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PROGRESS STATEMENT FOR THE KALGOORLIE STUDY AREA - STEINWAY PROSPECT, WESTERN AUSTRALIA

M.J. Lintern and D.J. Gray

CRC LEME OPEN FILE REPORT 88

January 2001

(CSIRO Division of Exploration and Mining Report 95R, 2nd Impression.)

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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 88) is a second impression (second printing) of CSIRO, Division of Exploration and Mining Restricted Report 95R, first issued in 1995, which formed part of the CSIRO/AMIRA Project P409.

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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, biogeochemistry, soil and regolith geochemistry of the Steinway district.

This progress statement summarizes the recent investigations undertaken at the Steinway deposit. Considerable effort has already been put into the investigation of this site by Narelle Gardiner as a University of Western Australia Bachelors degree Honours thesis entitled "Regolith Geology and Geochemistry of the Steinway Gold Prospect, Kalgoorlie, Western Australia" (Gardiner, 1993). One reason for investigating the Steinway site is the extraordinarily high Au content of the transported surficial material, which is strongly spatially related to the underlying mineralization. This is one of the few sites where a known apparent surface expression of mineralization exists and the surface is relatively undisturbed.

This is one of a number of similar studies in the Kalgoorlie-Kambalda region investigating whether there is a surface geochemical expression to gold mineralization concealed within or beneath sediments in palaeodrainages. Other sites that are, or have been, studied are Zuleika Sands (Ora Banda), Mulgarrie, Panglo (southern extension), Baseline, Lady Bountiful Extension, Kanowna QED, Kurnalpi, Enigma (Wollubar) and Argo.

C.R.M. Butt
R.E. Smith

Project Leaders

January 1995

PROGRESS STATEMENT FOR THE KALGOORLIE STUDY AREA - STEINWAY PROSPECT, WESTERN AUSTRALIA.

M.J. Lintern and D.J. Gray

SUMMARY

Investigations from previous AMIRA Projects have indicated that Au deposits may have geochemical expression throughout the regolith. In Project 409, knowledge gained from these earlier projects, dominantly in areas of erosional and relict landforms, is being extended to determine whether previously developed methods can be applied or adapted to depositional regimes. In the Kalgoorlie area, the work programme has been to investigate potential sample media in the transported regolith above mineralization at a number of dominantly palaeochannel environments. Specifically, the study has investigated the presence of:

(i) Gold in surficial horizons;
(ii) Sub-surface gold in transported overburden;
(iii) Pathfinder elements in transported and relict regolith and bedrock.

This progress statement summarizes recent investigations undertaken at the Steinway Au deposit. Steinway is one of a series of Au prospects located within several hundred metres of each other, about 25 km south of Kalgoorlie and 15 km west of the New Celebration Mine. Gold mineralization at Steinway is of two types: (i) supergene located beneath a palaeochannel system and (ii) primary mineralization associated with quartz stockwork veining within mafic andesites/amphibolites. The palaeochannel deposits are approximately 30m deep in the vicinity of Steinway. This site has an extraordinarily high Au content within transported surficial material, that is strongly spatially-related to the underlying mineralization, and is one of only a few sites where a known apparent surface expression of mineralization exists.

The results indicate:
1. The groundwater is acid and saline and Au will dissolve as Au chloride.
2. In some areas groundwater is sufficiently oxidising for major Au dissolution.
3. Vegetation does not define the location of the mineralization.
4. Gold is found to be correlated with Ca in the top 0.5m only of the soil profile.
5. The highest Au in soil anomaly (152 ppb) is located above mineralization.
6. Water- and iodide-soluble Au (partial extractions) is anomalous over mineralization.
7. The 0 - 1 m sample with the highest total Au has a relatively low proportion of water extractable Au.
8. High Au concentrations are found in ferruginous granules over mineralization.
9. More study is required to assess whether the Steinway soil anomaly is fortuitous.

More information needs to be gathered from the soil Au anomaly to examine whether the relationship between Au and Fe, and Au and Ca and possibly other elements is similar or variable throughout the entire anomaly. Other soil anomalies in the vicinity need to be examined in similar detail. Specifically, there is a need:

(i) to examine the relationship between the soil anomalies, underlying mineralization and position of the palaeochannel(s),
(ii) to examine the ferruginous lag containing Au in more detail to try and determine the nature of the Au contained therein, and
(iii) to collect and analyze soil samples from other parts of the Steinway and other anomalies by putting in costeans and/or soil pits, and by more augering.

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PROGRESS STATEMENT FOR THE KALGOORLIE STUDY AREA - STEINWAY PROSPECT, WESTERN AUSTRALIA.

M.J. Lintern and D.J. Gray

1 Introduction

Investigations from previous AMIRA Projects (P240, P240A, P241, P241A) have indicated that Au deposits may have geochemical expression throughout the regolith; there may be a surface expression even where the mineralization is overlain by barren sediments and/or leached saprolite. This implies that shallow sampling may be more cost- and technically- effective than routinely drilling to great depths. In Project 409, knowledge gained from earlier projects, dominantly in areas of erosional and relict landforms, is being tested to determine whether previously developed methods can be applied or adapted to depositional regimes. The Kalgoorlie area continues to be an important focus for study because of its high resource potential and ubiquitous nature of near-surface carbonate and ferruginous material. This particular study is one of a series from Kalgoorlie that specifically examines sample media from the transported regolith and assesses its potential for exploration. A multi-site approach has been adopted in order to examine (i) the effects of regolith types, and (ii) the potential to use similar sample media at different sites.

Two groups of sample media have particular value for Au exploration in the Yilgarn Craton:

(i) calcareous soil horizons, which are widespread in the semi-arid parts of the southern Yilgarn. Gold concentrations are often much greater in pedogenic carbonate, compared with adjacent horizons; failure to collect and analyze this horizon in an exploration programme may miss the target altogether;

(ii) ferruginous materials, particularly lateritic residuum; often at the surface but can be deeply buried, and drilling to target this sample medium has lead to the discovery of large ore bodies such as Bronzewing.

In the Kalgoorlie area, the work programme has been to investigate potential sample media in the transported regolith above mineralization. Specifically the study analysed for:

(i) Gold in surface horizons;

(ii) Gold below surface in transported overburden;

(iii) Pathfinder elements in transported and relict regolith and bedrock.

Several sites were offered by P409 sponsor companies for pilot studies (Table 1). All sites were visited and a preliminary set of samples was taken at most locations. Sites were assessed using various criteria (see Table 1) and the four most suitable sites, namely Argo, Steinway, Kurnalpi and Wollubar (Figure 1), were selected for more detailed investigations of the geochemistry of regolith materials, vegetation and groundwater. Some investigations of transported environments that were undertaken in previous studies (*e.g.*, at the Panglo and Zuleika Au deposits) will be also be discussed.

This progress statement summarizes the recent investigations undertaken at the Steinway deposit. This site has an extraordinarily high Au content in the transported surficial material, which is strongly spatially-related to the underlying mineralization, and was one of only a few sites where a known apparent surface expression of mineralization existed. The surface is relatively undisturbed.

Considerable effort has already been put into the investigation of this site by Narelle Gardiner whose Honours thesis entitled "Regolith Geology and Geochemistry of the Steinway Gold Prospect, Kalgoorlie, Western Australia" was sponsored by Newcrest Mining Limited (New Celebration Gold Mine) and CSIRO (Gardiner, 1993). Where required, this report will draw upon aspects of the thesis including site descriptions, regolith sections and some analytical results.

Table 1: Advantages and disadvantages of study sites examined during the P409 pilot study and previous AMIRA projects.

Site	Type of mineralization	Advantages	Disadvantages
Sites chosen			
Argo	At interface and saprolite, beneath 20 m or more of lacustrine sediments.	Extensive drilling available. Strong mineralization. Exposed pit. Distant from upslope Au deposit.	Surficial sampling not completed, due to pit excavation. Poor condition of drill material in top 10 m.
Steinway	In saprolite, 5 m beneath 30 m of transported sediments.	Known surficial anomaly. Extensive drilling available. Distant from known Au min.	Not scheduled to be mined. Weak mineralization.
Kurnalpi	At interface and saprolite, beneath 60 m of transported sediments.	Moderate drilling available. Distant from known Au min.	Not scheduled to be mined. Weak mineralization.
Wollubar (Enigma)	At interface and saprolite, beneath 55 m of transported sediments.	Moderate drilling available. Distant from upslope Au deposit.	Not scheduled to be mined. Weak mineralization
Sites not chosen			
Kurrawang	Little information available.	Known surficial anomaly. Exposed pit (at a later stage).	Surface regolith mostly residual. Little drill spoil.
Lake Cowan	Various deposits associated with palaeochannel and underlying saprolite.	Known surficial anomaly. Extensive drilling available.	Known upslope mineralization.
Kat Gap (Forrestania)	Little information available.	Moderate drilling available. Distant from upslope Au min.	Depth of transported material not determined - may be thin.
Gindalbie	With sulphides at interface, beneath 60 m of transported sediments.	Moderate drilling available. Distant from upslope Au deposit.	Poorly mineralized. Not scheduled to be mined.
Mt Celia	Beneath 5 to 15 m of transported deposits.	Extensive drilling available. Distant from upslope Au min.	Not scheduled to be mined. Not typical of regolith in Kal. area.
Lady Bountiful Extended	At interface beneath 25 m of transported deposits, and also in underlying quartz veins.	Moderate drilling available. Distant from upslope Au deposit. Exposed pit (at a later stage). Strong mineralization.	Severe surficial disturbance.
Samphire	Little information available.	Exposed pit.	Surface regolith mostly residual.
Previous studies			
Zuleika	At interface and saprolite, beneath 20 m of transported sediments.	Exposed pit. Extensively investigated in earlier project.	Known upslope mineralization. No further surface samples available.
Matt Dam	At interface and saprolite, 15m beneath 10m of transported sediments.	Extensively studied in earlier project. Known surficial anomaly.	This part of deposit not scheduled to be mined.
Baseline	Beneath 20 m of transported sediments.	Exposed pit. Known surficial anomaly.	Samples not available.
Panglo	Located in saprolite 20 m beneath base of 15 m of transported sediments.	Extensively studied in earlier project. Known surficial anomaly.	This part of deposit not scheduled to be mined.

2. Site Description

The Steinway Prospect is one of a series of Au prospects located within several hundred metres of each other, about 25 km south of Kalgoorlie and 15 km west of the New Celebration Mine. The area encompassing and immediately surrounding the Steinway soil anomaly forms a flat-lying, depositional plain (Figure 2) with higher areas rarely rising more than five metres above it. To the south is an erosional area (mafic saprolite) which includes the Penfold deposit, now being mined. Drainage is to a playa, White Lake, about 10 km to the north. Present-day shallow ephemeral channels cross the study area and generally flow in a northerly direction; such channels separate the Steinway, Penfold, St Helens and Greenback soil anomalies from each other (Figure 3). Vegetation is salmon gum open woodland with an understorey dominated by bluebush.

The regolith consists of the following units:

0-2m: calcareous, clay-rich red soil, with abundant ferruginous granules;
2-5m: non-calcareous clay containing large amounts of ferruginous granules;
5-15m: clay containing zones of Fe-rich material *e.g.*, mottles;
25-30m: variably sandy to silty clay with lenses of coarser sand-rich material; a sandy interface usually marks the lowest part of the channel, and mica-rich clays the beginning of the saprolite
30-50m: saprolite, clay-rich towards the top;
50m+: fresh rock.

Saprolite derived from weathered andesitic rocks dominates the upper part of the residual zone. The geology consists of mafic andesites with trachytes, porphyritic tuff and black shales (Figure 4).

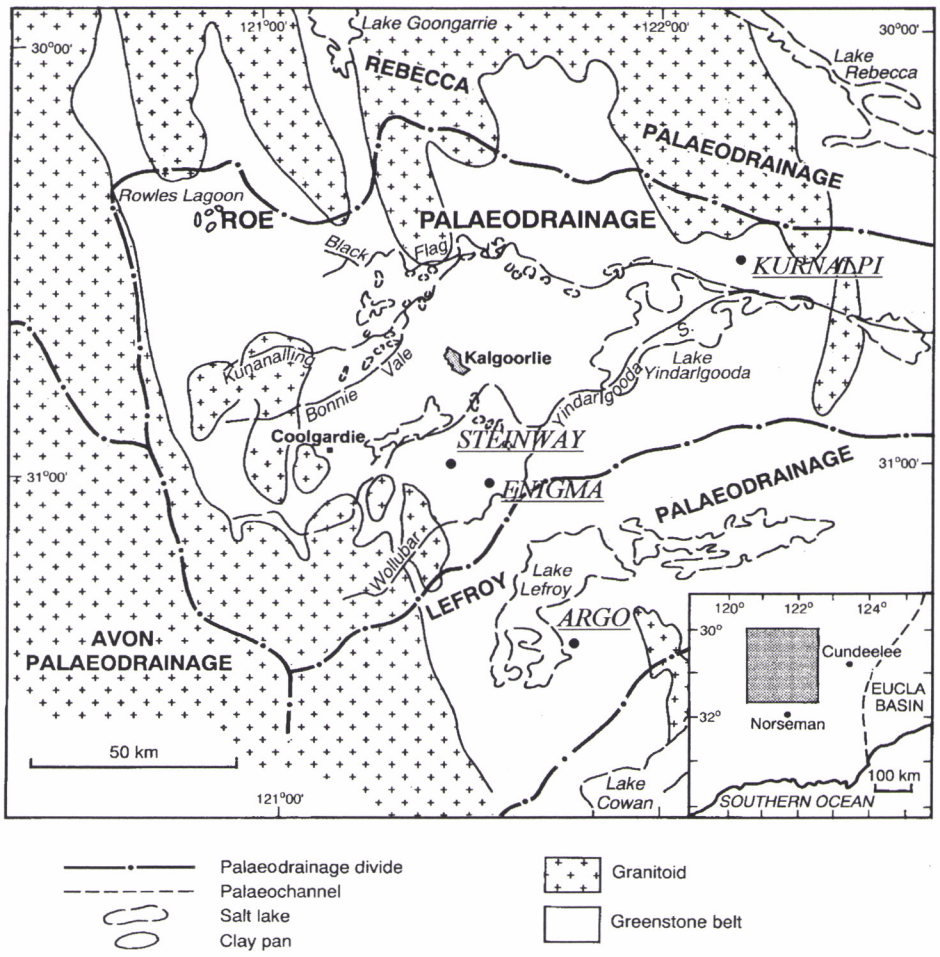

Figure 1: Location map (after Kern and Commander, 1993).

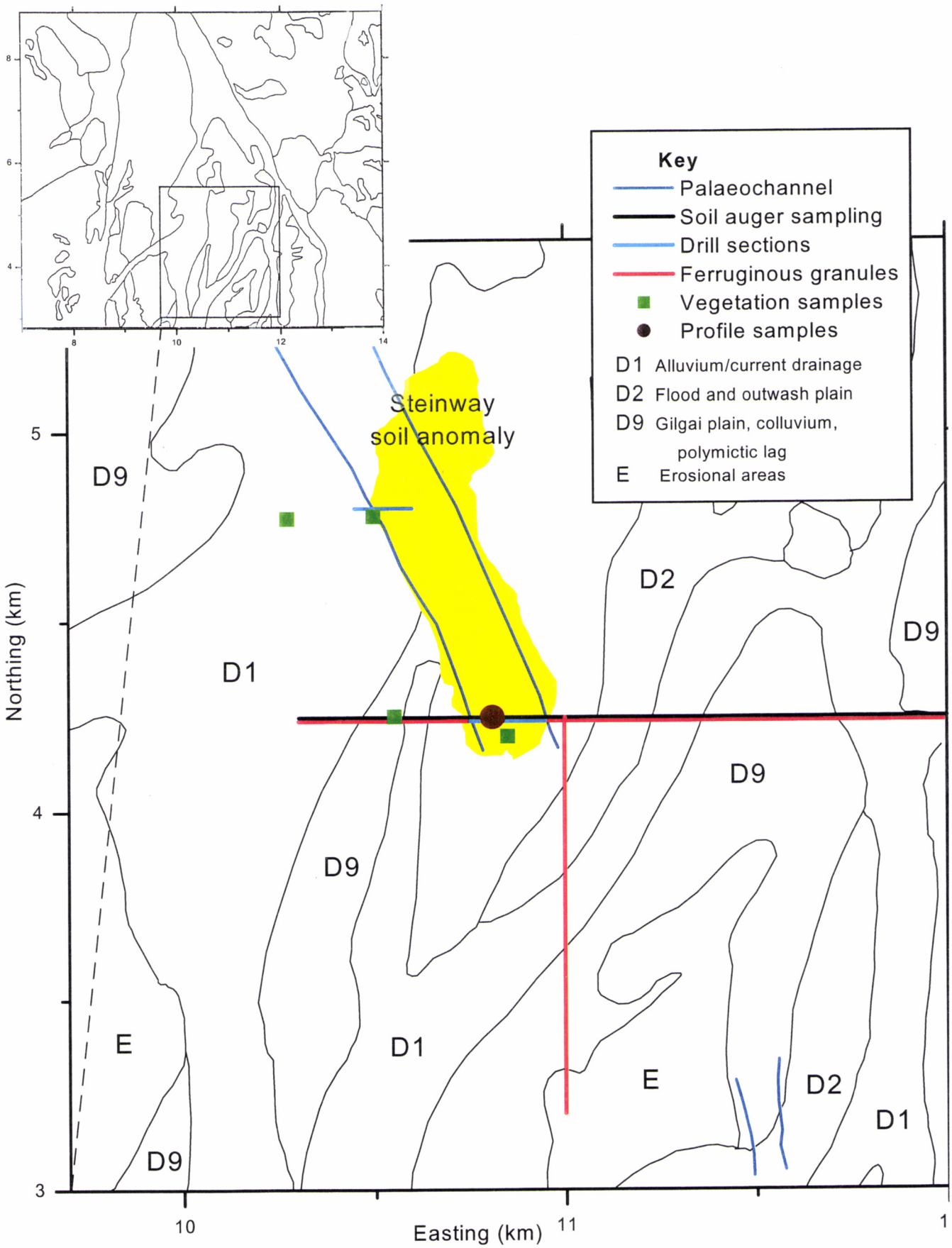

Figure 2: Regolith map of the Steinway area (after Gardiner, 1993), showing the location of the Steinway soil Au anomaly (> 24 ppb), palaeochannel and sampling points.

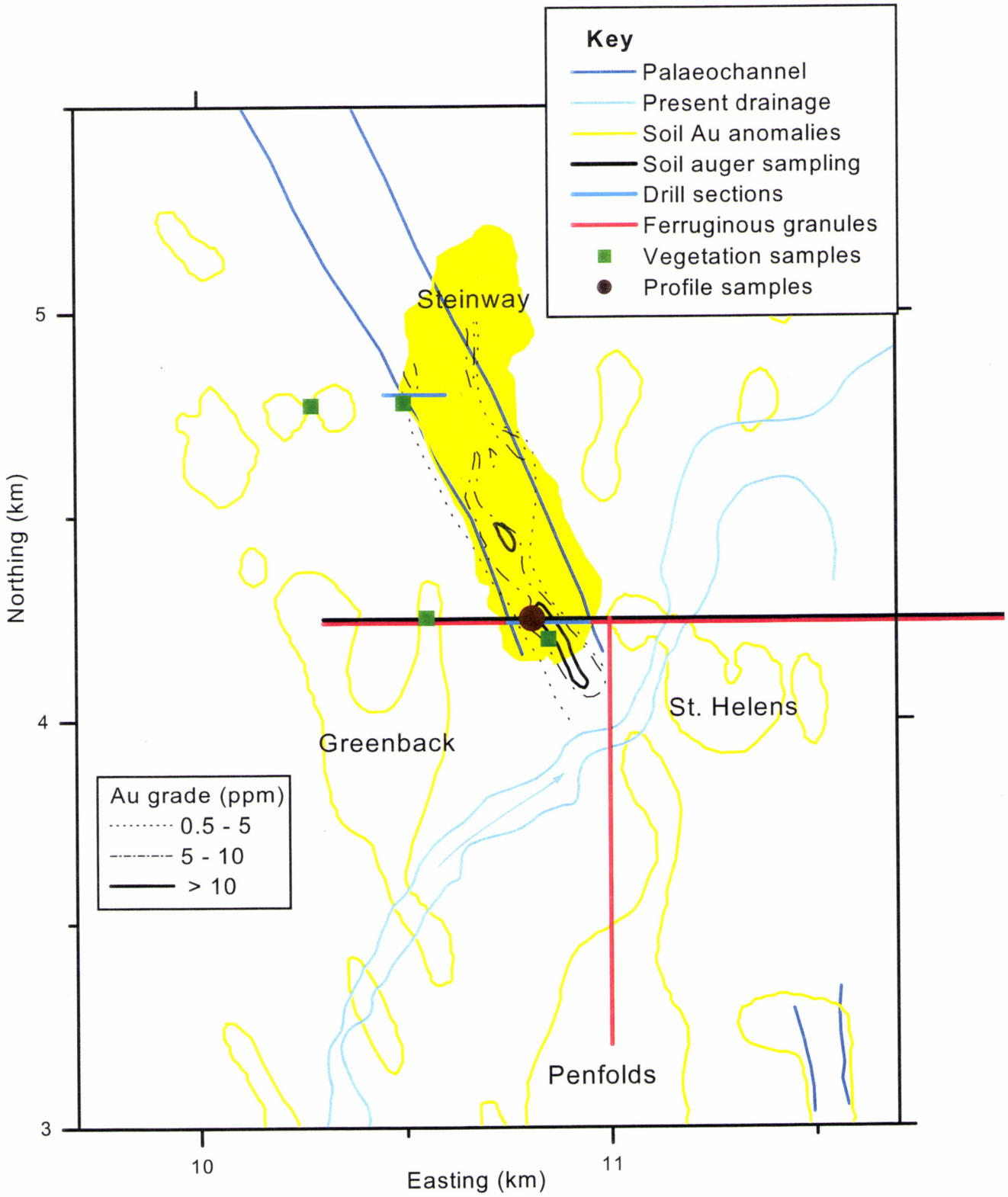

Figure 3: Plan of Au soil anomalies (> 24 ppb), also showing Au at depth at Steinway, sampling points, palaeochannel and surficial drainage (after Gardiner, 1993 and maps supplied by Newcrest Mining Ltd.).

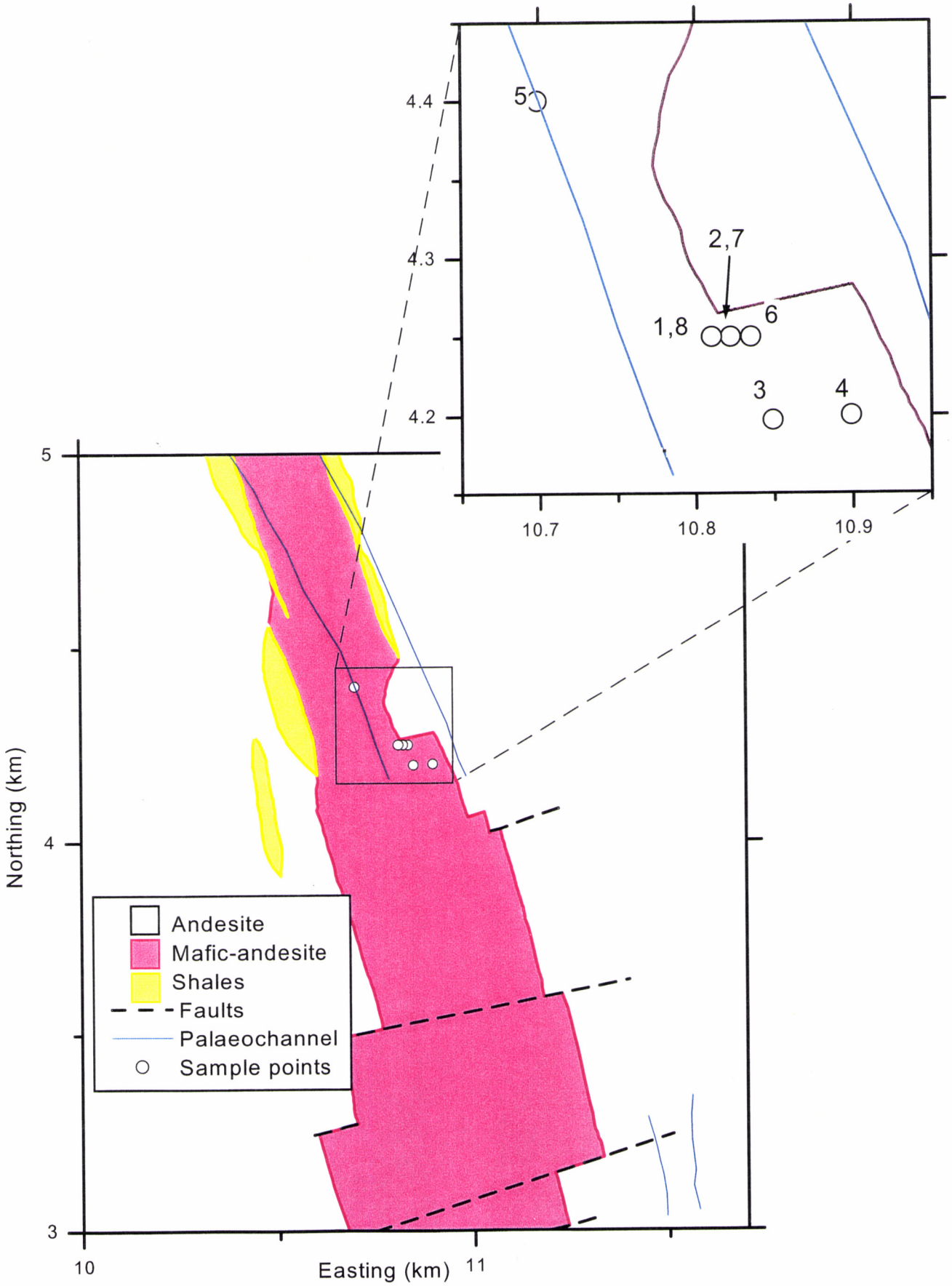

Figure 4: Groundwater sample points, geology and palaeodrainage at Steinway (courtesy, Newcrest Mining Ltd.).

According to M. Spivey and M. Miller, (Newcrest Mining Ltd, written communication, late 1994), there are two types of mineralization at Steinway: (i) supergene mineralization located below a palaeochannel system and (ii) primary mineralization associated with quartz stockwork veining within mafic andesites/amphibolites. The andesites and amphibolites consist of microporphyritic amphibolites dominated by hornblende, ubiquitous biotite, and lesser amounts of feldspar and garnet. Strongly altered areas generally display silicification, carbonate alteration, tourmaline quartz veining and disseminated pyrite.

3. Methods

A large selection of sample-types has been collected from Steinway. These included groundwater, vegetation, soil (0 - 0.1 m and 0 - 1 m composites), ferruginous granules, sediments, saprolite and bedrock. These samples have been analysed for a variety of elements and a synthesis of the results is presented below. All samples were analysed by CSIRO unless otherwise stated. The rationale for collecting these samples (some by Gardiner, 1993) are as follows:

(i) groundwaters: contain Au and may be important in the formation of mineralized horizons and other anomalies in the soils and sediments. Elements may be mobilized via capillarity, evapotranspiration (via vegetation) vapours, gases or other means from the groundwater through the transported overburden to the surface. Redox fronts are known as important sites for the accumulation of Fe, Au and other elements;

(ii) vegetation: implicated in the mobilization of Au in erosional and relict landscapes; vegetation that made up the bulk of the above ground biomass were collected from above, adjacent and distant to mineralization;

(iii) soils: soil is a complex body of mineral and organic constituents, commonly differentiated into horizons of variable thickness. It can be examined by several methods, including:

  (a) examination and analysis of different soil horizons collected from a costean or soil pit can provide detailed information on the preferential siting (if any) of elements and minerals. Characteristics of soil horizons allows better definition of anomalies that may be otherwise smothered or diluted by soil components of lower element concentration; this will enable the targeting of specific soil horizons;

  (b) topsoils (approximately 0 - 0.1 m), containing organic matter, can be readily sampled from the surface;

  (c) deeper soil composites (*i.e.*, 0 - 1 m) can be readily collected by augering; this relatively simple technique is being extensively used for Au exploration in erosional and relict landforms. Augering usually targets the carbonate horizon which is an important sample medium for Au and is nearly always present in the top 1 or 2 metres. Soil samples were used for partial extraction studies to determine whether various reagents extract Au at levels and proportions depending on the geomorphology or proximity to mineralization. The partial extraction concentrations, rather than total content, may provide a better target anomaly;

(iv) ferruginous (and other) separations: Fe oxides are important scavengers of many elements, including Au. They occur as segregations, granules, mottles, pisoliths, buried laterite, lag and coatings throughout the transported regolith;

(v) saprolite, saprock and bedrock: weathered and fresh material from beneath the transported overburden material was sampled and analysed for a suite of elements. Other elements associated with mineralization may present a better target for exploration than Au itself.

3.1 Groundwater

Two groundwater samples were collected and analysed in late 1992. A further 6 samples, including the two drill holes previously sampled, were collected in early 1994. Waters were analysed for pH, temperature, conductivity and oxidation potential (Eh) at the time of sampling. A 125 mL aliquot was collected in a polyethylene bottle (with overfilling to remove all air) for later HCO_3^- analysis by alkalinity titration in the laboratory. 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:

(i) Cu, Pb and Cd by Anodic Stripping Voltammetry;
(ii) Al, B, Ba, Be, Ca, Cd, 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;
(iii) Ag, Bi, Cd, Ce, Dy, Er, Eu, Ga, Gd, Ge, Ho, La, Mo, Nd, Pb, Pr, Rb, Sb, Sc, Sm, Sn, Tb, Th Tl, Tm, U, W, Y, Yb and Zr by Inductively Coupled Plasma - Mass Spectroscopy;
(iv) total phosphate (as P) by the molybdenum blue colormetric method (Murphy and Riley, 1962);
(v) I by subtraction of P from P/I concentration.

About 50 mL of the filtered water was collected separately, without acidification, and analysed for Cl by the Technicon Industrial method (Zall *et al.*, 1956).

One litre sub-sample of the filtered water was acidified with 1 mL 15 M HNO_3 and one gram sachet of activated carbon added. The bottle was rolled for eight days in the laboratory and the water discarded. The carbon was then analysed for Au by Instrumental Neutron Activation Analysis (INAA) at Becquerel Laboratories, Lucas Heights. The method was tested by shaking Au standards of varying concentrations, and in varying salinities, with activated carbon (Gray, unpublished data).

The solution species and degree of mineral saturation were computed from the solution compositions 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) for highly saline solutions, such as observed at this site, the specific ion interaction model known as the Pitzer equations was applied, using the program PHRQPITZ (courtesy USGS).

These programs are used to 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 and precipitation of this mineral (Drever, 1982).

The determinations are important in understanding solution processes at a site. They have particular value in determining whether the spatial distribution of an element is correlated with geological phenomena such as lithology or mineralization, 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.

3.2 Vegetation

Vegetation samples were collected from mineralized and background areas using secateurs (Figure 2). New growth was sampled where possible and leaves were collected from large eucalypt trees. Mull was collected from around the base of the eucalypt trees. Samples were washed with copious amounts of hot water and then rinsed with deionised water, before being dried in an oven at approximately 70°C. The samples were macerated to a moderately fine powder in a cross-beater mill before being dispatched for analysis. Samples were analysed only for Au, by INAA.

3.3 Regolith and Bedrock

Location of the various samples is given in Figure 3, with the sample preparation and analysis techniques used given in Section 3.3.1 for simplicity.

3.3.1 Sample preparation and analysis

Samples were dried at 70°C, and jaw-crushed as required (Denver jaw crusher) before pulverizing in a K1045-steel ring mill. The analyses used were:

(i) Gold only by INAA.
(ii) Antimony, As, Ba, Br, Ce, Cs, Cr, Co, Eu, Hf, Ir, Fe, Au, La, Lu, Mo, K, Rb, Sm, Sc, Se, Ag, Na, Ta, Th, W, U, Yb and Zn by INAA.
(iii) Bismuth, Cu, Fe, Mn, Ni, Pb, Sr, Ti, Zn and Zr by X-ray fluorescence (XRF; pressed powders).
(iv) Calcium and Mg by atomic adsorption spectrophotometry (AAS) after digesting in 5M HCl for 15 minutes and then diluting to 1M HCl.
(v) Carbonate by the method of Piper (1947).
(vi) Organic C by a modification of the standard method (Walkley, 1935), using a UV-Vis spectrometer.
(vii) Salinity of soil slurry (1 part soil to 2 parts deionised water) using a conductivity meter.

3.3.2 Topsoil (0 - 0.1 m)

Samples (1-2 kg) were collected from the top 0.1 m on 4250N using a hand auger and analysed for Au, Ca, Mg and organic C.

3.3.3 Soil profile.

Samples were collected from a 2m deep by 5m long trench (Figure 2). The face of the trench was first cleaned by removing loose material using a brush and geological pick. Samples (1-2 kg) were collected at 0.1 to 0.3 m intervals from the surface to the base of the trench and analysed for the INAA element suite, Ca, Mg and organic C.

3.3.4 0 - 1 m and 1 - 1.5 m samples

Samples were collected from 4250N and 11000E (Figure 2) using a vehicle-mounted, power auger and analysed for the INAA and XRF element suites, Ca, Mg, carbonate and salinity.

3.3.5 Ferruginous granules

Samples from 0.2 m and 1.6 m from the soil profile (Section 3.3.3) were wet-sieved to produce 4 sub-samples (A = > 710 μm, B = 710 - 250 μm, C = 250 - 53 μm and D = < 53 μm), and analysed for the INAA element suite.

3.3.6 Ferruginous components of the transported overburden

Six samples were wet sieved from drill cuttings through a (approximately) 0.8 mm screen, hand sorted, and the ferruginous fraction collected and analysed for the INAA and XRF element suites. Some samples were analysed for additional elements by XRF (fusion and pressed powders) and details of these are found in Appendix 7. The location and depth of the samples is found in Appendices 11 and 12.

3.3.7 Material from saprolite and bedrock

Samples were jaw-crushed as required (Denver jaw crusher) before pulverizing in a K1045-steel ring mill and analysed for the INAA and XRF element suites. Some samples were analysed for additional elements by XRF (fusion and pressed powders) and details of these are found in Appendix 8. The location and depth of the samples is found in Appendices 11 and 12.

3.4 Partial extractions.

Three in-house partial extraction solutions (Gray and Lintern, 1993), were used to test the solubility of Au. In all cases, a 25 g portion of unpulverized sample material was mixed with 50 mL of extractant in a screw-cap polyethylene plastic bottle, and then gently agitated for one week, after which the total Au extracted is measured. The three solutions are:

(i) deionised water: dissolves the most soluble Au.
(ii) iodide: a 0.1M KI solution is adjusted to pH 7.4 with HCl whilst CO_2 is bubbled through. This extraction dissolves more Au than water alone. Another form of this test did not involve pH adjustment; there is little difference in Au recovery between the two extraction variants when carbonate-rich soils are being analysed.
(iii) cyanide: 0.2% KCN solution saturated with CaO dissolves all but the most refractory Au - this can include larger pieces of Au and Au encapsulated within resistant material such as quartz.

The partial extraction tests were performed either on separate portions of the same sample or as a sequential extraction starting with water and finishing with cyanide. Batch effects have previously been noted with deionised water extraction and so all partial extraction tests were performed under identical conditions and at the same time; the reason for the batch effects has not been determined but does NOT occur with iodide or cyanide soluble Au.

4 Results

4.1 Groundwater

The sample locations are shown in Figure 4 and results are listed in Appendix 1. All samples were from the mineralized area: note that 4250-2 and 4250-3 were sampled twice. Groundwaters varied from moderately (pH 5.8) to highly (pH 3.4) acid. The total dissolved solids (TDS), a measure of groundwater salinity, were calculated from the major element contents. The concentrations of various ions at Steinway and at other sites are plotted versus TDS or pH in Appendix 2, Figures A2.1 - A2.47. The sea water data (Weast, 1983) are used to derive the line of possible values (denoted as the sea water line) if sea water were diluted with freshwater or concentrated by evaporation; this line is shown on each Figure except when the concentration in sea water is too low, relative to the concentration of the element in groundwaters. Nine other sites (eight of them mineralized) with saline groundwater were used for comparison:

(i) Wollubar: a palaeochannel crossing mineralized rocks about 40 km southeast of Kalgoorlie (south Yilgarn; Gray, 1993b);
(ii) Baseline: a Au deposit beneath a palaeochannel, some 30 km north of Kalgoorlie, with extensive transported material (up to 20m deep; south Yilgarn);
(iii) Panglo: a Au deposit 30 km north of Kalgoorlie, with mineralization concealed beneath 40 m of bleached saprolite (south Yilgarn; Gray, 1990);
(iv) Yalanbee: a non-mineralized site 70 km east of Perth (west Yilgarn);
(v) Mulgarrie: a Au deposit beneath and adjacent to a palaeochannel about 40 km north of Kalgoorlie (south Yilgarn; Gray 1992b);
(vi) Granny Smith: a Au deposit about 25 km south of Laverton (central Yilgarn; Gray 1993a);
(vii) Golden Hope: a Au deposit at New Celebration, some 40 km southeast of Kalgoorlie (south Yilgarn; Gray, 1993b);
(viii) Mt. Gibson: a Au deposit about 100 km north-east of Dalwallinu (central-west Yilgarn; Gray, 1991);
(ix) Boags: a Au deposit at Bottle Creek, located 210 km north north-west of Kalgoorlie (central Yilgarn; Gray, 1992a);

Wollubar, Baseline, Panglo and Yalanbee were acid groundwater systems, whereas the other sites primarily contained neutral groundwater. Panglo, Yalanbee, Golden Hope, Mt. Gibson and Boags are in dominantly relict or erosional landscapes, whereas the other sites have significant transported material. Comparisons with other sites may be useful in indicating the significance of any particular element anomaly, and whether the groundwater composition is affected by particular lithological interactions. Specific descriptions of the varying sites can be found in the referenced reports, with a generalized description of the hydrogeochemistry of the Yilgarn Craton given in Butt *et al.*, (1993).

SI values for varying minerals (Section 3.1) are tabulated in Appendix 3, and plotted in Figures A3.1 - A3.35. The equilibrium point is shown as the dashed line. Samples within one SI unit are at or near equilibrium with respect to that mineral; those above the line are oversaturated; and those below are undersaturated.

The Steinway groundwaters are appreciably saline (up to 2½ times sea water) and acid (Figure 5) and, as expected, have similar chemistry to Wollubar, Baseline and Panglo (Appendix 2). Thus, they are enriched in Al and Si (Figures A2.15 and A2.16), the transition metals Mn, Fe, Co, Ni, Cu and Zn (Figures A2.21 - A2.26), Y and the rare earth elements (REE; Figures A2.29 and A2.31 - A2.43), Pb and (in the most acid groundwater) U (Figures A2.46 and A2.47). These enrichments will commonly occur where acid groundwaters contact mafic rocks (Gray, 1990), as is demonstrated by the fact that these acid groundwaters are undersaturated with respect to the corresponding secondary minerals (Appendix 3), and therefore may not have any direct exploration significance, aside from indicating mafic lithologies. The Cr concentrations are below detection for the Steinway groundwaters (Figure A2.20), consistent with previous observations that Cr is only enriched in groundwaters contacting ultramafic lithologies.

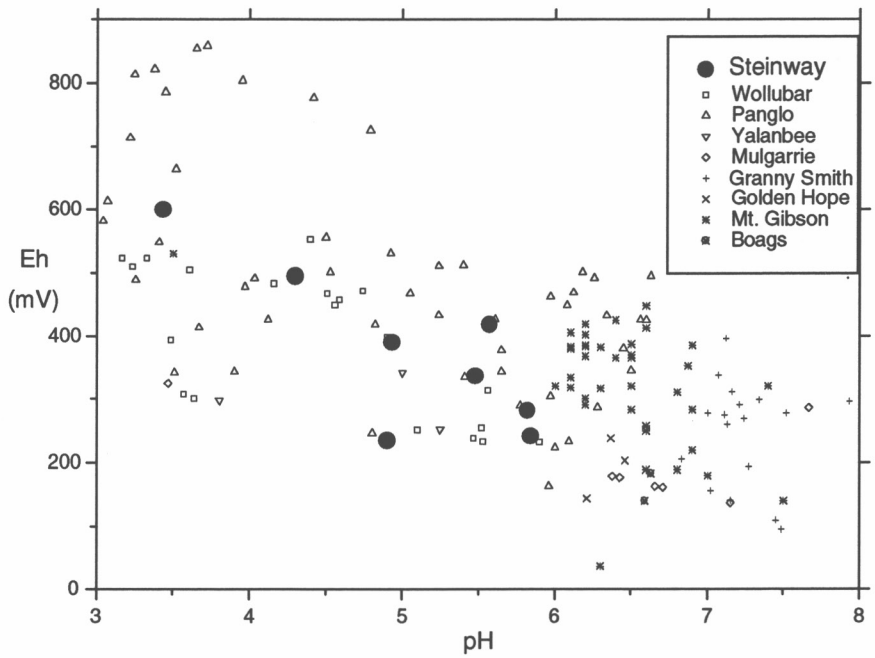

Figure 5: Eh vs. pH for groundwaters from Steinway and other sites.

Chalcophile elements that are enriched in *neutral* groundwaters in contact with weathering sulphides [*e.g.*, Ga[1], Mo, W (Figures A2.27, A2.30 and A2.44), Ag, Sb and Tl (Appendix 1)] have very low concentrations in the Steinway groundwaters, as expected. Iodine, however, has a high concentration in these groundwaters (Figure A2.10), as is also observed in other mineralized sites in the Yilgarn Craton.

In neutral groundwaters, the most likely mechanism for the dissolution of Au is as the thiosulphate complex, whereas in acid saline groundwater, such as at Steinway, Au chloride is expected to be important (Gray *et al.*, 1992). High redox potentials (Eh) are required for the dissolution of Au as Au chloride, and all but one of the Steinway samples are insufficiently oxidising for significant Au dissolution (Figure 6). The one highly oxidising groundwater contains 0.8 ppb Au, which is very anomalous, whereas the other samples all have low Au contents (< 0.03 ppb). However, groundwater Eh is very sensitive to a number of factors (*e.g.*, Fe and Mn contents and the degree of equilibration with atmospheric O_2), and could vary significantly over time. Under favourable conditions, therefore, dissolved Au concentration throughout the Steinway mineralized area could be high.

[1] Though generally considered an Al analogue, Ga can occur in sulphide minerals (Gottardi *et al.*, 1978), and appears to be enriched in some mineralized groundwaters in the Yilgarn (Gray, 1993b).

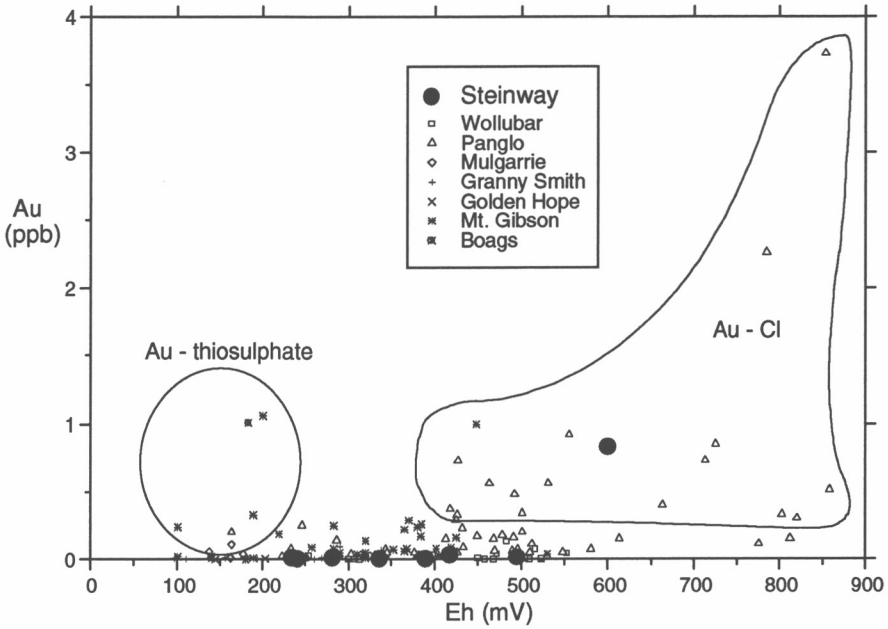

Figure 6: Au vs. Eh for groundwaters from Steinway and other sites, with Au dissolution zones marked.

The spatial distribution of the elemental abundances in groundwater (Appendix 4), show that Be, B, Si, I, transition elements, Y and the REE appear to be enriched on line 4250N, but this needs to be substantiated by further sampling.

4.2 Vegetation

Gardiner (1993) suggests that Au contents of vegetation (eucalyptus leaves, bark, twigs, mull or bluebush) does not indicate the presence of mineralization (Table 2). For depositional areas, the maximum concentrations of Au for bluebush and mull at Steinway are lower than those found at Zuleika, where up to 7.9 ppb (bluebush) and 5.8 ppb (mull) was reported (Lintern and Butt, 1992); maximum Au concentration in eucalyptus leaves was similar at Zuleika (0.6 ppb) but much lower (0.1 ppb) at Panglo (Lintern and Scott, 1990). For erosional areas, the maximum reported Au values for vegetation at Bounty (Lintern, 1989), Zuleika and Panglo are an order of magnitude greater than at Steinway.

Table 2: Au analyses (in ppb) of dried vegetation (from Gardiner, 1993).

Sample Type	Over mineralization	Over background
Eucalyptus leaves	0.8 <0.5	<0.5 <0.5
Eucalyptus bark	<0.5 <0.5	<0.5 <0.5
Eucalyptus twigs	1.1 1.1	1.2 0.5
Mull	3.8 4.4	4.1 <0.5
Maireana (bluebush)	0.9 1.7	1.8 1.7

4.3 Topsoil (0 - 0.1 m)

The highest Au concentration in topsoil (93 ppb) occurs over mineralization and is significantly higher than background (approximately 20 ppb, Figure 7). The highest concentration for topsoil appears to define slightly better the location of mineralization than that obtained by augering (Section 4.5), which is displaced slightly to the east (Figure 7); however, the contrast is no better.

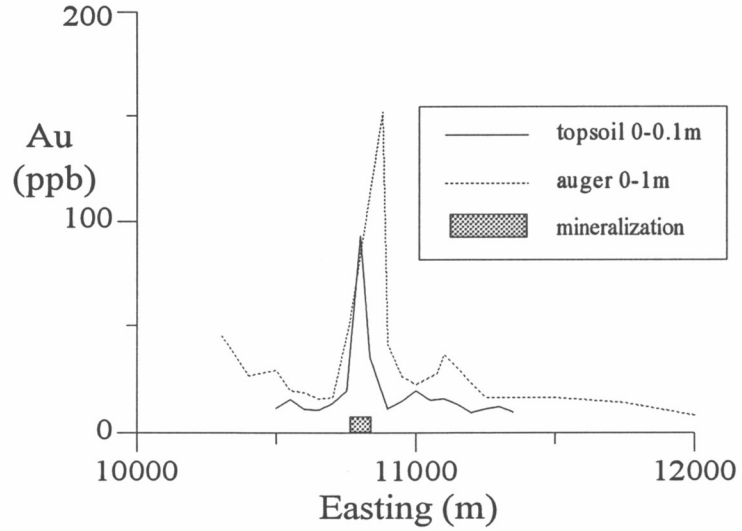

Figure 7: Results for topsoil and auger sample analysis for Au.

4.4 Soil profile

The soil profile (10818E, 4250N; Figure 3) is located above mineralization, close to the sites with the most Au-rich soils. Gold concentration gradually increases with depth (Figure 8), whereas Ca and Mg sharply increase then decrease; Fe concentration, in response to dilution from the alkaline earths, decreases sharply from the surface and then gradually increases with increasing depth (Appendix 6). Although Au and Ca concentrations are probably related in the upper horizons, the relationship is not as strong as that found elsewhere (*e.g.*, Lintern, 1989; Lintern and Scott, 1990; Lintern and Butt, 1991, 1992). Gold content may be related to the Fe in the lower part of the profile (below 0.5 m). Augering is considered an effective sampling technique at Steinway, since Au concentrations in the top metre are still anomalous (mean 200 ppb), even though concentrations are higher still in the second metre.

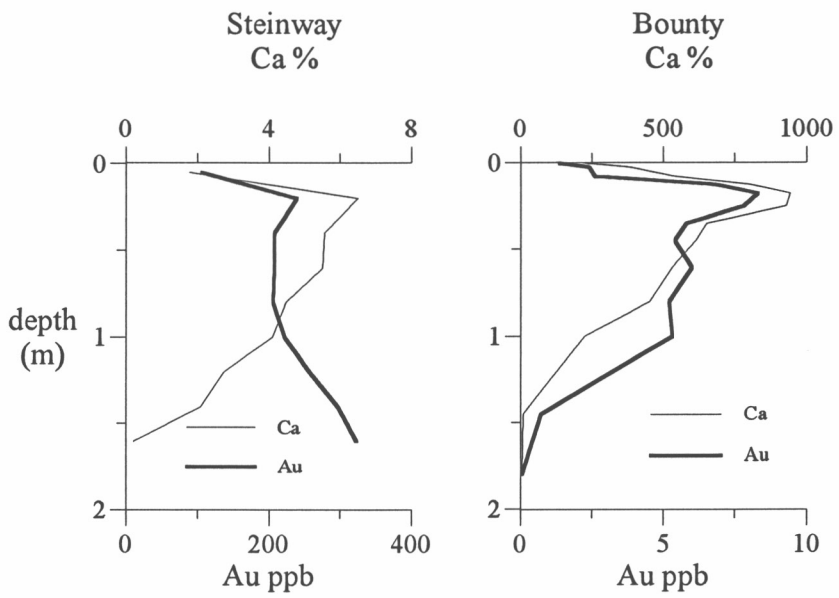

Figure 8: Gold and Ca results for the soil profile at Steinway and a typical soil profile from the Bounty deposit at Mt Hope (Lintern, 1989).

The moisture content of the soil (measured as weight loss after heating at 70°C for one week) increases with depth and is approximately correlated with Au content (Figure 9). This is also observed at Zuleika (Lintern and Butt, 1992) and Argo. The significance of this association is not known, although it may be an indication of the mobility of Au in the soil environment. Partial extraction experiments (see below) indicate that the amount and proportion of water soluble Au decreases with increasing depth *i.e.* where soil moisture is greatest.

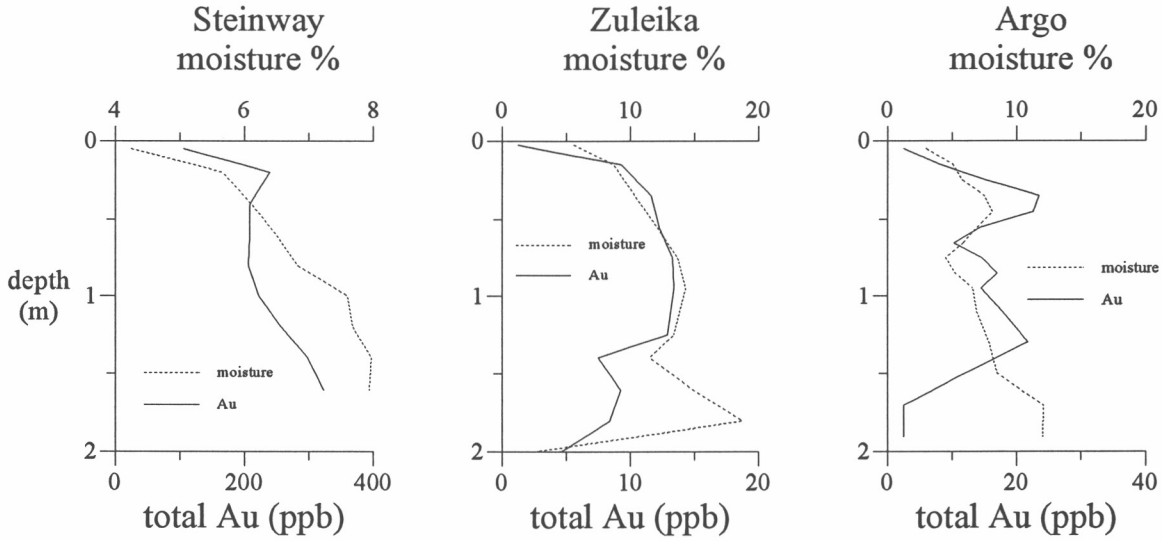

Figure 9: Gold and moisture results for the soil profile at Steinway and typical soil profiles from Zuleika (Lintern and Butt, 1992) and Argo.

Sequential extraction (water, iodide, cyanide) of unpulverized soils (taken at approximately 0.2 m intervals down to 1.7m) from the soil profile indicates that the proportion of water soluble Au in the profile decreases with depth (Figure 10), whereas total Au actually increases with depth (Figure 11).

The mean proportion of iodide soluble Au is approximately 80% of the total Au. Cyanide removes almost all of the remaining Au.

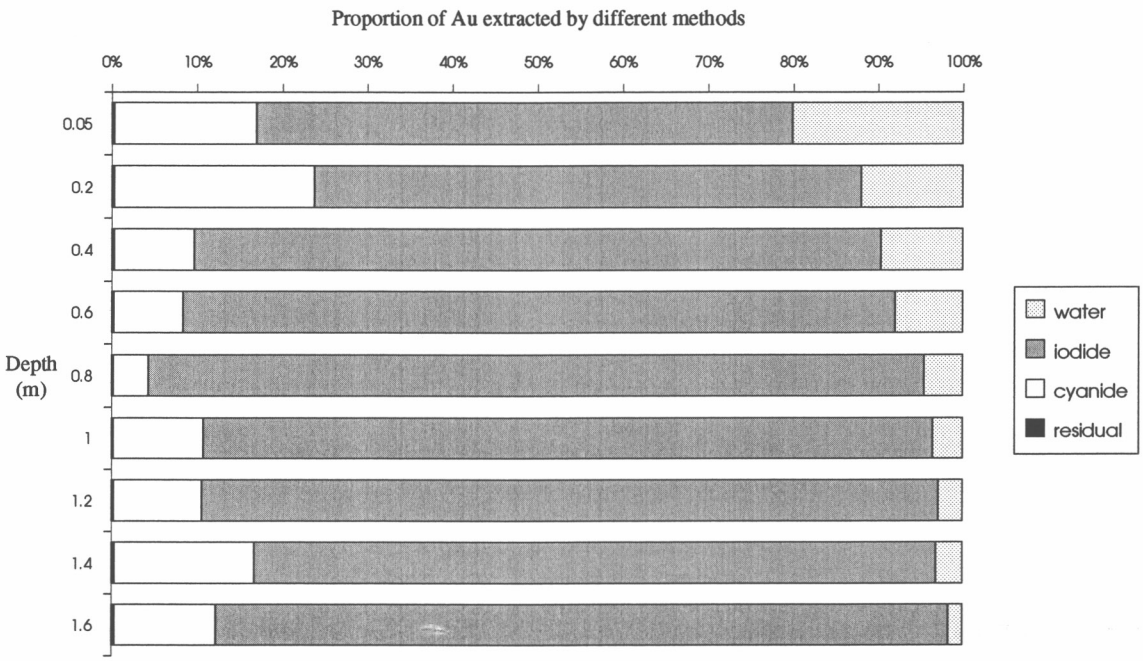

Figure 10: Sequential extraction of Au from the soil profile. Results expressed as proportion of total Au.

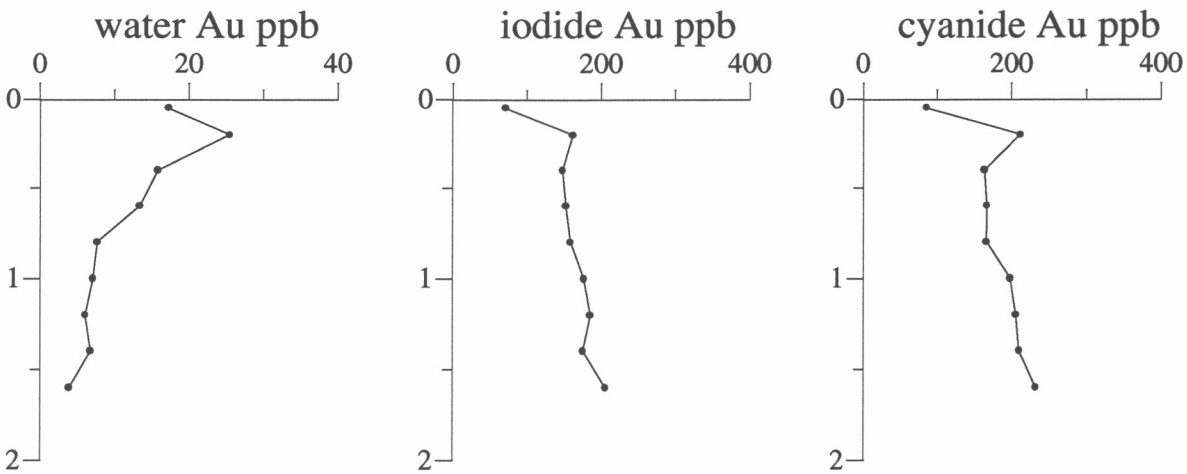

Figure 11: Sequential extraction of Au from the soil profile. The cyanide-extractable Au data includes Au extracted by iodide.

The concentration of water soluble Au in the soil profile appears to be strongly related to organic C content (Figure 12). However, this is not observed at the Bounty Au deposit, where water soluble Au is related to total Au and Ca.

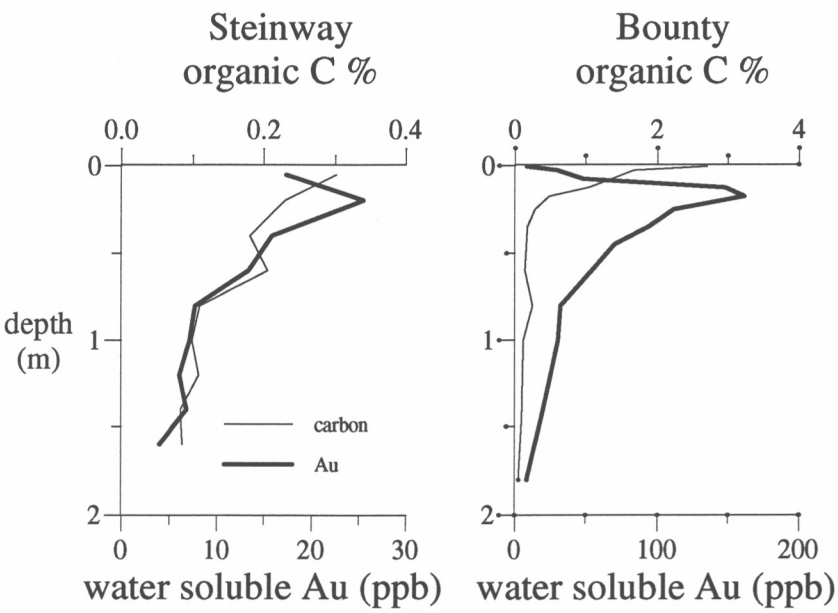

Figure 12: Water soluble Au and organic C results for the soil profile at Steinway and a typical soil profile from the Bounty deposit at Mt Hope.

4.5 0 - 1 m samples

The distribution of Au in the 0 - 1 m composite samples appears to be related to the underlying mineralization; the anomaly is particularly strong over Steinway (150 ppb) although there are subsidiary peaks above mineralization at St Helens (35 ppb) and Greenback (45 ppb), against a background of < 20 ppb. The anomaly (> 24 ppb) over Steinway is over 150m wide (3 samples; Figure 13) in the east-west direction and (according to previous Newcrest data in Gardiner, 1993) stretches over 1 km to the NW, following the direction of the palaeochannel. The coarse fractions (> 710 µm < 2 mm) sieved from the bulk soils have lower Au contents, but are still anomalous; these principally consist of ferruginous granules, quartz float and (over Penfold) ferruginous saprolite (Apeendix 7).

Partial extractions of auger samples by water, iodide and cyanide produce anomalies coincident with that produced from total Au analysis, and thus give no additional information than total Au analyses (Figure 13).

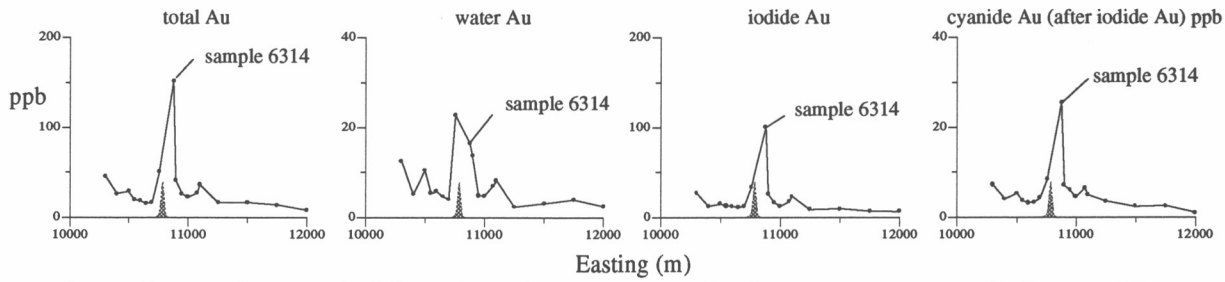

Figure 13: Total, water, iodide and cyanide soluble Au for the auger traverse at Steinway. The cyanide results are for the Au left after the iodide extraction. The shaded area below the plots is the location of mineralization at Steinway.

