmony probably due only to the higher sampling density in that zone.

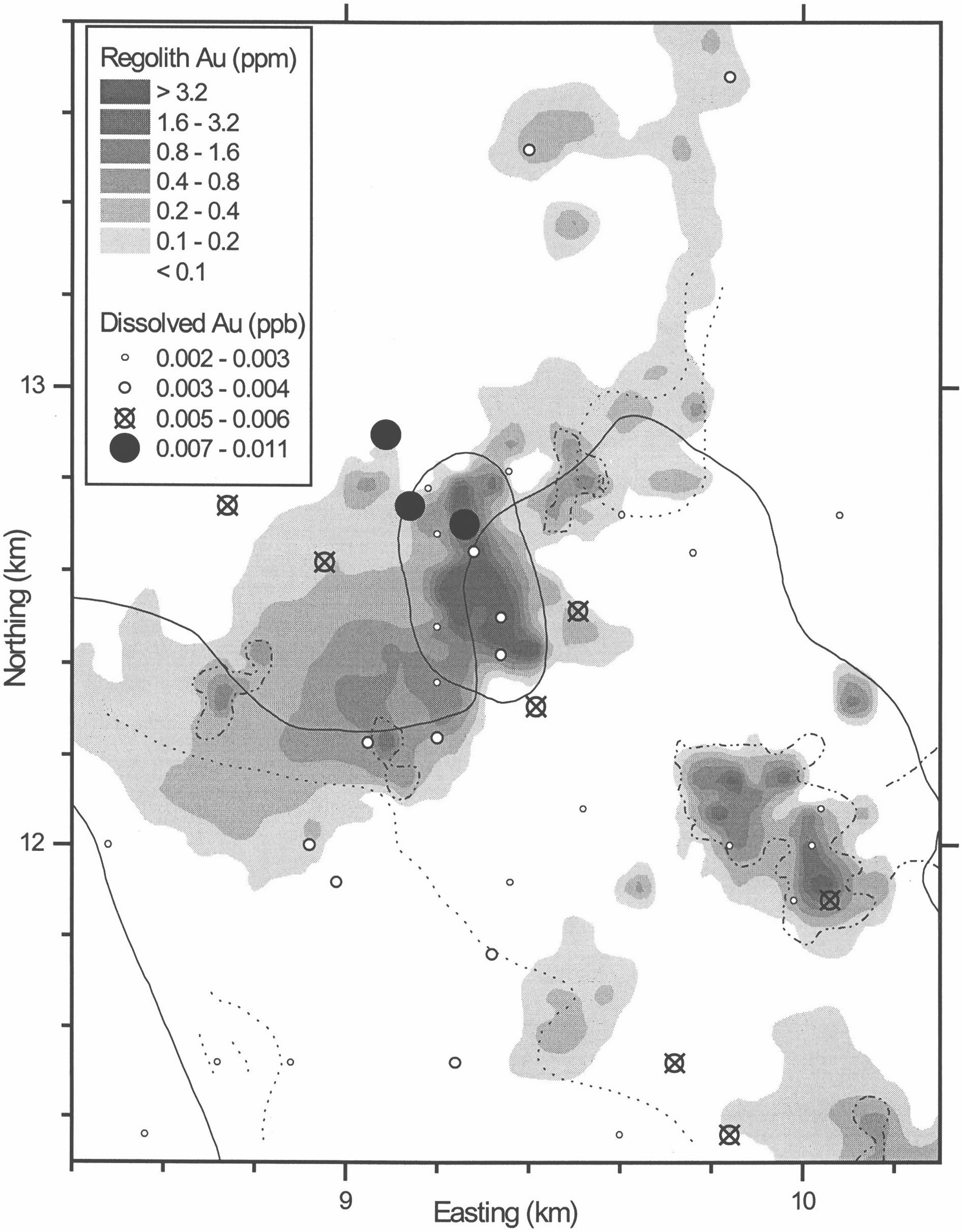

Figure 12: Dissolved Au distribution at Baxter (dots) superimposed on maximum Au contents in the regolith.

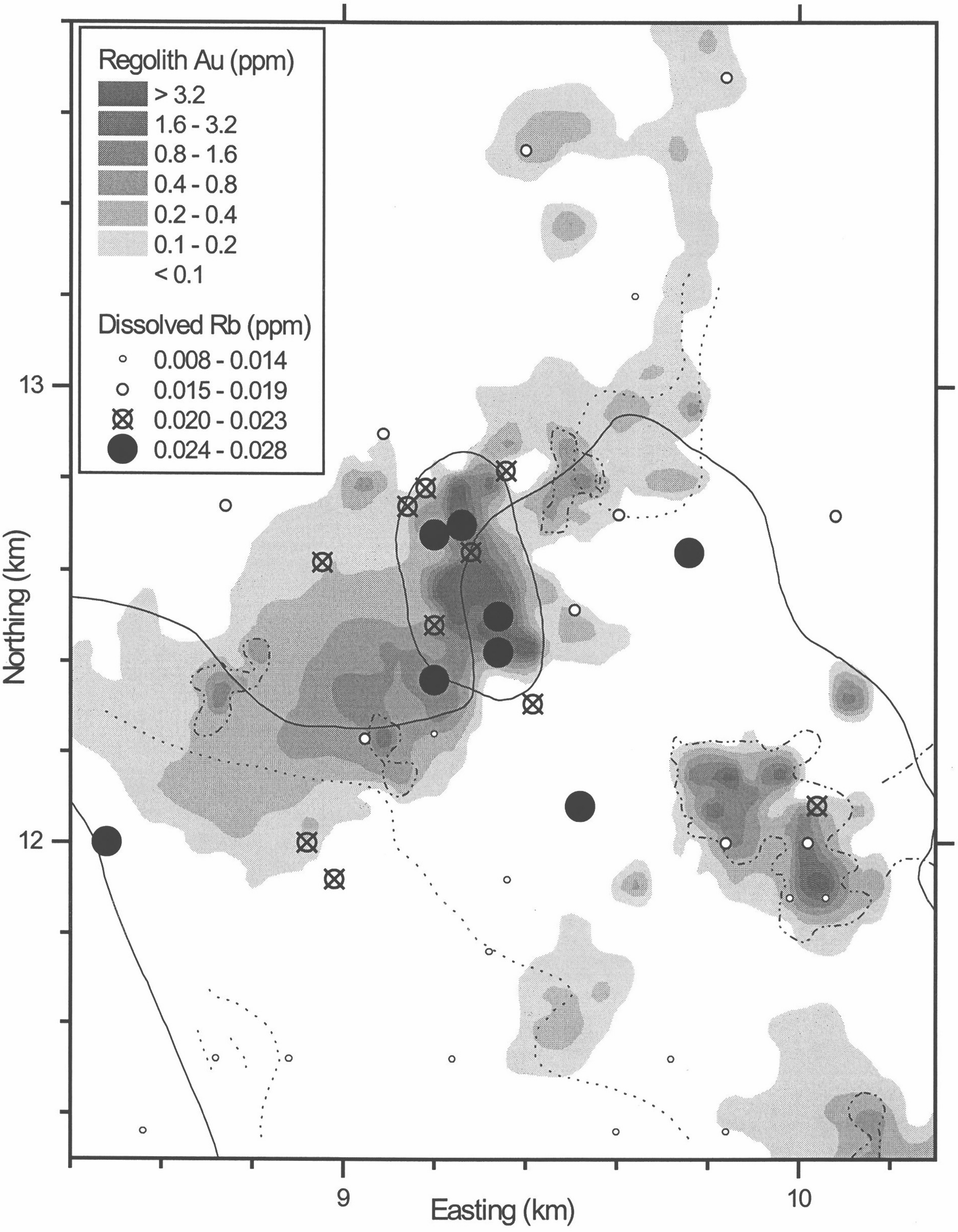

Figure 13: Dissolved Rb distribution at Baxter (dots) superimposed on maximum Au contents in the regolith.

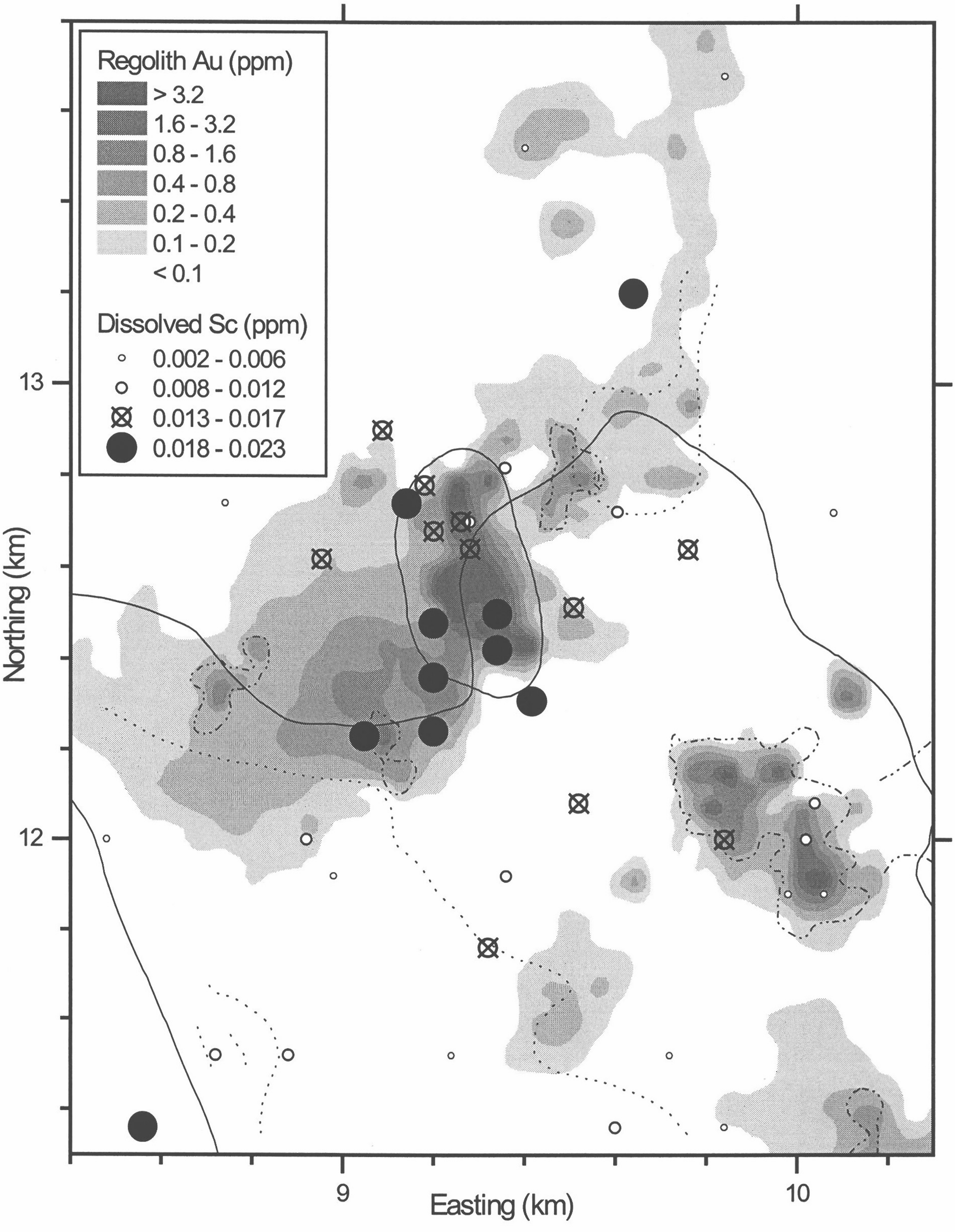

Figure 14: Dissolved Sc distribution at Baxter (dots) superimposed on maximum Au contents in the regolith.

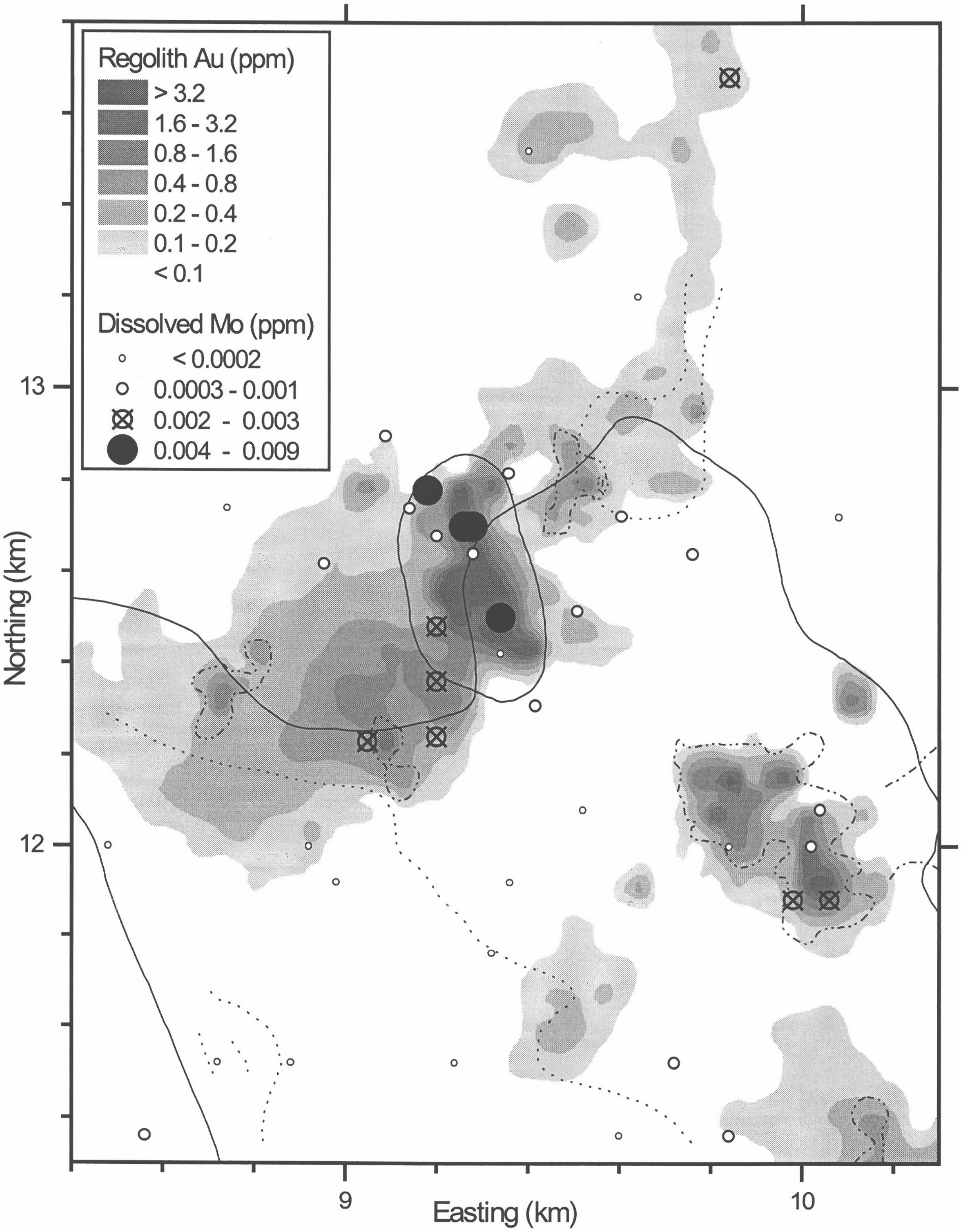

Figure 15: Dissolved Mo distribution at Baxter (dots) superimposed on maximum Au contents in the regolith.

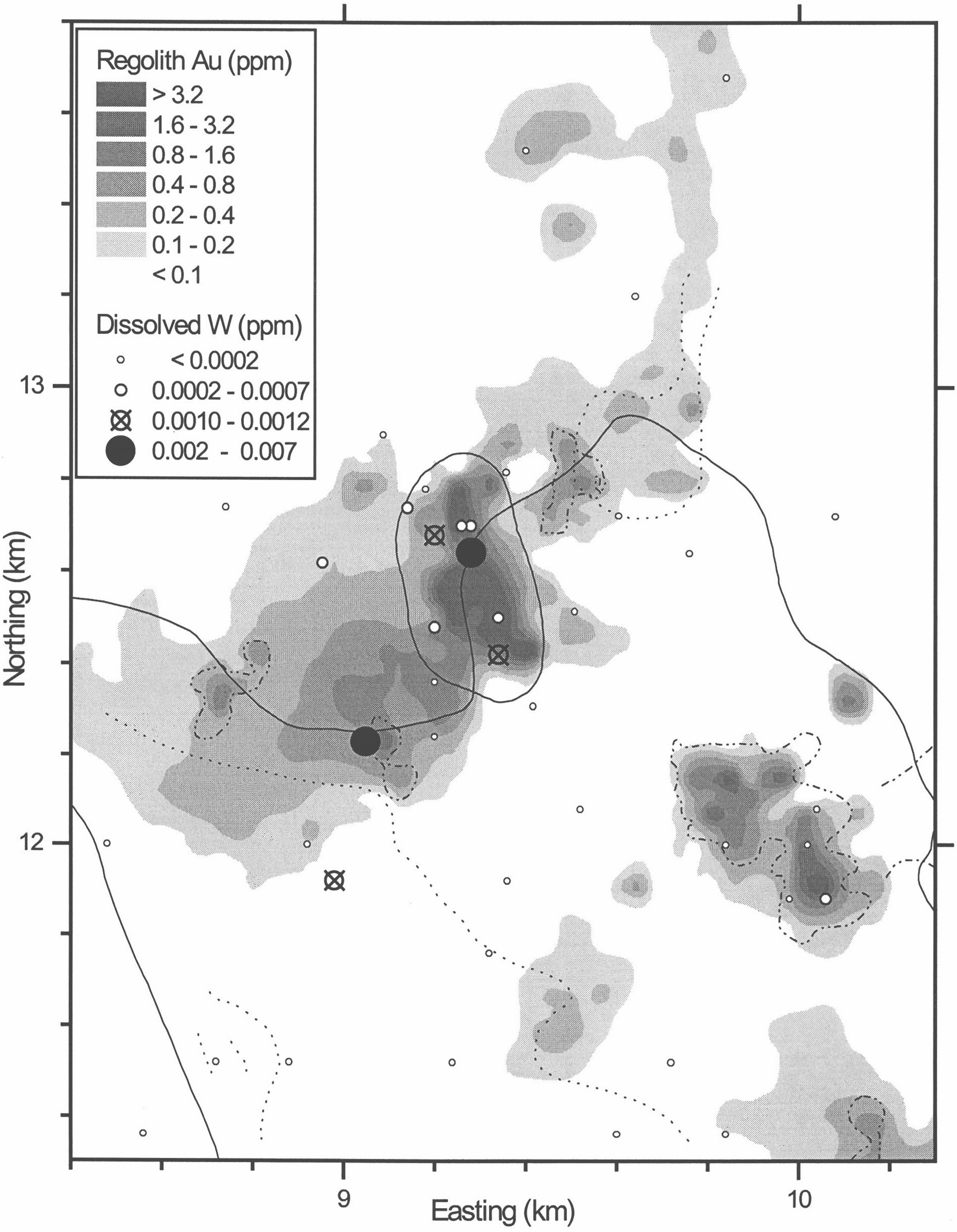

Figure 16: Dissolved W distribution at Baxter (dots) superimposed on maximum Au contents in the regolith.

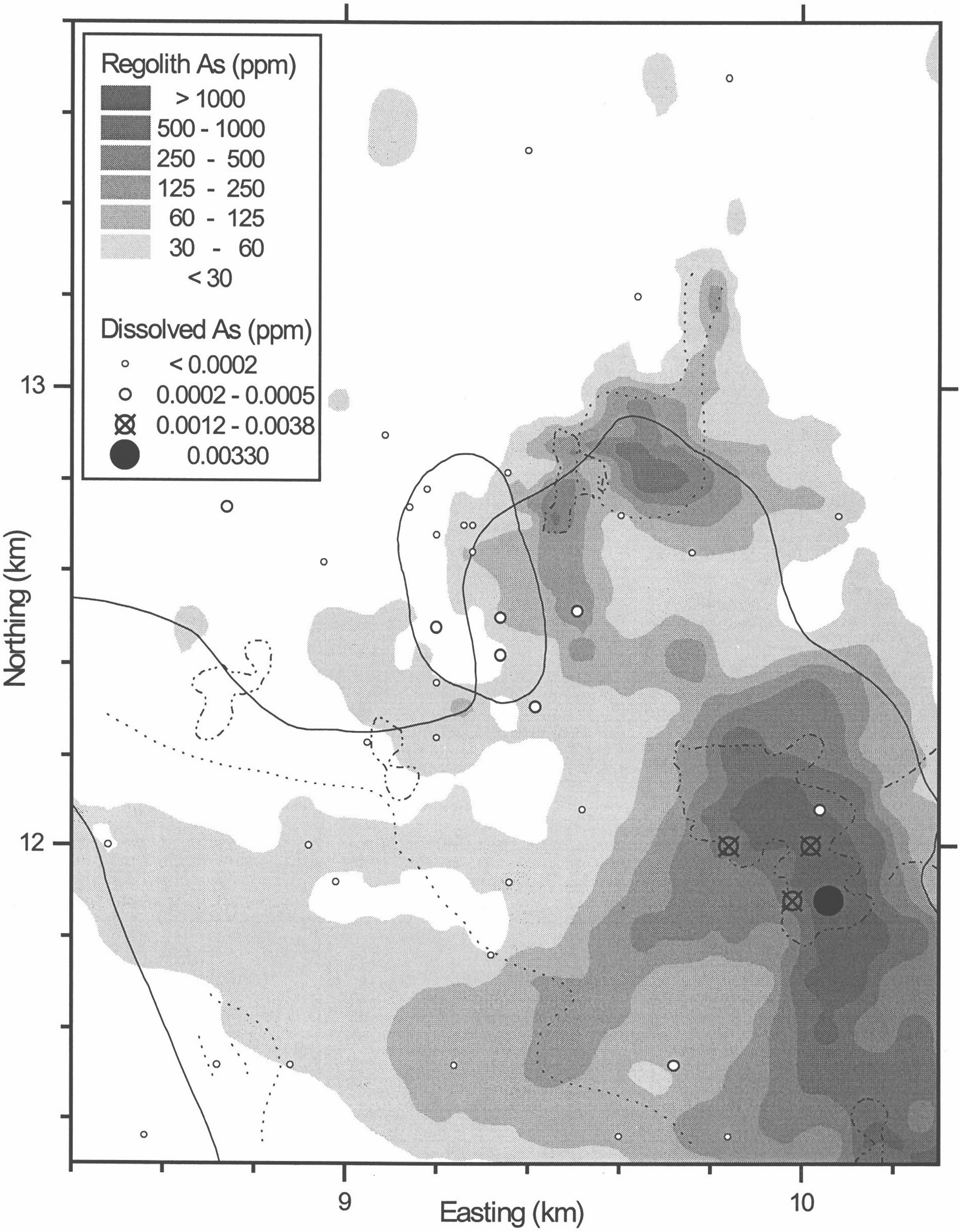

Figure 17: Dissolved As distribution at Baxter (dots) superimposed on maximum As contents in the regolith.

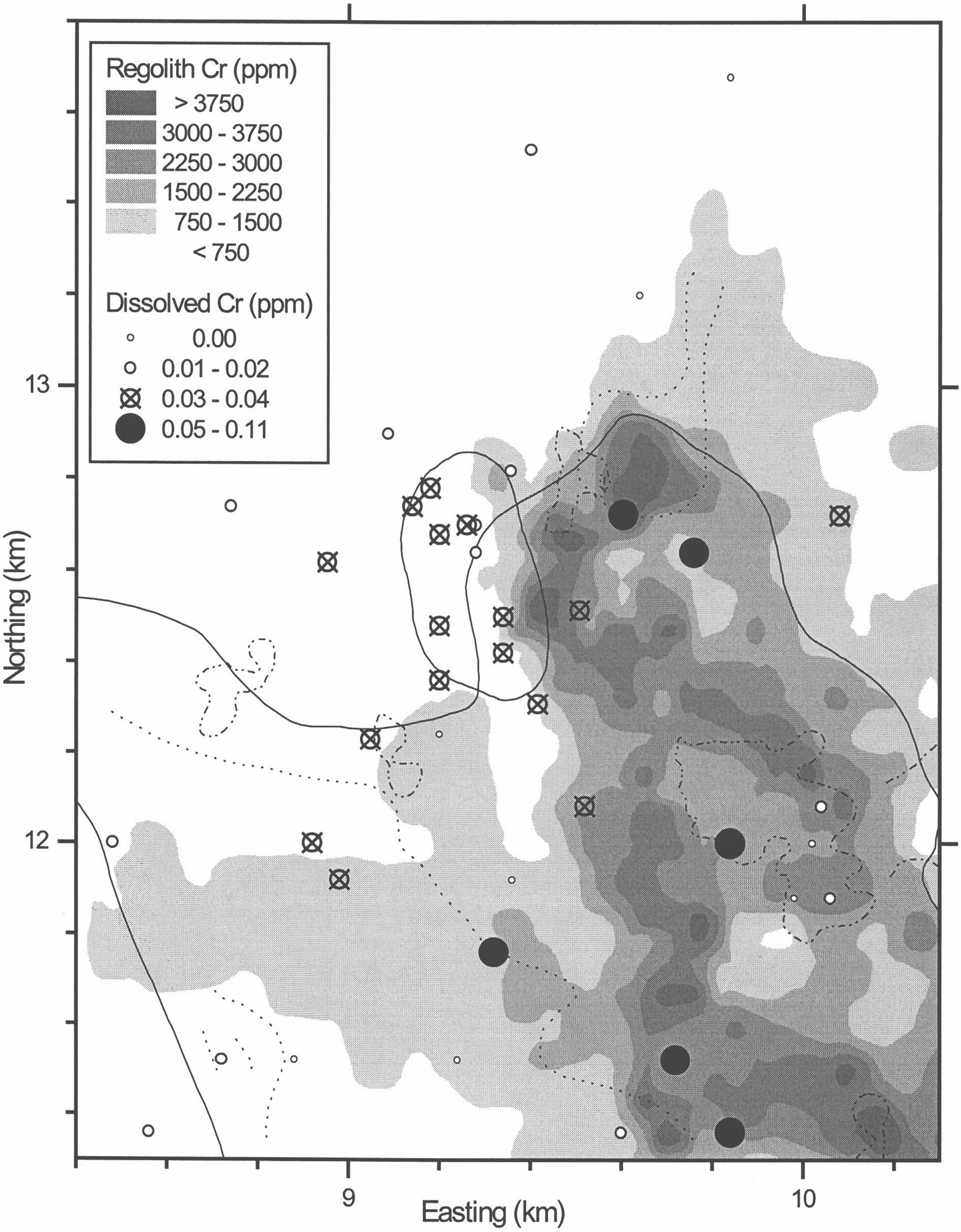

Figure 18: Dissolved Cr distribution at Baxter (dots) superimposed on maximum Cr contents in the regolith.

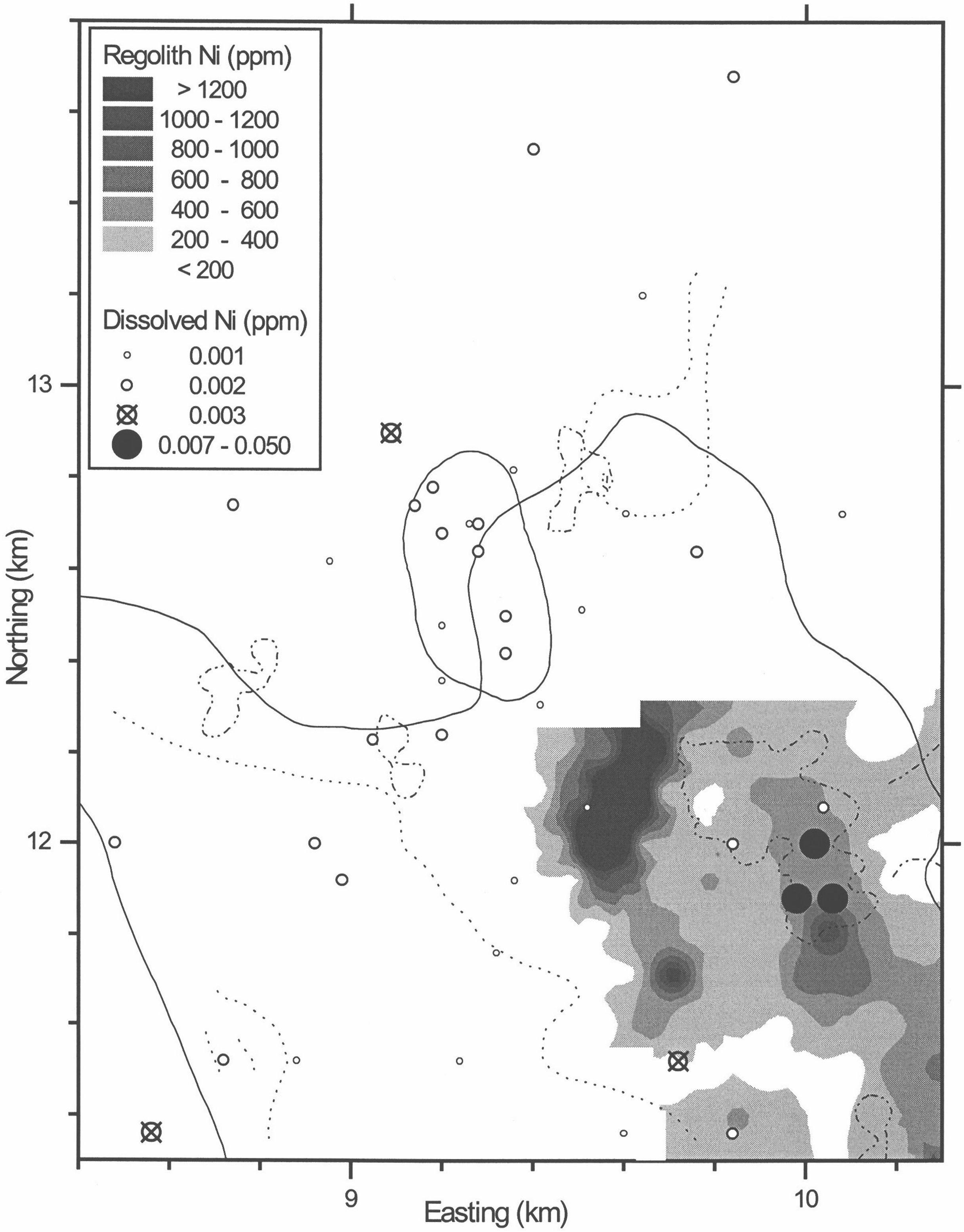

Figure 19: Dissolved Ni distribution at Baxter (dots) superimposed on maximum Ni contents in the regolith.

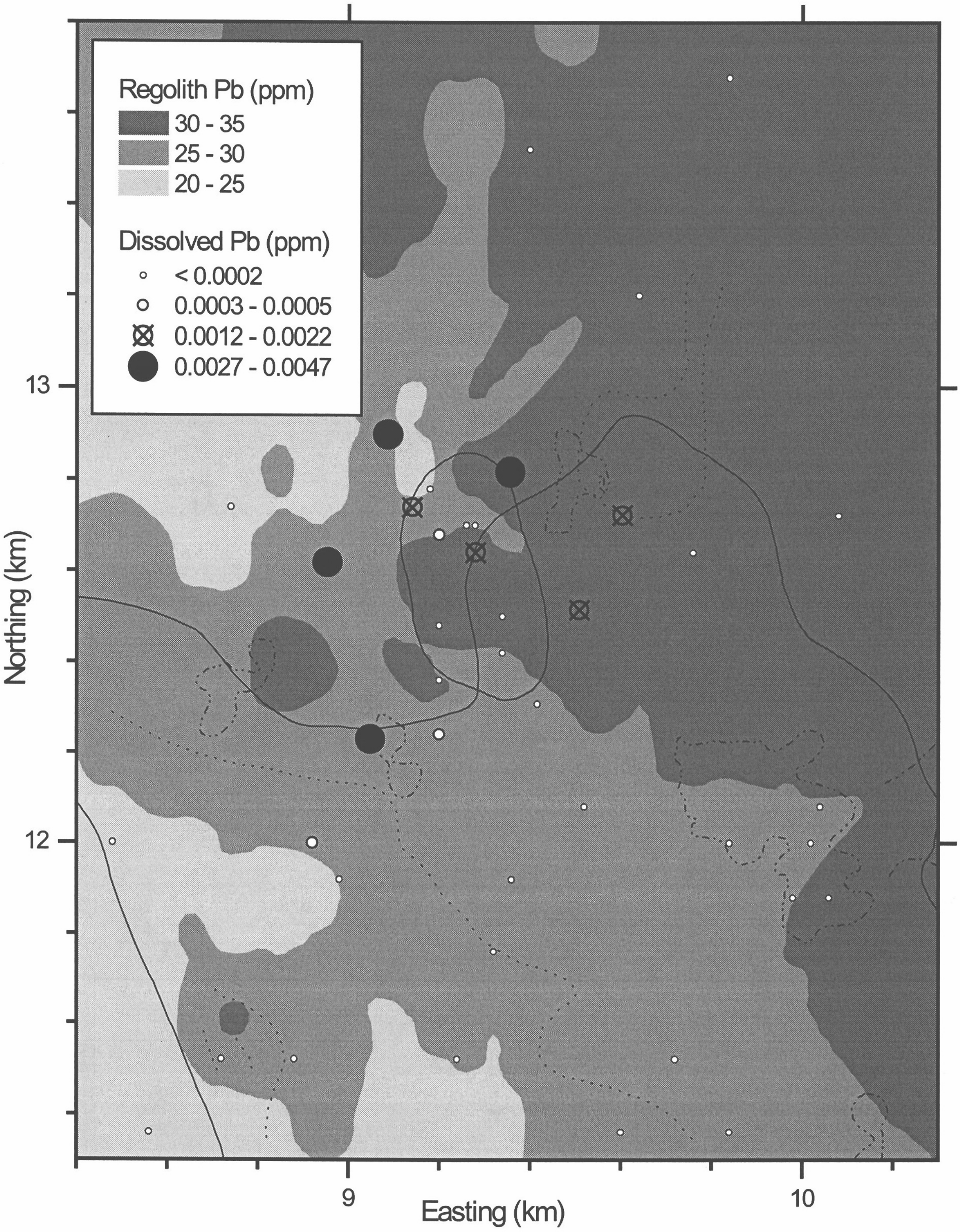

Figure 20: Dissolved Pb distribution at Baxter (dots) superimposed on maximum Pb contents in the regolith.

5 DISCUSSION AND CONCLUSIONS

Baxter is located north of the Menzies line with neutral, low salinity groundwaters, similar to those found at Lawlers (Gray, 1994). These contrast with the dominantly saline groundwaters further south (Gray, 1990, 1991, 1992a, b, 1993a, b). The low salinities of the Baxter and Lawlers groundwaters, coupled with the marked divergence from sea water ion ratios (Section 3.4), suggest that major ion concentrations are strongly controlled by lithology or hydrology. Elements that appear to be controlled by mineral equilibration in some or all groundwaters (Sections 3.4 and 3.5) are Ba (barite equilibration), Ca, Mg and HCO_3 (carbonate equilibration), Pb and V (chervitite; $Pb_2V_2O_7$).

The very low Au concentration (close to detection), suggests that dissolved Au would not have value either for deposit delineation or for regional investigations in similar areas. The low dissolved Au concentration also suggests that secondary anomalies and/or development of soil Au anomalies in overburden are unlikely to be forming at the present-day, with clear implications for exploration strategies to be used in such areas. Low concentrations (and therefore a poor exploration response) for dissolved Au in neutral groundwater sampled from areas of transported overburden have also been observed at Mulgarrie, Granny Smith and Lawlers (Gray, 1992b, 1993a, 1994), as opposed to acid/saline groundwaters which can have very high Au concentrations even in areas of extensive overburden (Gray 1990, 1993b, Lintern and Gray, 1995a, b).

There is, however, some potential for hydrogeochemical exploration for Au using pathfinder elements such as Mo, W, Sc and, possibly, Rb. This is a similar (though smaller) suite of elements to those observed for other sites (Gray, 1993a,b, 1994, Lintern and Gray, 1995a, b), suggesting a general potential for these elements in exploration hydrogeochemistry. These elements may be chemically transported into overburden and/or soils and selective extraction of these elements may be a useful exploration tool.

Other dissolved elements may indicate underlying lithology or other geochemical features. Thus, dissolved Cr concentrations correlate well with the presence of ultramafic rocks (Figure 18), even though the contact is in strongly altered regolith. This relationship could be used to locate ultramafic rocks at sites where they can not be recognized by logging. This correlation is also observed elsewhere, but surprisingly does not apply to Ni, presumably because more severe (*i.e.* acidic) conditions are required to dissolve Ni from the solids than to dissolve Cr (Butt *et al.*, 1993). Dissolved As and, to a lesser degree, Ni also appear to correlate with a zone of As-enriched rocks.

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REFERENCES

Bergeron, M. and Choinère, J., 1989. L'or dans les eaux souterraines: implications pour l'exploration. J. Geochem. Explor., 31: 319-328.

Butt, C.R.M., Gray, D.J., Lintern, M.J. and Robertson, I.D.M., 1993. Gold and Associated Elements in the Regolith - Dispersion Processes and Implications for Exploration. Final Report, Project P241A. CSIRO Division of Exploration Geoscience Restricted Report 396R. 64pp.

Butt, C.R.M., Robertson, I.D.M., Anand, R.R., King, J.D., Munday, T.J., Phang, C., Smith, R.E. and Gray, D.J., 1995. Murchison field trip, 5 - 8 September 1995. CSIRO Division of Exploration and Mining Restricted Report 164R. 59pp.

Cidu, R. and Edmunds, W.M., 1990. Preliminary studies of a hydrogeochemical method for gold prospecting - results from the United Kingdom. Trans. Instn Min. Metall. (Sect. B: Appl. earth sci.), 99: Sept-Dec 1990.

Dekkers , M.J., Vriend, S.P., van der Weijden, C.H. and van Gaans, P.F.M., 1989. Uranium anomaly evaluation in groundwaters: a hydrochemical study in the Nisa region, Portugal. Applied Geochemistry, 4: 375-394.

Dissanayake, C.B. and Weerasooriya, S.V.R., 1986. Fluorine as an indicator of mineralization - hydrogeochemistry of a Precambrian mineralized belt in Sri Lanka. Chemical Geology, 56: 257-270.

Drever, J.I., 1982. "The Geochemistry of Natural Waters." (Prentice-Hall, Inc., Englewood Cliffs, N.J. U.S.A.). 388 p.

Evans Jr, H.T. and Krauskopf, K.B., 1978. Tungsten. *In* "Handbook of Geochemistry, II-5." (Ed. K.H. Wedepohl). (Springer-Verlag, Berlin, Germany.)

Evans Jr, H.T., Manheim, F.T. and Landergren, S.F., 1978. Molybdenum. *In* "Handbook of Geochemistry, II-4." (Ed. K.H. Wedepohl). (Springer-Verlag, Berlin, Germany.)

Frondel, C., 1978. Scandium. *In* "Handbook of Geochemistry, II-2." (Ed. K.H. Wedepohl). (Springer-Verlag, Berlin, Germany.)

Gee, R.D. 1987 (2nd Ed.); *1:250,000 Geological Map Explanatory Notes - Peak Hill, W.A., GSWA.*

Giblin, A.M., 1990. Application of Hydrogeochemistry to Mineral Exploration. Final Report Part I (CSIRO/AMIRA 84/P211). CSIRO Division of Exploration Geoscience Restricted Report 145R. 342pp.

Giblin, A.M. and Snelling, A.A., 1984. Application of hydrogeochemistry to uranium exploration in the Pine Creek Geosyncline, Northern Territory, Australia. J. Geochem. Explor., 19: 33-55.

Goldschmidt, V.M., 1954. "Geochemistry." (Oxford Press, London). 730 p.

Gray, D.J., 1990. Hydrogeochemistry of the Panglo Gold Deposit. CSIRO Division of Exploration Geoscience Restricted Report 125R. 74pp.

Gray, D.J., 1991. Hydrogeochemistry in the Mount Gibson Gold District. CSIRO Division of Exploration Geoscience Restricted Report 120R. 80pp.

Gray, D.J., 1992a. Hydrogeochemistry of Sulphide Weathering at Boags Pit, Bottle Creek, Western Australia. CSIRO Division of Exploration Geoscience Restricted Report 237R. 13pp.

Gray, D.J., 1992b. Geochemical and Hydrogeochemical Investigations of Alluvium at Mulgarrie, Western Australia. CSIRO Division of Exploration Geoscience Restricted Report 339R. 66pp.

Gray, D.J., 1993a. Investigation of the Hydrogeochemical Dispersion of Gold and other Elements from Mineralized Zones at the Granny Smith Gold Deposit, Western Australia. CSIRO Division of Exploration Geoscience Restricted Report 383R. Vols I and II. 93pp.

Gray, D.J., 1993b. Investigation of the Hydrogeochemical Dispersion of Gold and other Elements in the Wollubar Palaeodrainage, Western Australia. CSIRO Division of Exploration Geoscience Restricted Report 387R. Vols I and II. 133pp.

Gray, D.J., 1994. Investigation of the Hydrogeochemical Dispersion of Gold and other Elements at Lawlers, Western Australia. CSIRO Division of Exploration and Mining Restricted Report 26R. Vols I and II. 151 pp.

Hall, G.E.M., Vaive, J.E. and Ballantyne, S.B., 1986. Field and laboratory procedures for determining gold in natural waters: relative merits of preconcentration with activated charcoal. J. Geochem. Explor., 26: 191-202.

Hamilton, T.W., Ellis, J., Florence, T.M. and Fardy, J.J., 1983. Analysis of gold in surface waters from Australian goldfields: An investigation into direct hydrogeochemical prospecting for gold. Econ. Geol., 78: 1335-1341.

Lintern, M.J., and Gray, D.J., 1995a. Progress Statement for the Kalgoorlie Study Area - Steinway Prospect, Western Australia. CSIRO Division of Exploration and Mining Restricted Report No. 95R. 121 pp.

Lintern, M.J., and Gray, D.J., 1995b. Progress Statement for the Kalgoorlie Study Area - Argo Deposit, Western Australia. CSIRO Division of Exploration and Mining Restricted Report No. 96R. 153 pp.

McHugh, J.B., 1988. Concentration of gold in natural waters. J. Geochem. Explor., 30: 85-94.

Morris, B.J., 1982. Groundwater hydrogeochemistry in South Australia and its application to mineral exploration. Quarterly Geological Notes, Geological Survey of South Australia v82: 7-12.

Murphy, J. and Riley, J.P., 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta, 27: 31-36.

Parkhurst, D.L., Thorstenson, D.C. and Plummer, L.N., 1980. PHREEQE, a computer program for geochemical calculations. U.S. Geol. Surv. Water Resources Investigations 80-96, 210p.

Runnels, D.D., 1984. Workshop 3: Hydrochemistry in mineral exploration. J. Geochem. Explor., 21: 1-3.