The plot of water extractable Au versus total Au (tested and confirmed with duplicate samples; Table 3) indicates that the sample with the greatest total Au (sample 6314, 152 ppb) has the lowest

proportion of water soluble Au (11%), compared with all the other samples (mean 27%). The proportions of each type of soluble Au is approximately the same for all other samples from the traverse (Figure 14). The unusually low water soluble Au for sample 6314 may be due to:

(i) a high proportion of material greater than 2 mm, or
(ii) an association between Au and another phase, *e.g.* Fe oxides (see profile results),

from which the water, but not the iodide, is less capable of leaching Au. Earlier studies have shown that Au associated with Ca dissolves comparatively readily with water.

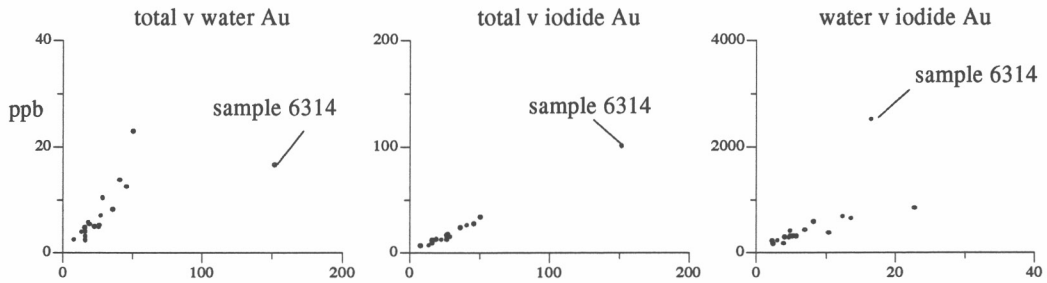

Figure 14: Water soluble versus iodide versus total Au for the Steinway traverse. First component in header is X axis

Table 3: Duplicates for water soluble and iodide soluble Au. Note that duplicates for water soluble Au, performed several weeks after the original experiment, are poor due to batch effects, the cause of which are not known. However, the duplicate for water soluble Au in sample 6314 is even lower than the original test confirming that this sample has an unusually high proportion of water insoluble Au.

sample	water soluble Au in ppb	duplicate		iodide-soluble Au in ppb	duplicate
6313	14	7		26	25
6314	17	6		101	99
6315	23	21		34	33

Analyses of elements other than Au on the bulk soil and coarse fraction (> 710 μm < 2 mm), indicates that there are relatively high concentrations of Fe coincident with and adjacent to the Steinway soil Au anomaly (Appendix 7). Chromium, As, Sc, and Sb appear to be related to the Fe concentration; the distributions of REE, Zn, Co and, possibly, Ni are similar to that of Mn.

4.6 Ferruginous granules

In order to investigate the distribution of the Au in more detail, samples from 0.2m and 1.6m from the soil profile were wet-sieved to produce 4 sub-samples (A = > 710 μm, B = 710 - 250 μm, C = 250 - 53 μm and D = < 53 μm), and analysed for Au and other elements (Figure 15, and Appendix 6). The highest Au concentration is in the coarse fraction (>710 μm) at 1.6m (A-1.6m, 450 ppb). This sub-sample represents 10.6% of the total weight of the entire sample from this depth and has 17% of the total mass of Au; most of the Au (80%) is found in the <53 μm fraction. Sample A-1.6m is also concentrated in As, Cr, Eu, Fe, La, Sb, Sc, Sm, Th and W. The distribution of Au and Ce is similar for each size fraction at 1.6m (Figure 15).

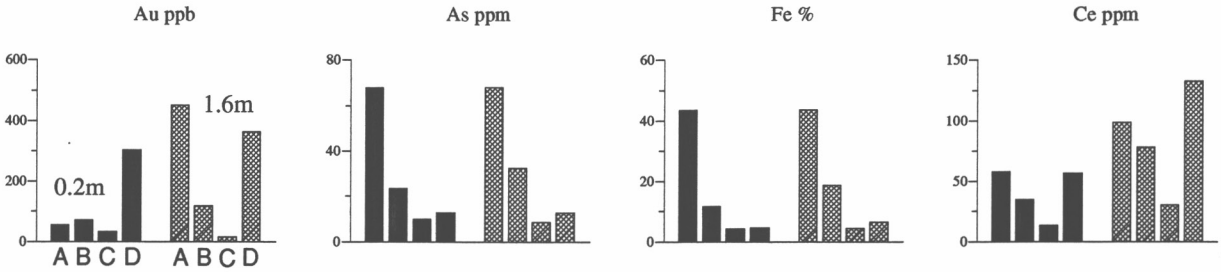

Figure 15: The distribution of Au, As, Fe and Ce in ferruginous granules from 4 size fractions (A = > 710 μm, B = 710 - 250 μm, C = 250 - 53 μm and D = < 53 μm) within two horizons (0.2m, 1.6m).

A detailed study of the petrology of the ferruginous granules indicates that saprolitic fabrics (after primary silicates) are present. This points to the allochthonous nature of this material; although it does not exclude post-depositional modification, including the addition of Au.

4.7 Ferruginous separations and other material from the transported sediments

Gold concentrations in ferruginous material separated from 6 samples of transported material collected from 6 to 20m depth do not exceed 20 ppb and are thus much lower than surficial samples (Appendices 11 and 13). The sample with the most Au (17 ppb) also has the highest Fe, Ba, Ce, Cr, Eu, La, Lu, Mn, Ni, Pb, Sb, Sc, Sm, Th, U and Yb; these elements are probably concentrated within Fe and/or Mn oxides rather than being specifically related to Au.

Data from Gardiner (1993) for selected samples from the transported regolith indicate :

(i) that Lu and Yb have relatively high concentrations in samples containing medium (0.1 to 1 ppm) to high (>1 ppm) concentrations of Au (Figure 16, Appendices 11 and 13); these elements are also more concentrated in selected saprolite and bedrock samples;
(ii) multi-element concentrations for hole ST-1 (10808E 4250N) suggest there is a surface enrichment (0 - 5 m) of Au, Ca, K, Mg, Mn, S, Cl, Cs, Cu, Pb, Rb, Sr, Zn and REE, compared with the sub-surface (5 - 10 m) (Appendices 11 and 13);
(iii) that Fe content appears to influence the concentration of several elements, including As, Ni, Sb, Sc and V;
(iv) palaeochannel sediments are enriched in Al, Br, Cr, Hf, Th and Zr with respect to the saprolite and basement;
(v) a S-rich unit at about 15 m shows elevated total Au concentrations (up to 85 ppb) relative to adjacent sediments (< 20 ppb). Gardiner (1993) suggests that the patchy distribution of this unit diminishes its suitability as a sample medium;
(vi) the ratios of As/Fe and Cr/Fe from drill hole ST-1 also indicate that there may be at least two distinct types of sediments that make up the transported overburden. The boundary between the two types appears to be close to 15m below the surface.

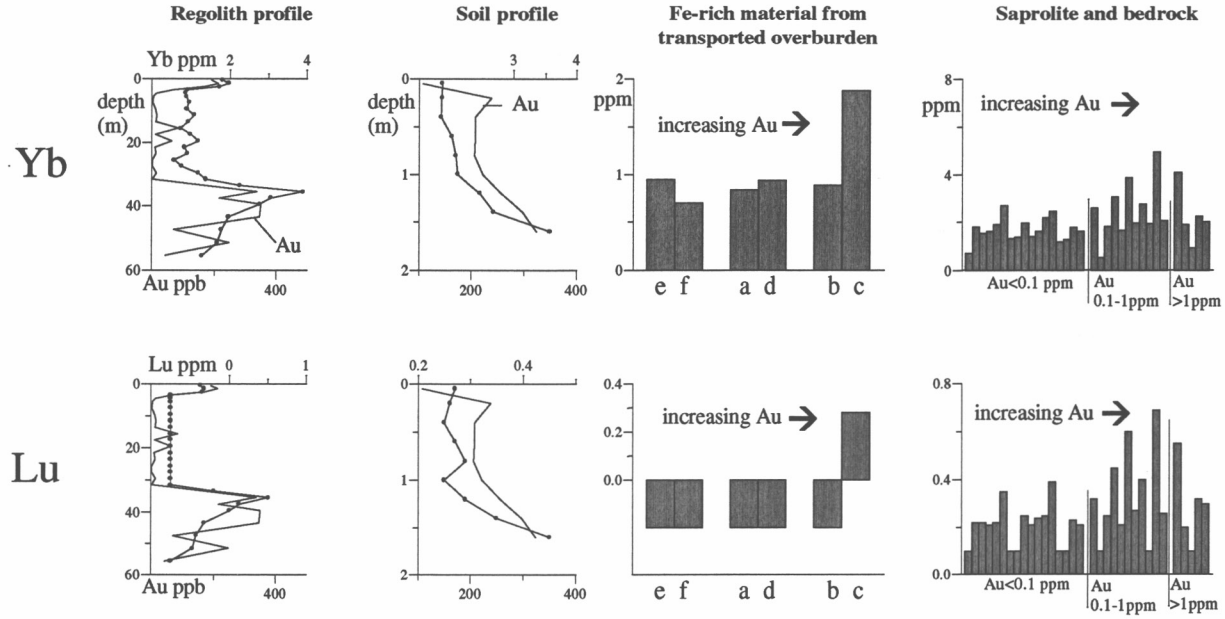

Figure 16: Distribution of Yb and Lu in relation to the concentration of Au in surficial, transported material and saprolite/bedrock. Results for Lu shown less than 0 ppm are below detection. For depth and description of samples a to f see Appendix A12.6.

5 Discussion

Of the four study sites examined in detail, Steinway is unusual in two respects:

(i) it has the highest Au concentrations found in the soil;
(ii) the highest Au contents almost directly overlie the underlying mineralization.

The reason(s) for the distribution of Au at Steinway is of prime importance to the Kalgoorlie studies. There are two hypotheses for the origin of the surface Au anomaly:

Hypothesis 1:
The soil anomaly is derived from the underlying mineralization. The Steinway soil anomaly is almost exactly defined by the boundaries of the sand base of the palaeochannel. This suggests that the channel itself may be playing a role in the formation of the anomaly, and/or that the channel position has been influenced by the geology. In this study, the distribution and tenor of Au mineralization has only been determined for two sections and so its relationship to the channel over a broader area needs to be established. Furthermore, the presence of other mineralization in the area and its spatial relationship with the other soil anomalies needs to be investigated. Only when this is done can the probability of success of locating buried mineralization from the surface be assessed. It may be that it is only anomalies over the axis of the palaeochannels that can be used to locate underlying mineralization; if this is substantiated at other sites (as at Zuleika), then groundwater flows or the sand horizons of the transported regolith may be playing a role. Gold has been detected in the groundwater close to mineralization.

Hypothesis 2:
The soil anomaly is not derived from the underlying mineralization. Evidence has been presented for the possible origin of Au from upslope, and includes:

(i) the presence of saprolitic fabrics in ferruginous granules containing high Au concentrations; the ferruginous granules should be studied in some detail. If Au is found within saprolitic material

within the ferruginous granules then this is strong evidence for at least some of the Au being of exotic origin.

(ii) Au being associated with Fe, rather than Ca in the lower part of the soil profile; the negative correlation with Ca is interesting since it implies that this particular Au is not behaving in the same way as most Au found in erosional and relict areas where there is a very close correlation. Profiles at Zuleika also indicate that the association between Au and Ca is not as strong in depositional areas. Indeed, the Au/Ca relationship at Steinway is similar to that at Mulline (Lintern and Butt, 1991), where there appears to be an association between Au and Ca at the surface and between Au and Fe in the lower part of the profile; Mulline profiles are relict.

(iii) the sample with the highest total Au concentration in the 0 - 1m composite sample is the only one which is relatively insoluble when extracted with water. The form of the Au has not been determined from these extractions but from experiments conducted on samples from other sites water soluble Au is often directly proportional relationship to total Au in carbonate-rich soils. This is the case at Steinway except close to mineralization, where presumably the Au is associated with Fe rather than Ca.

If Hypothesis 2 is true (that Au in the soil is NOT derived from underlying mineralization) then a possible mechanism for the formation of the anomaly is as follows: Au has been transported from upslope within ferruginous granules, now at 1-2m, that represent a former land surface *i.e.* a buried lag. The granules have undergone some post-depositional weathering, remobilizing some Au, which is now incorporated in pedogenic carbonate.

6 Recommendations

Future studies at Steinway are required. More information needs to be gathered from the soil Au anomaly to examine whether the relationship between Au and Fe, and Au and Ca and possibly other elements is similar or variable throughout the entire anomaly. Other soil anomalies need to be examined in similar detail. There is some supporting evidence of a strong association between Au and Ca (and not Fe) (Gardiner, 1993) from drill spoil (10550E, 4250N and 10501E, 4800N) about 250 m away from the soil profile described in this report. Also, there is evidence for the presence of anomalous Au in deeper parts of the transported overburden (drill hole ST-1) and this needs to tested for consistency in other areas at Steinway to see if there is any relationship with soil anomalies and/or underlying mineralization. Specifically, there is a need:

(i) to examine the relationship between the soil anomalies, underlying mineralization and position of the palaeochannel(s),

(ii) to examine the ferruginous lag containing Au in more detail to try and determine the nature of the Au contained therein, and

(iii) to collect and analyze soil samples from other parts of the Steinway and other anomalies by putting in costeans and/or soil pits, and by more augering.

Acknowledgements

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References

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/AMIRA Project P241A). CSIRO Division of Exploration Geoscience Restricted Report 396R. 64pp.

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

Gardiner, N., 1993. Regolith geology and geochemistry of the Steinway gold prospect, Kalgoorlie, Western Australia. University of Western Australia, unpublished thesis. 165 pp.

Gottardi, G. Burton, J.D. and Culkin, F., 1978. Gallium. *In* "Handbook of Geochemistry, II-3." (Ed. K.H. Wedepohl). (Springer-Verlag, Berlin, Germany.)

Gray, D.J., 1990. Hydrogeochemistry of the Panglo Gold Deposit. (CSIRO/AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 125R. 74pp.

Gray, D.J., 1991. Hydrogeochemistry in the Mount Gibson Gold District. (CSIRO/AMIRA P240: Laterite Geochemistry). 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/AMIRA P241A: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 237R. 13pp.

Gray, D.J., 1992b. Geochemical and Hydrogeochemical Investigations of Alluvium at Mulgarrie, Western Australia. (CSIRO/AMIRA P241A: Weathering Processes). 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 Weathering Processes Group). 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/AMIRA P241A: Weathering Processes Group). CSIRO Division of Exploration Geoscience Restricted Report 387R. Vols I and II. 133pp.

Gray, D.J. and Lintern, M.J., 1993. Further aspects of the chemistry of gold in some Western Australian soils. (CSIRO/AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 391R. 50pp.

Gray, D.J., Butt, C.R.M. and Lawrance, L.M., 1992. "The Geochemistry of Gold in the Weathering Environment." *In* Regolith Geochemistry in Tropically Weathered Terrain. Handbook of Geochemical Exploration, Vol. 4 (Eds. C.R.M. Butt and H. Zeegers).

Kern, A.M. and Commander, D.P., 1993. Cainozoic stratigraphy in the Roe Palaeodrainage of the Kalgoolie region, Western Australia. *In* Report 34, Professional Papers. Geological Survey of Western Australia. pp 85 - 95.

Lintern, M.J., 1989. Study of the distribution of gold in soils at Mt. Hope, Western Australia. (AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 24R. 36pp.

Lintern, M.J.. and Butt, C.R.M., 1991. Distribution of gold and other elements in soils from the Mulline area, Western Australia. (AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 159R. 56pp.

Lintern, M.J.. and Butt, C.R.M., 1992. The distribution of gold and other elements in soils and vegetation at Zulieka, Western Australia. (AMIRA P241A: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 328R. 90pp.

Lintern, M.J. and Scott, K.M., 1990. The distribution of gold and other elements in soils and vegetation at Panglo, Western Australia. (AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 129R. 96pp.

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.

Piper, C. S., 1947. "Soil and Plant Analysis." (University of Adelaide, Adelaide). 135-136.

Walkley, A, 1935. An examination of methods for determining organic carbon and nitrogen in soils. Journal of Agricultural Science, 25: 598-609.

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 contents

Appendix 1: Tabulated groundwater data

Table A1: Groundwater Sample Positions and Elemental Abundances (in ppm unless otherwise noted) at Steinway

No.	3	4	5	6	7	2	8	1
Name	4200-3	4200-1	4400-6	4250-1	4250-2	4250-2	4250-3	4250-3
East	10849	10899	10699	10835	10822	10822	10810	10810
North	4197	4200	4400	4250	4250	4250	4250	4250
pH	4.30	5.84	5.82	3.44	4.93	5.48	4.90	5.57
Eh (mV)	495	241	281	600	390	336	235	418
TDS	73146	81807	74235	49384	53443	57687	51890	55878
Na	22300	26200	22600	14900	15900	17510	15100	16990
Mg	3055	3375	3640	2275	2760	2756	2630	2780
Ca	725	850	905	325	605	661	555	651
K	141	160	153	96	112	88	108	87
Cl	41749	45467	41344	27428	29657	32000	29188	30700
SO_4	5138	5647	5527	4148	4344	4500	4239	4520
HCO_3	2	117	78	nil	7	30	14	36
P	0.017	0.013	0.013	0.024	0.015	0.013	0.015	0.012
Li	1.5	1.3	1.8	1.9	1.7	nd	1.8	nd
Be	<0.005	<0.005	<0.005	0.031	0.011	nd	0.006	nd
Rb	0.025	0.031	0.018	<0.002	<0.002	nd	<0.002	nd
Sr	6.3	8.4	7.0	3.0	4.8	5.7	4.5	5.6
Ba	0.122	0.155	0.070	0.088	0.082	0.086	0.108	0.063
B	6.5	6.3	6.4	9.0	8.1	nd	8.0	nd
Al	2.63	0.025	<0.005	130	2.86	0.76	0.66	0.89
Si	11	7	5	45	20	18	23	22
I	5.5	5.4	5.6	4.7	4.8	6.3	4.7	6.2
Sc	0.032	0.020	0.008	0.036	0.009	nd	<0.005	nd
Ti	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V	<0.005	<0.005	<0.005	<0.005	<0.005	nd	<0.005	nd
Cr	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Mn	16	15	13	27	25	25	32	26
Fe	1.0	20	2.9	7.2	8.5	22.8	2.7	1.8
Co	0.31	0.18	0.20	1.16	0.81	0.93	0.94	0.90
Ni	0.36	0.14	0.18	1.28	1.05	1.14	1.31	1.24
Cu	0.167	0.004	0.092	0.399	0.443	0.171	<0.005	0.166
Zn	0.36	0.11	0.04	0.82	0.55	0.51	0.36	0.44
Ga	0.007	<0.005	<0.005	<0.005	<0.005	0.001	<0.005	<0.005
Ge	0.028	0.019	0.005	0.023	0.009	nd	<0.005	nd
Y	0.150	0.005	0.004	0.401	0.255	0.140	0.425	0.260
Zr	<0.001	<0.001	<0.001	<0.001	<0.001	nd	<0.001	nd
Mo	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ag	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Cd	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sn	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
La	0.093	0.014	0.007	0.914	0.190	0.065	0.283	0.141
Ce	0.366	0.027	0.012	2.725	0.351	0.106	0.362	0.186
Pr	0.031	0.002	<0.002	0.310	0.048	0.014	0.050	0.026
Nd	0.135	0.009	0.004	1.232	0.217	0.057	0.244	0.113
Sm	0.031	<0.002	<0.002	0.237	0.046	0.013	0.057	0.025
Eu	0.007	<0.002	<0.002	0.063	0.017	0.005	0.025	0.010
Gd	0.036	<0.002	<0.002	0.214	0.068	0.027	0.103	0.058
Tb	0.005	<0.002	<0.002	0.024	0.010	0.004	0.016	0.008
Dy	0.028	<0.002	<0.002	0.122	0.069	0.018	0.105	0.044
Ho	0.006	<0.002	<0.002	0.022	0.013	0.004	0.023	0.009
Er	0.016	<0.002	<0.002	0.059	0.043	0.011	0.059	0.024
Tm	<0.002	<0.002	<0.002	0.007	0.005	<0.002	0.008	0.003
Yb	0.011	<0.002	<0.002	0.038	0.024	0.006	0.035	0.016
W	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Au (ppb)	0.015	<0.005	0.013	0.827	<0.005	<0.005	0.011	0.029
Tl	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Pb	2.121	0.646	0.259	0.127	0.385	0.221	<0.003	0.217
Bi	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Th	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
U	<0.002	0.003	<0.002	0.061	0.004	<0.002	<0.002	<0.002

nd: not determined

Appendix 2: Element/ion concentration for groundwaters - graphed

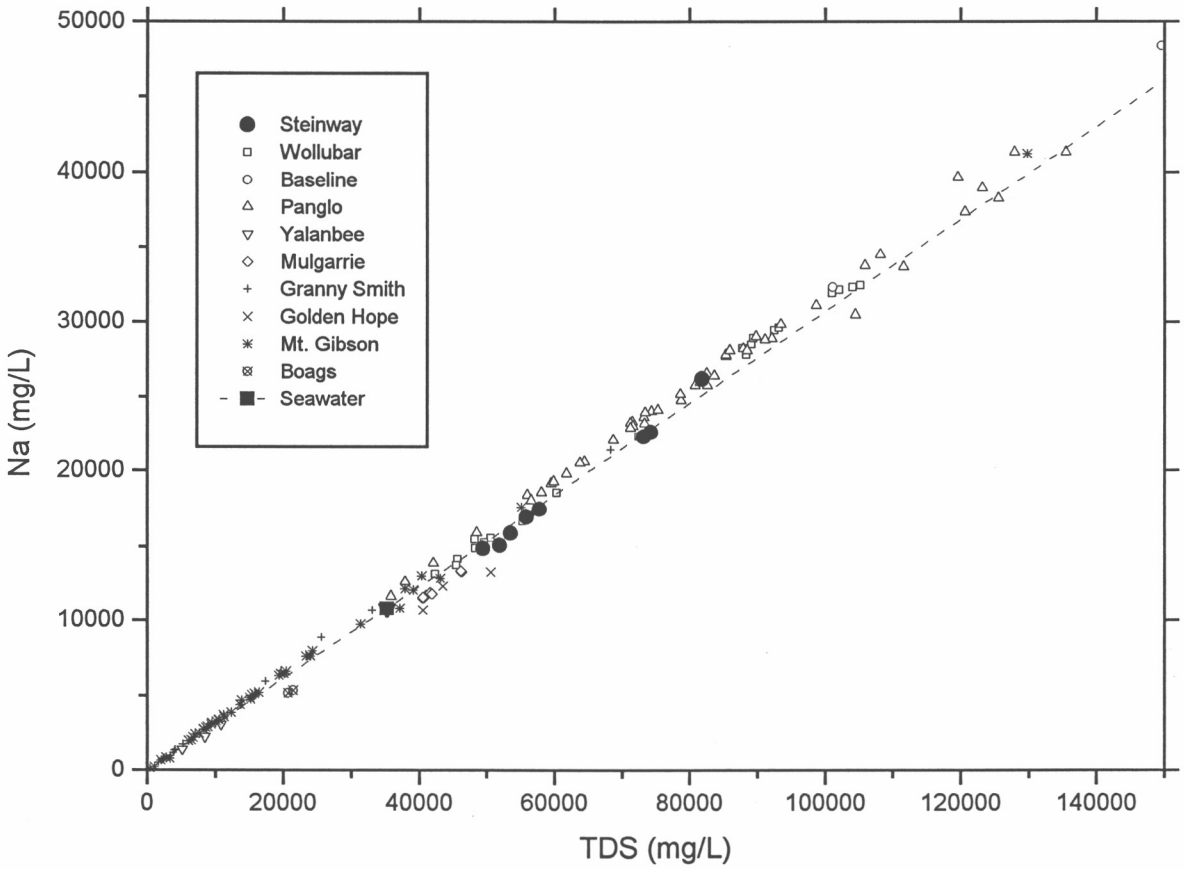


Figure A2.1: Na vs. TDS for groundwaters from Steinway and other sites.

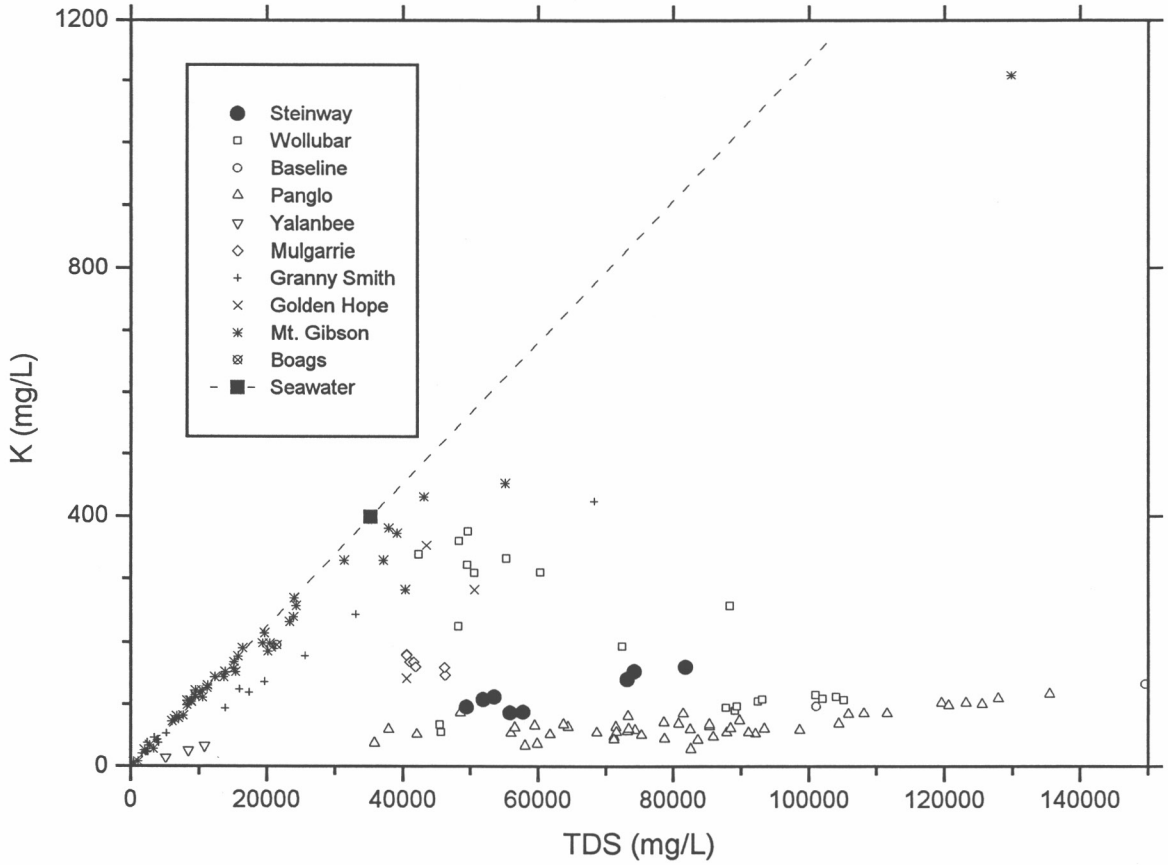


Figure A2.2: K vs. TDS for groundwaters from Steinway and other sites.

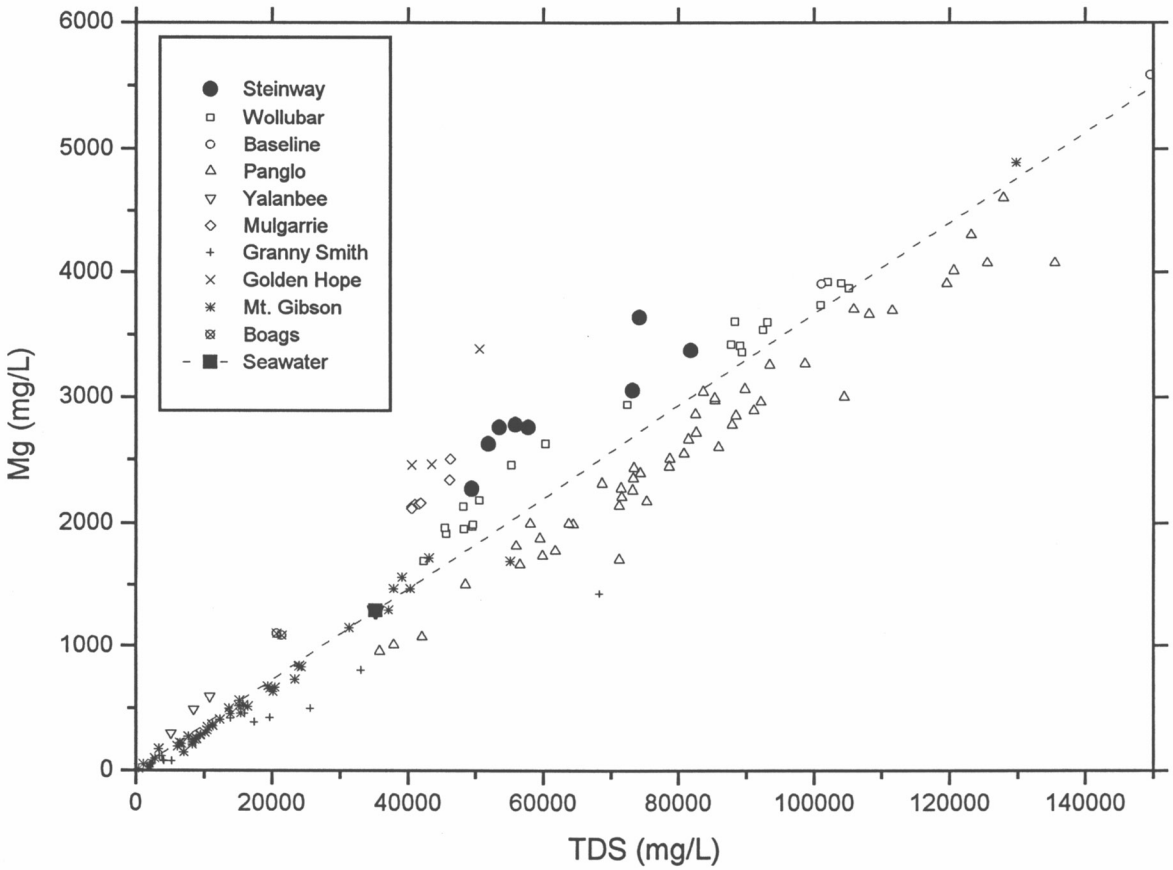


Figure A2.3: Mg vs. TDS for groundwaters from Steinway and other sites.

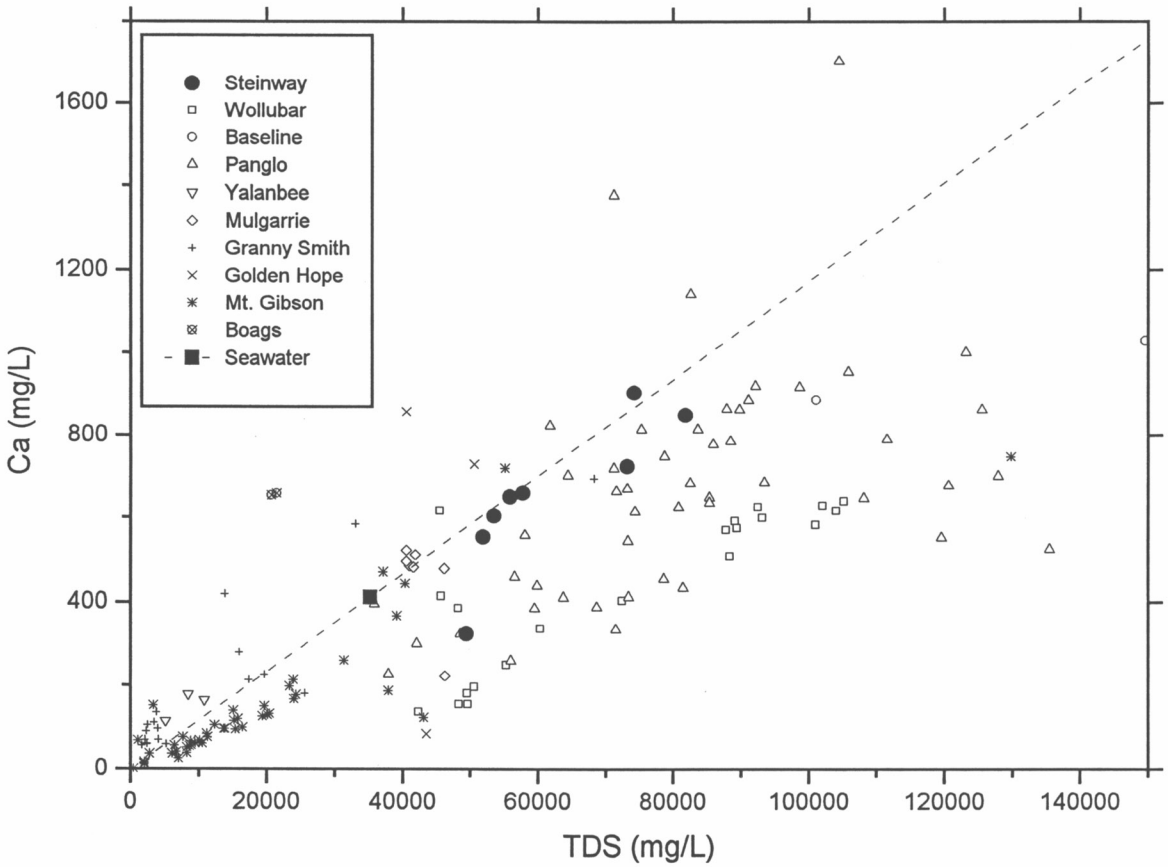


Figure A2.4: Ca vs. TDS for groundwaters from Steinway and other sites.

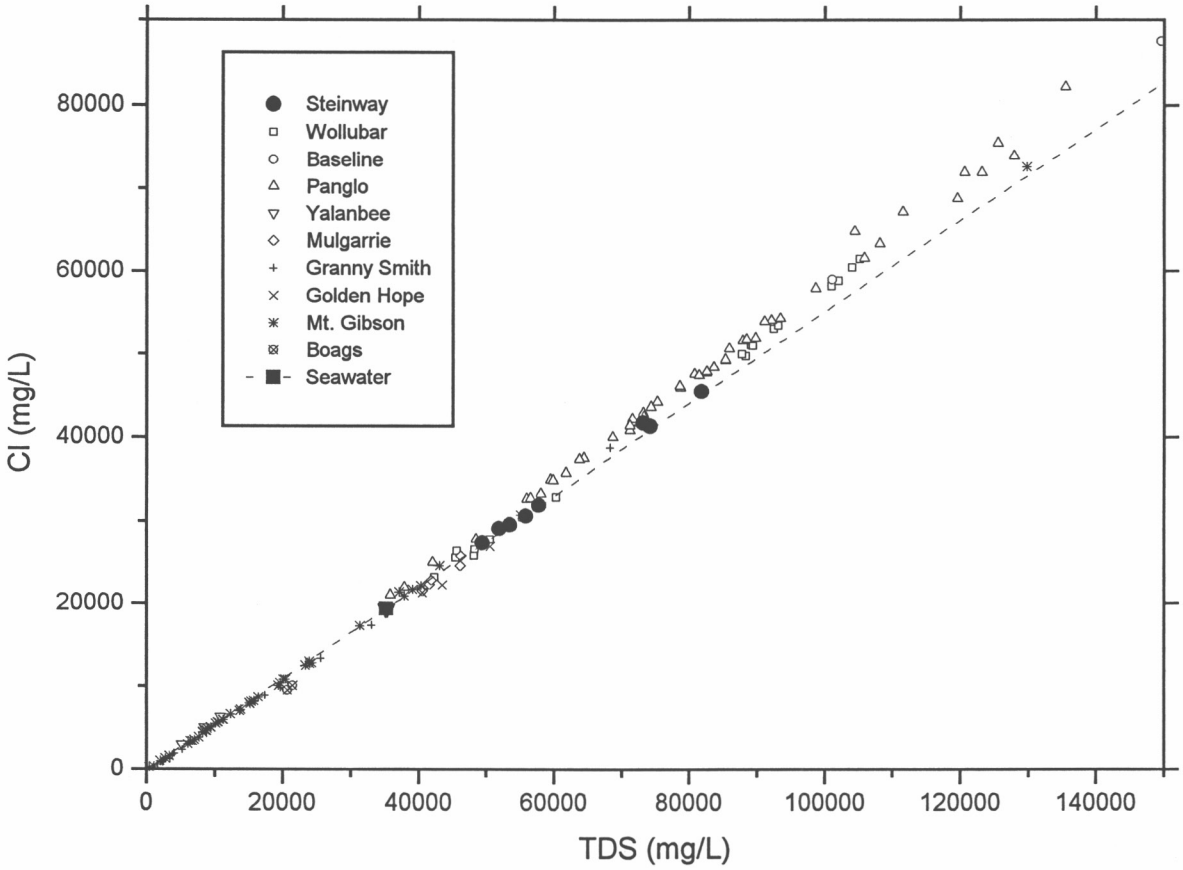


Figure A2.5: Cl vs. TDS for groundwaters from Steinway and other sites.

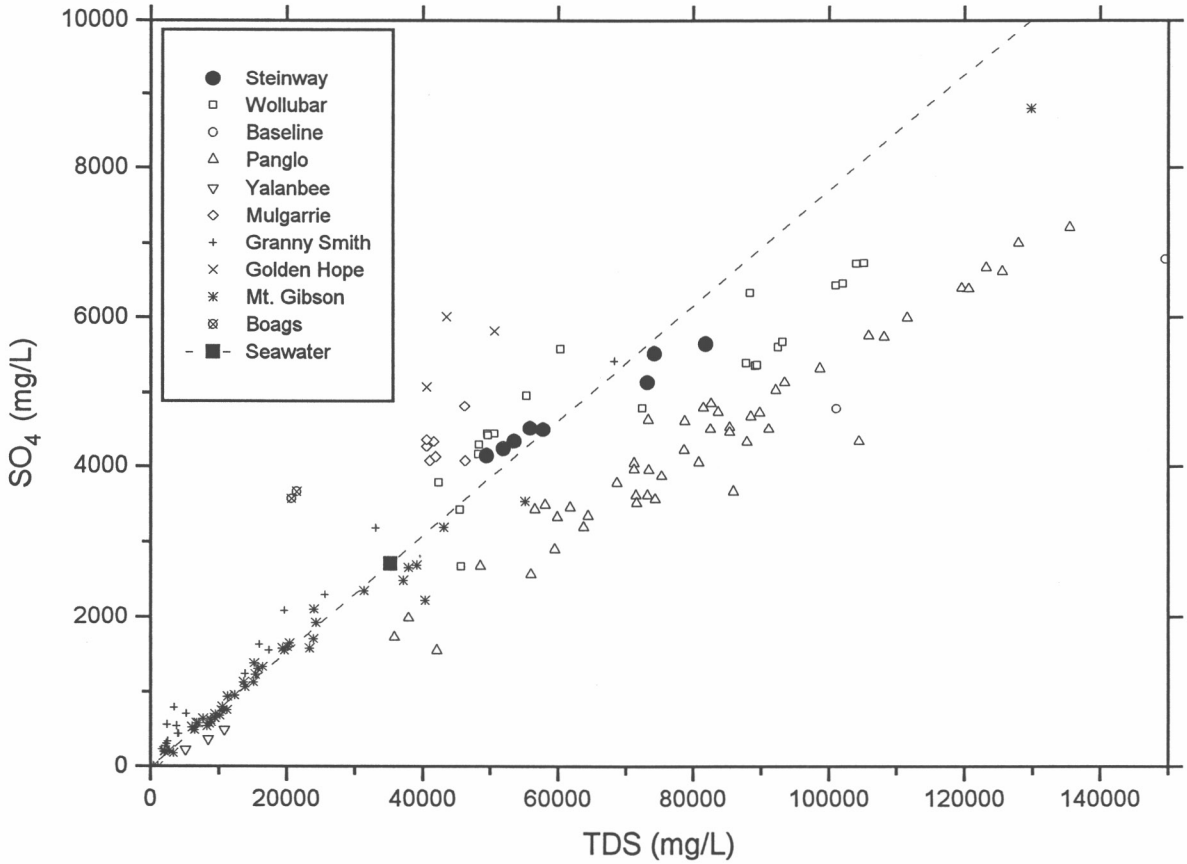


Figure A2.6: SO_4 vs. TDS for groundwaters from Steinway and other sites.

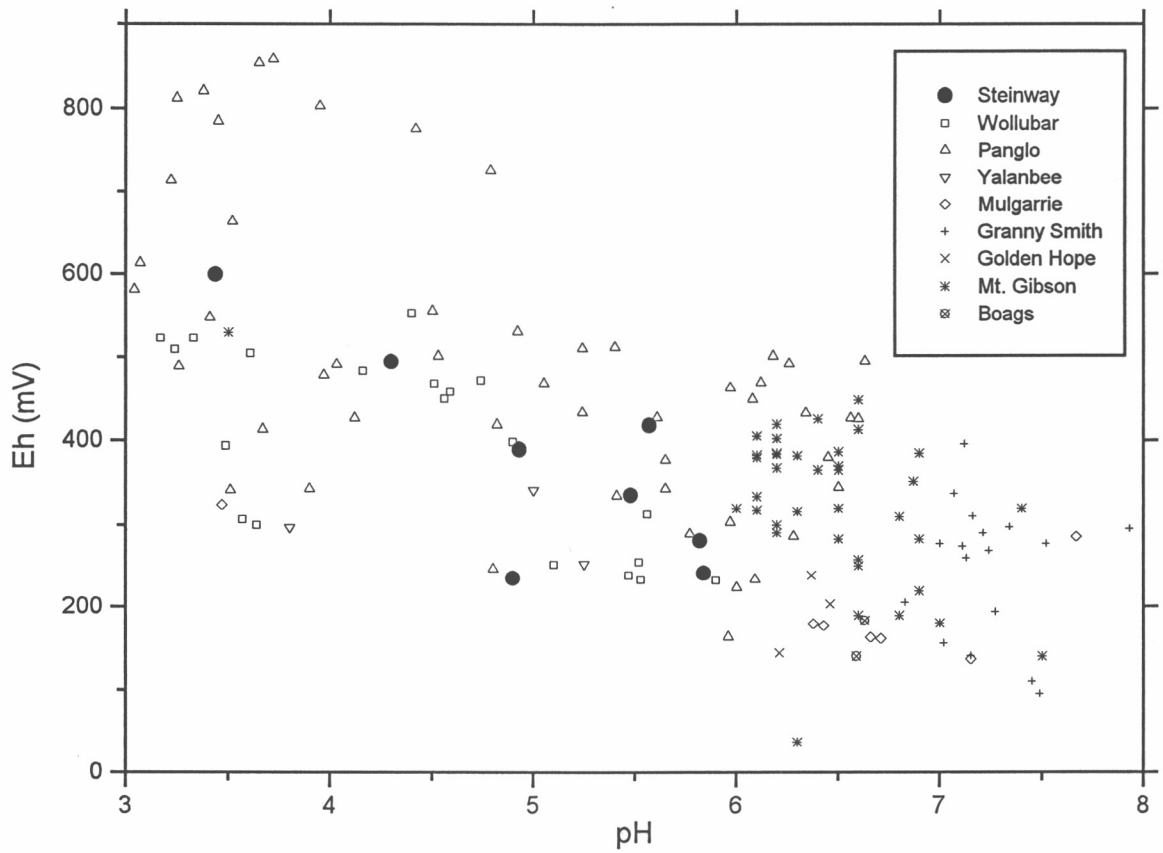


Figure A2.7: Eh vs. pH for groundwaters from Steinway and other sites.

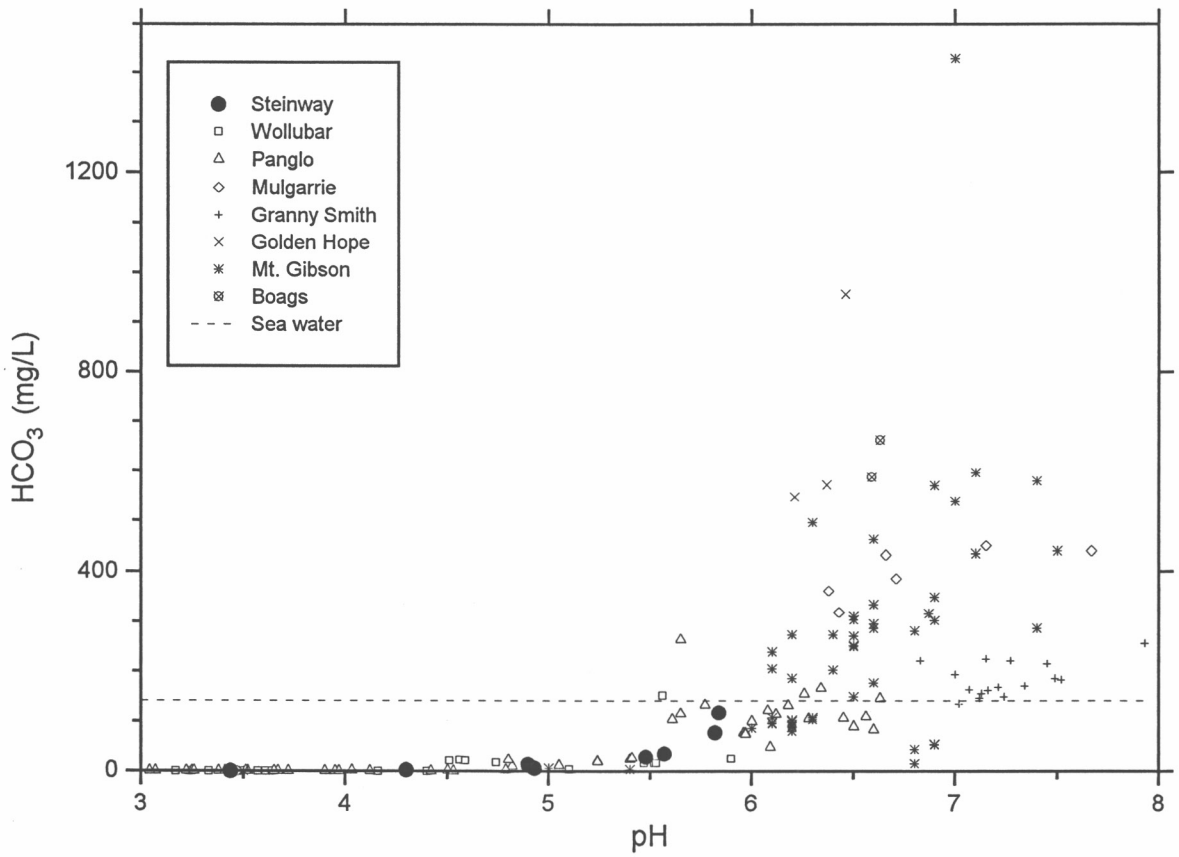


Figure A2.8: HCO_3 vs. pH for groundwaters from Steinway and other sites.

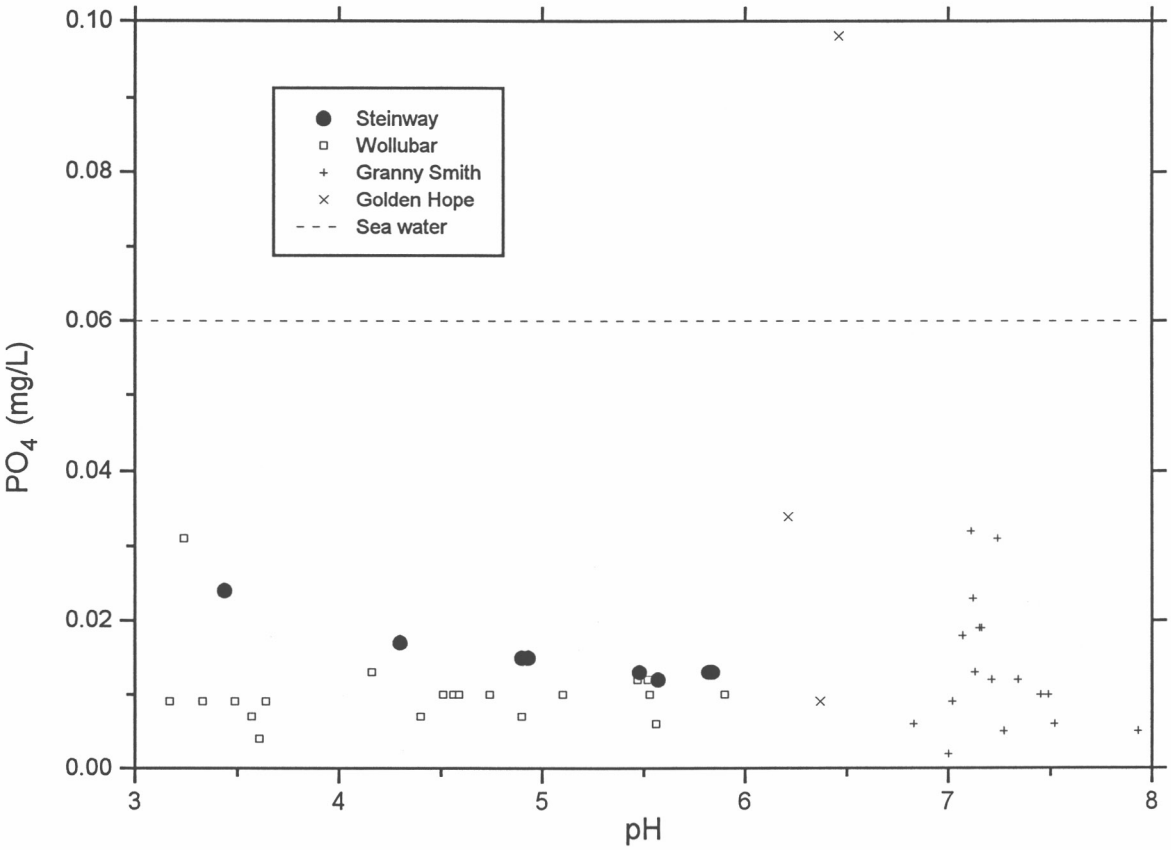


Figure A2.9: PO_4 vs. pH for groundwaters from Steinway and other sites.

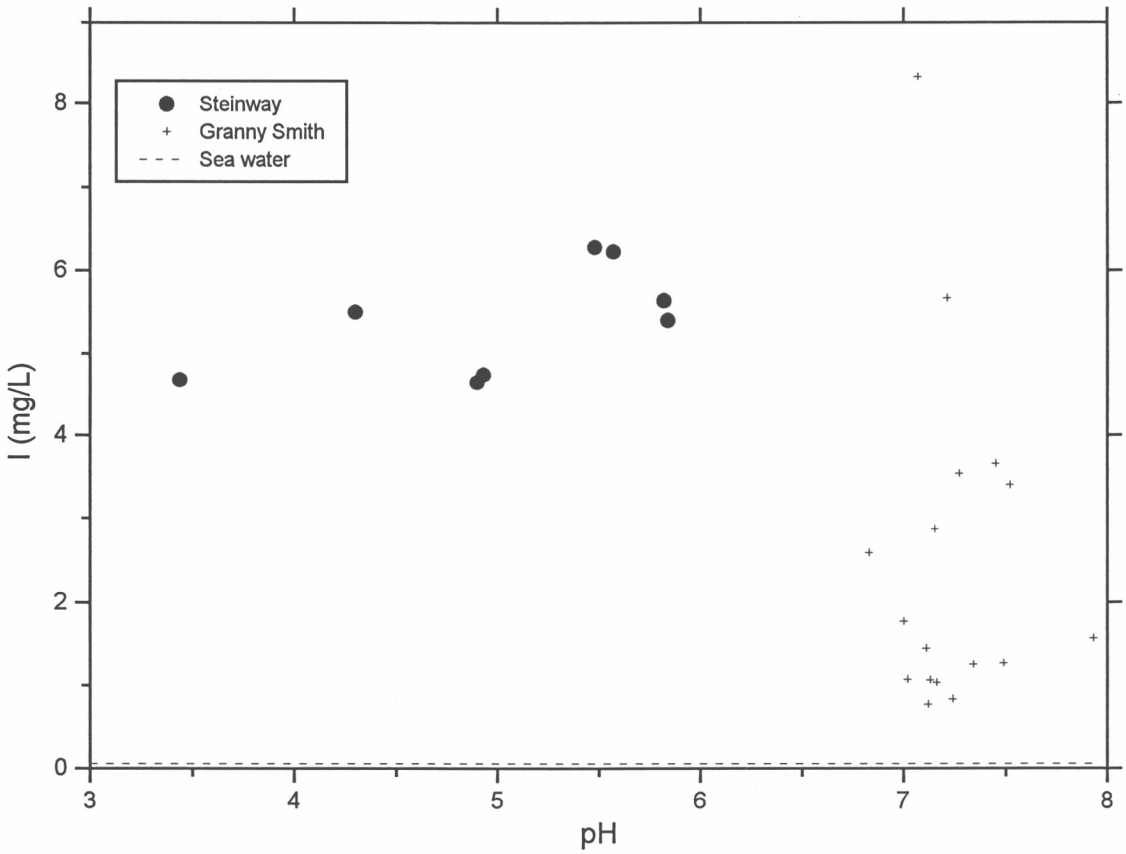


Figure A2.10: I vs. pH for groundwaters from Steinway and other sites.

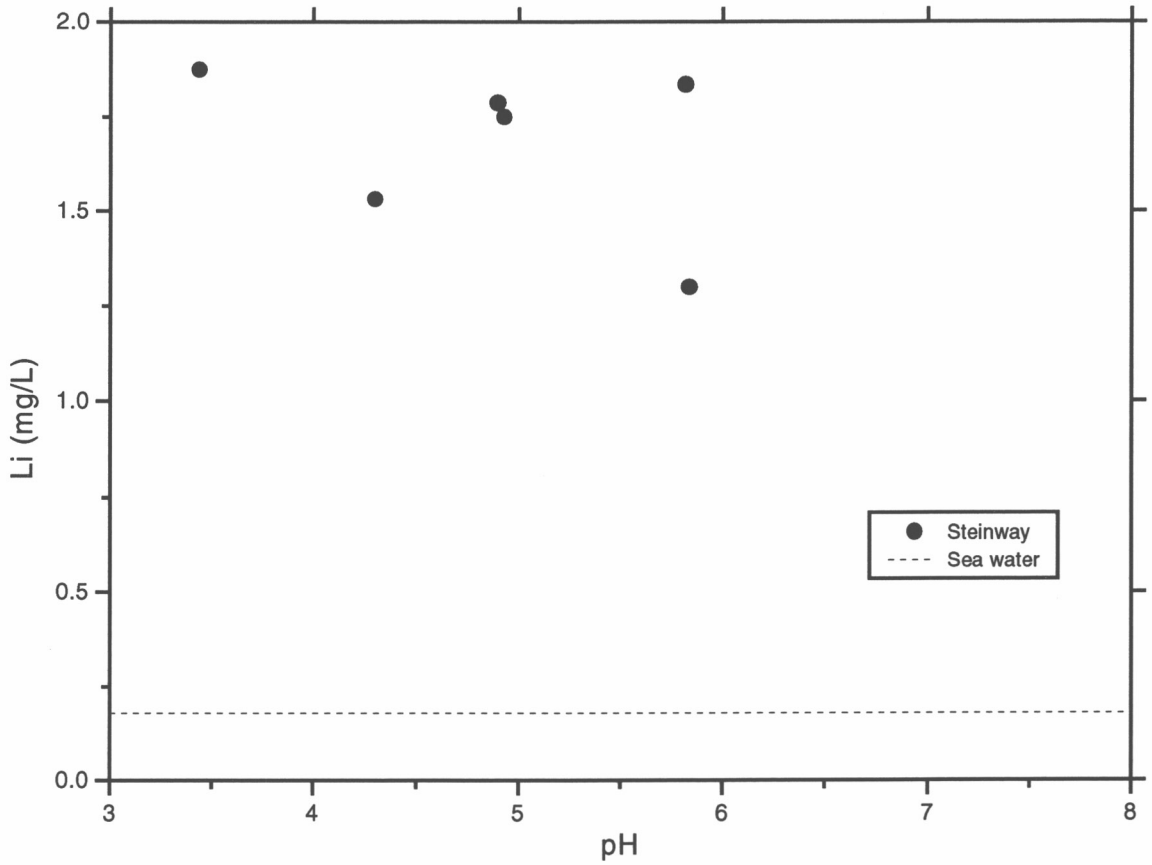


Figure A2.11: Li vs. pH for groundwaters from Steinway.

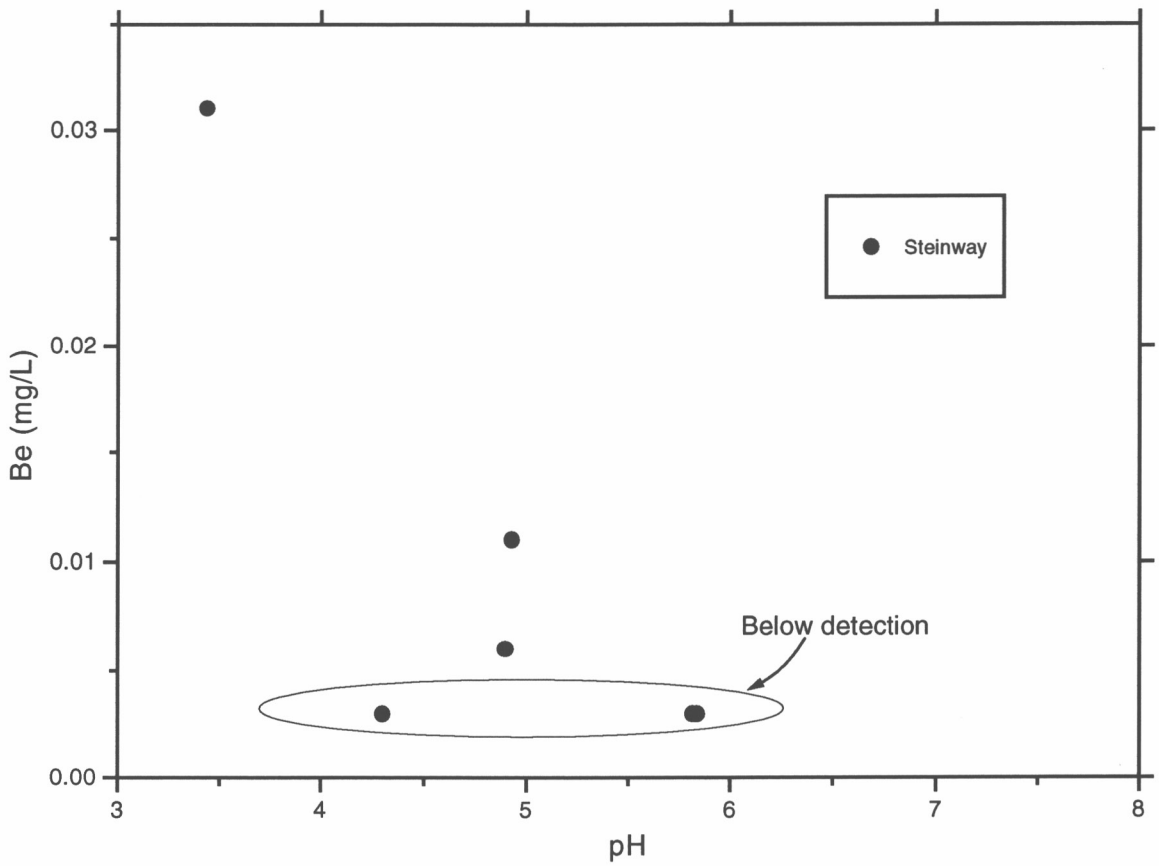


Figure A2.12: Be vs. pH for groundwaters from Steinway.

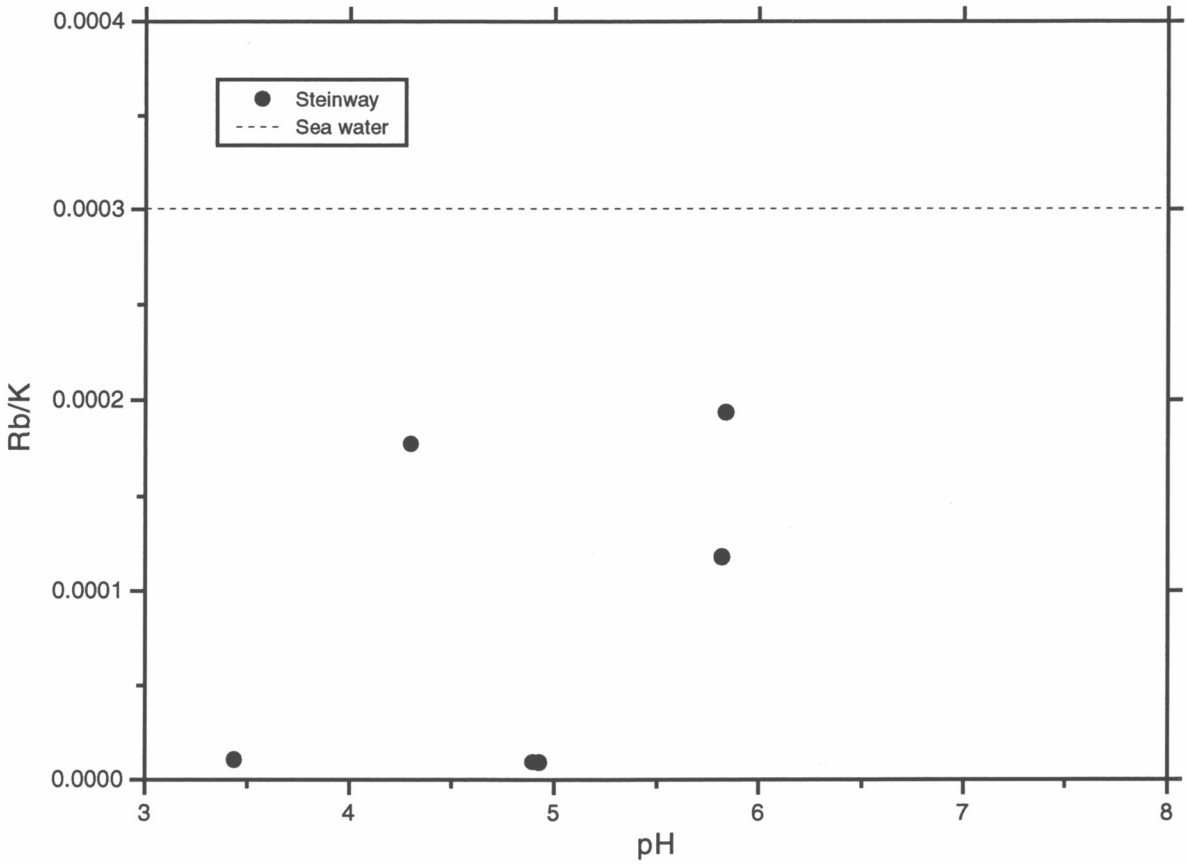


Figure A2.13: Rb/K vs. pH for groundwaters from Steinway.

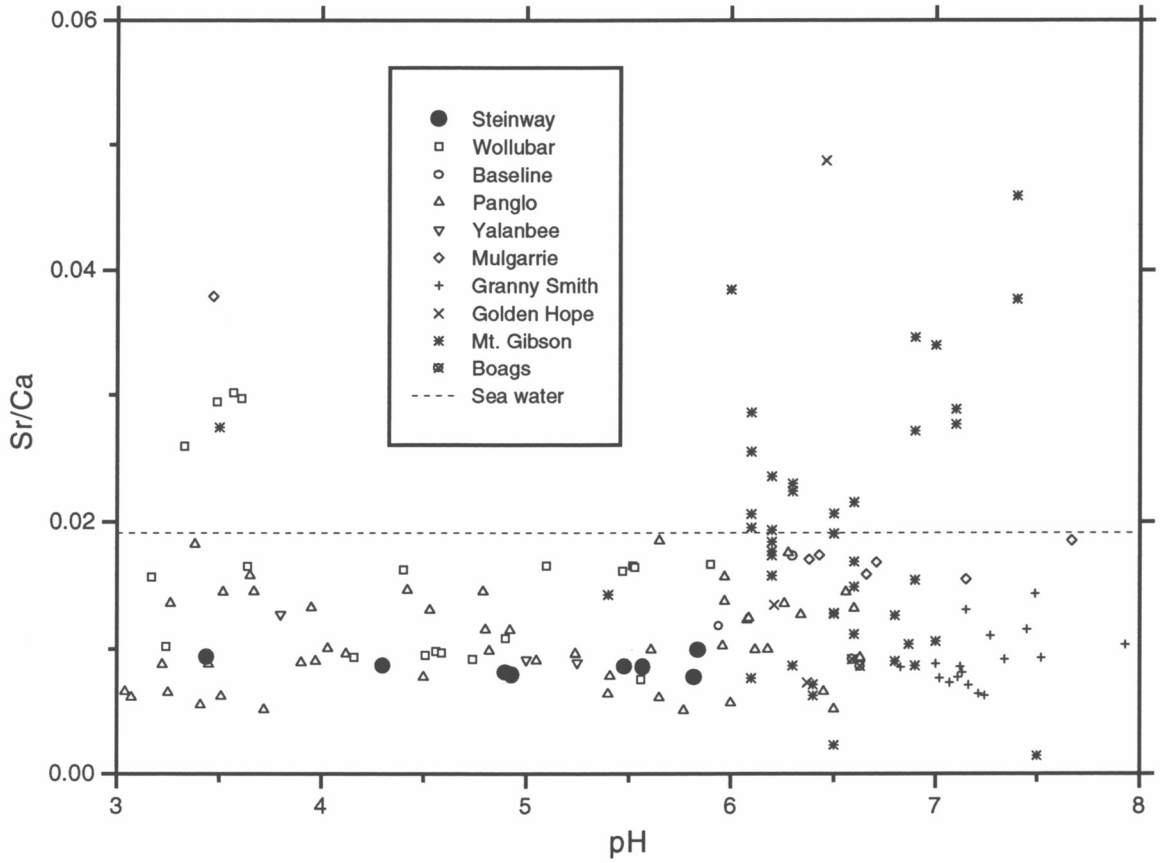


Figure A2.14: Sr/Ca vs. pH for groundwaters from Steinway and other sites.

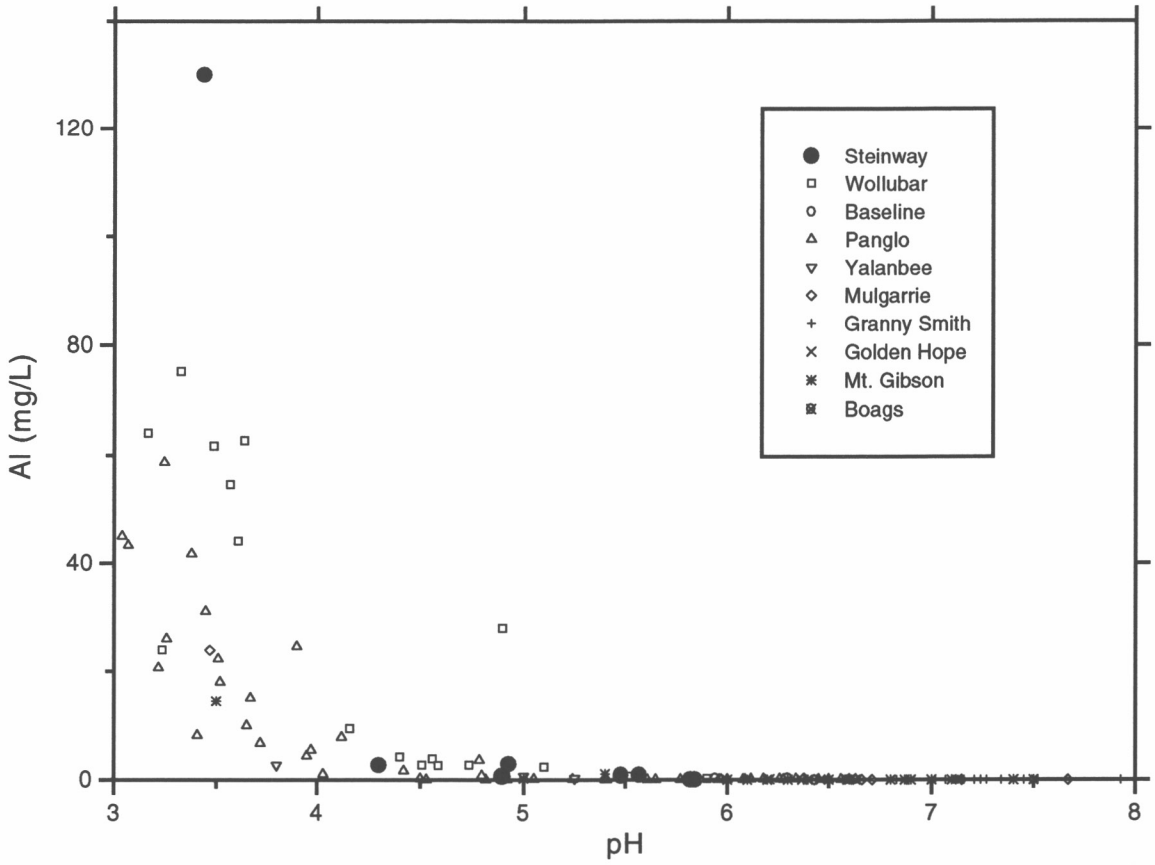


Figure A2.15: Al vs. pH for groundwaters from Steinway and other sites.

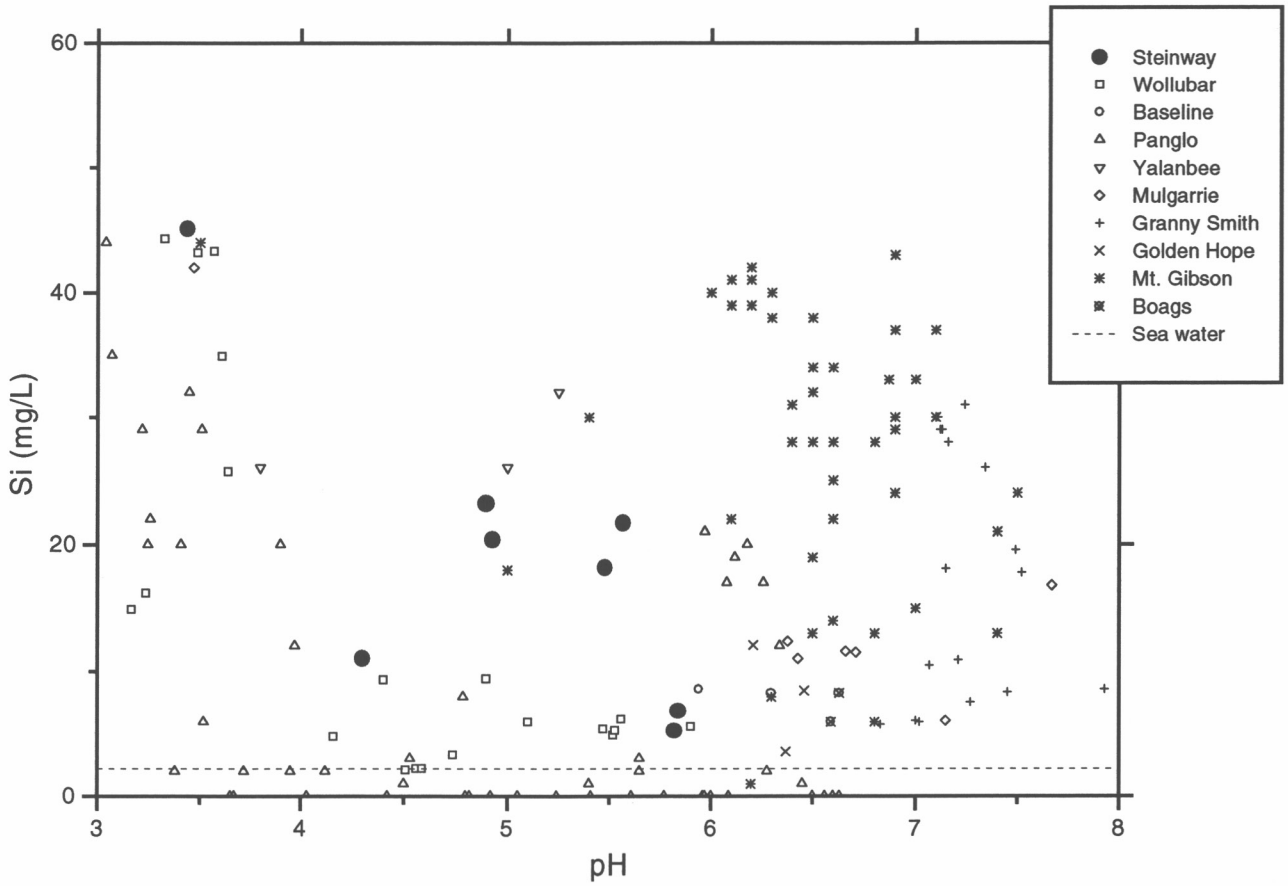


Figure A2.16: Si vs. pH for groundwaters from Steinway and other sites.

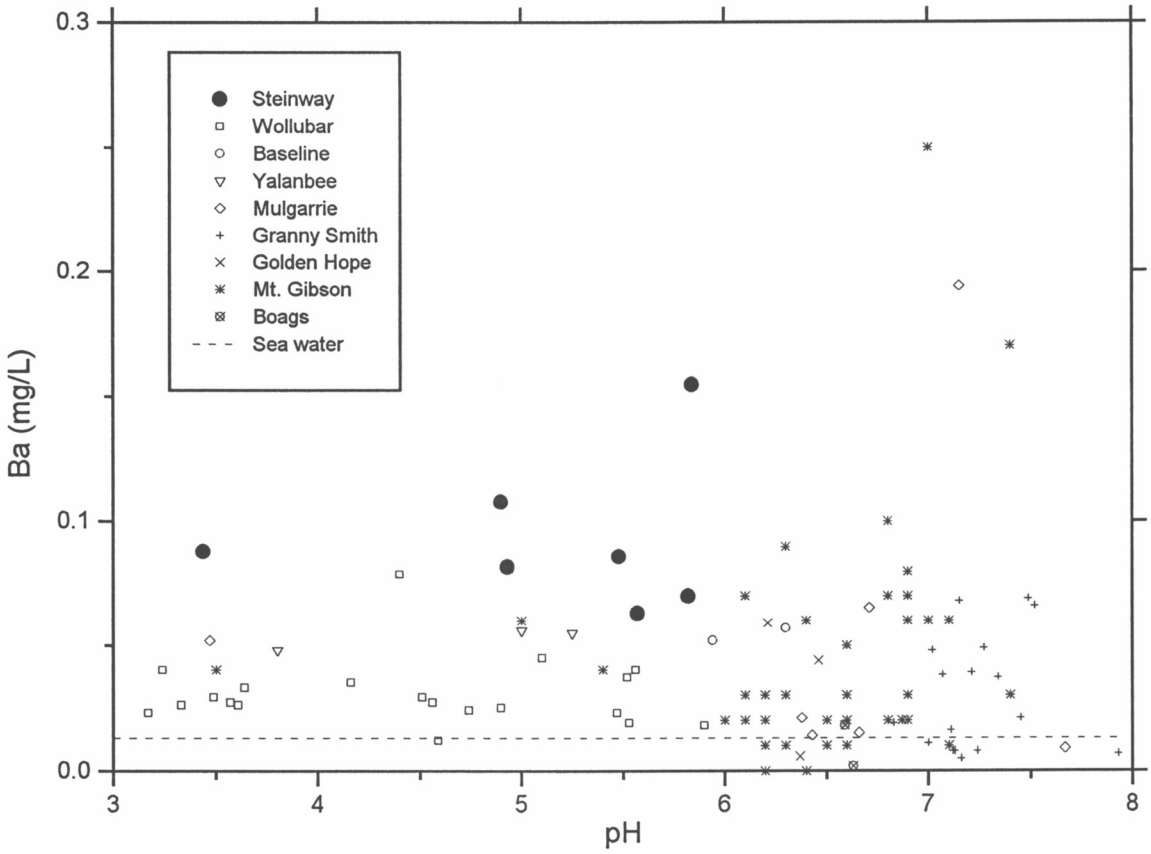


Figure A2.17: Ba vs. pH for groundwaters from Steinway and other sites.

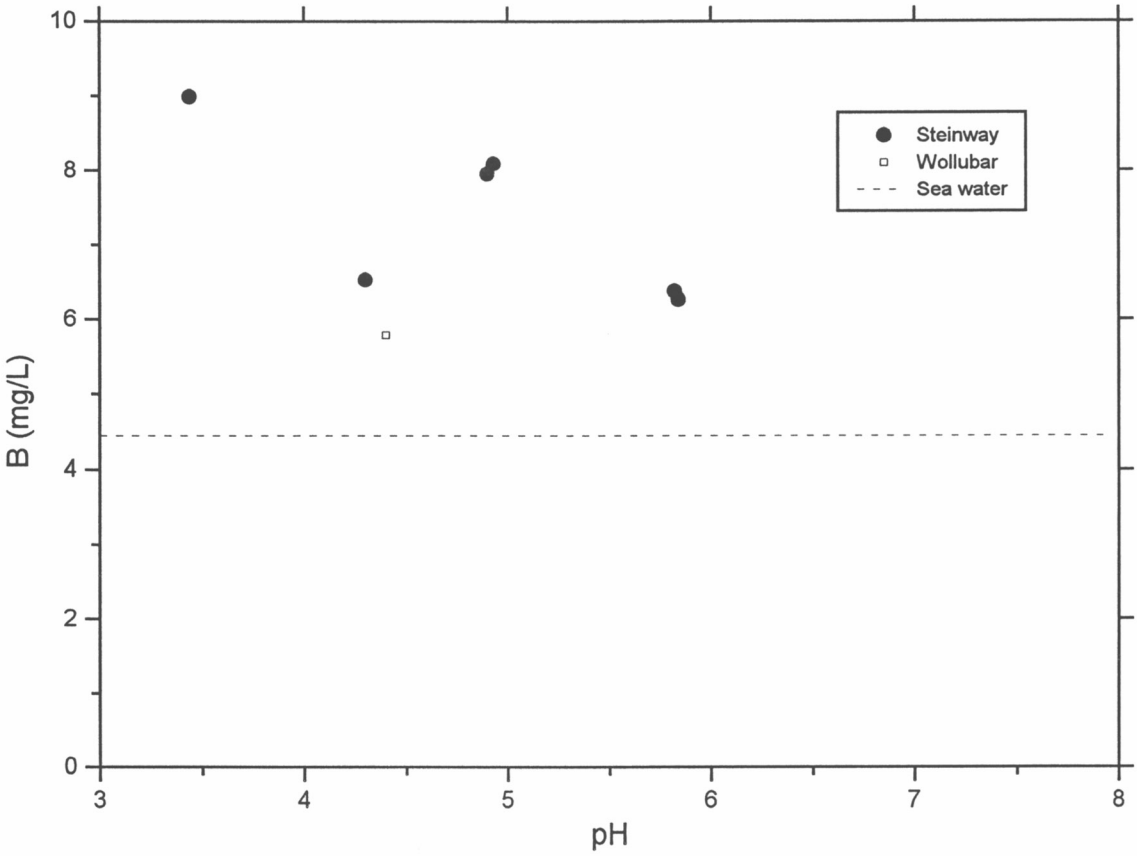


Figure A2.18: B vs. pH for groundwaters from Steinway and other sites.

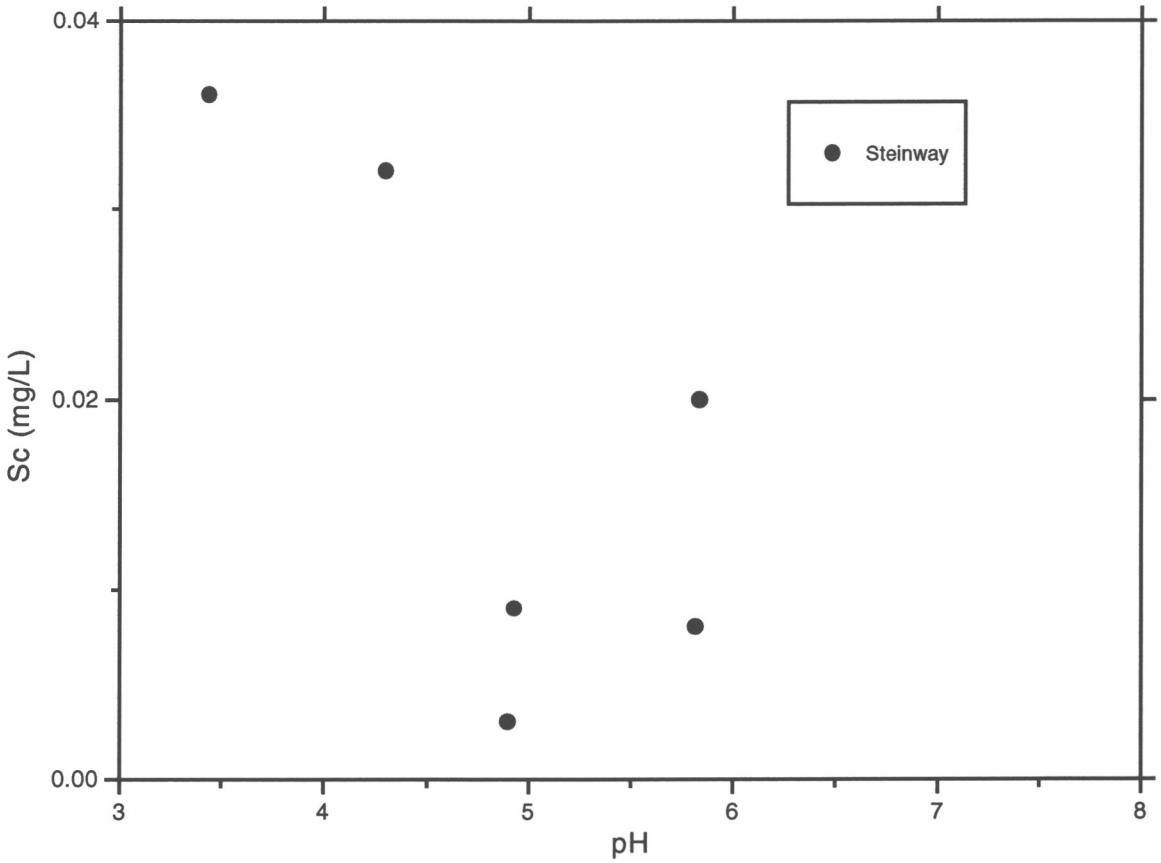


Figure A2.19: Sc vs. pH for groundwaters from Steinway.

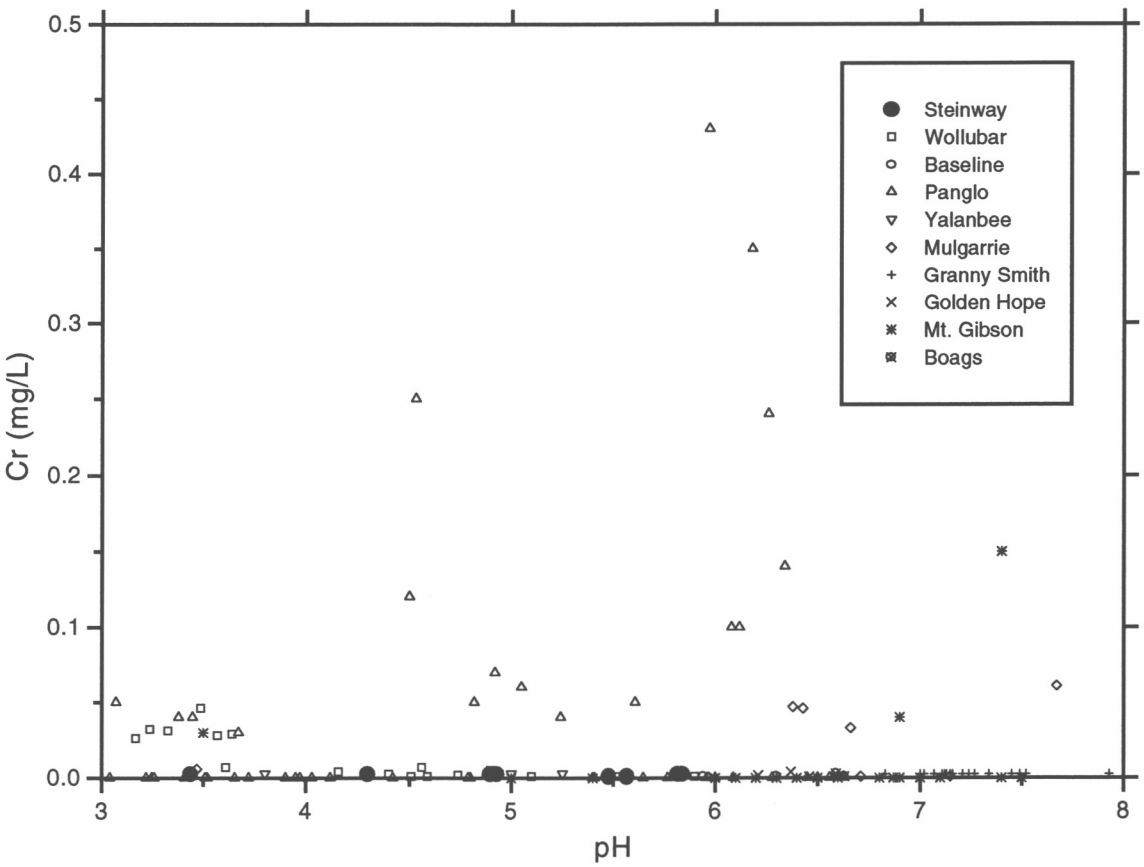


Figure A2.20: Cr vs. pH for groundwaters from Steinway and other sites.

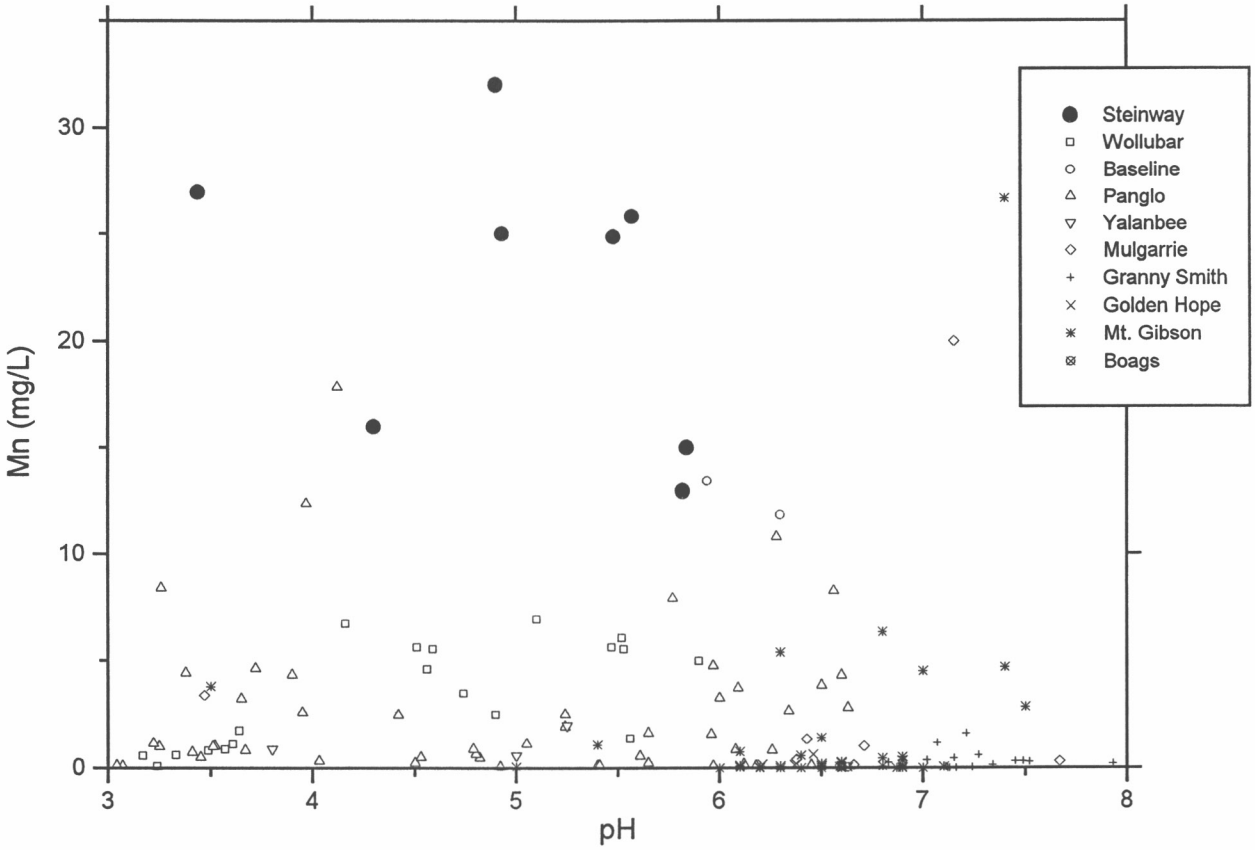


Figure A2.21: Mn vs. pH for groundwaters from Steinway and other sites.

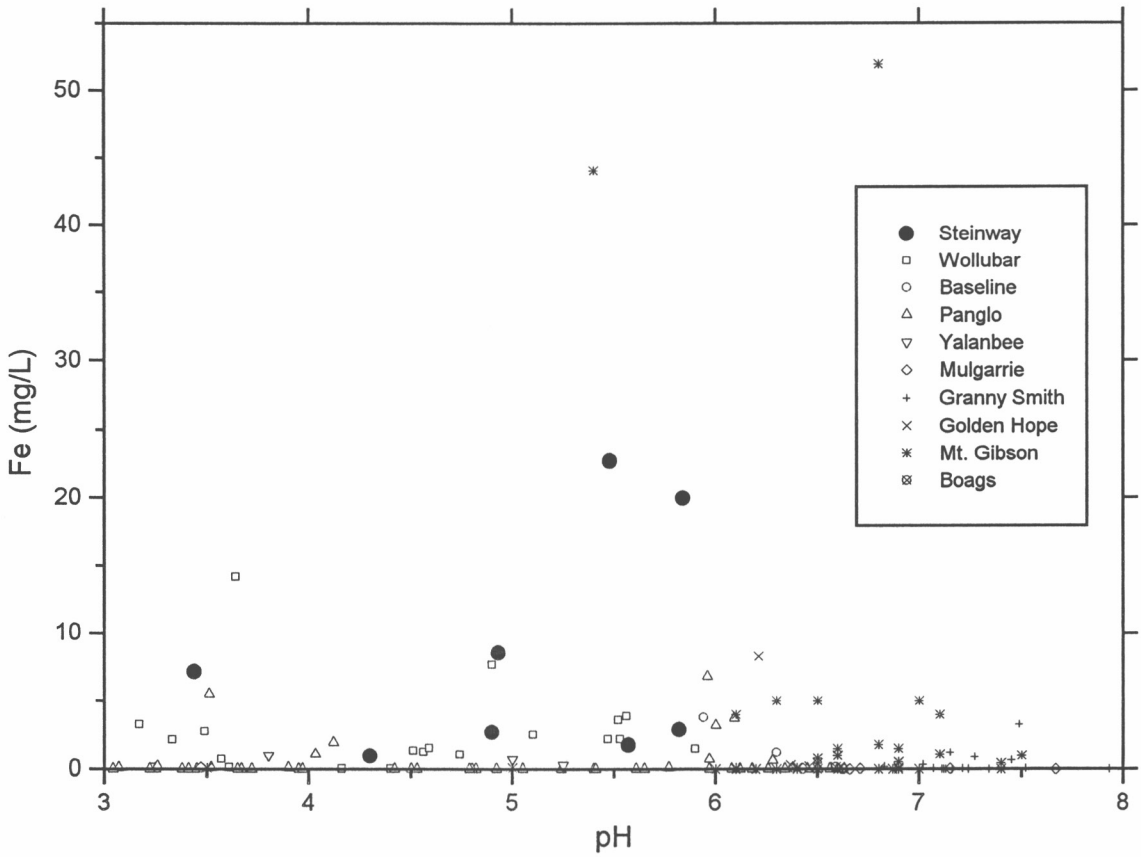


Figure A2.22: Fe vs. pH for groundwaters from Steinway and other sites.

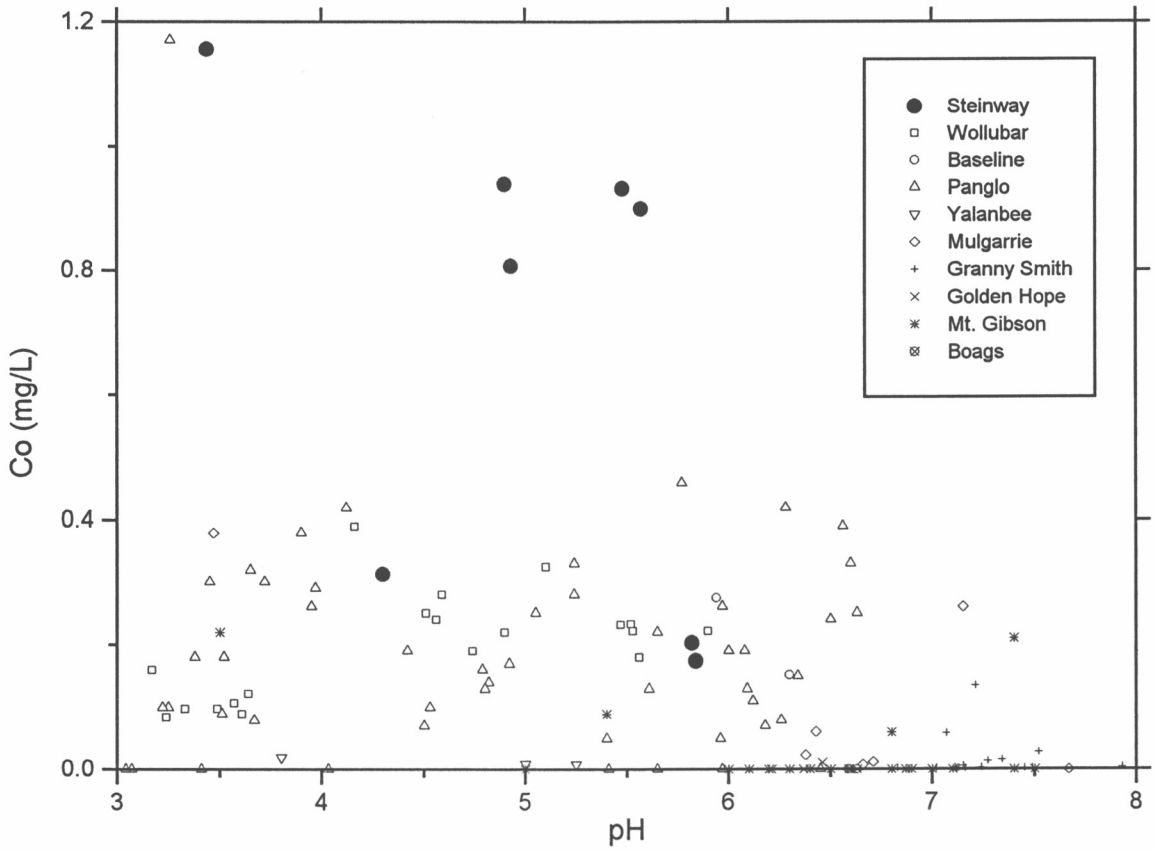


Figure A2.23: Co vs. pH for groundwaters from Steinway and other sites.

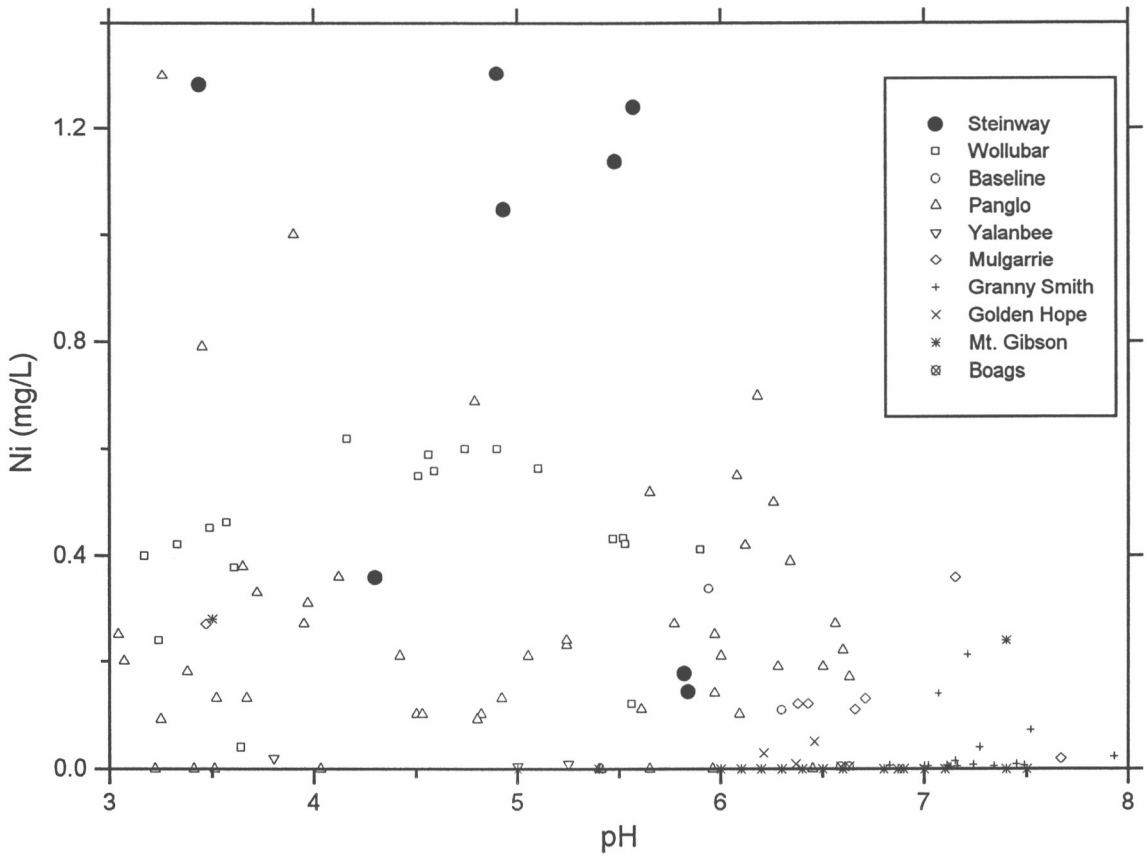


Figure A2.24: Ni vs. pH for groundwaters from Steinway and other sites.

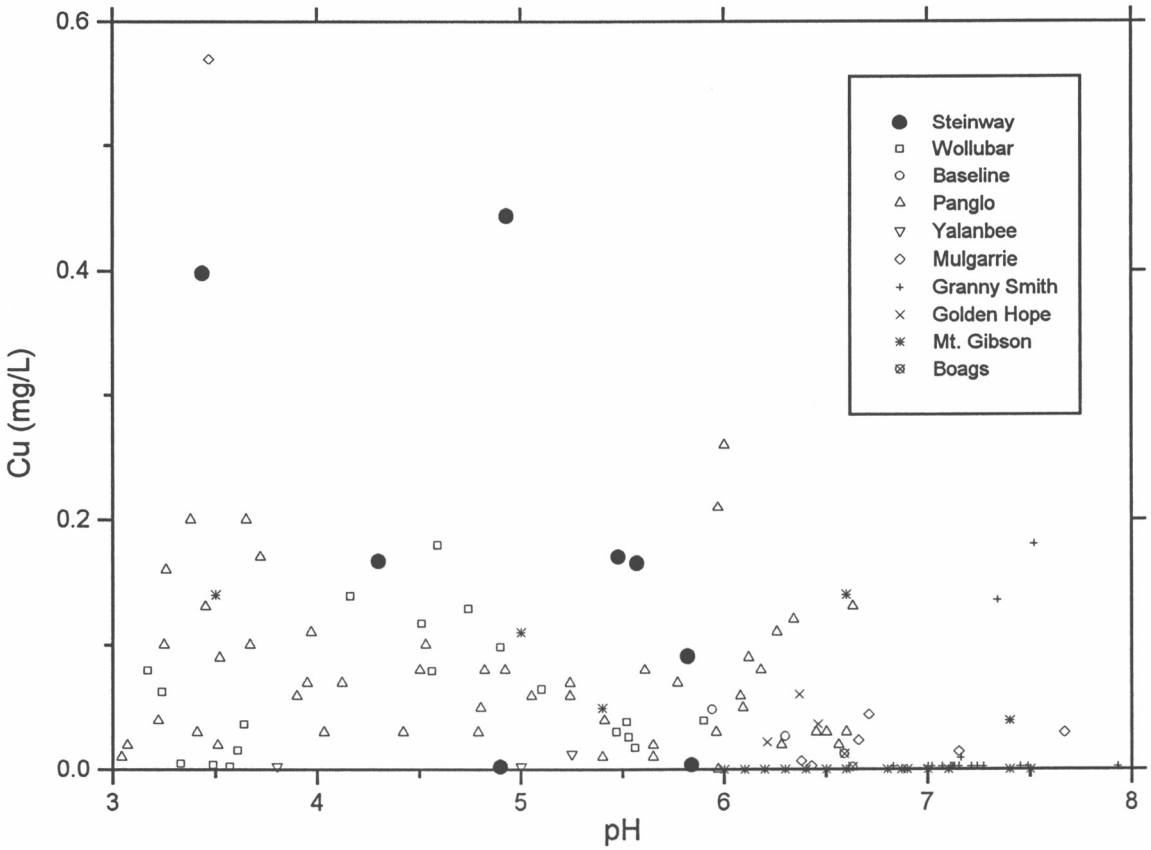


Figure A2.25: Cu vs. pH for groundwaters from Steinway and other sites.

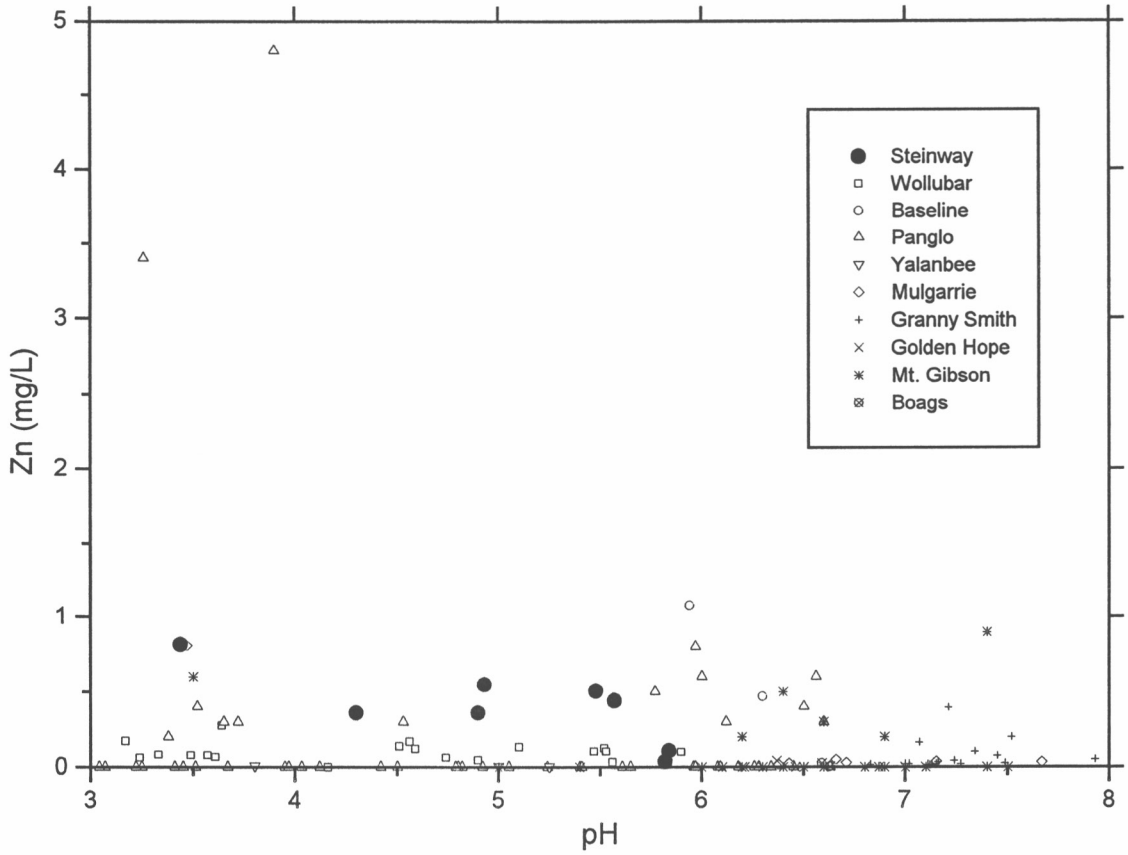


Figure A2.26: Zn vs. pH for groundwaters from Steinway and other sites.

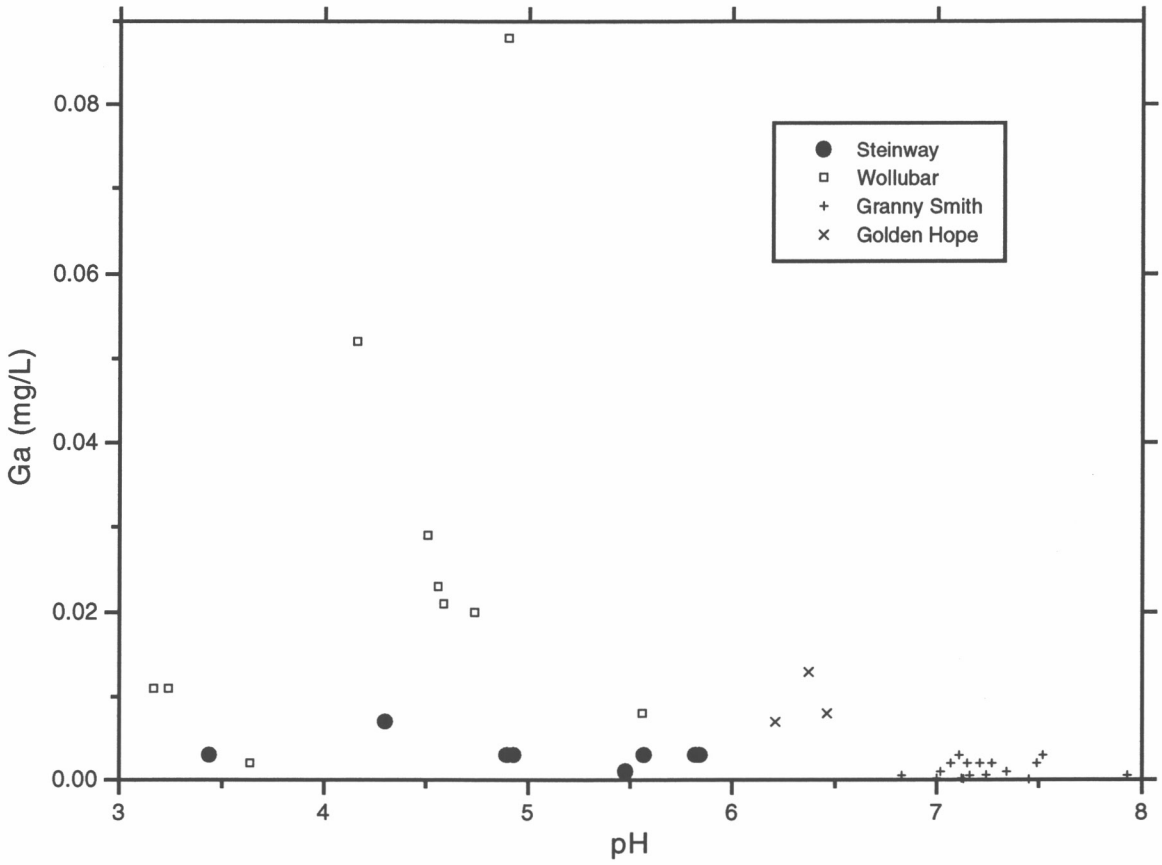


Figure A2.27: Ga vs. pH for groundwaters from Steinway and other sites.

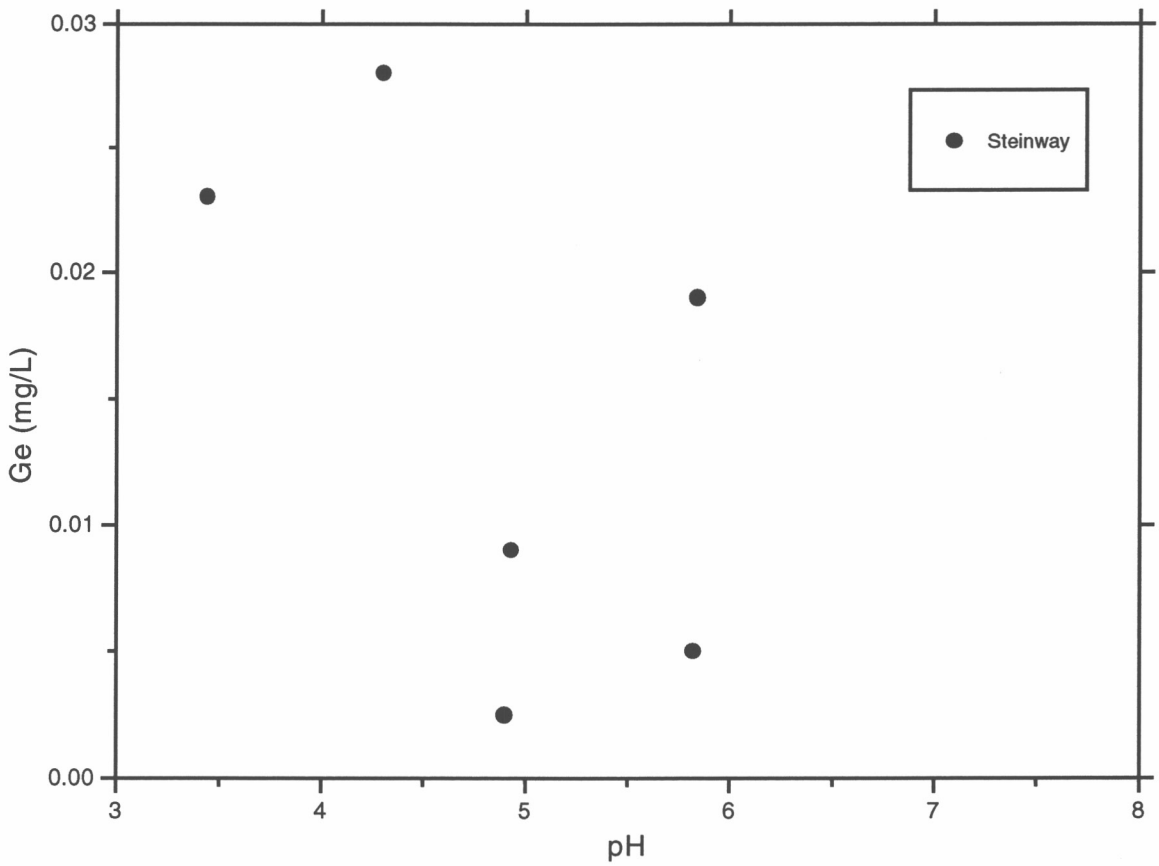


Figure A2.28: Ge vs. pH for groundwaters from Steinway.

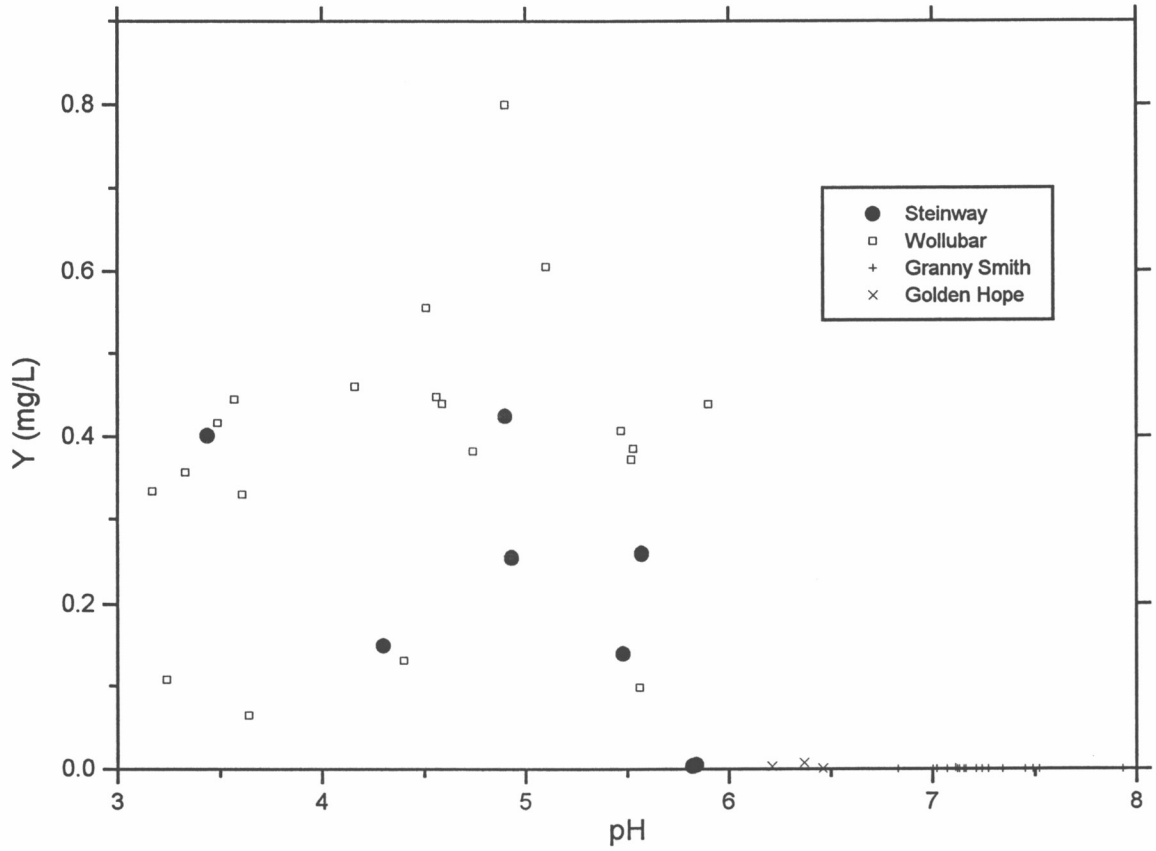


Figure A2.29: Y vs. pH for groundwaters from Steinway and other sites.

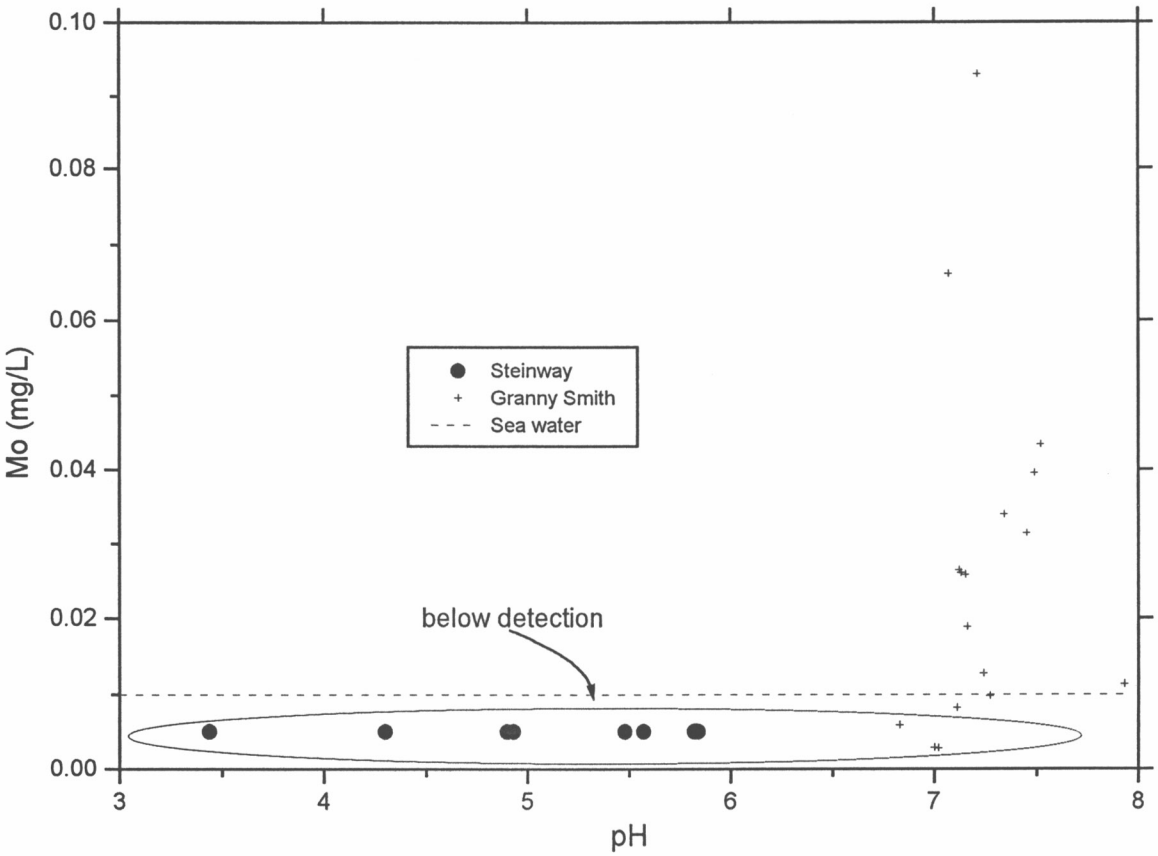


Figure A2.30: Mo vs. pH for groundwaters from Steinway and other sites.

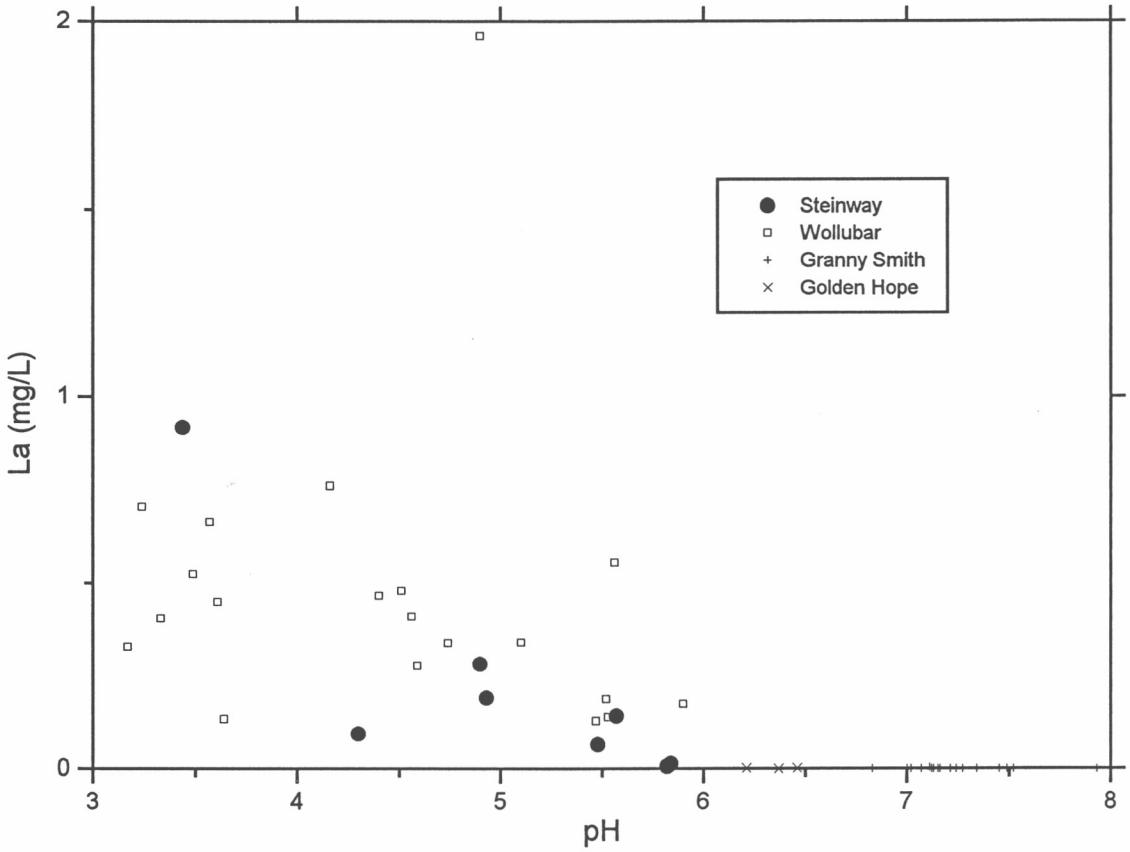


Figure A2.31: La vs. pH for groundwaters from Steinway and other sites.

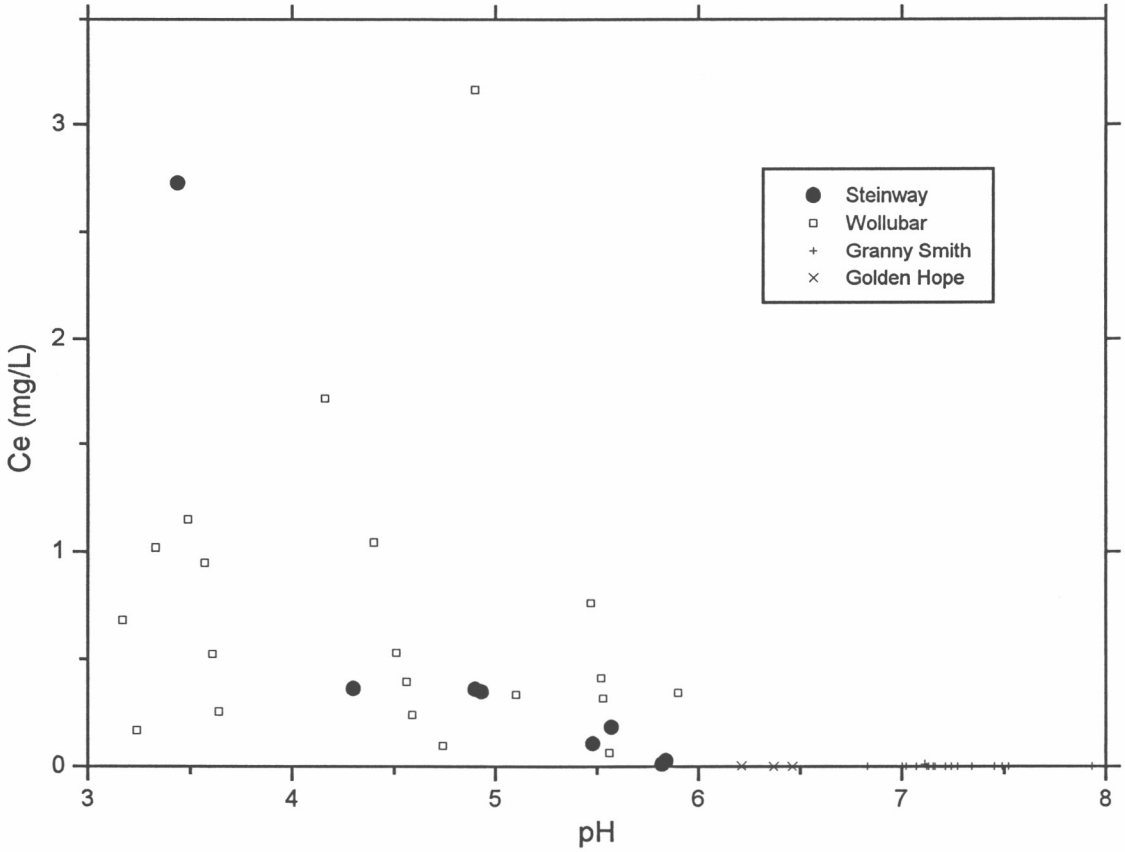


Figure A2.32: Ce vs. pH for groundwaters from Steinway and other sites.