Robertson, I.D.M., Phang, C. and Munday, T.J., 1995. The Regolith Geology and Geochemistry of the Area around the Harmony Gold Deposit, Peak Hill, WA. CSIRO Division of Exploration and Mining Restricted Report 194R. (In prep.)

Weast, R.C., 1983. CRC Handbook of Chemistry and Physics, 63rd Edition. CRC Press, Inc., Boca Raton, Florida.

Zall, D.M., Fisher, D. and Garner, M.D., 1956. Photometric determination of chlorides in water. Analytical Chemistry, 28:1665.

APPENDICES

Appendix 1: Compiled Groundwater Data

							Concentrations										
No	Drill hole	East (m)	North (m)	RL (m)	pH	Eh (mV)	TDS	Na	Mg	Ca	K	Cl	SO_4	HCO_3	P	Li	Be
	Included samples																
1	Piezo 1	9091	12894	555.5	7.08	288	517	82	25	55	15	148	57	75	0.015	<0.005	<0.002
2	Piezo 2	8952	12620	555.5	7.56	279	389	71	24	53	14	108	51	79	0.007	<0.005	<0.002
3	Piezo 3	9052	12236	555.5	7.29	273	373	73	24	59	11	107	63	10	0.023	<0.005	<0.002
4	Piezo 4	9500	12515	555.5	7.25	259	382	65	27	50	15	108	42	94	0.009	<0.005	<0.002
5	Piezo 5	9602	12725	555.5	7.26	283	457	92	26	48	16	142	78	71	0.003	<0.005	<0.002
6	Piezo 6	9352	12821	555.5	7.13	274	394	77	24	47	16	112	57	86	0.014	<0.005	<0.002
7	Piezo 7	9275	12640	555.6	7.13	289	470	85	28	57	18	145	75	84	0.013	<0.005	<0.002
8	HRC083	9200	12680	555.9	7.18	305	449	84	27	55	17	138	69	69	0.024	<0.005	<0.002
10	HRC207	9140	12740	556.4	7.4	274	399	78	23	48	20	109	57	73	0.013	<0.005	<0.002
11	HRC219	9180	12780	555.8	7.22	283	450	89	25	54	18	134	69	76	0.013	<0.005	<0.002
12	HRC233	9281	12701	556.1	6.98	307	161	27	10	20	12	40	14	49	0.006	<0.005	<0.002
13	HRC190	9261	12700	556.2	7.03	318	442	81	27	54	19	137	72	65	0.005	<0.005	<0.002
14	HRC151	9341	12500	555.7	7.25	313	559	104	33	68	18	168	87	99	0.008	<0.005	<0.002
15	HRC078	9201	12480	555.5	7.35	317	429	77	26	58	15	122	60	87	0.009	<0.005	<0.002
16	HRC275	9200	12360	554.7	7.18	324	488	81	32	71	16	144	57	106	0.007	<0.005	<0.002
18	263H923	9200	12240	554.9	6.71	263	198	27	14	26	9	48	13	63	0.014	<0.005	<0.002
19	HRC056	9340	12420	555.5	7.25	304	509	87	32	68	17	155	75	89	0.010	<0.005	<0.002
22	297H1210	10040	12080	558.5	7.09	283	556	111	33	63	17	178	102	74	0.011	<0.005	<0.002
23	nd	10020	12000	559.2	7.3	317	558	111	34	65	17	171	99	94	0.009	<0.005	<0.002
24	263H704	9840	12001	558.3	7.15	321	480	90	29	56	16	136	81	95	0.015	<0.005	<0.002
26	263H832	9520	12080	557.0	7.23	258	384	68	27	48	18	113	36	96	0.015	<0.005	<0.002
27	263H816	9360	11920	556.5	6.68	282	235	45	13	21	12	63	24	72	0.044	<0.005	<0.002
28	297H1101	8980	11920	554.8	7.38	283	458	69	34	68	15	148	63	99	0.008	<0.005	<0.002
29	297H1173	8480	12000	552.5	7.12	269	401	61	30	58	14	121	60	98	0.014	<0.005	<0.002
30	297H1095	8905	12001	554.3	7.28	273	479	71	35	70	15	148	81	92	0.004	<0.005	<0.002
31	297H1113	9320	11760	556.1	7.09	317	344	71	21	33	14	96	57	48	0.007	<0.005	<0.002
33	263H1056	8880	11520	554.5	6.78	270	228	40	13	24	12	61	18	84	0.020	<0.005	<0.002
34	263H1060	8720	11520	553.8	6.77	312	377	65	27	44	17	118	51	78	0.012	<0.005	<0.002
35	263H1047	9240	11520	555.0	7.35	288	137	27	9	16	8	23	10	80	0.023	<0.005	<0.002
36	263H1067	9600	11360	554.7	6.69	344	149	30	8	15	8	45	16	26	0.009	<0.005	<0.002
38	263H616	9642	13201	556.4	6.86	372	258	14	20	46	9	82	4	90	0.007	<0.005	<0.002
42	263H546	9400	13519	556.1	6.88	377	429	82	27	46	19	159	54	60	0.006	<0.005	<0.002
43	263H529	9840	13679	558.1	7.43	123	646	117	41	68	20	225	75	187	0.028	<0.005	<0.002
46	263H739	10080	12720	558.9	7.25	261	584	109	35	74	18	206	99	70	0.011	<0.005	<0.002
47	263H884	9760	12640	557.5	6.79	285	476	91	28	50	17	139	78	99	0.008	<0.005	<0.002
49	263H494	9422	12306	556.1	7.04	257	479	78	32	62	15	133	63	124	0.032	<0.005	<0.002
50	682H1155	8560	11360	554.5	6.94	295	365	57	24	40	15	110	51	67	0.009	<0.005	<0.002
53	nd	9980	11880	558.6	7.44	342	508	103	32	55	16	149	81	116	0.007	<0.005	<0.002
54	nd	10060	11880	558.3	7.49	343	588	120	34	62	17	182	102	107	0.048	<0.005	<0.002
55	263H1041	9720	11520	555.7	7.13	351	335	66	24	37	13	94	36	84	0.035	<0.005	<0.002
56	263H1061	9840	11360	555.2	6.19	388	228	50	12	24	10	72	25	21	0.006	<0.005	<0.002
57	RBX01	7638	12250	550.2	7.17	347	405	74	23	51	15	114	54	85	0.051	<0.005	<0.002
	Excluded samples																
9	HDH032	9120	12700	555.5	7.22	109	19866	325	312	790	8160	10092	87	113	0.031	nd	<0.002
17	263H416	9205	12226	555.0	6.13	143	132	15	10	20	6	16	13	61	0.004	<0.005	<0.002
20	263H842	10240	12319	559.7	6.87	171	354	60	21	43	15	114	36	112	0.013	<0.005	<0.002
21	263H843	10200	12319	559.6	5.93	165	57	15	2	2	4	9	3	33	0.006	<0.005	<0.002
25	263H824	9640	12000	557.8	6.8	142	490	86	35	67	18	130	16	234	0.200	<0.005	<0.002
32	263H1033	8920	11680	554.3	7.13	289	197	21	16	29	10	37	29	96	0.065	<0.005	<0.002
37	263H1079	9120	11360	554.5	5.82	405	96	17	4	7	7	19	13	43	0.003	<0.005	<0.002
39	263H558	9840	13359	557.1	6.45	163	197	34	11	17	10	40	42	63	0.009	<0.005	<0.002
40	263H565	9540	13361	556.0	6.15	298	28	0	2	4	3	1	1	23	0.002	<0.005	<0.002
41	263H553	9560	13439	556.4	6.12	180	38	1	3	6	4	1	1	35	0.006	<0.005	<0.002
44	263H532	9720	13681	557.6	6.28	285	85	13	3	5	5	7	6	43	0.027	<0.005	<0.002
45	263H754	9680	13000	557.1	6.24	300	81	9	5	10	5	16	17	26	0.007	<0.005	<0.002
48	263H851	9880	12321	558.4	6.45	173	57	9	3	6	5	3	1	46	0.007	<0.005	<0.002
51	1350	9040	13280	555.0	6.26	429	391	72	22	47	17	135	63	11	0.008	<0.005	<0.002
52	1328	8800	13760	554.8	6.21	410	613	129	36	63	23	228	105	33	0.002	<0.005	<0.002

All concentrations in mg/L unless otherwise noted

nd: not determined

	Concentrations														
No	Rb	Sr	Cs	Ba	B	Al	Si	I	Sc	Ti	V	Cr	Mn	Fe	Co	Ni
	Included samples															
1	0.02	0.27	<0.0002	0.007	0.41	0.01	23	0.16	0.013	0.003	0.005	0.013	0.022	<0.005	0.0007	0.003
2	0.02	0.24	<0.0002	0.031	0.44	0.006	29	0.19	0.017	<0.002	<0.005	0.029	<0.002	<0.005	0.0003	0.001
3	0.02	0.25	<0.0002	0.086	0.40	0.006	30	0.20	0.018	<0.002	<0.005	0.028	<0.002	0.005	0.0003	0.002
4	0.02	0.26	<0.0002	0.040	0.48	0.005	28	0.13	0.017	<0.002	0.016	0.043	0.003	<0.005	0.0002	0.001
5	0.02	0.26	<0.0002	0.031	0.60	<0.002	19	0.17	0.012	<0.002	0.009	0.114	0.002	<0.005	0.0002	0.001
6	0.02	0.26	<0.0002	0.014	0.64	0.003	18	0.21	0.011	<0.002	<0.005	0.024	<0.002	<0.005	0.0002	0.001
7	0.02	0.28	<0.0002	0.028	0.53	0.003	20	0.22	0.013	<0.002	0.006	0.007	0.056	<0.005	0.0005	0.002
8	0.03	0.28	<0.0002	0.008	0.55	0.005	24	0.20	0.015	<0.002	<0.005	0.040	0.002	<0.005	0.0003	0.002
10	0.02	0.25	<0.0002	0.031	0.49	0.007	28	0.21	0.018	<0.002	0.008	0.044	<0.002	<0.005	0.0004	0.002
11	0.02	0.28	<0.0002	0.009	0.56	0.005	23	0.25	0.017	<0.002	<0.005	0.031	0.003	<0.005	0.0003	0.002
12	0.02	0.11	<0.0002	0.023	0.25	0.006	13	0.08	0.009	<0.002	<0.005	0.009	0.013	0.008	<0.0002	0.002
13	0.03	0.29	<0.0002	0.034	0.57	0.004	19	0.21	0.014	<0.002	<0.005	0.030	0.002	<0.005	0.0003	0.001
14	0.03	0.32	<0.0002	0.027	0.59	<0.002	32	0.24	0.023	<0.002	0.025	0.042	0.004	<0.005	0.0003	0.002
15	0.02	0.25	<0.0002	0.021	0.45	<0.002	28	0.21	0.020	<0.002	0.013	0.039	<0.002	<0.005	0.0002	0.001
16	0.02	0.33	<0.0002	0.050	0.43	<0.002	35	0.20	0.023	<0.002	0.009	0.034	<0.002	<0.005	0.0003	0.001
18	0.01	0.13	<0.0002	0.071	0.22	0.004	29	0.07	0.019	<0.002	0.008	0.003	0.069	0.009	0.0004	0.002
19	0.03	0.32	<0.0002	0.058	0.48	0.002	31	0.22	0.019	<0.002	0.027	0.044	<0.002	<0.005	0.0002	0.002
22	0.02	0.38	<0.0002	0.032	0.61	0.002	15	0.22	0.009	<0.002	<0.005	0.021	0.006	<0.005	0.0003	0.002
23	0.02	0.39	<0.0002	0.014	0.61	<0.002	14	0.30	0.008	<0.002	<0.005	0.003	0.003	<0.005	0.0007	0.008
24	0.02	0.31	<0.0002	0.040	0.59	<0.002	24	0.17	0.015	<0.002	0.008	0.056	0.003	<0.005	0.0003	0.002
26	0.03	0.35	<0.0002	0.010	0.46	<0.002	26	0.19	0.016	<0.002	0.031	0.035	0.006	<0.005	0.0002	0.001
27	0.01	0.17	<0.0002	0.014	0.30	0.010	21	0.18	0.012	<0.002	0.010	0.002	0.039	0.009	0.0003	0.001
28	0.02	0.39	<0.0002	0.092	0.53	0.014	11	0.27	0.006	<0.002	0.007	0.040	<0.002	<0.005	0.0002	0.002
29	0.02	0.38	<0.0002	0.100	0.57	0.011	8	0.67	0.004	<0.002	0.042	0.023	0.003	<0.005	0.0002	0.002
30	0.02	0.41	<0.0002	0.065	0.46	<0.002	13	0.24	0.008	<0.002	<0.005	0.038	<0.002	<0.005	0.0002	0.002
31	0.01	0.28	<0.0002	0.050	0.45	0.003	28	0.22	0.016	<0.002	0.009	0.058	<0.002	<0.005	<0.0002	0.001
33	0.01	0.16	<0.0002	0.061	0.30	0.004	19	0.17	0.010	<0.002	0.007	0.001	0.089	<0.005	0.0006	0.001
34	0.01	0.33	<0.0002	0.081	0.49	<0.002	16	0.19	0.009	<0.002	<0.005	0.016	0.063	<0.005	0.0005	0.002
35	0.01	0.10	<0.0002	0.030	0.20	0.010	5	0.08	0.003	<0.002	0.007	0.002	0.010	<0.005	0.0003	0.001
36	0.01	0.11	<0.0002	0.073	0.23	0.010	14	0.07	0.008	<0.002	<0.005	0.017	0.039	<0.005	<0.0002	0.001
38	0.01	0.18	<0.0002	0.109	0.21	0.007	39	<0.06	0.022	<0.002	<0.005	0.003	0.021	<0.005	0.0002	0.001
42	0.02	0.28	<0.0002	0.055	0.65	0.005	11	0.15	0.006	<0.002	<0.005	0.024	0.062	<0.005	0.0002	0.002
43	0.02	0.36	<0.0002	0.062	1.01	0.003	6	0.30	0.004	<0.002	<0.005	0.002	0.187	0.012	0.0005	0.002
46	0.02	0.42	<0.0002	0.003	0.60	0.002	8	0.24	0.005	<0.002	<0.005	0.031	0.006	<0.005	0.0003	0.001
47	0.02	0.25	<0.0002	0.041	0.61	<0.002	24	0.22	0.014	<0.002	0.013	0.052	0.008	0.007	0.0004	0.002
49	0.02	0.33	<0.0002	0.034	0.47	0.005	34	0.17	0.019	<0.002	0.015	0.028	0.006	<0.005	0.0002	0.001
50	0.01	0.31	<0.0002	0.122	0.36	0.003	34	0.18	0.020	<0.002	0.008	0.008	0.007	<0.005	0.0006	0.003
53	0.01	0.35	<0.0002	0.029	0.60	0.002	14	0.56	0.002	<0.002	<0.005	0.003	0.012	<0.005	0.0003	0.017
54	0.01	0.37	<0.0002	0.051	0.61	0.003	18	0.23	0.003	<0.002	0.011	0.018	0.017	<0.005	0.0040	0.050
55	0.01	0.27	<0.0002	0.012	0.42	0.002	24	0.27	0.004	<0.002	0.022	0.096	<0.002	<0.005	<0.0002	0.0031
56	0.01	0.15	<0.0002	0.039	0.41	0.007	24	0.16	0.004	<0.002	<0.005	0.048	0.052	<0.005	<0.0002	0.0019
57	0.02	0.25	<0.0002	0.082	0.45	0.005	32	0.57	0.006	<0.002	0.009	0.020	0.007	<0.005	<0.0002	0.0019
	Excluded samples															
9	nd	4.70	nd	nd	0.44	<0.002	19	0.23	nd	nd	<0.005	0.007	2.450	0.119	nd	nd
17	0.01	0.10	<0.0002	0.084	0.09	0.007	19	0.28	0.013	<0.002	<0.005	0.002	2.730	1.010	0.0129	0.010
20	0.02	0.28	<0.0002	0.189	0.34	0.002	8	0.11	0.005	<0.002	0.007	0.002	0.984	0.024	0.0016	0.004
21	0.00	0.02	<0.0002	0.008	0.06	0.019	5	<0.01	0.003	<0.002	<0.005	0.002	0.200	0.787	0.0012	0.001
25	0.03	0.39	<0.0002	0.119	0.46	0.008	22	0.39	0.014	<0.002	0.013	0.003	0.673	0.260	0.0053	0.007
32	0.02	0.16	<0.0002	0.118	0.22	0.005	8	0.21	0.004	0.003	0.006	0.004	0.143	0.006	0.0010	0.002
37	0.02	0.04	<0.0002	0.018	0.10	0.016	7	0.06	0.004	<0.002	<0.005	0.001	0.036	0.008	<0.0002	0.001
39	0.01	0.12	<0.0002	0.054	0.32	0.008	10	0.11	0.005	<0.002	<0.005	0.001	0.966	1.240	0.0084	0.004
40	0.00	0.03	<0.0002	0.013	0.05	0.020	4	<0.03	0.002	<0.002	<0.005	0.001	0.435	0.033	0.0003	0.001
41	0.00	0.05	<0.0002	0.031	0.04	0.009	4	<0.01	0.002	<0.002	<0.005	0.001	1.540	0.022	0.0010	0.001
44	0.00	0.03	<0.0002	0.013	0.18	0.032	24	0.14	0.014	<0.002	<0.005	0.001	0.418	0.049	0.0010	0.001
45	0.01	0.06	<0.0002	0.029	0.10	0.021	7	<0.08	0.004	<0.002	<0.005	0.001	0.486	0.012	0.0018	0.003
48	0.01	0.03	<0.0002	0.016	0.04	0.032	8	<0.01	0.005	<0.002	0.009	0.002	0.155	0.022	0.0014	0.002
51	0.02	0.28	<0.0002	0.076	0.43	0.009	28	0.18	0.004	<0.002	<0.005	0.025	1.310	0.009	0.0020	0.011
52	0.02	0.36	<0.0002	0.068	0.75	0.005	11	0.75	0.002	<0.002	<0.005	0.059	0.888	<0.005	0.0017	0.0072

nd: not determined

	Concentrations												
No	Cu	Zn	Ga	Ge	As	Y	Zr	Mo	Ag	Cd	Sn	Sb	La
	Included samples												
1	0.009	0.012	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	0.0006	<0.0002	<0.0004	0.0008	0.0002	<0.0002
2	<0.005	0.007	0.0016	<0.0005	<0.0002	<0.0002	<0.0002	0.0005	<0.0002	<0.0004	0.0002	<0.0002	<0.0002
3	<0.005	<0.005	0.0045	<0.0005	<0.0002	<0.0002	<0.0002	0.0022	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
4	<0.005	0.008	0.0021	<0.0005	0.0004	<0.0002	<0.0002	0.0004	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
5	<0.005	<0.005	0.0017	<0.0005	<0.0002	<0.0002	<0.0002	0.0006	<0.0002	<0.0004	0.0002	<0.0002	<0.0002
6	<0.005	0.007	0.0008	<0.0005	<0.0002	<0.0002	<0.0002	0.0007	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
7	<0.005	0.011	0.0016	<0.0005	<0.0002	<0.0002	<0.0002	0.0009	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
8	<0.005	0.007	0.0006	<0.0005	<0.0002	<0.0002	<0.0002	0.0009	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
10	<0.005	0.006	0.0015	<0.0005	<0.0002	<0.0002	<0.0002	0.0006	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
11	<0.005	0.018	0.0008	<0.0005	<0.0002	<0.0002	<0.0002	0.0089	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
12	<0.005	<0.005	0.0014	<0.0005	<0.0002	<0.0002	<0.0002	0.0064	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
13	<0.005	<0.005	0.0023	<0.0005	<0.0002	<0.0002	<0.0002	0.0045	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
14	<0.005	0.008	0.0019	<0.0005	0.0005	<0.0002	<0.0002	0.0035	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
15	<0.005	0.006	0.0014	<0.0005	0.0002	<0.0002	<0.0002	0.0026	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
16	<0.005	0.008	0.0029	<0.0005	<0.0002	<0.0002	<0.0002	0.0021	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
18	<0.005	0.009	0.0043	<0.0005	<0.0002	<0.0002	<0.0002	0.0024	<0.0002	<0.0004	0.0003	<0.0002	<0.0002
19	<0.005	<0.005	0.0029	<0.0005	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
22	<0.005	<0.005	0.0019	<0.0005	0.0004	<0.0002	<0.0002	0.0003	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
23	<0.005	<0.005	0.0008	<0.0005	0.0020	<0.0002	<0.0002	0.0011	<0.0002	<0.0004	<0.0002	0.0004	<0.0002
24	<0.005	0.015	0.0024	<0.0005	0.0012	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
26	<0.005	<0.005	0.0006	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
27	<0.005	<0.005	0.0007	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
28	<0.005	0.017	0.0049	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
29	<0.005	0.015	0.0052	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
30	<0.005	<0.005	0.0034	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
31	<0.005	0.008	0.0026	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
33	<0.005	0.006	0.0030	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
34	<0.005	<0.005	0.0040	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
35	<0.005	<0.005	0.0017	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	0.0002	<0.0002	<0.0002
36	<0.005	<0.005	0.0037	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
38	<0.005	<0.005	0.0047	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
42	<0.005	<0.005	0.0026	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
43	<0.005	0.014	0.0030	<0.0005	<0.0002	<0.0002	<0.0002	0.0018	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
46	<0.005	<0.005	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
47	<0.005	<0.005	0.0019	<0.0005	<0.0002	0.0004	<0.0002	0.0003	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
49	<0.005	<0.005	0.0015	<0.0005	0.0004	<0.0002	<0.0002	0.0003	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
50	<0.005	0.011	0.0057	<0.0005	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
53	<0.005	<0.005	<0.0005	<0.0005	0.0038	<0.0002	<0.0002	0.0029	<0.0002	0.00025	<0.0002	0.0009	<0.0002
54	<0.005	0.021	<0.0005	<0.0005	0.0330	<0.0002	<0.0002	0.0029	<0.0002	0.00025	<0.0002	0.0006	<0.0002
55	<0.005	0.006	<0.0005	<0.0005	0.0004	<0.0002	<0.0002	0.0005	<0.0002	0.00025	<0.0002	<0.0002	<0.0002
56	<0.005	0.018	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	0.0003	<0.0002	0.00025	<0.0002	<0.0002	<0.0002
57	<0.005	0.018	<0.0005	<0.0005	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	0.00025	<0.0002	<0.0002	<0.0002
	Excluded samples												
9	<0.005	<0.005	nd	nd	nd	nd	nd	nd	<0.0002	<0.0004	0.0009	<0.0002	<0.0002
17	<0.005	<0.005	0.0051	<0.0005	<0.0002	<0.0002	<0.0002	0.0022	<0.0002	<0.0004	<0.0002	<0.0002	0.0004
20	<0.005	<0.005	0.0097	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
21	<0.005	<0.005	0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	0.0003	<0.0002	<0.0002
25	<0.005	0.006	0.0068	0.0005	0.0017	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
32	0.009	0.018	0.0057	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
37	<0.005	0.008	0.0009	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
39	<0.005	0.006	0.0025	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
40	<0.005	0.011	0.0006	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
41	<0.005	0.009	0.0014	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
44	<0.005	<0.005	0.0006	<0.0005	<0.0002	<0.0002	<0.0002	0.0005	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
45	<0.005	0.005	0.0014	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
48	<0.005	0.007	0.0008	0.0005	0.0021	<0.0002	<0.0002	0.0002	<0.0002	<0.0004	<0.0002	<0.0002	<0.0002
51	0.010	0.176	<0.0005	<0.0005	0.0011	<0.0002	<0.0002	<0.0002	<0.0002	0.00025	<0.0002	<0.0002	0.0002
52	0.005	0.030	<0.0005	<0.0005	0.0008	0.0008	<0.0002	<0.0002	<0.0002	0.00025	<0.0002	<0.0002	0.0010

nd: not determined

	Concentrations												
No	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	W
	Included samples												
1	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
2	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
3	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0022
4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
6	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
7	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0074
8	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0012
10	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004
11	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
12	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004
13	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0007
14	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
15	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
16	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
18	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
19	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0010
22	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
23	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
24	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
26	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
27	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
28	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0012
29	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
30	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
31	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
33	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
34	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
35	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
36	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
38	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
42	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
43	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
46	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
47	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
49	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
50	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
53	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
54	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0007
55	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
56	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
57	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	Excluded samples												
9	0.0003	<0.0002	<0.0002	<0.0002	0.0004	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0021
17	0.0011	<0.0002	0.0009	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
20	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
21	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
25	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003
32	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
37	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
39	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
40	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
41	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
44	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
45	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
48	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
51	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
52	0.0026	0.0002	0.0010	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002

nd: not determined

No	Concentrations							Saturation Indices					
	Au (ppb)	Hg	Tl	Pb	Bi	Th	U	Calcite	Dolomite	Magnesite	Gypsum	Celestine	Barite
	Included samples												
1	0.008	<0.0002	<0.0002	0.0047	<0.0002	<0.0002	0.0003	-0.9	-1.6	-1.6	-1.9	-2.7	-1.3
2	0.005	<0.0002	<0.0002	0.0030	<0.0002	<0.0002	<0.0002	-0.4	-0.6	-1.1	-2.0	-2.8	-0.6
3	0.004	<0.0002	<0.0002	0.0027	<0.0002	<0.0002	0.0006	-1.5	-2.9	-2.2	-1.9	-2.7	-0.1
4	0.005	<0.0002	<0.0002	0.0022	<0.0002	<0.0002	<0.0002	-0.6	-1.0	-1.3	-2.1	-2.8	-0.6
5	0.003	<0.0002	<0.0002	0.0014	<0.0002	<0.0002	<0.0002	-0.8	-1.4	-1.4	-1.9	-2.6	-0.5
6	0.003	<0.0002	<0.0002	0.0027	<0.0002	<0.0002	<0.0002	-0.8	-1.5	-1.5	-2.0	-2.7	-0.9
7	0.004	<0.0002	<0.0002	0.0012	<0.0002	<0.0002	<0.0002	-0.8	-1.4	-1.4	-1.8	-2.6	-0.5
8	0.002	<0.0002	<0.0002	0.0005	<0.0002	<0.0002	<0.0002	-0.8	-1.5	-1.5	-1.9	-2.6	-1.1
10	0.011	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.6	-1.1	-1.3	-2.0	-2.7	-0.6
11	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.7	-1.3	-1.4	-1.9	-2.6	-1.1
12	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.5	-2.8	-2.2	-2.8	-3.5	-1.2
13	0.007	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.0	-1.8	-1.7	-1.9	-2.6	-0.5
14	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.5	-0.9	-1.2	-1.7	-2.5	-0.5
15	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.5	-0.9	-1.2	-1.9	-2.7	-0.8
16	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.5	-0.9	-1.2	-1.9	-2.6	-0.4
18	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.6	-2.9	-2.2	-2.8	-3.5	-0.7
19	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.6	-1.0	-1.2	-1.8	-2.5	-0.3
22	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	-0.9	-1.5	-1.5	-1.7	-2.3	-0.4
23	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	-0.5	-0.8	-1.2	-1.7	-2.3	-0.8
24	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.7	-1.2	-1.3	-1.8	-2.5	-0.4
26	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.7	-1.1	-1.3	-2.2	-2.7	-1.3
27	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.6	-3.0	-2.2	-2.6	-3.1	-1.2
28	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0005	-0.4	-0.6	-1.0	-1.8	-2.5	-0.1
29	0.002	<0.0002	<0.0002	0.0005	<0.0002	<0.0002	0.0004	-0.7	-1.2	-1.3	-1.9	-2.5	-0.1
30	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	-0.5	-0.8	-1.2	-1.7	-2.4	-0.2
31	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.3	-2.2	-1.8	-2.1	-2.6	-0.3
33	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.4	-2.6	-2.0	-2.7	-3.3	-0.7
34	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.3	-2.2	-1.8	-2.1	-2.6	-0.2
35	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	-1.0	-1.8	-1.6	-3.1	-3.7	-1.2
36	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-2.2	-4.2	-2.8	-2.9	-3.4	-0.6
38	nd	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	-1.0	-1.9	-1.8	-3.1	-3.9	-1.1
42	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.2	-2.2	-1.8	-2.0	-2.7	-0.4
43	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0068	-0.1	0.1	-0.7	-1.8	-2.5	-0.3
46	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004	-0.6	-1.1	-1.3	-1.6	-2.3	-1.4
47	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.1	-2.0	-1.7	-1.9	-2.6	-0.4
49	0.006	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.7	-1.1	-1.3	-1.9	-2.6	-0.5
50	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-1.2	-2.1	-1.8	-2.1	-2.6	0.0
53	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	-0.4	-0.5	-0.9	-1.8	-2.5	-0.5
54	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	-0.3	-0.4	-0.9	-1.7	-2.4	-0.2
55	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.9	-1.5	-1.5	-2.3	-2.8	-1.2
56	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-2.6	-5.0	-3.3	-2.5	-3.2	-0.7
57	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-0.8	-1.4	-1.5	-2.0	-2.7	-0.2
	Excluded samples												
9	0.007	<0.0002	<0.0002	0.0017	<0.0002	0.0002	0.0004	0.1	0.2	-0.7	-1.6	-2.2	nd
17	0.005	<0.0002	<0.0002	0.0003	<0.0002	<0.0002	<0.0002	-2.3	-4.3	-2.9	-2.8	-3.6	-0.6
20	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	-1.0	-1.8	-1.7	-2.2	-2.8	0.0
21	0.005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-3.6	-6.9	-4.1	-4.3	-4.9	-2.2
25	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	-0.6	-1.0	-1.2	-2.4	-3.1	-0.6
32	0.009	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0004	-0.9	-1.6	-1.5	-2.4	-3.1	-0.2
37	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-3.1	-6.0	-3.7	-3.2	-3.9	-1.3
39	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-2.0	-3.7	-2.6	-2.4	-3.0	-0.4
40	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-3.3	-6.3	-3.9	-4.4	-4.9	-2.3
41	0.005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-3.0	-5.8	-3.6	-4.5	-5.1	-2.2
44	0.001	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	-2.8	-5.3	-3.4	-3.7	-4.3	-1.7
45	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-2.8	-5.4	-3.5	-3.0	-3.7	-0.9
48	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-2.6	-4.9	-3.2	-4.3	-5.0	-2.2
51	0.004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-2.6	-5.0	-3.3	-1.9	-2.6	-0.2
52	0.010	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-2.1	-3.9	-2.7	-1.7	-2.4	-0.1

Where space is blank, at least one of the mineral components is below detection in solution

No	Saturation Indices														
	Halite	SiO2 (am)	AlOH3 (am)	Alunite	Jurbanite	Kaolinite	Siderite	Ferrihyd	Rhodochrosite	Tenorite	Smithsonite	Cerussite	Theophrasite	Sphaerocobaltite	Eskolaite
	Included samples														
1	-6.5	-0.4	-1.3	-3.0	-4.8	4.6			-1.7	-1.0	-3.2	-1.2	-4.1	-4.4	7.1
2	-6.7	-0.3	-1.9	-6.5	-6.4	3.5					-3.0	-1.0	-3.6	-4.3	9.0
3	-6.7	-0.3	-1.7	-4.9	-5.5	4.0	-3.6	1.3				-2.0	-3.9	-5.4	8.4
4	-6.7	-0.3	-1.7	-5.1	-5.7	3.9			-2.3		-3.1	-1.3	-4.3	-4.6	8.6
5	-6.5	-0.5							-2.6			-1.6	-4.3	-4.7	9.5
6	-6.6	-0.5	-1.8	-4.8	-5.4	3.3					-3.3	-1.4	-4.4	-4.8	7.8
7	-6.5	-0.4	-1.8	-4.5	-5.3	3.4			-1.3		-3.2	-1.8	-4.4	-4.5	6.6
8	-6.5	-0.4	-1.7	-4.2	-5.3	3.9			-2.7		-3.4	-2.2	-4.2	-4.8	8.4
10	-6.6	-0.3	-1.7	-5.1	-5.8	3.9					-3.2		-3.7	-4.4	9.0
11	-6.5	-0.4	-1.7	-4.4	-5.4	3.8			-2.5		-2.9		-4.1	-4.7	8.3
12	-7.5	-0.6	-1.4	-4.1	-5.2	3.9	-2.9	1.4	-2.1				-4.5		6.6
13	-6.5	-0.5	-1.6	-3.6	-4.9	3.7			-2.9				-4.6	-4.9	7.8
14	-6.3	-0.2							-2.2		-3.1		-4.1	-4.5	8.6
15	-6.6	-0.3									-3.2		-4.1	-4.6	8.8
16	-6.5	-0.2									-3.2		-4.4	-4.6	8.2
18	-7.4	-0.3	-1.4	-3.5	-4.6	4.6	-3.1	0.6	-1.6		-3.7		-5.1	-5.0	4.6
19	-6.5	-0.2	-2.1	-5.8	-5.9	3.2							-4.1	-4.7	8.6
22	-6.3	-0.6	-2.0	-4.6	-5.3	2.8			-2.3				-4.4	-4.8	7.6
23	-6.3	-0.6							-2.4				-3.3	-4.1	6.7
24	-6.5	-0.4							-2.5		-3.0		-4.3	-4.7	8.6
26	-6.7	-0.3							-2.0				-4.2	-4.6	8.4
27	-7.1	-0.4	-0.9	-1.5	-3.9	5.2	-3.1	0.8	-1.8				-5.4	-5.1	3.3
28	-6.6	-0.7	-1.4	-4.3	-5.5	3.7					-2.7		-3.8	-4.4	8.9
29	-6.7	-0.8	-1.3	-3.1	-4.8	3.7			-2.5		-3.0	-2.1	-4.4	-4.7	7.7
30	-6.6	-0.6											-4.0	-4.6	8.6
31	-6.7	-0.3	-1.8	-4.5	-5.3	3.7					-3.5		-4.6		8.4
33	-7.2	-0.5	-1.4	-3.4	-4.7	4.2			-1.3		-3.7		-5.2	-4.7	
34	-6.7	-0.5							-1.6				-5.0	-4.8	6.3
35	-7.7	-1.0	-1.5	-6.0	-6.2	2.9			-1.7				-3.9	-4.4	5.4
36	-7.4	-0.6	-0.9	-1.9	-4.1	4.8			-2.2				-5.4		6.2
38	-7.5	-0.1	-1.2	-4.6	-5.4	5.2			-1.8				-5.0	-5.0	5.4
42	-6.5	-0.7	-1.4	-2.7	-4.5	3.7			-1.6				-4.8	-5.1	7.0
43	-6.2	-0.9	-2.1	-6.4	-6.2	1.8	-1.9	0.5	-0.2		-2.5		-3.7	-3.9	5.4
46	-6.2	-0.8	-2.1	-5.6	-5.8	2.0			-2.2				-4.2	-4.6	8.3
47	-6.5	-0.4					-3.0	0.9	-2.4				-5.0	-4.8	7.4
49	-6.6	-0.2	-1.5	-3.6	-4.9	4.4			-2.2				-4.6	-4.7	7.6
50	-6.8	-0.2	-1.7	-3.8	-4.9	4.2			-2.4		-3.4		-4.5	-4.6	6.2
53	-6.4	-0.6	-2.3	-6.9	-6.4	2.1			-1.5				-2.7	-4.3	
54	-6.3	-0.5	-2.2	-6.5	-6.3	2.6			-1.4		-2.5		-2.1	-3.1	8.4
55	-6.8	-0.4	-2.0	-5.7	-5.8	3.2					-3.4		-4.0		9.0
56	-7.0	-0.4	-1.0	-0.2	-3.0	5.2			-2.7		-4.4		-6.1		5.4
57	-6.6	-0.2	-1.7	-4.4	-5.3	4.1			-2.1		-2.9		-4.2		7.7
	Excluded samples														
9	-4.3	-0.4					-1.8	0.3	0.0			-2.3	-3.3	-3.5	7.0
17	-8.2	-0.5	-1.0	-0.8	-3.1	5.0	-1.6	-1.0	-0.6			-3.4	-5.5	-4.0	2.5
20	-6.7	-0.8	-1.8	-4.2	-5.0	2.7	-2.3	0.0	-0.1				-4.5	-4.0	3.8
21	-8.4	-1.0	-0.7	-0.5	-3.0	4.5	-2.1	-1.3	-2.1				-6.7	-5.5	0.7
25	-6.5	-0.4	-1.1	-2.8	-4.6	4.8	-1.1	0.3	-0.1		-3.3		-4.4	-3.3	4.9
32	-7.7	-0.9	-1.6	-4.7	-5.4	3.0	-2.7	1.3	-0.7	-1.0	-2.8		-4.1	-4.0	4.6
37	-8.0	-0.9	-0.9	0.7	-2.3	4.4	-4.1	0.2	-2.9		-4.7		-7.3		
39	-7.4	-0.8	-0.9	-0.3	-3.2	4.5	-1.2	0.3	-0.7		-4.1		-5.2	-3.9	
40	-10.9	-1.1	-0.5	-1.6	-3.6	4.6	-3.4	0.2	-1.7		-4.5		-6.5	-6.0	
41	-10.4	-1.1	-0.9	-3.0	-4.2	3.9	-3.4	-2.1	-1.0		-4.4		-6.4	-5.3	
44	-8.6	-0.4	-0.3	0.4	-3.0	6.6	-2.9	0.5	-1.3			-3.3	-6.0	-5.1	
45	-8.4	-0.9	-0.5	0.7	-2.7	5.2	-3.7	0.0	-1.5		-4.7		-5.8	-5.1	
48	-9.1	-0.8	-0.3	-1.5	-4.0	5.6	-3.0	-1.2	-1.6		-4.1		-5.4	-4.8	2.5
51	-6.6	-0.3	-0.9	0.8	-2.7	5.6	-4.3	1.0	-1.6	-2.1	-3.6		-5.2	-5.6	5.0
52	-6.1	-0.7	-1.2	0.6	-2.7	4.2			-1.4	-2.6	-4.0		-5.5	-5.3	5.5

Where space is blank, at least one of the mineral components is below detection in solution

No	Saturation Indices												
	Au Metal	$Sb(OH)_3$	Bismoclite	Fe-Vanad	$Pb_2V_2O_7$	Uraninite	Rutherfordine	Na-Autunite	Carnotite	$CaMoO_4$	$FeWO_4$	$LaPO_4$	$CePO_4$
	Included samples												
1	5.2	-1.6			-0.1	-9.8	-5.7	-9.9	-3.5	-3.4			
2	4.2									-3.5			
3	4.7					-9.1	-6.2	-8.7		-2.8	-6.8		
4	5.2				0.1					-3.6			
5	4.5				-0.3					-3.5			
6	4.8									-3.5			
7	4.7				-0.6					-3.3			
8	4.0									-3.3			
10	5.0									-3.5			
11	4.5									-2.3			
12	4.6									-2.7	-7.1		
13	4.6									-2.6			
14	4.1									-2.6			
15	3.7									-2.8			
16	3.8									-2.8			
18	6.0			-1.4						-3.1			
19	4.3												
22	4.7					-9.6	-5.7	-10.0		-3.8			
23	3.6	-1.4				-11.2	-5.8	-10.4		-3.2			
24	4.0												
26	4.8												
27	5.3			-1.3									
28	4.4					-10.0	-5.7	-10.6	-3.2				
29	4.5				-0.2	-9.2	-5.7	-10.3	-2.6				
30	4.7					-9.7	-5.9	-11.5					
31	4.3												
33	5.3												
34	4.7												
35	4.4					-10.6	-6.2	-11.0	-3.9				
36	4.6												
38						-12.2	-5.4	-11.7					
42	3.8												
43	6.9					-4.2	-5.0	-8.3		-2.9			
46	4.7					-8.8	-5.6	-9.5					
47	5.2			-1.4						-3.8			
49	5.6									-3.8			
50	4.6									-3.9			
53	3.1	-1.0				-12.5	-6.1	-11.3		-2.8			
54	3.1	-1.2				-12.8	-6.3	-9.8	-3.5	-2.8			
55	3.7									-3.6			
56	3.9									-4.0			
57	3.3												
	Excluded samples												
9	7.7					-4.3	-6.1	-10.0		-1.9	-5.2		-0.1
17	7.9									-3.2		-0.9	-0.5
20	7.1			-1.3		-5.6	-5.6	-10.4	-3.6				
21	9.4												
25	7.0			-0.5		-6.5	-7.2	-11.8	-5.3		-5.0		
32	5.1			-2.0		-10.7	-6.4	-11.3	-4.4				
37	4.7												
39	7.9												
40	6.5												
41	8.8												
44										-4.4			
45	6.0												
48	8.1			-1.1						-4.6			
51	3.3											-0.9	-0.5
52	2.9											-1.0	-0.5

Where space is blank, at least one of the mineral components is below detection in solution

	Saturation Indices					
No	CeO_2	$PrPO_4$	$NdPO_4$	$EuPO_4$	$GdPO_4$	YPO_4
	Included samples					
1						
2						
3						
4						
5						
6						
7						
8						
10						
11						
12						
13						
14						
15						
16						
18						
19						
22						
23						
24						
26						
27						
28						
29						
30						
31						
33						
34						
35						
36						
38						
42						
43						
46						
47						-0.7
49						
50						
53						
54						
55						
56						
57						
	Excluded samples					
9	-0.9			-0.5	-0.5	-0.7
17	-3.1		-0.7			
20						
21						
25						
32						
37						
39						
40						
41						
44						
45						
48						
51	1.8					
52	1.9	-1.6	-1.1		-1.6	-1.1

Where space is blank, at least one of the mineral components is below detection in solution

Appendix 2: Element/Ion Concentration Plots

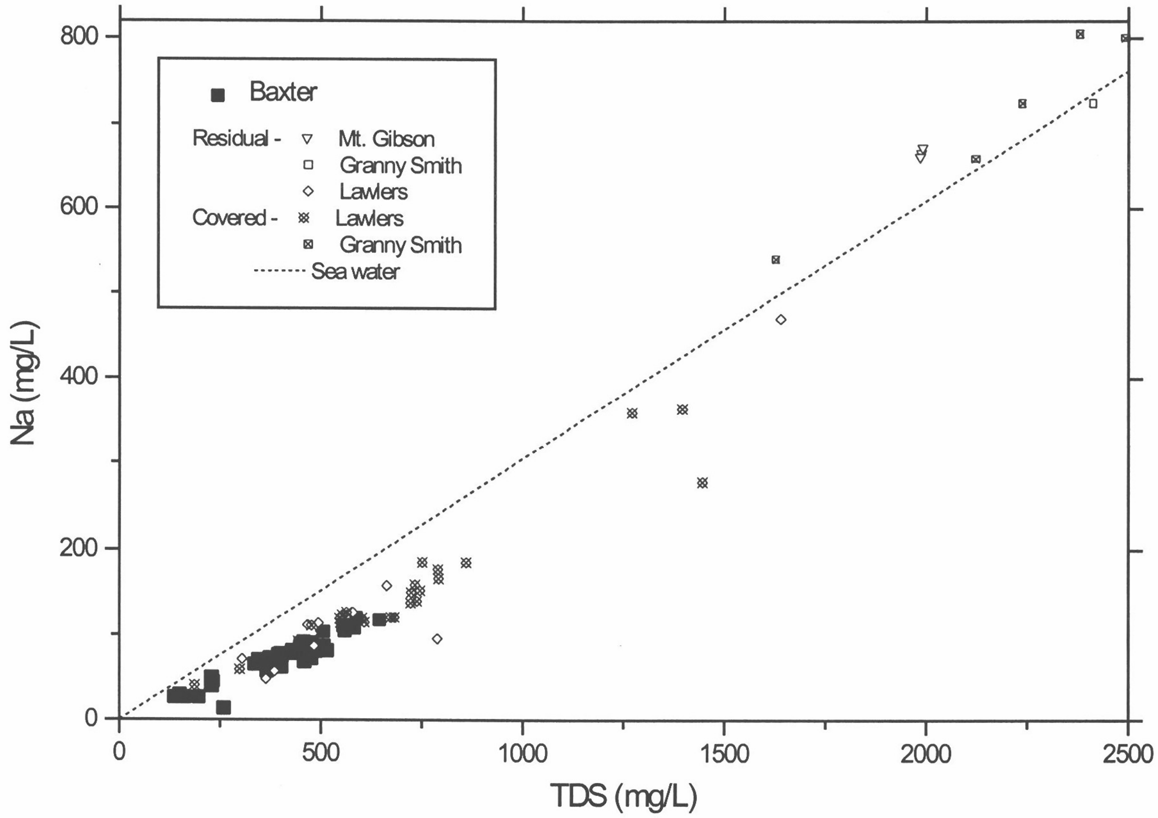

Figure A2.1: Na vs. TDS for groundwaters from Baxter and other sites.