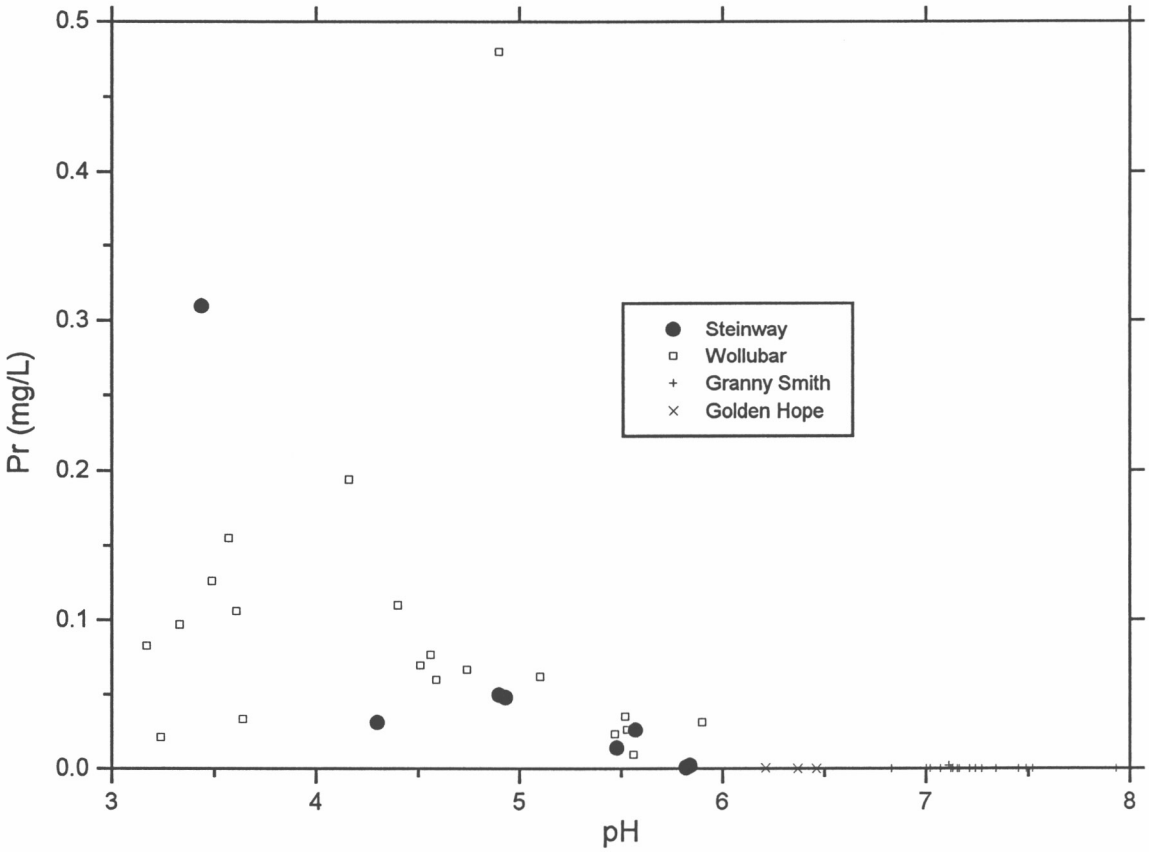


Figure A2.33: Pr vs. pH for groundwaters from Steinway and other sites.

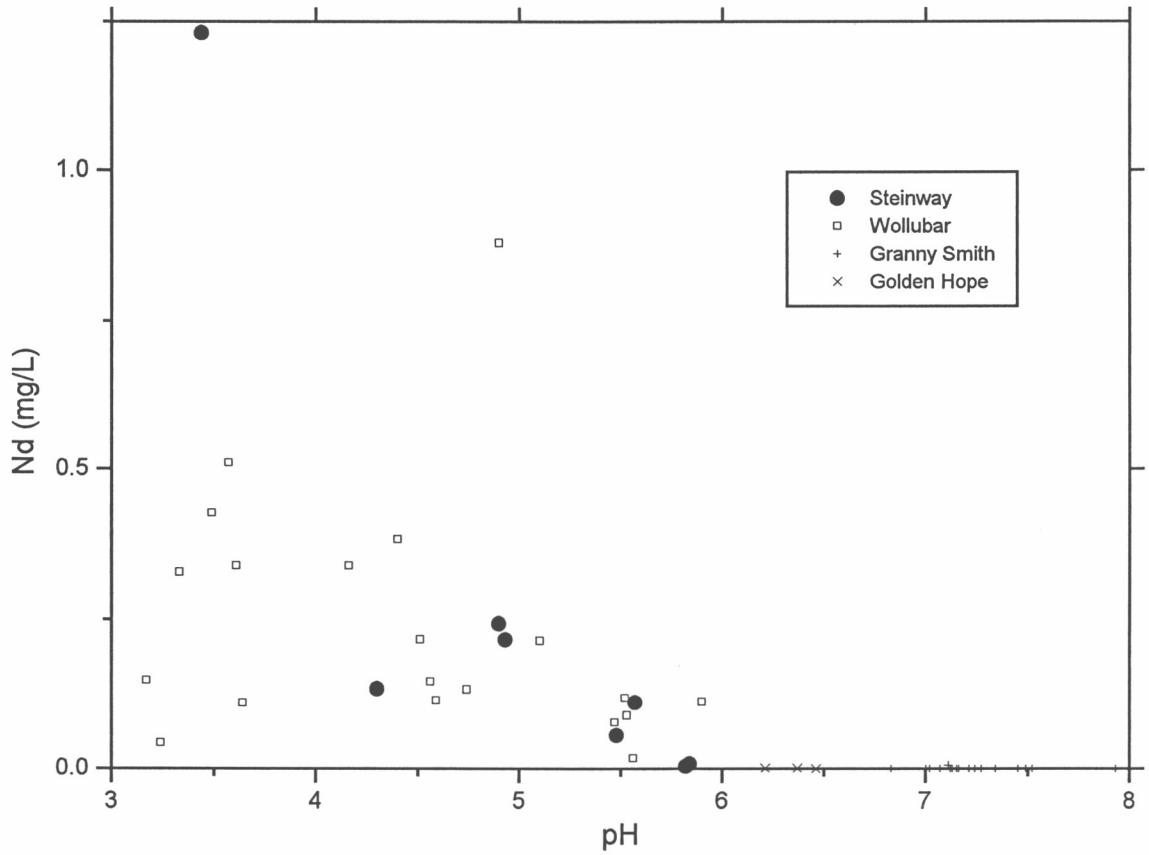


Figure A2.34: Ce vs. pH for groundwaters from Steinway and other sites.

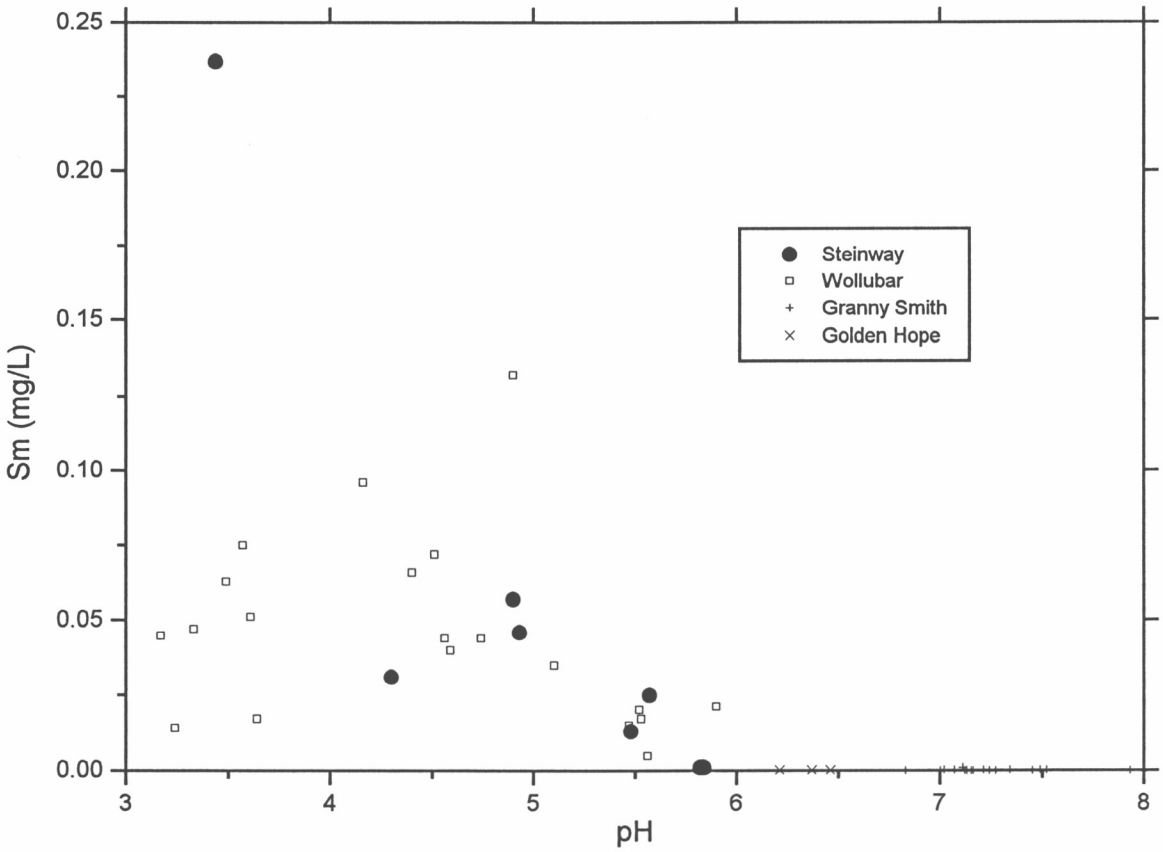


Figure A2.35: Sm vs. pH for groundwaters from Steinway and other sites.

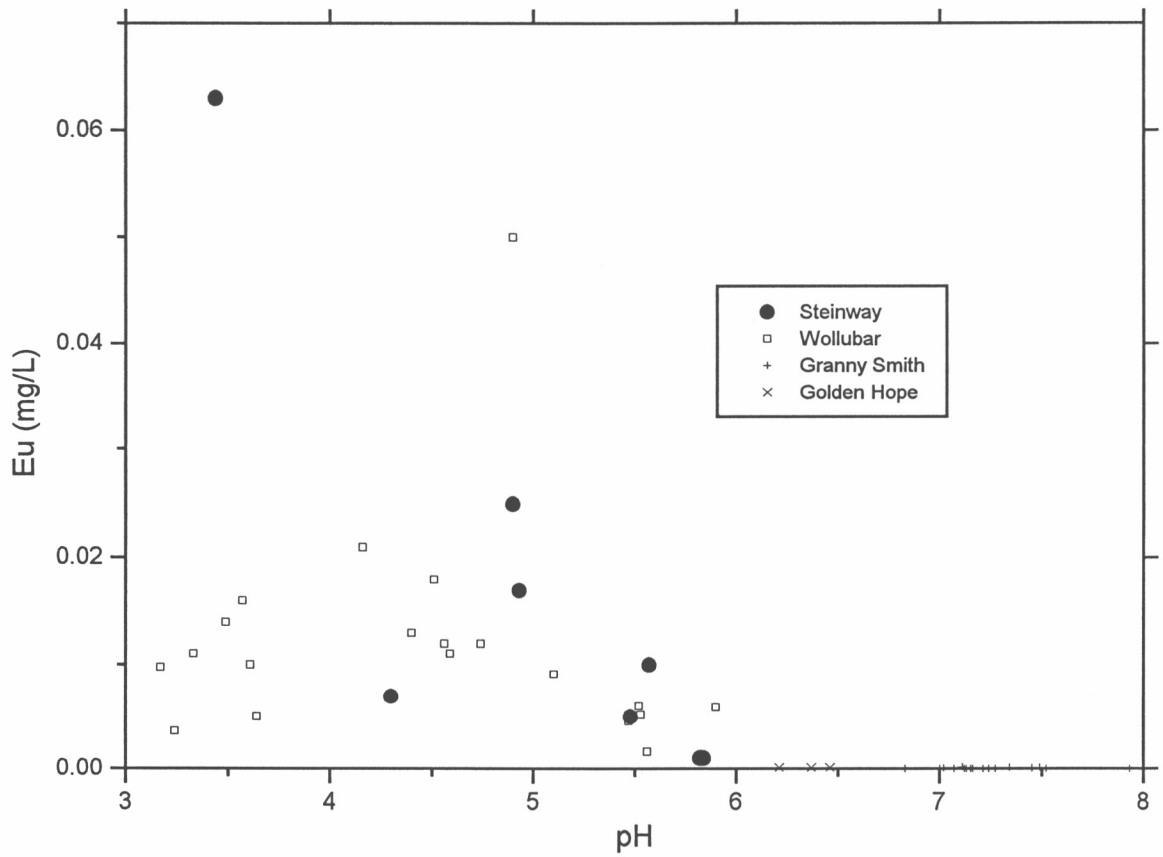


Figure A2.36: Eu vs. pH for groundwaters from Steinway and other sites.

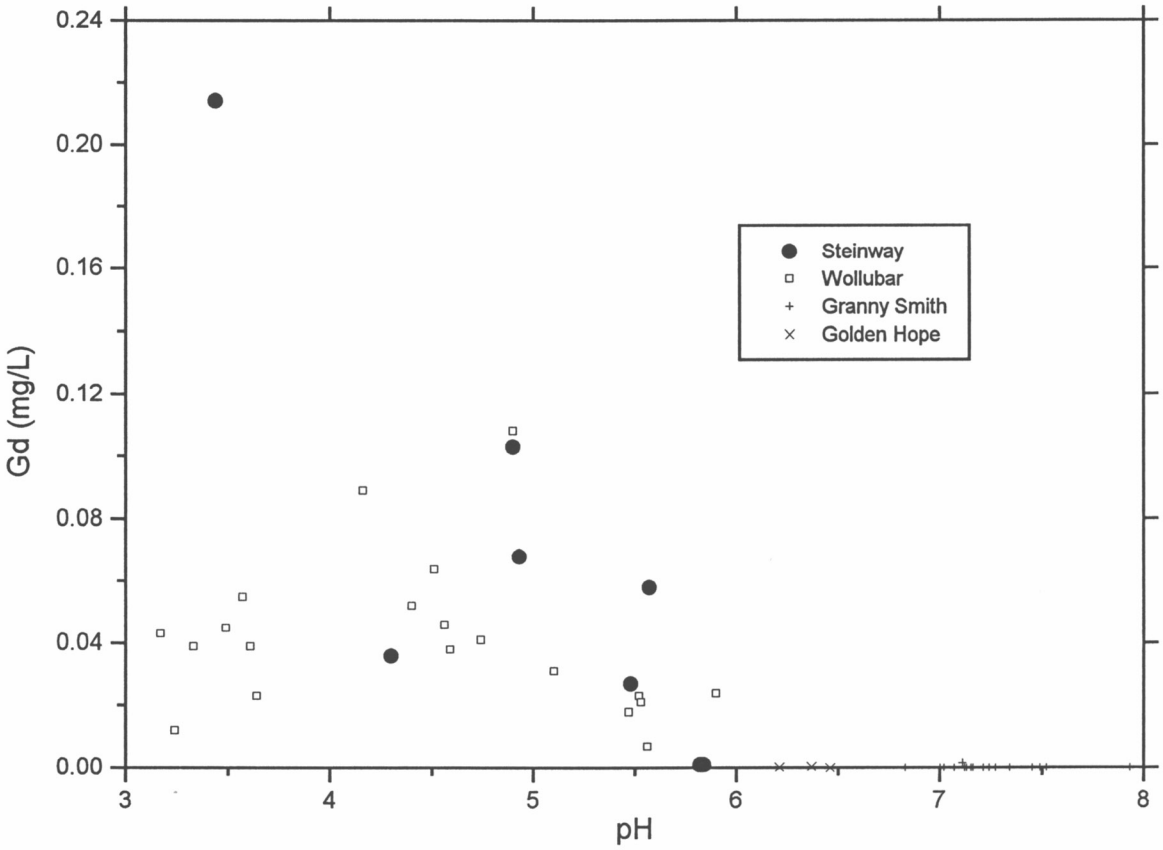


Figure A2.37: Gd vs. pH for groundwaters from Steinway and other sites.

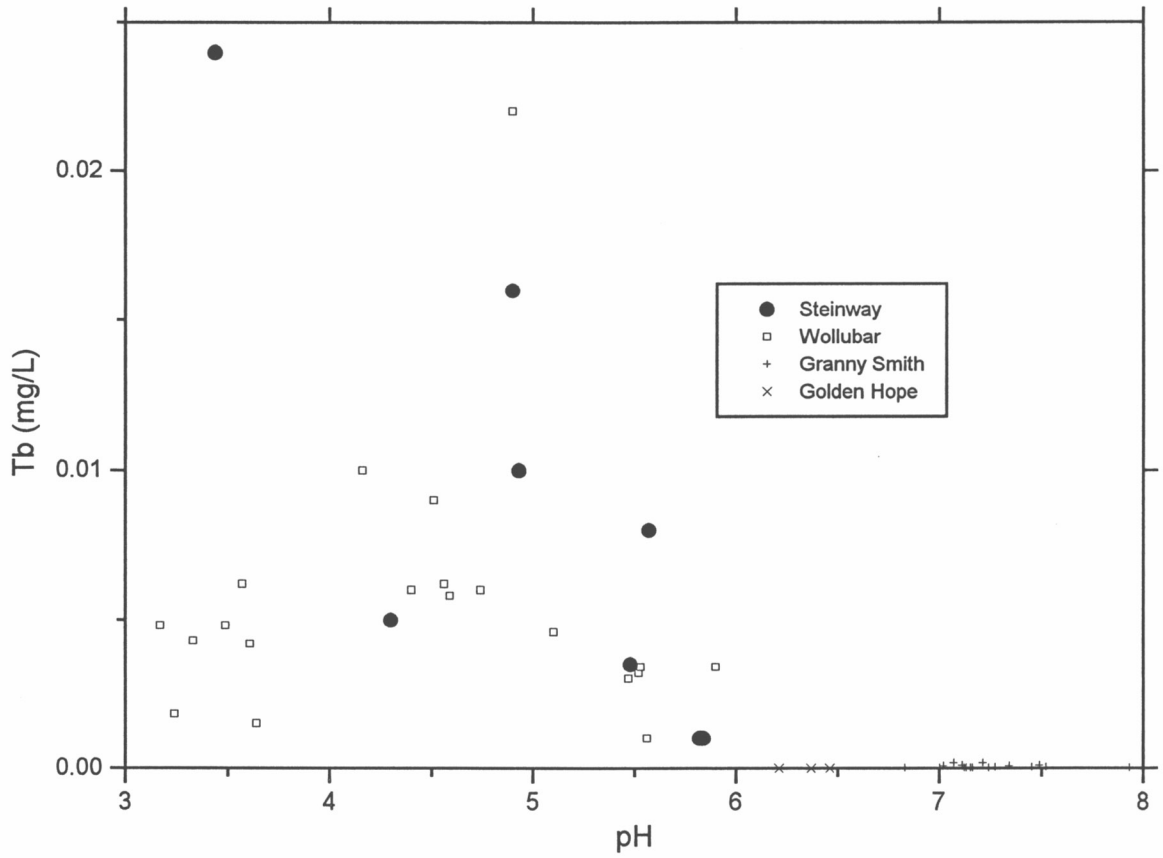


Figure A2.38: Tb vs. pH for groundwaters from Steinway and other sites.

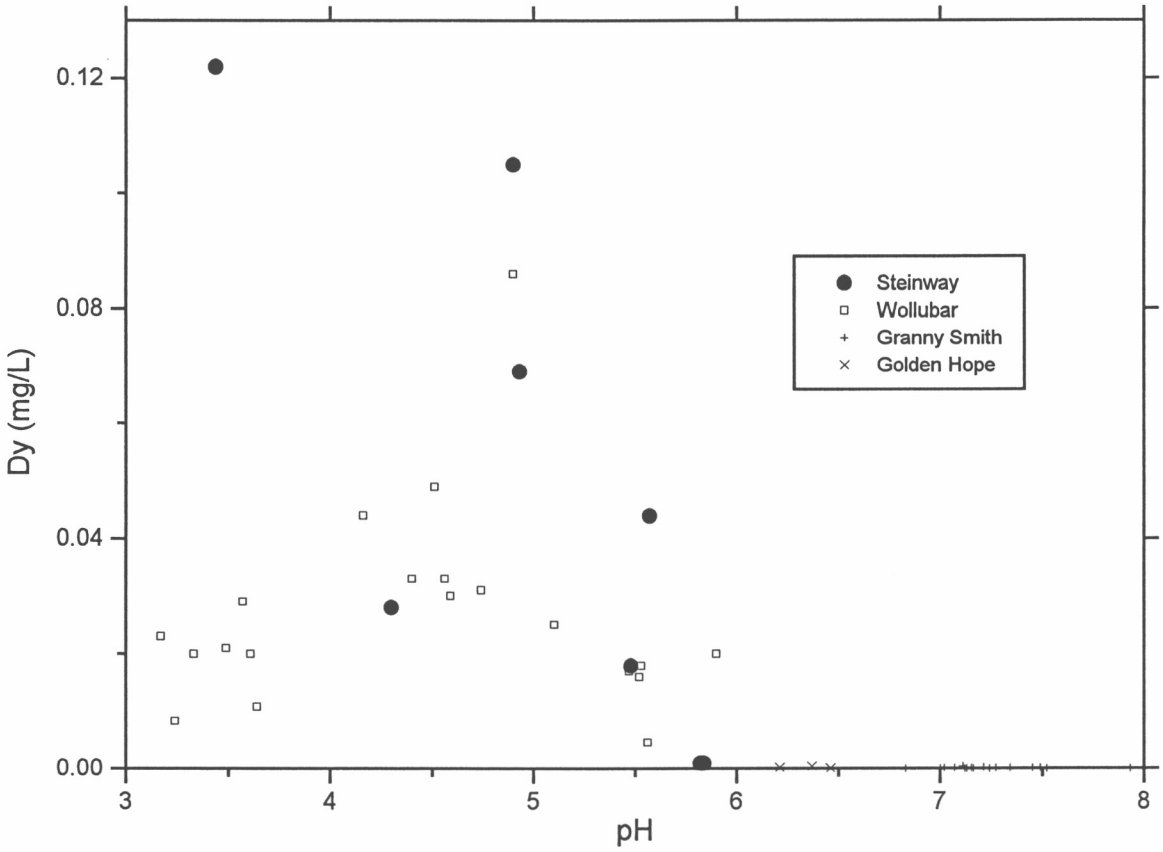


Figure A2.39: Dy vs. pH for groundwaters from Steinway and other sites.

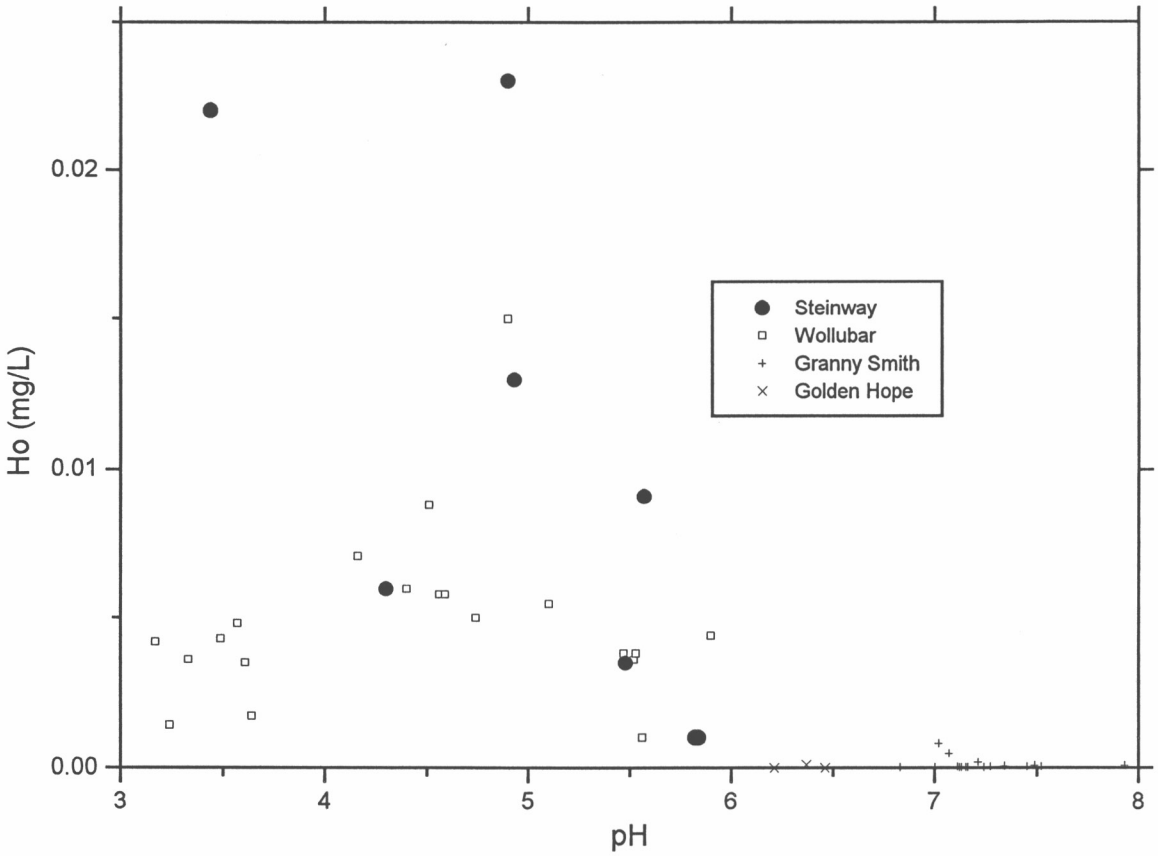


Figure A2.40: Ho vs. pH for groundwaters from Steinway and other sites.

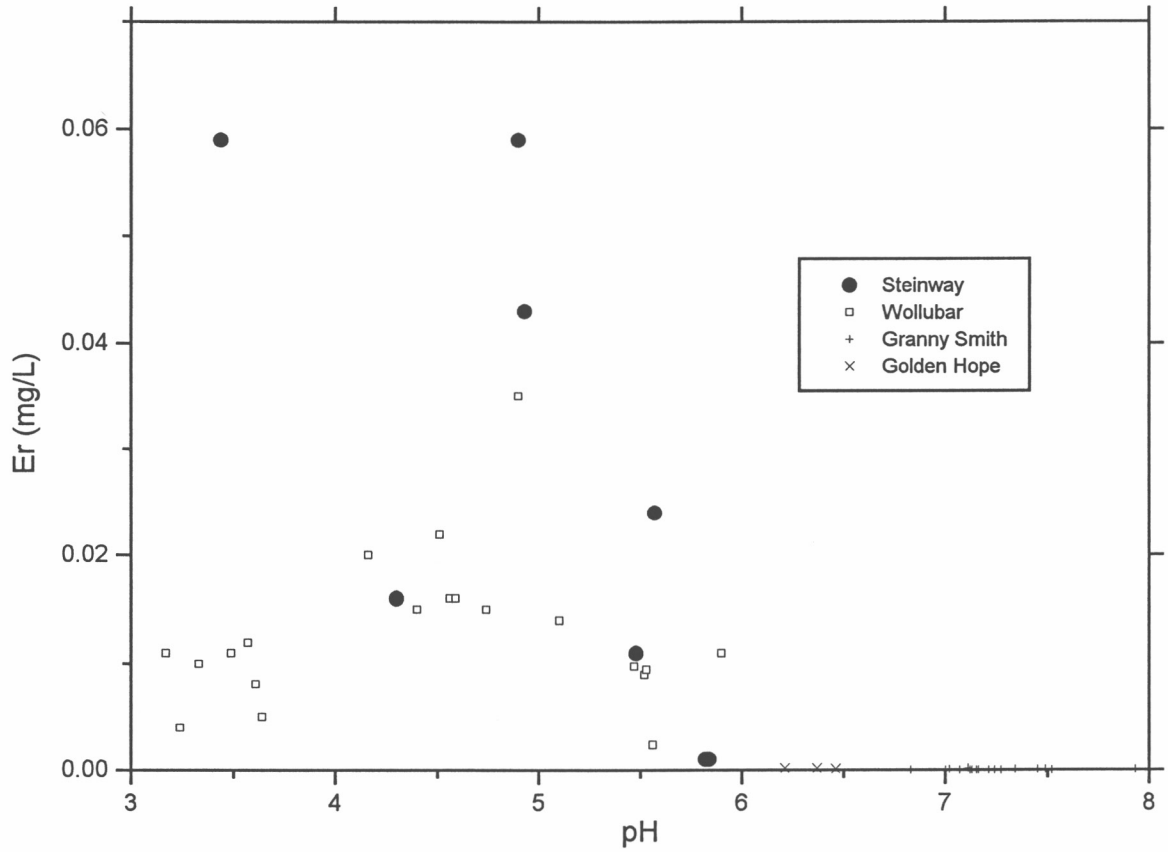


Figure A2.41: Er vs. pH for groundwaters from Steinway and other sites.

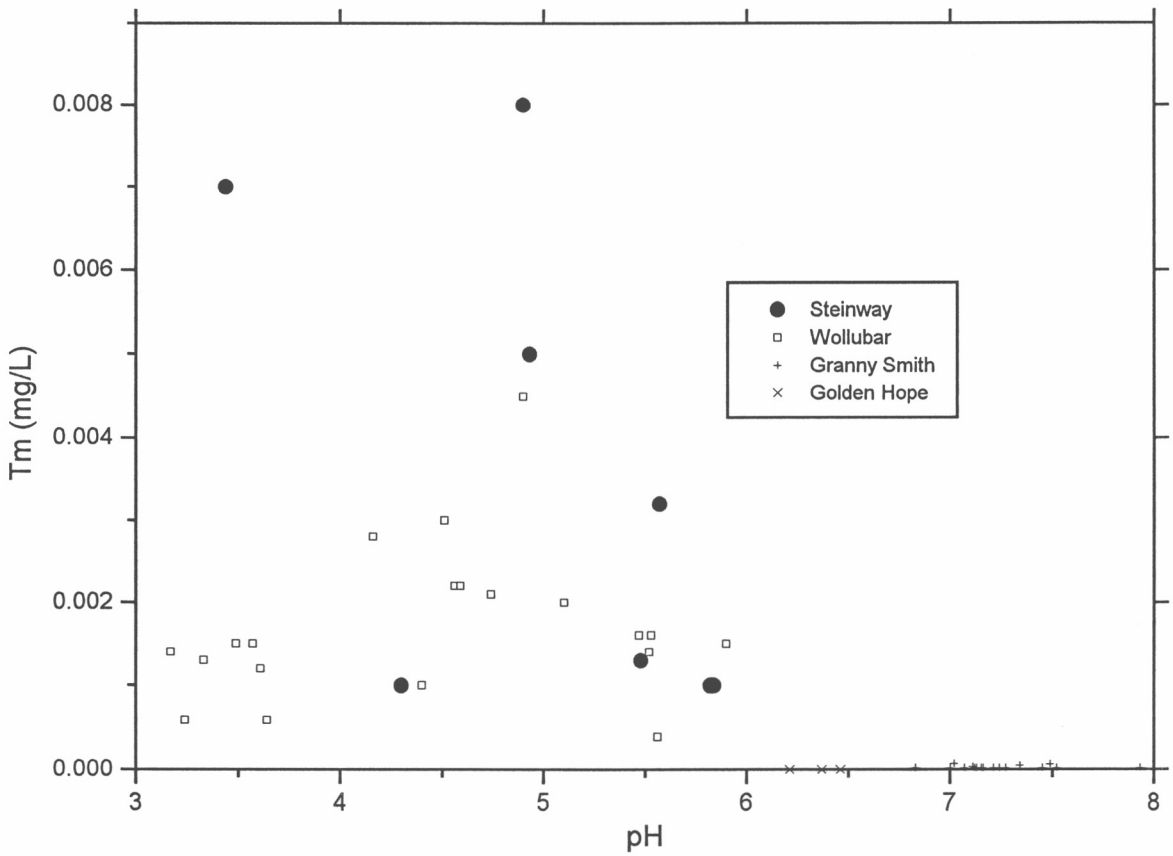


Figure A2.42: Tm vs. pH for groundwaters from Steinway and other sites.

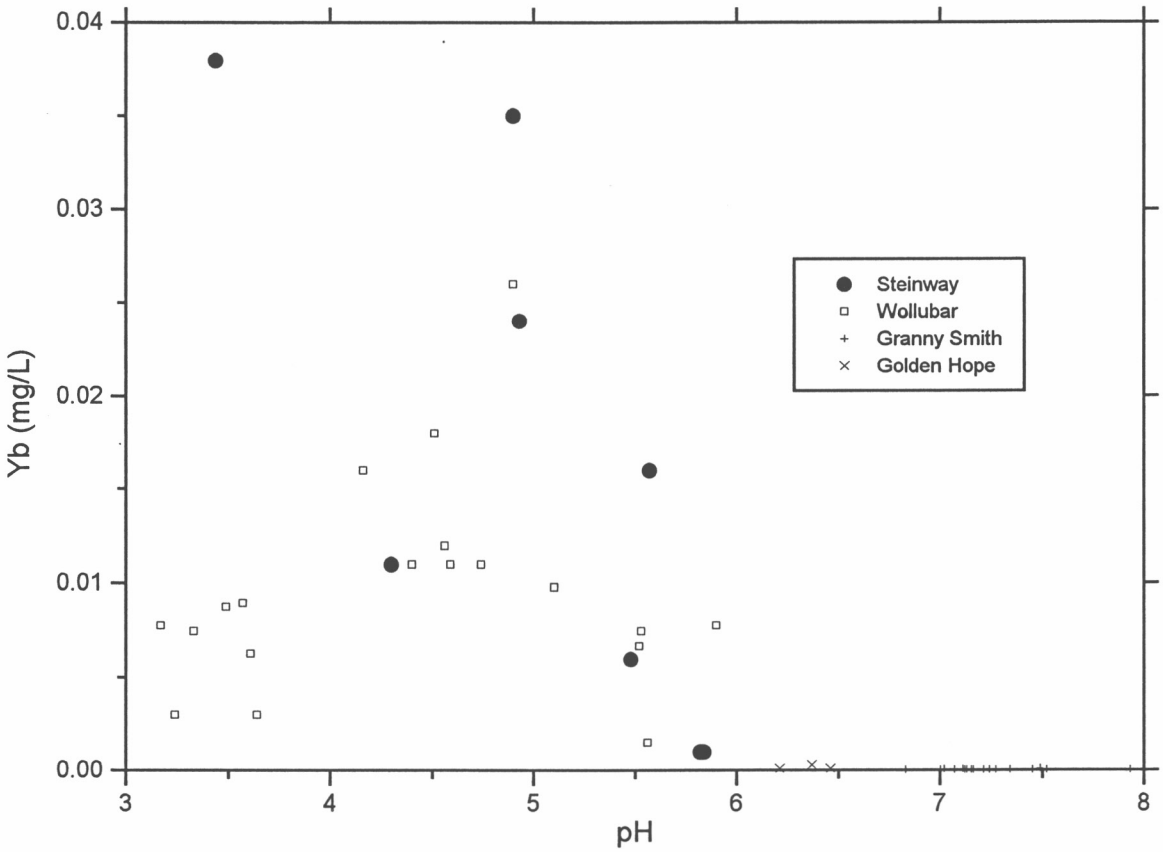


Figure A2.43: Yb vs. pH for groundwaters from Steinway and other sites.

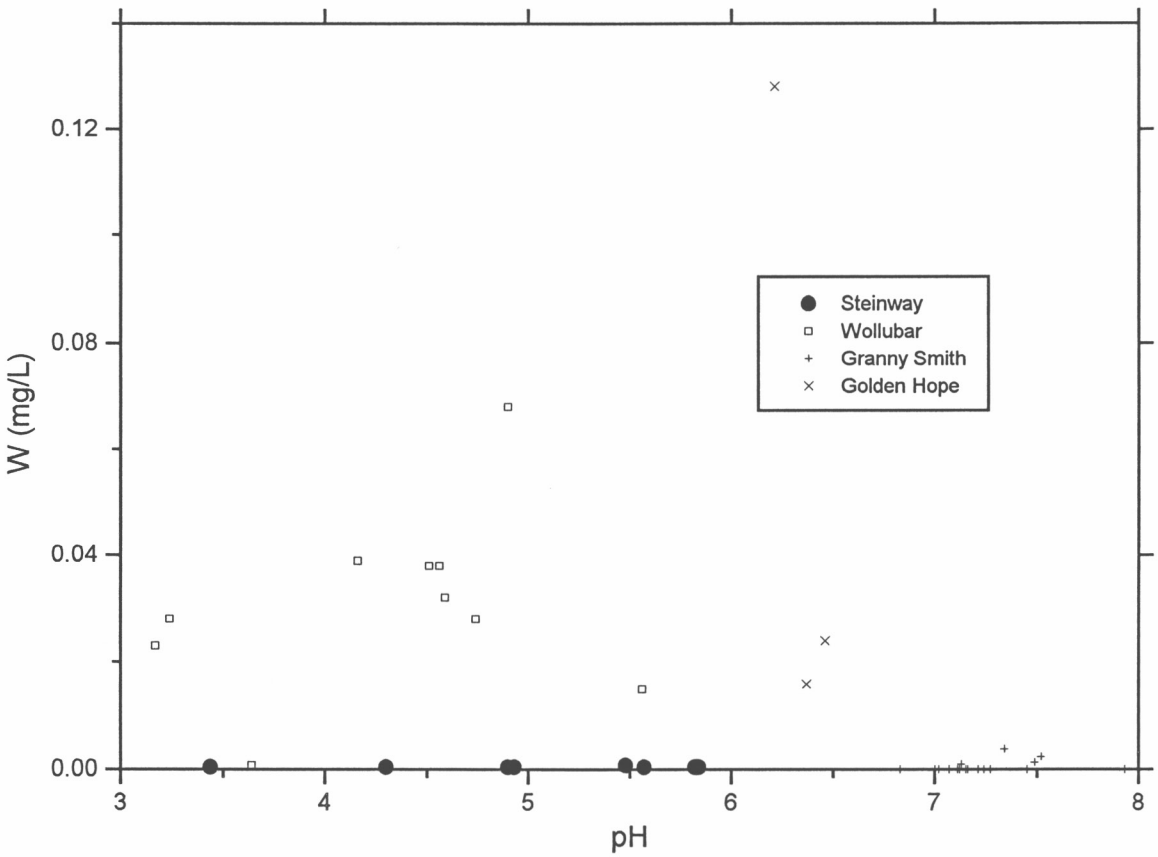


Figure A2.44: W vs. pH for groundwaters from Steinway and other sites.

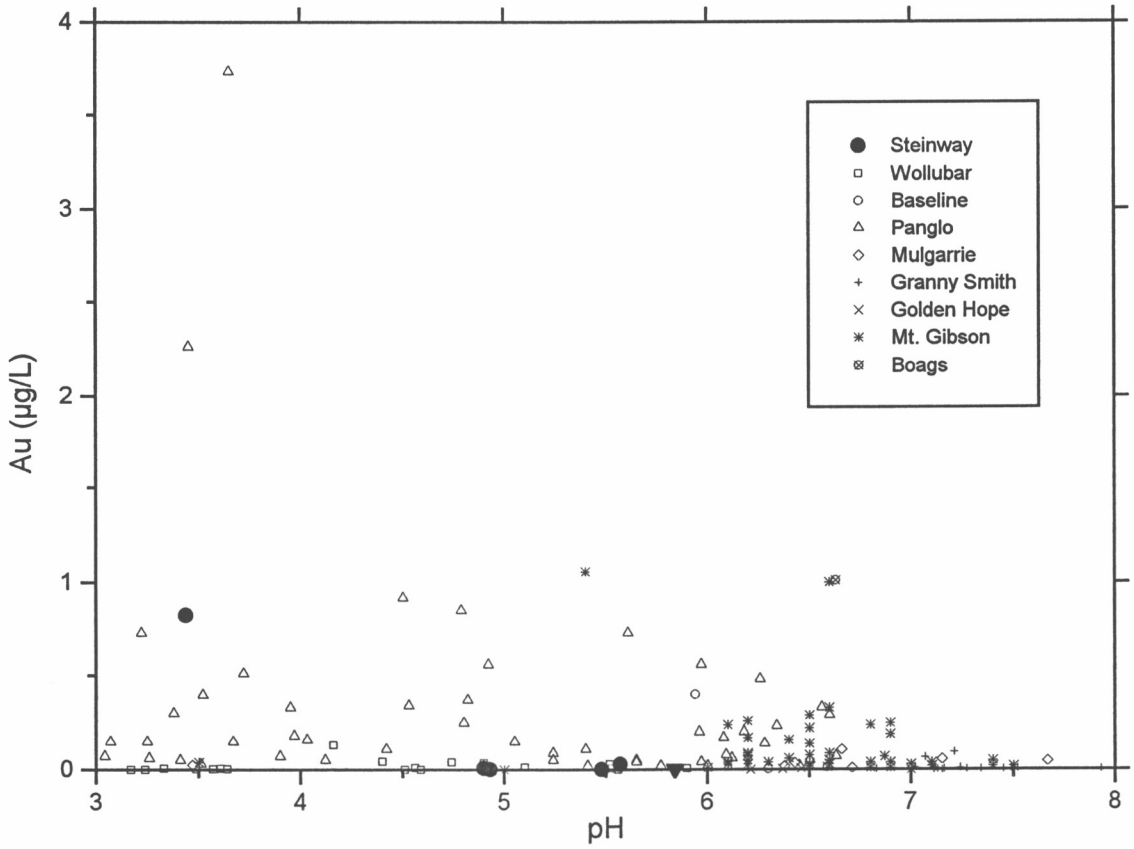


Figure A2.45: Au vs. pH for groundwaters from Steinway and other sites.

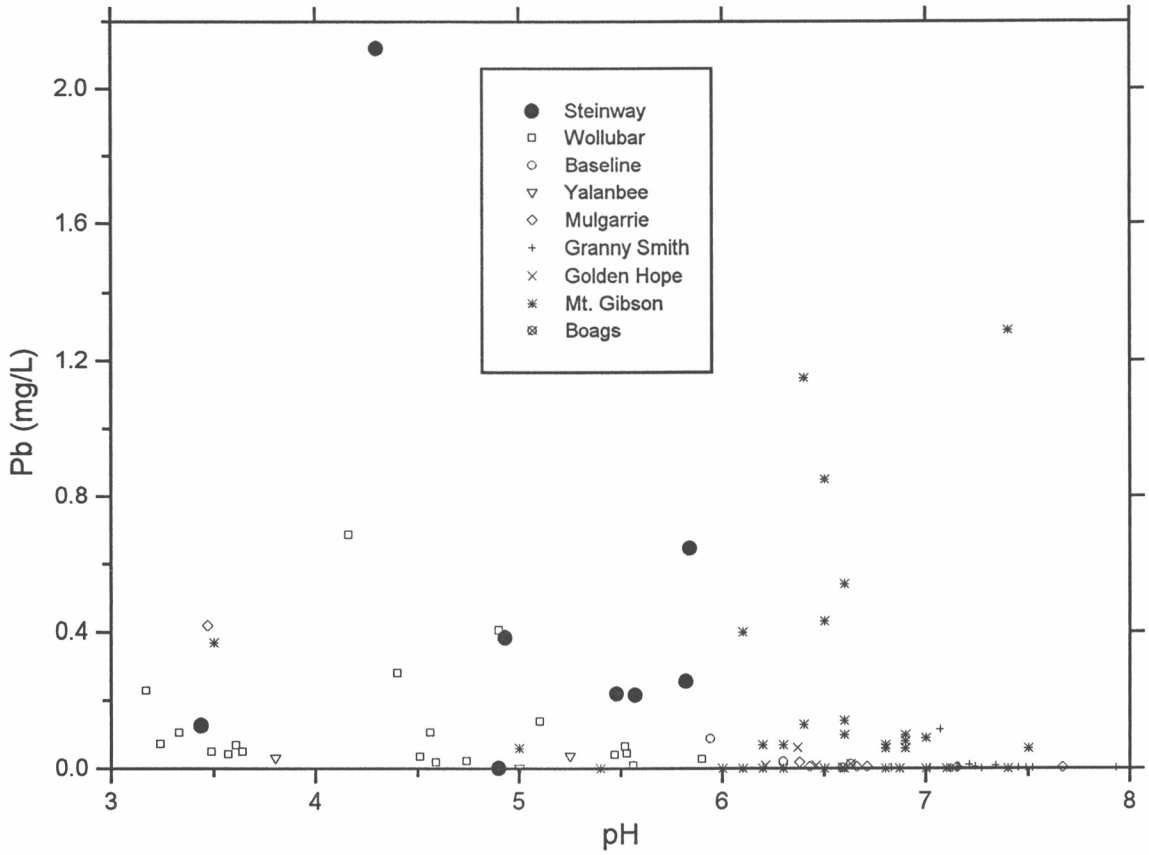


Figure A2.46: Pb vs. pH for groundwaters from Steinway and other sites.

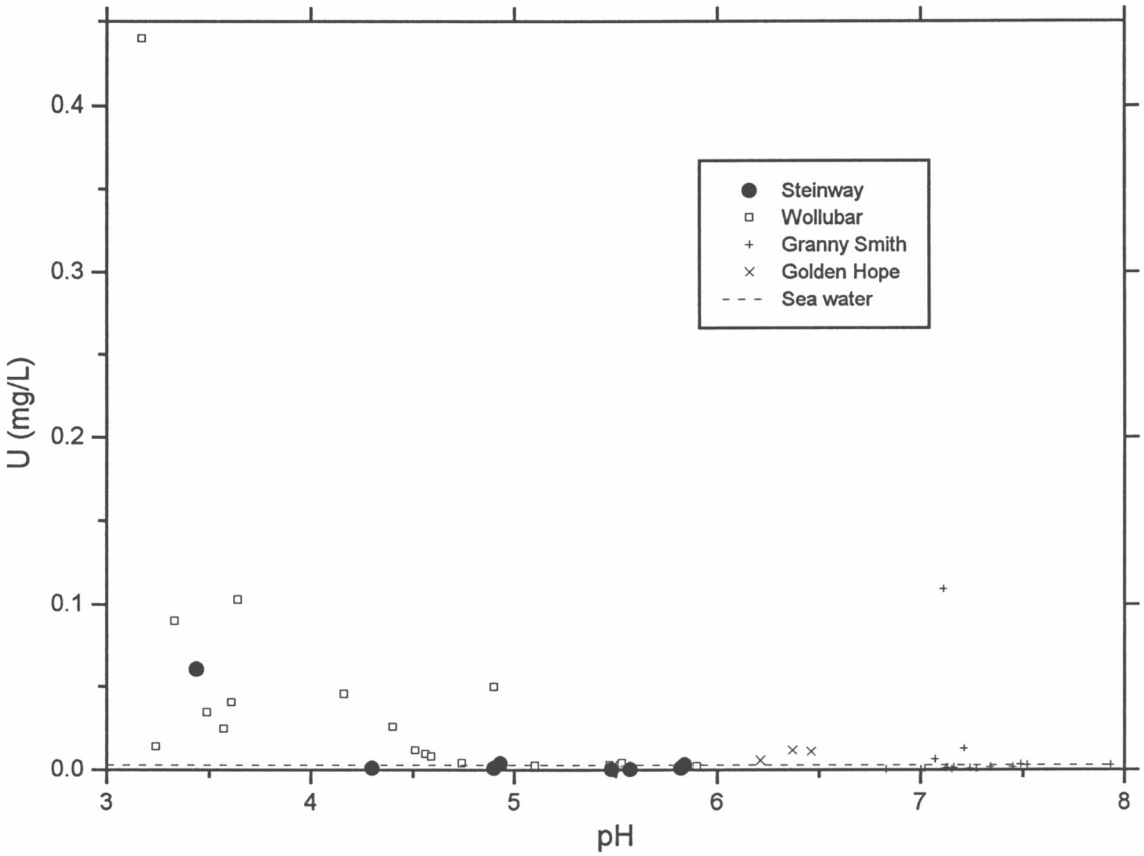


Figure A2.47: U vs. pH for groundwaters from Steinway and other sites.

Appendix 3: Saturation Indices - groundwaters

Table A3: SI values for Groundwaters at Steinway

Mineral	Formula	3	4	5	6	7	2	8	1
Halite	$NaCl$	-1.9	-1.8	-1.9	-2.2	-2.2	-2.1	-2.2	-2.1
Gypsum	$CaSO_4.2H_2O$	-0.4	-0.3	-0.3	-0.7	-0.5	-0.4	-0.5	-0.4
Celestine	$SrSO_4$	-0.9	-0.8	-0.9	-1.2	-1.0	-1.0	-1.0	-1.0
Barite	$BaSO_4$	0.3	0.3	0.0	0.2	0.1	0.1	0.3	0.0
Calcite	$CaCO_3$	-4.9	-1.5	-1.7	nd	-3.8	-2.6	-3.5	-2.4
Dolomite	$CaMg(CO_3)_2$	-8.5	-1.8	-2.2	nd	-6.3	-3.9	-5.8	-3.6
amorphous silica	SiO_2	-0.5	-0.7	-0.8	0.1	-0.3	-0.3	-0.2	-0.3
amorphous alumina	$AlOH_3$	-2.4	-0.7	nd	-3.5	-0.7	0.1	-1.5	0.3
Jurbanite	$AlOHSO_4$	0.6	-0.8	nd	1.2	1.0	0.7	0.3	0.8
Kaolinite	$Al_2Si_2O_5(OH)_4$	2.2	5.1	nd	1.0	5.9	7.4	4.5	8.0
Siderite	$FeCO_3$	-5.8	-1.2	-2.3	nd	-3.7	-2.1	-3.9	-3.0
Ferrihydrite	$Fe(OH)_3$	-1.3	0.4	0.2	-1.2	-0.2	1.0	-3.4	1.5
Rhodochrosite	$MnCO_3$	-4.2	-1.0	-1.2	nd	-2.8	-1.6	-2.4	-1.4
Copper hydroxide	$Cu(OH)_2.H_2O$	-5.4	-7.4	-5.4	-6.6	-4.5	-4.7	nd	-3.3
Smithsonite	$ZnCO_3$	-6.9	-4.1	-4.8	nd	-5.5	-4.3	-5.4	-4.2
Cerussite	$PbCO_3$	-4.5	-1.8	-2.3	nd	-3.9	-3.0	nd	-2.8
Theophrasite	$Ni(OH)_2$	-8.3	-5.6	-5.5	-9.4	-6.5	-5.4	-6.5	-5.1
Sphaerocobaltite	$CoCO_3$	-6.7	-3.6	-3.8	nd	-5.1	-3.9	-4.8	-3.7
Native Gold	Au	-0.1	nd	3.4	0.0	nd	nd	4.3	1.4
Sodium autunite	$Na_2(UO_2)_2(PO_4)_2$	nd	-3.5	nd	-5.7	-3.7	-5.5	nd	-5.1
Ferberite	$FeWO_4$	nd	nd	nd	nd	nd	-3.3	nd	-4.7
Monazite-(La)	$LaPO_4$	-2.8	-0.8	-1.1	-3.4	-1.3	-0.8	-1.2	-0.3
Monazite-(Ce)	$CePO_4$	-2.0	-0.4	-0.8	-2.8	-1.0	-0.5	-1.0	-0.1
"Monazite-(Sm)"	$SmPO_4$	-3.2	nd	nd	-3.9	-1.9	-1.4	-1.9	-1.0
"Monazite-(Dy)"	$DyPO_4$	-3.3	nd	nd	-4.3	-1.8	-1.4	-1.7	-0.9
"Monazite-(Yb)"	$YbPO_4$	-3.6	nd	nd	-4.7	-2.2	-1.8	-2.1	-1.3
Xenotime	YPO_4	-2.1	-0.9	-1.1	-3.4	-0.8	-0.1	-0.7	0.3

nd: not determined (data for one or more solution constituents unknown or below detection)

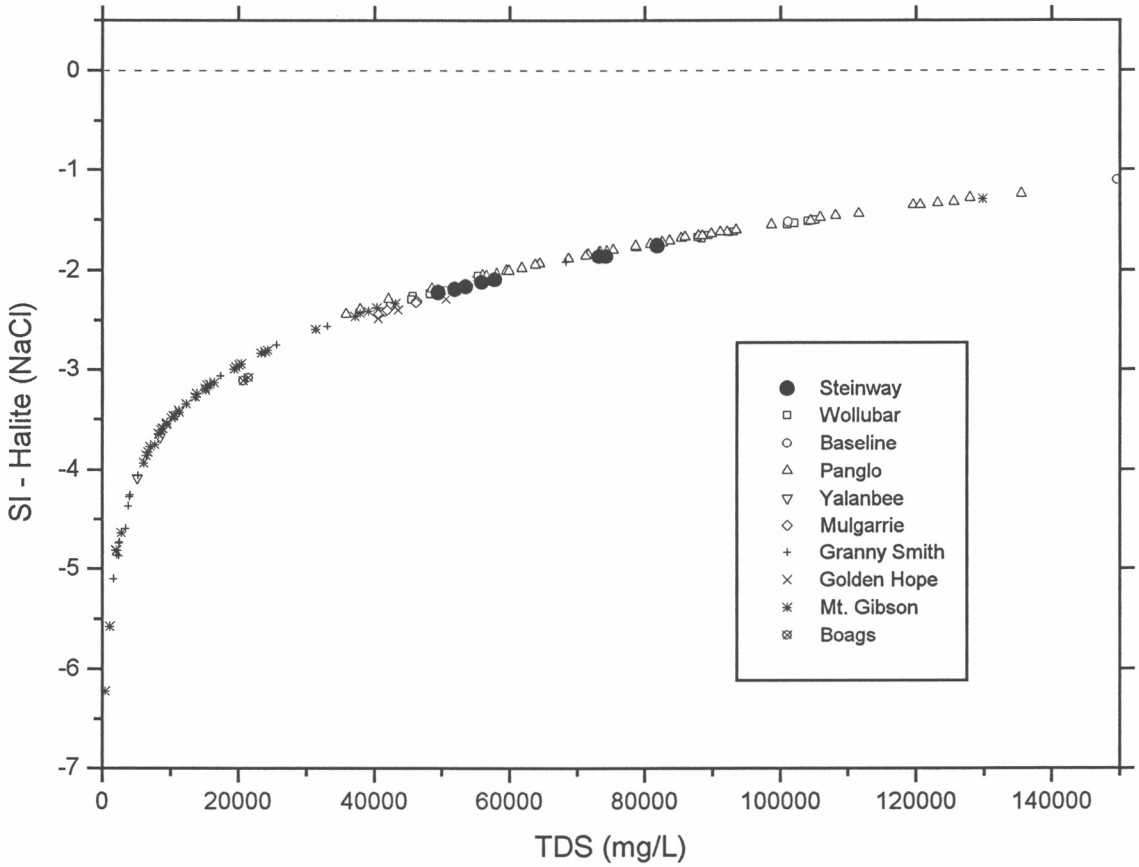


Figure A3.1: SI for halite vs. TDS for groundwaters from Steinway and other sites.

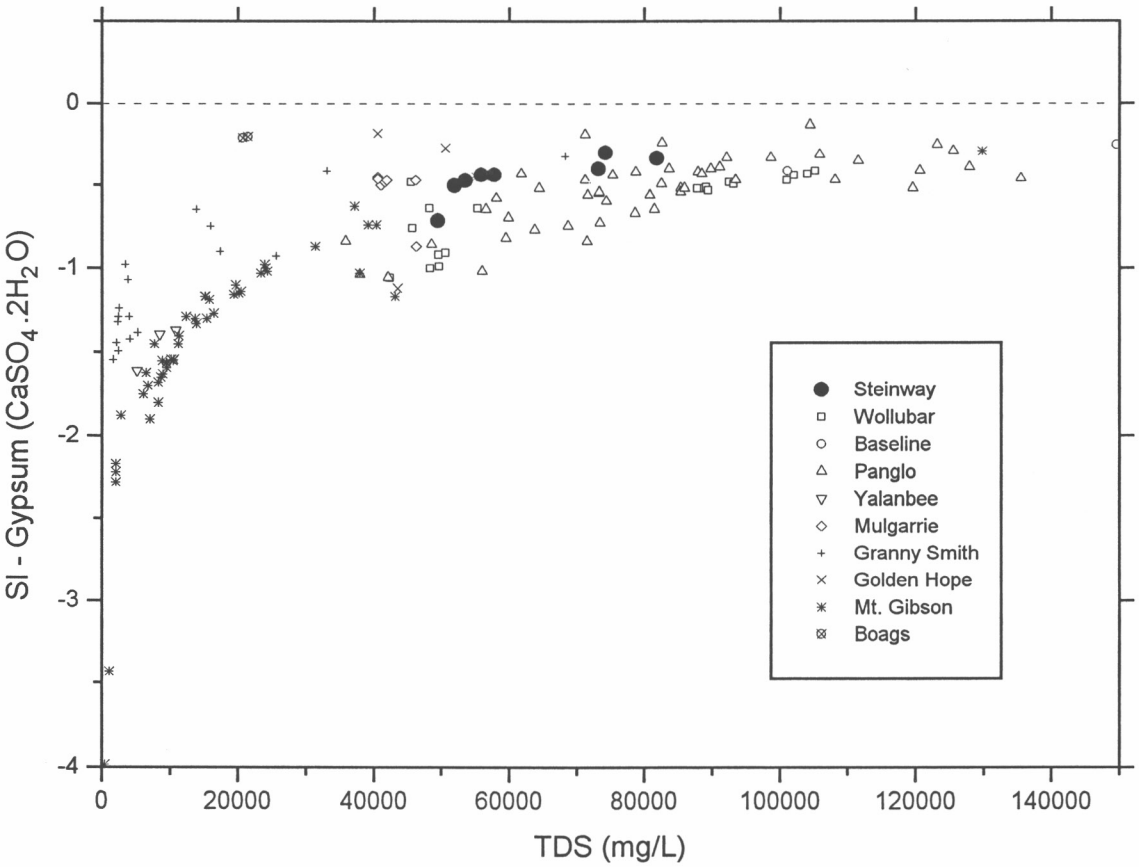


Figure A3.2: SI for gypsum vs. TDS for groundwaters from Steinway and other sites.

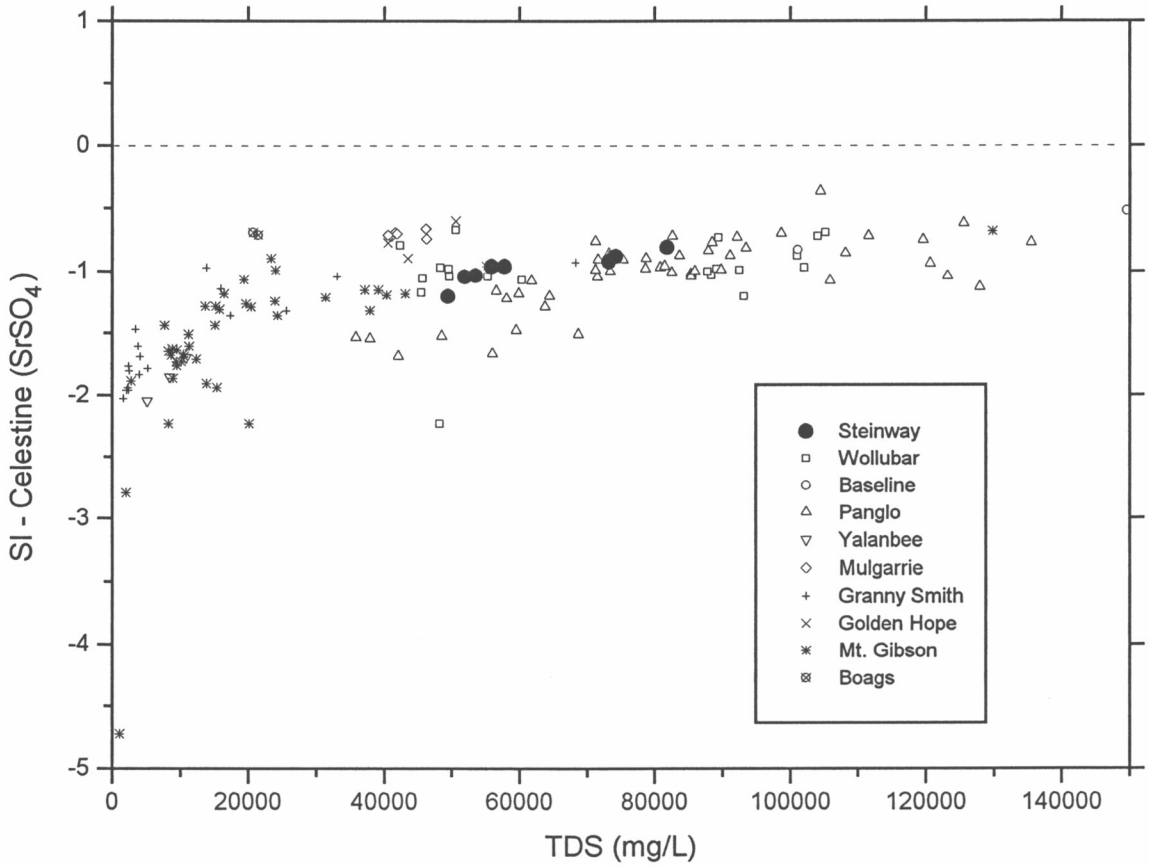


Figure A3.3: SI for celestine vs. TDS for groundwaters from Steinway and other sites.

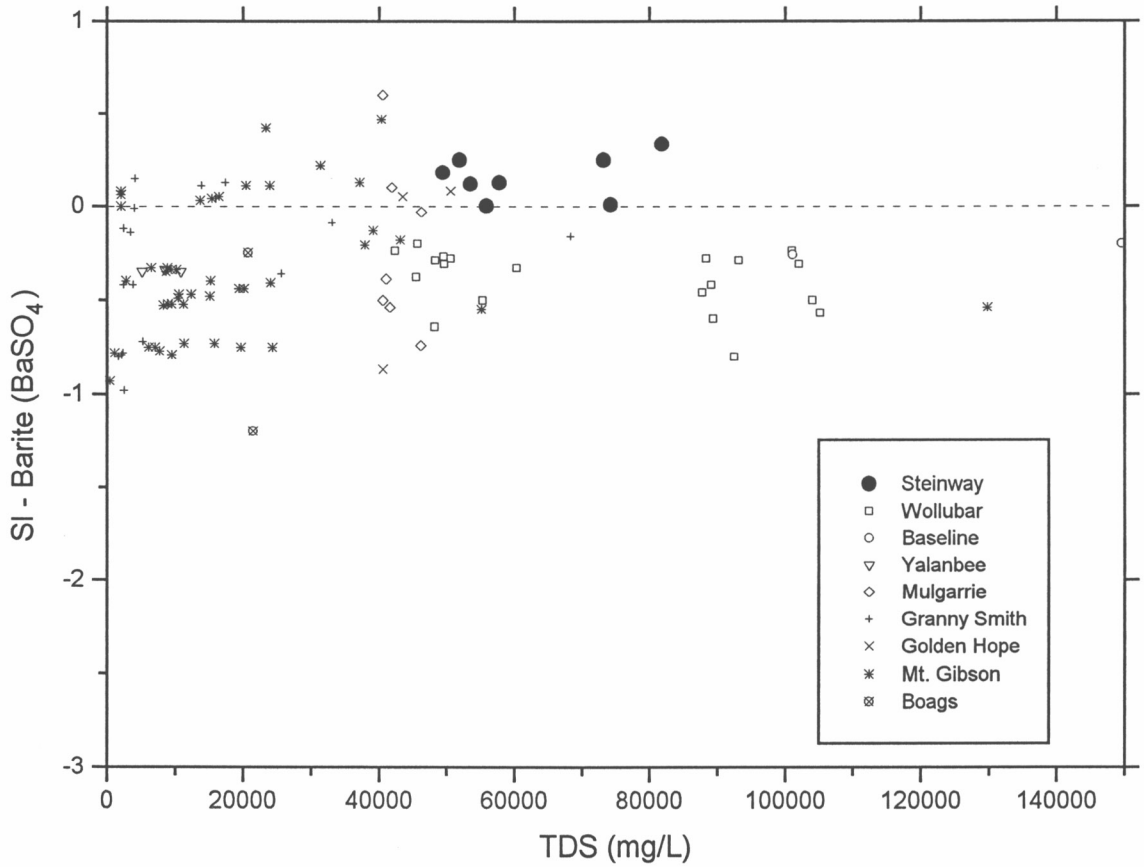


Figure A3.4: SI for barite vs. TDS for groundwaters from Steinway and other sites.

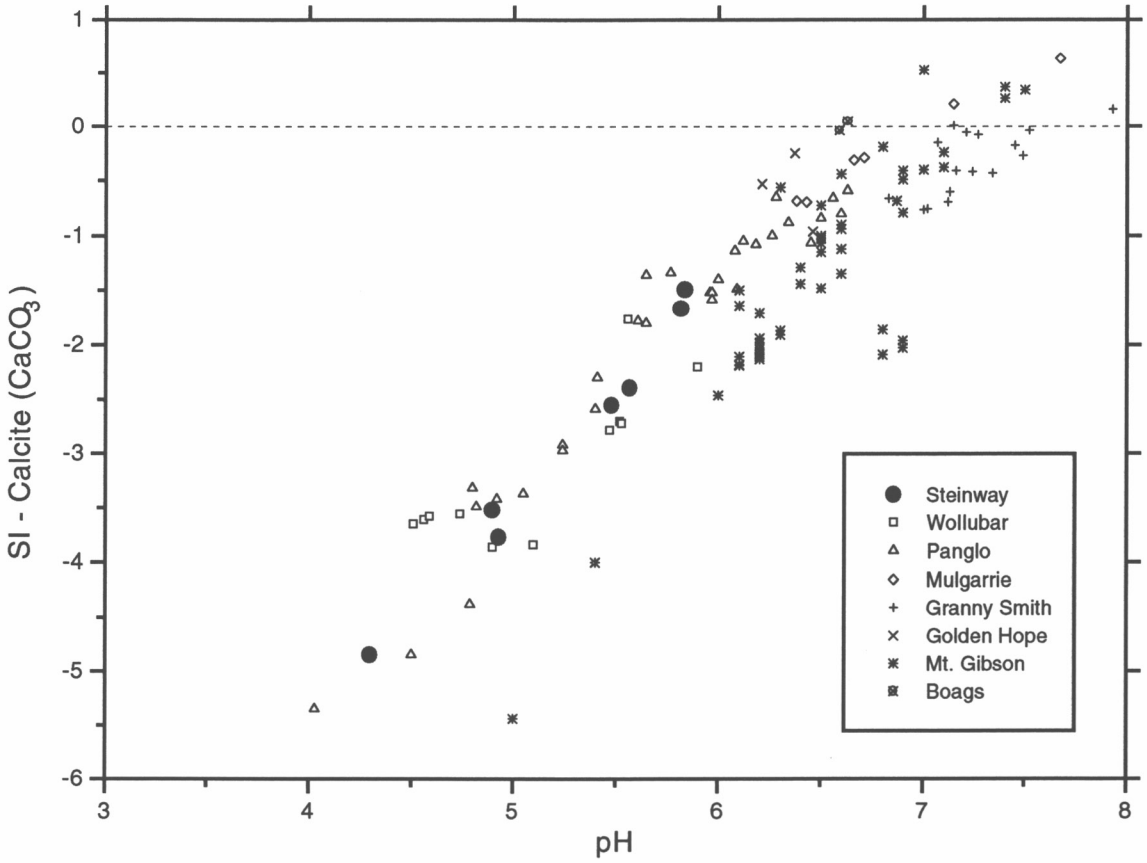


Figure A3.5: SI for calcite vs. pH for groundwaters from Steinway and other sites.

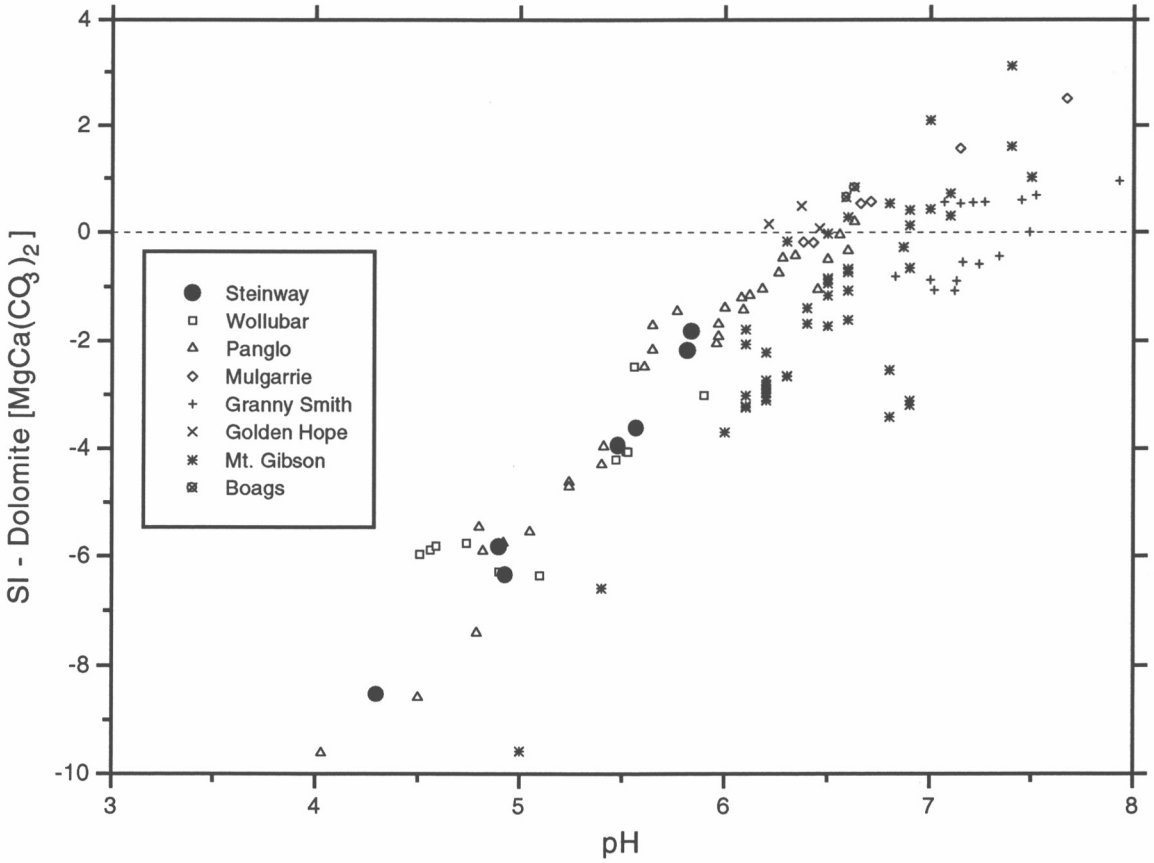


Figure A3.6: SI for dolomite vs. pH for groundwaters from Steinway and other sites.

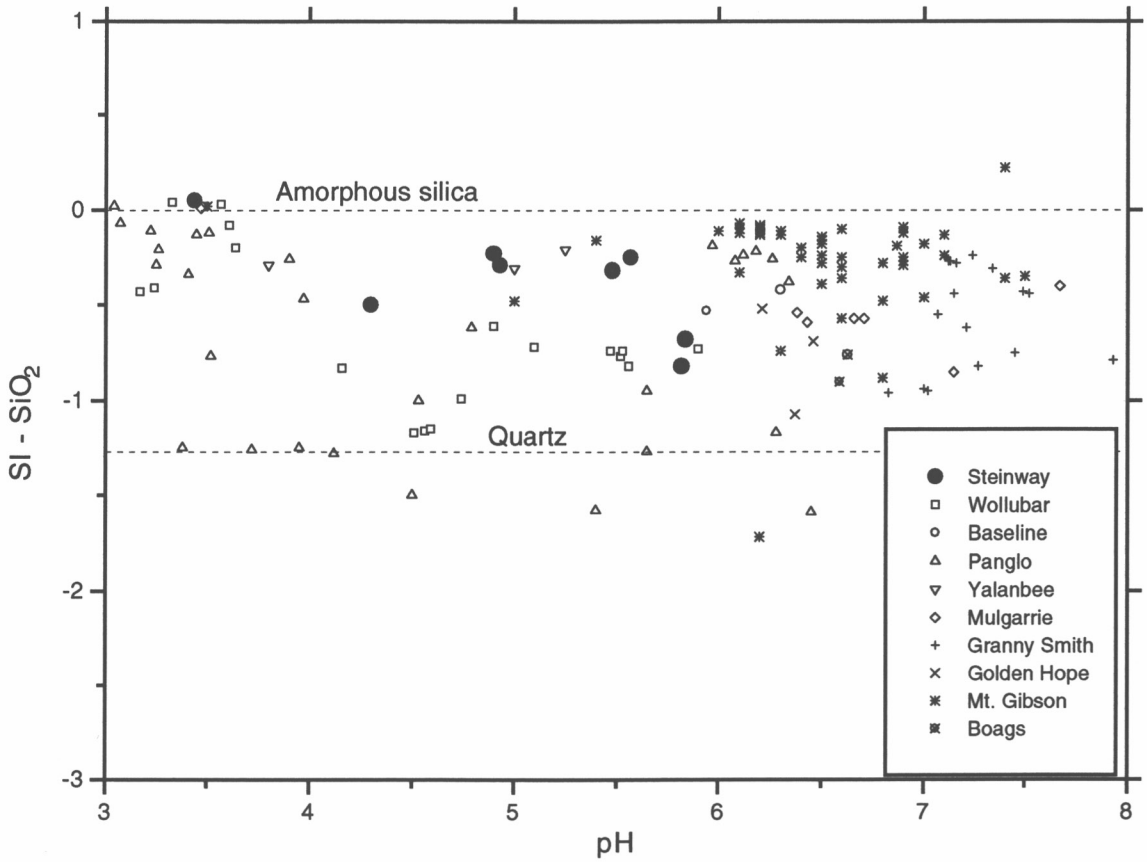


Figure A3.7: SI for SiO_2 vs. pH for groundwaters from Steinway and other sites.

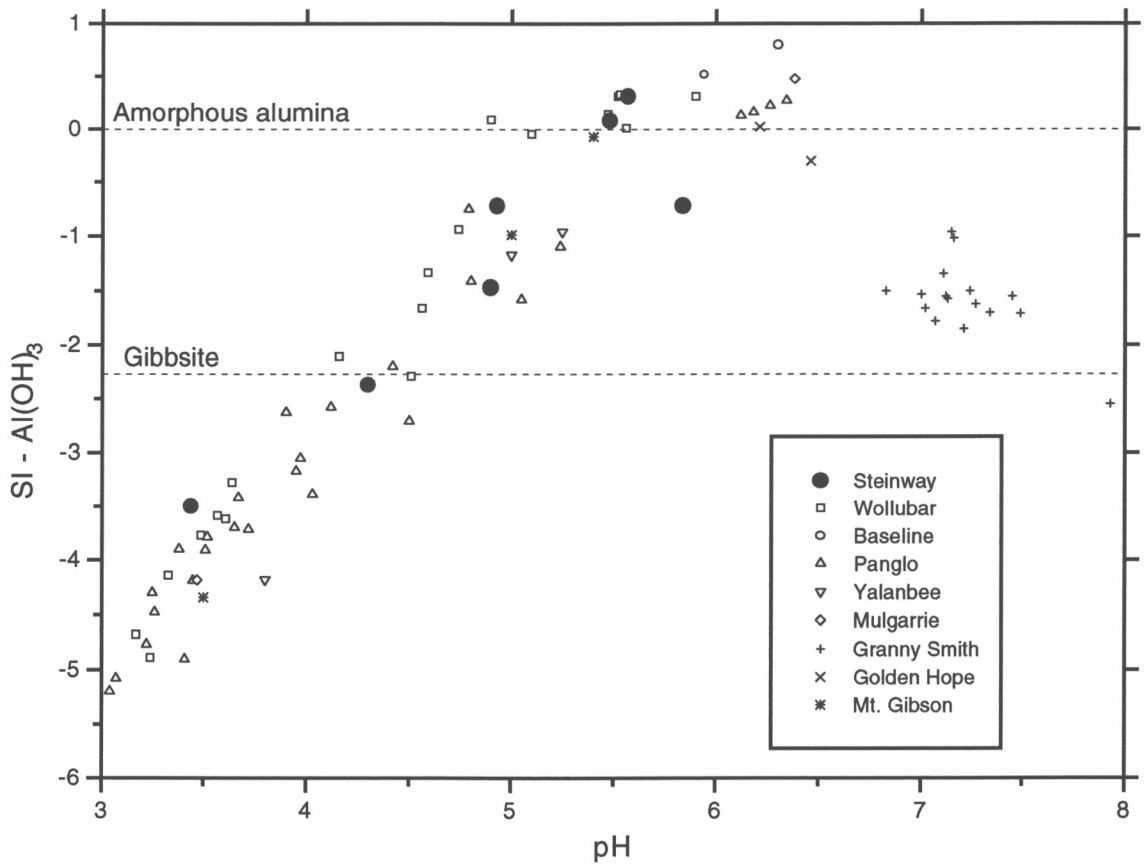


Figure A3.8: SI for $Al(OH)_3$ vs. pH for groundwaters from Steinway and other sites.

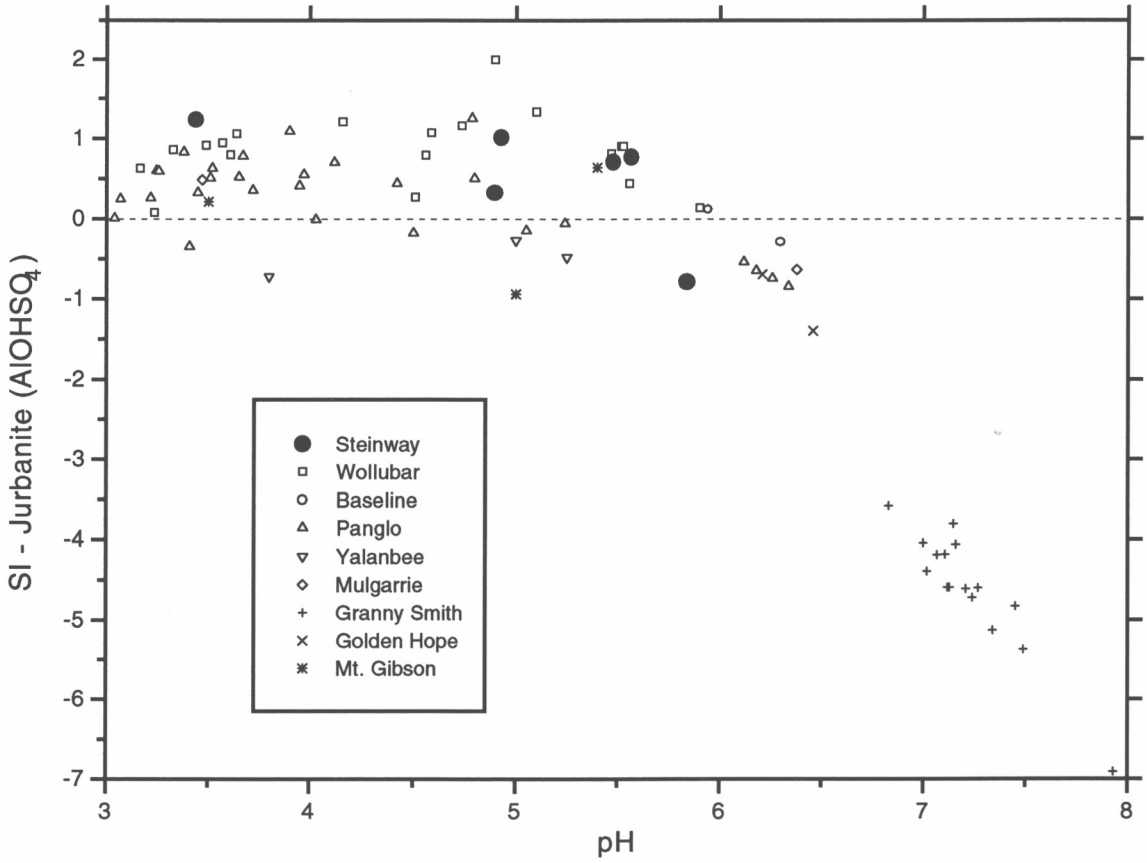


Figure A3.9: SI for jurbanite vs. pH for groundwaters from Steinway and other sites.

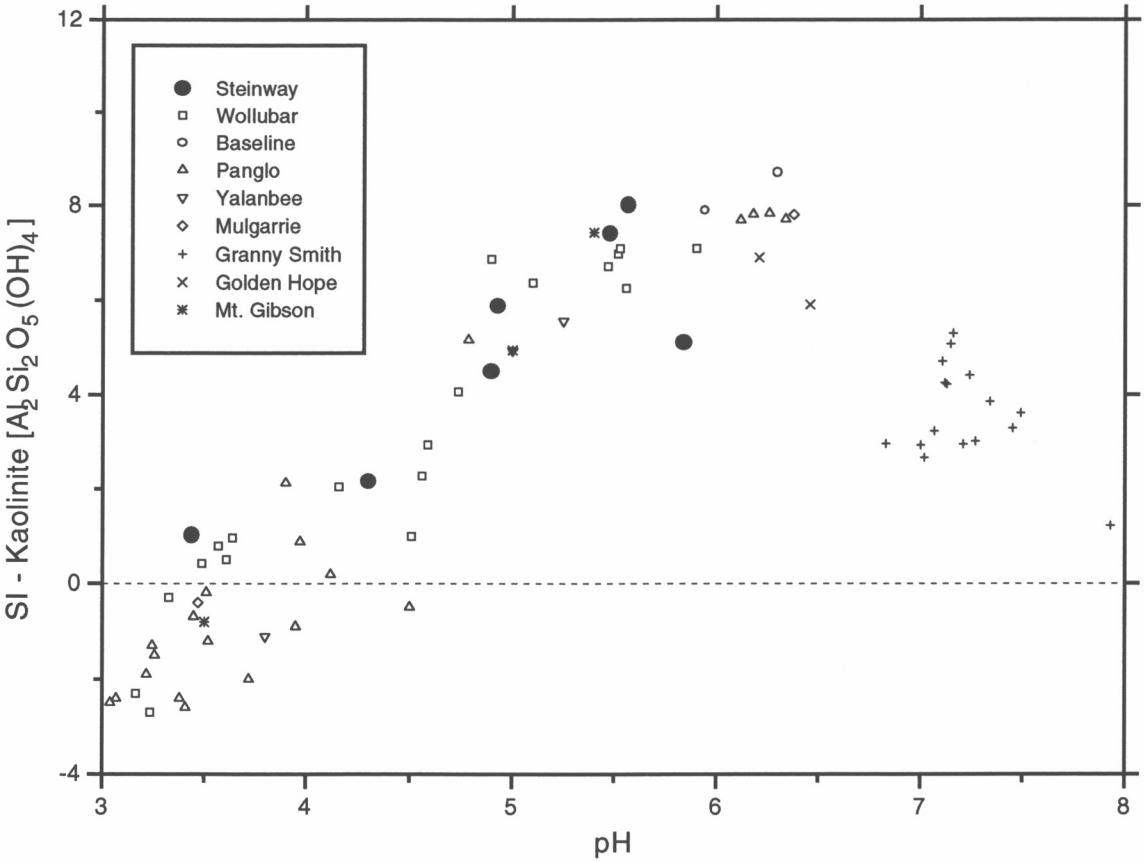


Figure A3.10: SI for kaolinite vs. pH for groundwaters from Steinway and other sites.

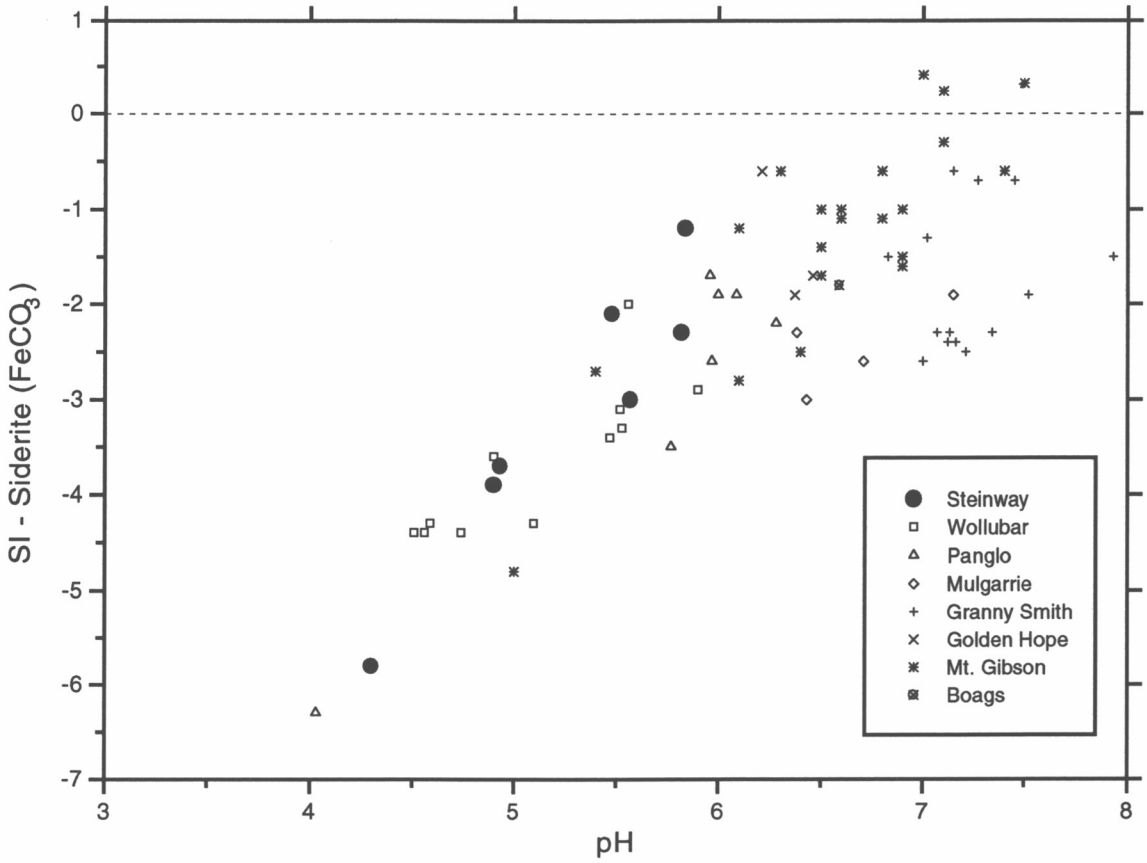


Figure A3.11: SI for siderite vs. pH for groundwaters from Steinway and other sites.

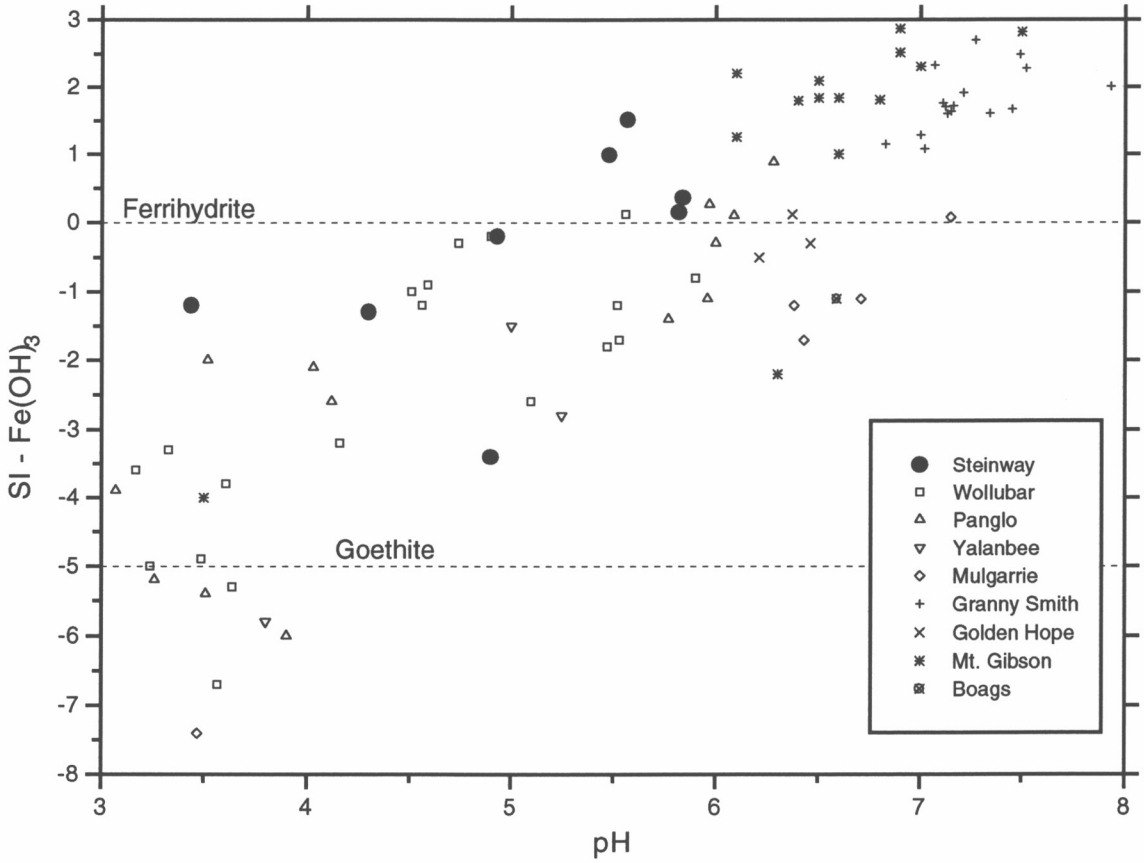


Figure A3.12: SI for $Fe(OH)_3$ vs. pH for groundwaters from Steinway and other sites.

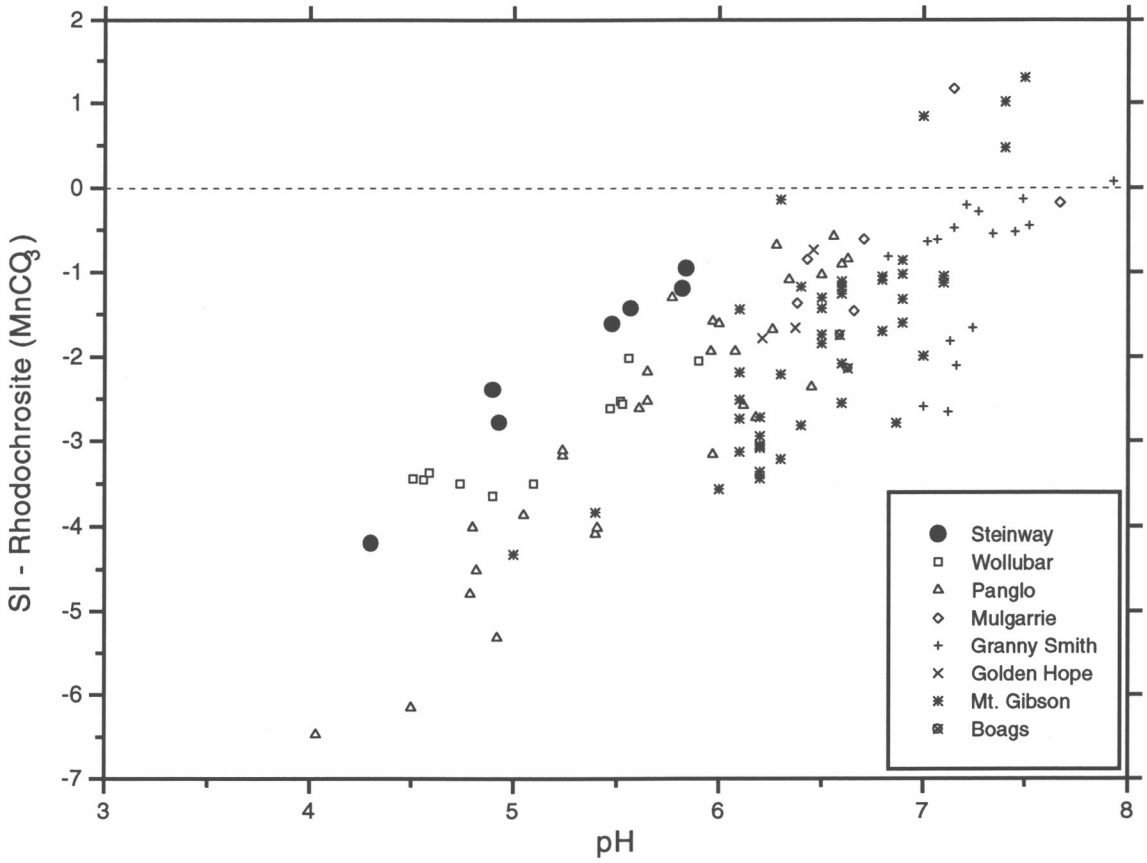


Figure A3.13: SI for rhodochrosite vs. pH for groundwaters from Steinway and other sites.

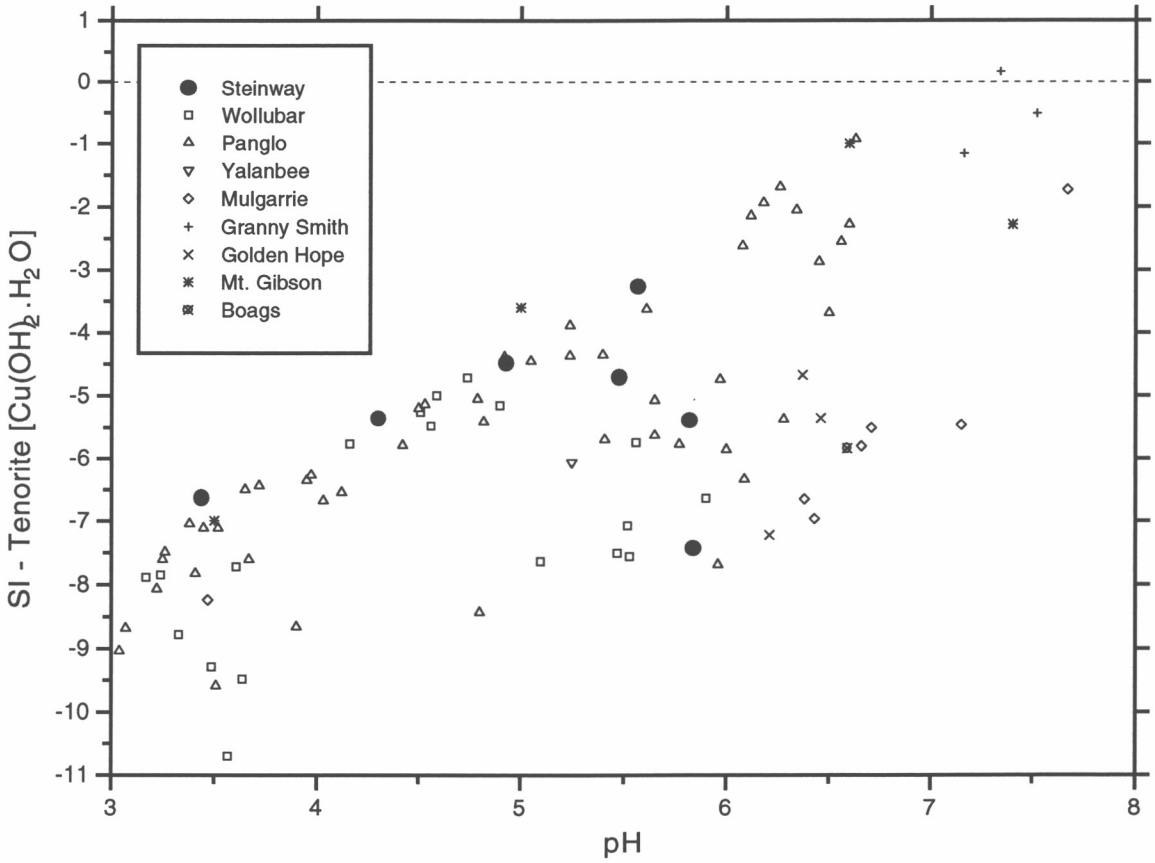


Figure A3.14: SI for tenorite vs. pH for groundwaters from Steinway and other sites.

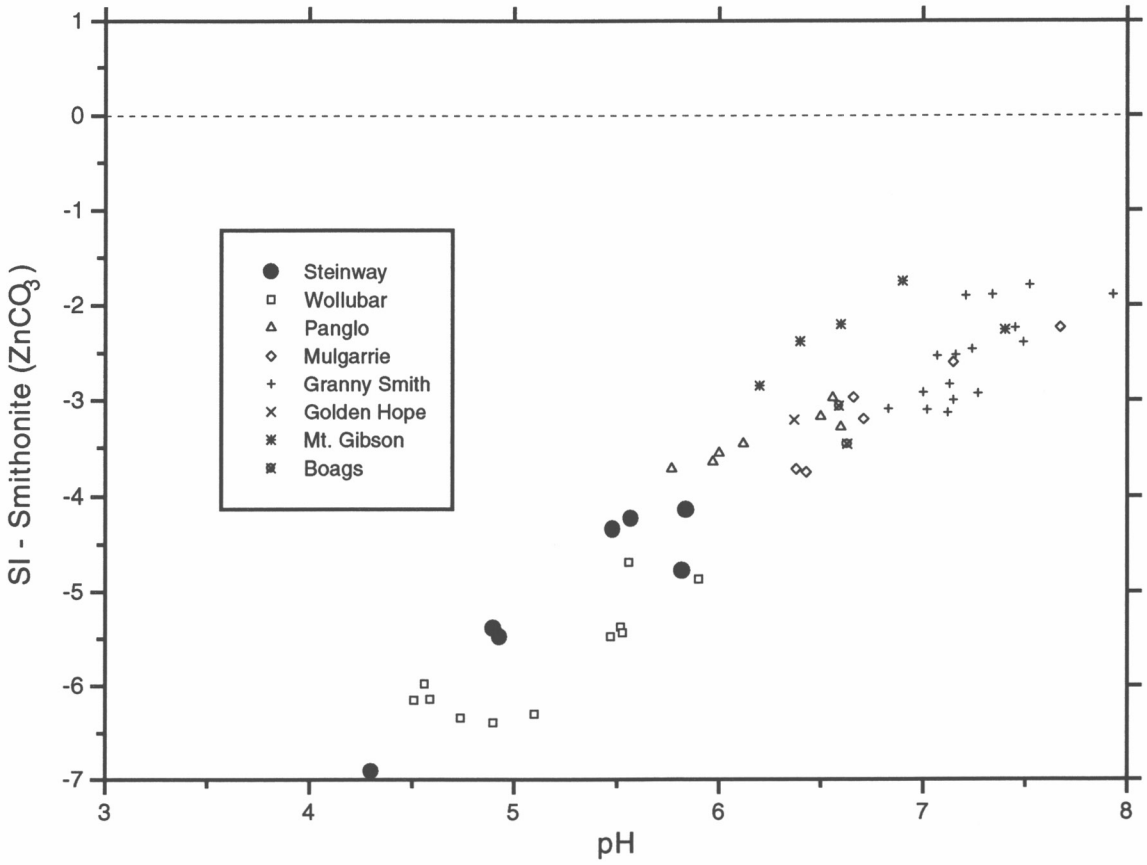


Figure A3.15: SI for smithonite vs. pH for groundwaters from Steinway and other sites.

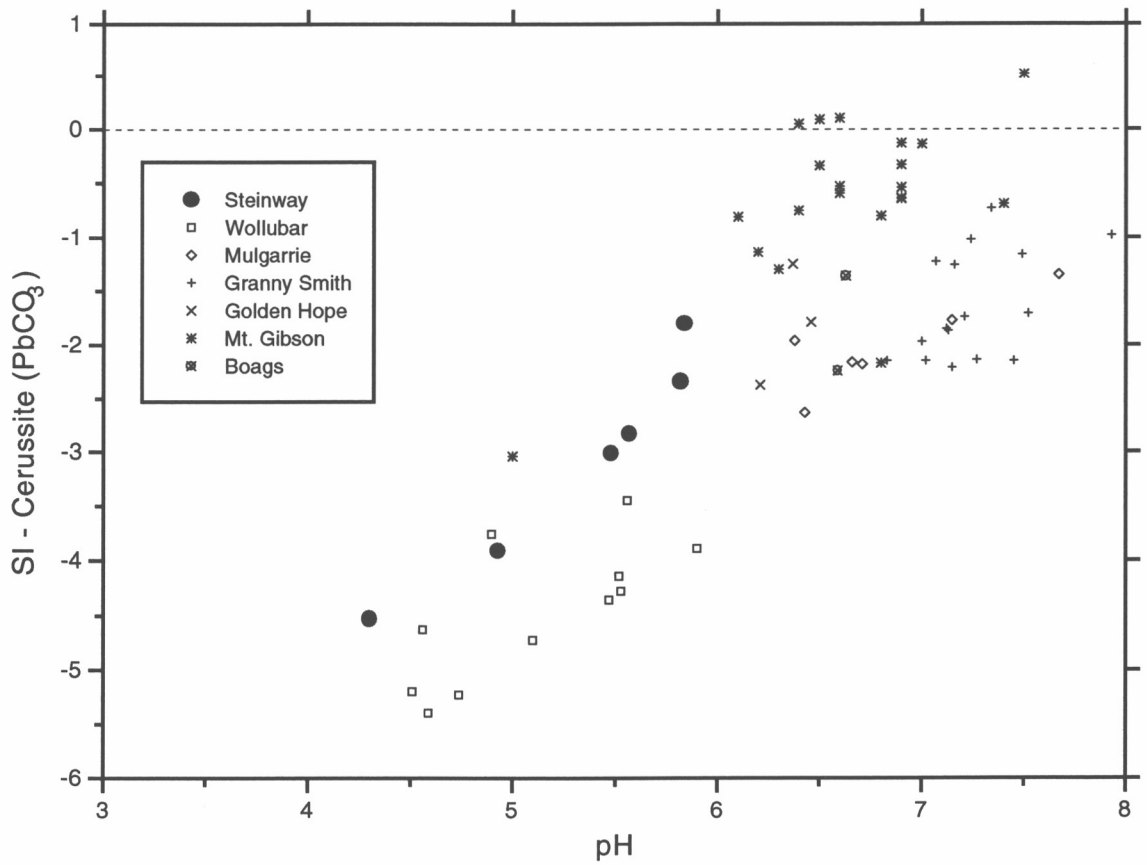


Figure A3.16: SI for cerussite vs. pH for groundwaters from Steinway and other sites.

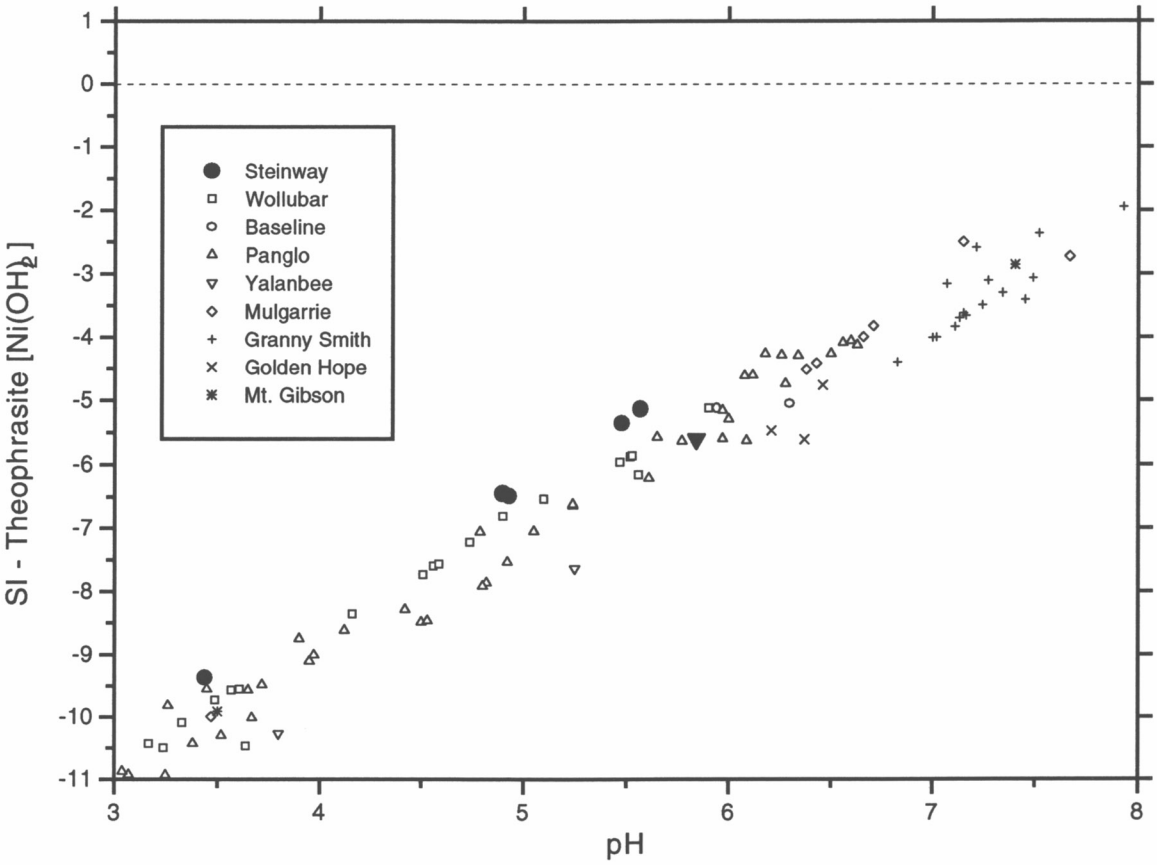


Figure A3.17: SI for theophrasite vs. pH for groundwaters from Steinway and other sites.

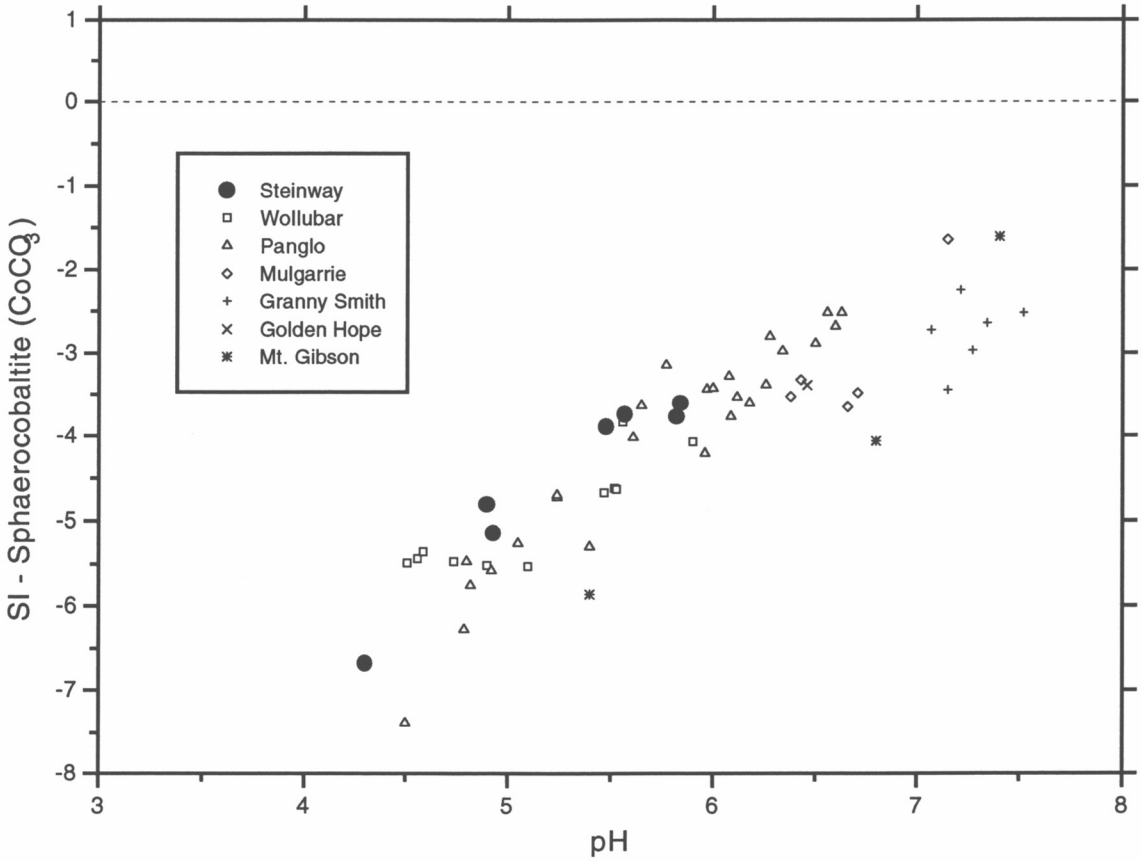


Figure A3.18: SI for sphaerocobaltite vs. pH for groundwaters from Steinway and other sites.

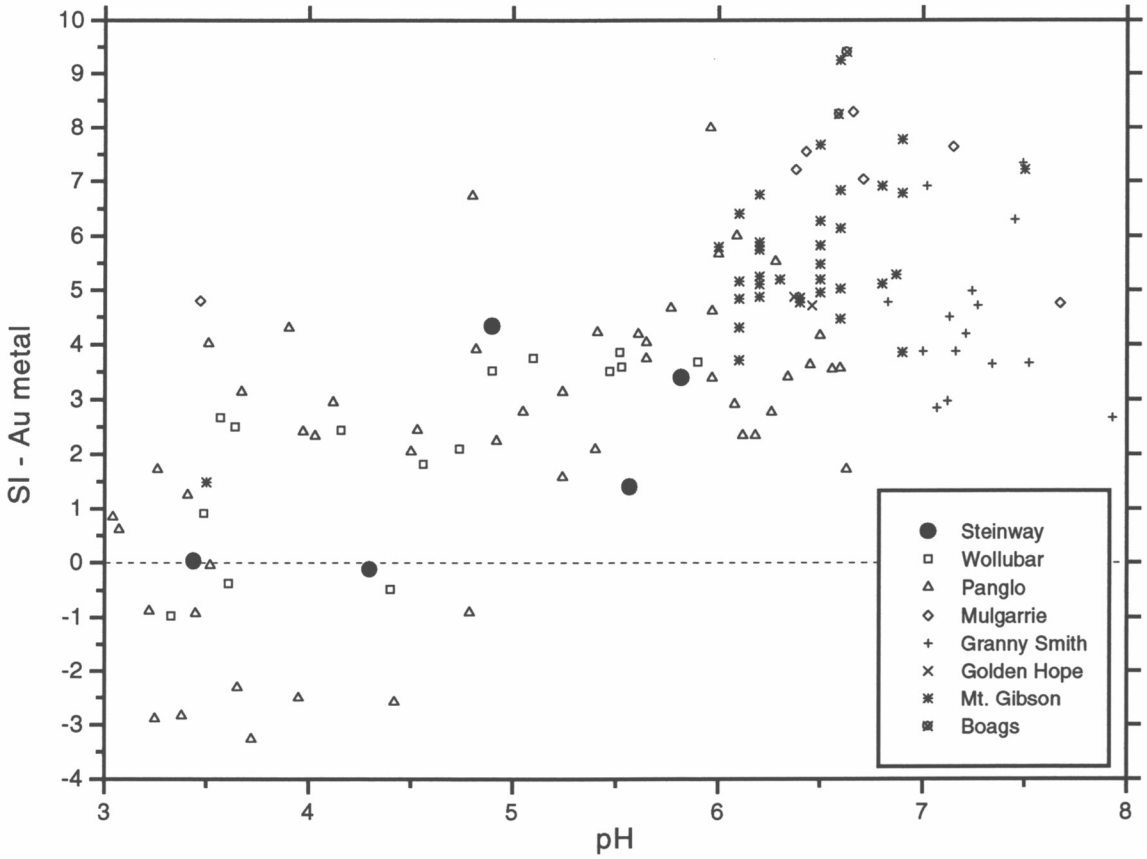


Figure A3.19: SI for Au metal vs. pH for groundwaters from Steinway and other sites.

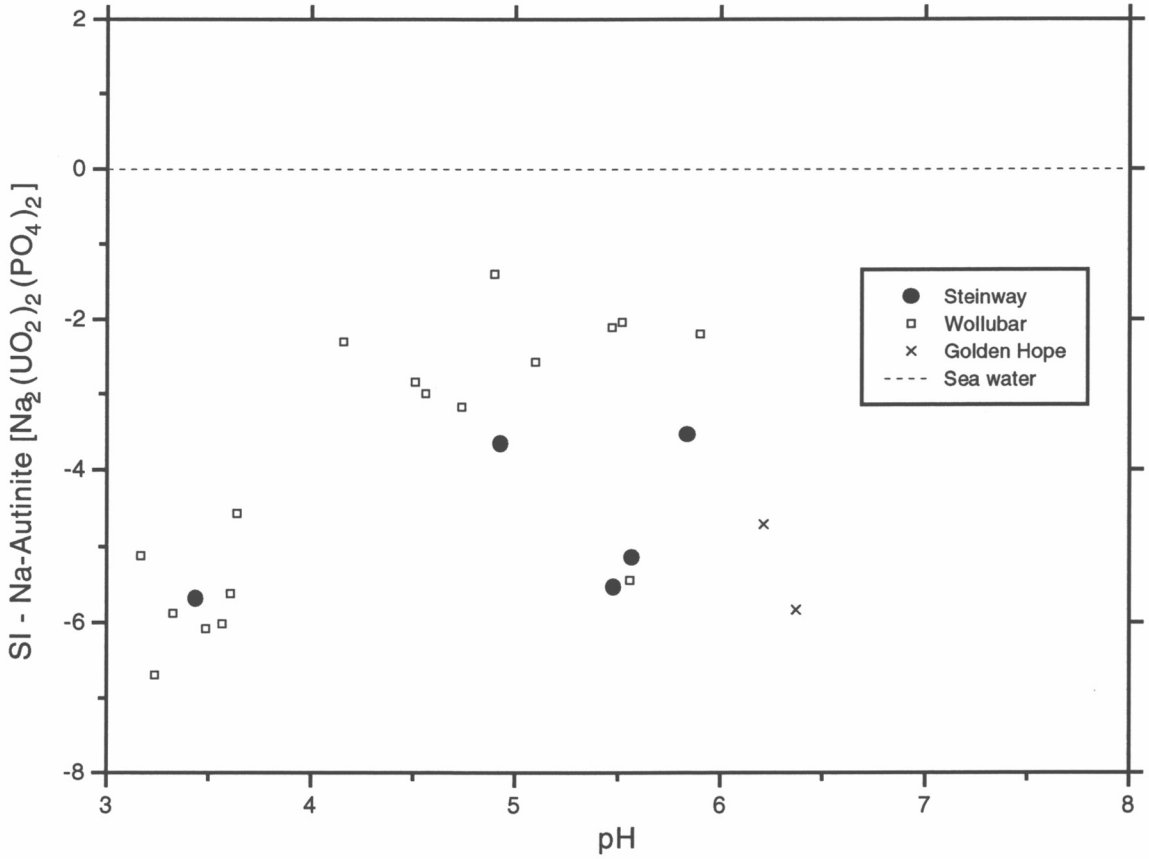


Figure A3.20: SI for Na-autinite vs. pH for groundwaters from Steinway and other sites.

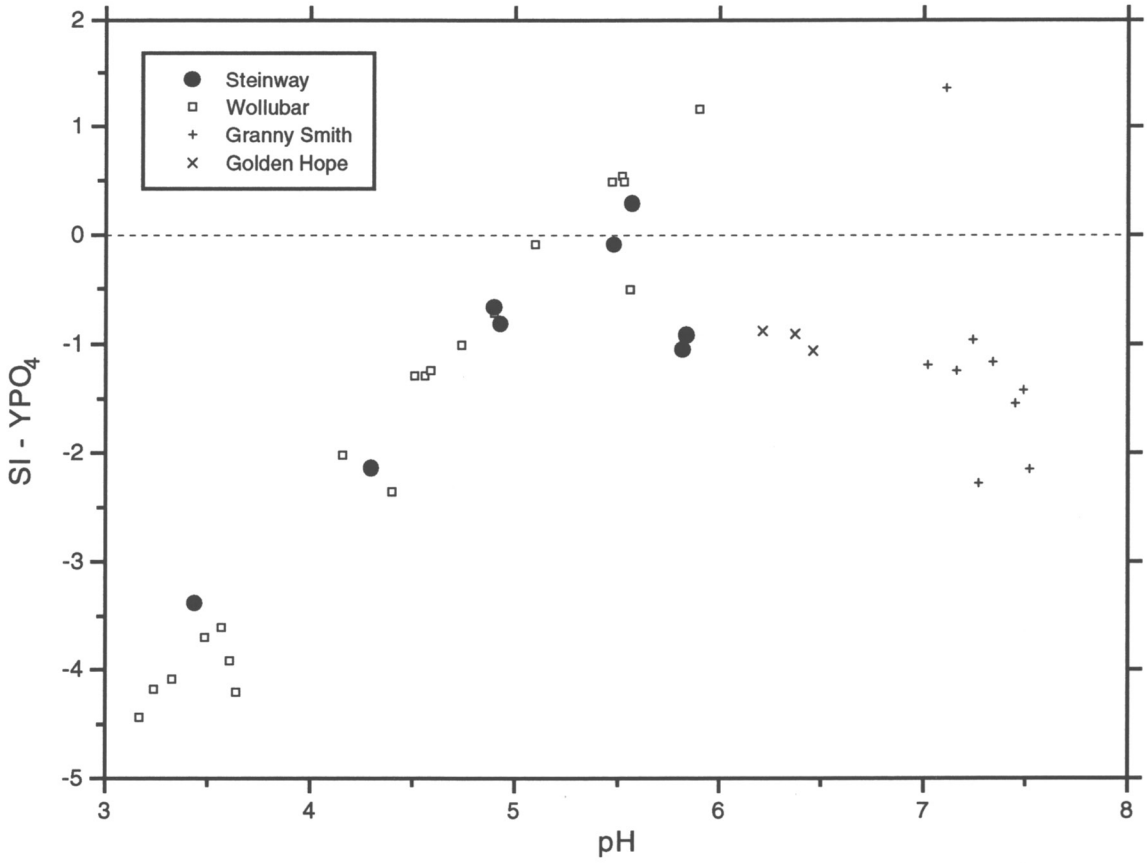


Figure A3.21: SI for YPO_4 vs. pH for groundwaters from Steinway and other sites.

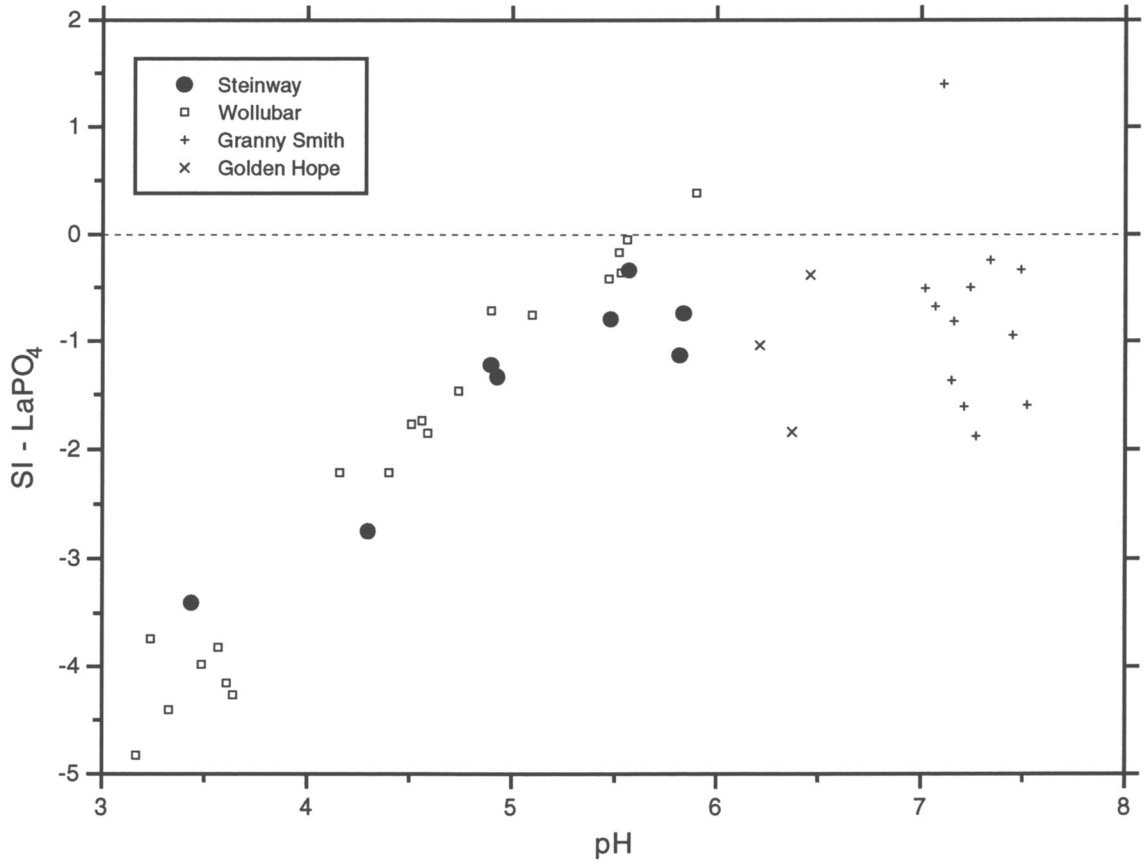


Figure A3.22: SI for $LaPO_4$ vs. pH for groundwaters from Steinway and other sites.