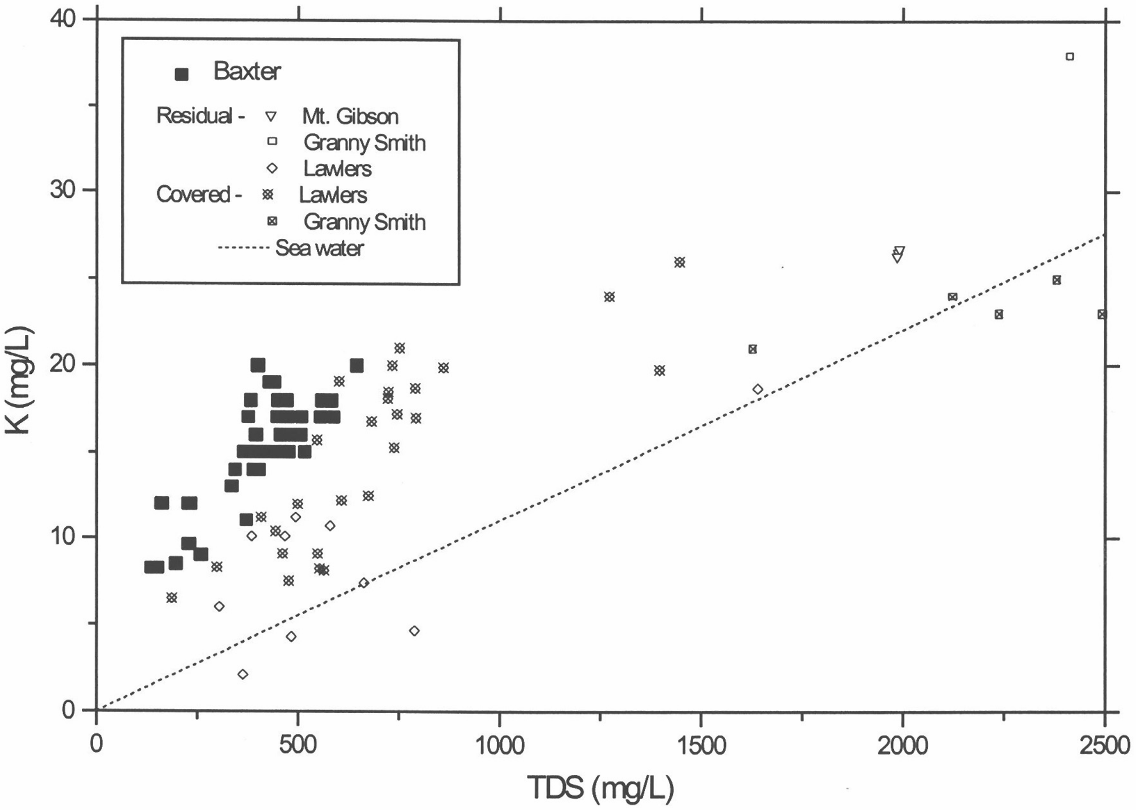

Figure A2.2: K vs. TDS for groundwaters from Baxter and other sites.

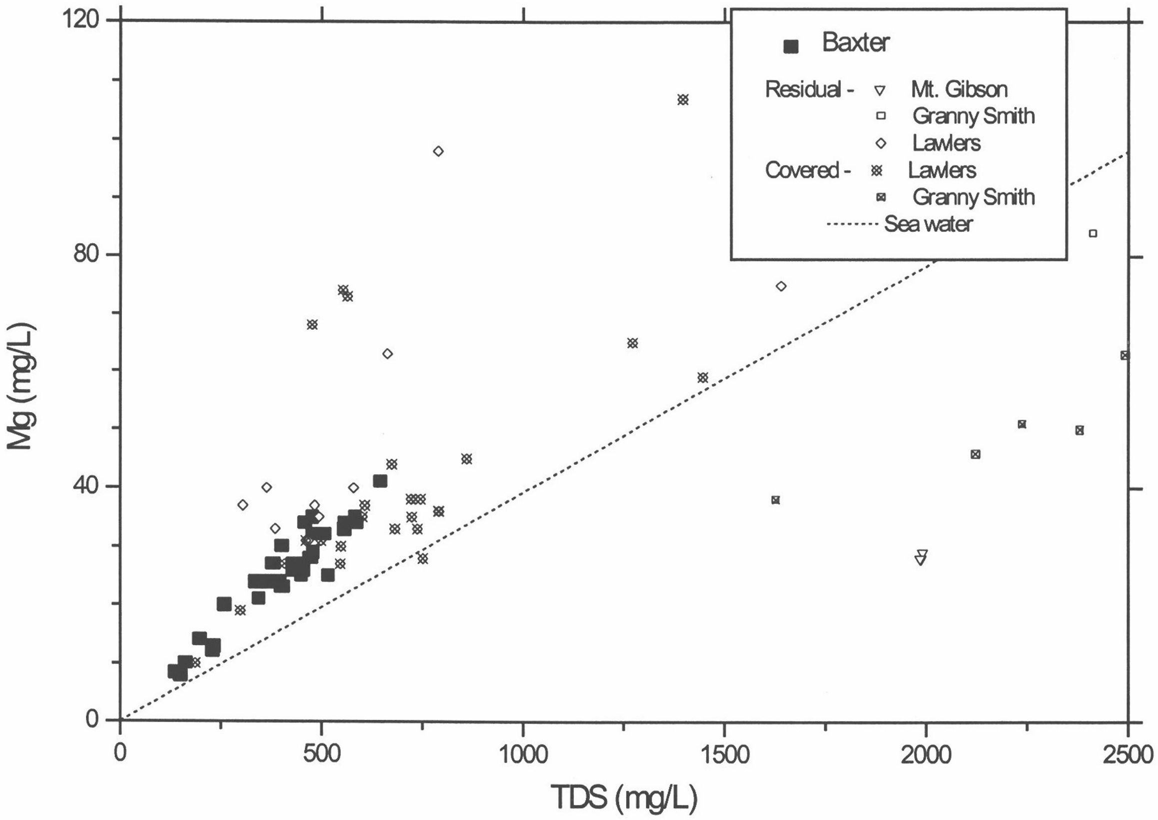

Figure A2.3: Mg vs. TDS for groundwaters from Baxter and other sites.

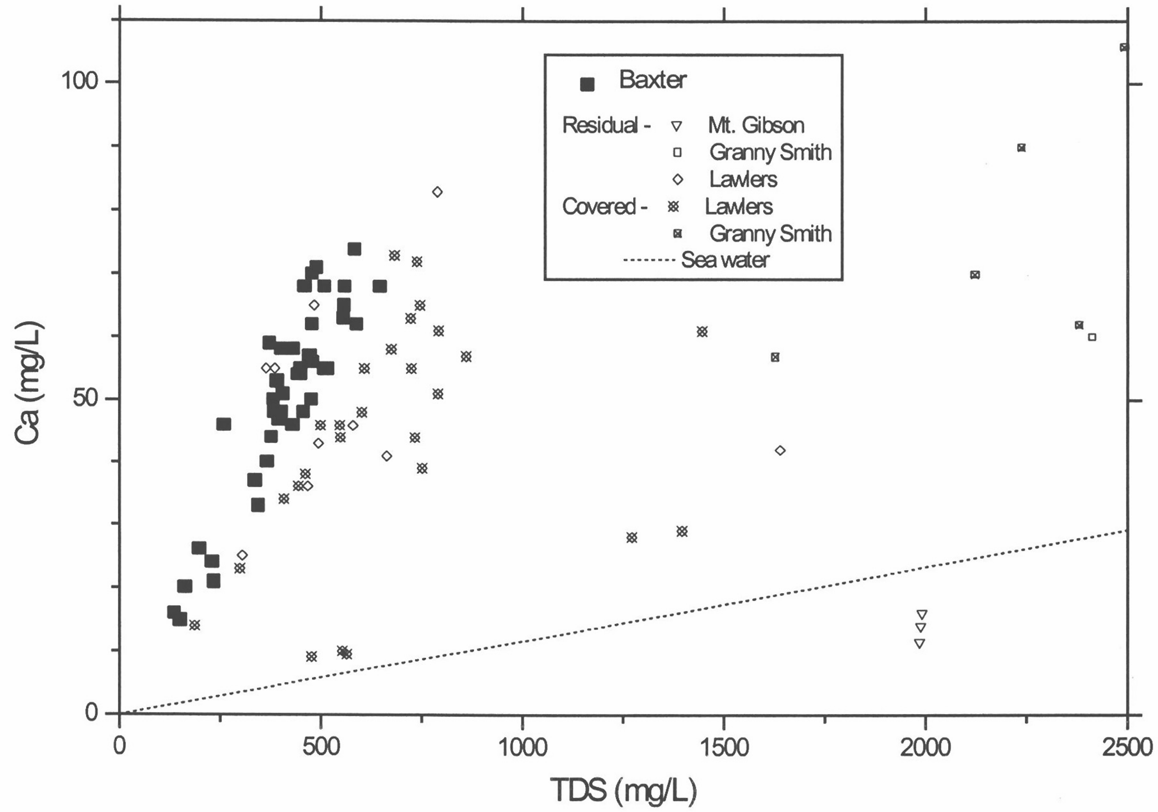

Figure A2.4: Ca vs. TDS for groundwaters from Baxter and other sites.

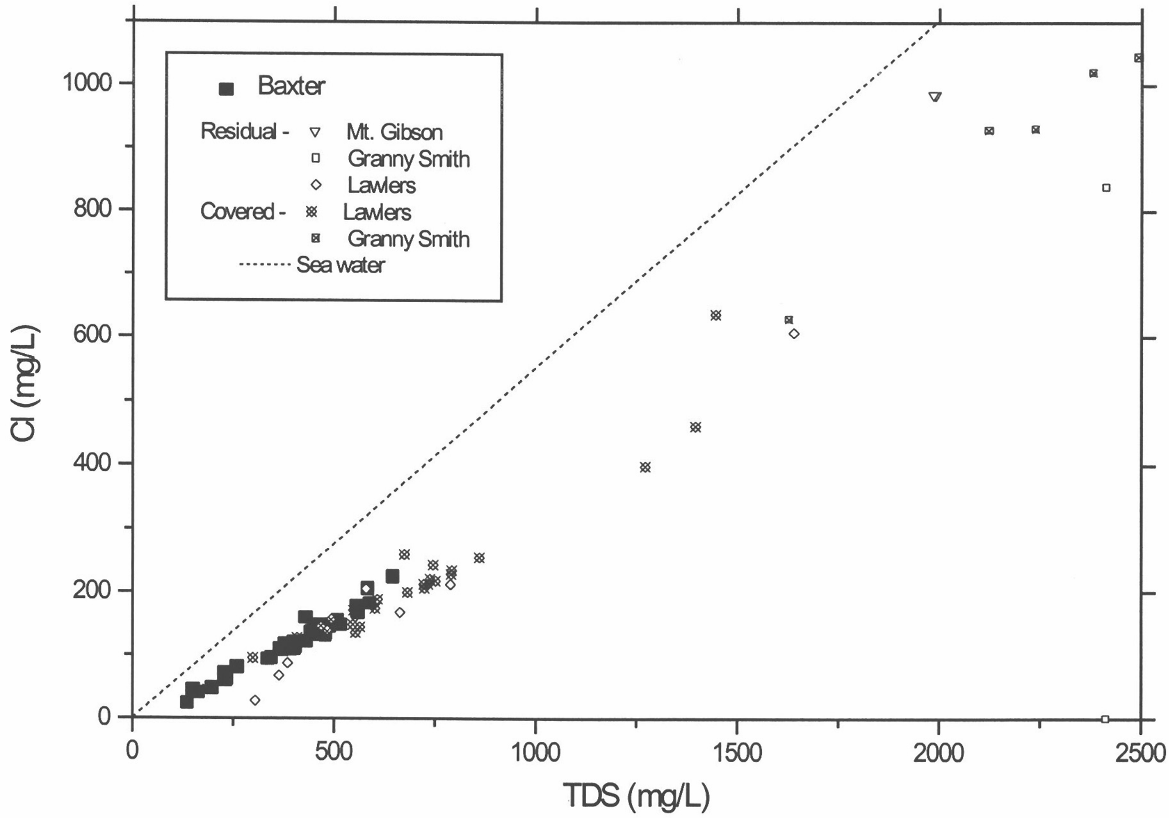

Figure A2.5: Cl vs. TDS for groundwaters from Baxter and other sites.

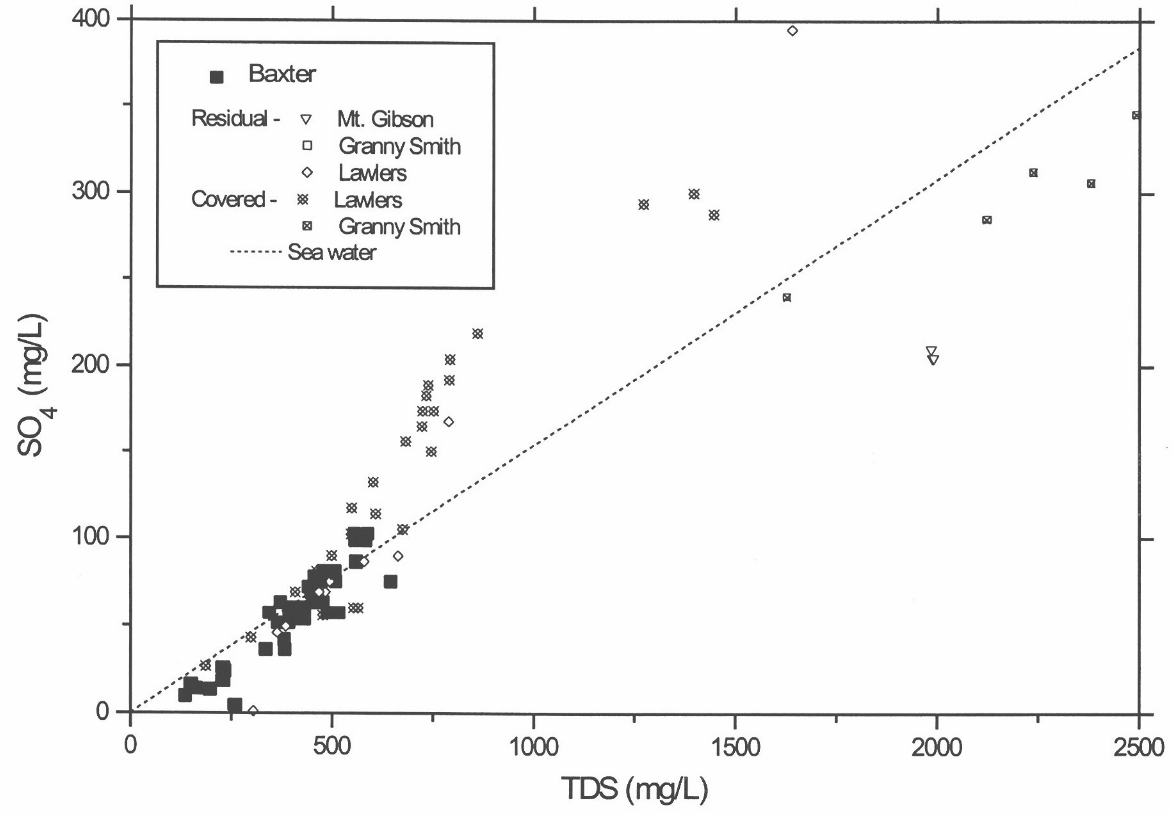

Figure A2.6: SO_4 vs. TDS for groundwaters from Baxter and other sites.

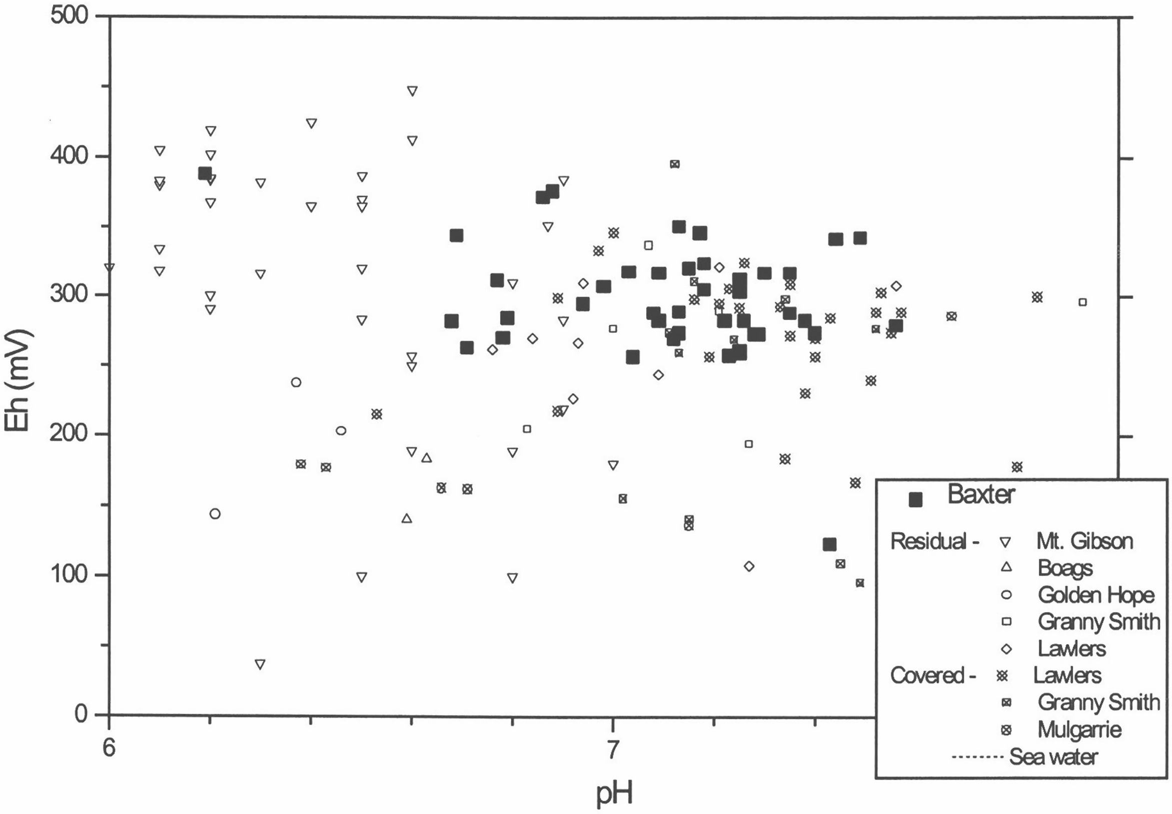

Figure A2.7: Eh vs. pH for groundwaters from Baxter and other sites.

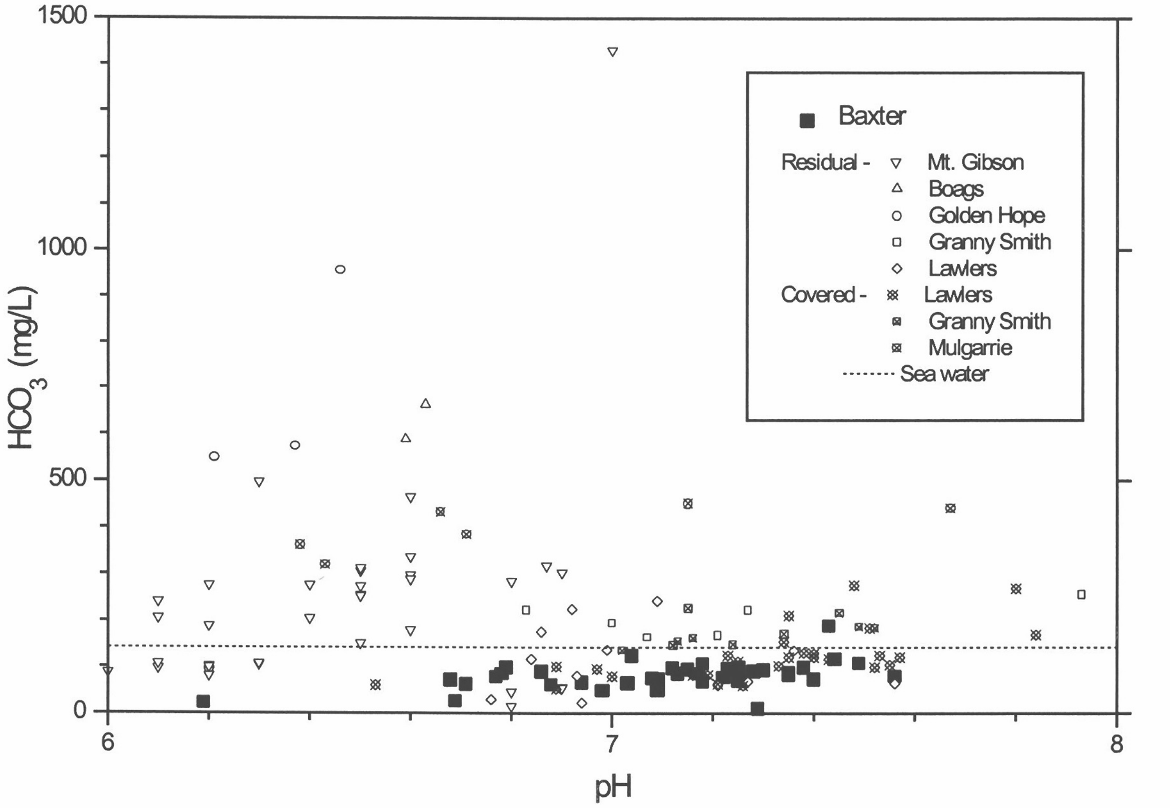

Figure A2.8: HCO_3 vs. pH for groundwaters from Baxter and other sites.

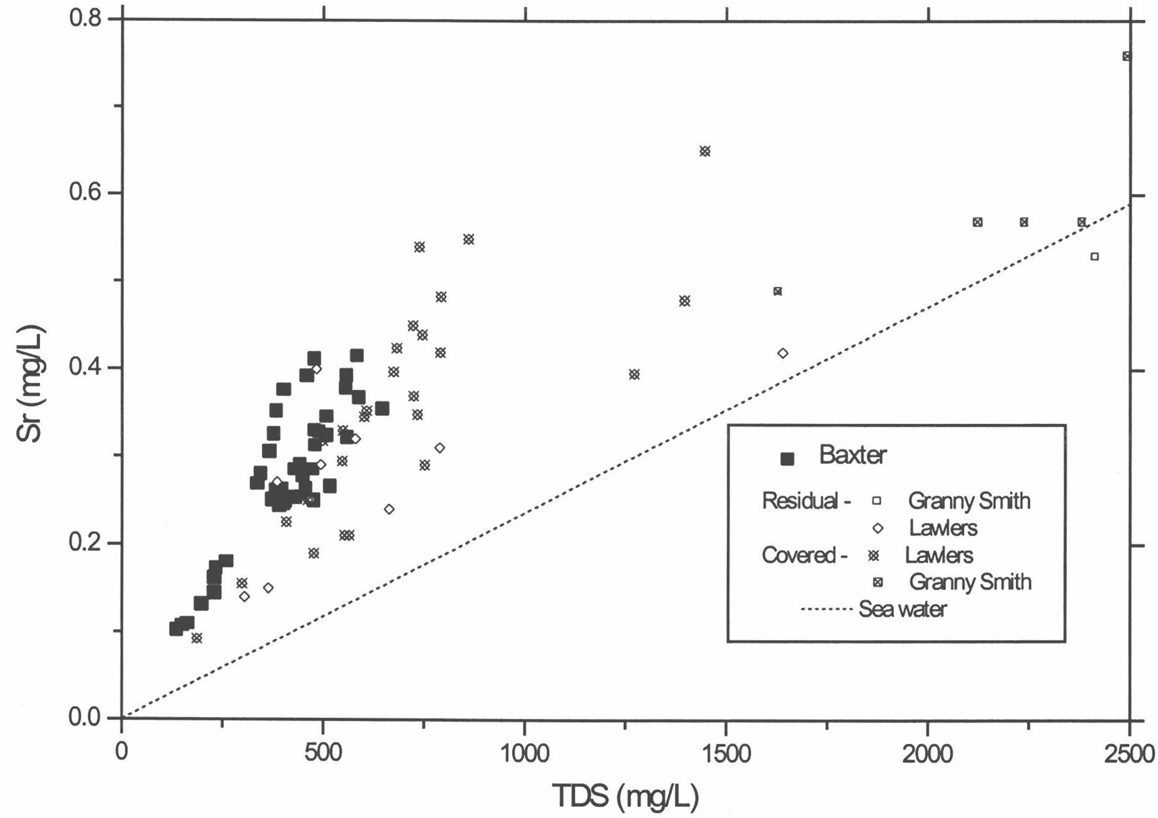

Figure A2.9: Sr vs. TDS for groundwaters from Baxter and other sites.

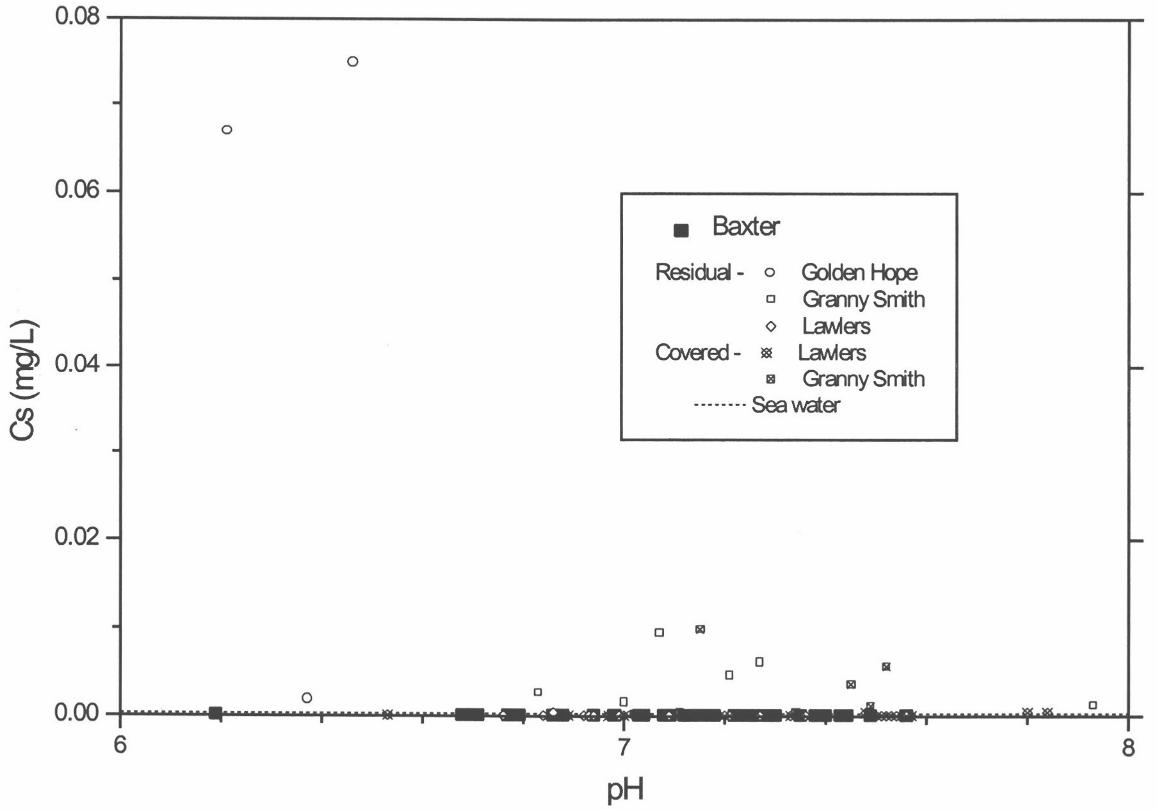

Figure A2.10: Cs vs. pH for groundwaters from Baxter and other sites.

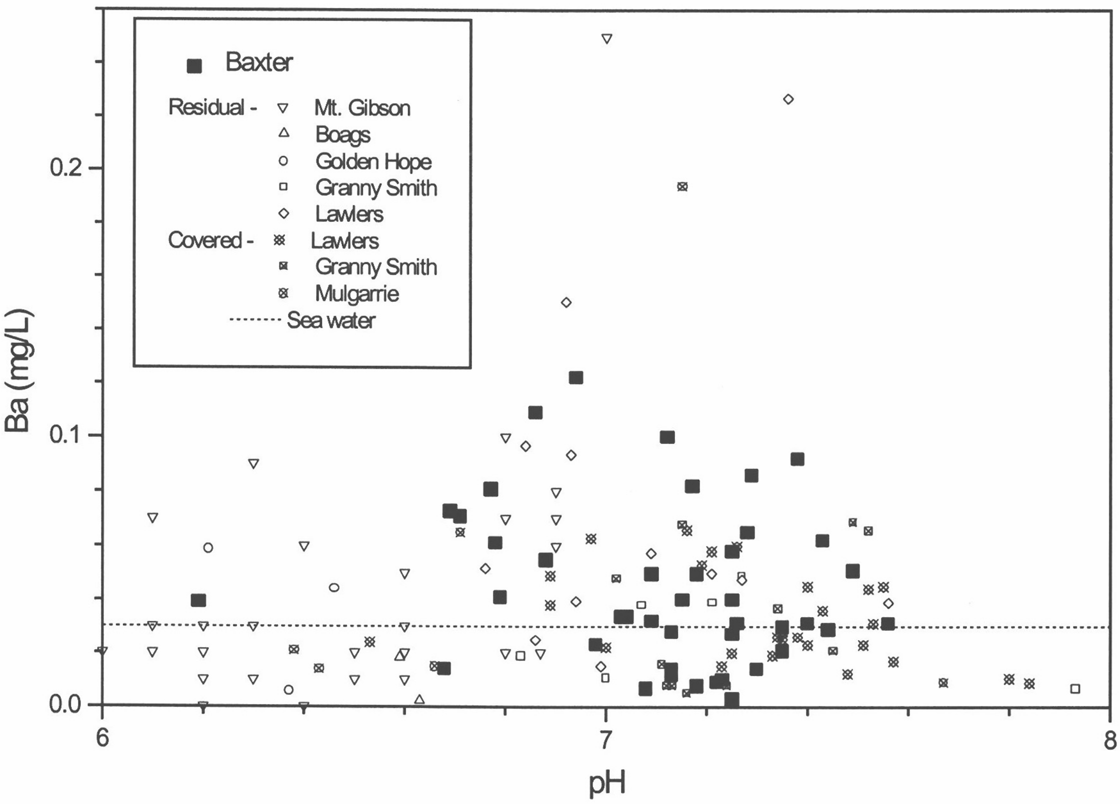

Figure A2.11: Ba vs. pH for groundwaters from Baxter and other sites.

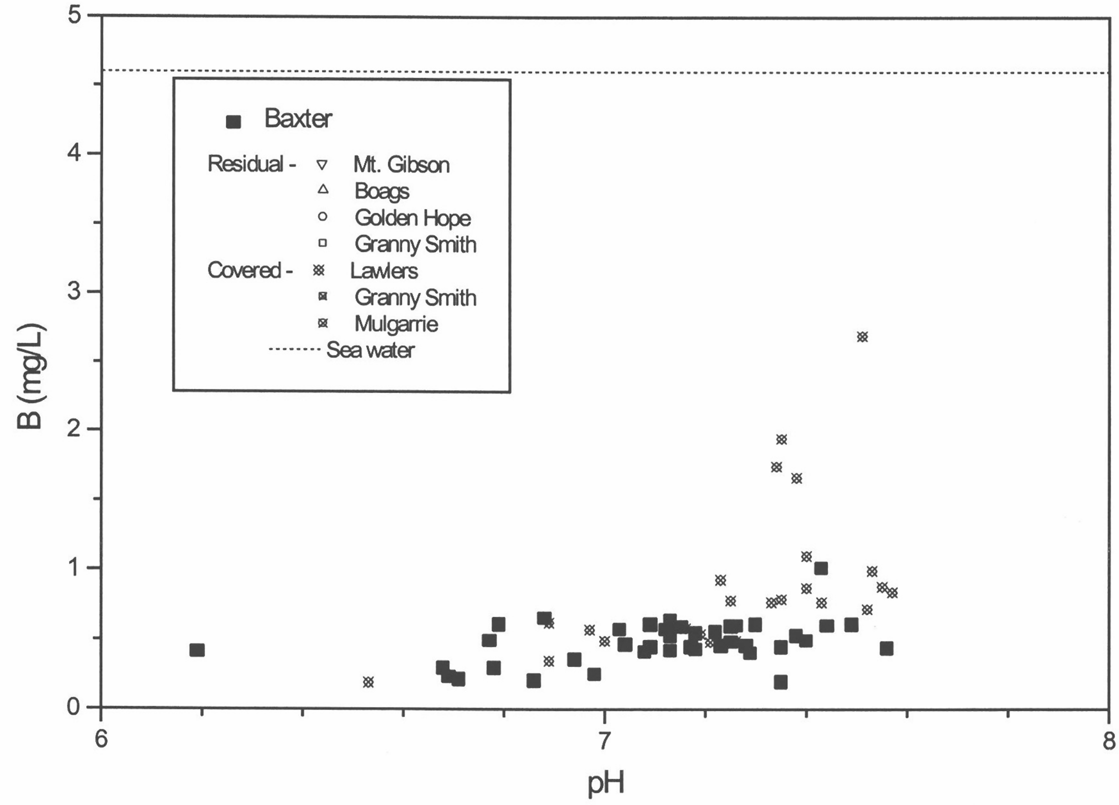

Figure A2.12: B vs. pH for groundwaters from Baxter and other sites.

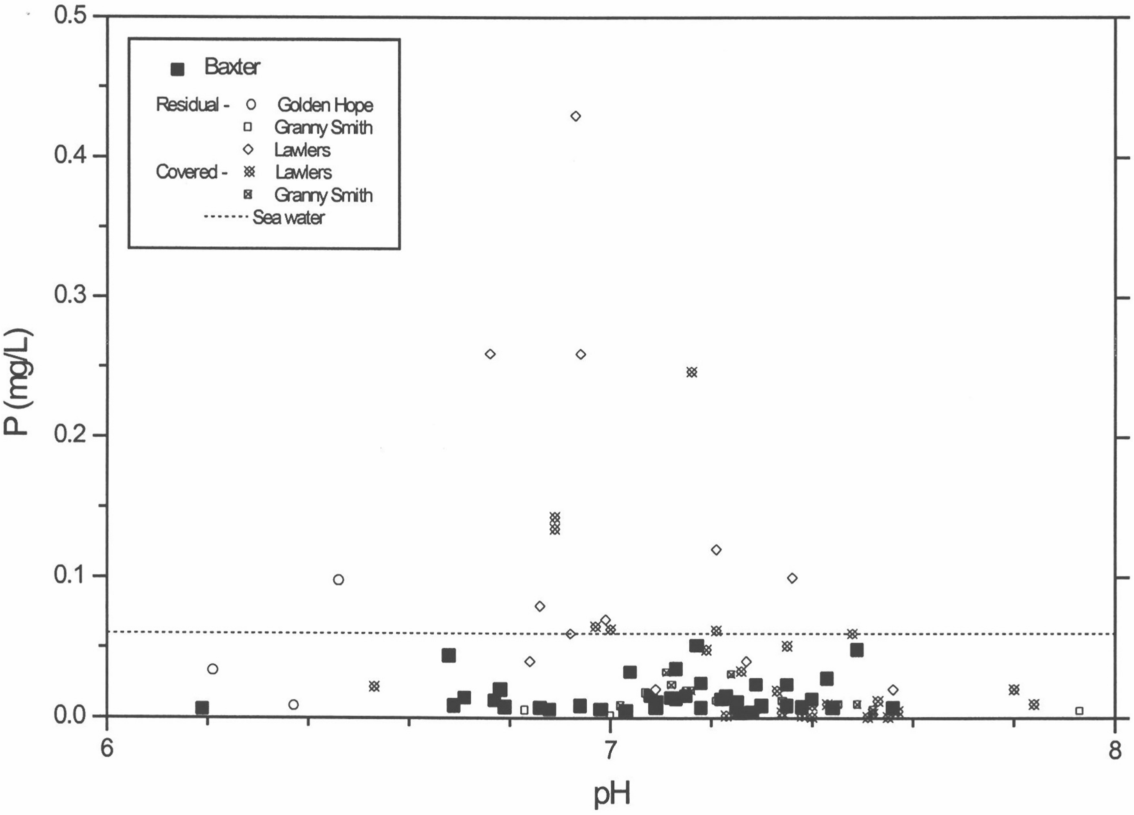

Figure A2.13: P vs. pH for groundwaters from Baxter and other sites.

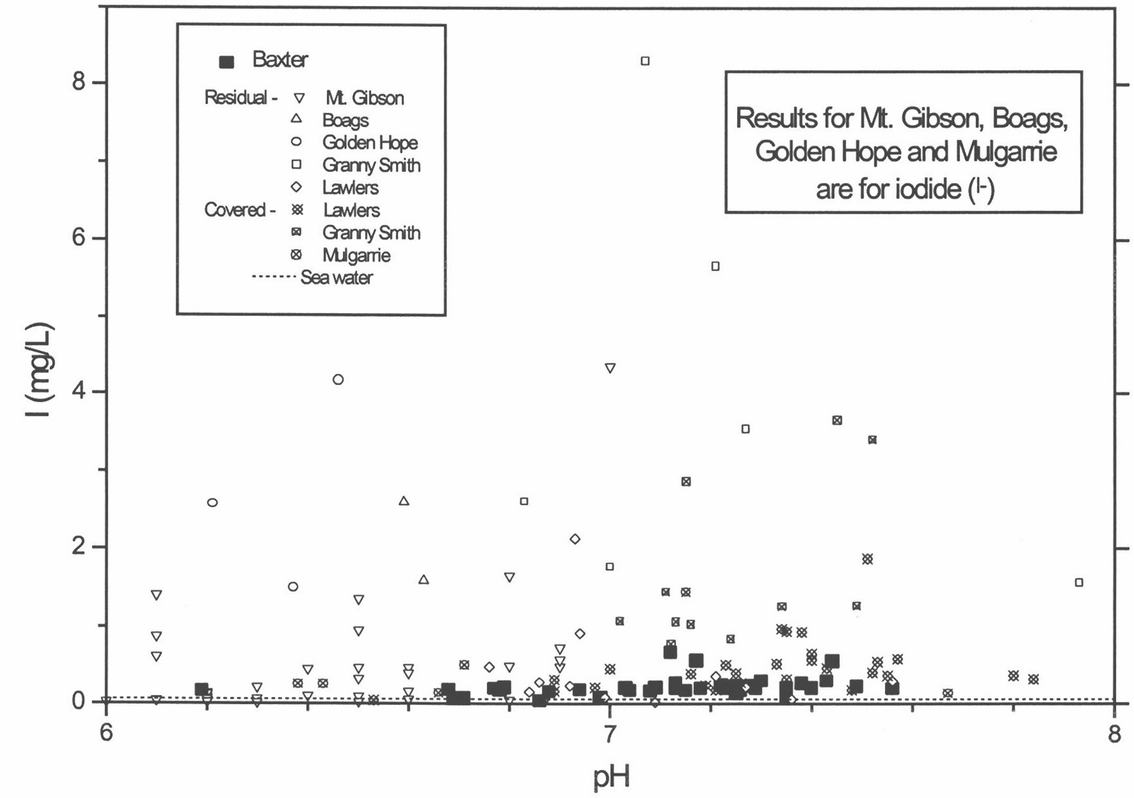

Figure A2.14: I vs. pH for groundwaters from Baxter and other sites.

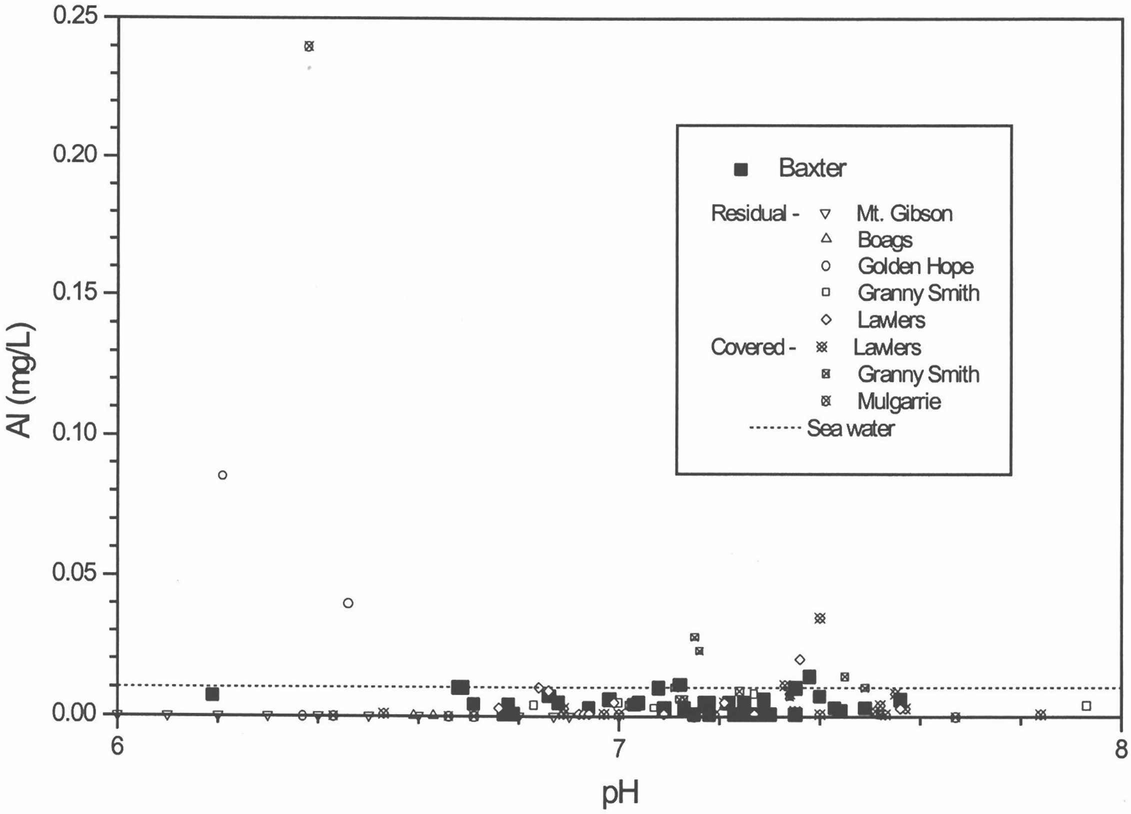

Figure A2.15: Al vs. pH for groundwaters from Baxter and other sites.

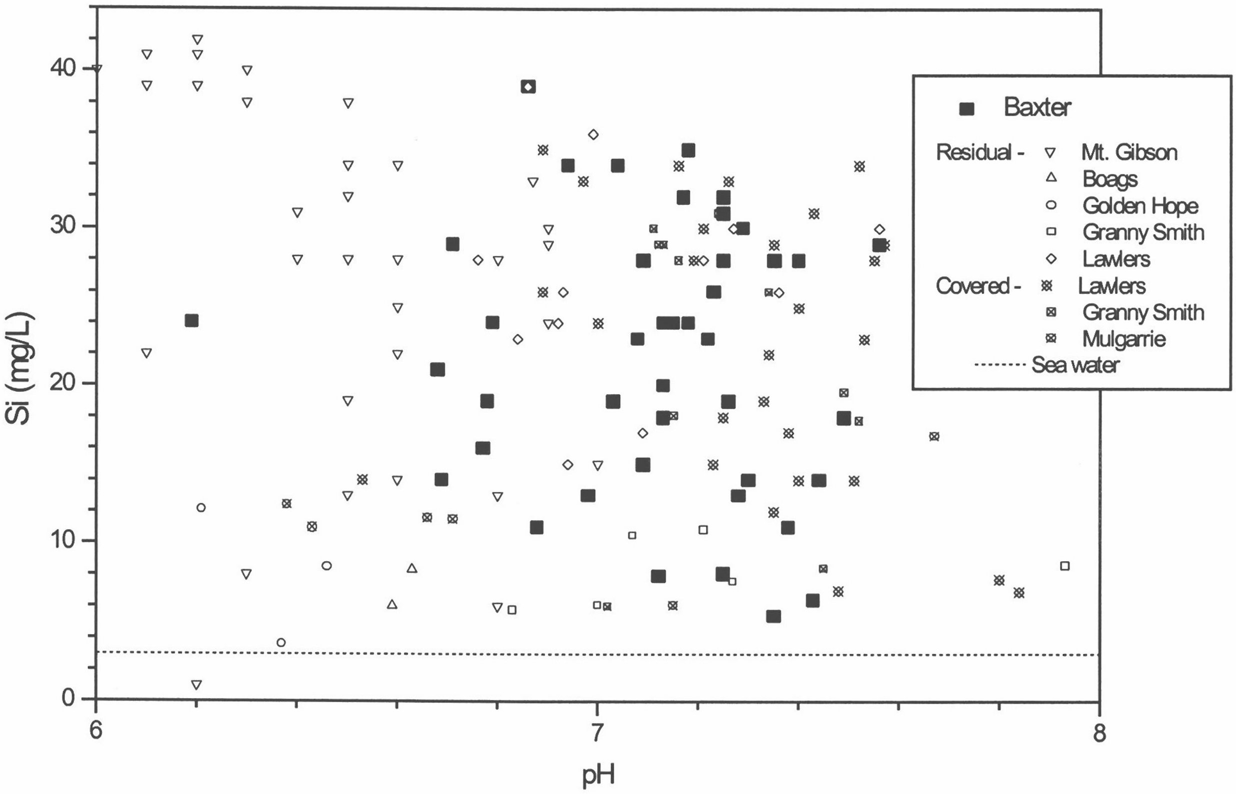

Figure A2.16: Si vs. pH for groundwaters from Lawlers and other sites.

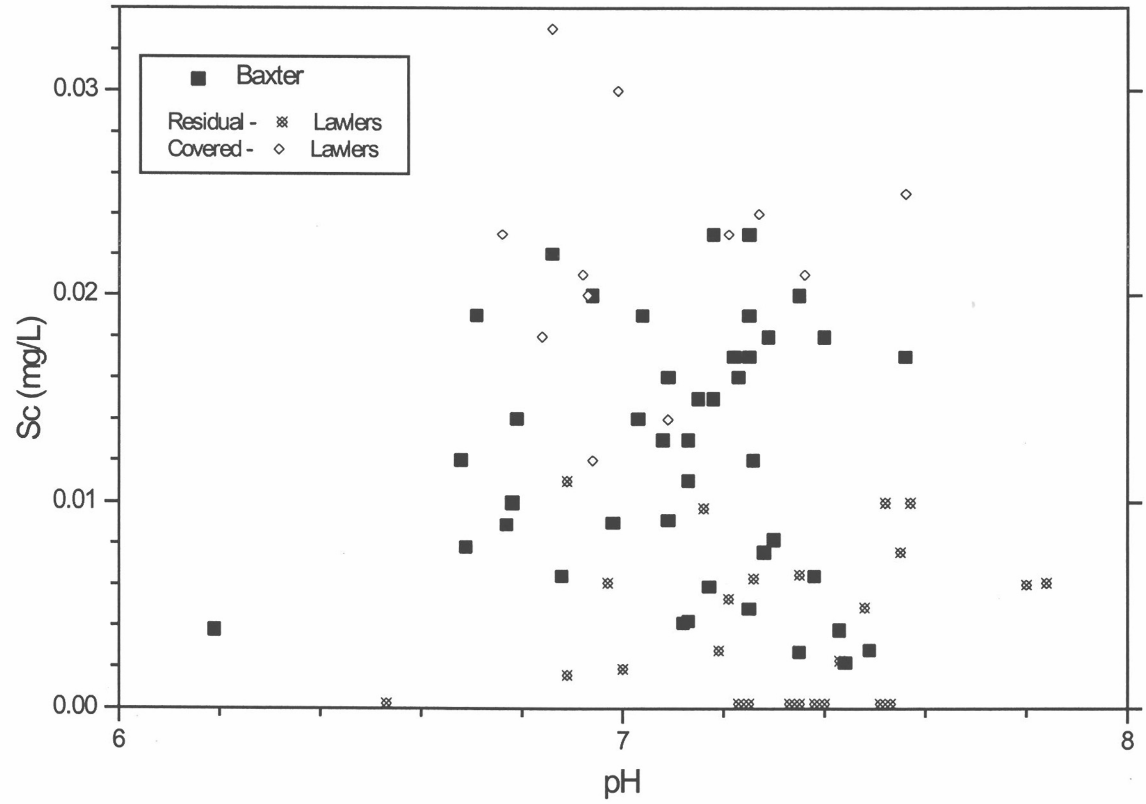

Figure A2.17: Sc vs. pH for groundwaters from Baxter and other sites. (Value for sea water concentration not available)

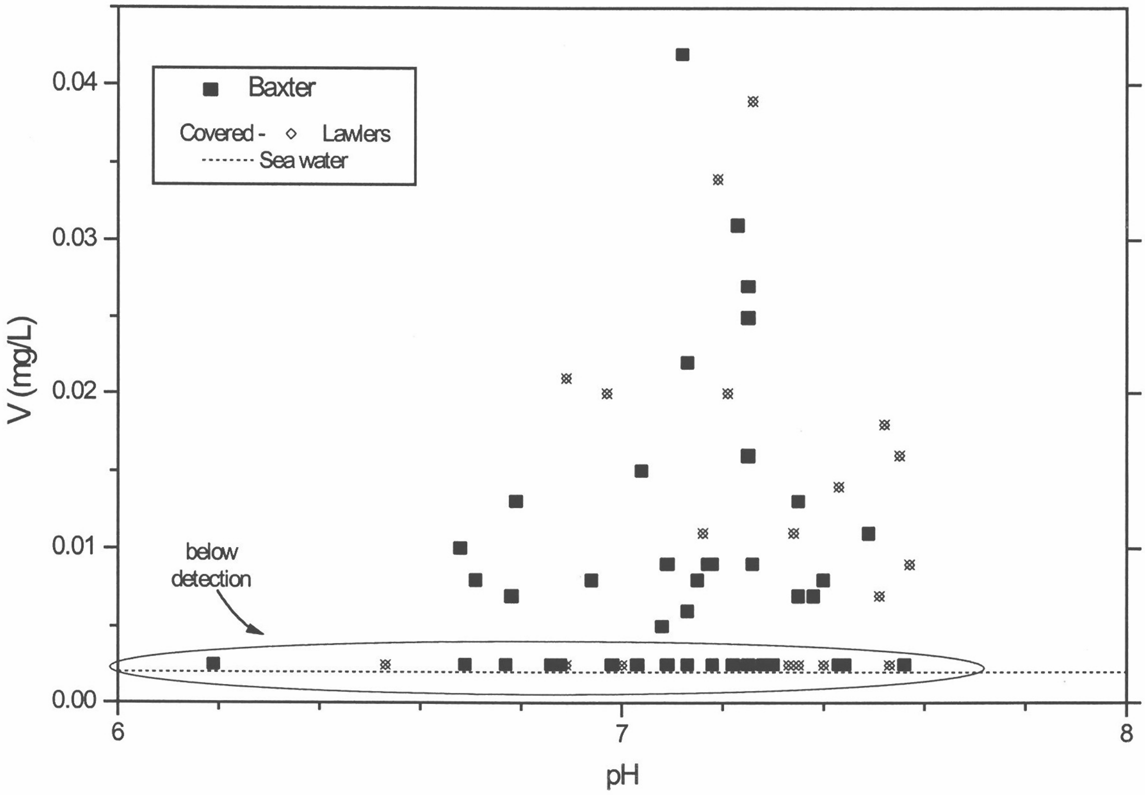

Figure A2.18: V vs. pH for groundwaters from Baxter and other sites.

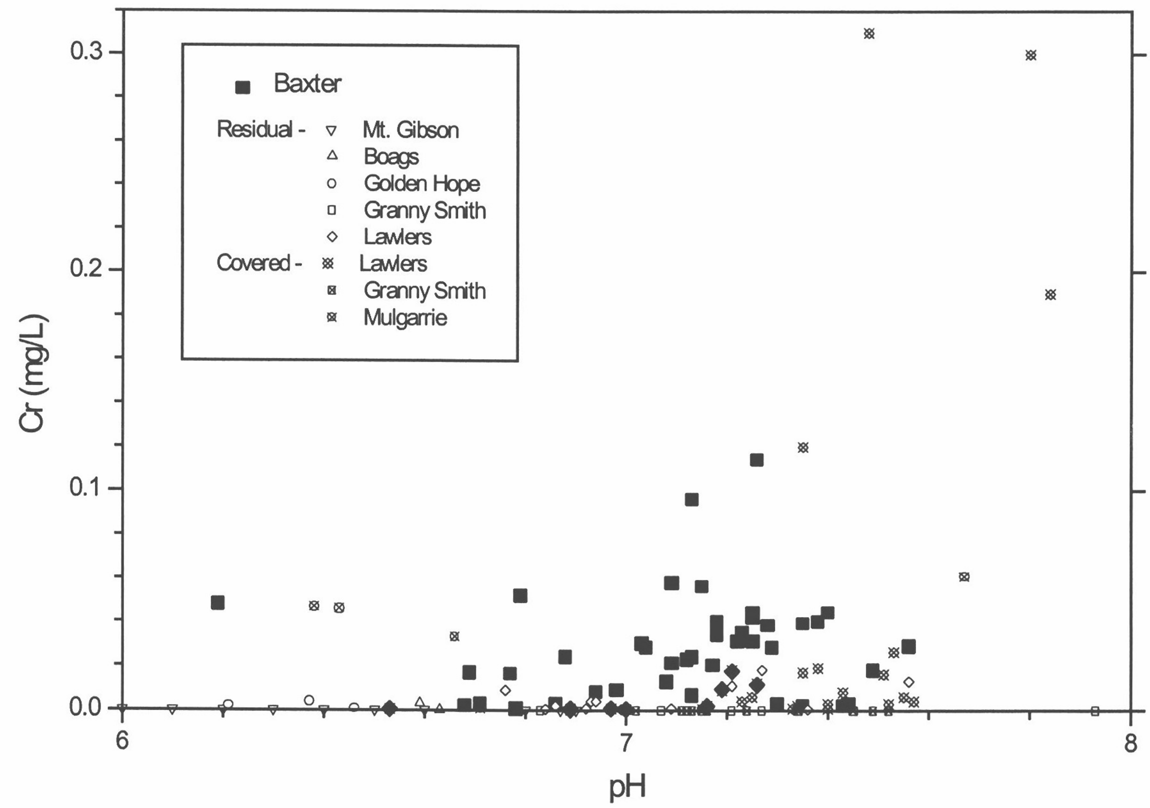

Figure A2.19: Cr vs. pH for groundwaters from Baxter and other sites.

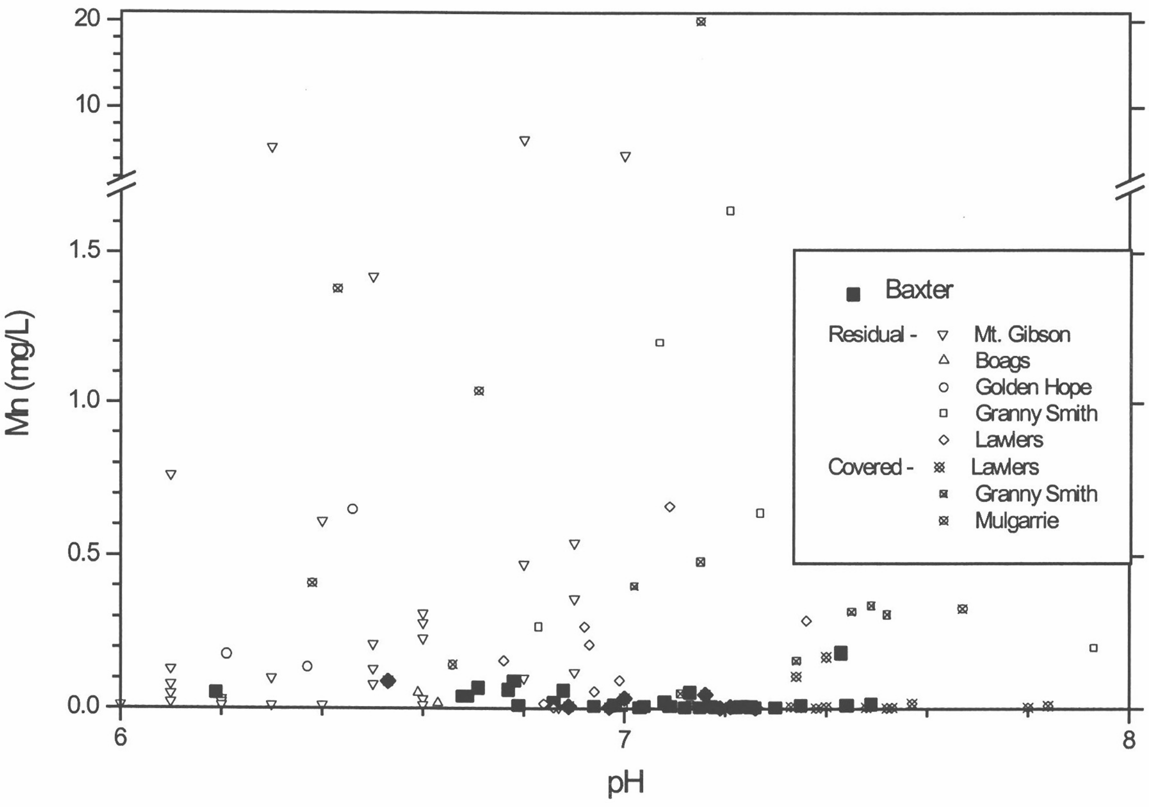

Figure A2.20: Mn vs. pH for groundwaters from Baxter and other sites.

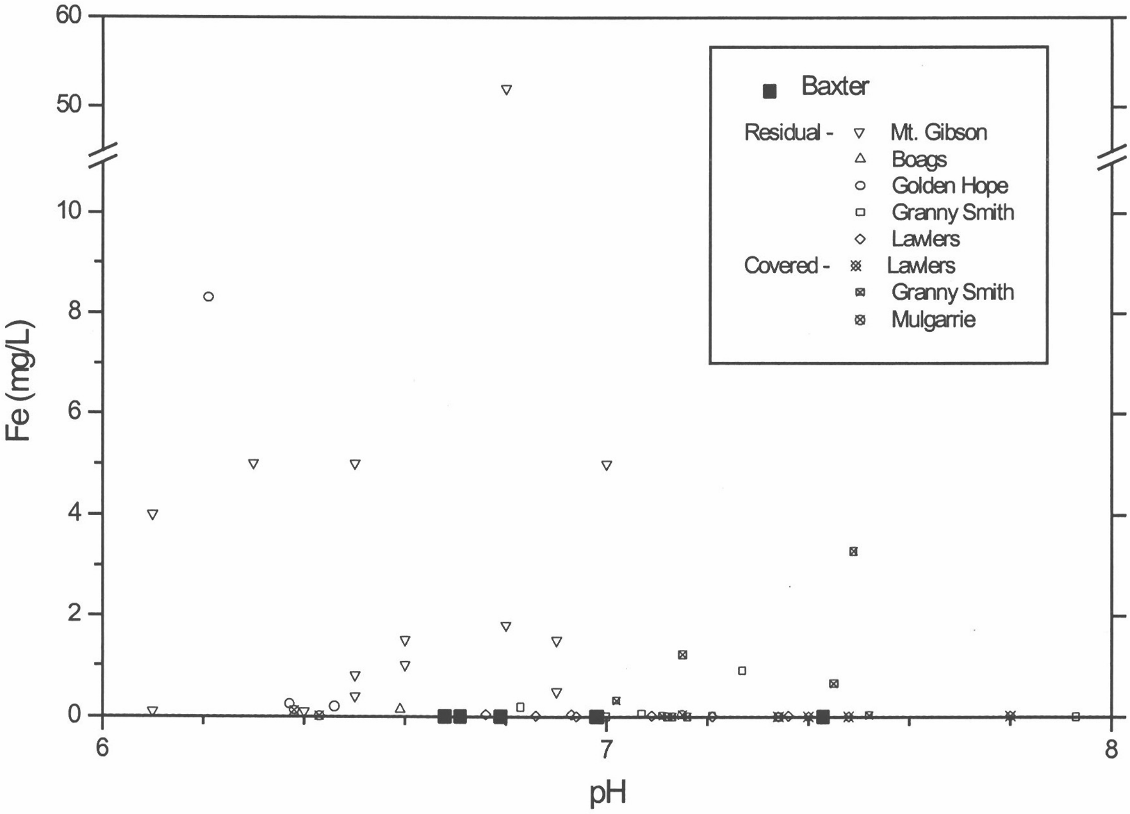

Figure A2.21: Fe vs. pH for groundwaters from Baxter and other sites.

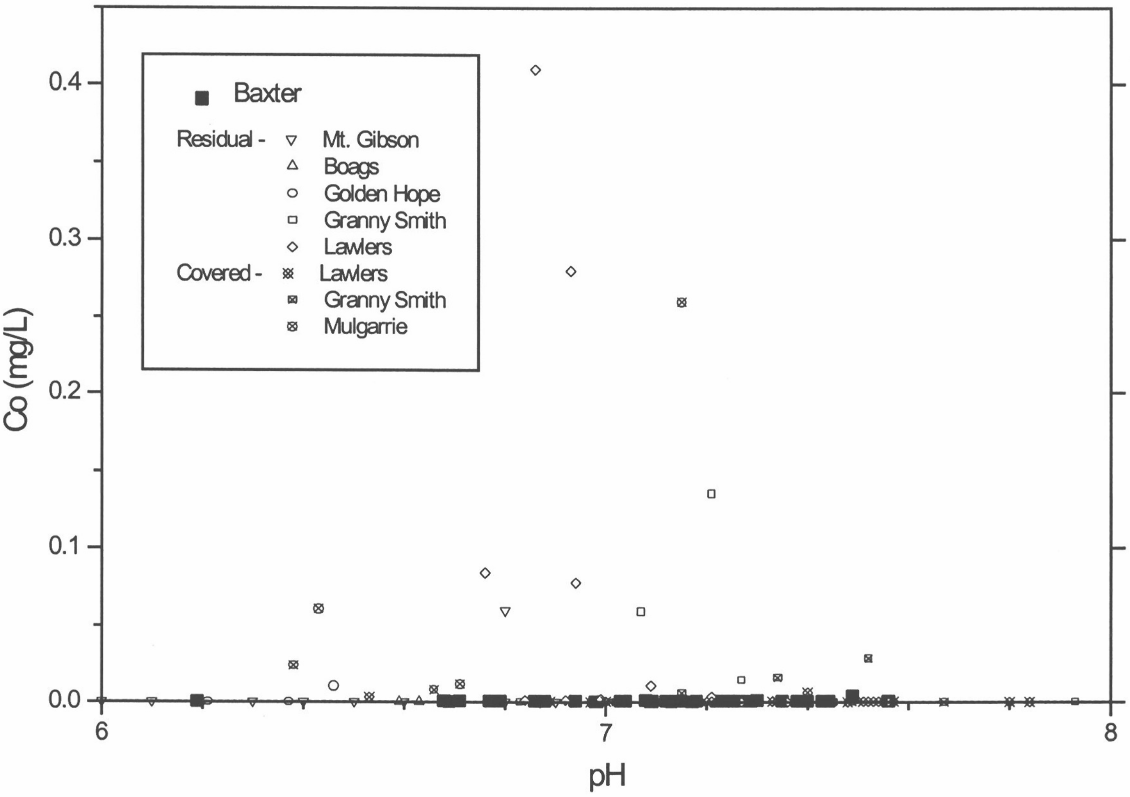

Figure A2.22: Co vs. pH for groundwaters from Baxter and other sites.

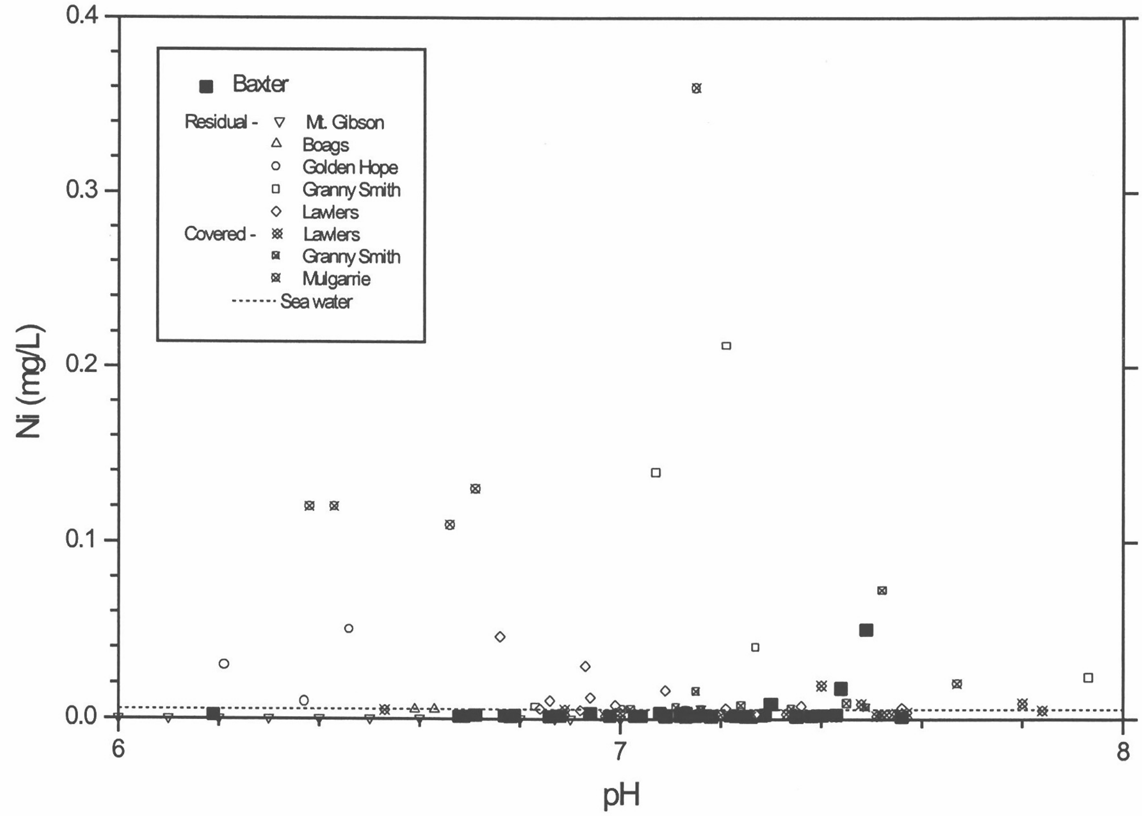

Figure A2.23: Ni vs. pH for groundwaters from Baxter and other sites.

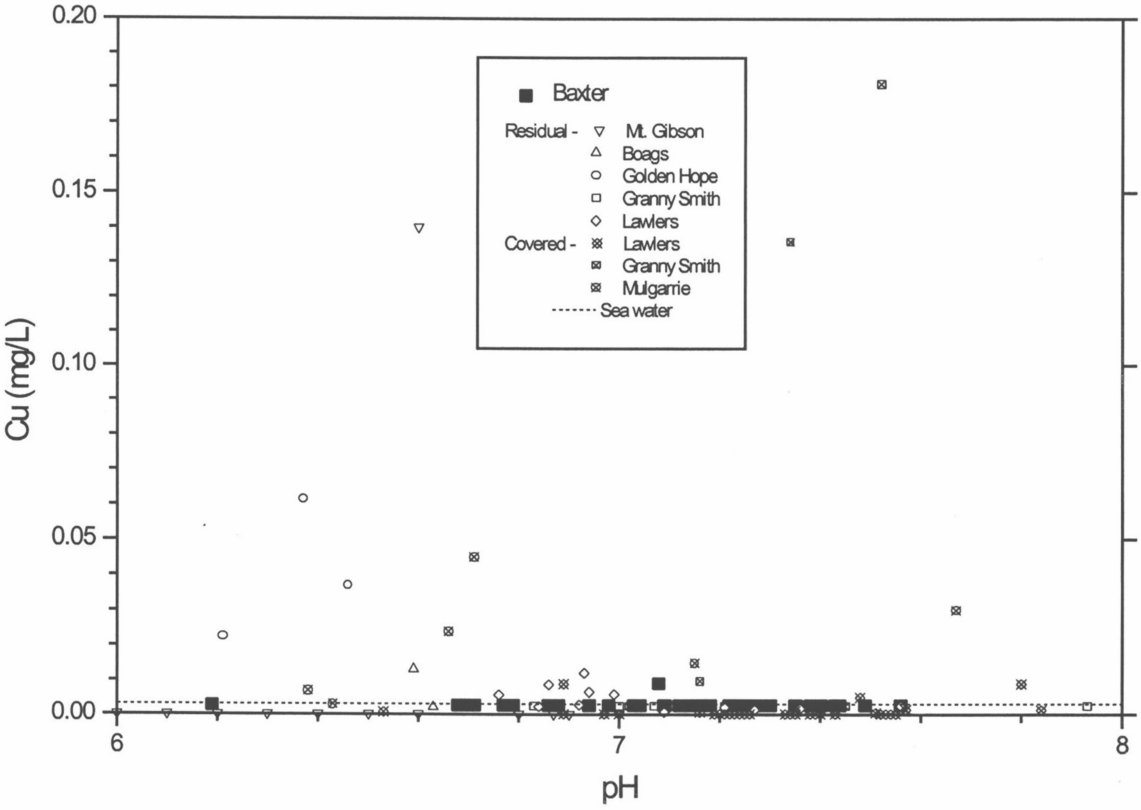

Figure A2.24: Cu vs. pH for groundwaters from Baxter and other sites.

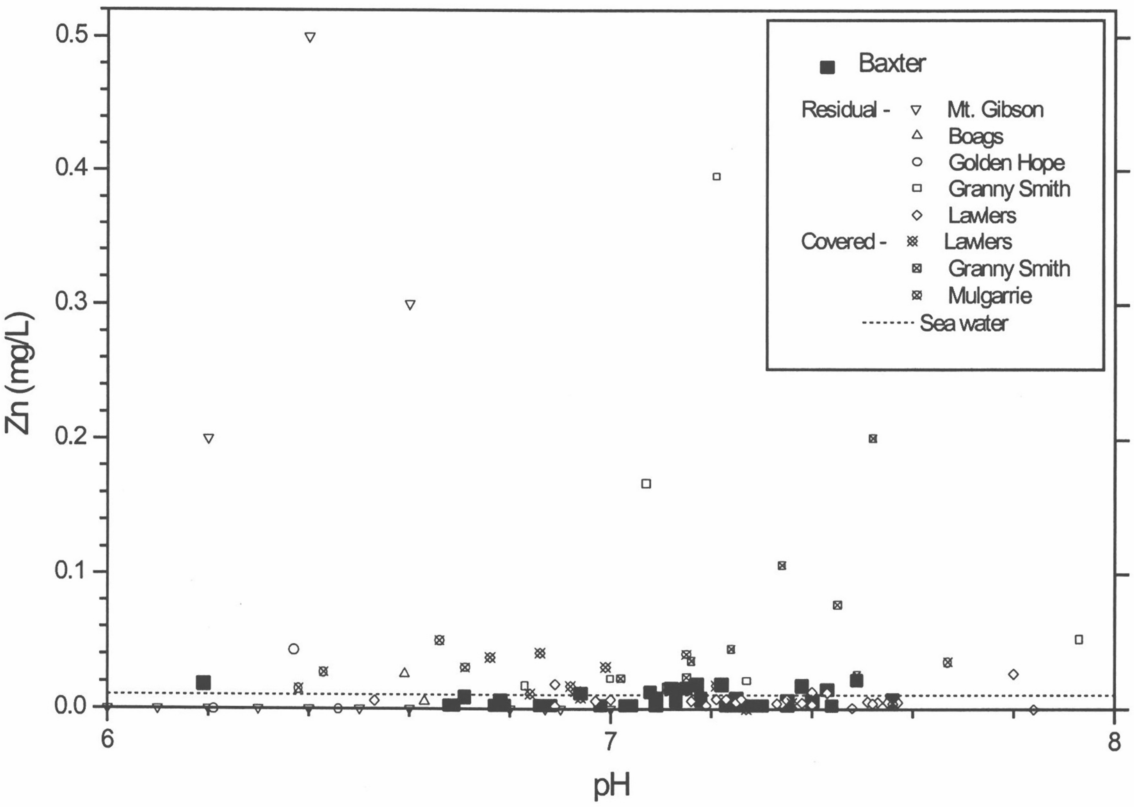

Figure A2.25: Zn vs. pH for groundwaters from Baxter and other sites.

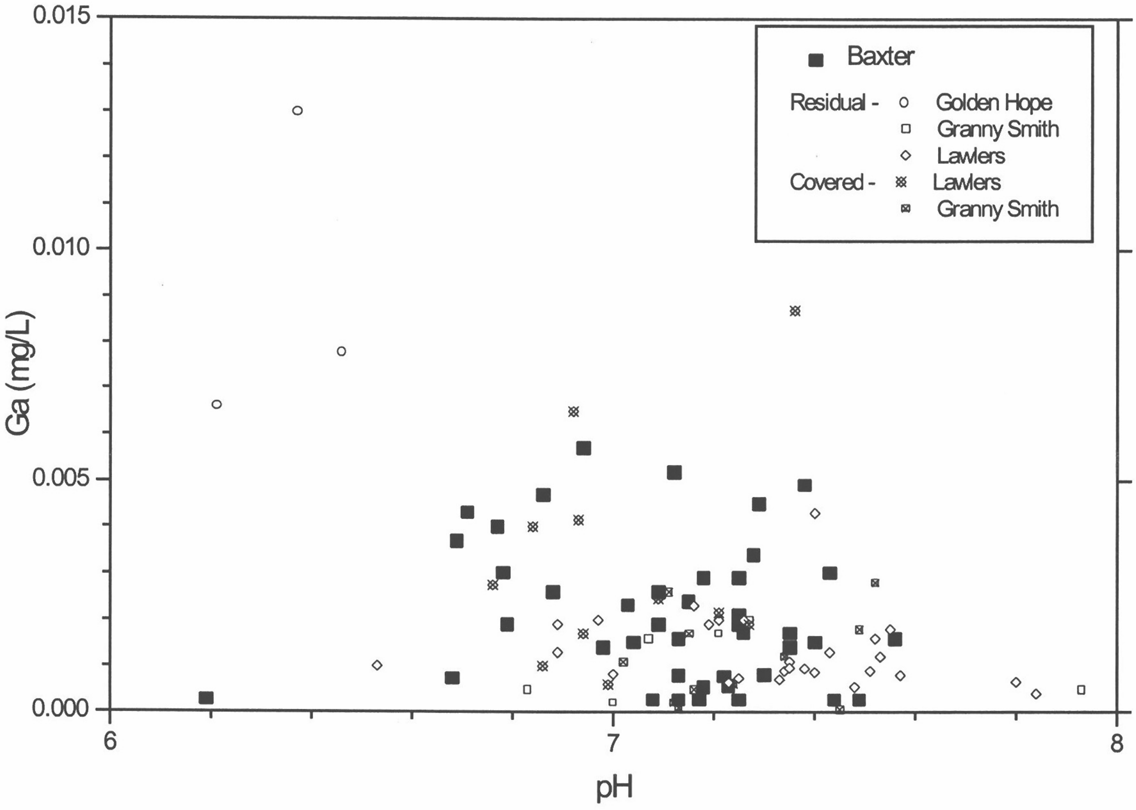

Figure A2.26: Ga vs. pH for groundwaters from Baxter and other sites.

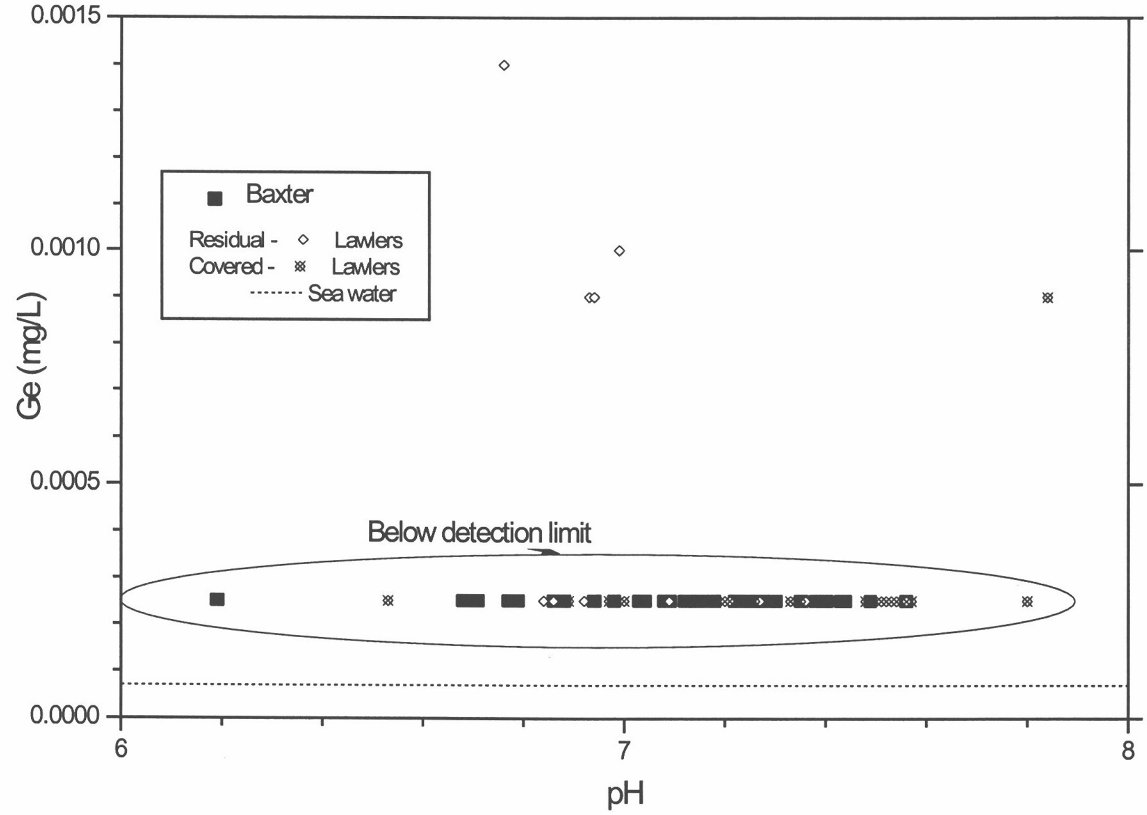

Figure A2.27: Ge vs. pH for groundwaters from Baxter and other sites.

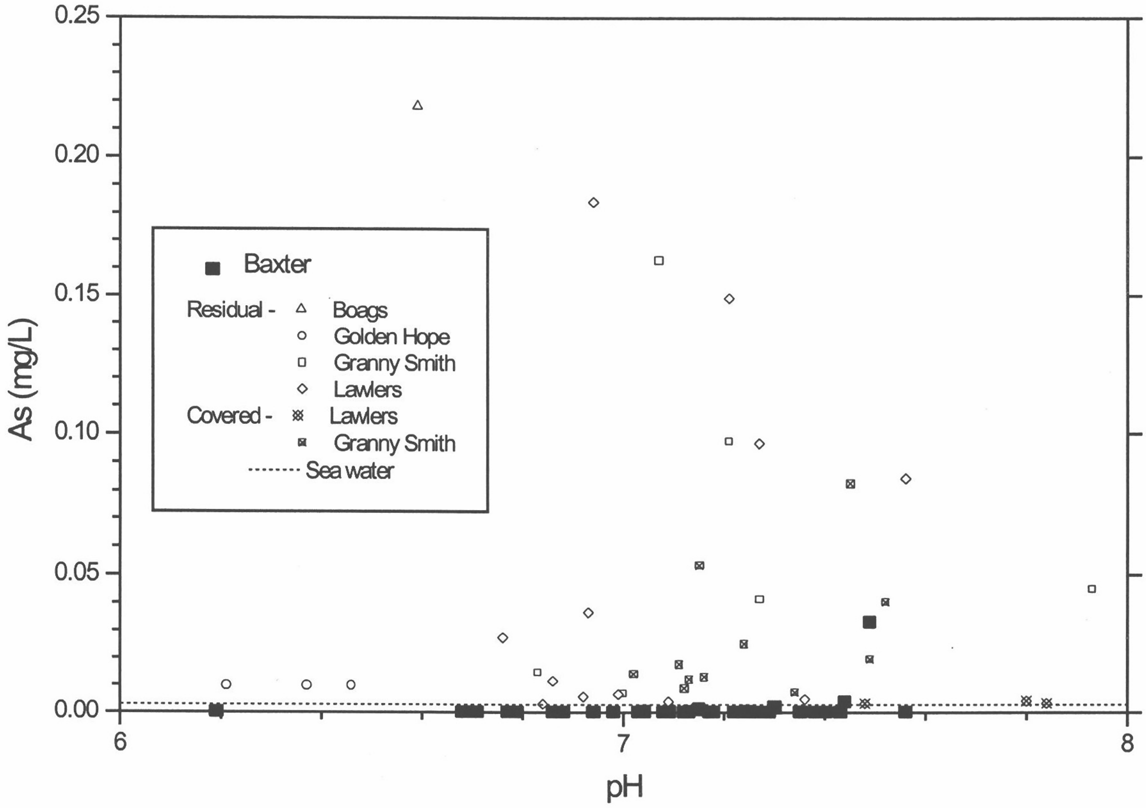

Figure A2.28: As vs. pH for groundwaters from Baxter and other sites.

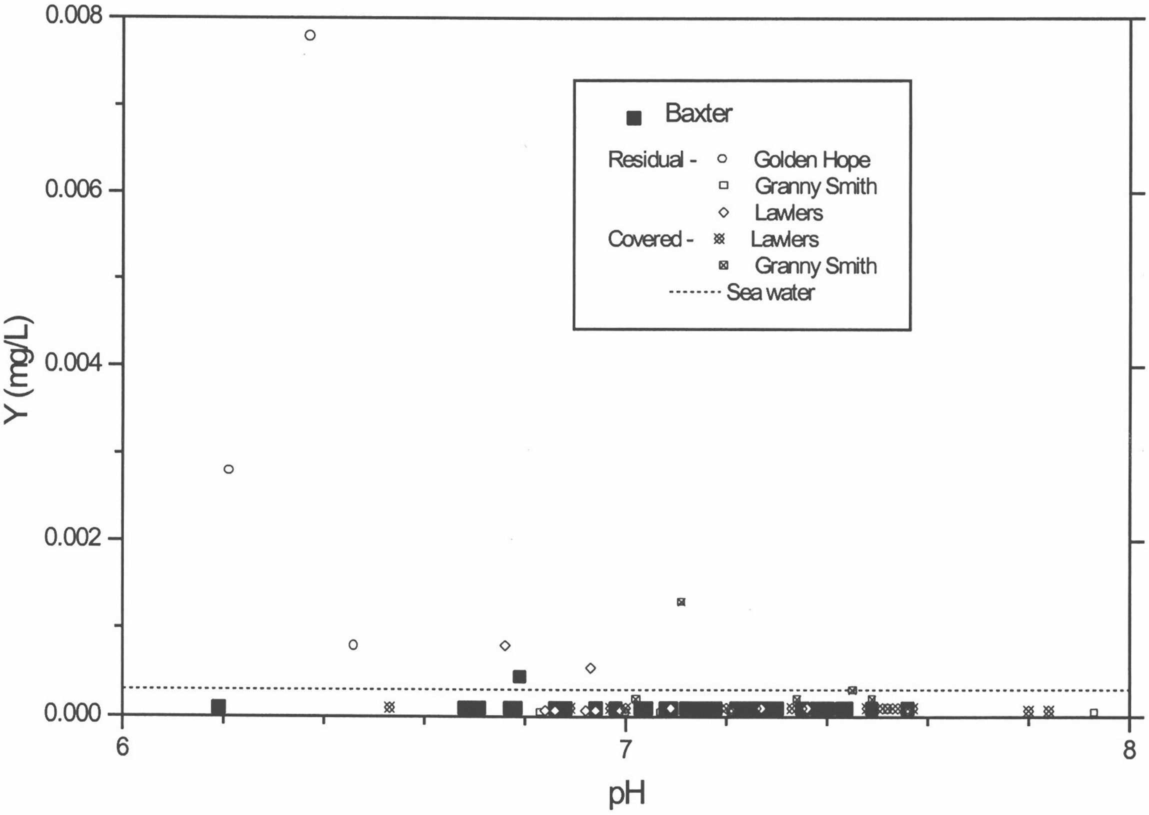

Figure A2.29: Y vs. pH for groundwaters from Baxter and other sites.