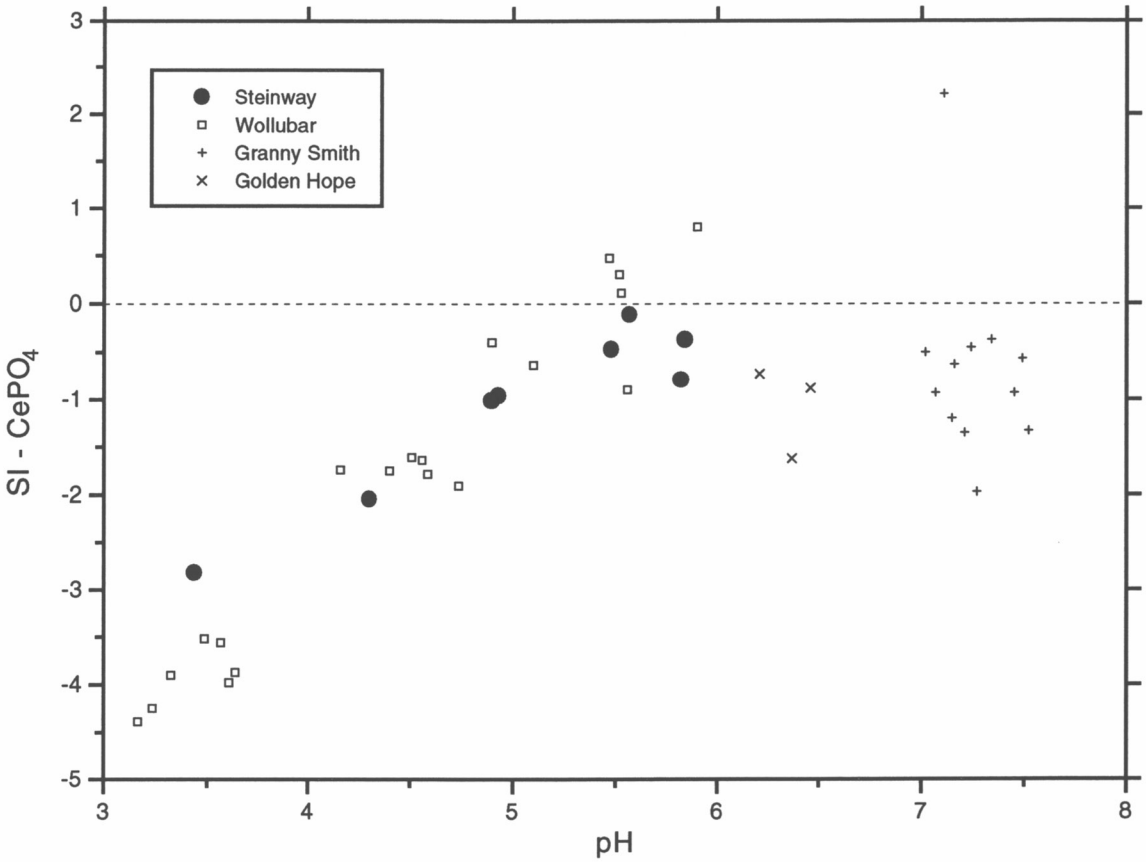


Figure A3.23: SI for $CePO_4$ vs. pH for groundwaters from Steinway and other sites.

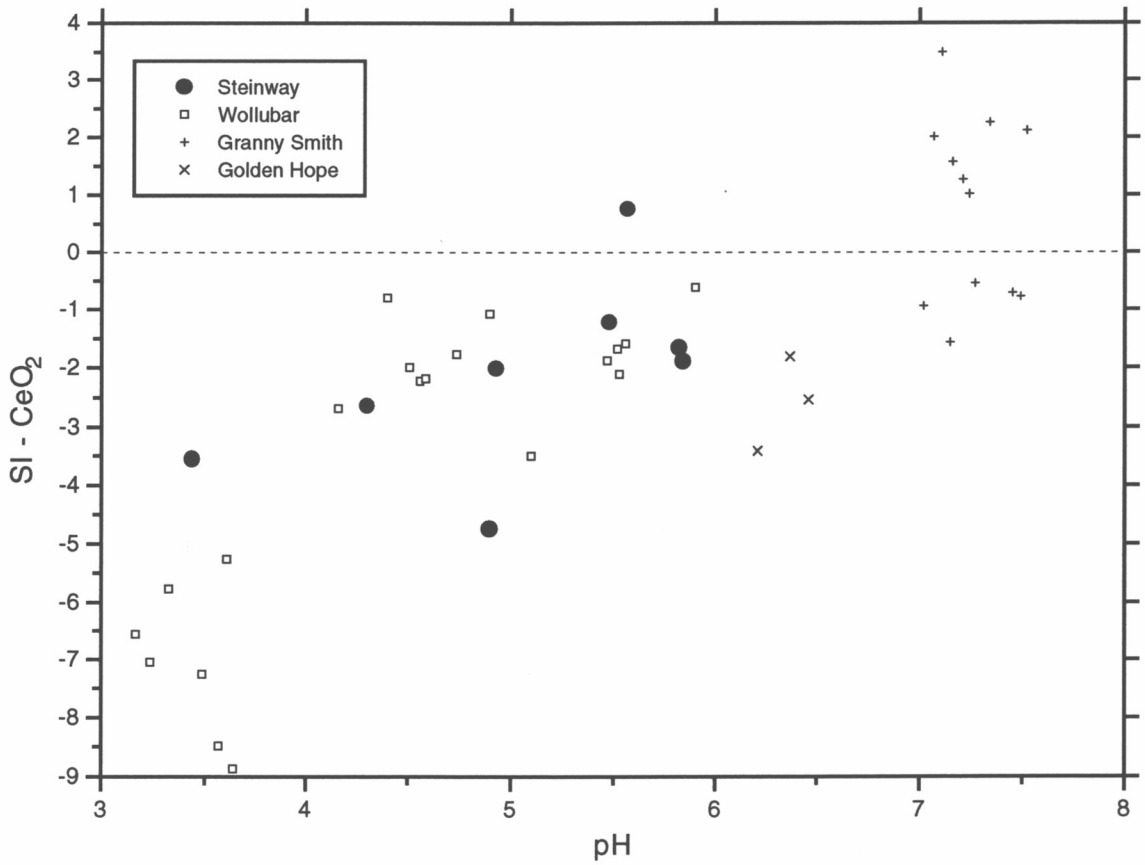


Figure A3.24: SI for CeO_2 vs. pH for groundwaters from Steinway and other sites.

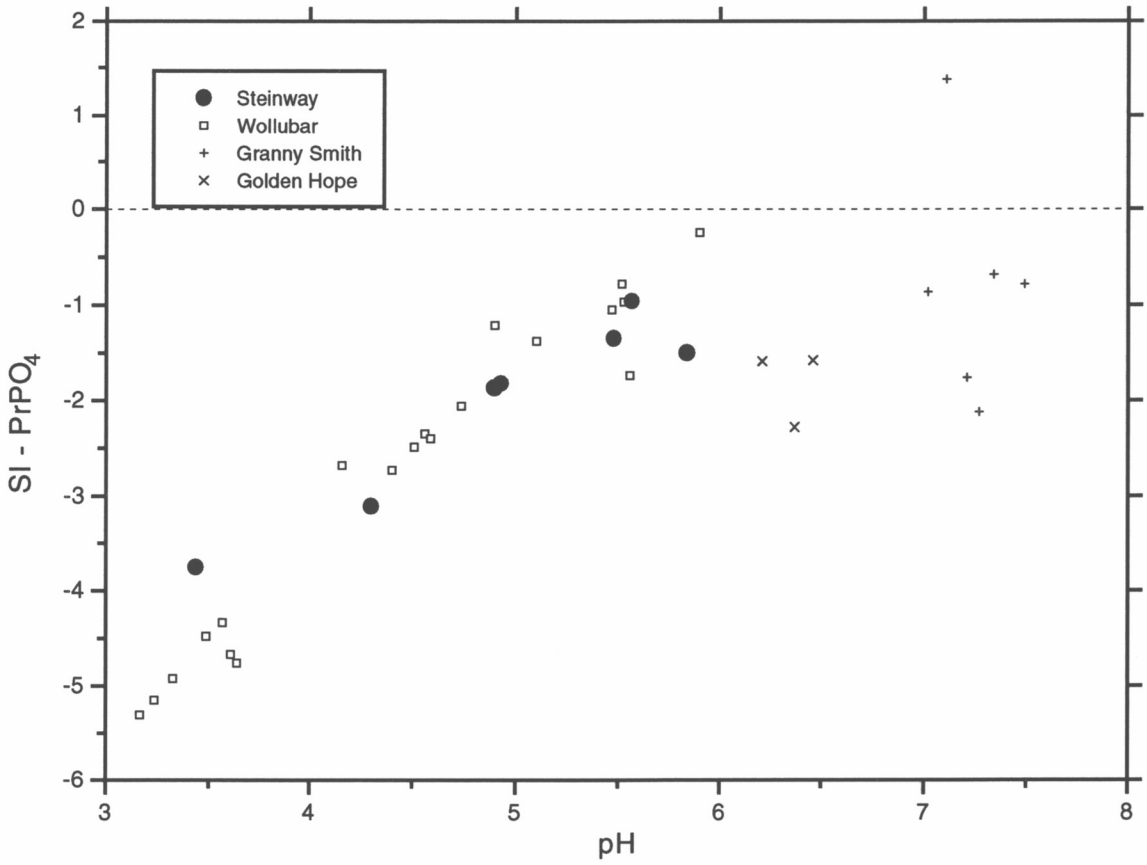


Figure A3.25: SI for $PrPO_4$ vs. pH for groundwaters from Steinway and other sites.

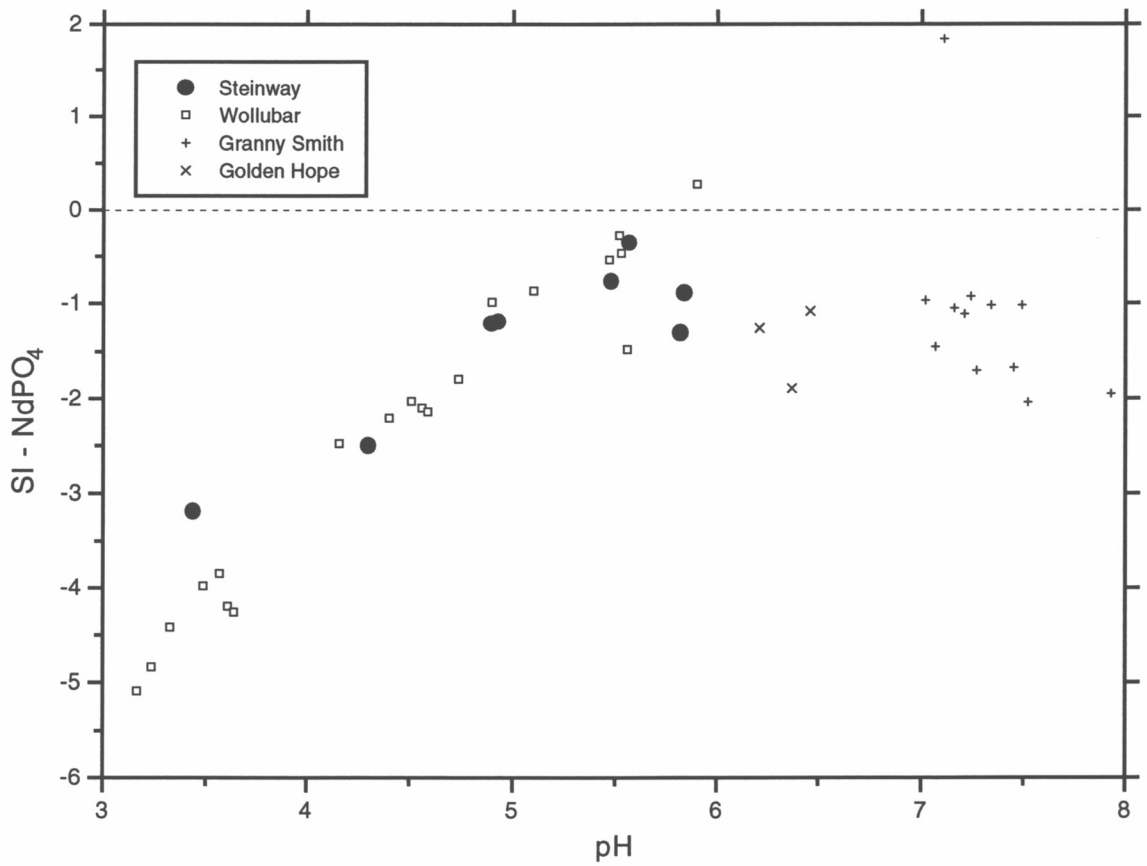


Figure A3.26: SI for $NdPO_4$ vs. pH for groundwaters from Steinway and other sites.

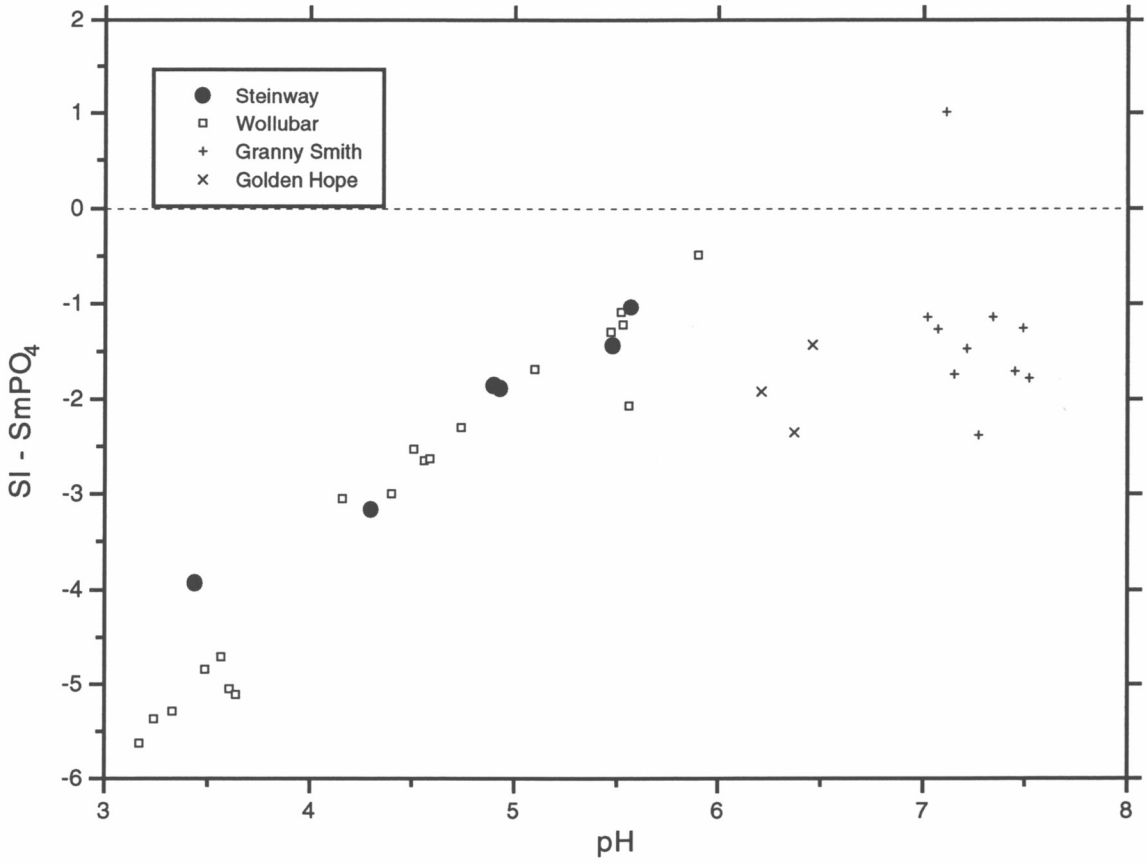


Figure A3.27: SI for $SmPO_4$ vs. pH for groundwaters from Steinway and other sites.

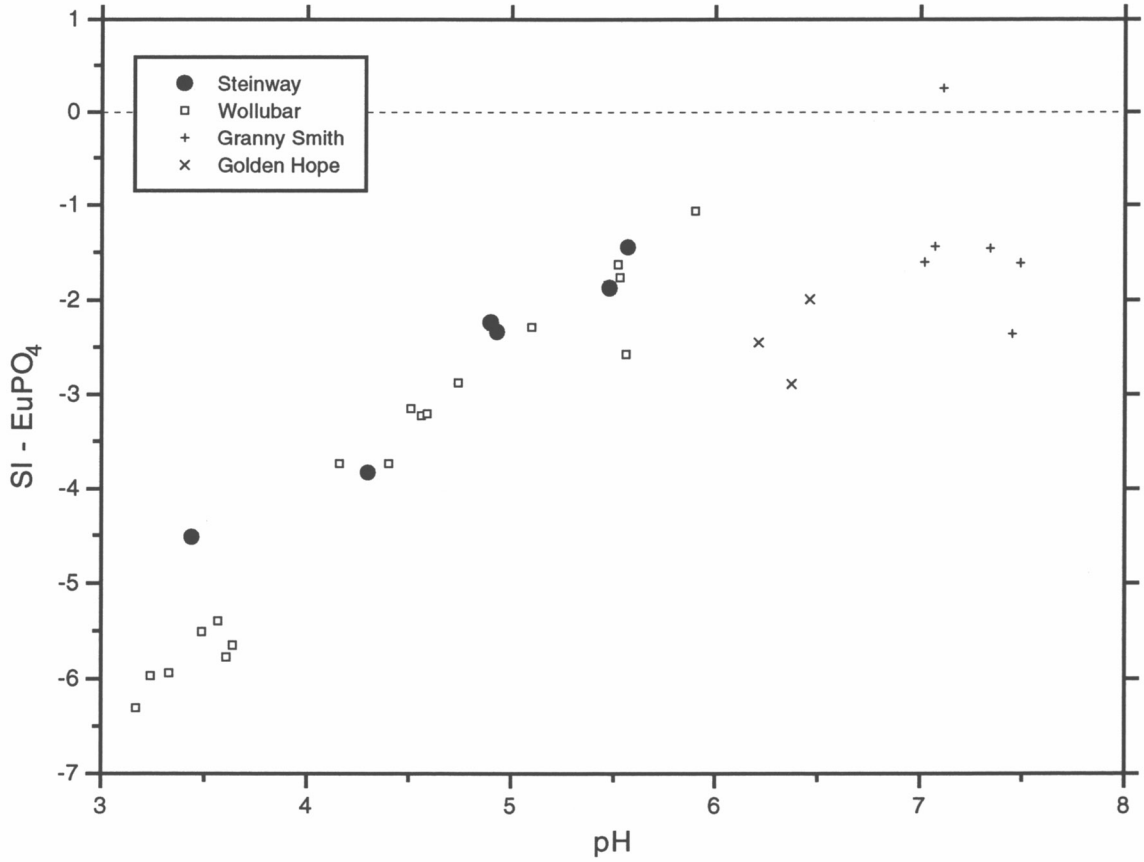


Figure A3.28: SI for $EuPO_4$ vs. pH for groundwaters from Steinway and other sites.

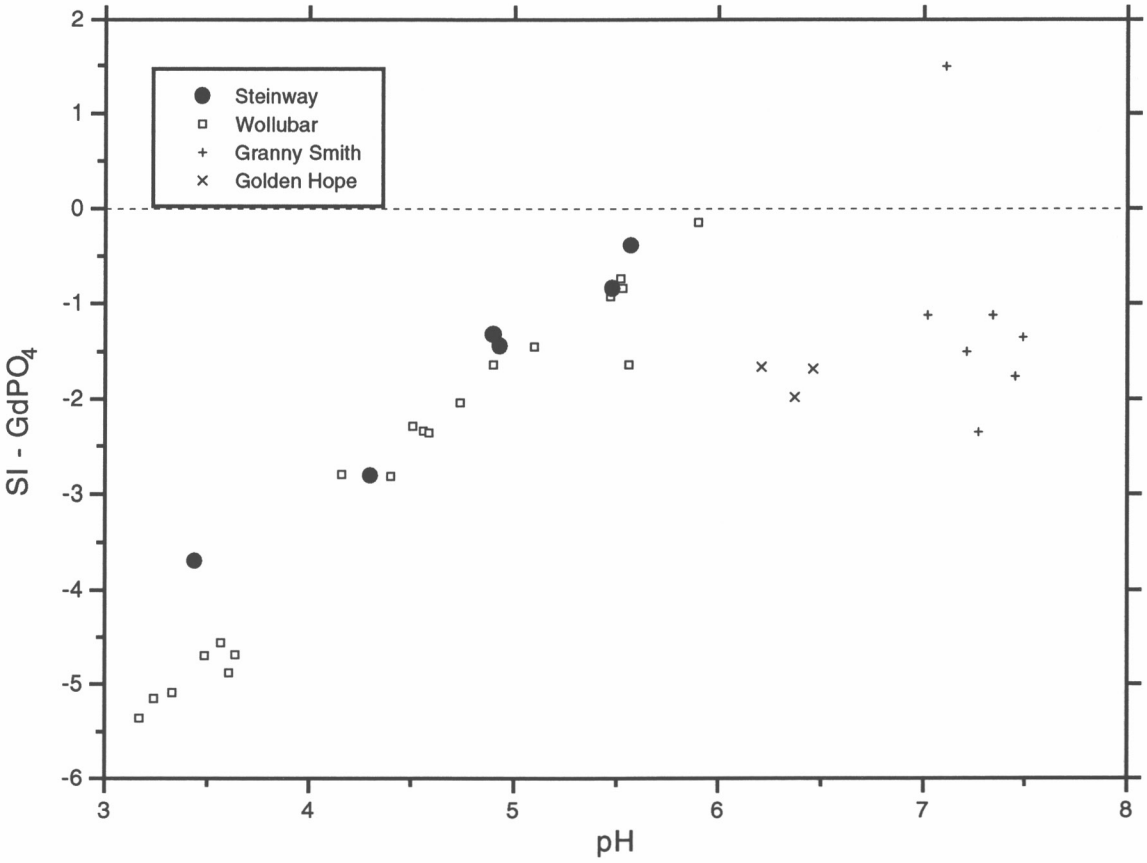


Figure A3.29: SI for $GdPO_4$ vs. pH for groundwaters from Steinway and other sites.

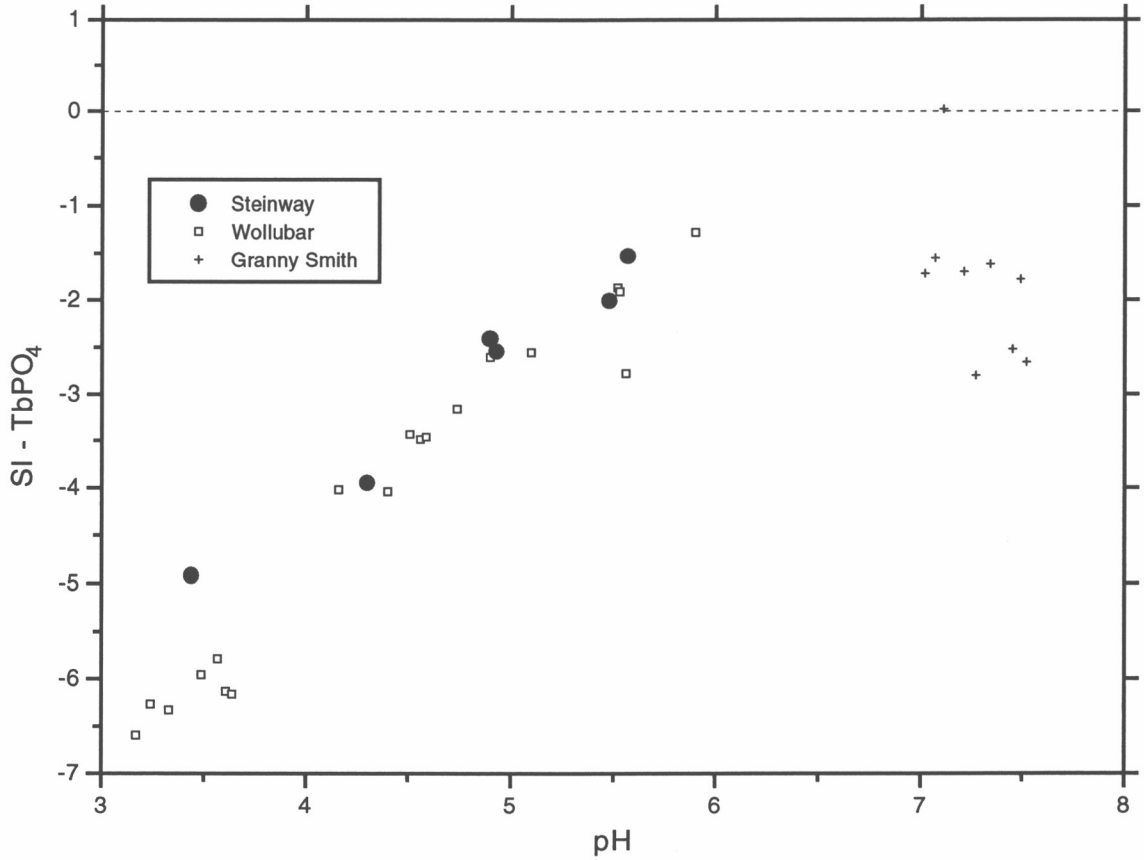


Figure A3.30: SI for $TbPO_4$ vs. pH for groundwaters from Steinway and other sites.

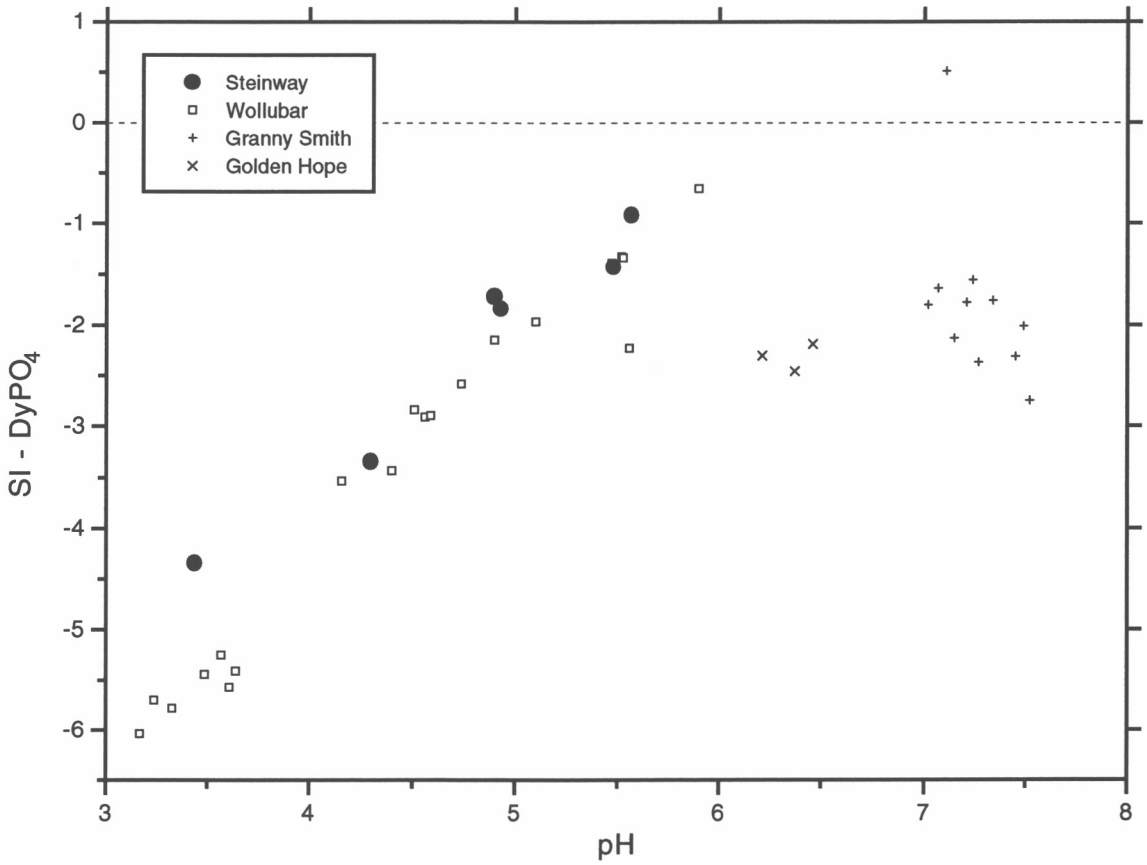


Figure A3.31: SI for $DyPO_4$ vs. pH for groundwaters from Steinway and other sites.

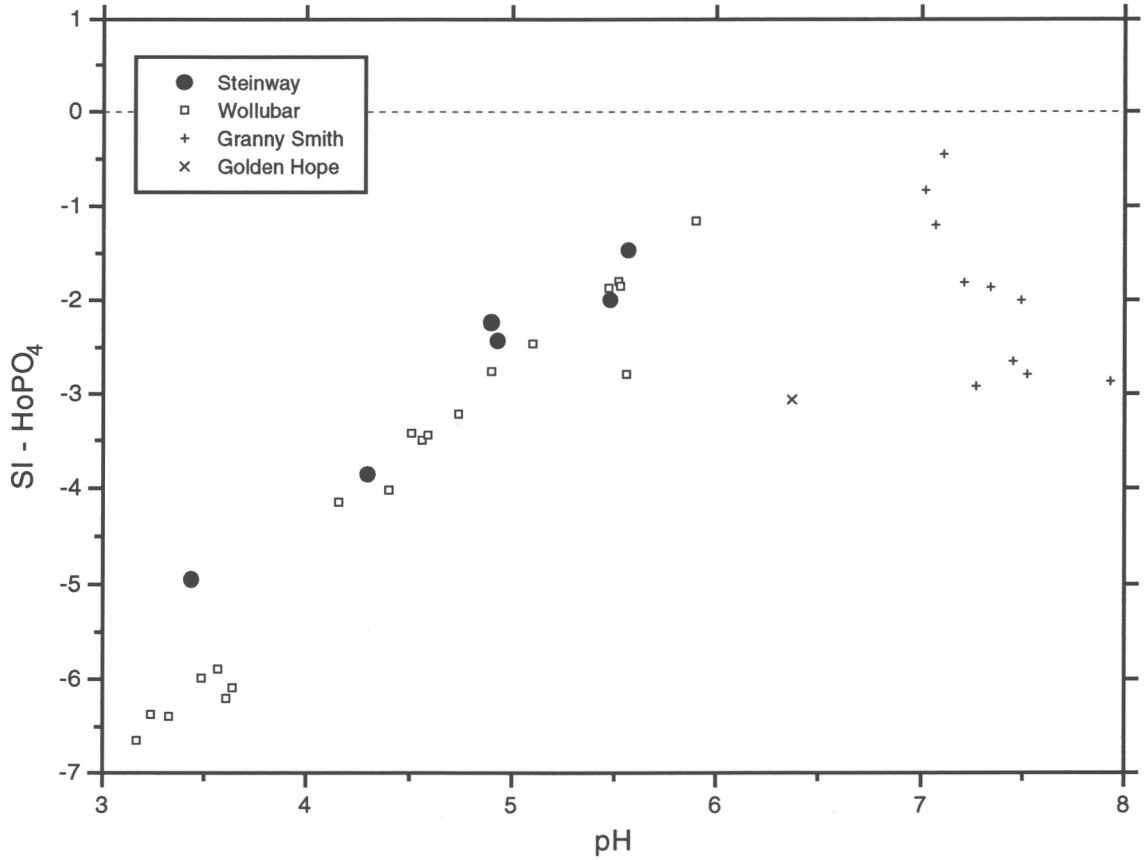


Figure A3.32: SI for $HoPO_4$ vs. pH for groundwaters from Steinway and other sites.

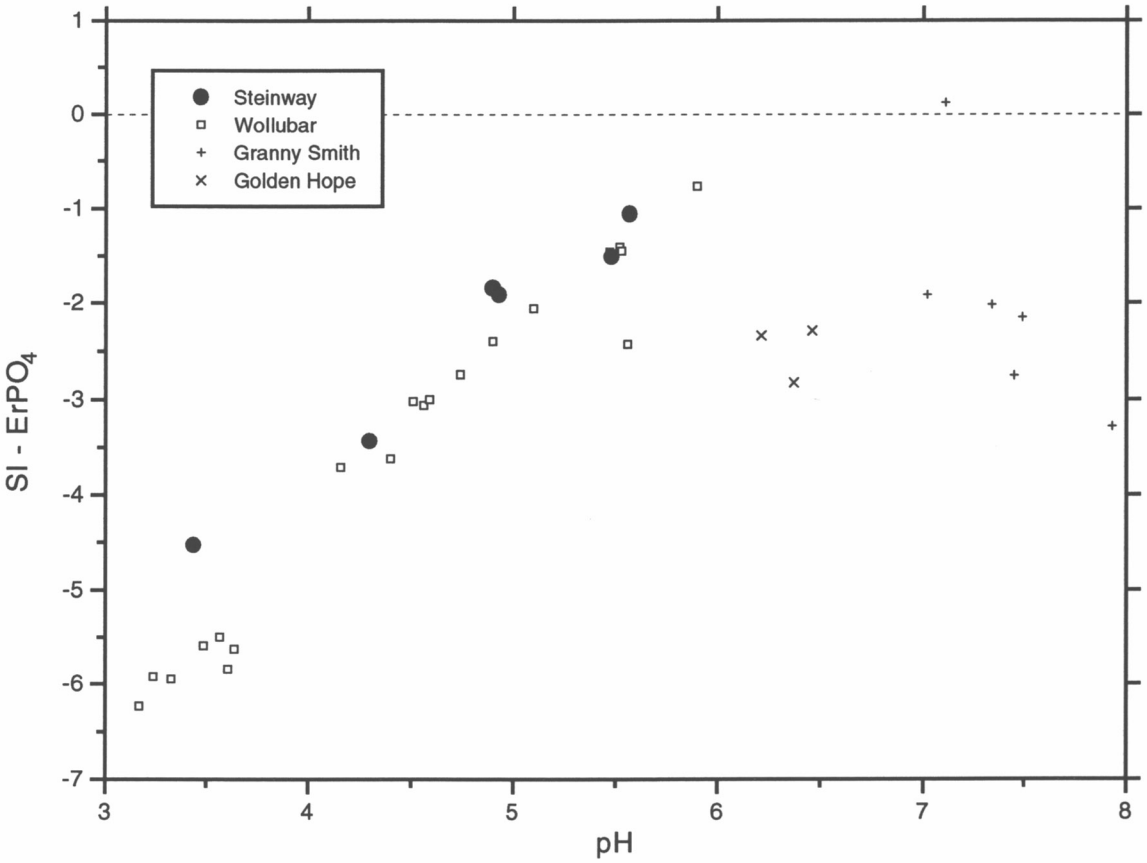


Figure A3.33: SI for $ErPO_4$ vs. pH for groundwaters from Steinway and other sites.

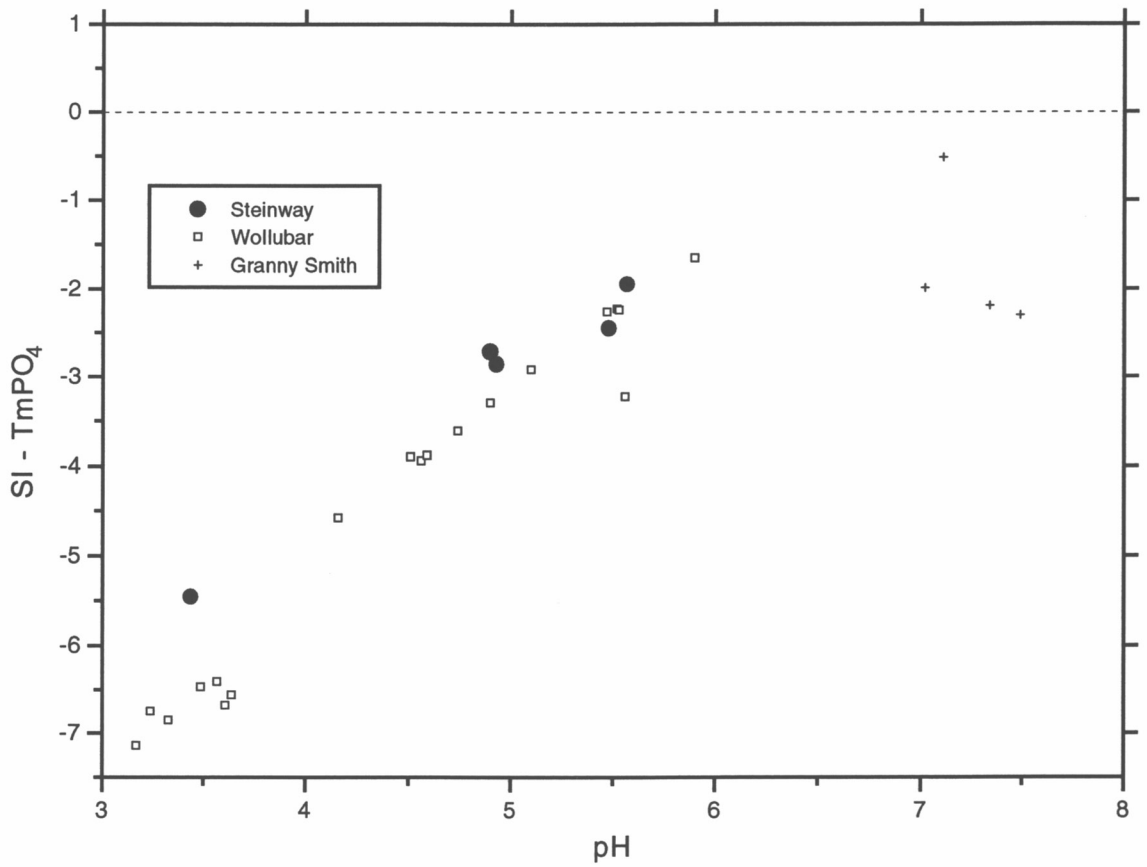


Figure A3.34: SI for $TmPO_4$ vs. pH for groundwaters from Steinway and other sites.

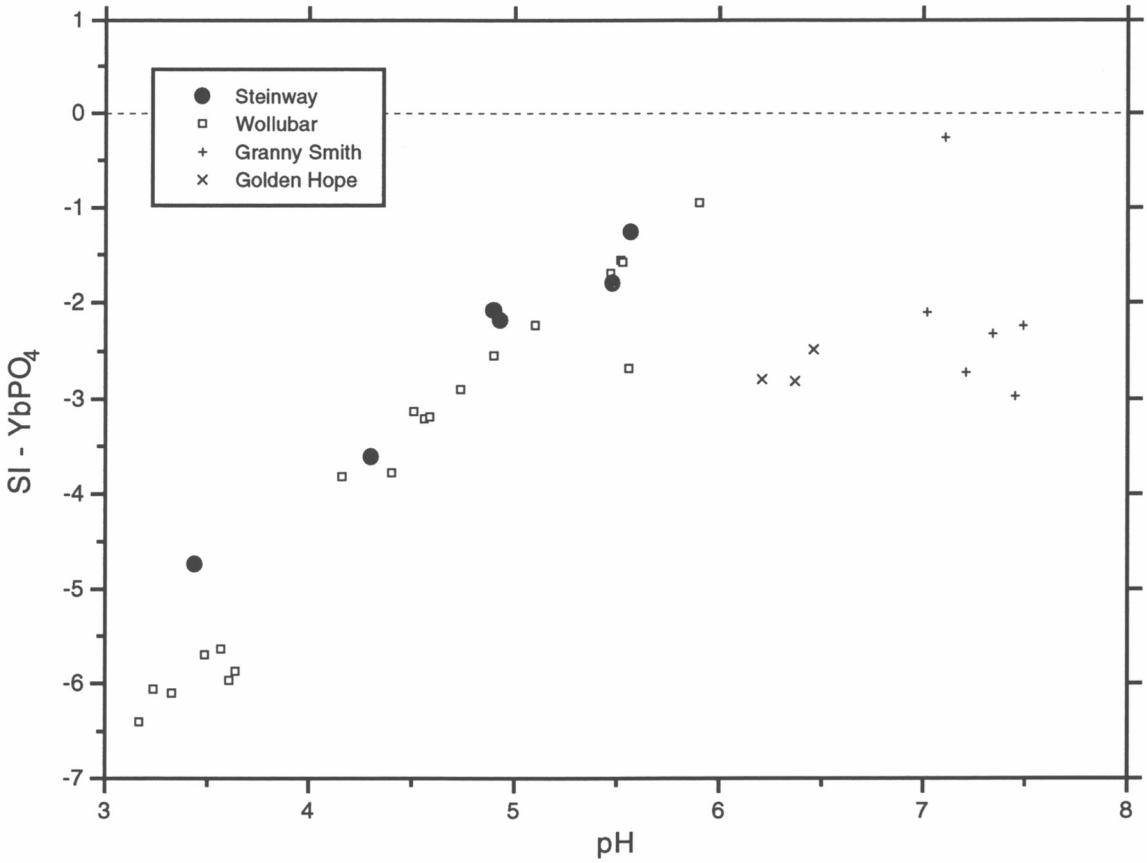


Figure A3.35: SI for $YbPO_4$ vs. pH for groundwaters from Steinway and other sites.

Appendix 4: Element/ion distribution maps - groundwaters

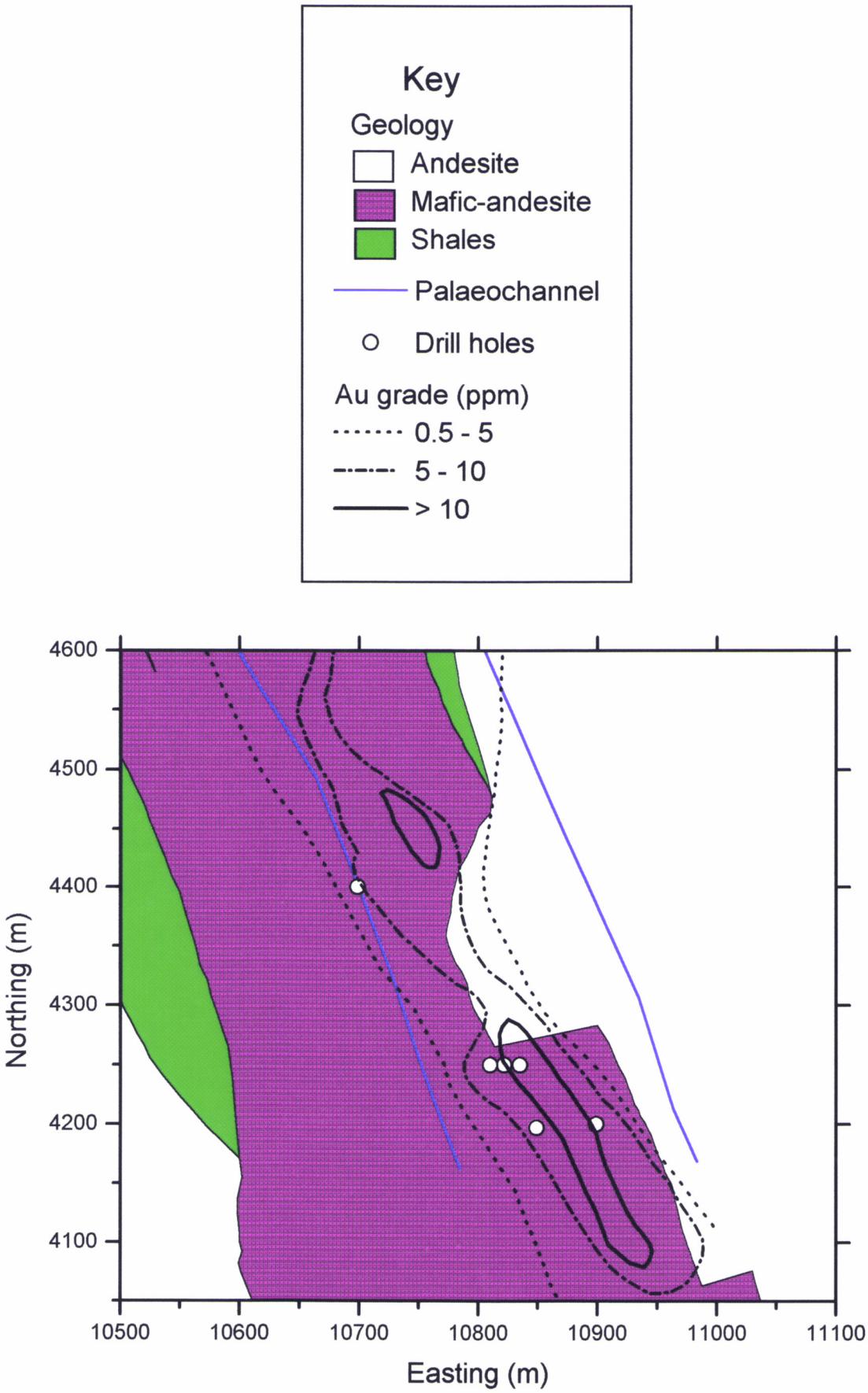


Figure A4.1: Geology, palaeochannel, groundwater sample points and saprolite Au grade (RC and RAB data combined) at Steinway (courtesy, Newcrest Mining Ltd.).

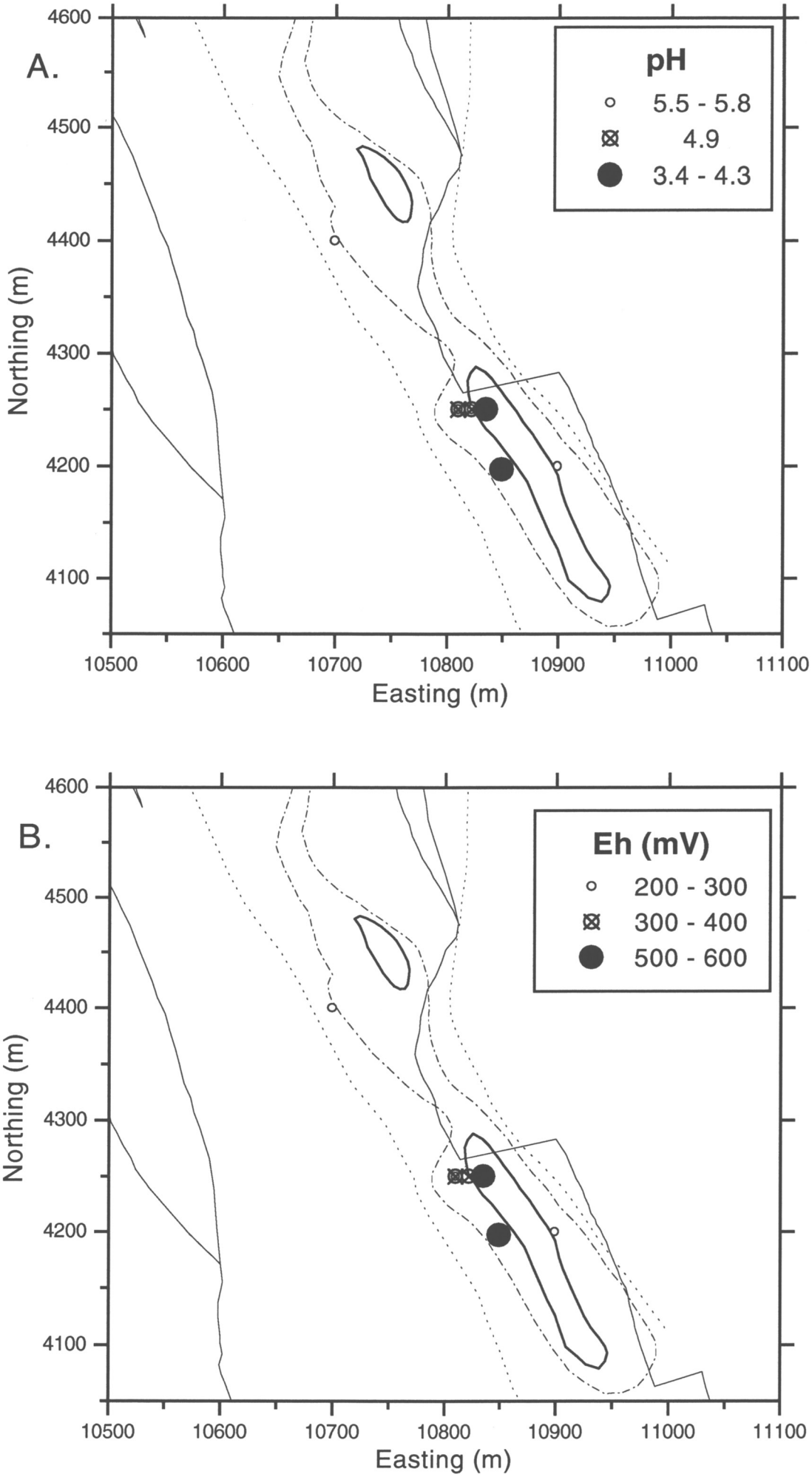
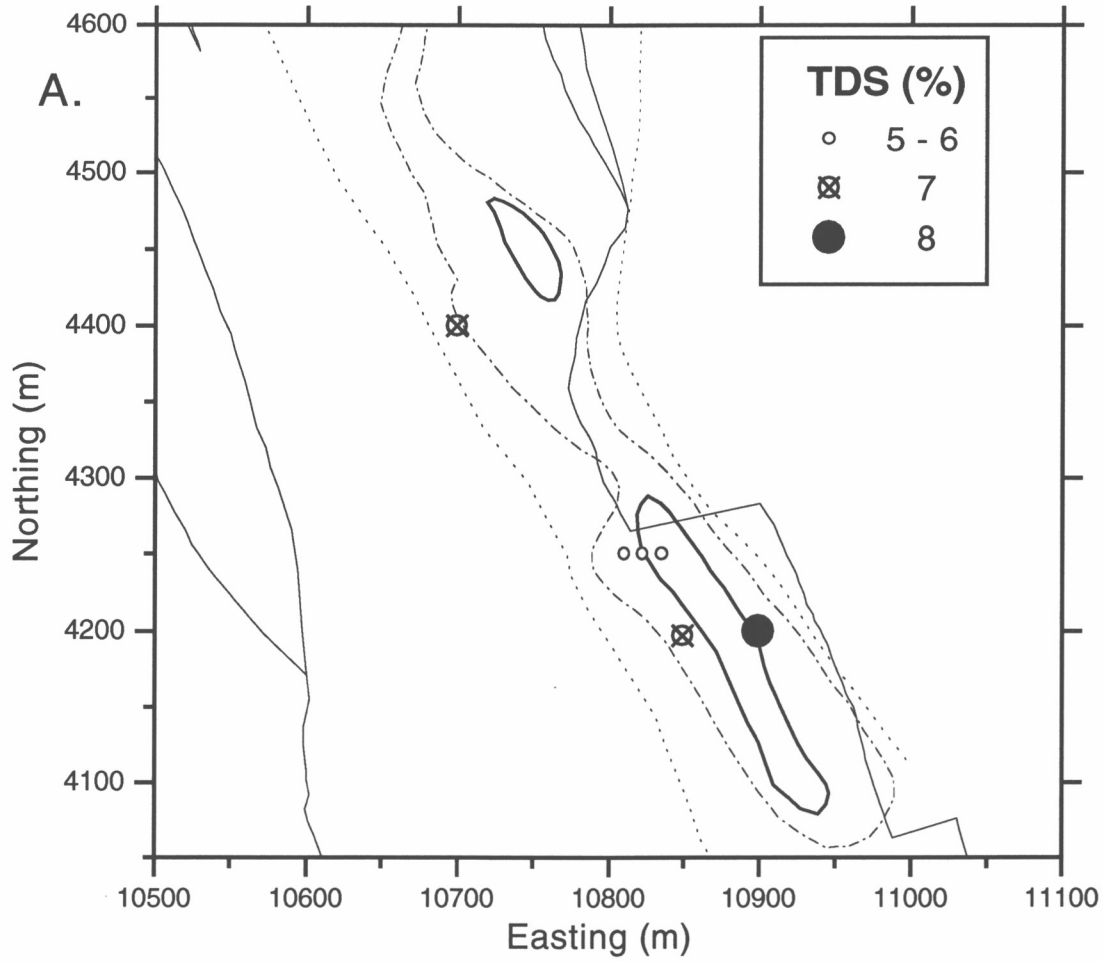


Figure A4.2: Variation in (A) pH and (B) Eh in groundwaters at Steinway.



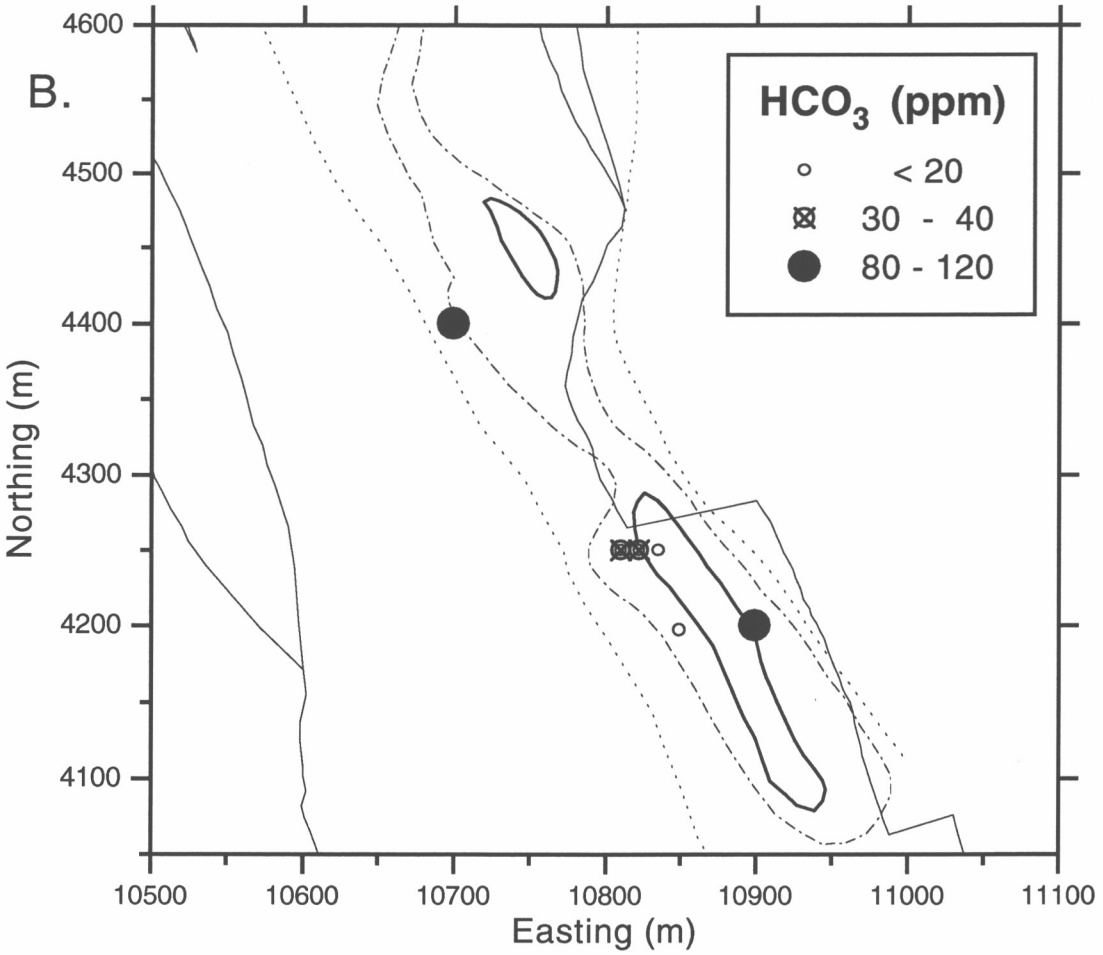
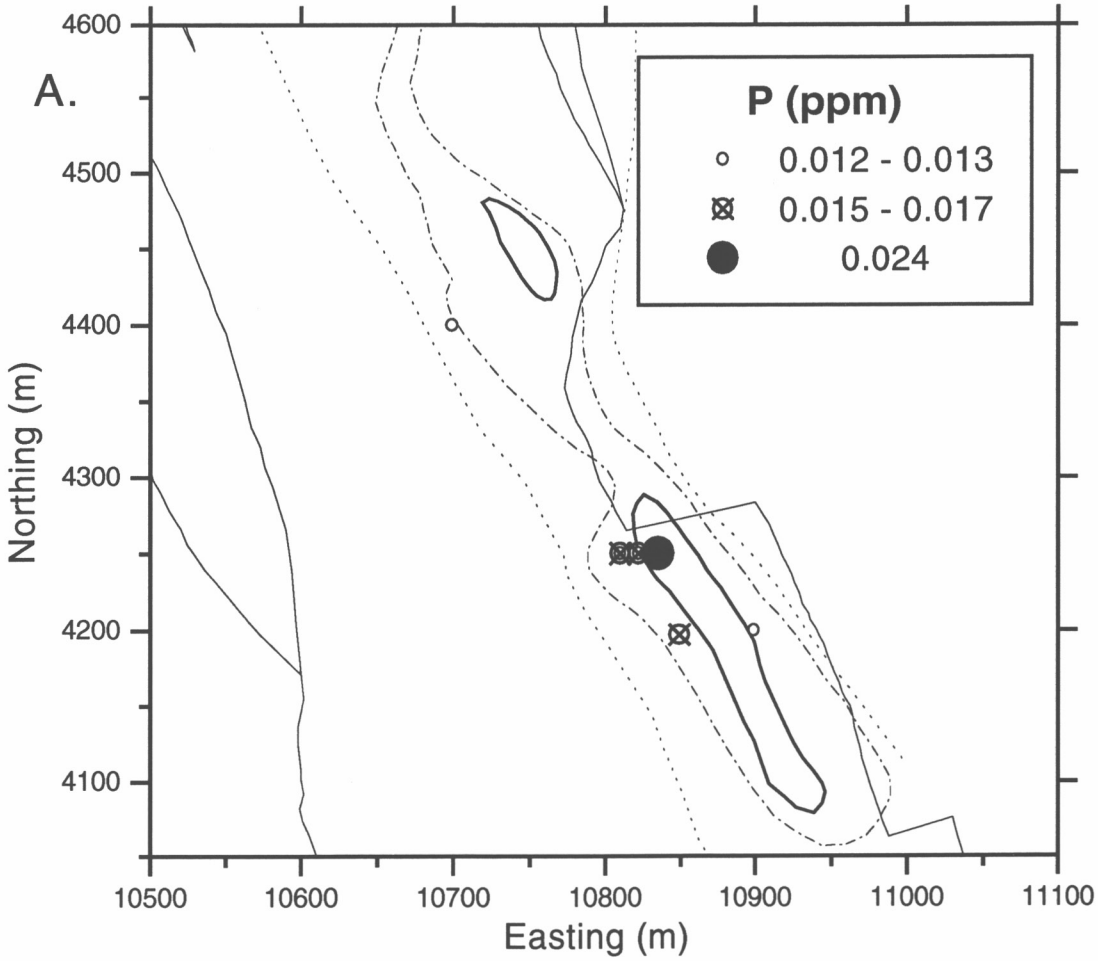


Figure A4.3: Variation in (A) TDS and (B) HCO_3 in groundwaters at Steinway.



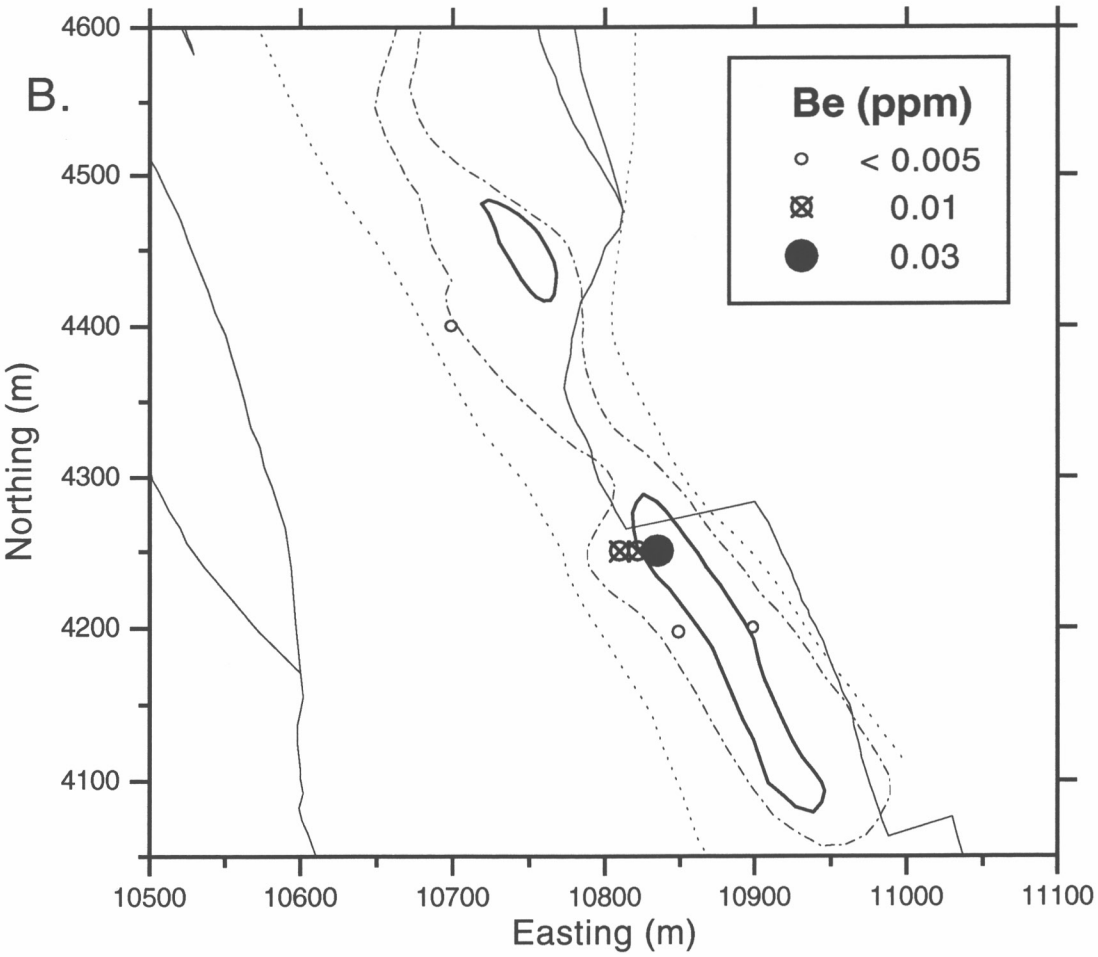


Figure A4.4: Variation in (A) P and (B) Be in groundwaters at Steinway.