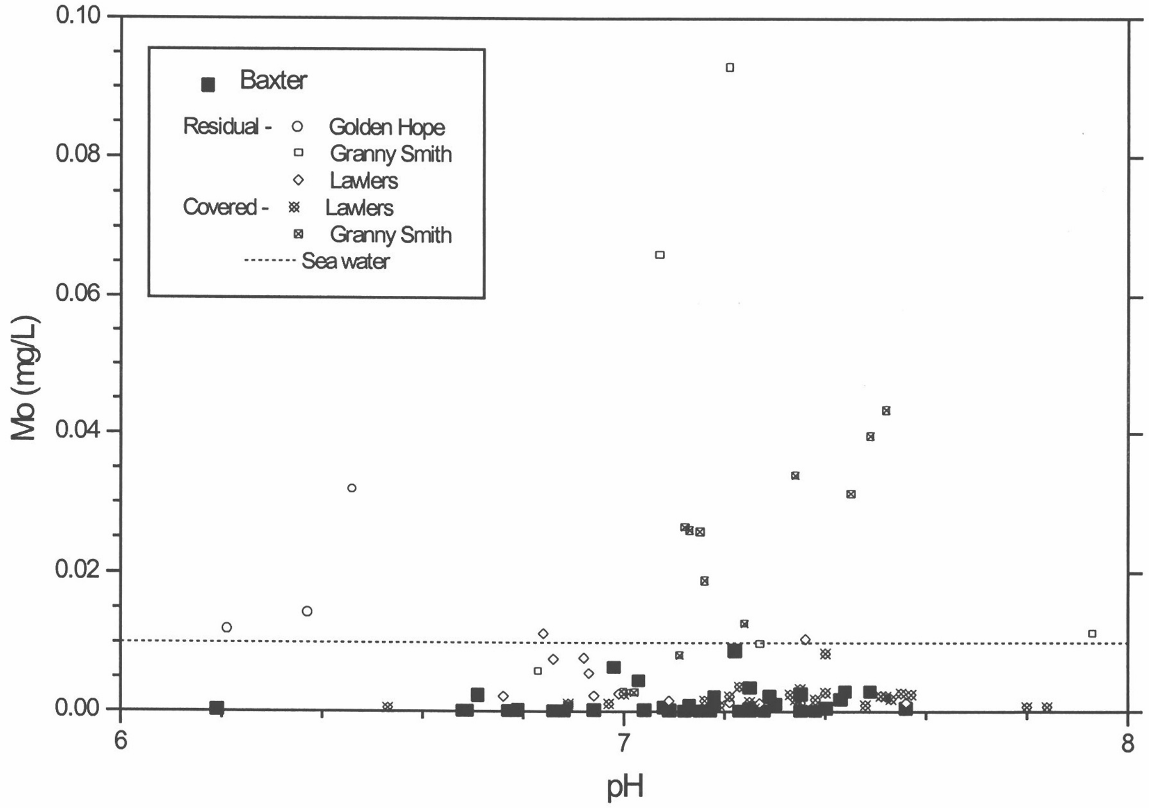

Figure A2.30: Mo vs. pH for groundwaters from Baxter and other sites.

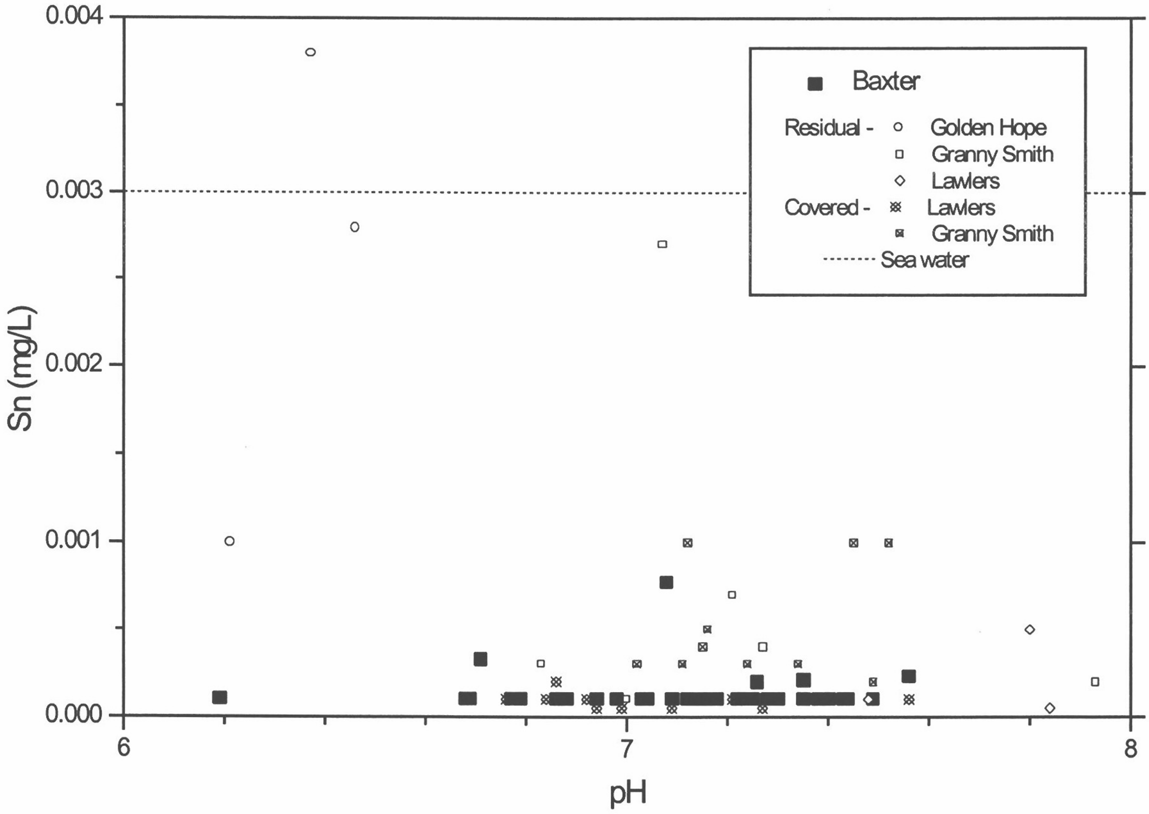

Figure A2.31: Sn vs. pH for groundwaters from Baxter and other sites.

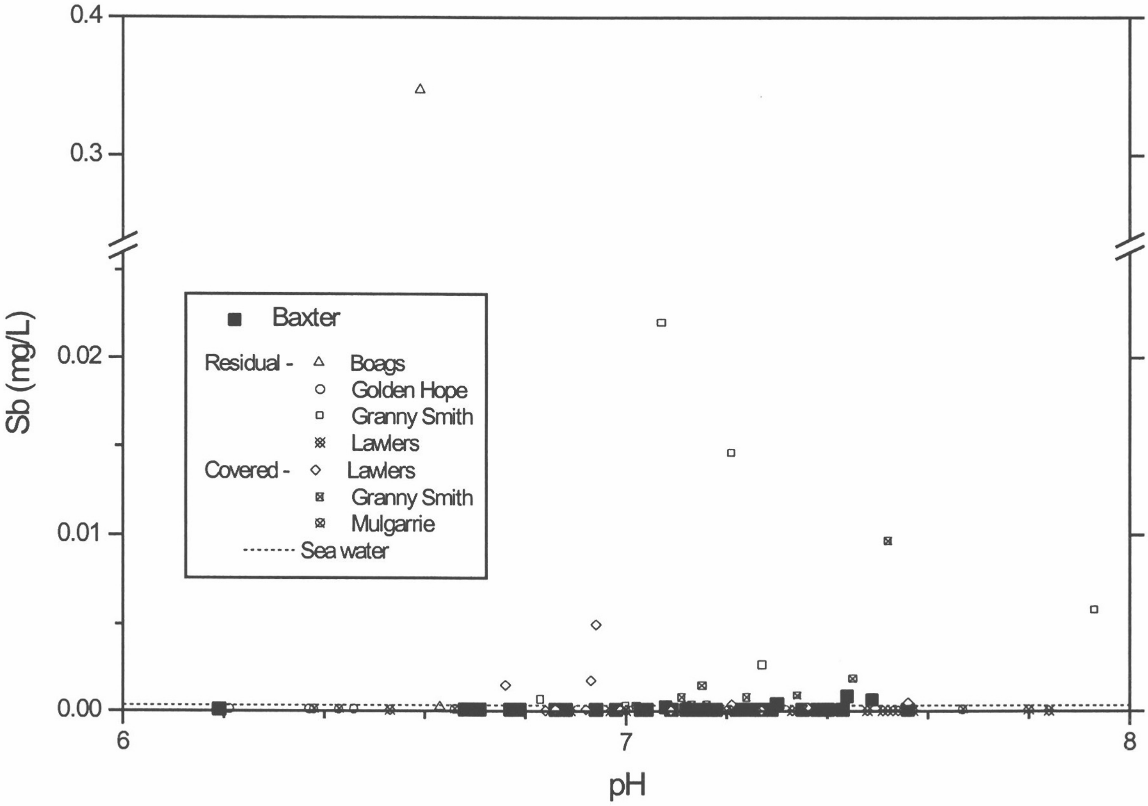

Figure A2.32: Sb vs. pH for groundwaters from Baxter and other sites.

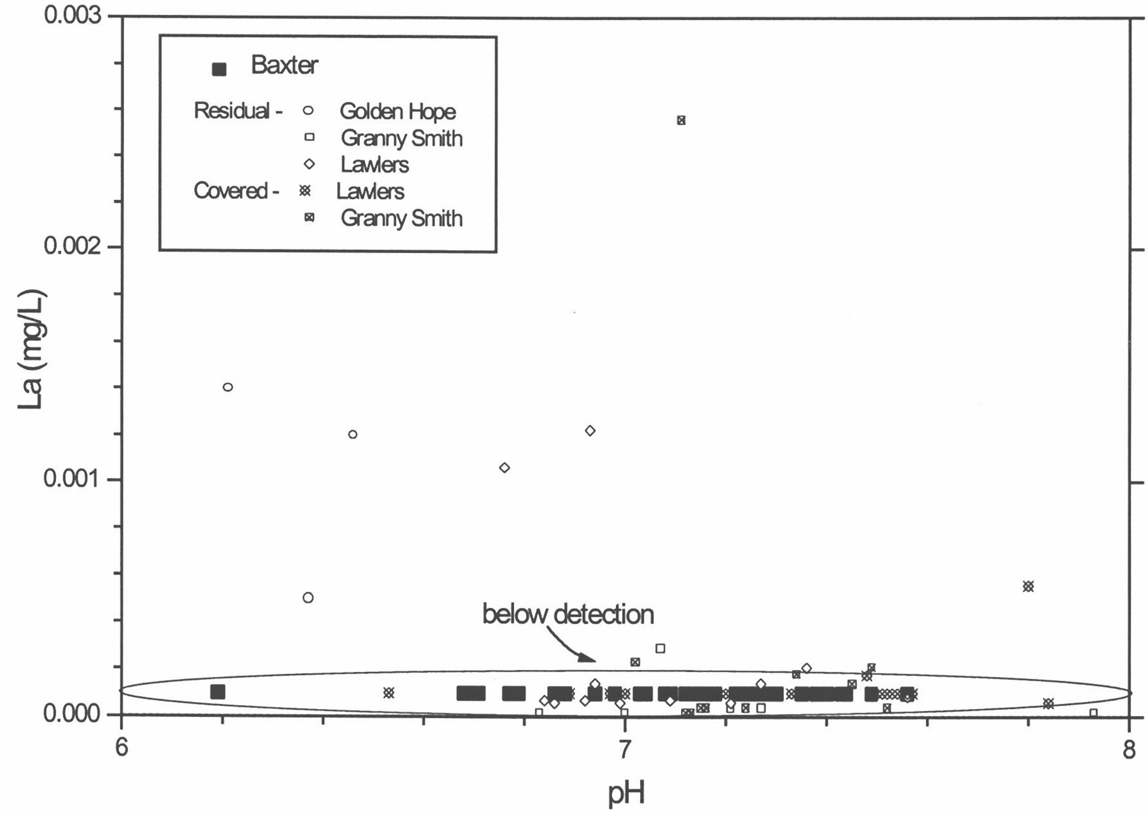

Figure A2.33: La vs. pH for groundwaters from Baxter and other sites.

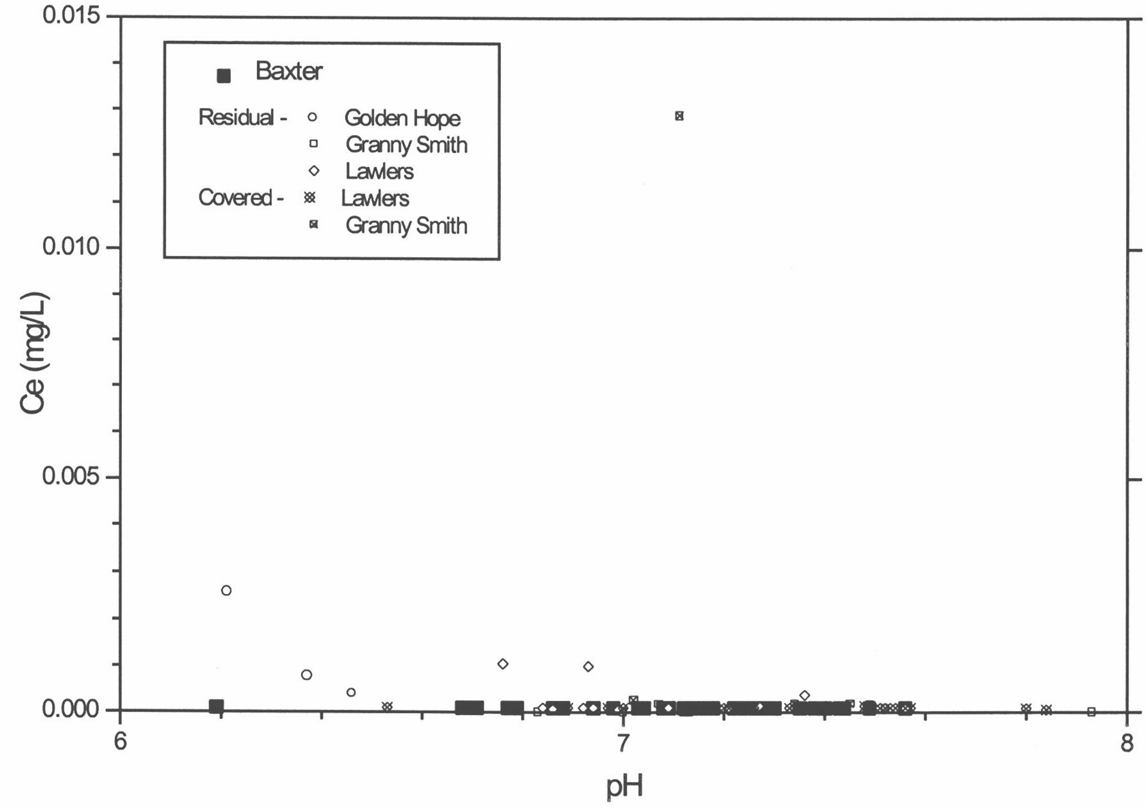

Figure A2.34: Ce vs. pH for groundwaters from Baxter and other sites.

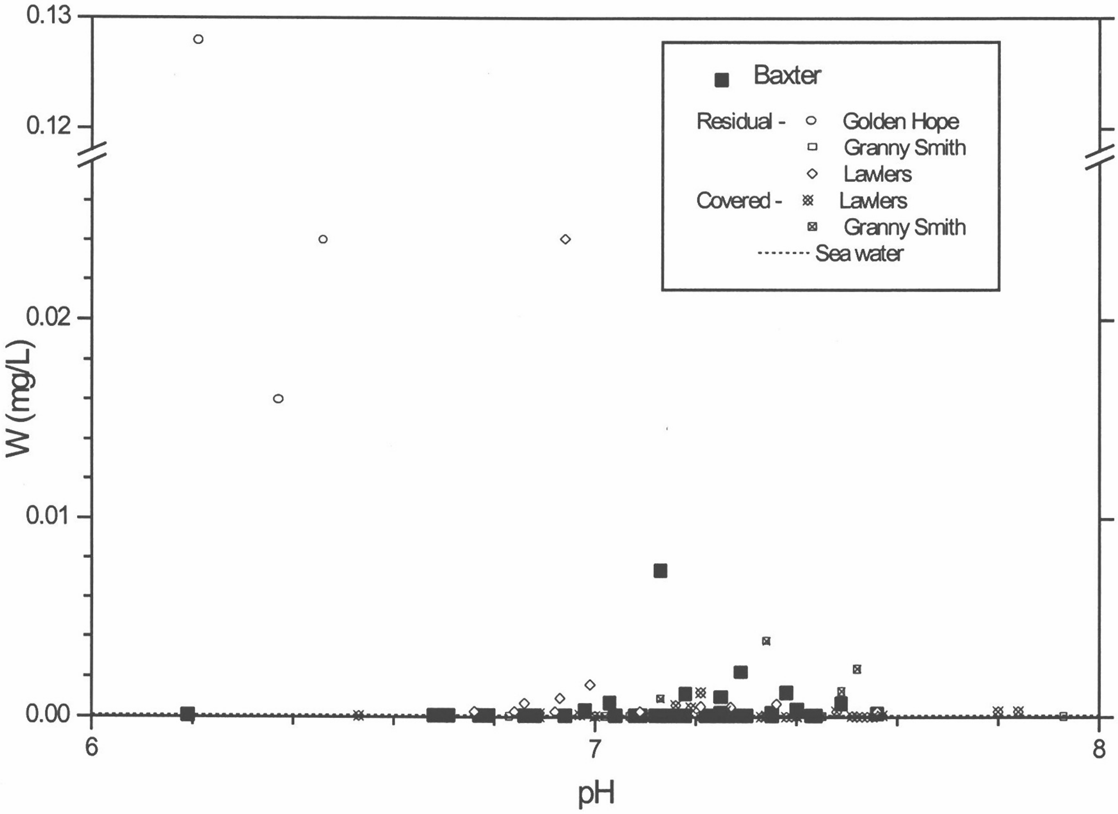

Figure A2.35: W vs. pH for groundwaters from Baxter and other sites.

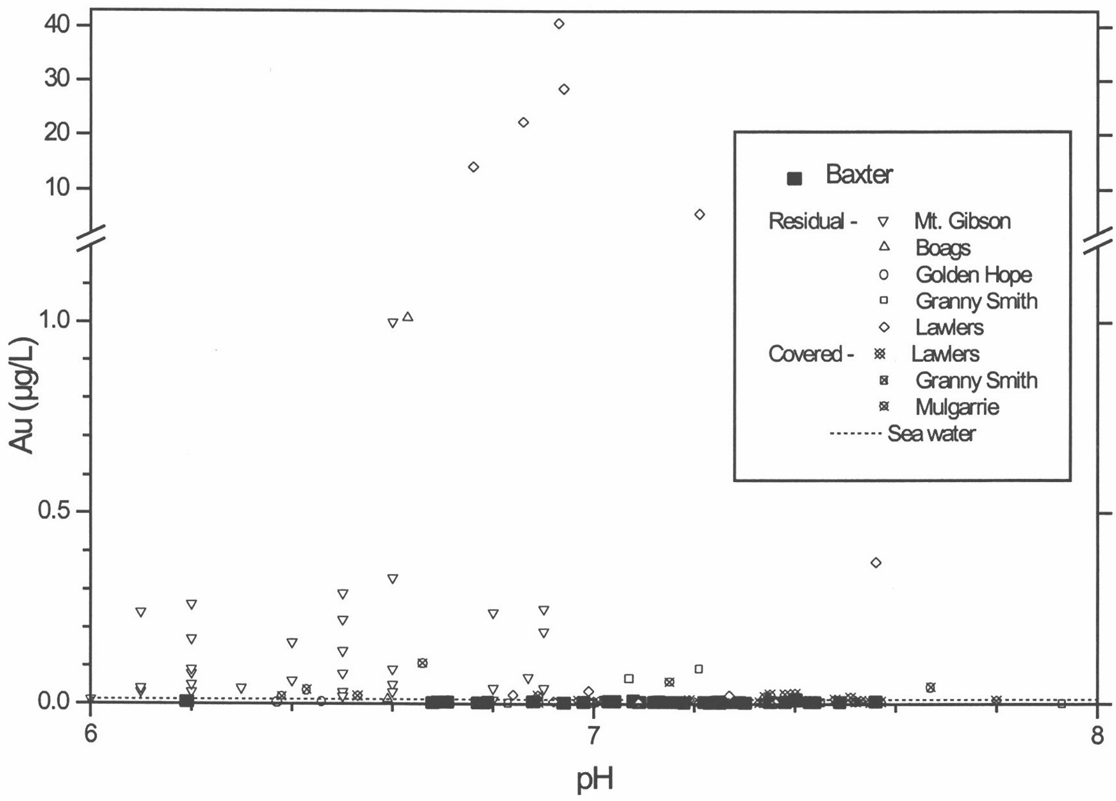

Figure A2.36: Au vs. pH for groundwaters from Baxter and other sites.

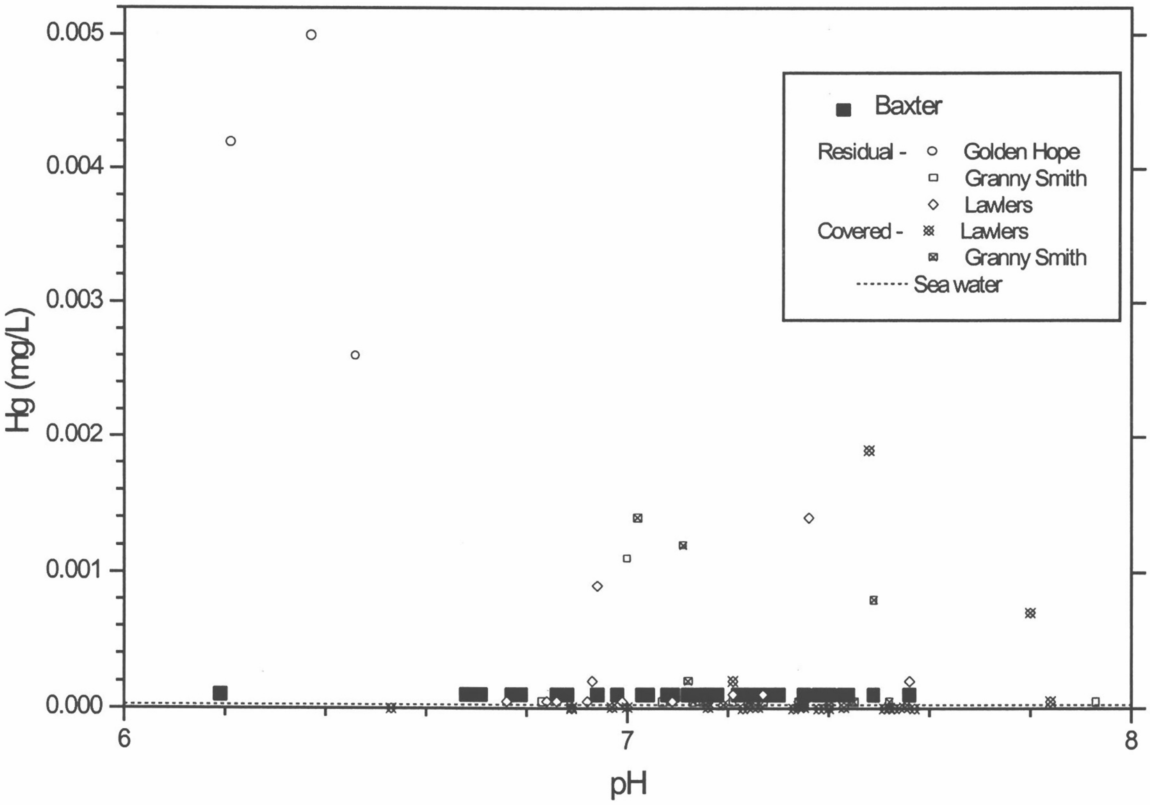

Figure A2.37: Hg vs. pH for groundwaters from Baxter and other sites.

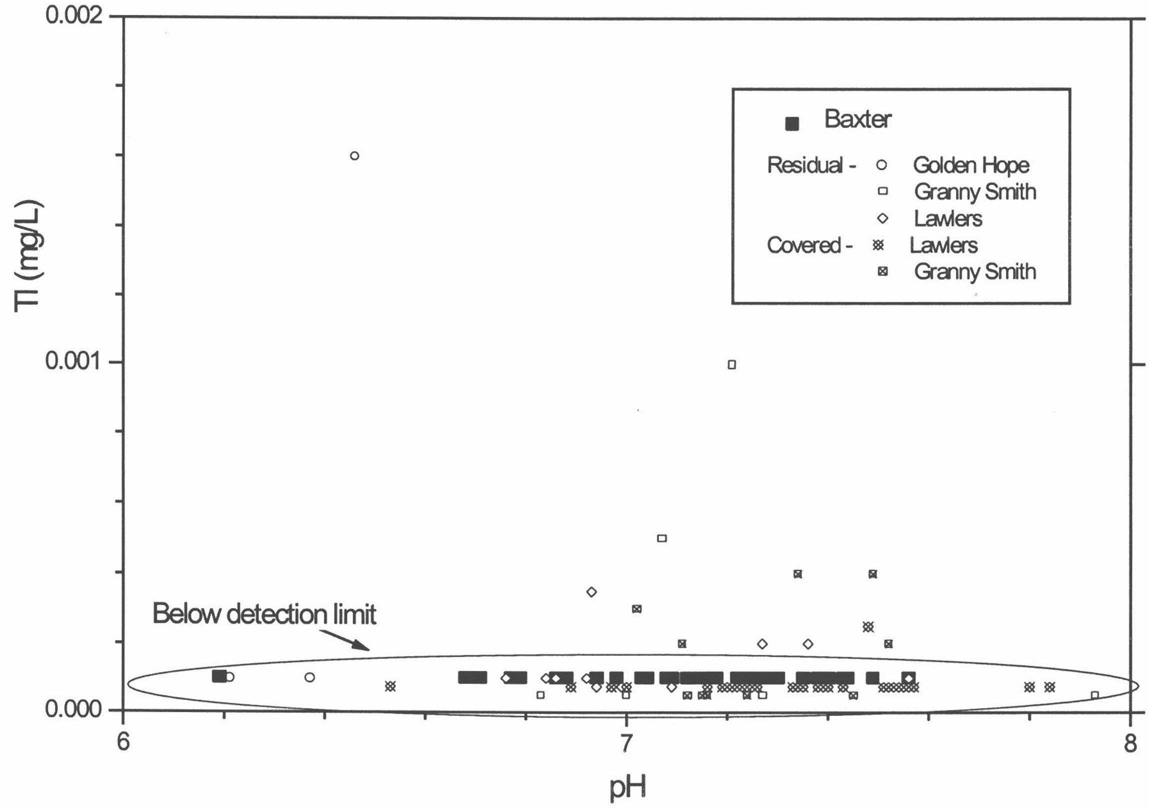

Figure A2.38: Tl vs. pH for groundwaters from Baxter and other sites.

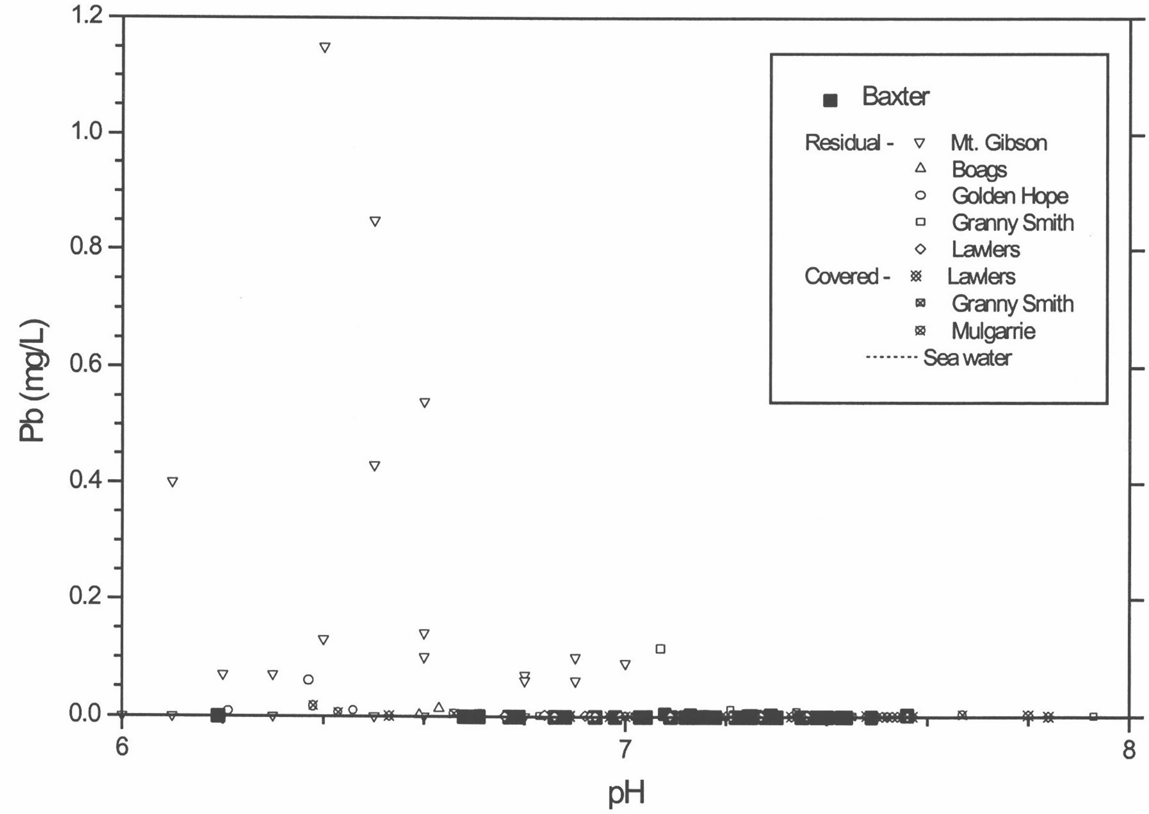

Figure A2.39: Pb vs. pH for groundwaters from Baxter and other sites.

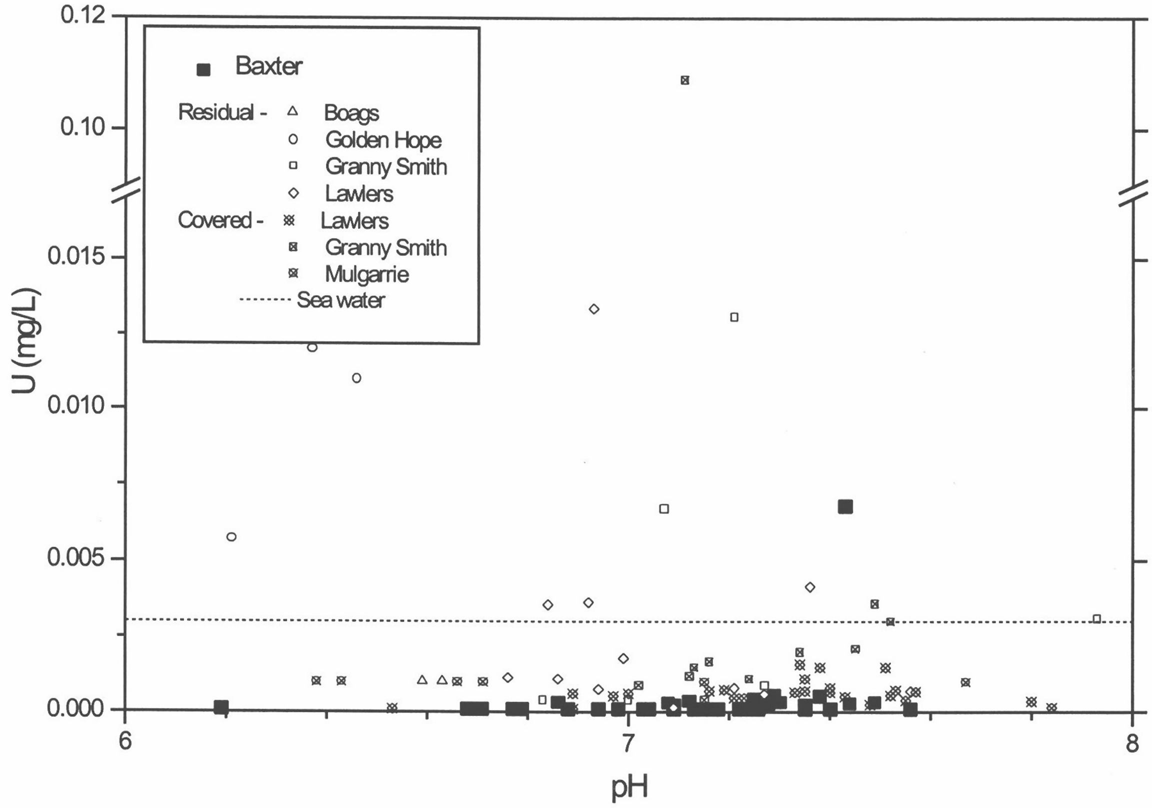

Figure A2.40: U vs. pH for groundwaters from Baxter and other sites.

Appendix 3: Speciation Analysis Output

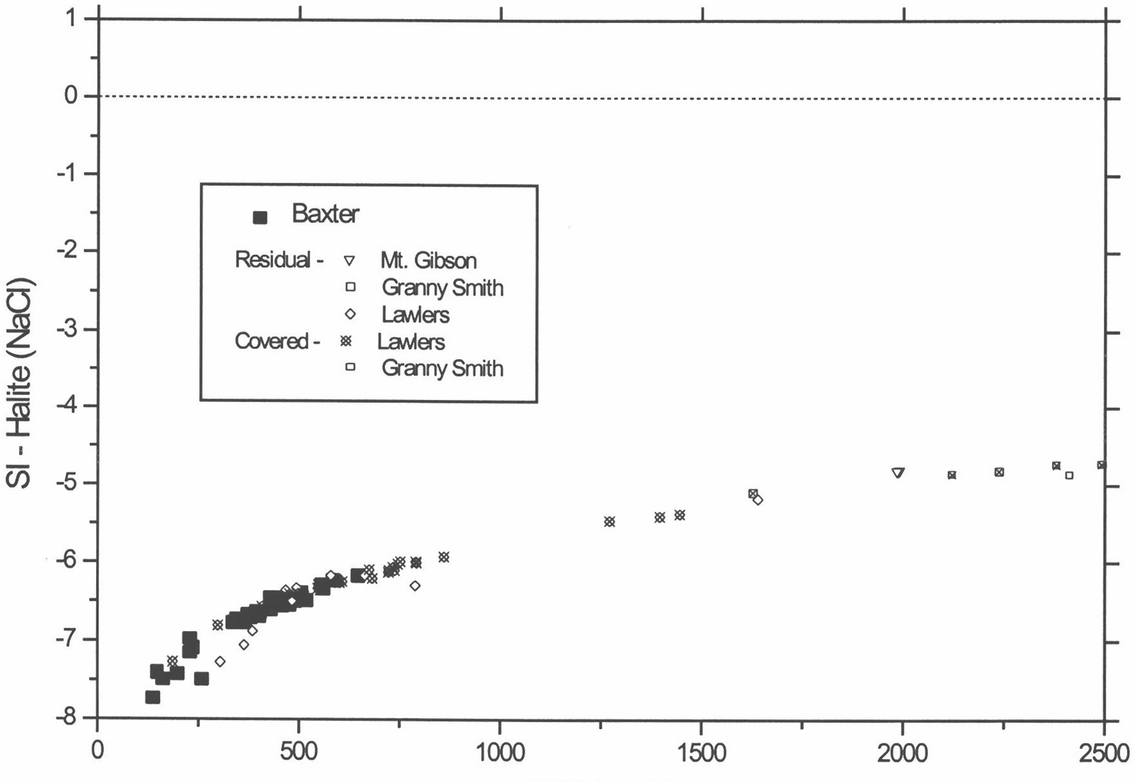

Figure A3.1: SI for halite vs. TDS for groundwaters from Baxter and other sites.

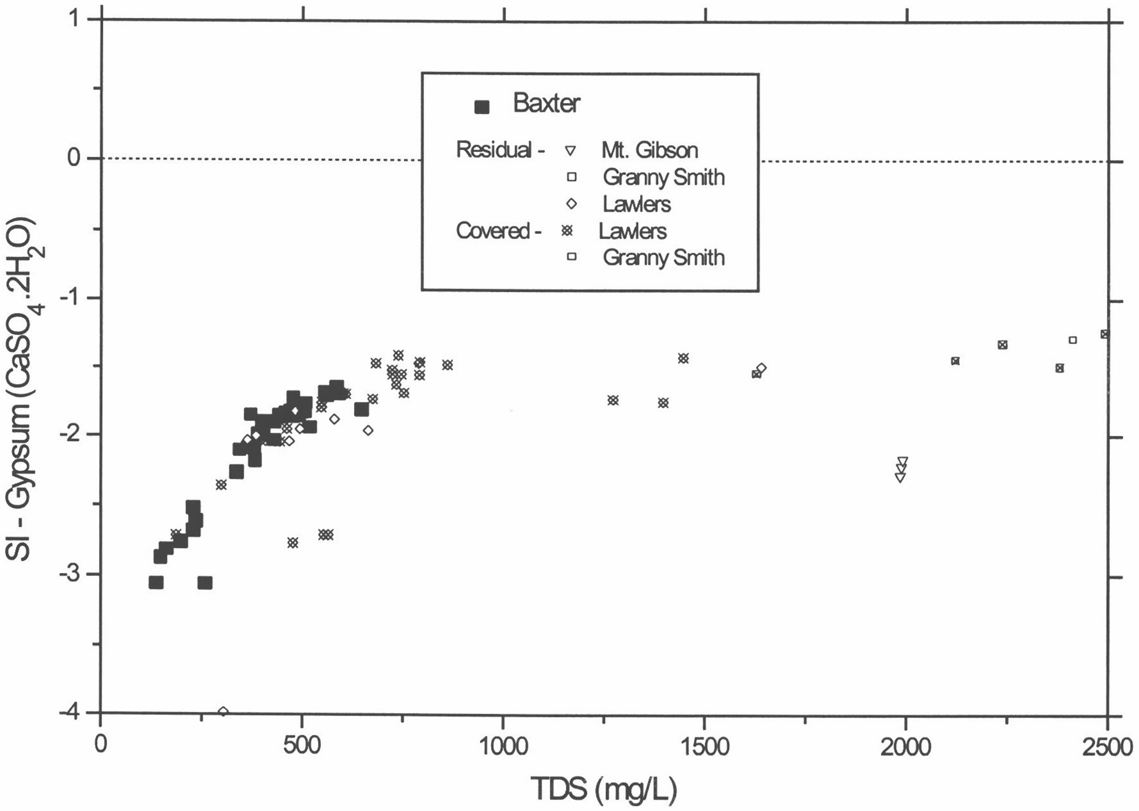

Figure A3.2: SI for gypsum vs. TDS for groundwaters from Baxter and other sites.

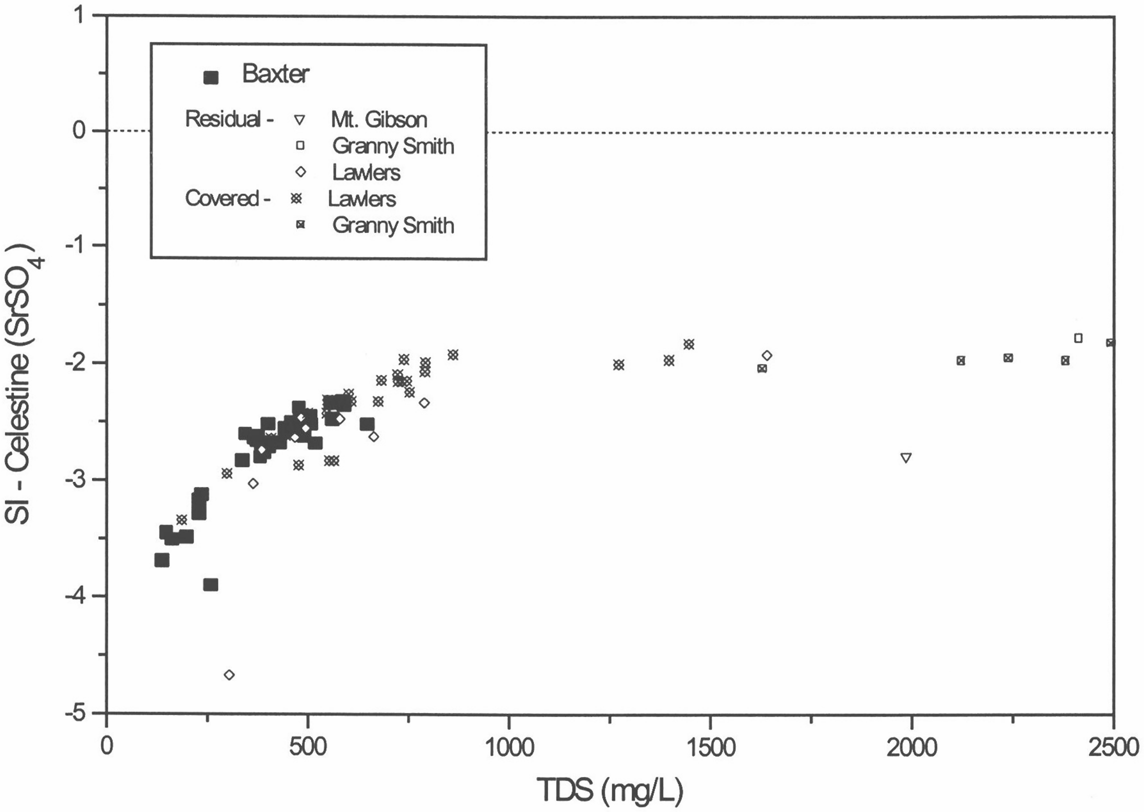

Figure A3.3: SI for celestine vs. TDS for groundwaters from Baxter and other sites.

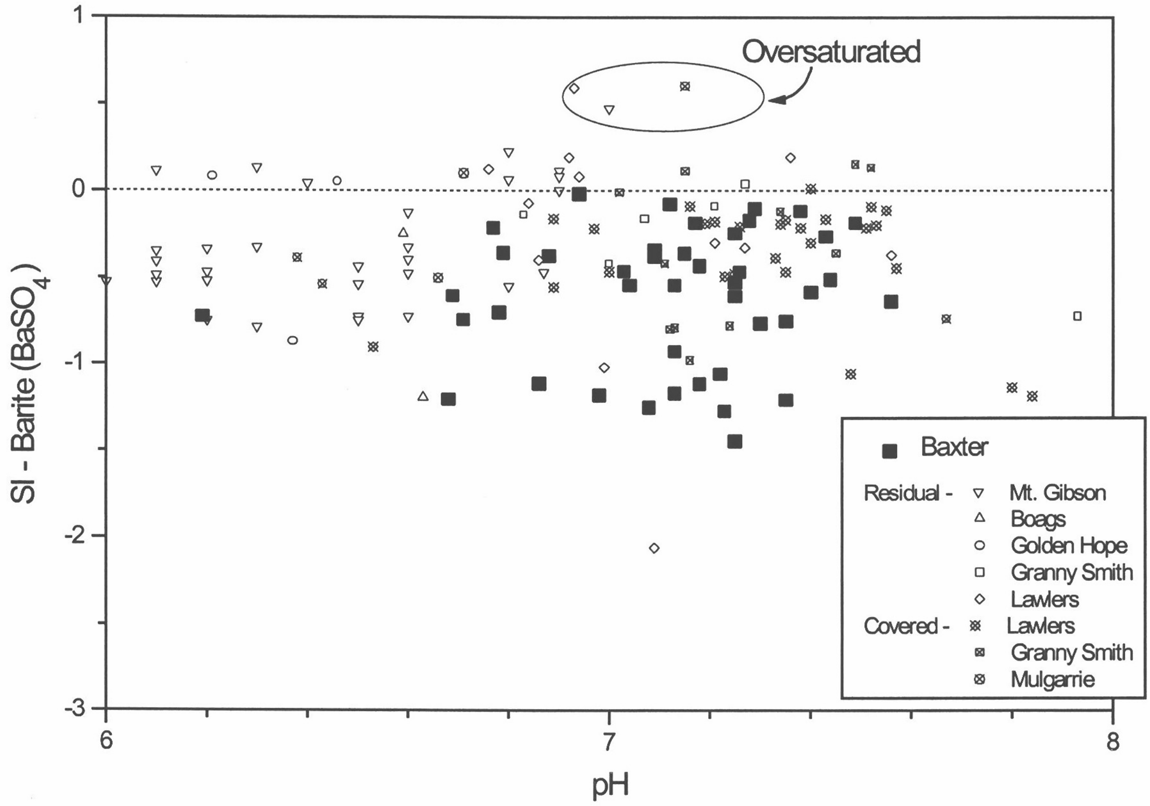

Figure A3.4: SI for barite vs. pH for groundwaters from Baxter and other sites.

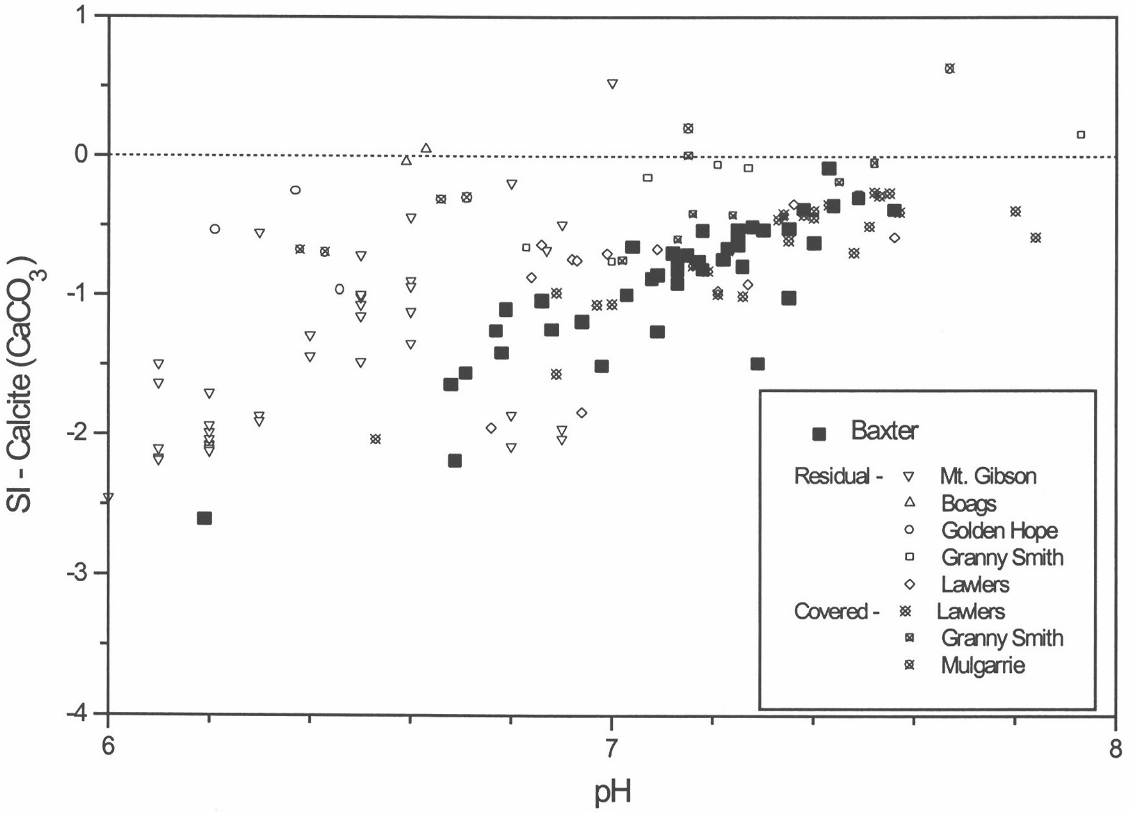

Figure A3.5: SI for calcite vs. pH for groundwaters from Baxter and other sites.

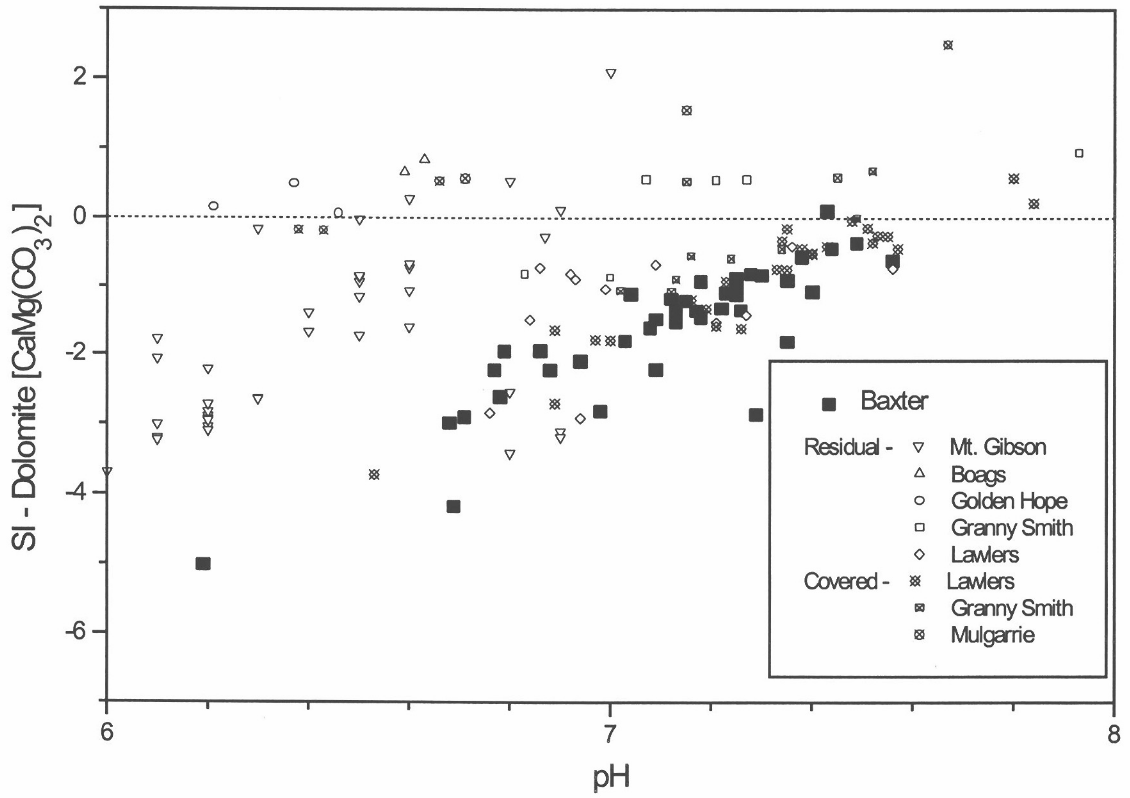

Figure A3.6: SI for dolomite vs. pH for groundwaters from Baxter and other sites.

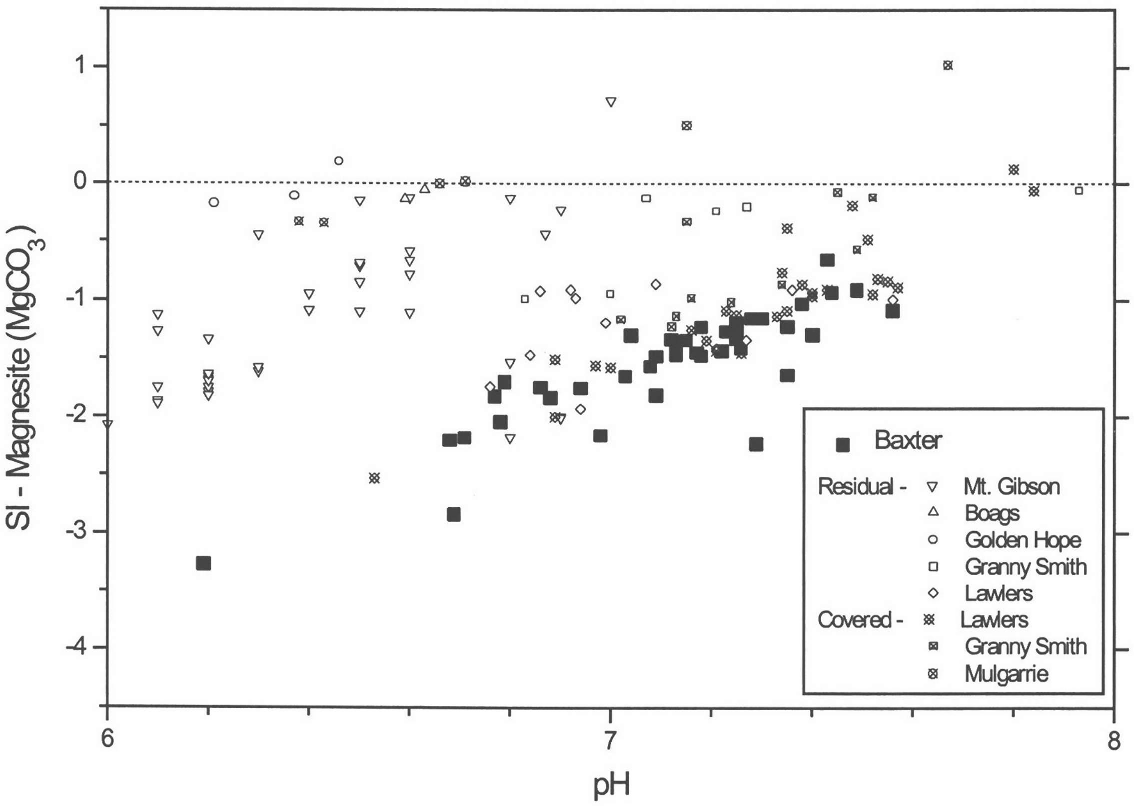

Figure A3.7: SI for magnesite vs. pH for groundwaters from Baxter and other sites.

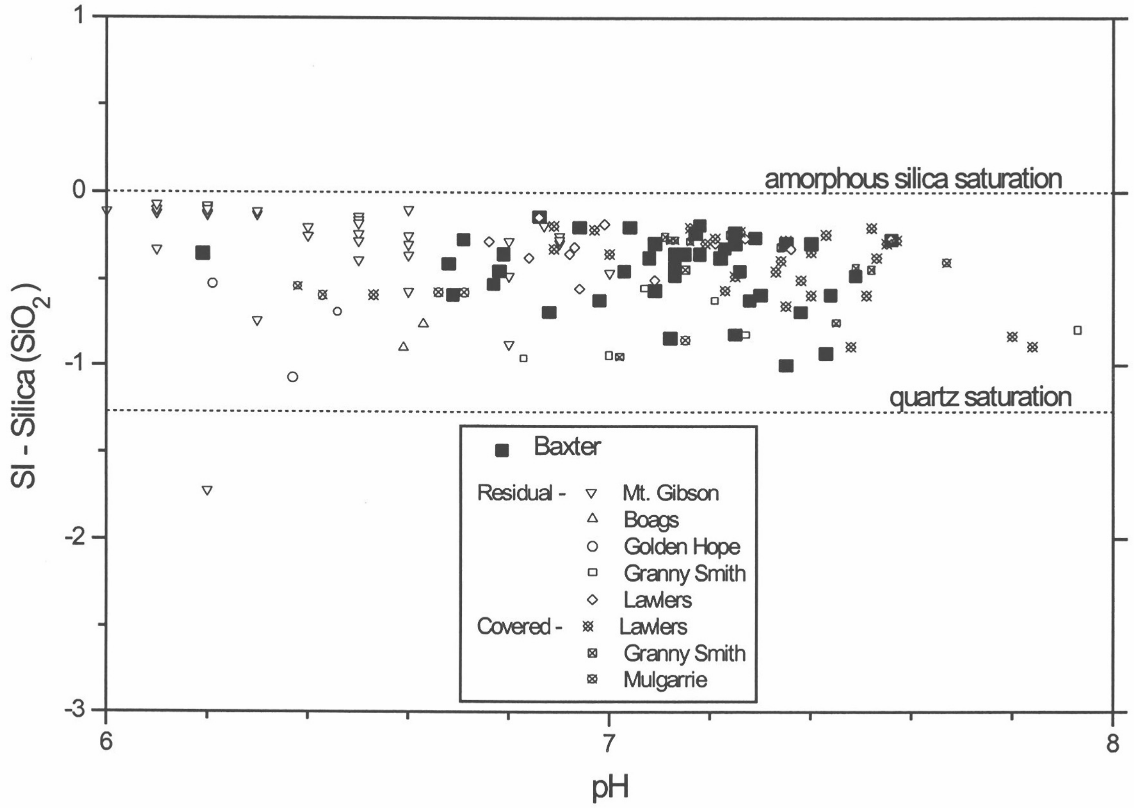

Figure A3.8: SI for silica vs. pH for groundwaters from Baxter and other sites.

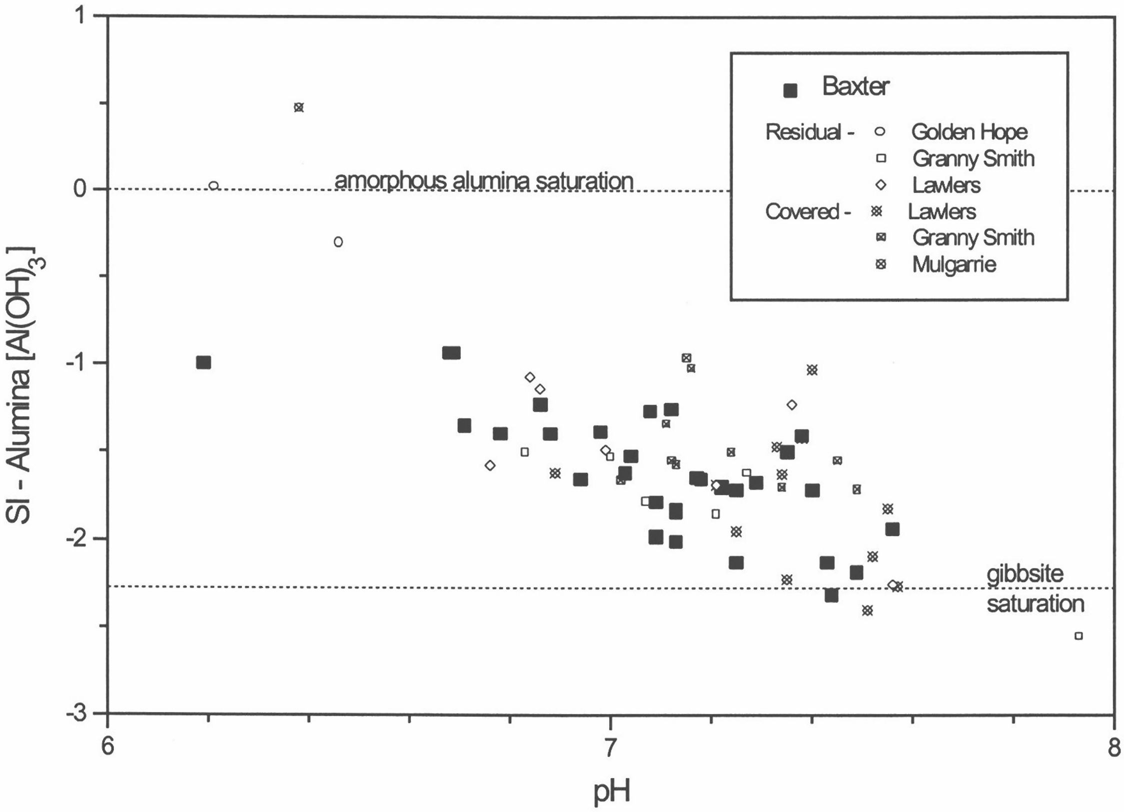

Figure A3.9: SI for alumina vs. pH for groundwaters from Baxter and other sites.

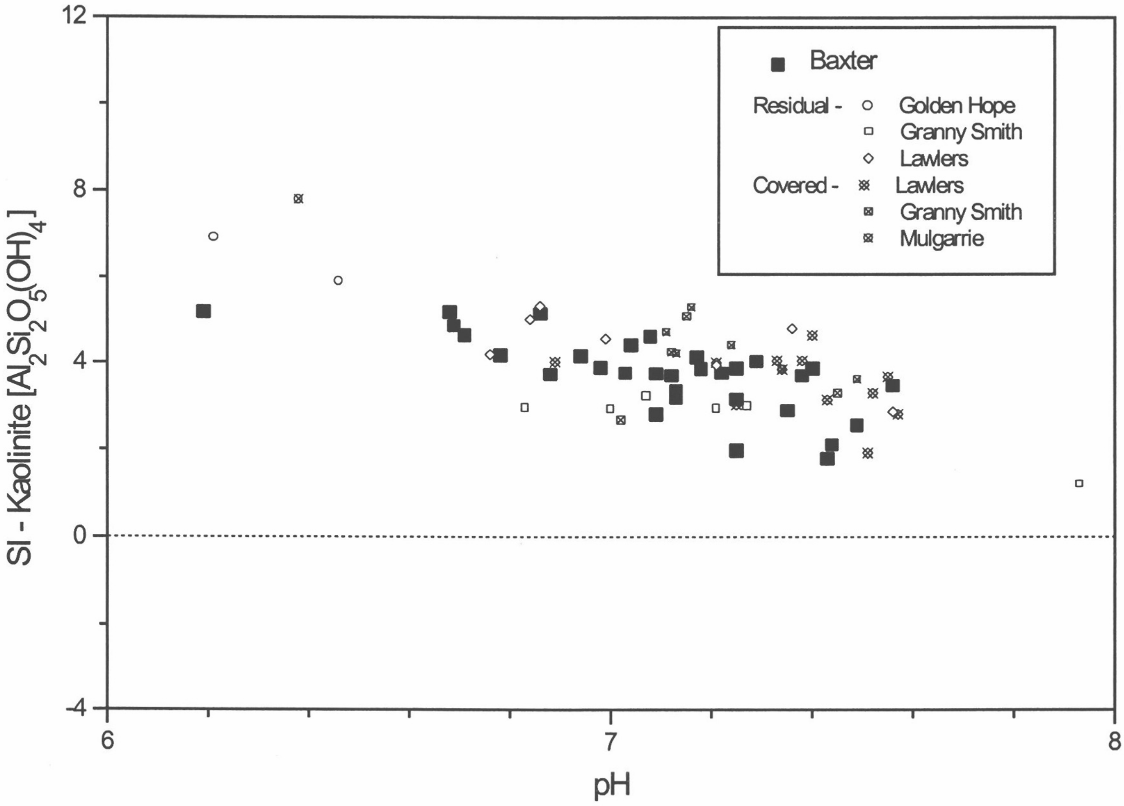

Figure A3.10: SI for kaolinite vs. pH for groundwaters from Baxter and other sites.

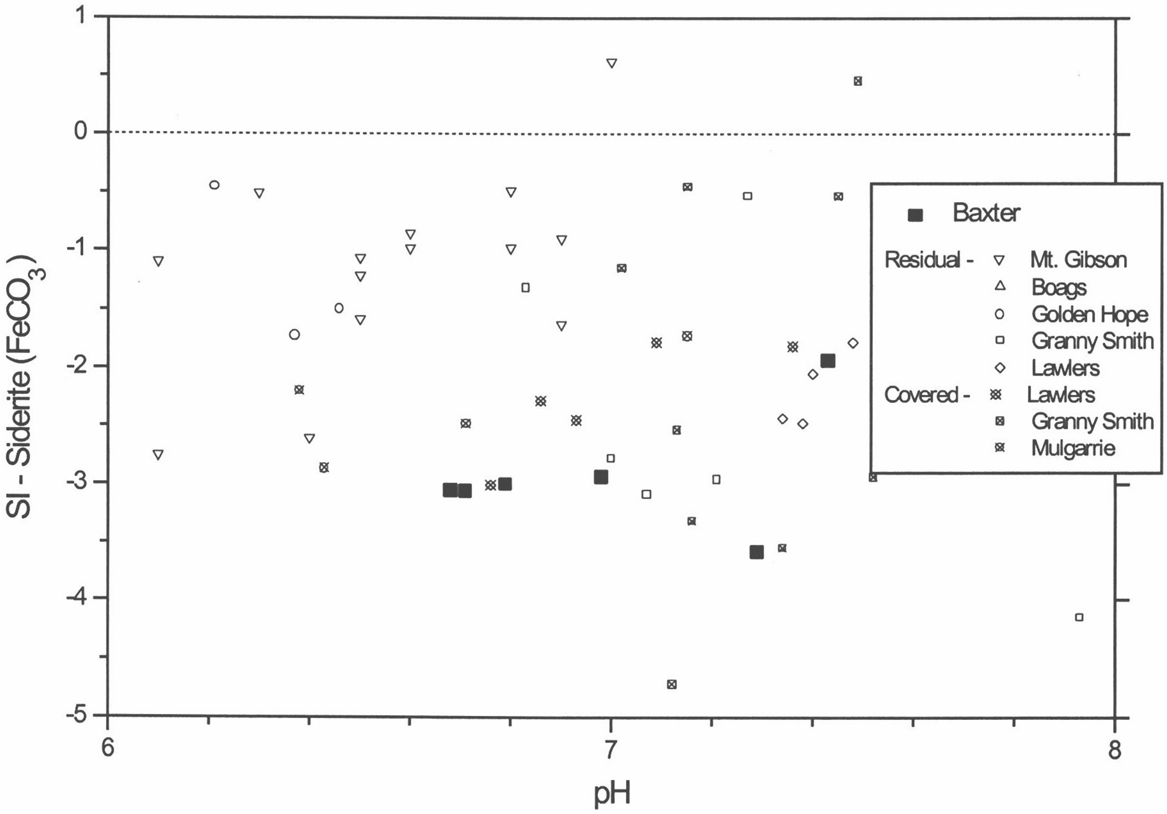

Figure A3.11: SI for siderite vs. pH for groundwaters from Baxter and other sites.

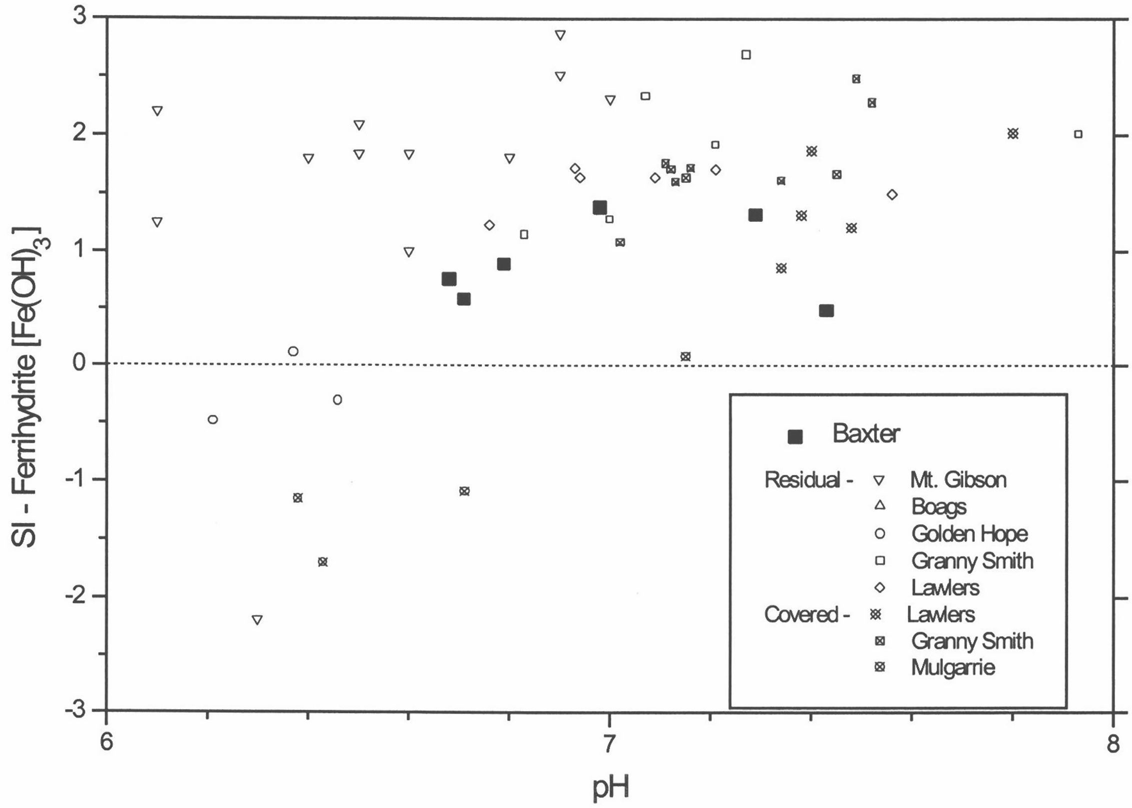

Figure A3.12: SI for ferrihydrite vs. pH for groundwaters from Baxter and other sites.

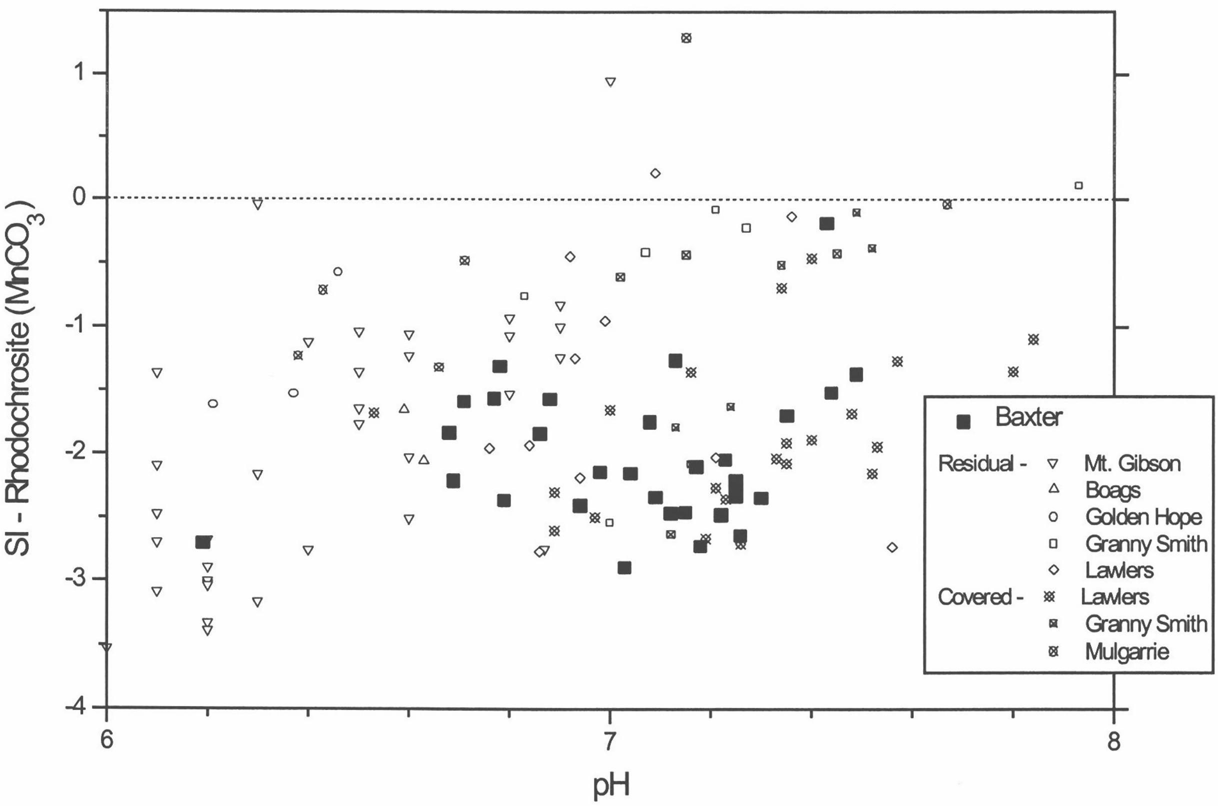

Figure A3.13: SI for rhodochrosite vs. pH for groundwaters from Baxter and other sites.

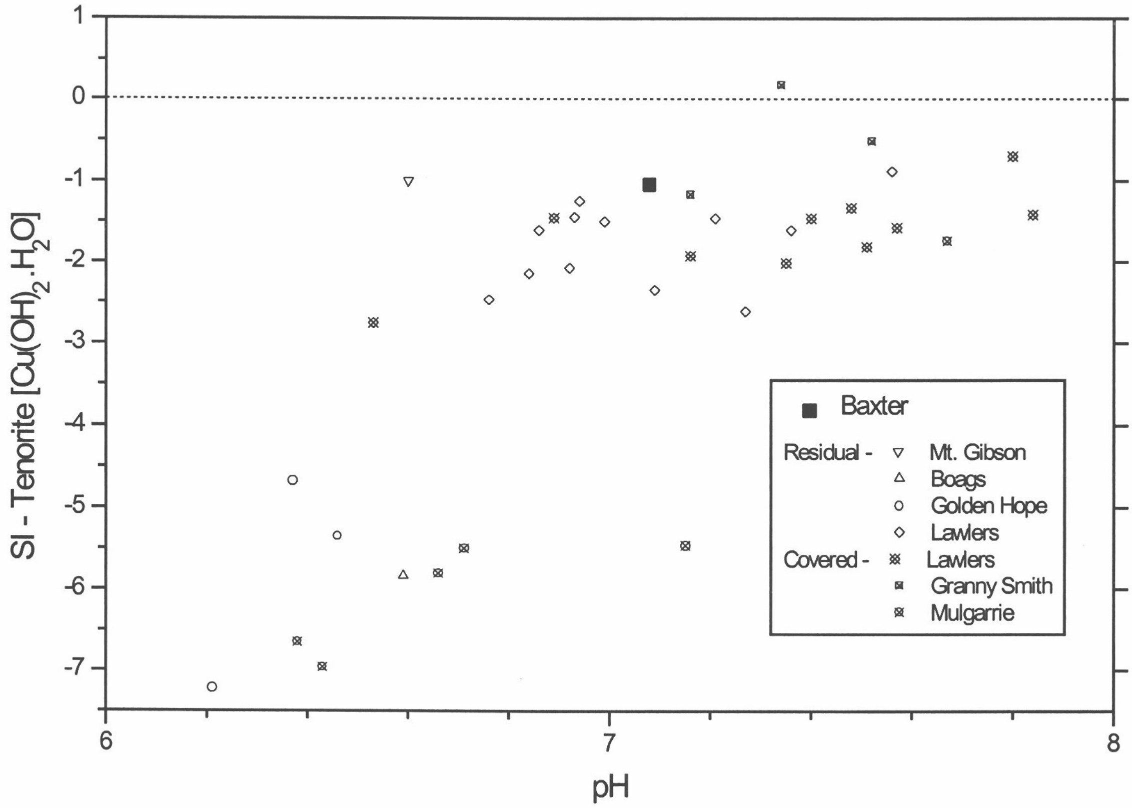

Figure A3.14: SI for tenorite vs. pH for groundwaters from Baxter and other sites.

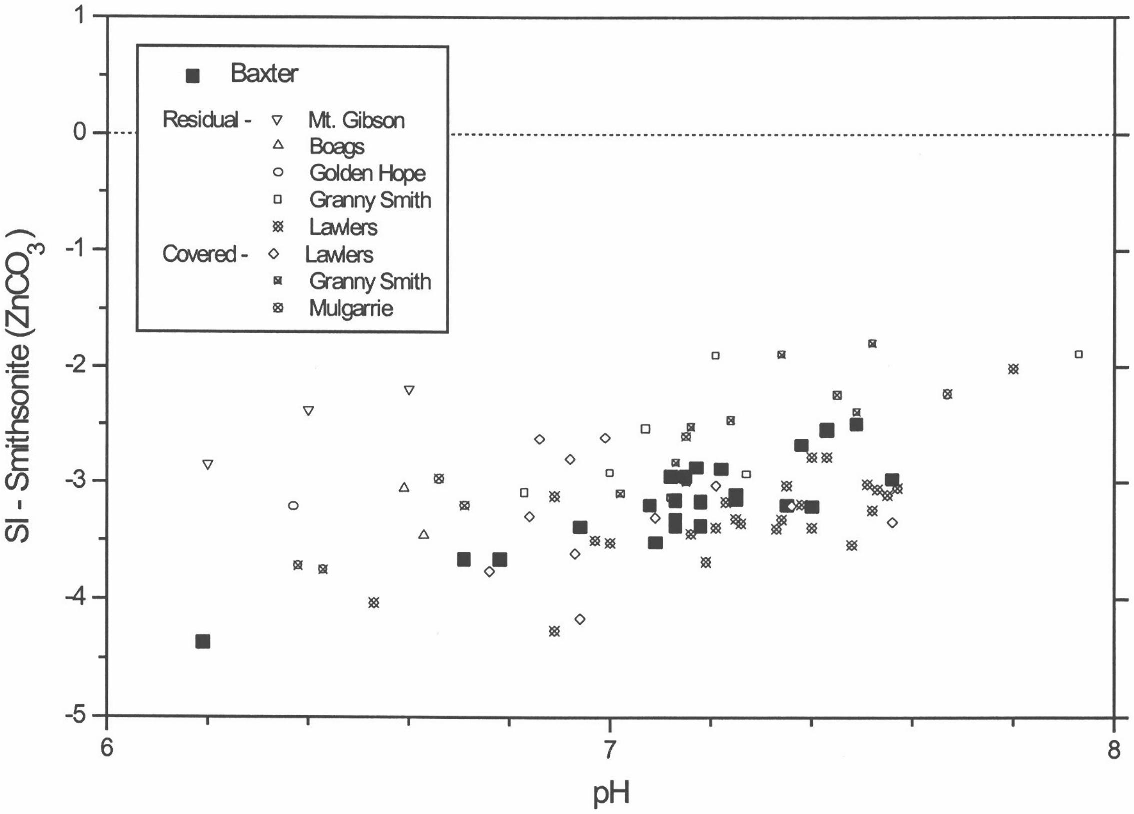

Figure A3.15: SI for smithsonite vs. pH for groundwaters from Baxter and other sites.

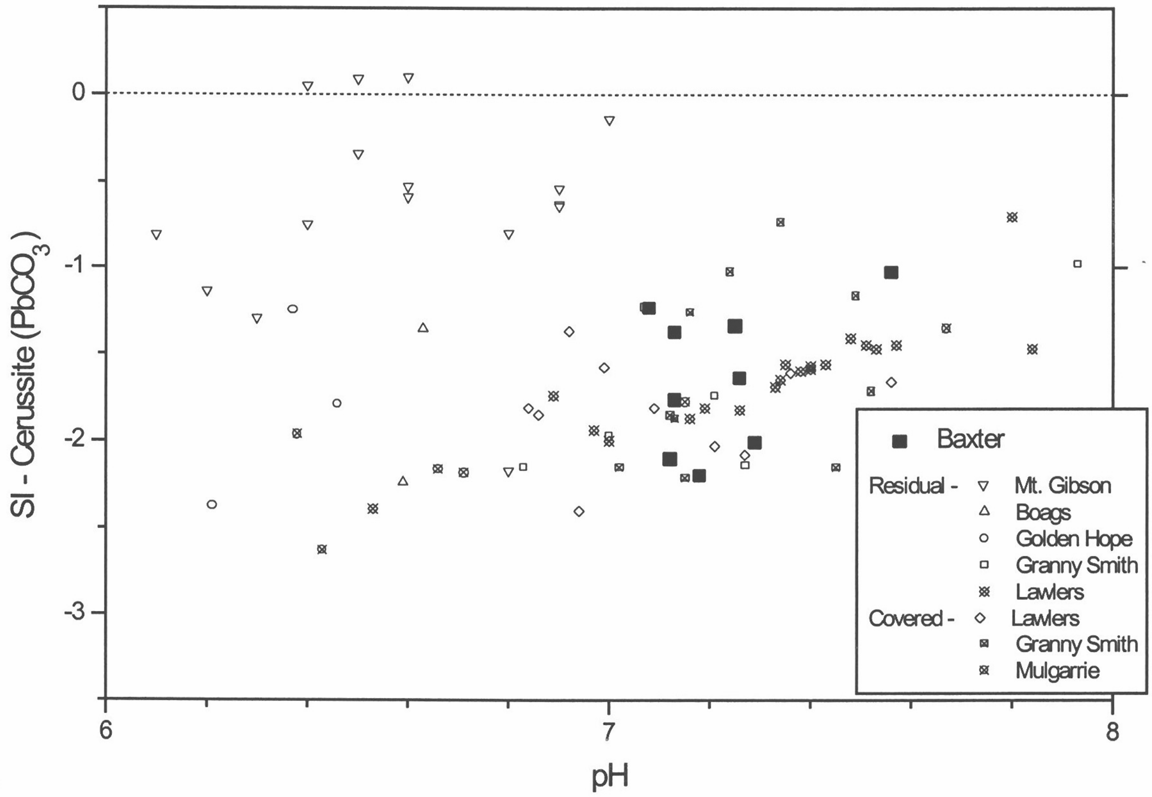

Figure A3.16: SI for cerussite vs. pH for groundwaters from Baxter and other sites.

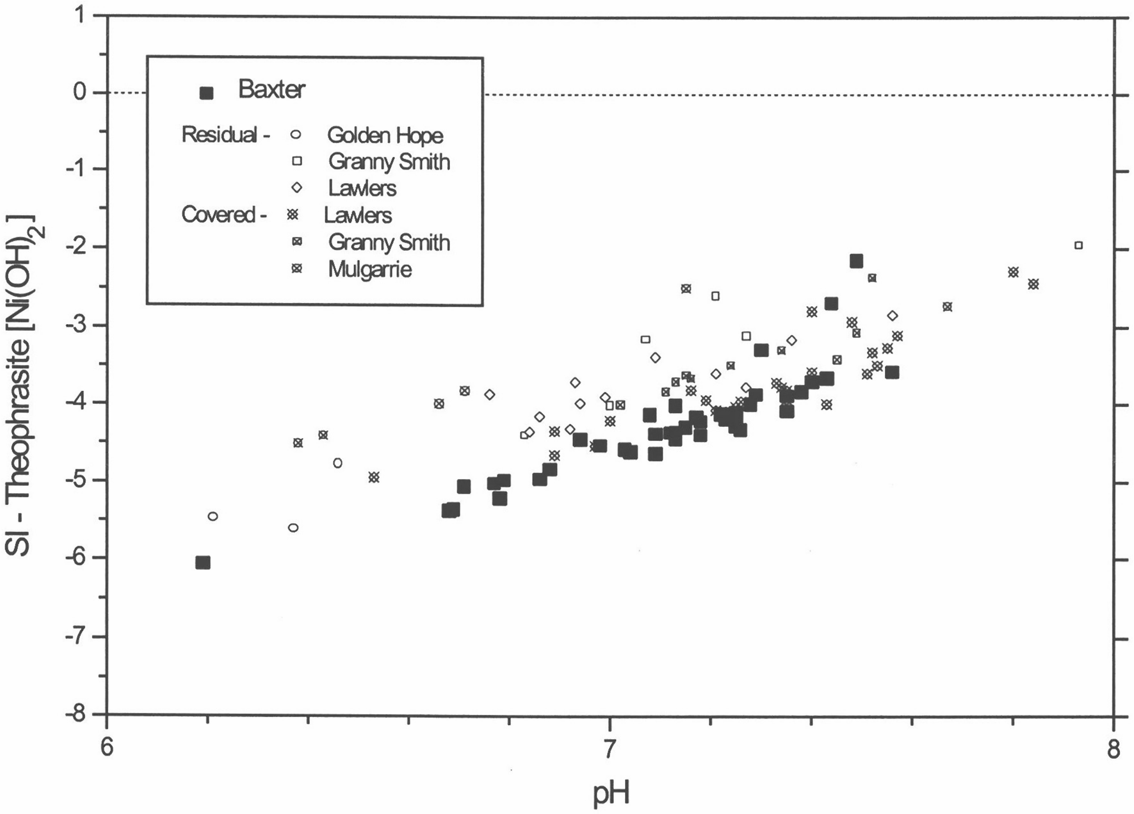

Figure A3.17: SI for theophrasite vs. pH for groundwaters from Baxter and other sites.

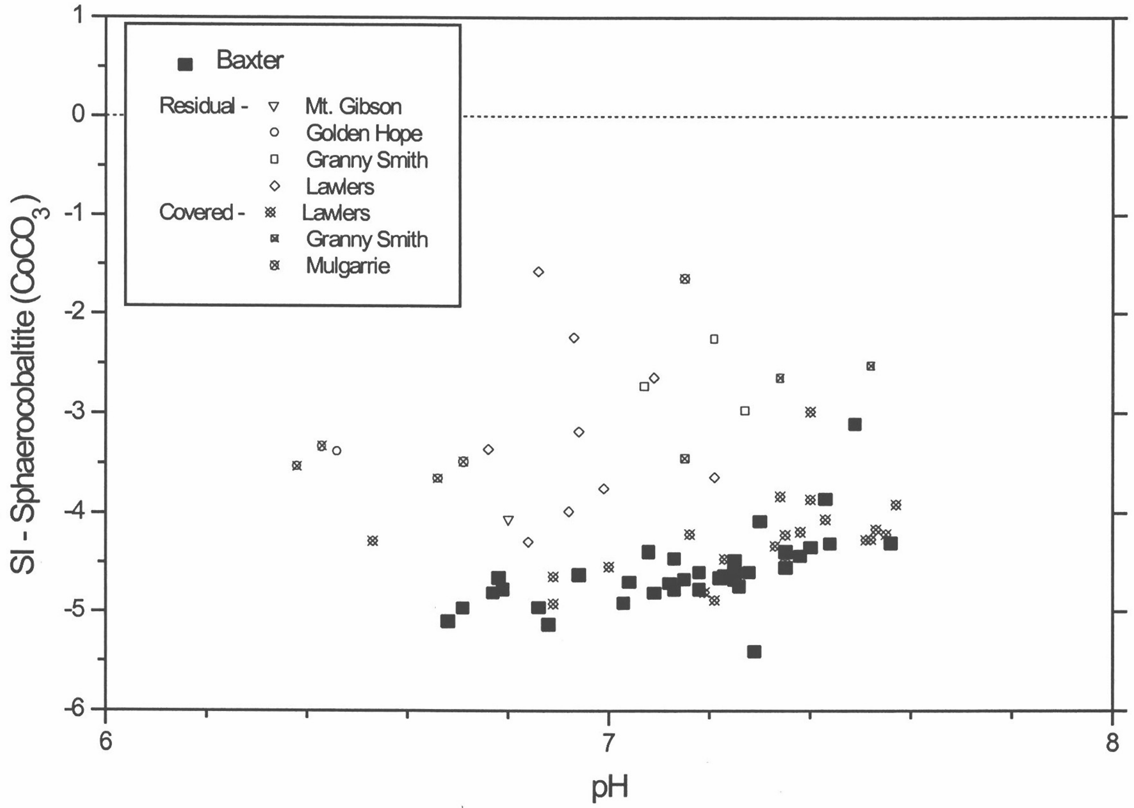

Figure A3.18: SI for sphaerocobaltite vs. pH for groundwaters from Baxter and other sites.