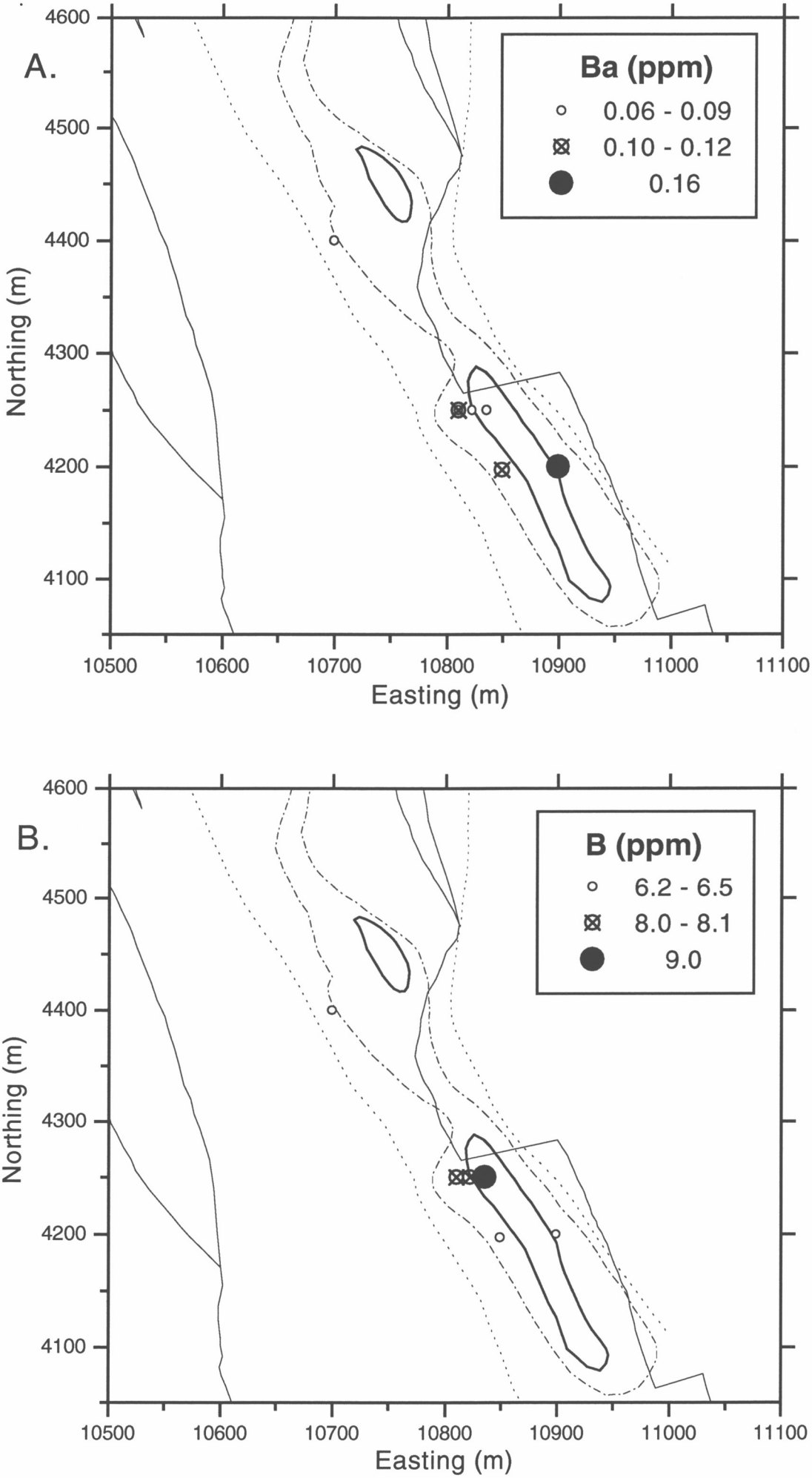


Figure A4.5: Variation in (A) Ba and (B) B in groundwaters at Steinway.

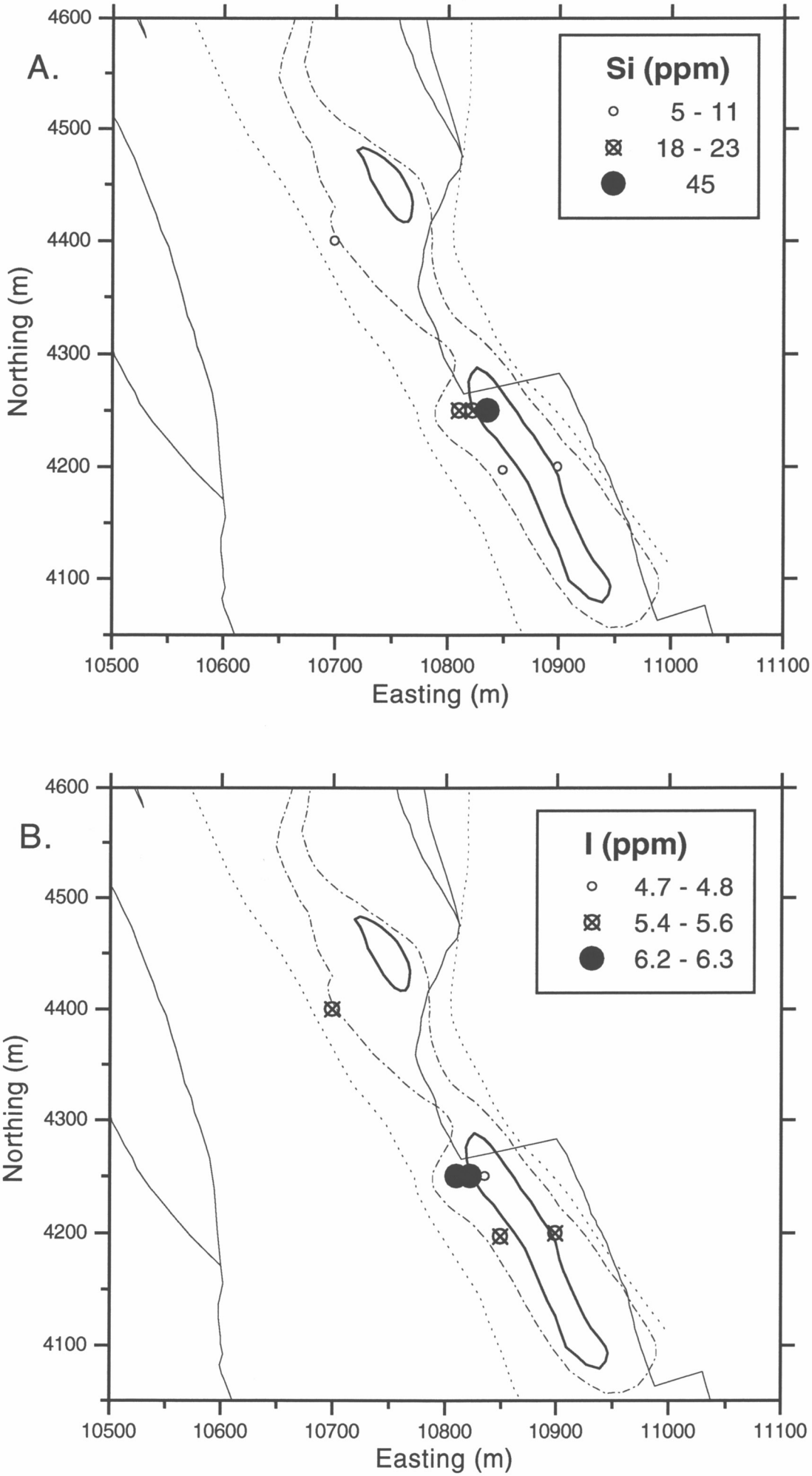


Figure A4.6: Variation in (A) Si and (B) I in groundwaters at Steinway.

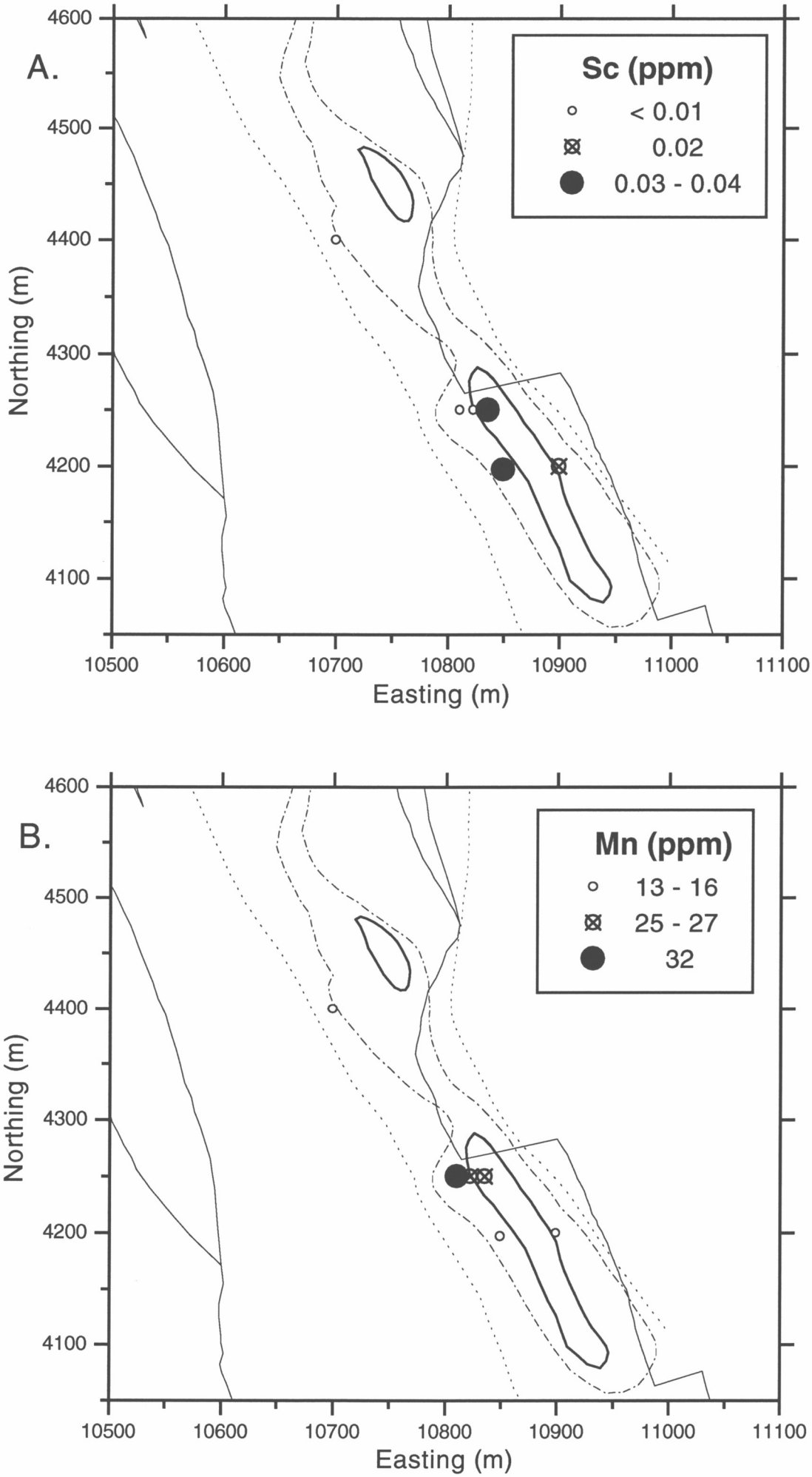
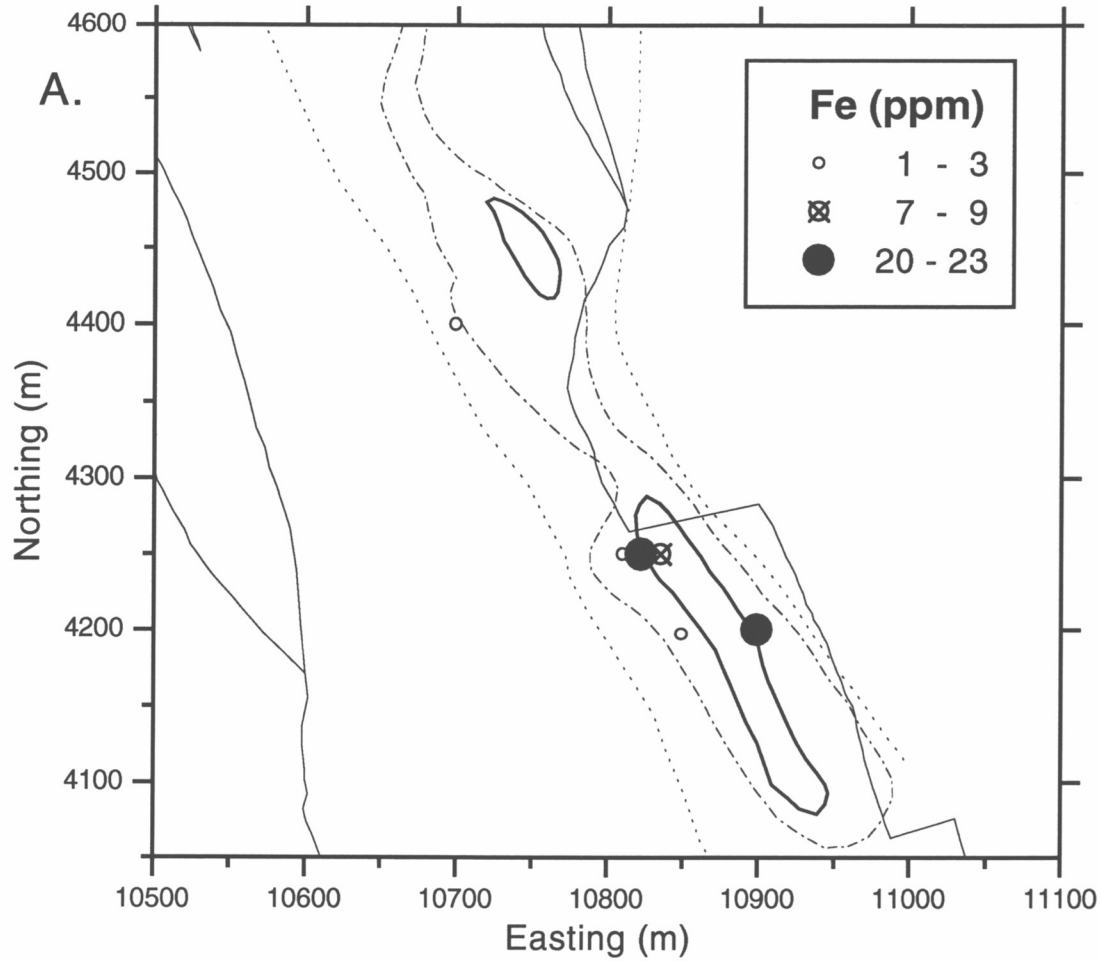


Figure A4.7: Variation in (A) Sc and (B) Mn in groundwaters at Steinway.



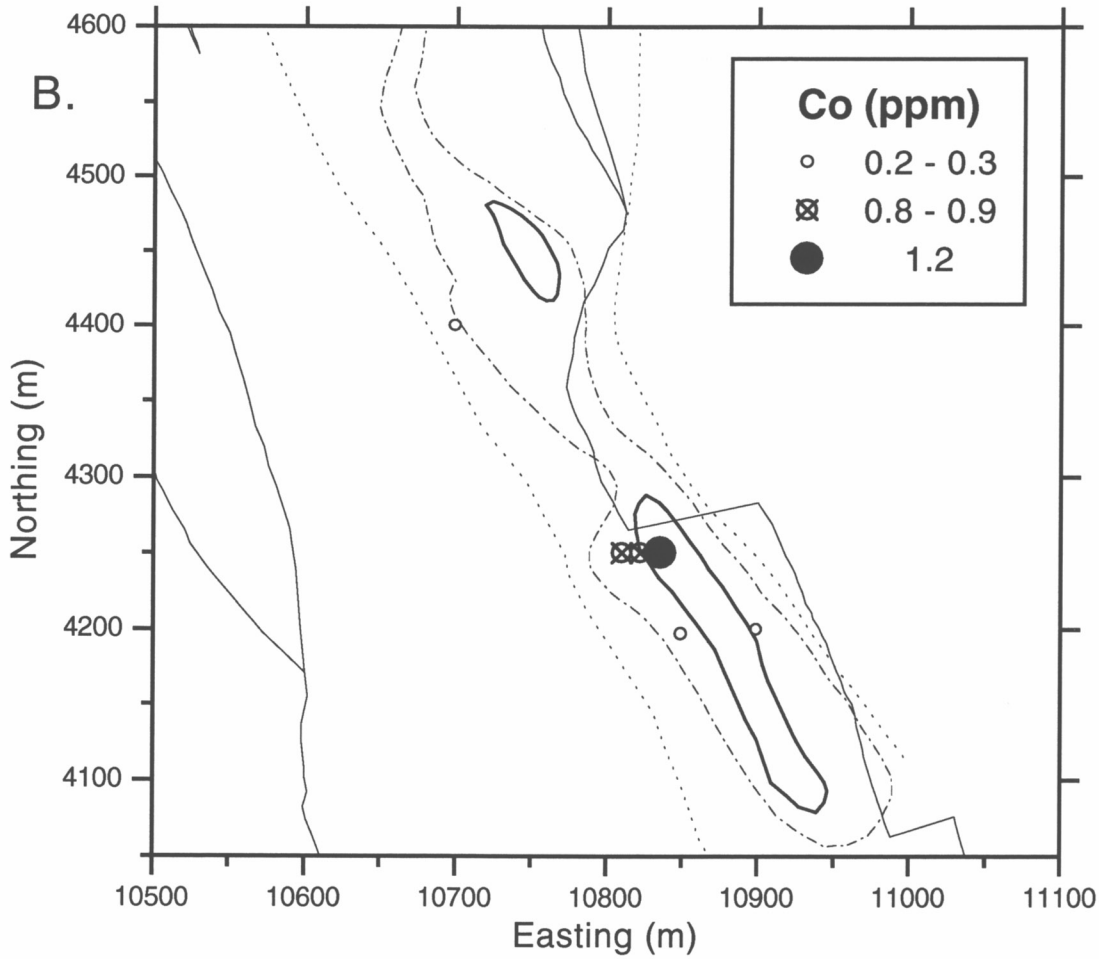
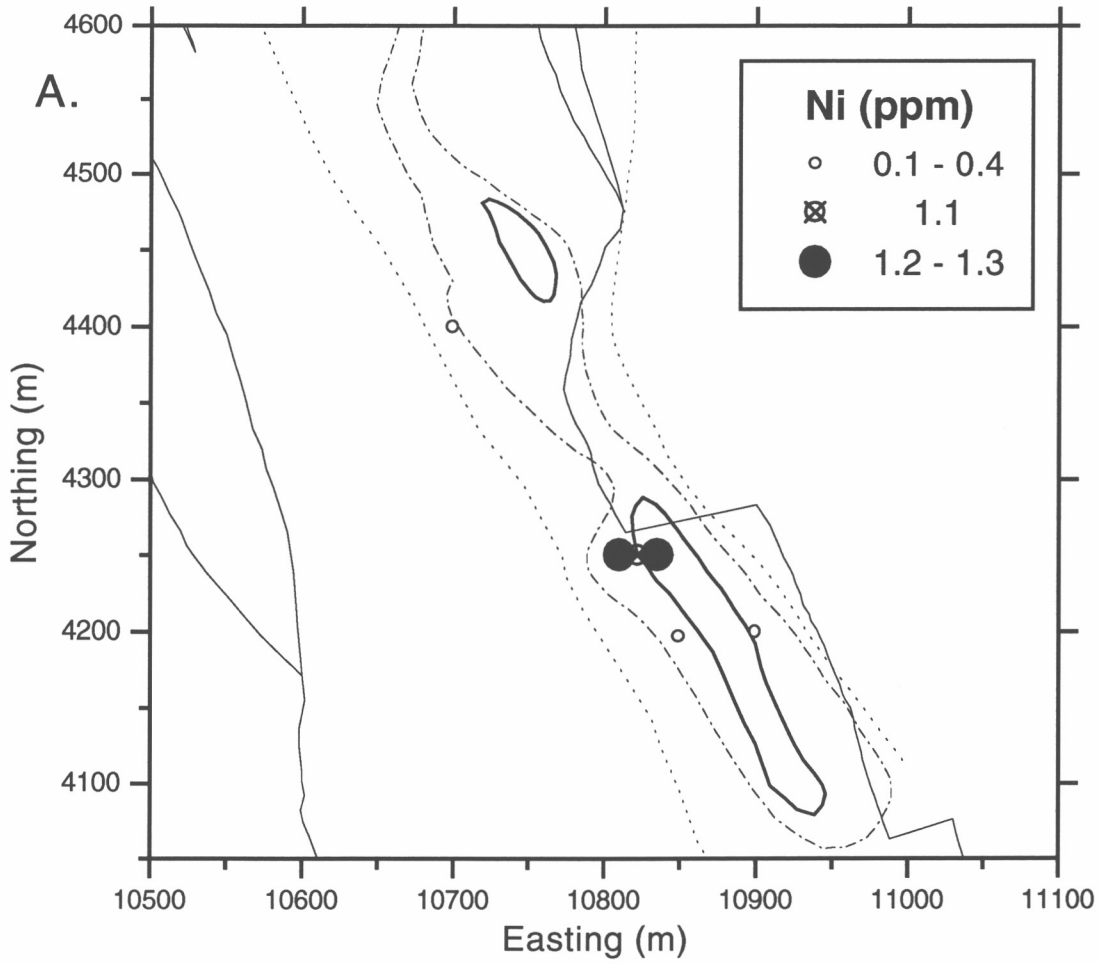


Figure A4.8: Variation in (A) Fe and (B) Co in groundwaters at Steinway.



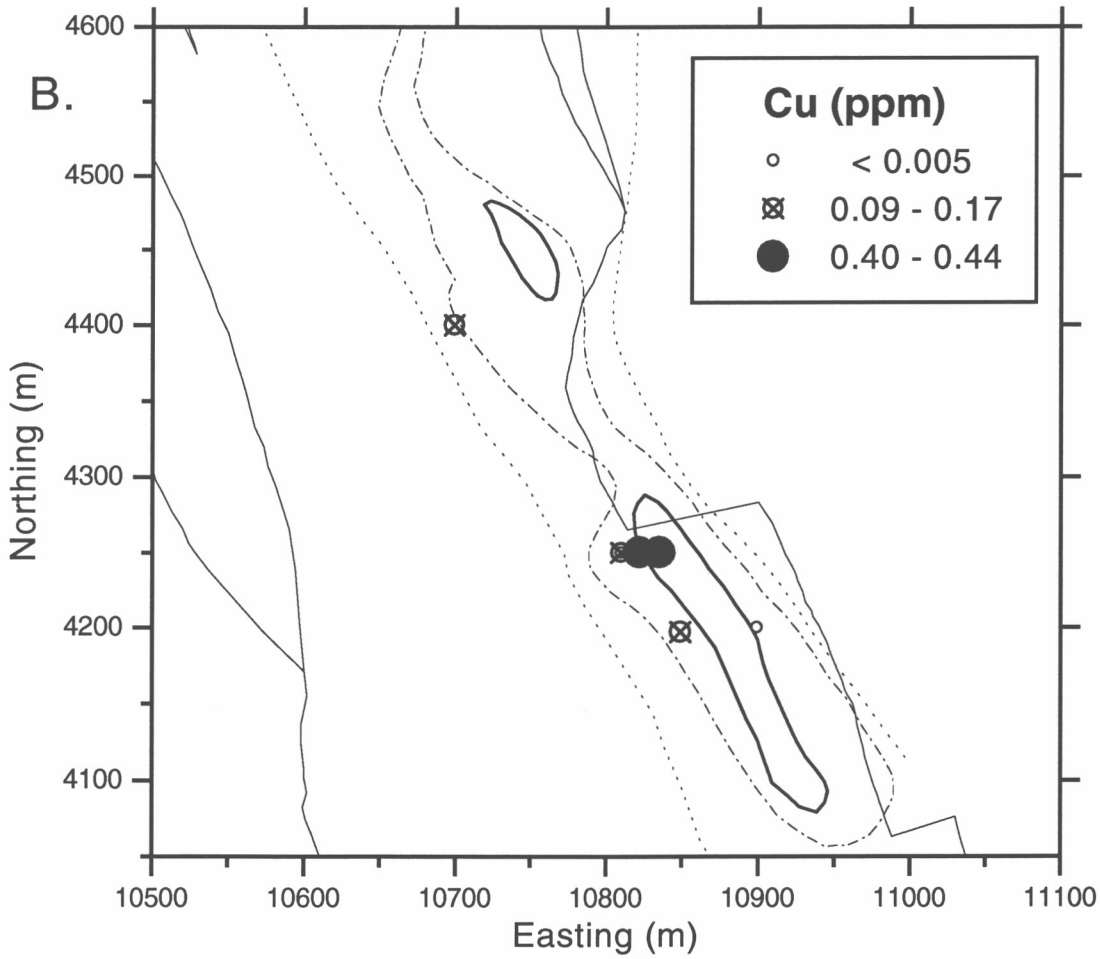
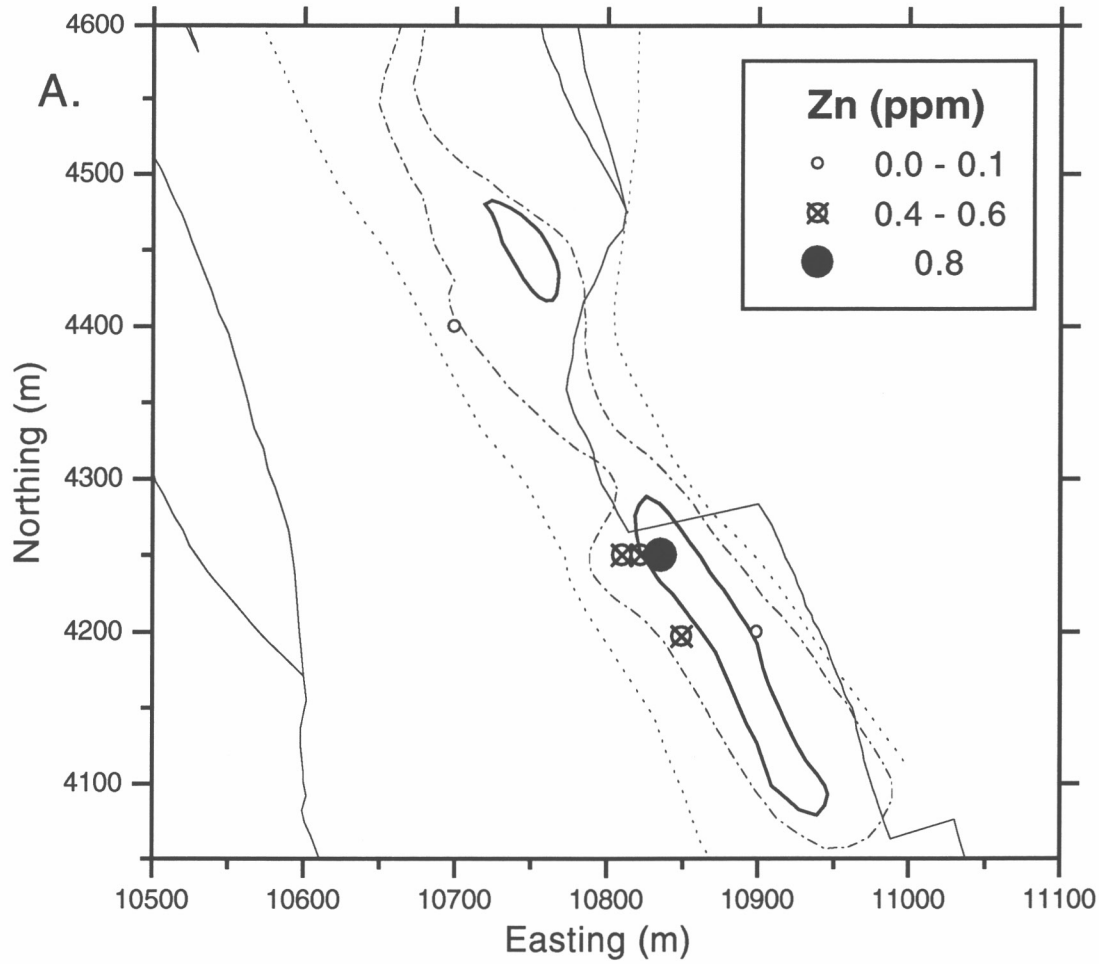


Figure A4.9: Variation in (A) Ni and (B) Cu in groundwaters at Steinway.



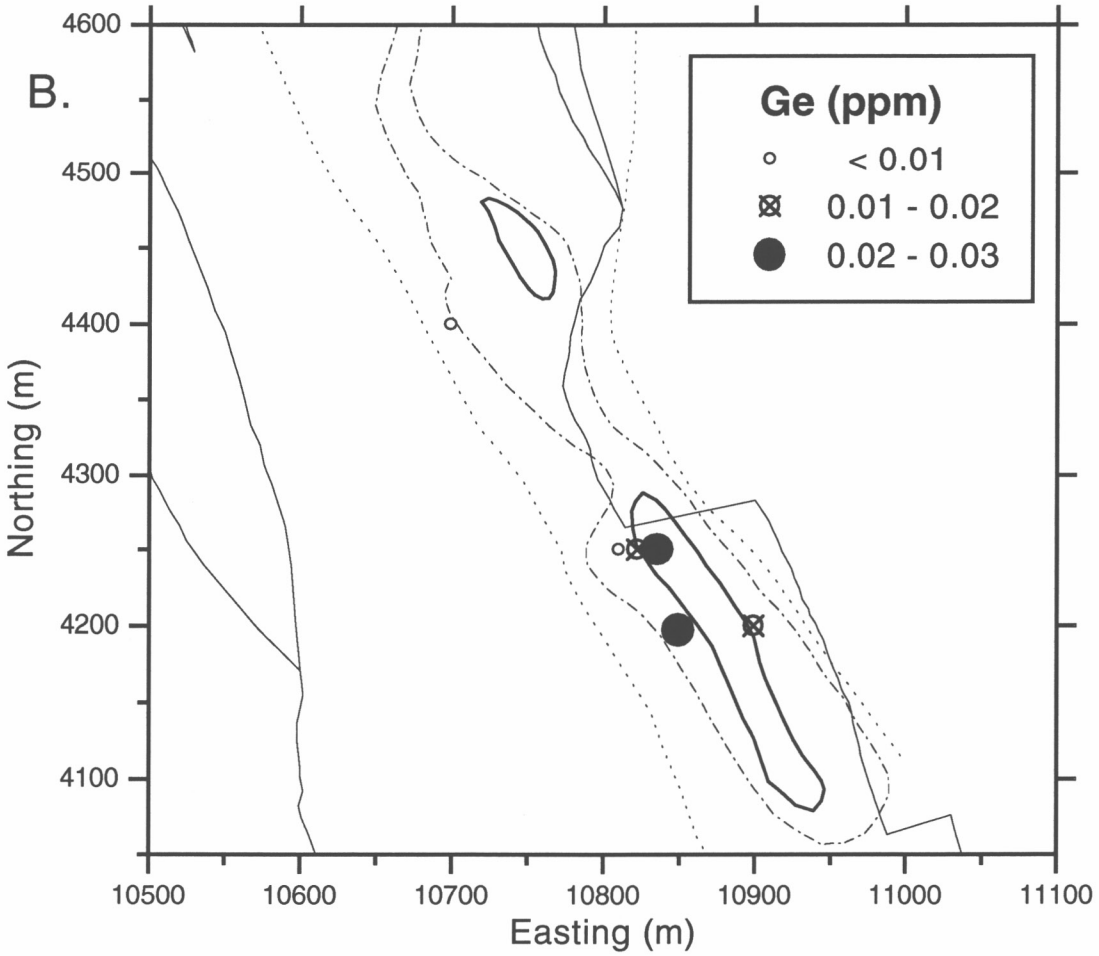
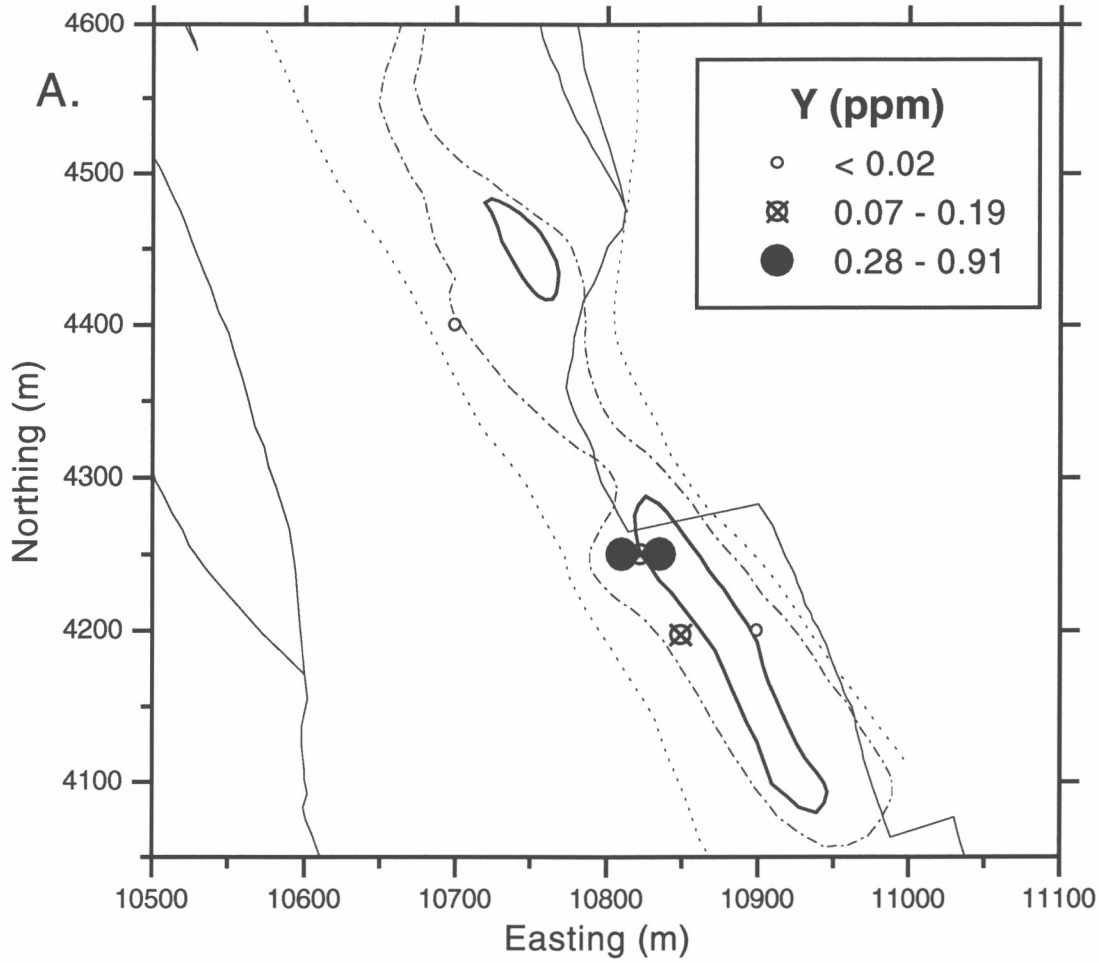


Figure A4.10: Variation in (A) Zn and (B) Ge in groundwaters at Steinway.



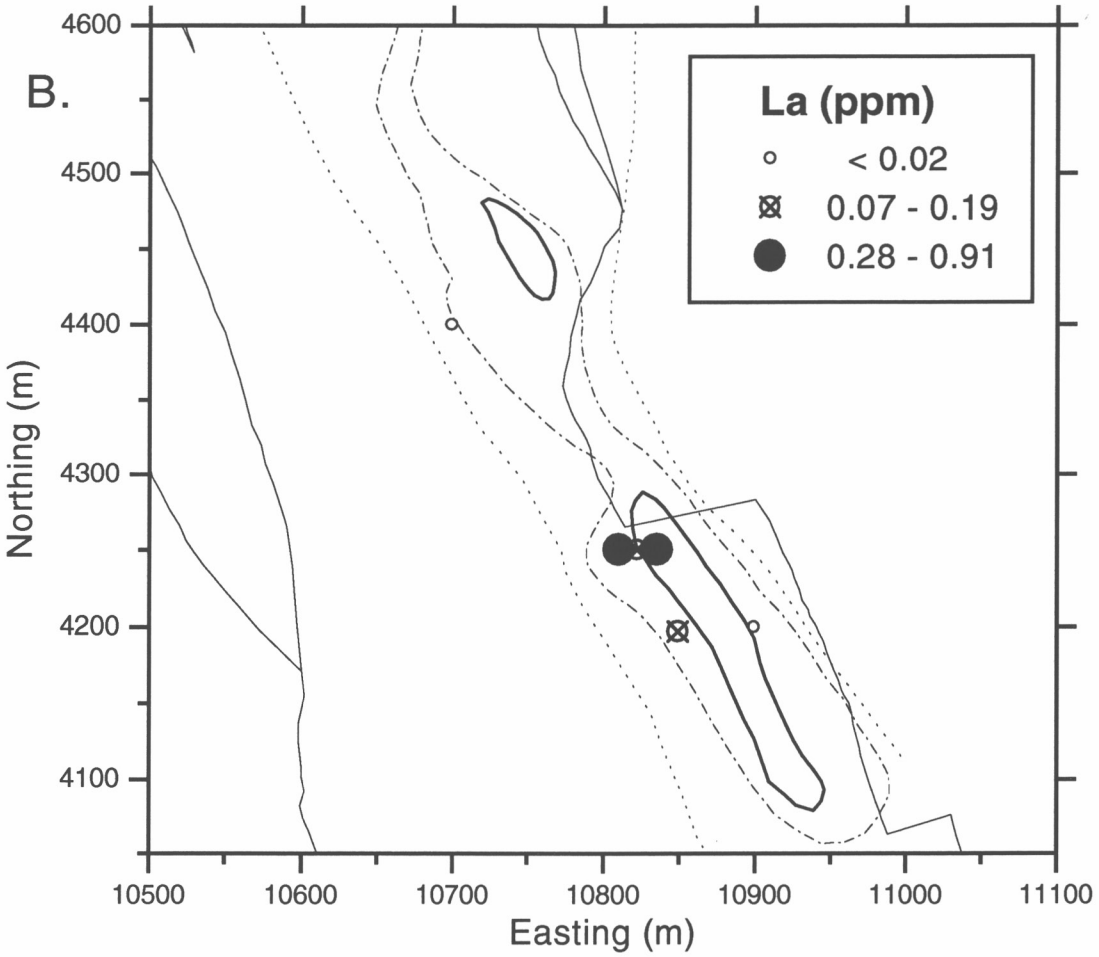
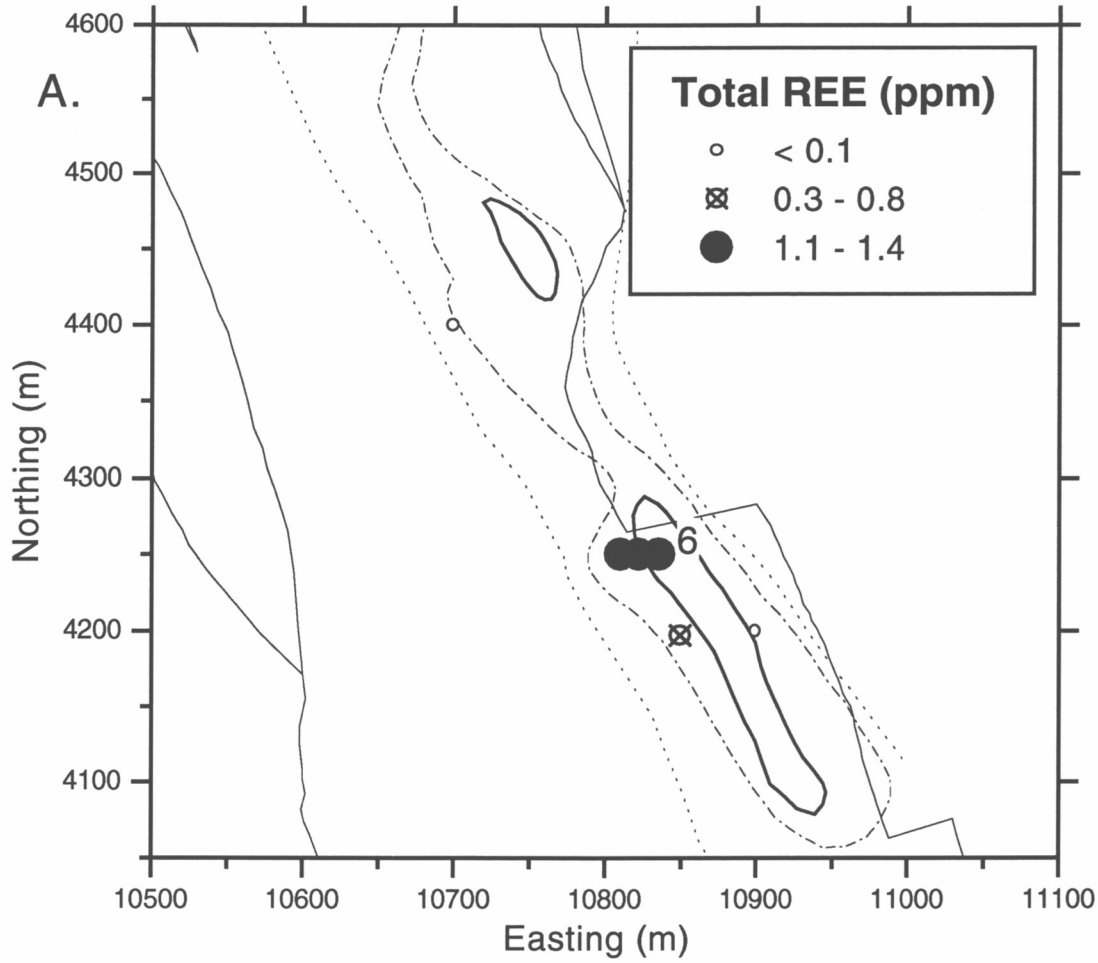


Figure A4.11: Variation in (A) Y and (B) La in groundwaters at Steinway.



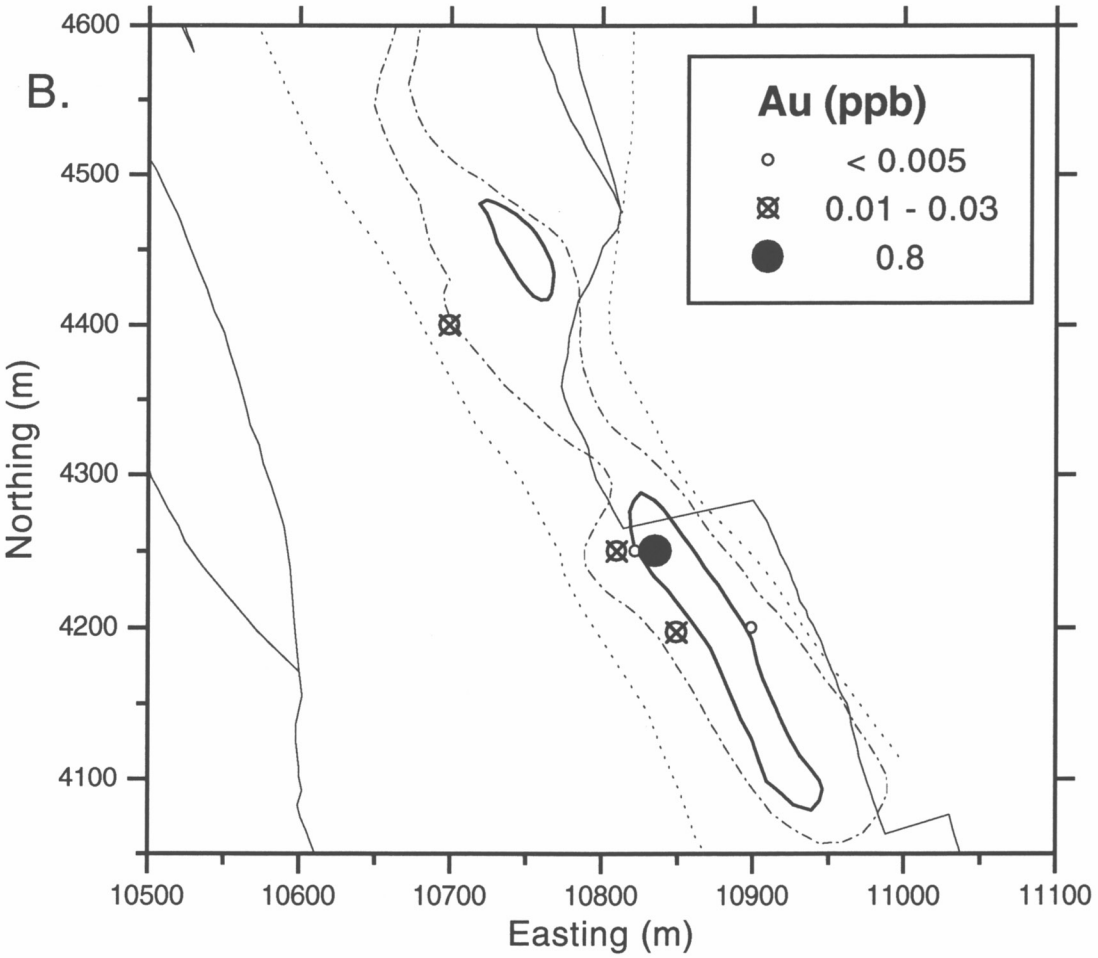
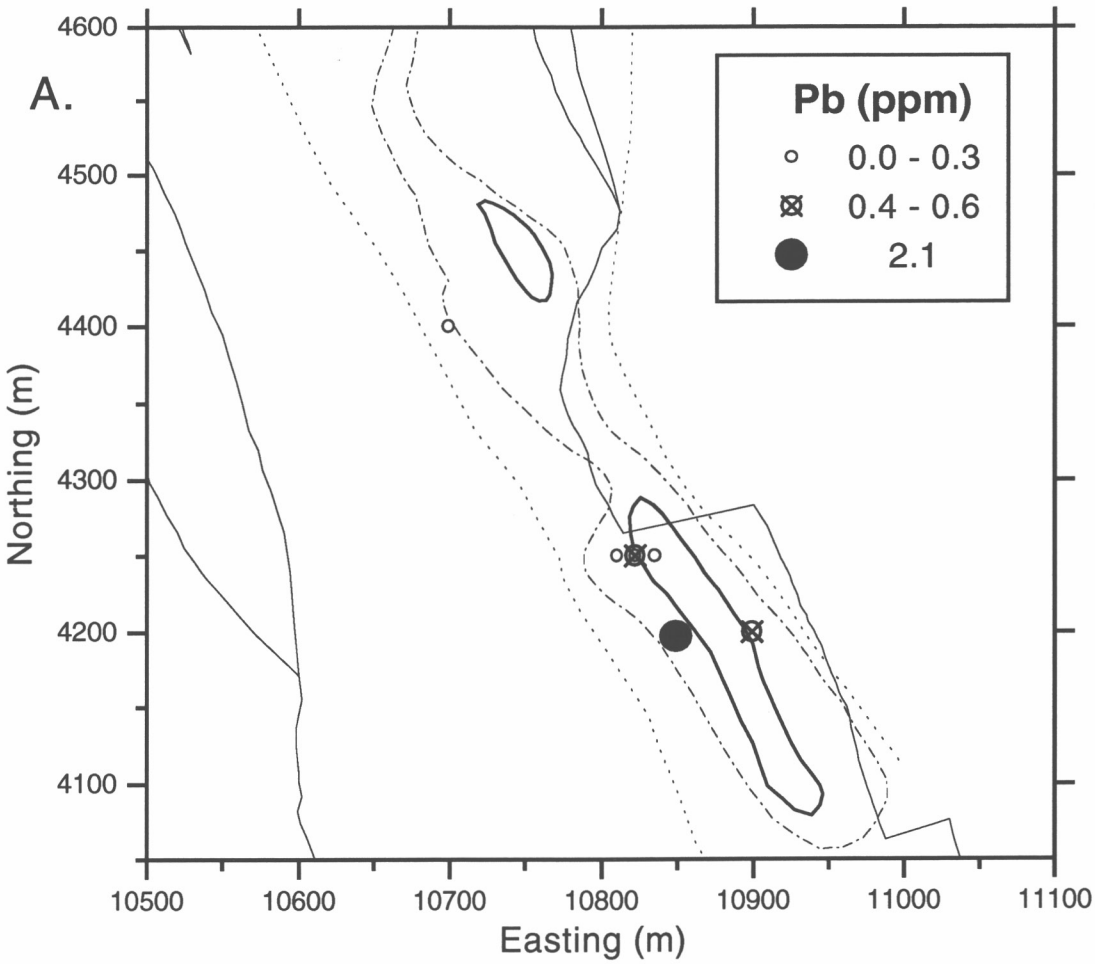


Figure A4.12: Variation in (A) Total REE and (B) Au in groundwaters at Steinway.



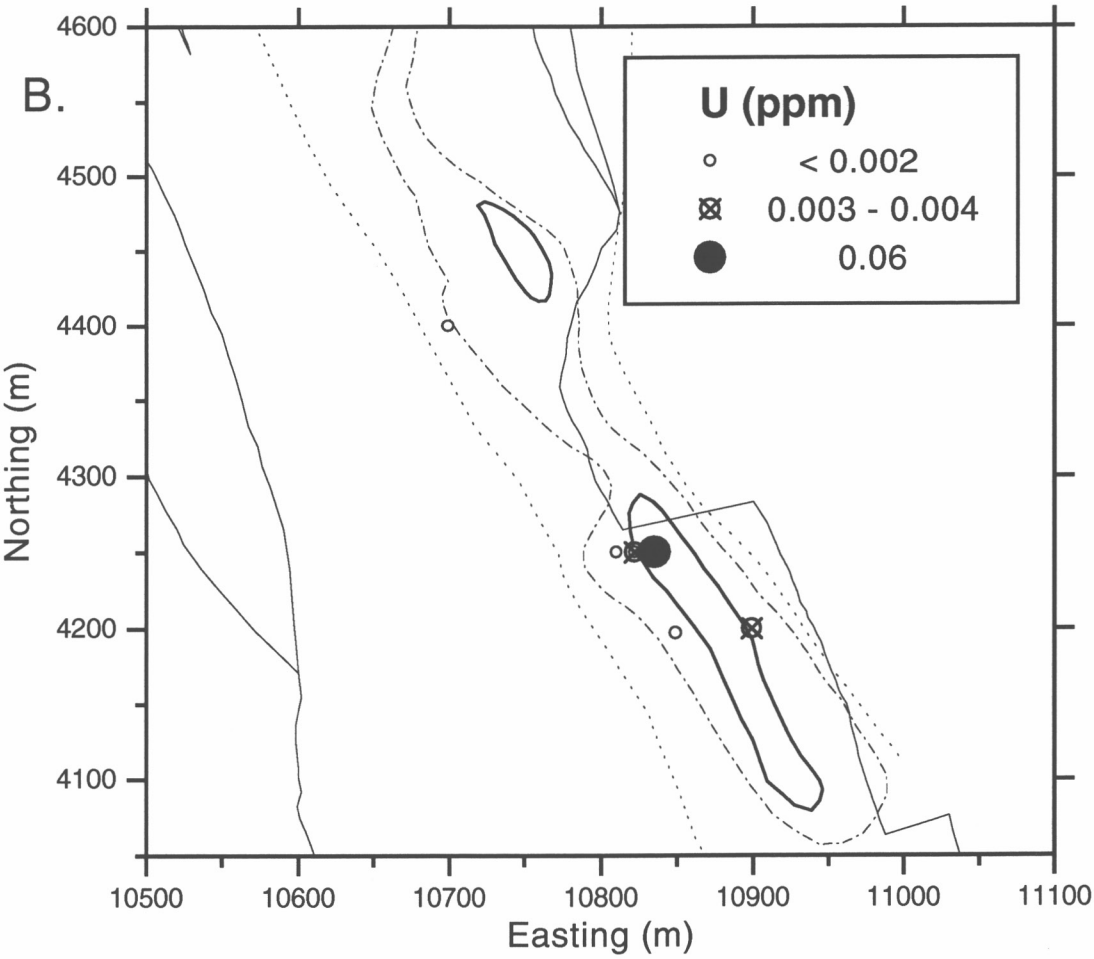


Figure A4.13: Variation in (A) Pb and (B) U in groundwaters at Steinway.

Appendix 5: Topsoil (0 - 0.1 m) sampling results - graphed

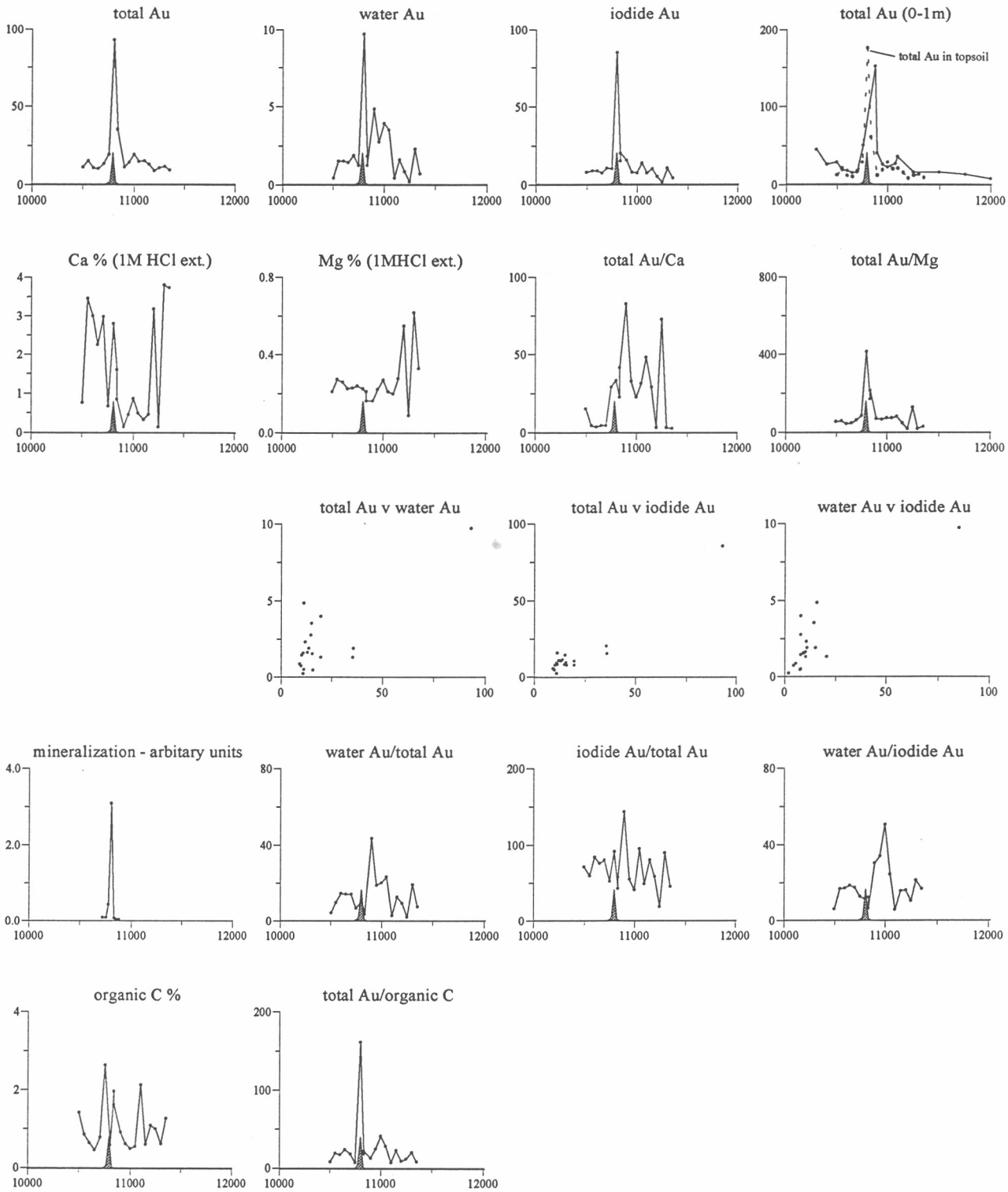


Figure A5: Elemental abundances for topsoil (0 - 0.1 m) from 4250N at Steinway.
All values in ppb unless otherwise stated.
Hatched area indicates position of mineralization.
For scatter plots, first element in header is the X axis, otherwise X is Easting.

Appendix 6: Profile sampling results - graphed

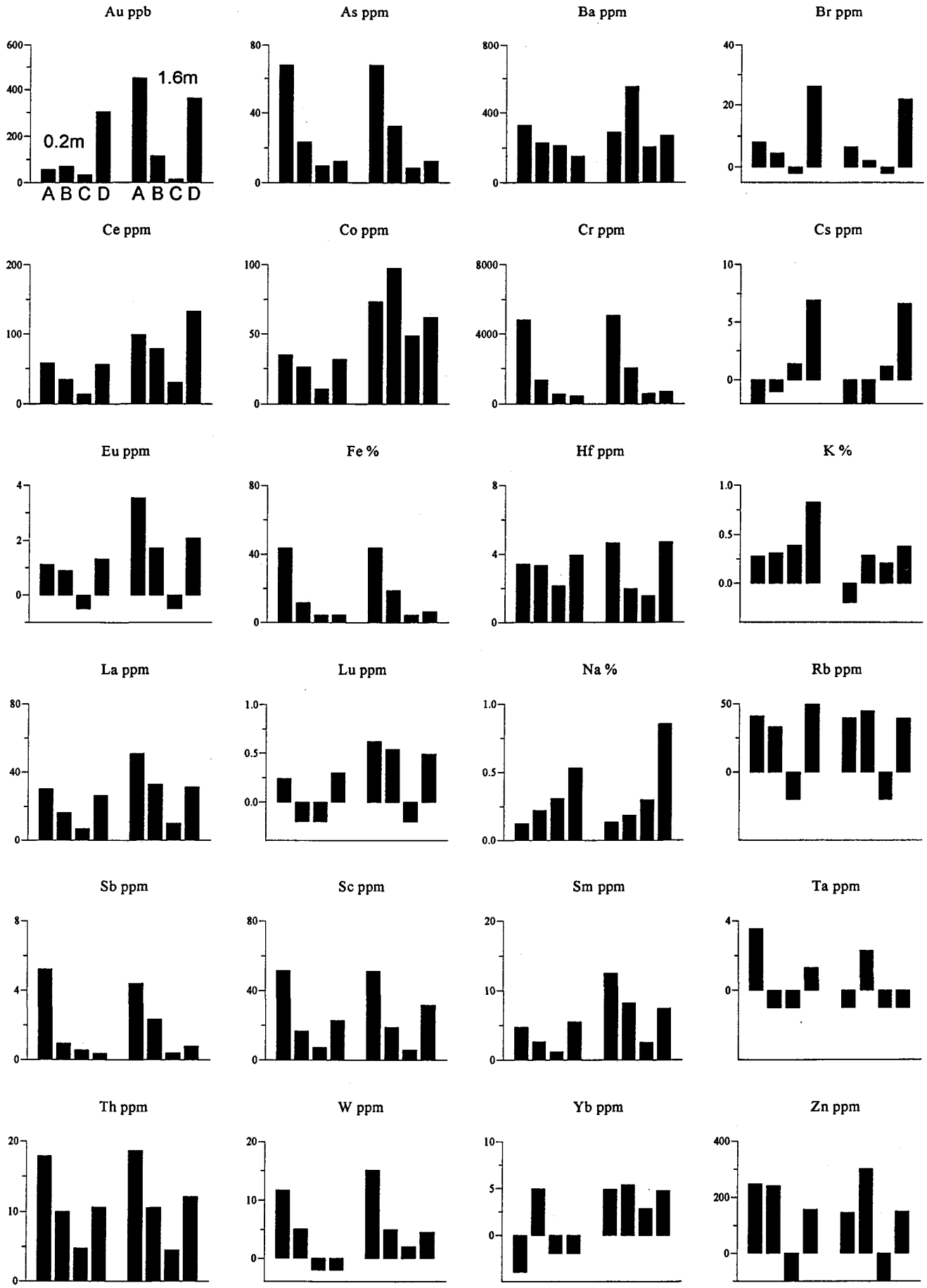


Figure A6.1: Elemental abundancies for four size fractions from two soil samples from the soil profile (10810E 4250N) at Steinway. For all samples, Ir (20 ppb), Mo (5 ppm), Se (5 ppm) and Ag (5 ppm) were below the limits of detection indicated in brackets. Negative data are below detection.
A = +710μm (8.4% and 10.6% of total wt of 0.2m and 1.6m samples respectively);
B = 710-250μm (5.6%, 4.2%); C = 250-53μm (26.6%, 27.2%); D = -53μm (59.4%, 63.0%).