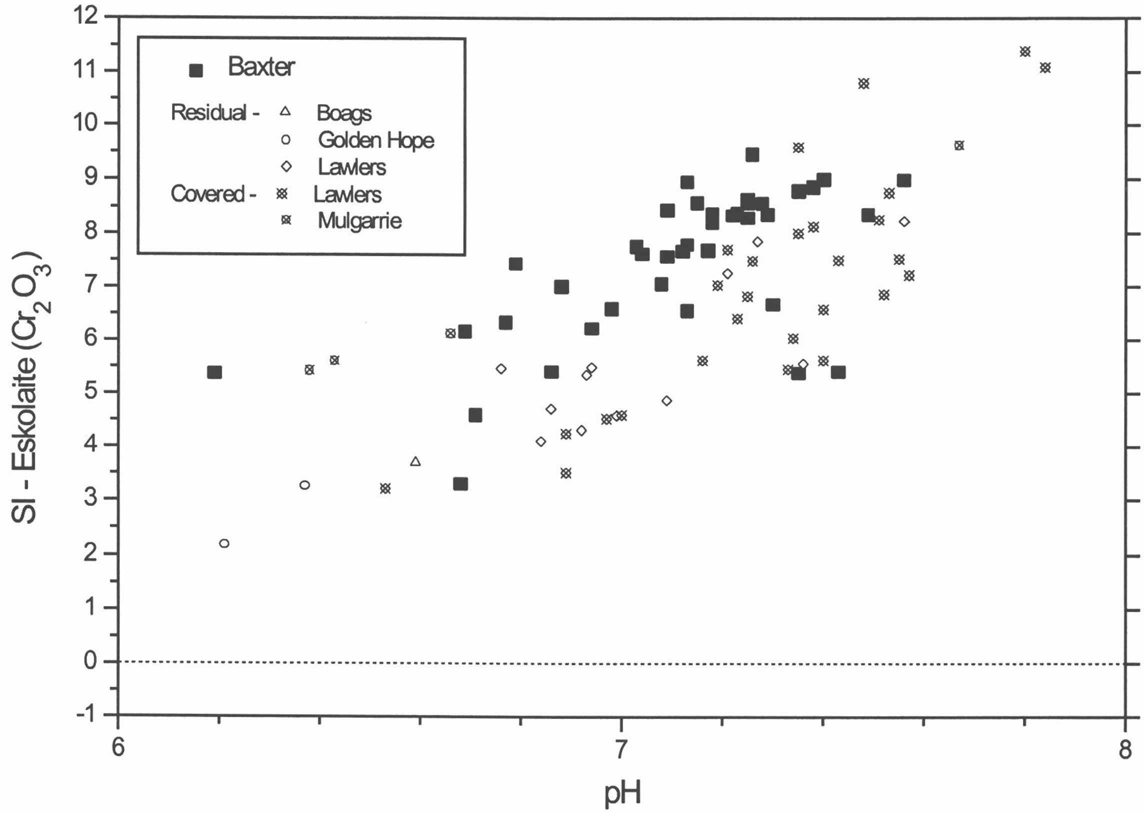

Figure A3.19: SI for eskolaite vs. pH for groundwaters from Baxter and other sites.

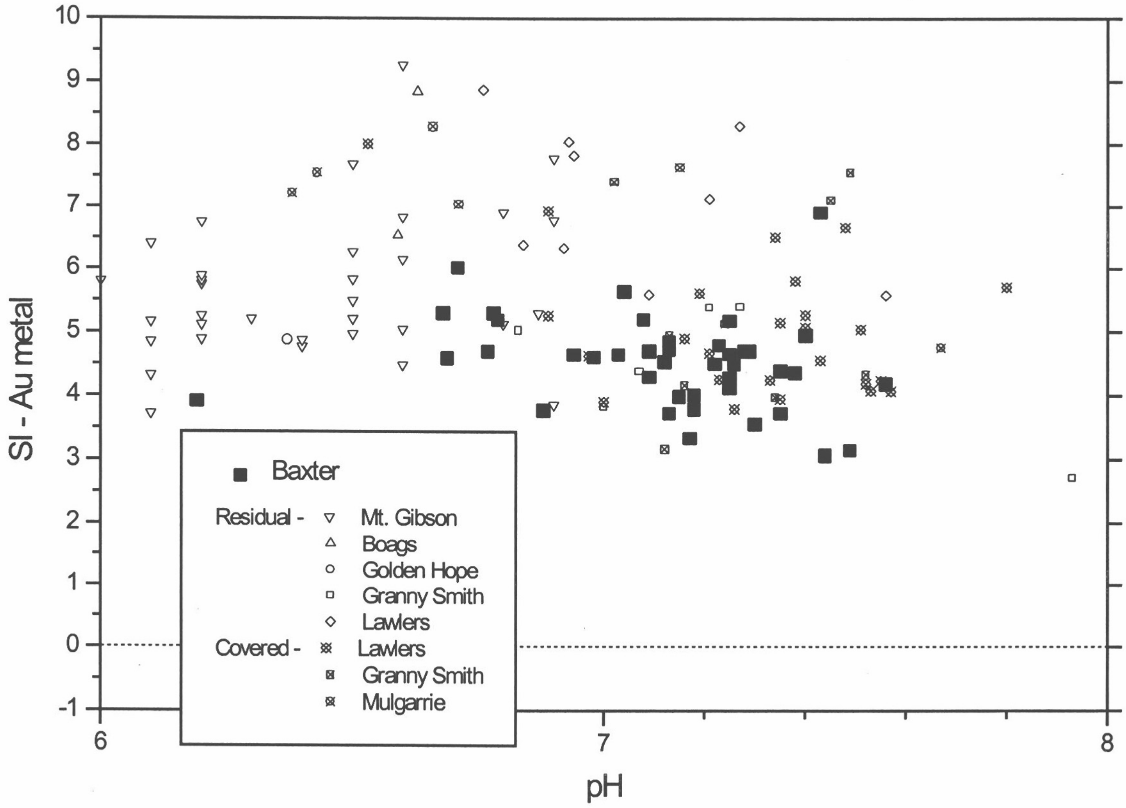

Figure A3.20: SI for Au metal vs. pH for groundwaters from Baxter and other sites.

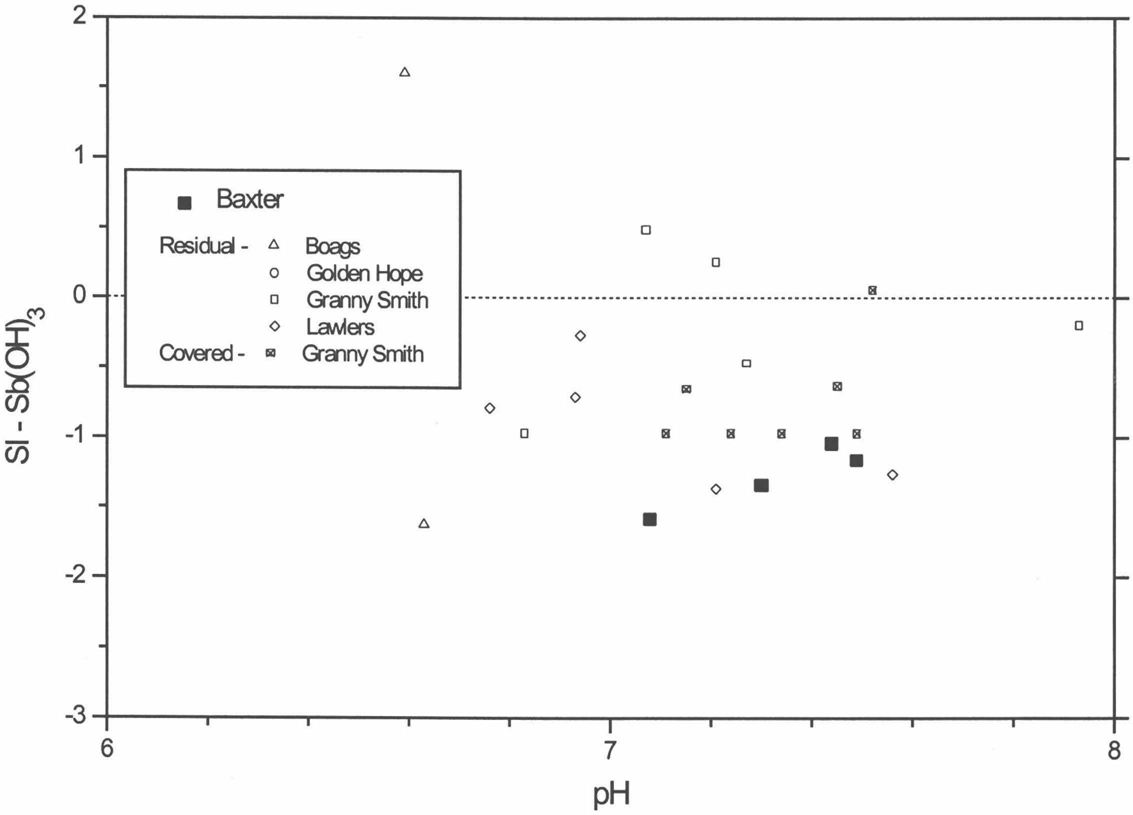

Figure A3.21: SI for $Sb(OH)_3$ vs. pH for groundwaters from Baxter and other sites.

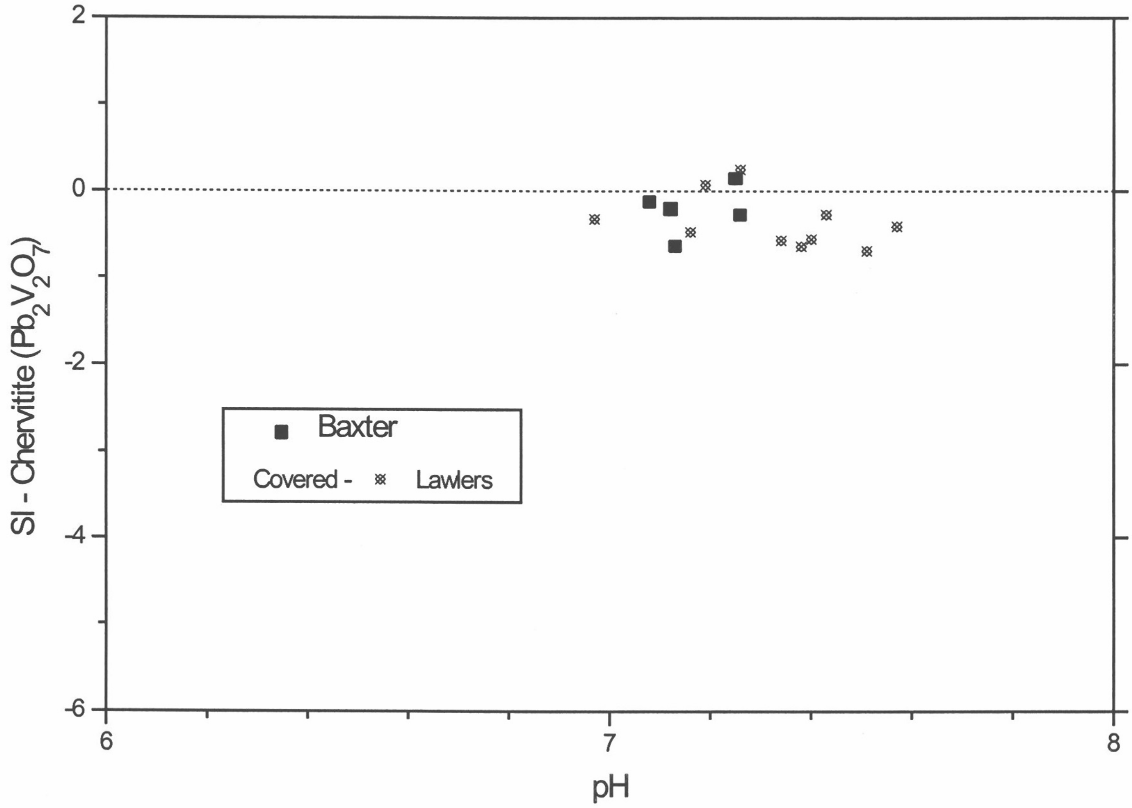

Figure A3.22: SI for chervitite vs. pH for groundwaters from Baxter and other sites.

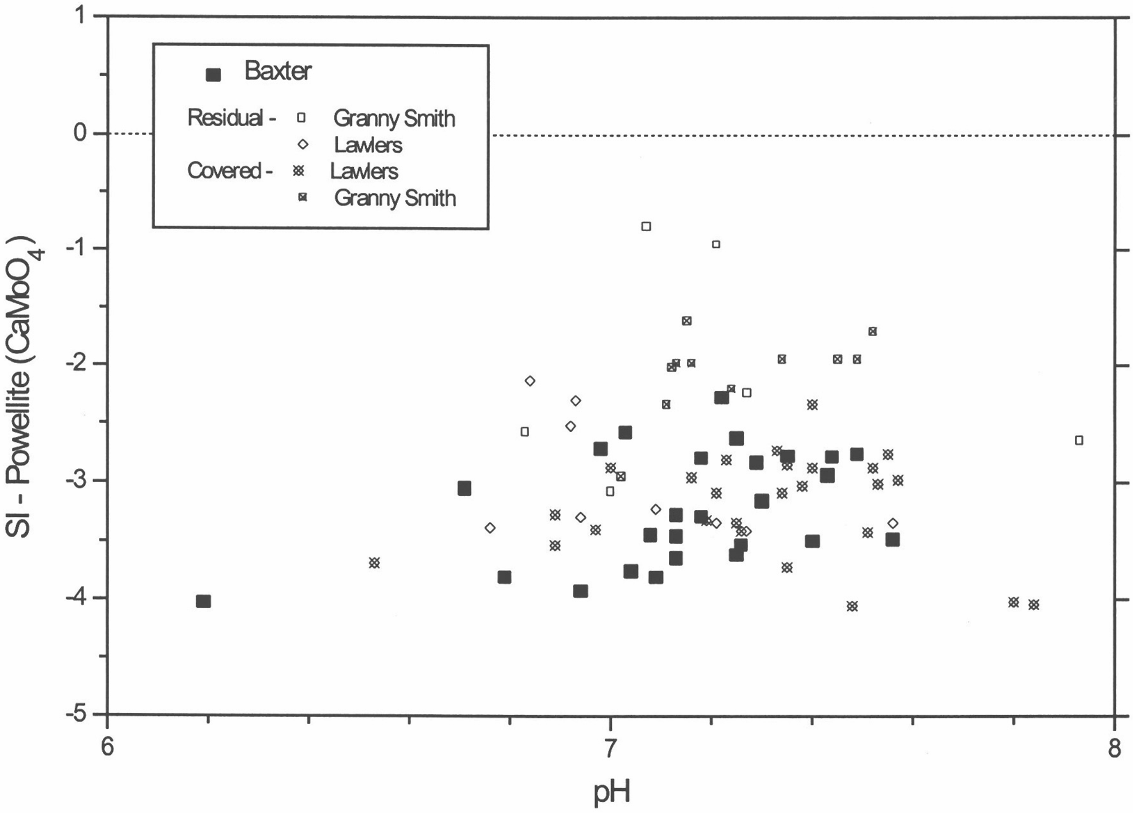

Figure A3.23: SI for powellite vs. pH for groundwaters from Baxter and other sites.

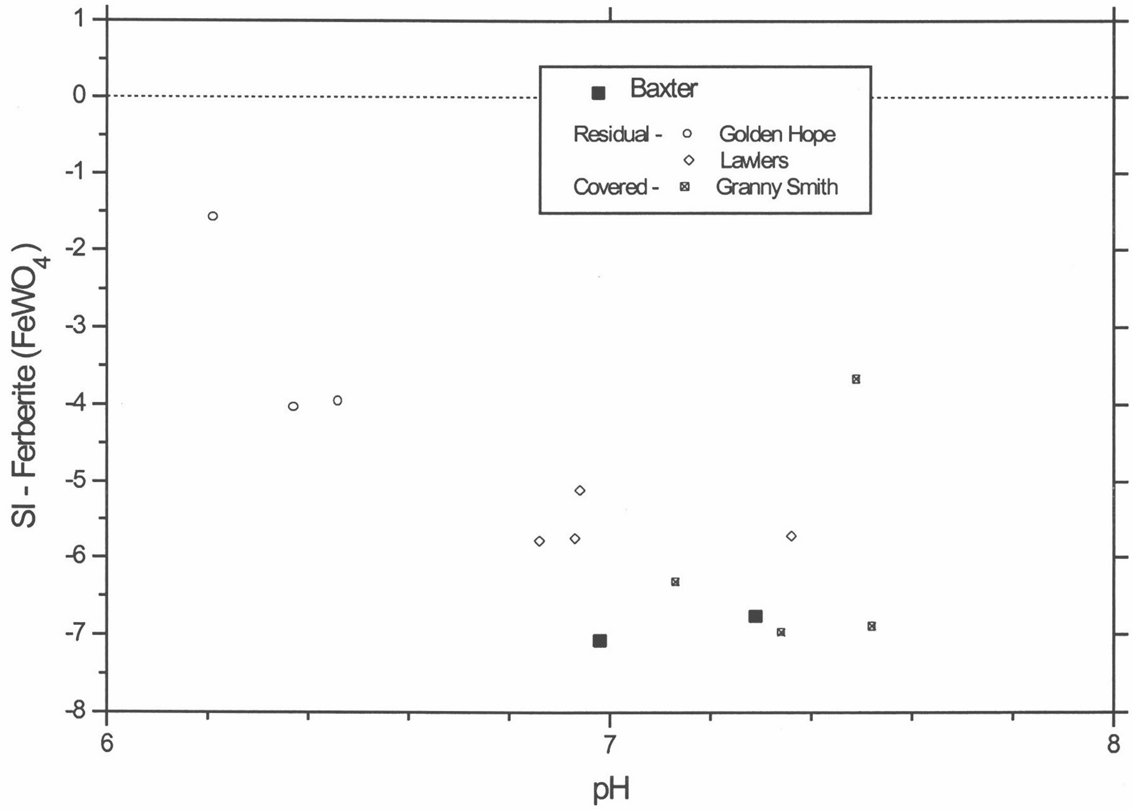

Figure A3.24: SI for ferberite vs. pH for groundwaters from Baxter and other sites.

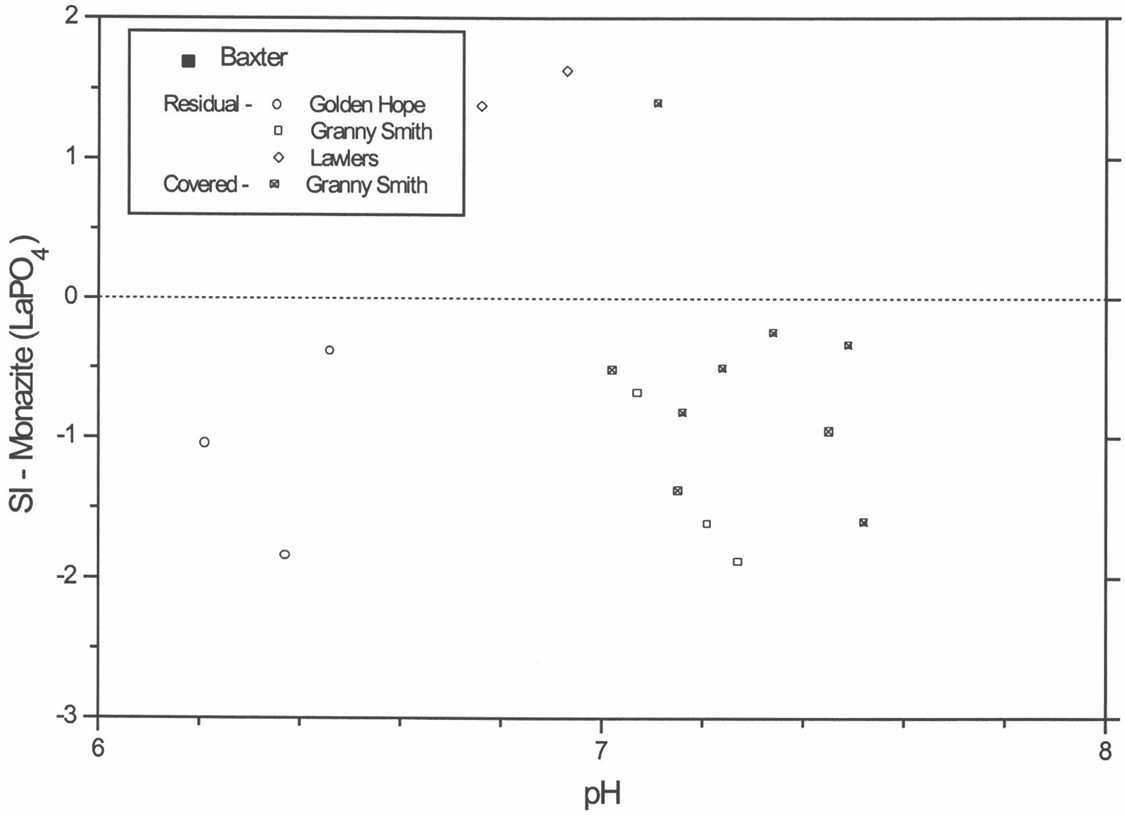

Figure A3.25: SI for monazite-(La) vs. pH for groundwaters from Baxter and other sites.

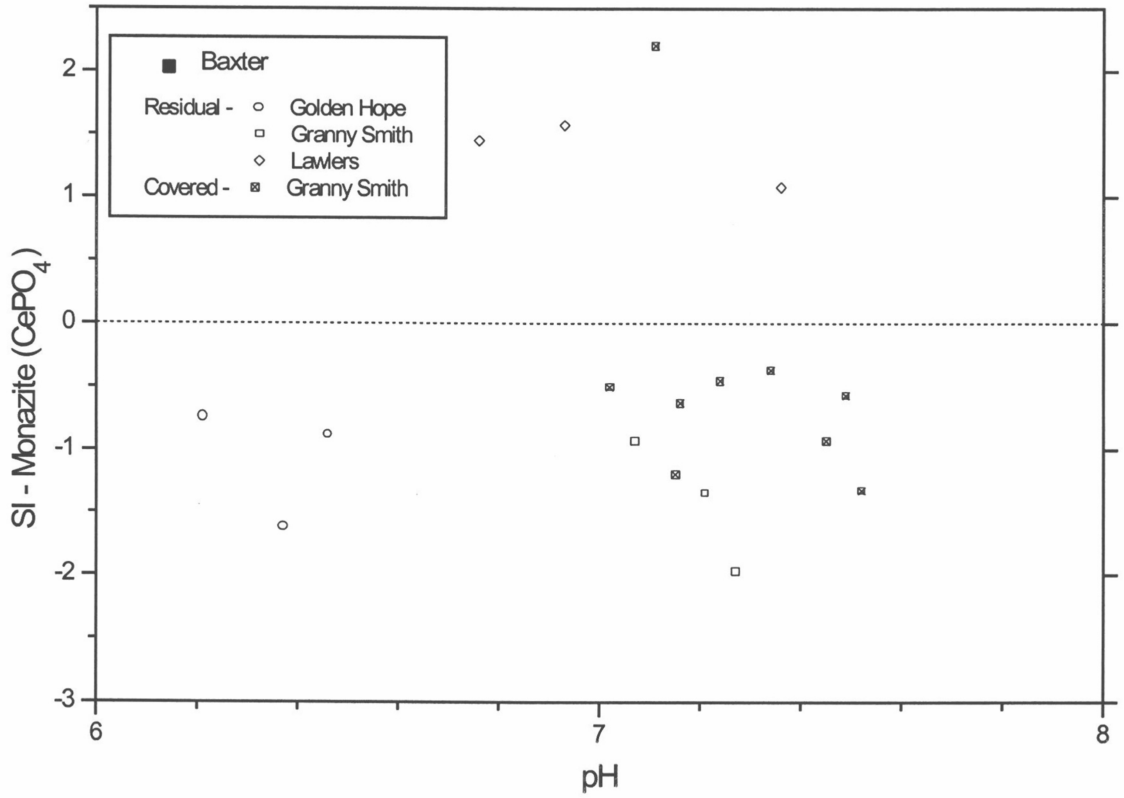

Figure A3.26: SI for monazite-(Ce) vs. pH for groundwaters from Baxter and other sites.

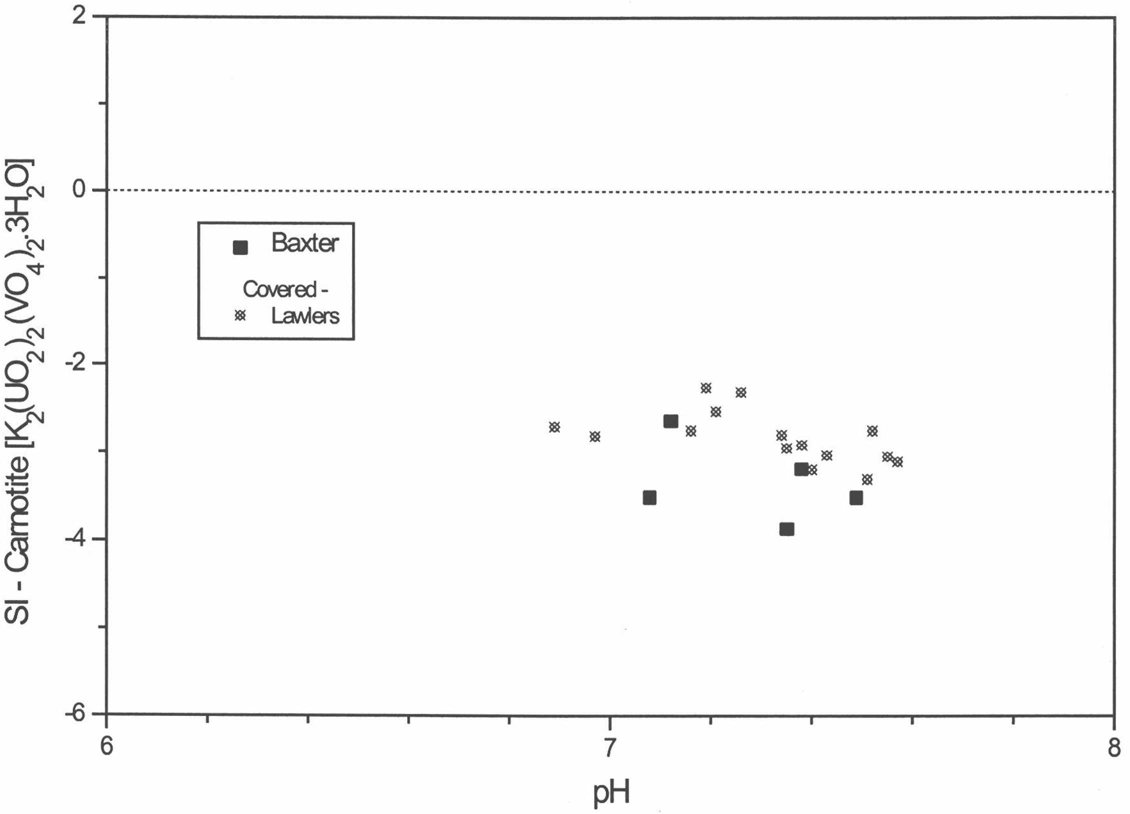

Figure A3.27: SI for Carnotite vs. pH for groundwaters from Baxter and other sites.

Appendix 4: Element/Ion Distribution Maps

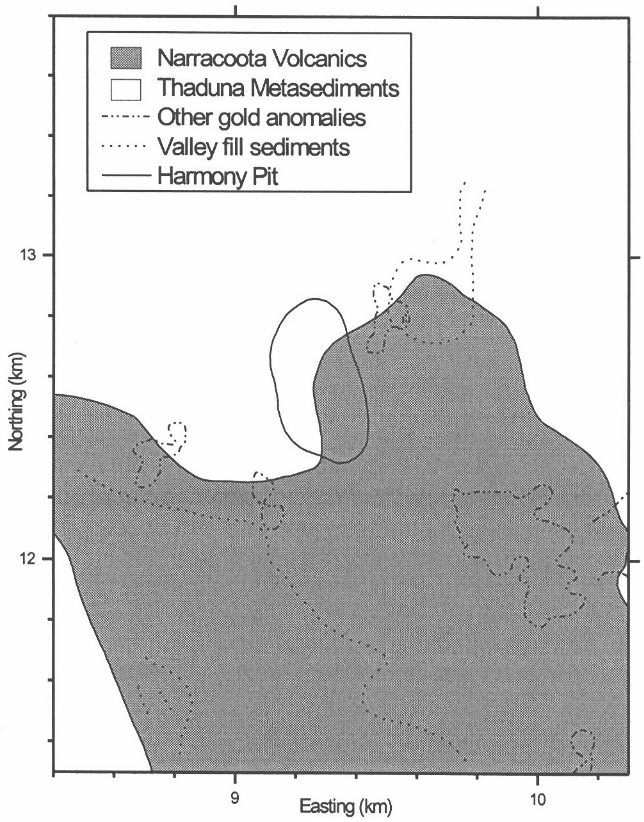

Figure A4.1: Geology of the Baxter study area, showing the Harmony Pit, other Au anomalies and valley fill sediments.

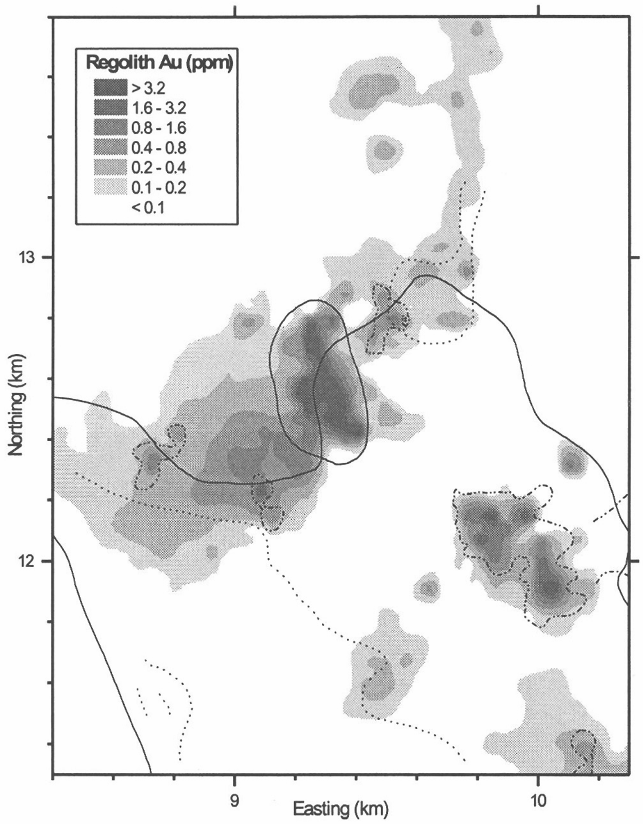

Figure A4.2: Contours of maximum Au from RAB drill cuttings at Baxter.

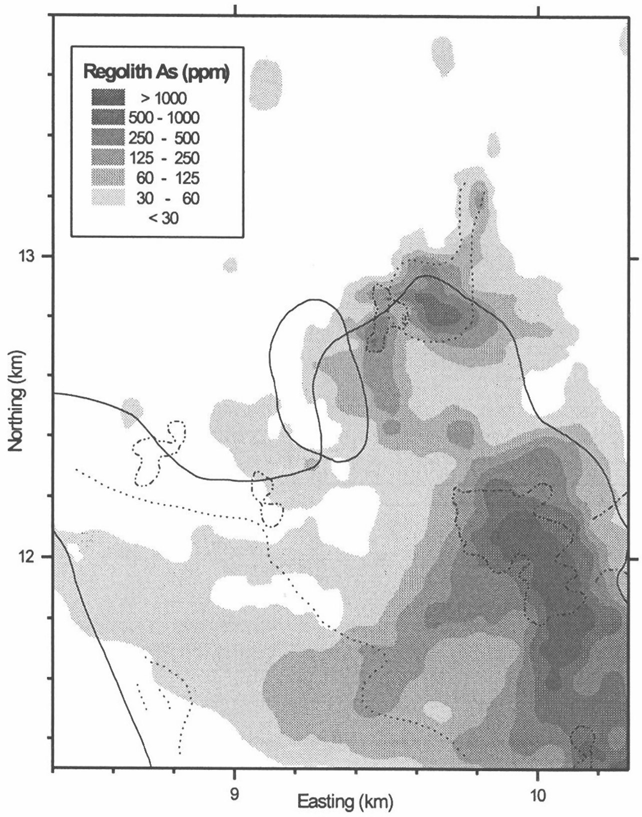

Figure A4.3: Contours of maximum As from RAB drill cuttings at Baxter.

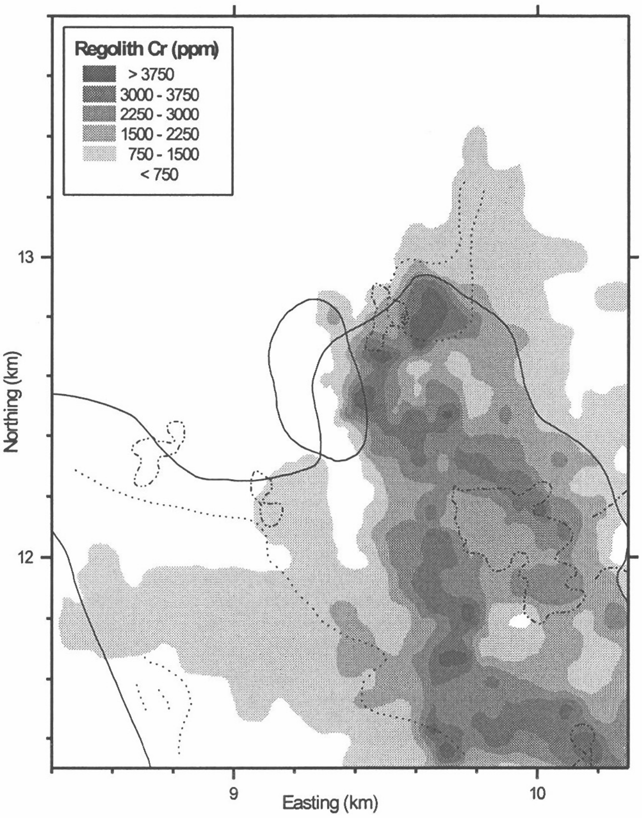

Figure A4.4: Contours of maximum Cr from RAB drill cuttings at Baxter.

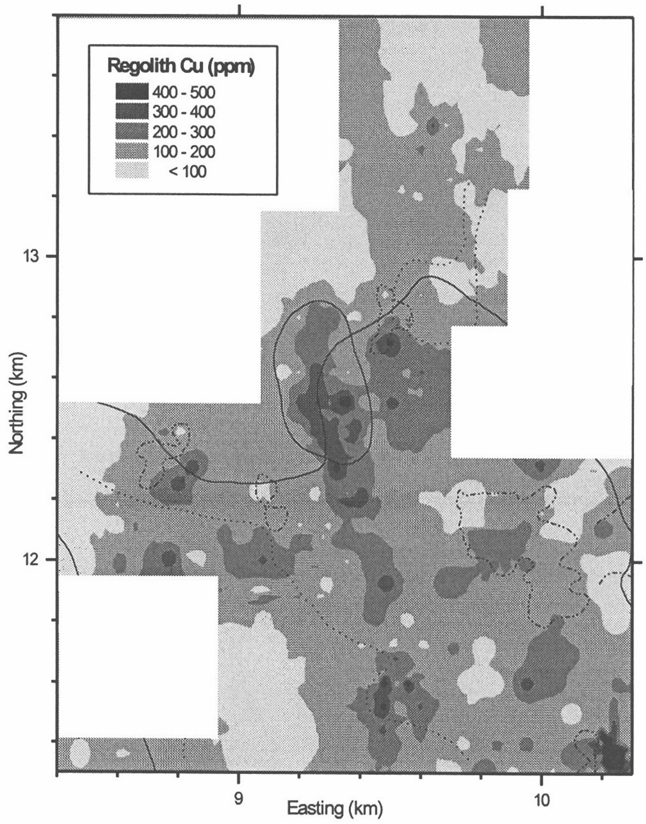

Figure A4.5: Contours of maximum Cu from RAB drill cuttings at Baxter.

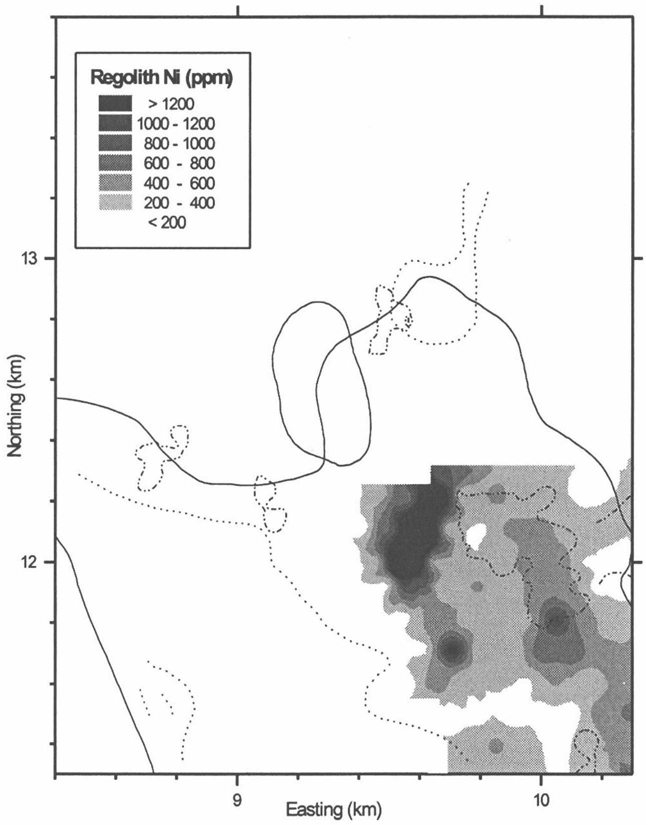

Figure A4.6: Contours of maximum Ni from RAB drill cuttings at Baxter.

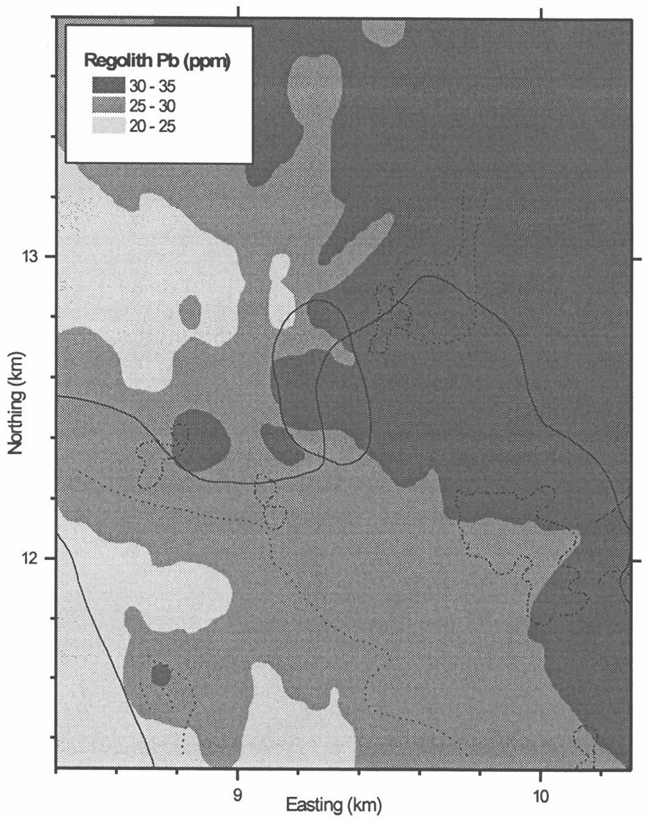

Figure A4.7: Contours of maximum Pb from RAB drill cuttings at Baxter.

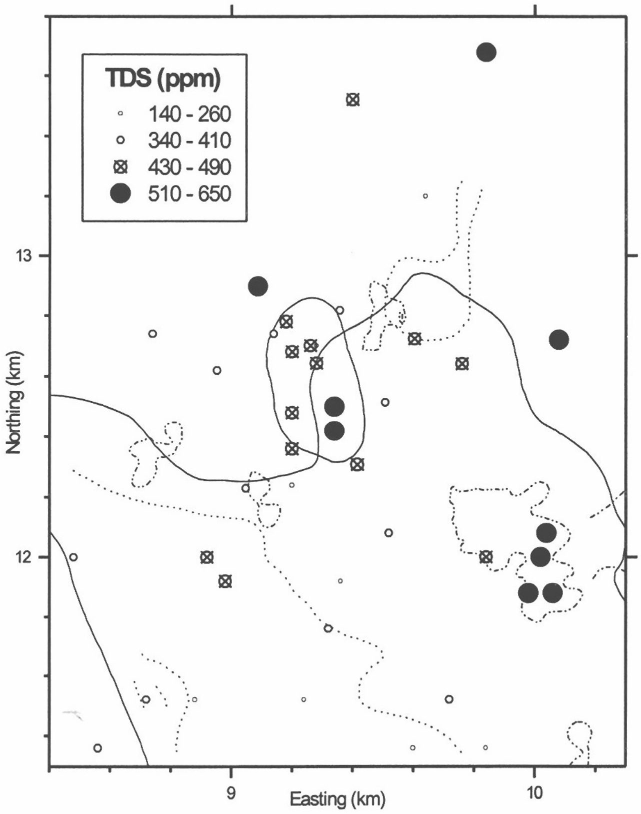

Figure A4.8: TDS distribution in Baxter groundwaters.

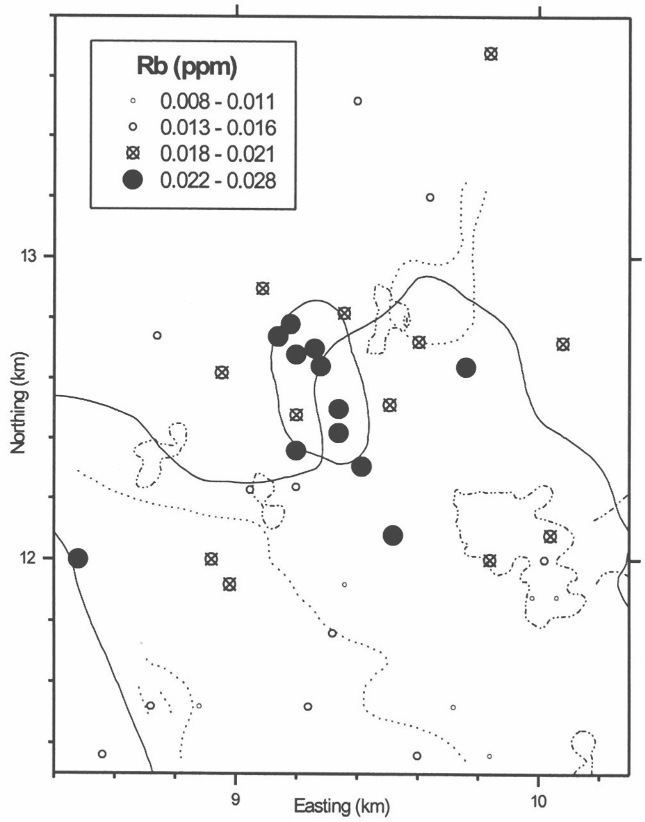

Figure A4.9: Rb distribution in Baxter groundwaters.

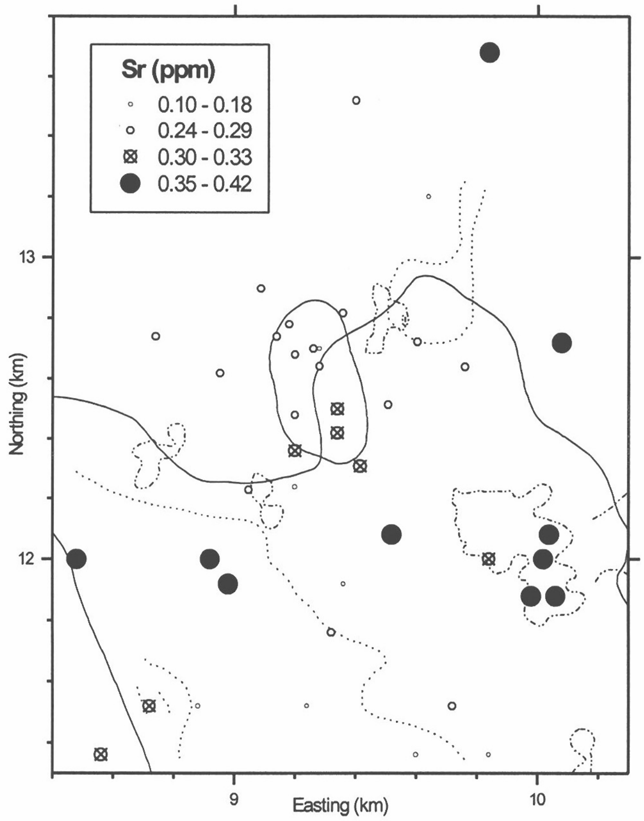

Figure A4.10: Sr distribution in Baxter groundwaters.

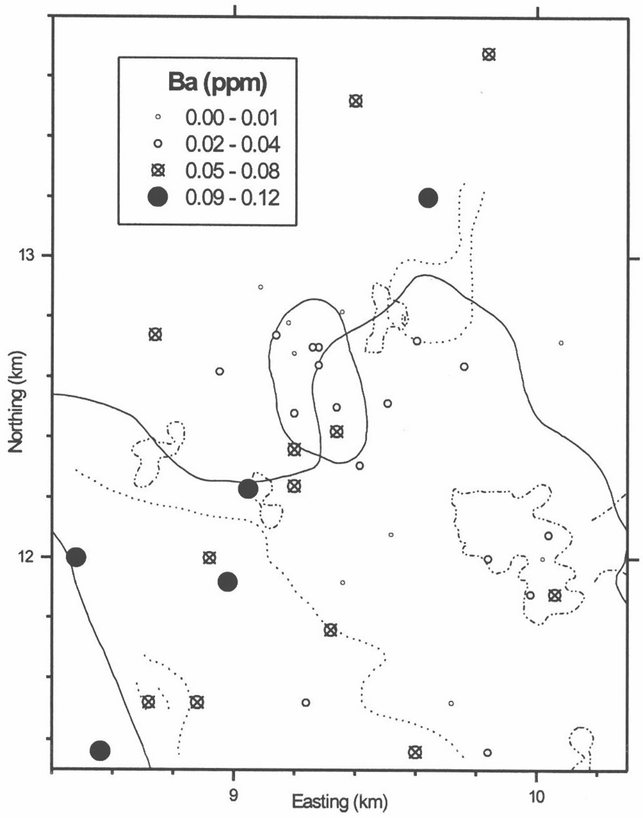

Figure A4.11: Ba distribution in Baxter groundwaters.

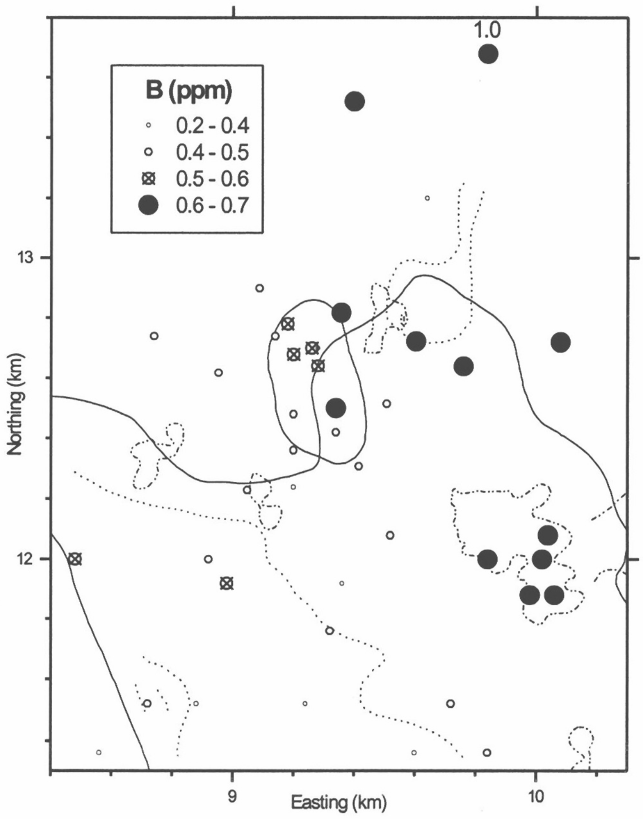

Figure A4.12: B distribution in Baxter groundwaters.

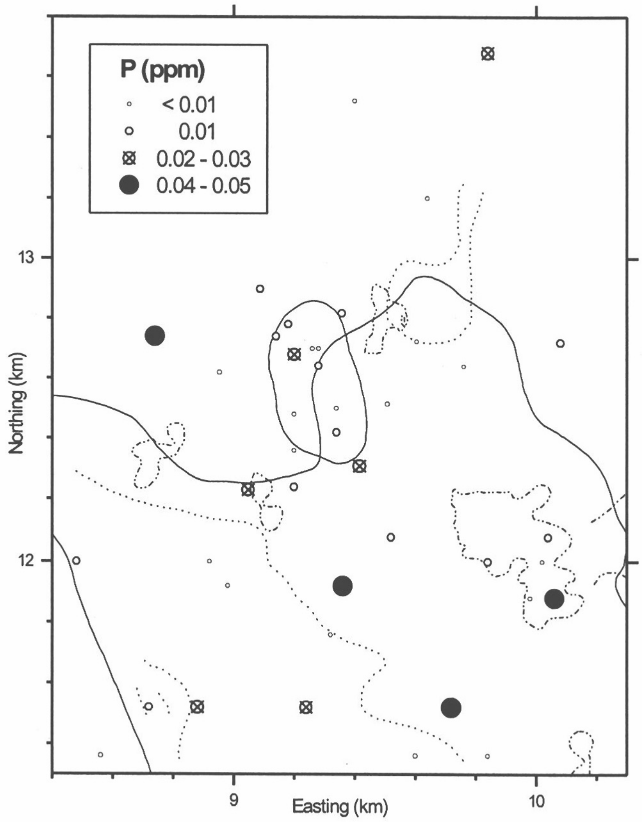

Figure A4.13: P distribution in Baxter groundwaters.

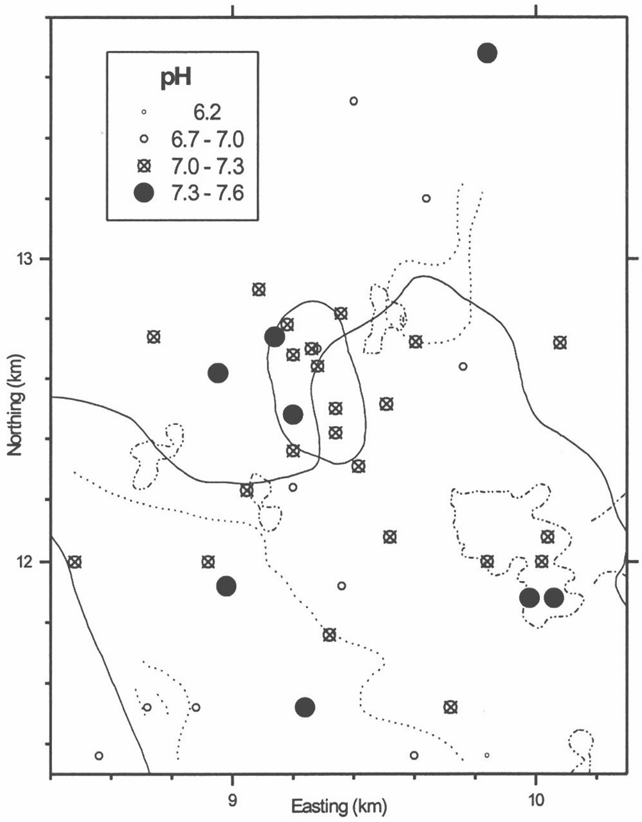

Figure A4.14: pH distribution in Baxter groundwaters.

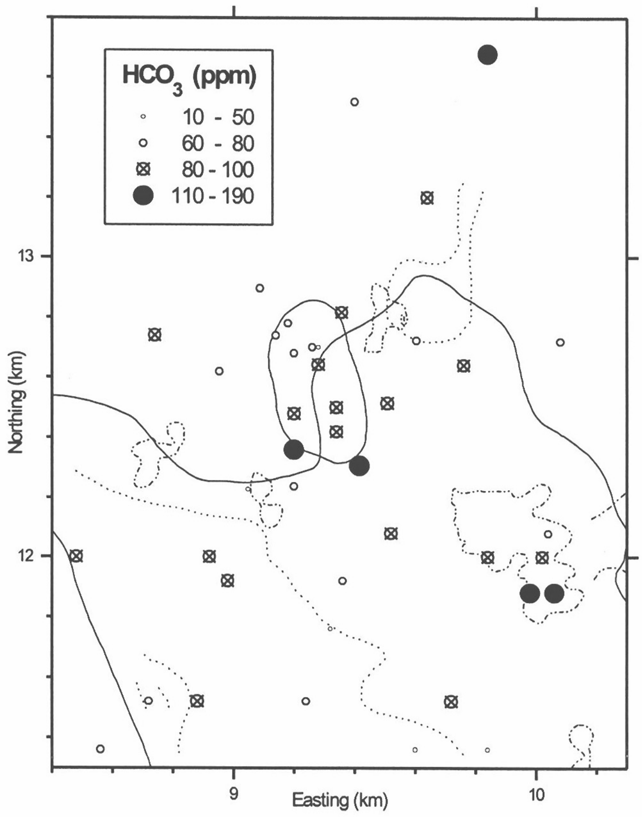

Figure A4.15: HCO_3 distribution in Baxter groundwaters.

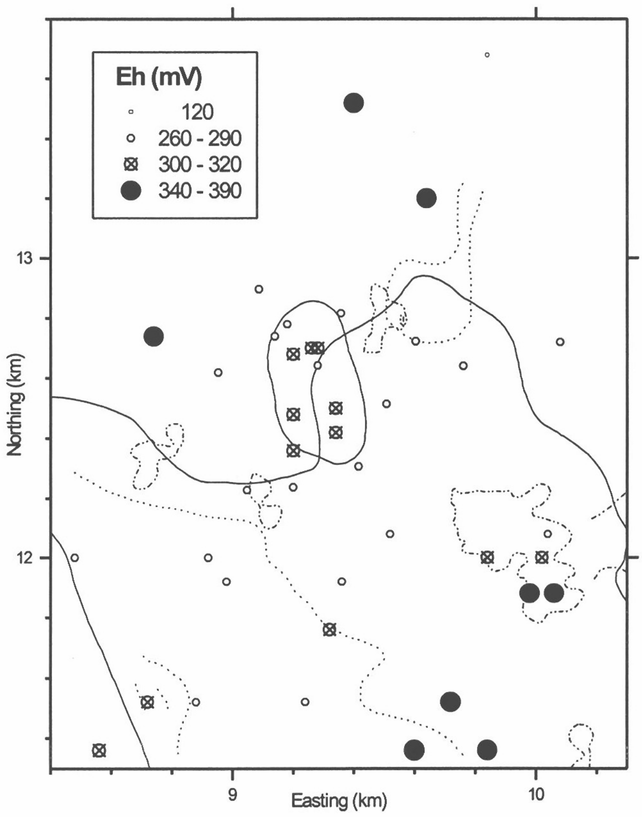

Figure A4.16: Eh distribution in Baxter groundwaters.

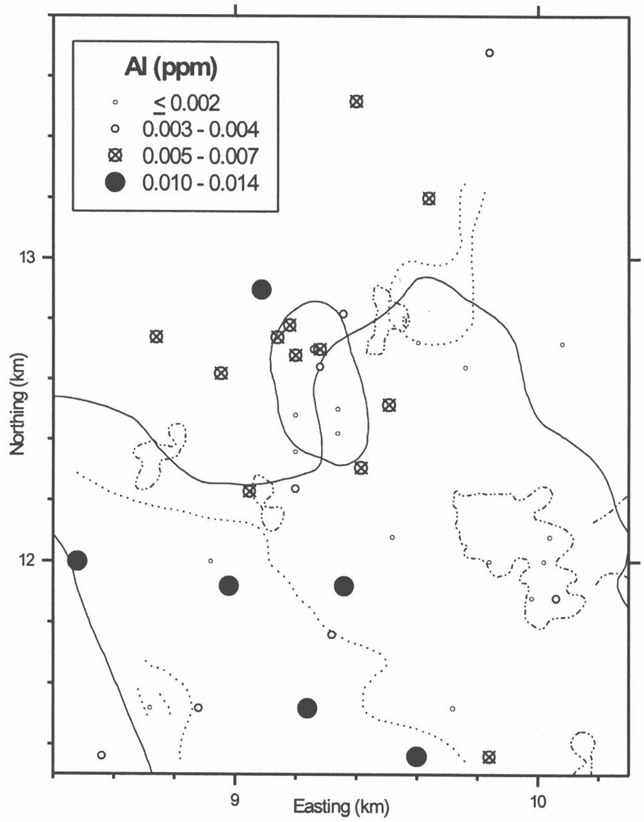

Figure A4.17: Al distribution in Baxter groundwaters.

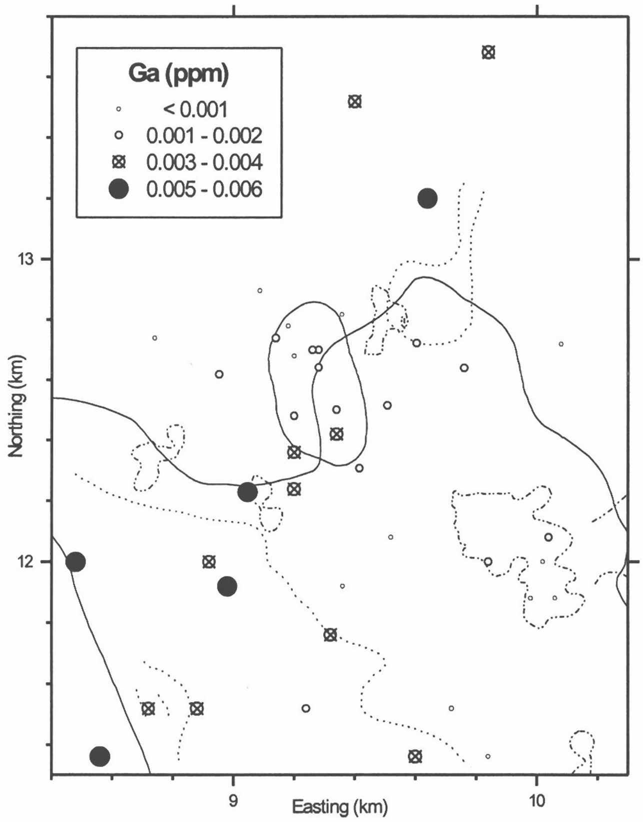

Figure A4.18: Ga distribution in Baxter groundwaters.

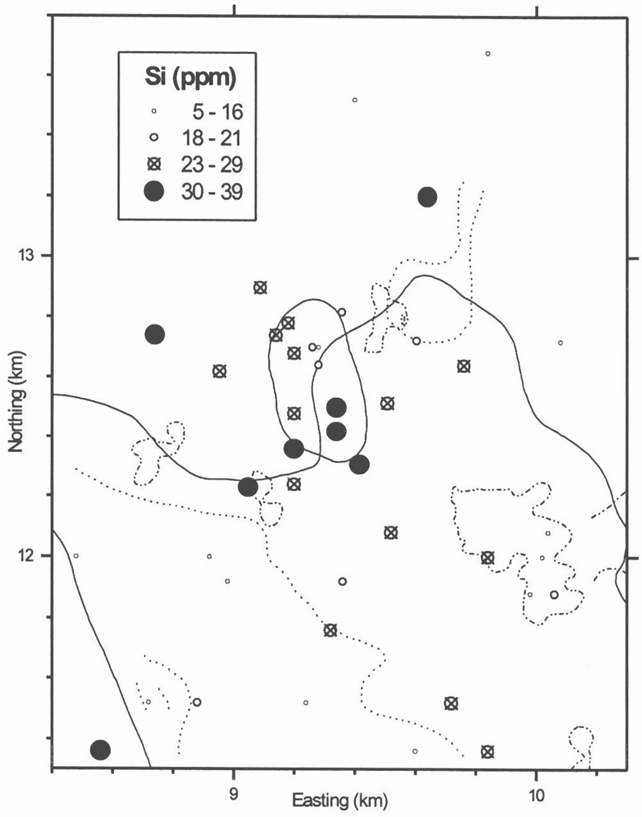

Figure A4.19: Si distribution in Baxter groundwaters.

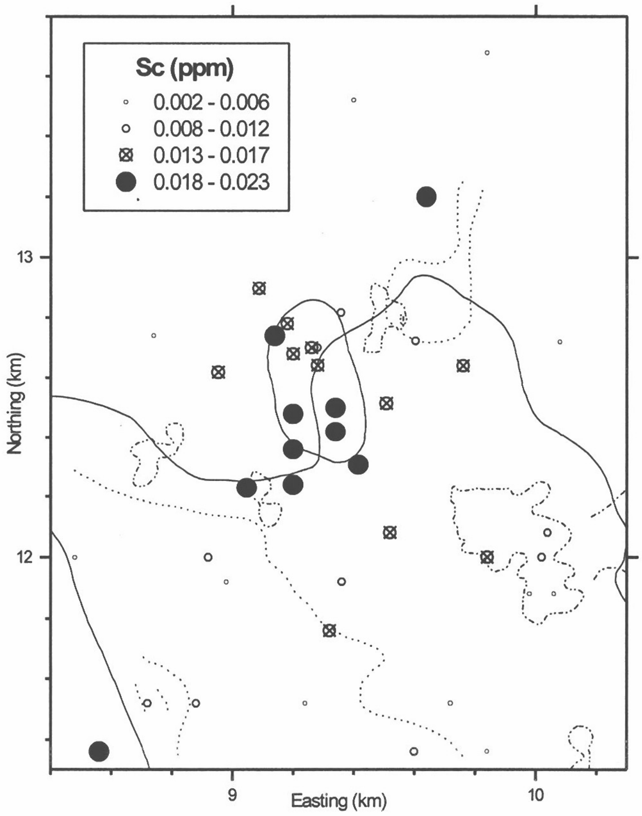

Figure A4.20: Sc distribution in Baxter groundwaters.

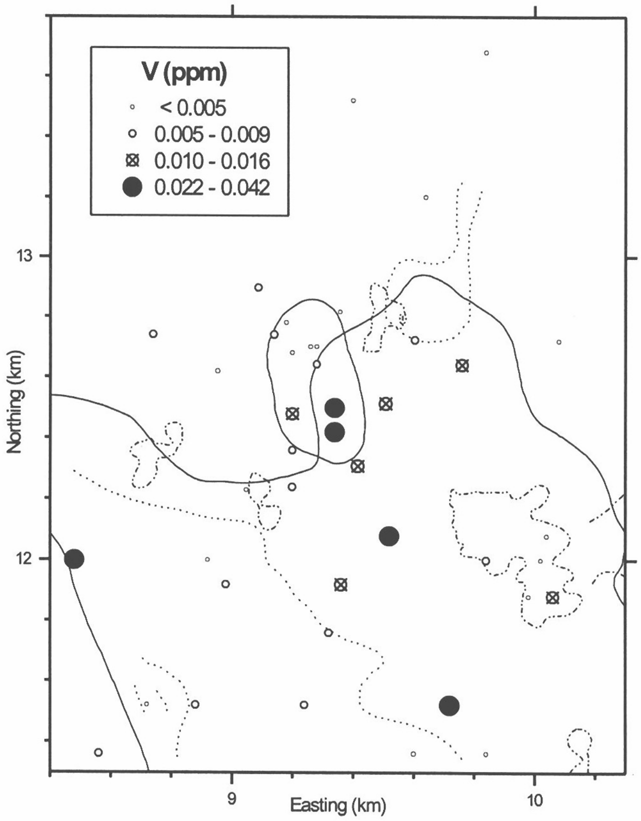

Figure A4.21: V distribution in Baxter groundwaters.

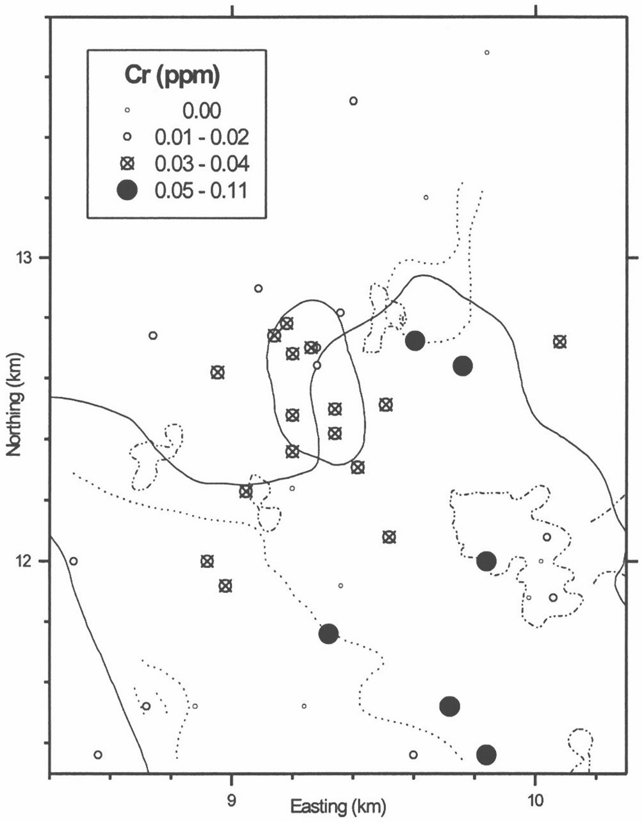

Figure A4.22: Cr distribution in Baxter groundwaters.

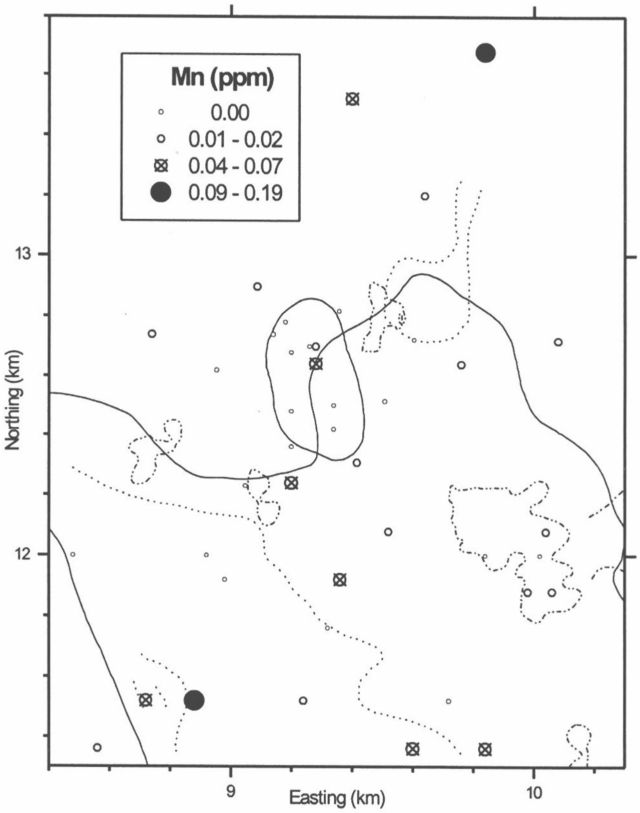

Figure A4.23: Mn distribution in Baxter groundwaters.

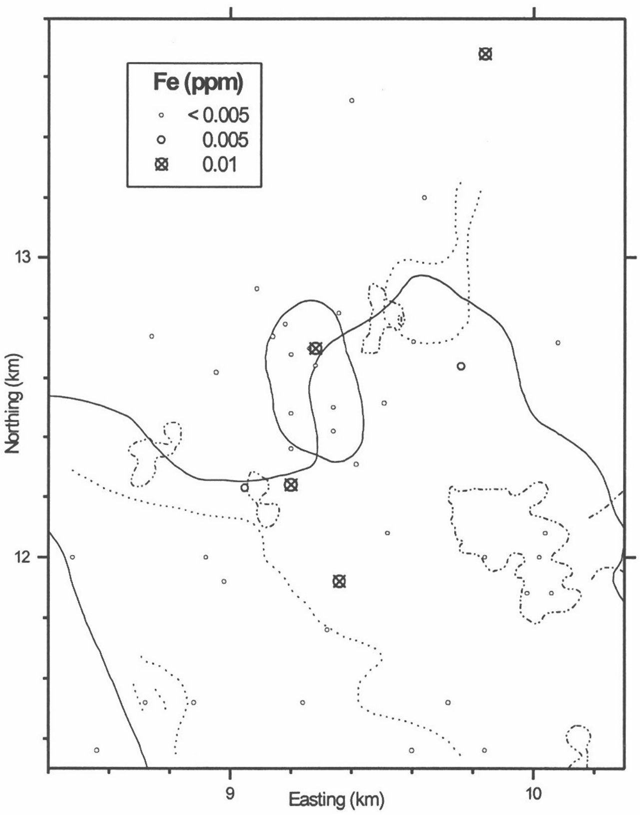

Figure A4.24: Fe distribution in Baxter groundwaters.

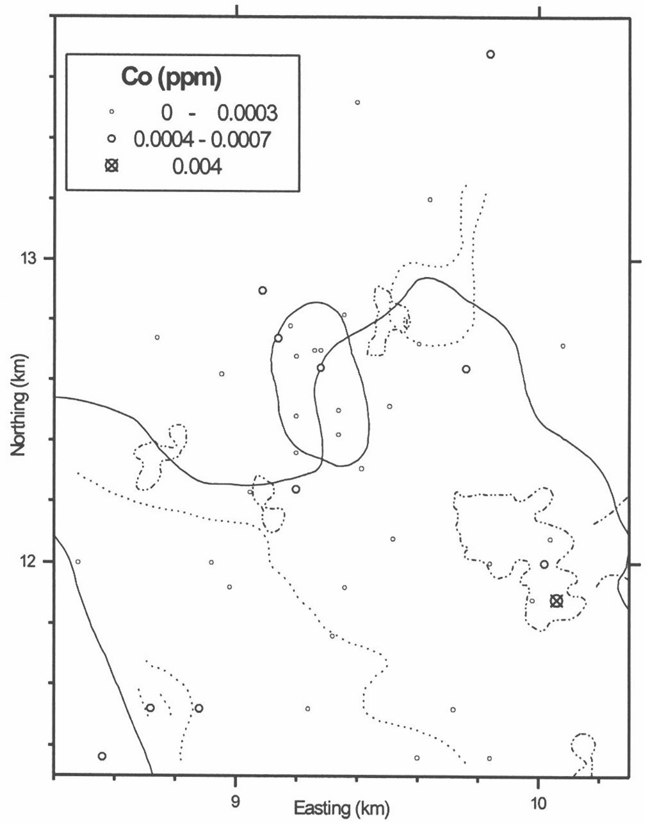

Figure A4.25: Co distribution in Baxter groundwaters.

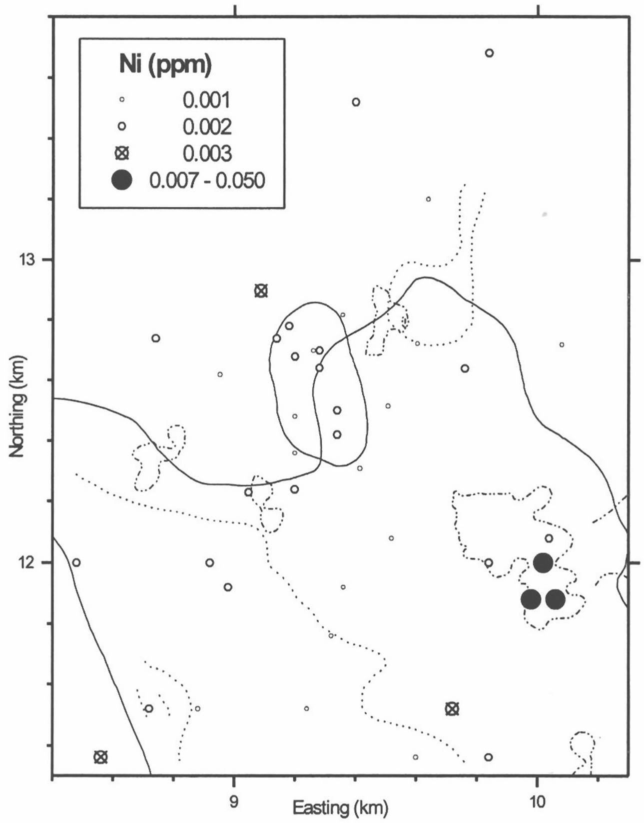

Figure A4.26: Ni distribution in Baxter groundwaters.

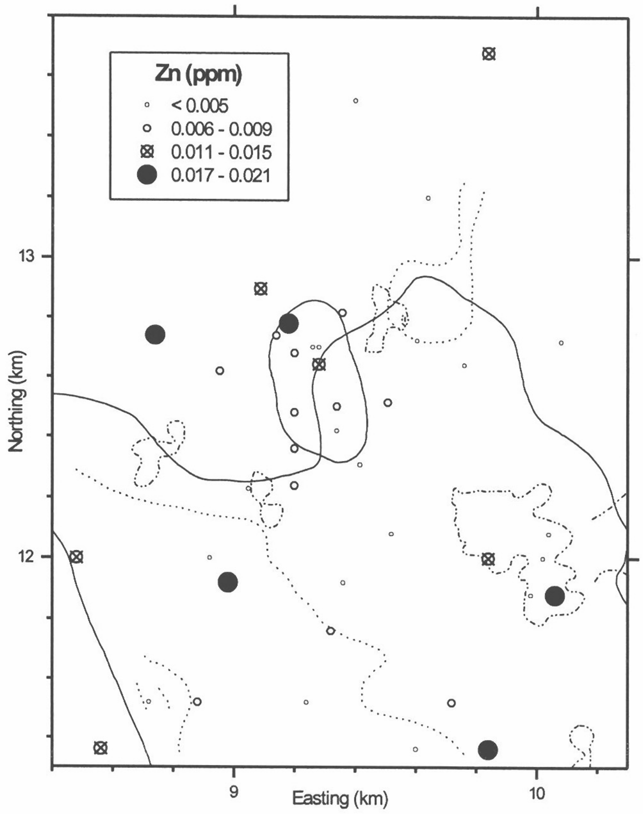

Figure A4.27: Zn distribution in Baxter groundwaters.

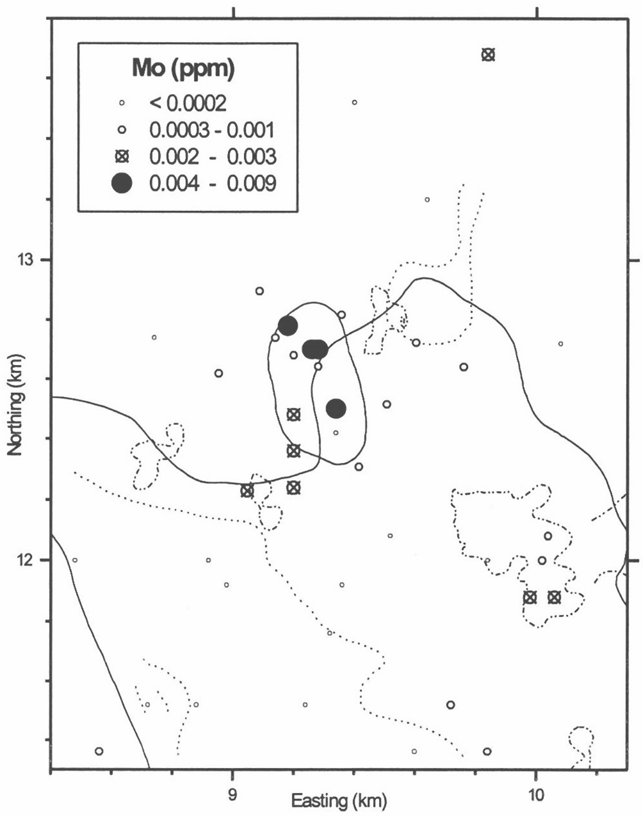

Figure A4.28: Mo distribution in Baxter groundwaters.

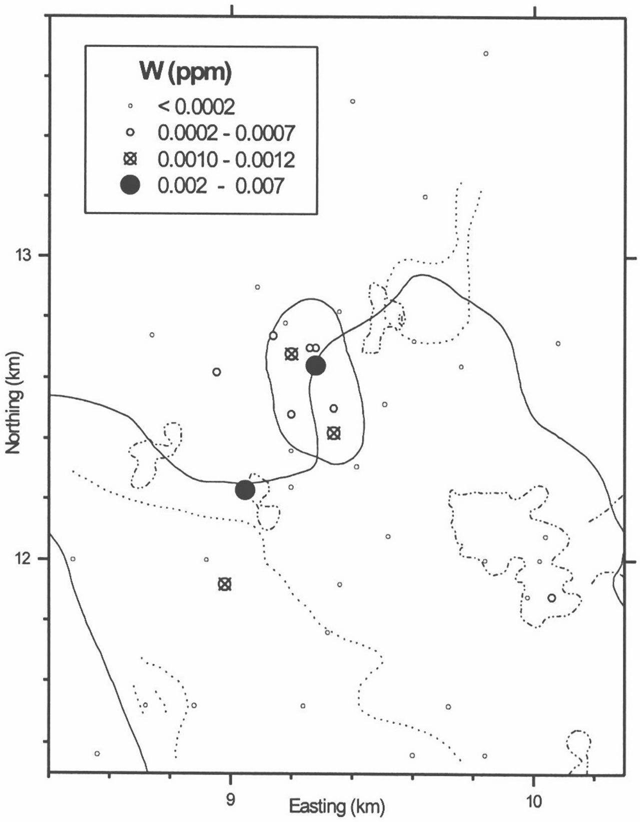

Figure A4.29: W distribution in Baxter groundwaters.

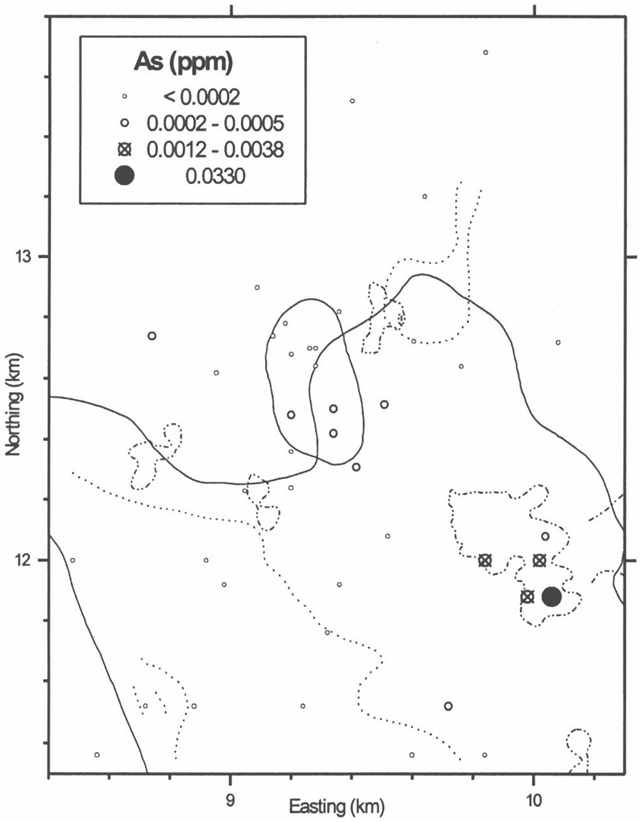

Figure A4.30: As distribution in Baxter groundwaters.

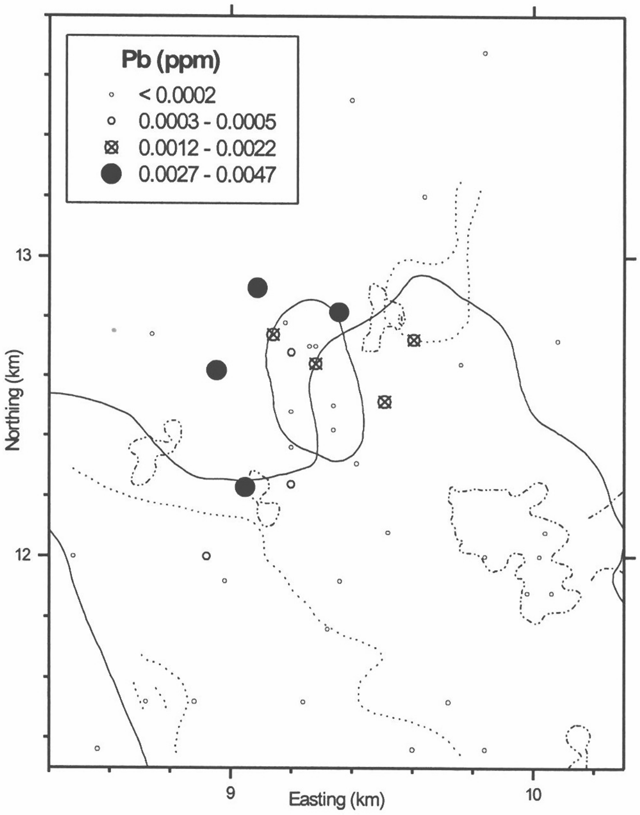

Figure A4.31: Pb distribution in Baxter groundwaters.

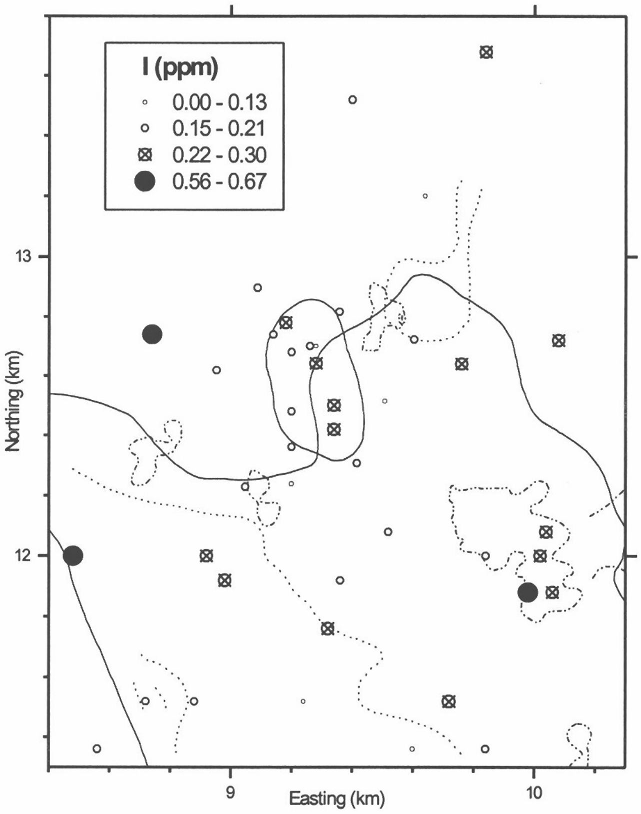

Figure A4.32: I distribution in Baxter groundwaters.

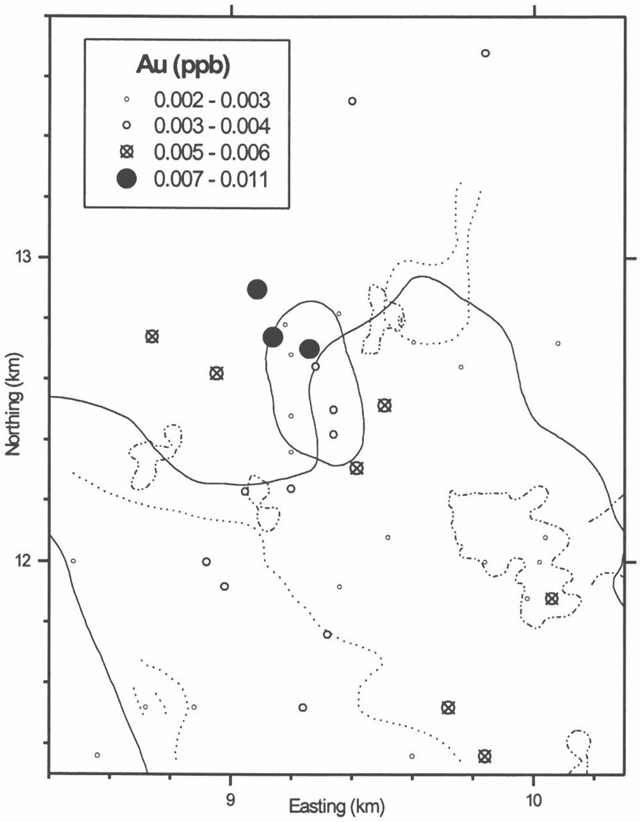

Figure A4.33: Au distribution in Baxter groundwaters.