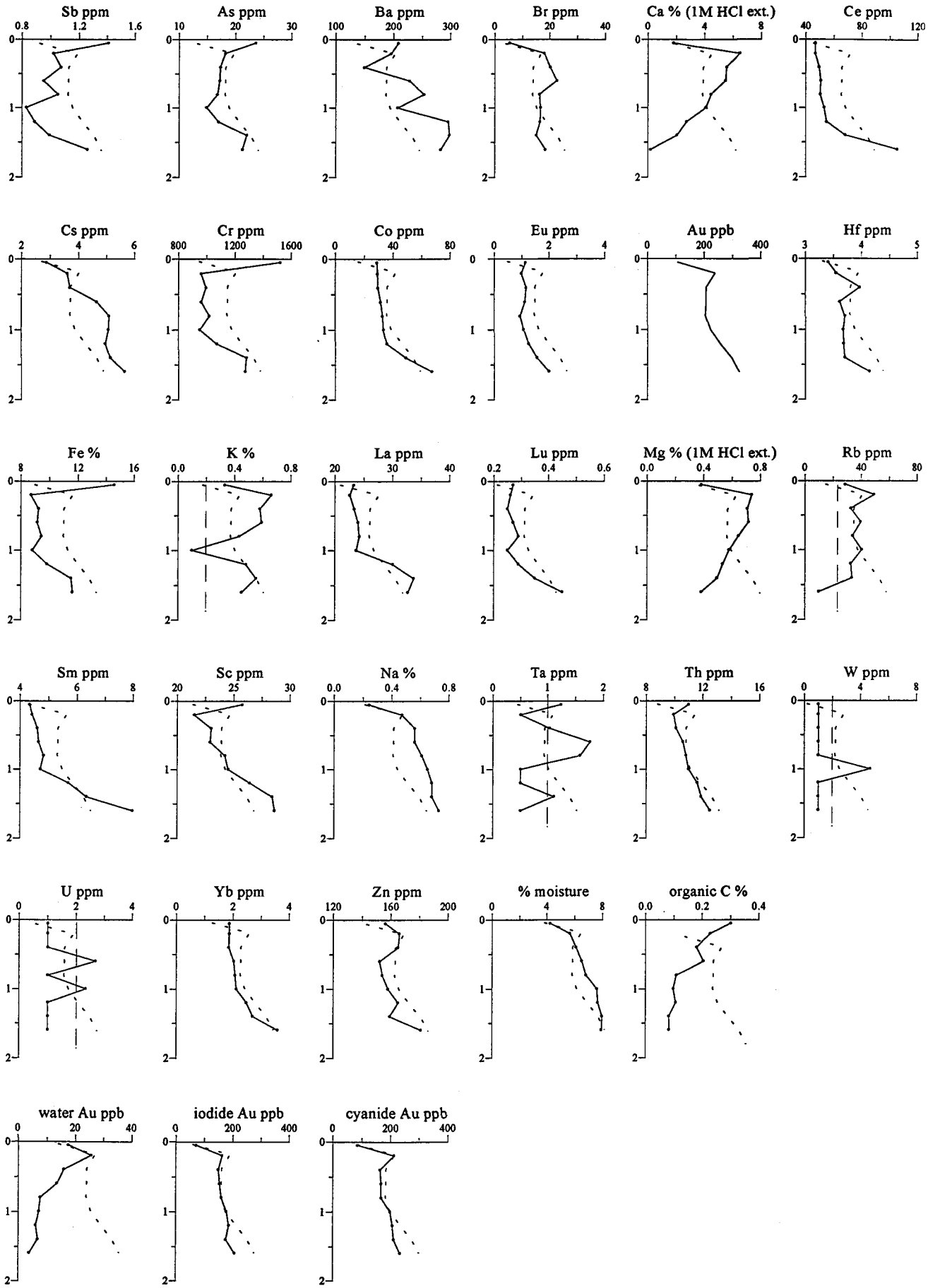


Figure A6.2: Elemental abundances for soil profile samples (10810E 4250N) at Steinway.
For all samples, Mo (5 ppm), Se (5 ppm), Ir (20 ppb) and Ag (5 ppm) were below detection limits (in brackets).
Broken straight line indicates detection limit. Y axis is depth (m).
Dotted line is the plot of Au superimposed (not to scale).

Appendix 7: 0 - 1 m results - graphed

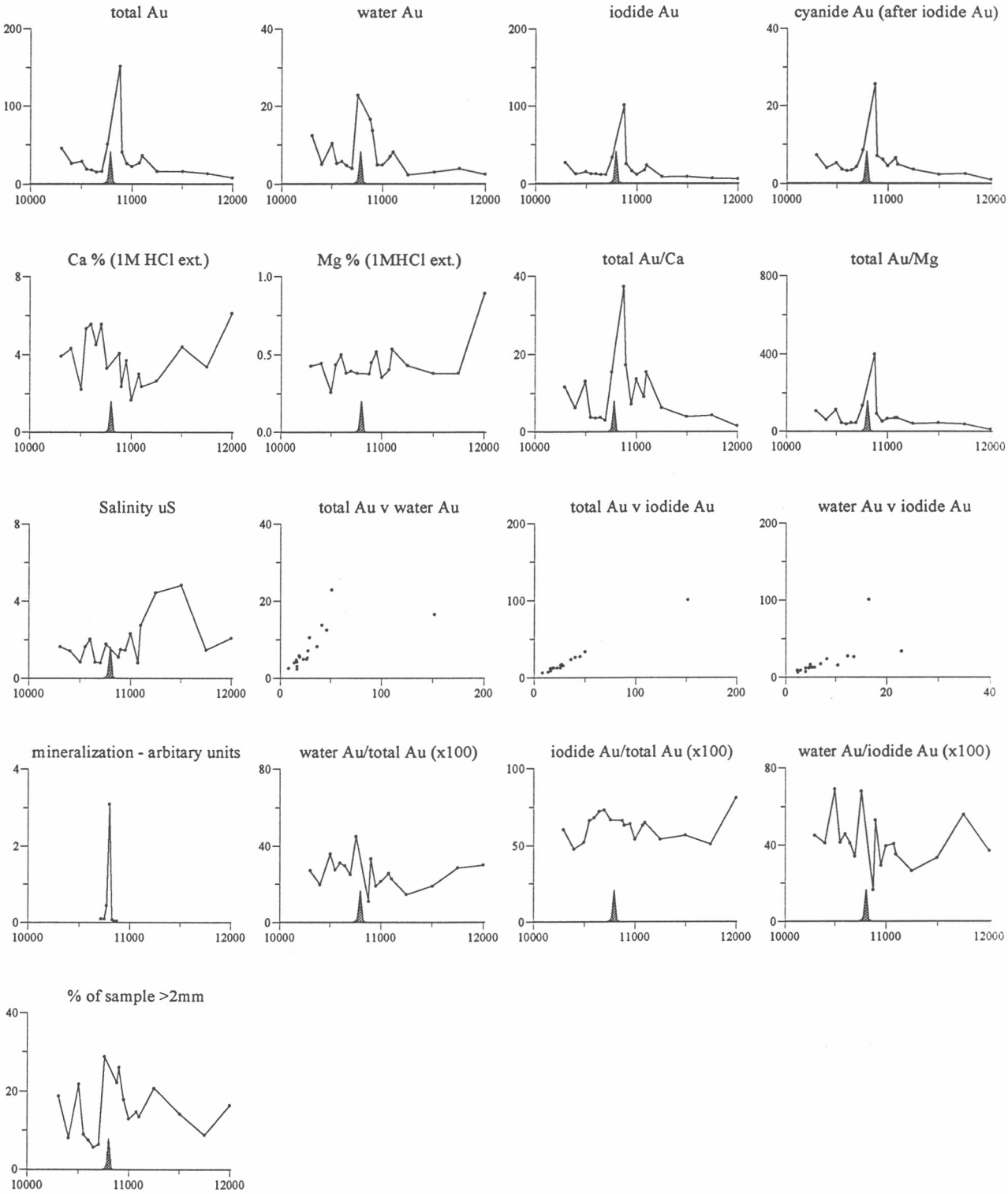


Figure A7.1: Elemental abundances and scatter plots for 0 - 1 m samples from 4250N at Steinway.
All values in ppb unless otherwise stated.
For scatter plots, first element in header is the X axis, otherwise X axis is Easting (m).
Hatched area indicates mineralization.

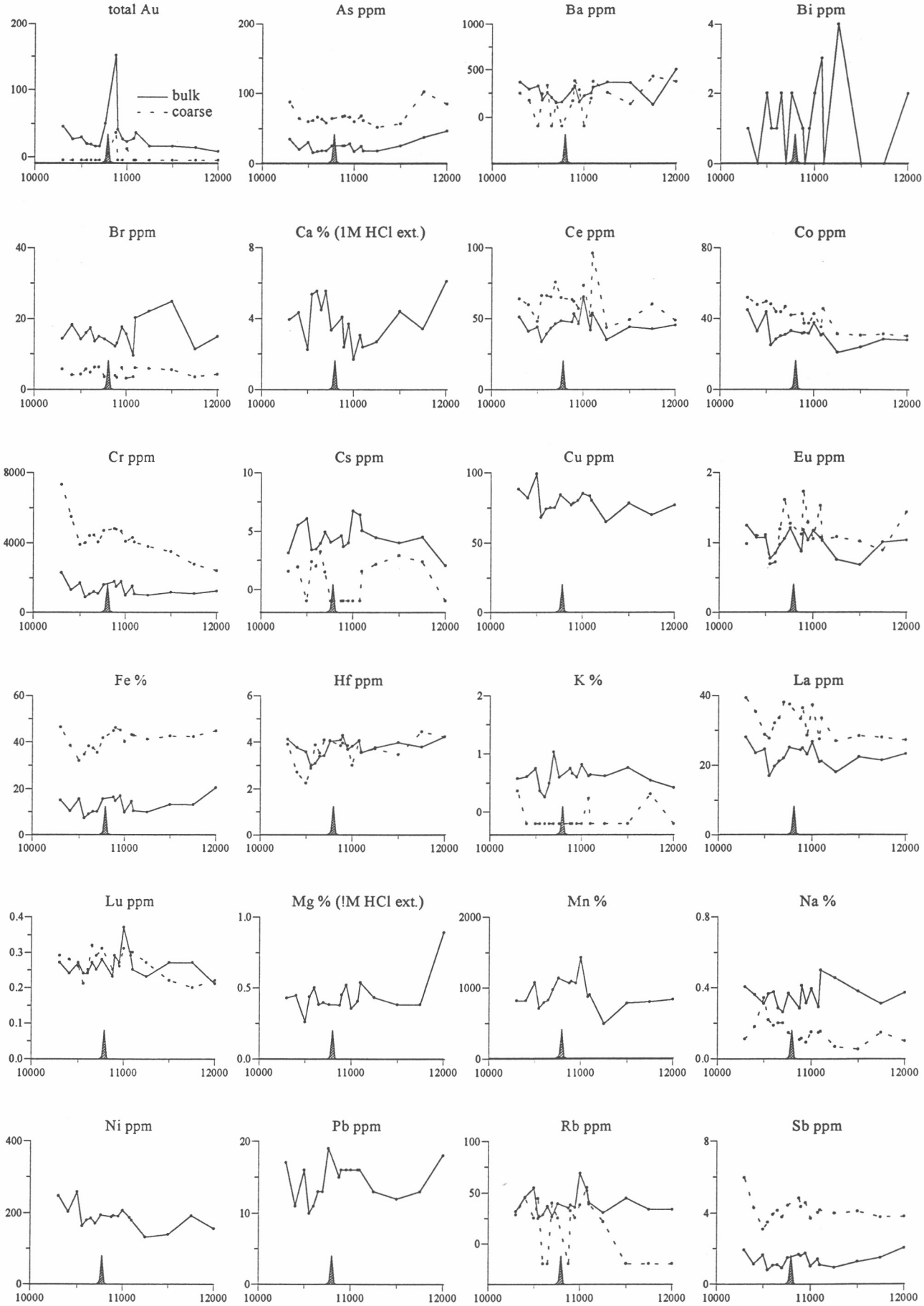


Figure A7.2: Elemental abundances for 0 - 1 m samples for 4250N at Steinway.
Bulk samples in continuous line; coarse fraction (2 - 4 mm) for selected elements in dotted line. X axis is Easting (m).
For all samples, Ag (5 ppm), Ir (20 ppb), Mo (5 ppm) and Se (5 ppm) were below detection indicated in brackets.
Negative data are below detection. Hatched area indicates mineralization.

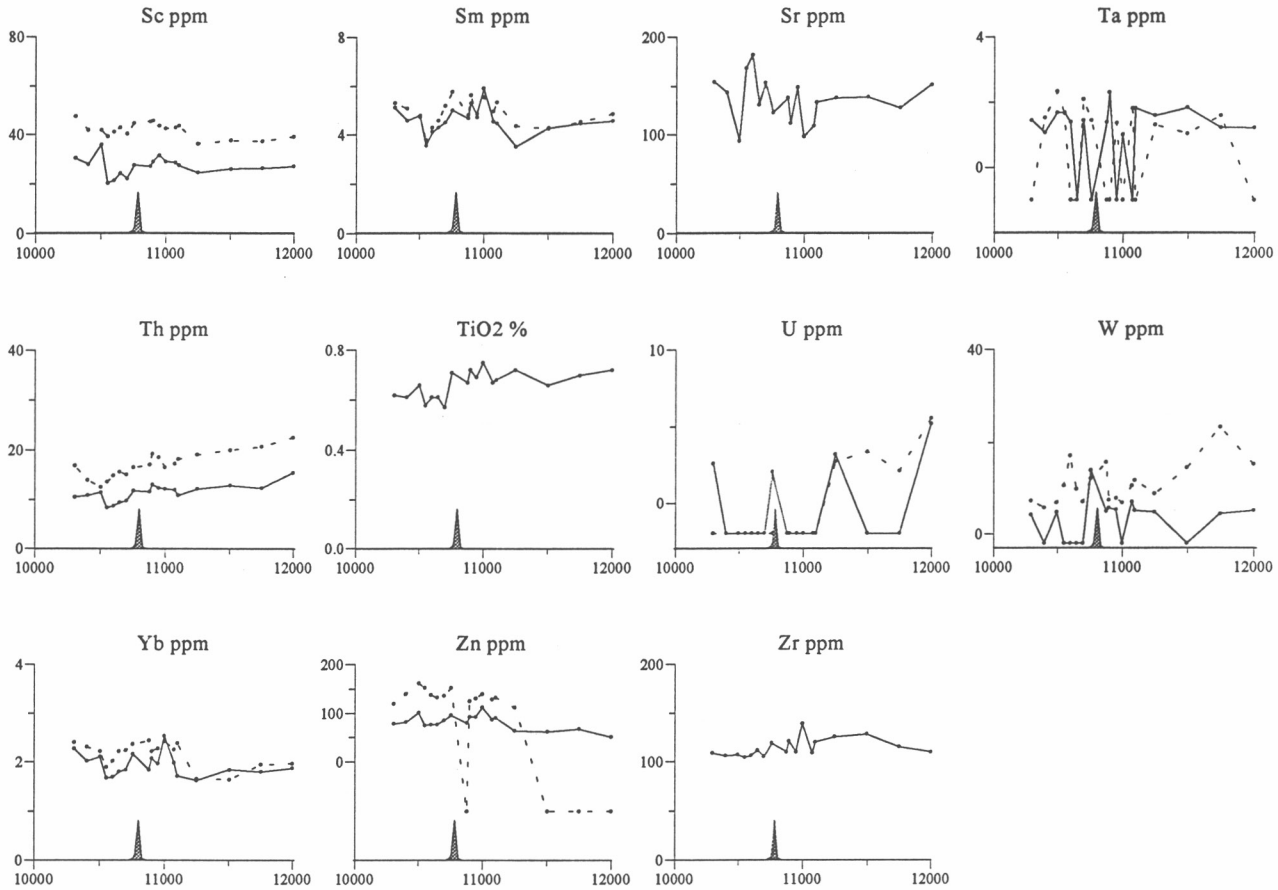


Figure A7.2 (continued).

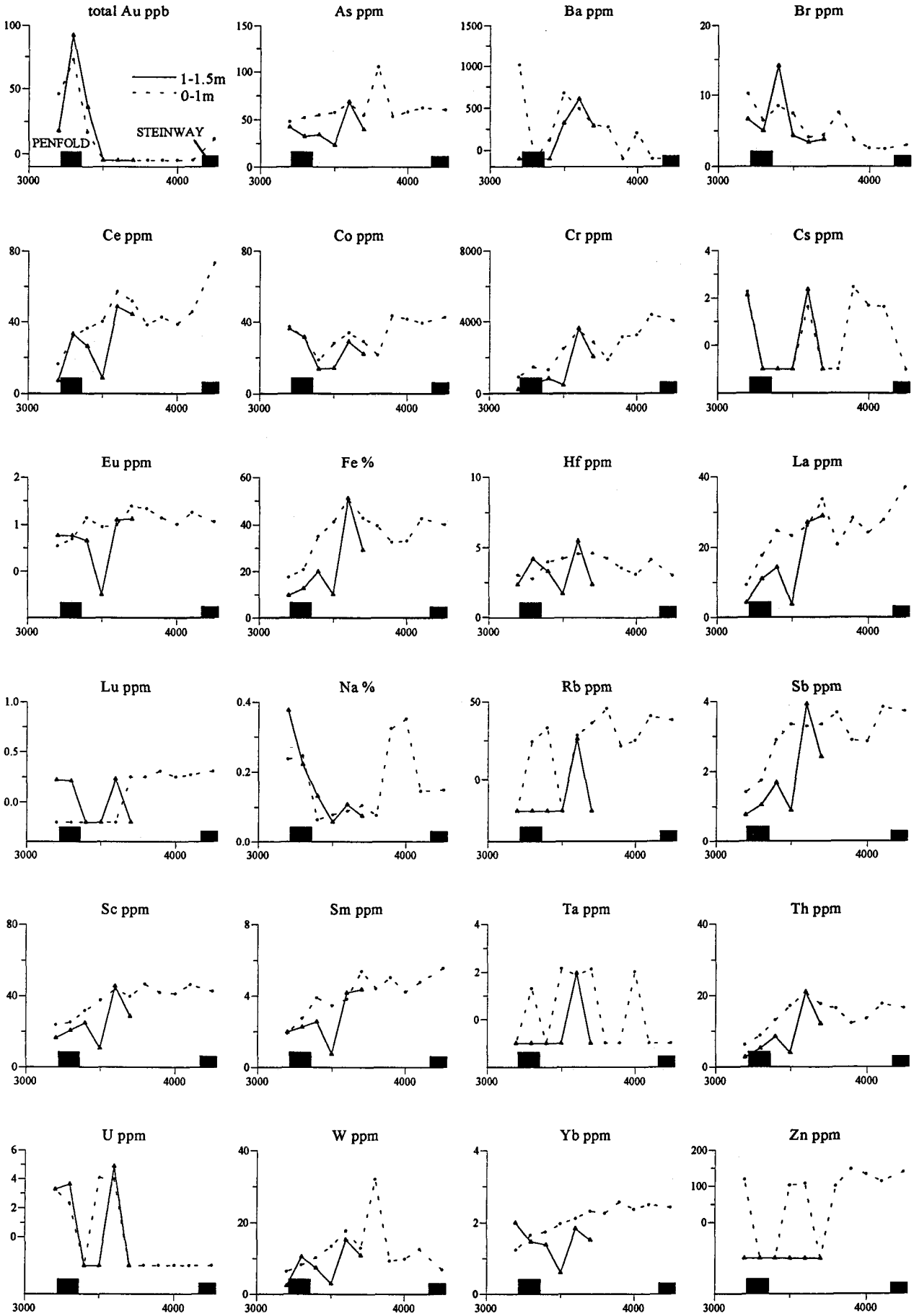


Figure A7.3: Elemental abundances for 0 - 1 m and 1 - 1.5 m coarse fractions (2 - 4mm) from Penfold - Steinway on 11000E.
X axis is Northing (m). Negative data below detection.
For all samples, Ag (5 ppm), Ir (20 ppb), K (0.2%, Mo (5 ppm) and Se (5 ppm) were below detection limits indicated in brackets.
Blocked area locates approximate position of mineralization at Penfold and Steinway.

Appendix 8: Ferruginous material separated from transported overburden - graphed

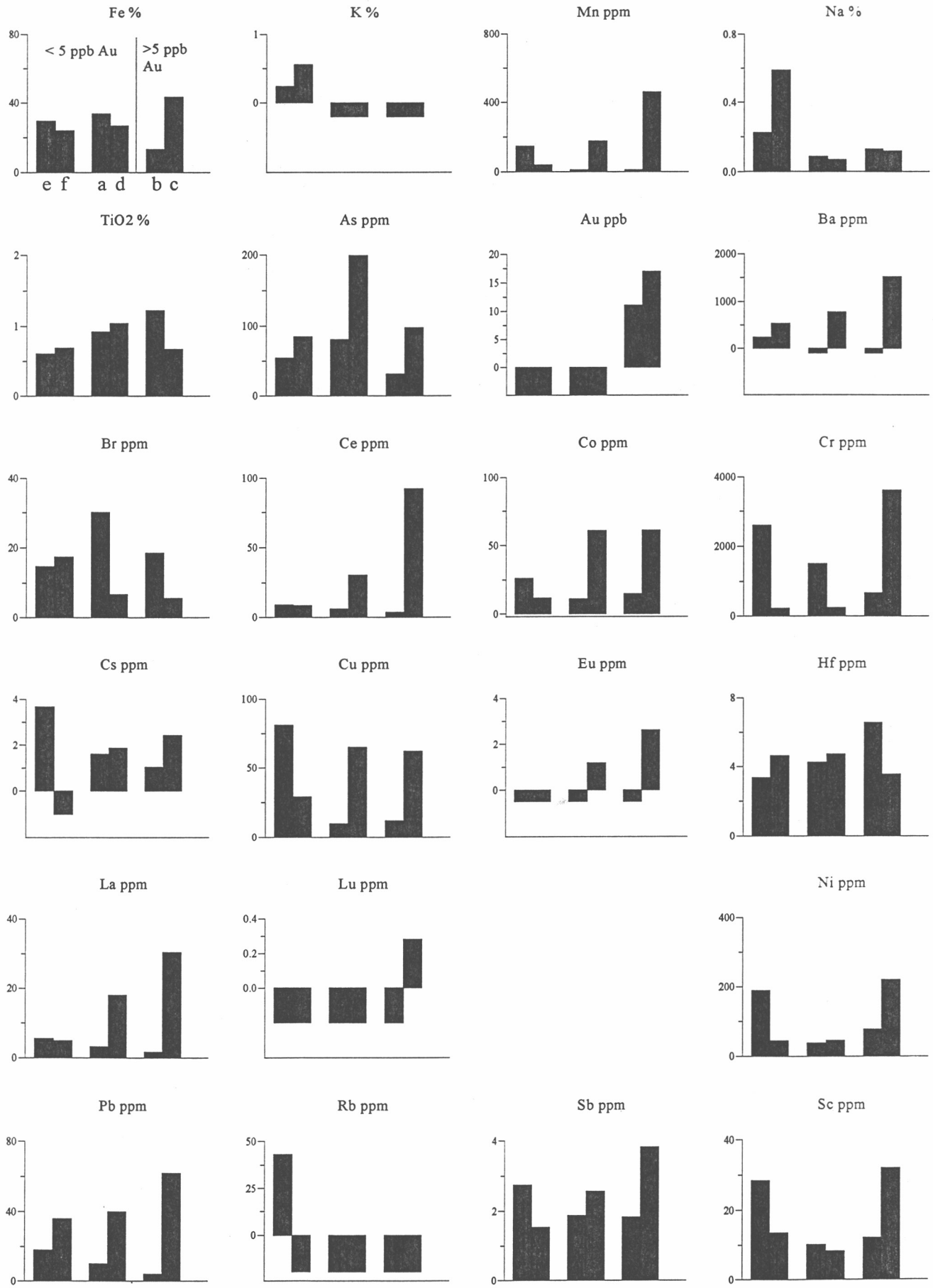


Figure A8: Elemental abundances for ferruginous material hand-picked from the bulk sample from the transported overburden overlying mineralization at Steinway.
Samples a, d, e and f: <5 ppb Au; samples b and c: >5 ppb Au. Negative data below detection. See Appendix 11 for locations.
For all samples, Ag (5 ppm), Bi (1 ppm), Ir (20 ppb), Mo (5 ppm), Se (5 ppm) and Ta (1 ppm) were at or below detection limits indicated in brackets.

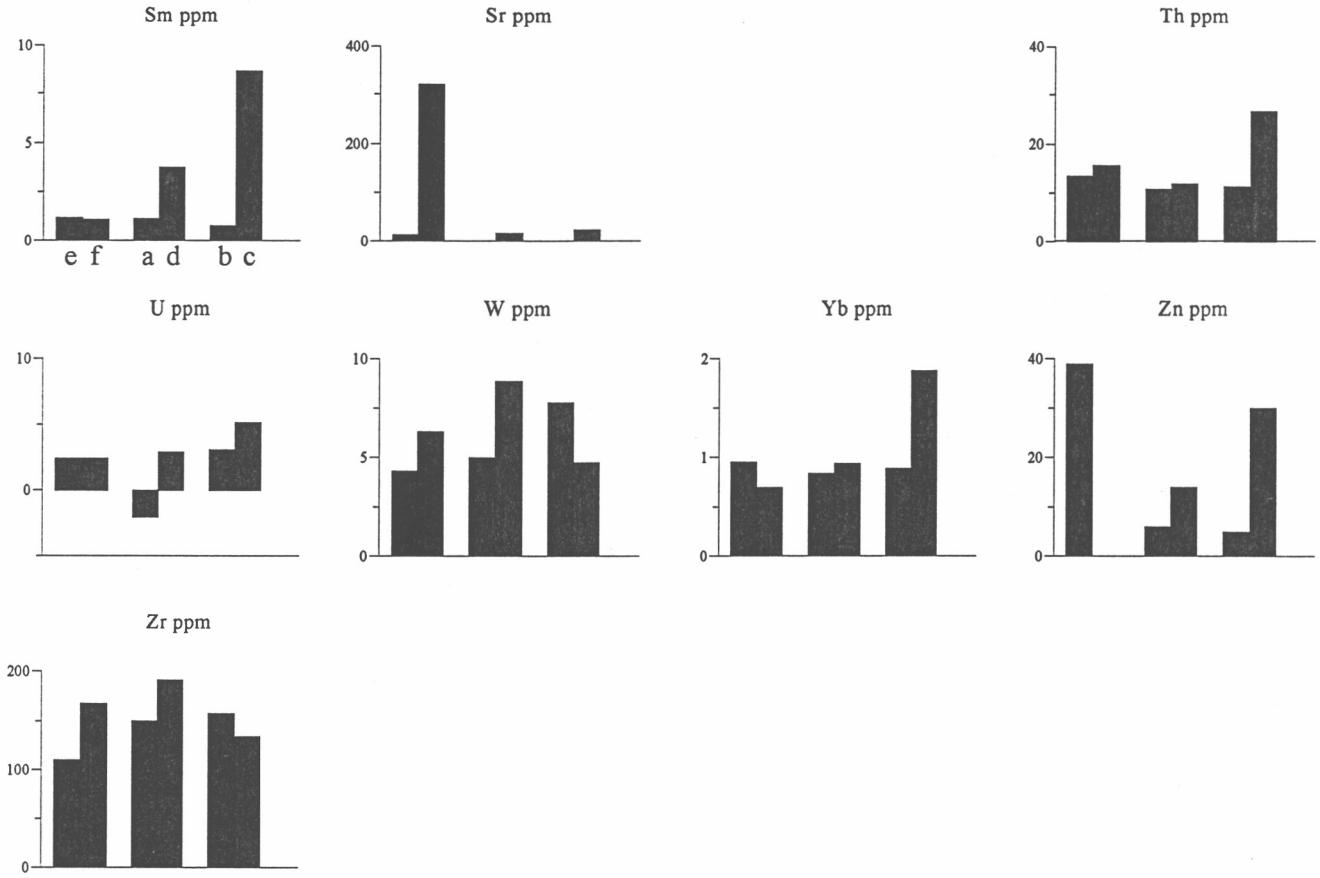


Figure A8 (continued).

Appendix 9: Saprolite and bedrock - graphed

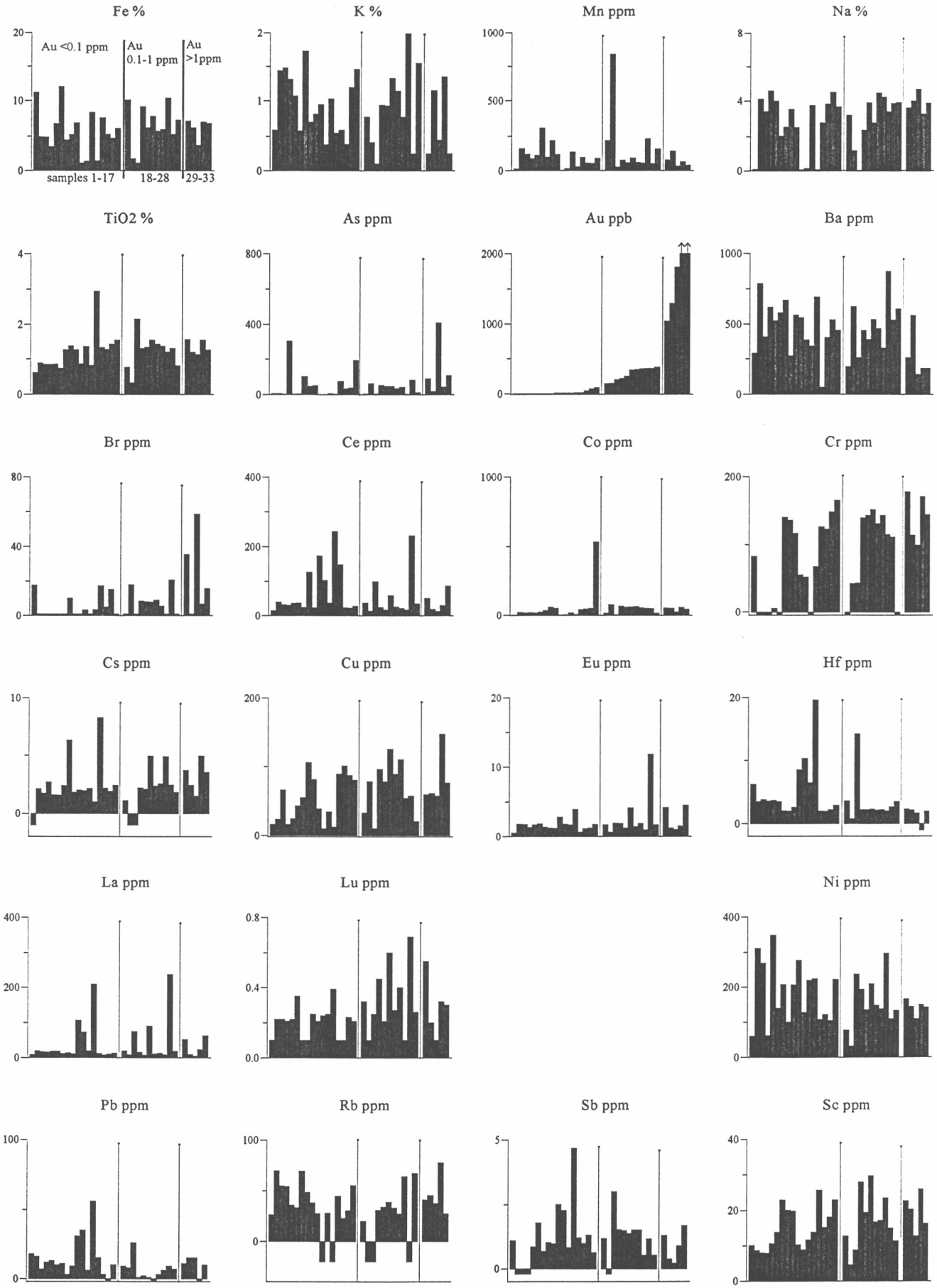


Figure A9.1: Elemental abundances for selected saprolite and bedrock samples from Steinway. Samples grouped into 3 according to Au content (<0.1 ppm, 0.1-1 ppm and >1 ppm). See Appendix 11 for sample locations. Negative data are below detection. For all samples, Ag (5 ppm), Bi (1 ppm), Ir (20 ppb), Mo (5 ppm), Se (5 ppm) and U (2 ppm) were at or below detection limits indicated in brackets.

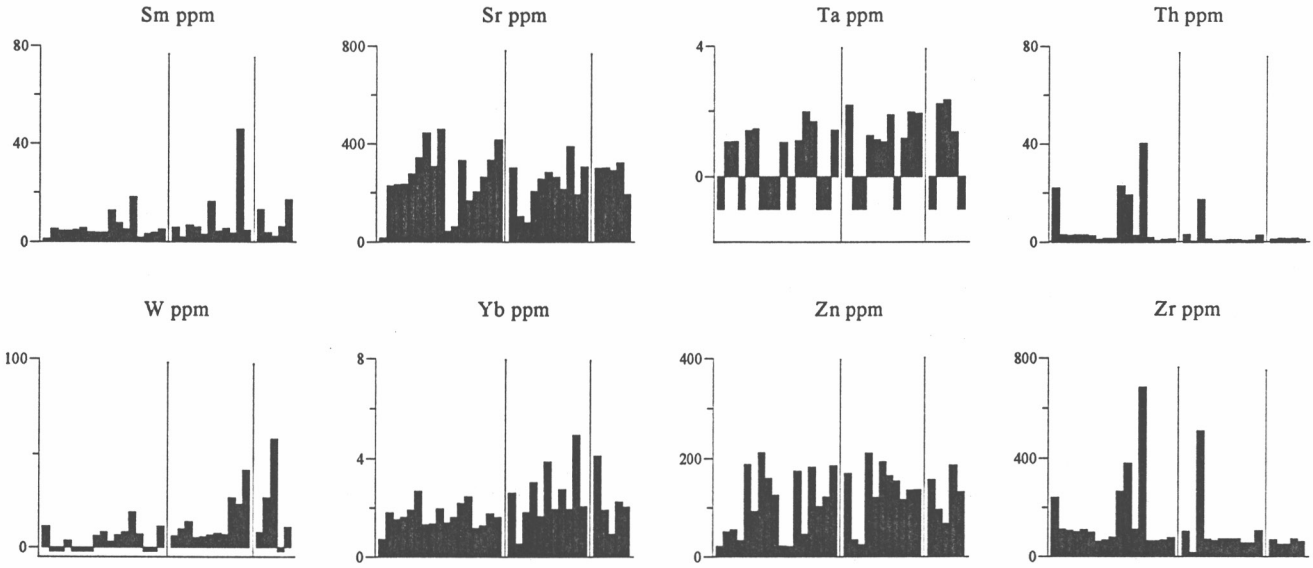


Figure A9.1 (continued).

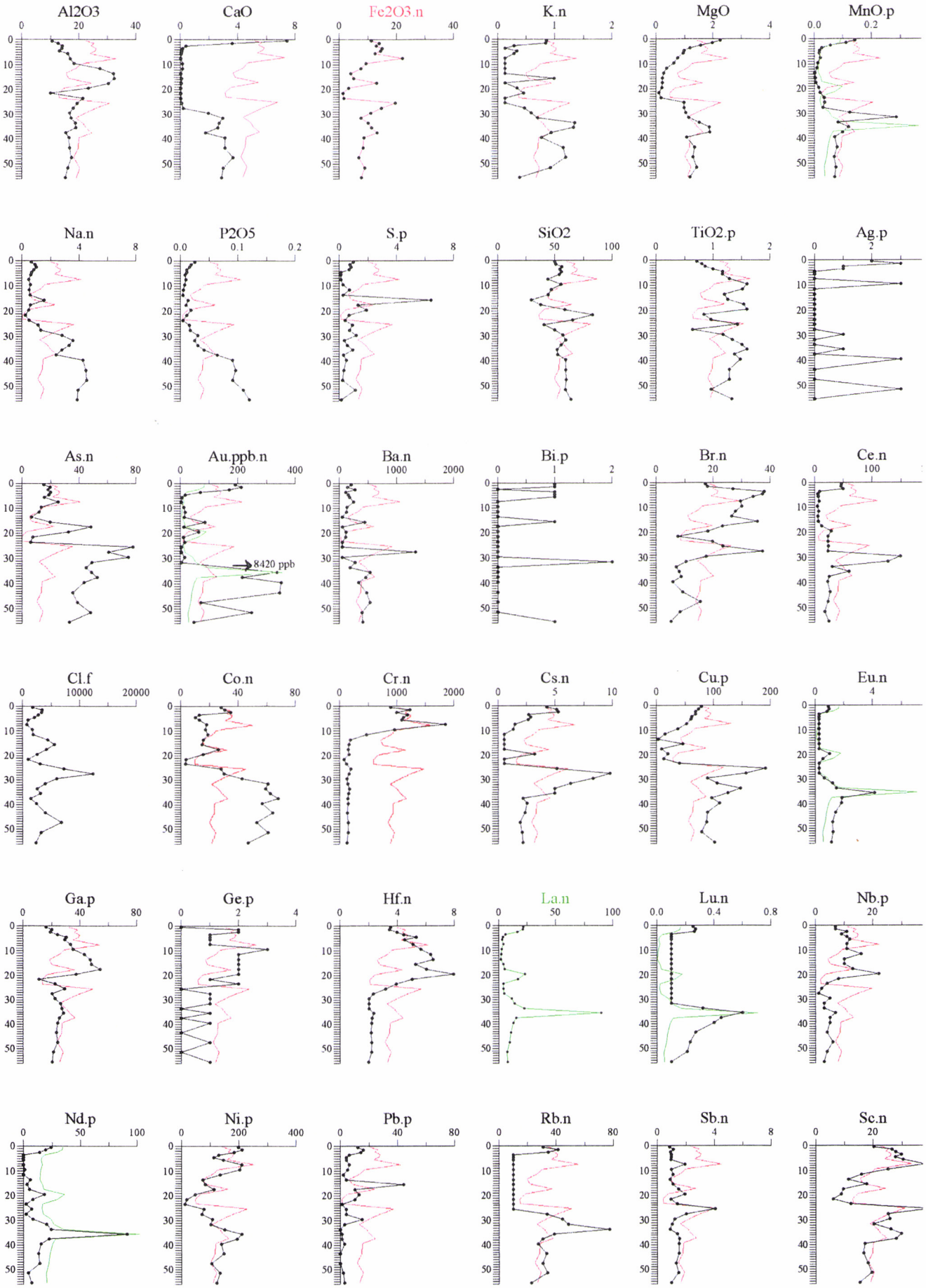


Figure A9.2: Elemental abundances for drill hole ST-1 (10808E 4250N) at Steinway
Red line indicates Fe abundance - not to scale; green line indicates La abundance - not to scale. Y axis is Depth (m).
Analyses by INAA(n), XRF fusion(f) and XRF pressed powders(p). Majors in %, trace elements in ppm unless otherwise stated.

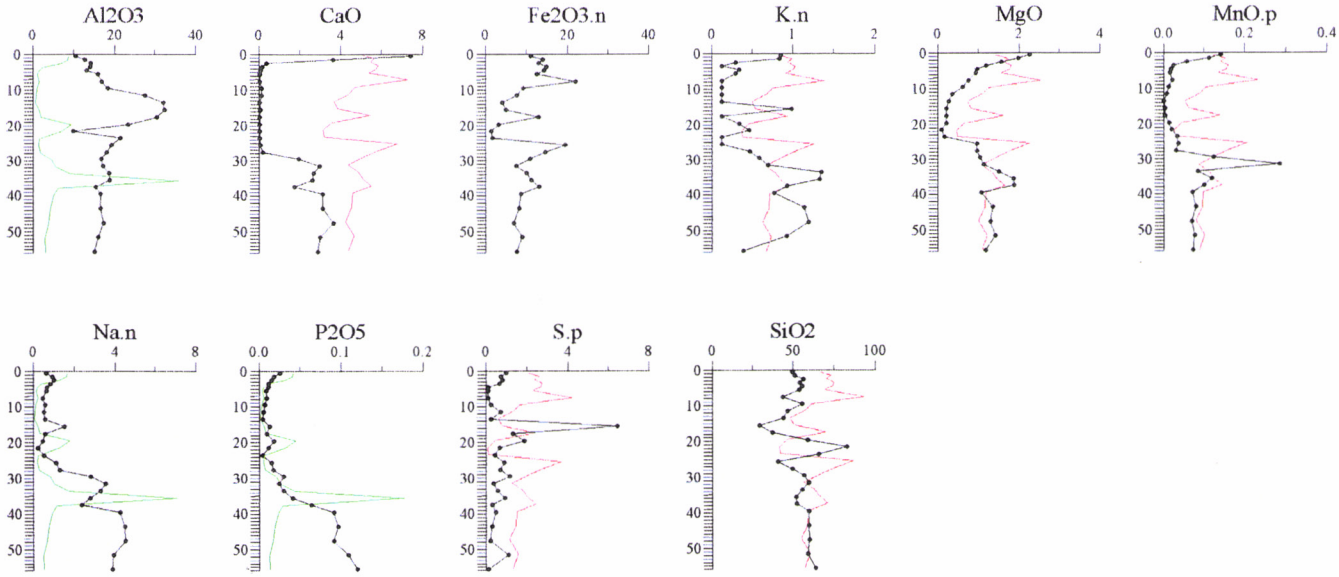


Figure A9.2 (continued).

Appendix 10: Selected scatter plots

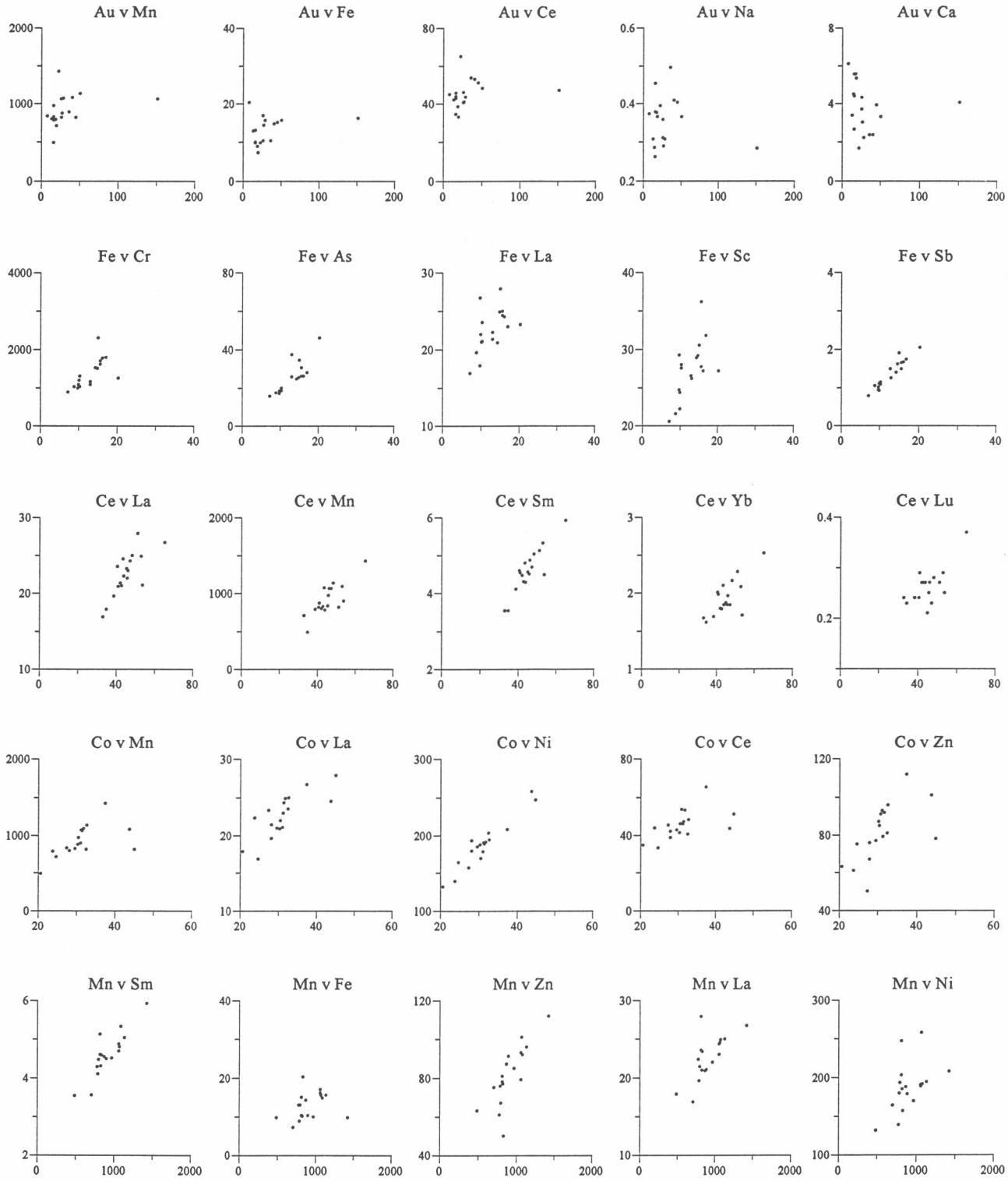


Figure A10.1: Selected element v element abundance plots for 0 - 1m bulk samples from 4250N at Steinway. First element in header is the x axis. Major elements in %, trace elements in ppm, Au in ppb.

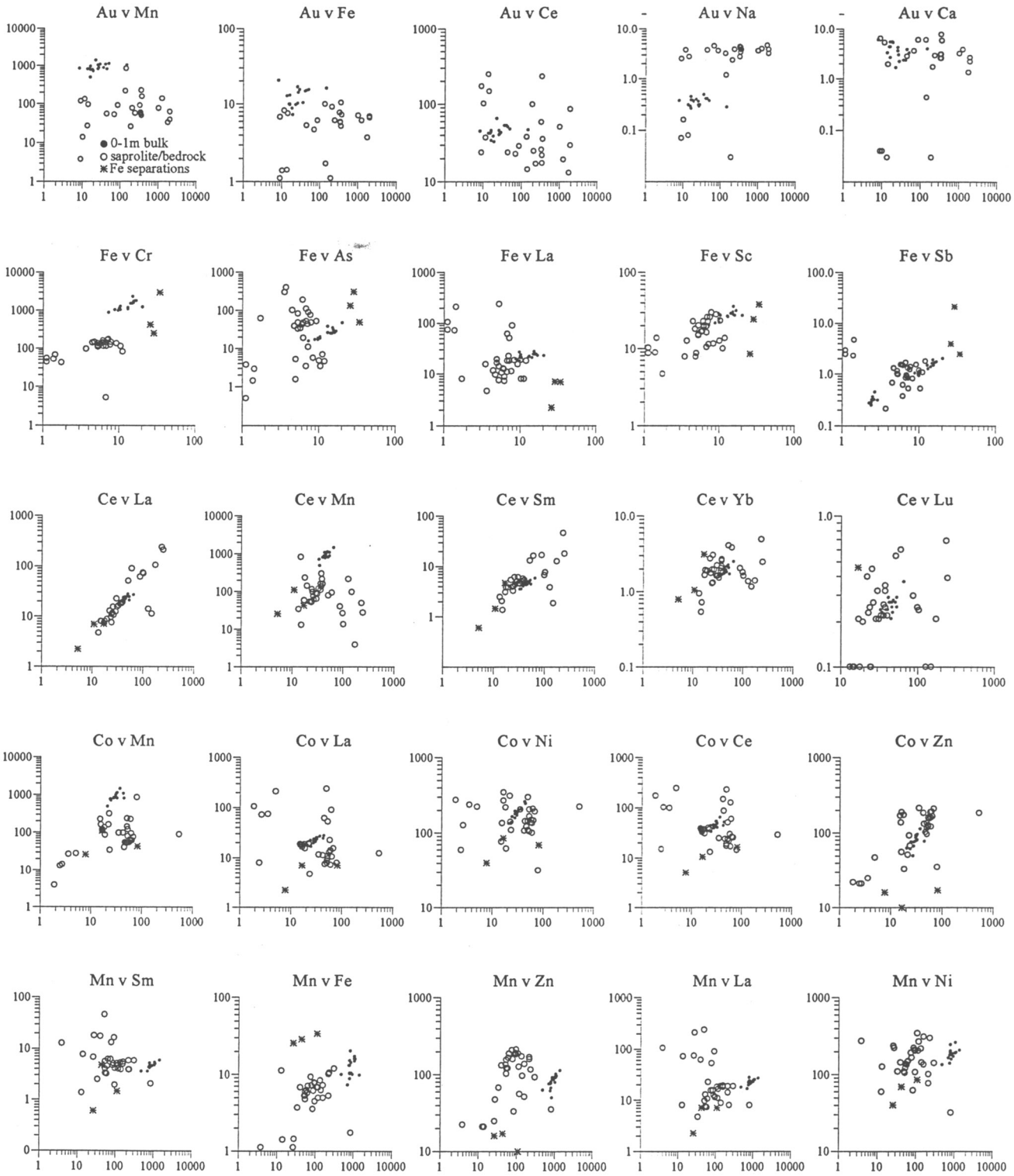
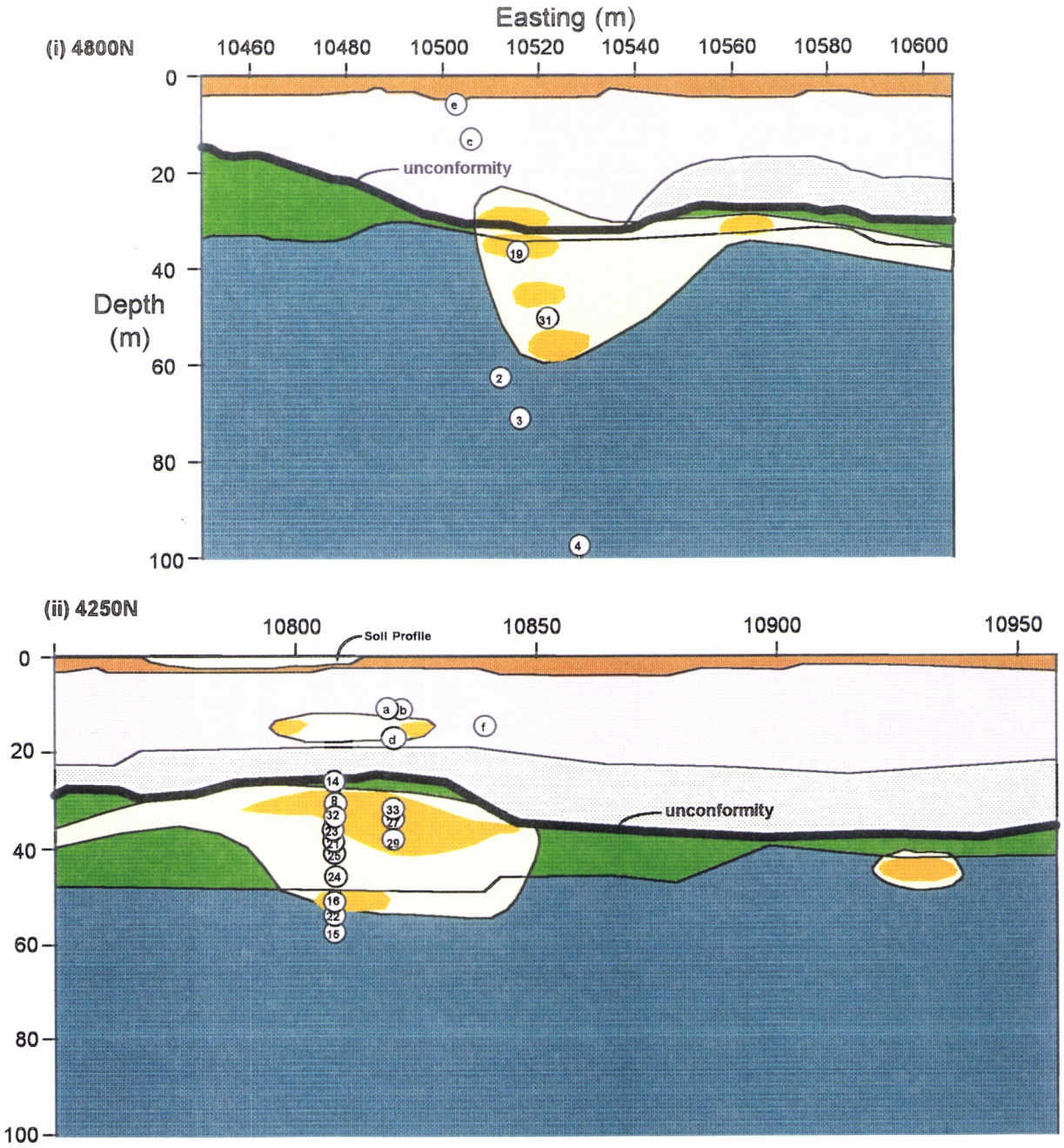


Figure A10.2: Selected element v element abundance plots for 0 - 1m bulk samples, Fe-rich material hand-picked from the overburden and material from saprolite and bedrock. Majors in %, trace elements in ppm, Au in ppb.
Some samples not plotted as below detection for some elements.
First element in header is the x axis.

Appendix 11: Sections



Calcareous red clay with Ca-rich nodules and Fe-rich granules and nodules.

Non-calcareous clays (pink, yellow, white and purple) with Fe-rich granules and pisoliths. Clays often puggy.

Pale silty sand with sand-rich lenses and some coarse quartz gravels.

Saprolite, clay-rich towards the top.

Fresh rock.

Au 0.1-1 ppm.

Au >1 ppm.

② Sample points (see Appendices 8 and 9 for graphed elemental abundances).

Figure A11: Regolith stratigraphy and Au abundance for (i) 4800N and (ii) 4250N at Steinway. After Gardiner (1993) and data supplied by Newcrest Mining Ltd.

Appendix 12: Tabulated results for mineral samples

Sample	East.	North.	Sb	As	Ba	Bi	Br	Ca	Cs	Ce	Co	Cr	Cu	Eu
6301	12000	4250	2.05	46.3	503	2	14.7	6.10	2.02	45.3	27.5	1250	77	1.04
6303	11750	4250	1.49	37.5	129	<1	11.3	3.38	4.47	42.2	28.1	1080	70	1.01
6306	11500	4250	1.26	25.7	362	<1	24.8	4.40	3.99	43.9	23.8	1170	78	0.68
6308	11250	4250	0.95	18.5	365	4	22	2.65	4.45	34.7	20.7	993	65	0.76
6309	11100	4250	1.09	18.6	315	<1	20.2	2.36	5.05	53.7	31	1040	80	1.03
6310	11075	4250	1.4	24.8	252	3	9.54	3.03	6.41	41.2	30.3	1530	83	1.07
6311	11000	4250	1.02	17.2	226	2	15.5	1.68	6.74	65.3	37.4	1000	85	1.17
6312	10950	4250	1.75	28.1	156	1	17.5	3.70	4	46.2	31.2	1790	80	1.04
6313	10900	4250	1.61	25.3	323	<1	12.9	2.37	3.68	53.2	31.8	1500	78	1.18
6314	10880	4250	1.67	26	295	1	12.1	4.08	4.62	47.2	31.4	1780	77	0.87
6315	10760	4250	1.48	26.1	158	2	14.1	3.30	4.04	48.4	32.8	1610	84	1.21
6316	10700	4250	0.92	18.6	148	<1	14.8	5.55	4.92	45.9	30.5	1090	75	1.06
6317	10650	4250	1.1	18.5	204	2	13.4	4.50	3.97	42.9	29.7	1200	75	0.97
6318	10600	4250	1.05	17.4	257	1	17.3	5.55	3.48	38.7	28.1	1040	74	0.85
6319	10550	4250	0.78	15.6	175	1	15.8	5.35	3.41	33.2	24.8	890	68	0.77
6324	10500	4250	1.65	30.6	329	2	14	2.23	6.09	43.6	43.8	1710	99	1.07
6326	10400	4250	1.14	19.9	293	<1	18.2	4.33	5.51	40.7	32.5	1300	82	1.07
6328	10300	4250	1.91	34.4	370	1	14.2	3.93	3.15	51.2	45	2300	88	1.25

Sample	total Au	Fe	Hf	La	Pb	Lu	Mg	Mn	Na	Ni	K	Rb	Sm	Sc
6301	8.3	20.3	4.22	23.3	18	0.21	0.89	833	0.372	157	0.42	33.7	4.57	27.2
6303	13.9	13	3.79	21.4	13	0.27	0.38	801	0.308	193	0.54	33.8	4.47	26.5
6306	16.4	13.1	3.97	22.3	12	0.27	0.38	784	0.378	139	0.76	44.7	4.28	26.2
6308	16.5	9.84	3.76	17.9	13	0.23	0.43	492	0.454	132	0.61	30.3	3.54	24.7
6309	36.3	10.4	3.53	21.1	16	0.25	0.54	896	0.497	179	0.64	40.5	4.48	27.5
6310	27.4	14.3	4.05	20.9	16	0.29	0.40	875	0.289	188	0.61	51.4	4.54	28.9
6311	22.9	9.8	3.81	26.7	16	0.37	0.35	1427	0.394	208	0.81	68.8	5.92	29.3
6312	26.1	17	3.69	23	16	0.27	0.52	1067	0.311	191	0.59	35.7	4.87	31.8
6313	41.0	14.8	4.27	24.9	16	0.29	0.45	1086	0.41	192	0.66	37.9	5.33	29.2
6314	152.0	16.2	4.08	24.3	15	0.23	0.38	1062	0.283	189	0.74	35.1	4.69	27.2
6315	50.7	15.6	4.03	25	19	0.28	0.38	1136	0.366	194	0.59	39.6	5.04	27.7
6316	16.4	10	3.41	22	13	0.25	0.39	971	0.262	170	1.03	26.9	4.5	22.2
6317	15.9	10.1	3.38	21	13	0.27	0.38	824	0.285	185	0.49	37.2	4.31	24.4
6318	18.6	8.85	3.09	19.6	11	0.24	0.50	794	0.376	180	0.25	28.6	4.1	21.5
6319	19.5	7.29	2.95	16.9	10	0.24	0.44	711	0.365	164	0.36	24.9	3.55	20.5
6324	29.1	15.6	3.58	24.5	16	0.27	0.26	1075	0.307	258	0.74	54.6	4.8	36.2
6326	26.5	10.3	3.76	23.5	11	0.24	0.44	816	0.358	203	0.6	45.6	4.59	28
6328	45.8	15.1	4.11	27.9	17	0.27	0.43	816	0.404	247	0.57	32.1	5.12	30.5

Sample	Sr	Ta	Th	TiO2	U	W	Yb	Zn	Zr	Salinity	water Au	iodide Au	cyanide Au	>2mm%
6301	152	1.21	15.5	0.72	5.21	5.14	1.87	50	110	2.08	2.484	6.72	1.072	16.4
6303	128	1.23	12.3	0.7	<2	4.47	1.8	67	115	1.46	3.964	7.08	2.556	8.6
6306	139	1.84	12.9	0.66	<2	<2	1.84	61	128	4.83	3.104	9.28	2.416	14.2
6308	138	1.59	12.1	0.72	3.18	4.86	1.62	63	125	4.45	2.368	8.92	3.612	20.8
6309	134	1.82	10.9	0.68	<2	5.17	1.71	91	120	2.76	8.24	23.52	5	13.4
6310	109	<1	11.9	0.67	<2	7.22	1.98	87	109	0.80	7.04	17.28	6.52	14.7
6311	98	1.01	12.2	0.75	<2	<2	2.53	112	139	2.33	4.88	12.32	4.56	12.8
6312	149	<1	12.4	0.69	<2	5.32	1.96	93	110	1.44	4.92	16.72	6.12	17.7
6313	112	2.31	13.1	0.72	<2	5.7	2.08	92	121	1.50	13.72	25.88	7.12	25.9
6314	138	1.39	11.6	0.67	<2	5	1.84	79	110	1.10	16.56	100.8	25.64	22.2
6315	123	<1	11.8	0.71	2.06	14	2.16	96	119	1.78	22.88	33.76	8.52	28.7
6316	154	1.45	9.72	0.57	<2	<2	1.84	85	105	0.80	4.08	12	4.32	6.4
6317	131	<1	9.44	0.61	<2	<2	1.79	77	112	0.82	4.72	11.48	3.404	5.5
6318	182	1.38	8.78	0.61	<2	<2	1.69	76	106	2.02	5.8	12.64	3.236	7.4
6319	168	1.69	8.28	0.58	<2	<2	1.67	75	104	1.62	5.36	12.92	3.732	8.8
6324	94	1.69	11.5	0.66	<2	4.75	2.1	101	107	0.83	10.44	15.16	5.32	21.8
6326	144	1.05	10.8	0.61	<2	<2	2.01	81	106	1.40	5.2	12.64	4.08	8.0
6328	155	1.44	10.6	0.62	2.62	4.2	2.28	78	109	1.64	12.44	27.56	7.24	18.6

Table A12.1: Elemental abundances at Steinway for 0-1m material.
Majors are in %, traces in ppm and Au in ppb.
Ir(20ppb), Mo(5ppm), Se(5ppm) and Ag(5ppm) are below detection (in brackets) for all samples.

Sample	Easting	Northing	Depth	Sb	As	Ba	Br	Ce	Cs	Cr	Co	Eu	Au ppb	Hf	Fe %	K %
6301G	12000	4250	0-1m	3.8	84.4	375	4.28	48.8	<1	2410	30	1.44	<5	4.22	44.8	<0.2
6303G	11750	4250	0-1m	3.79	102	429	3.55	60.1	2.37	2760	30.8	0.89	<5	4.44	42.3	0.31
6306G	11500	4250	0-1m	4.1	57.7	133	5.56	49.2	2.9	3480	30.3	1.02	<5	3.45	42.5	<0.2
6308G	11250	4250	0-1m	3.98	52	258	5.85	43.4	2.17	3800	30.9	1.08	<5	3.7	41.1	<0.2
6309G	11100	4250	0-1m	4.17	62.1	375	6.09	95.9	1.57	4030	45.6	1.04	<5	3.58	42.9	<0.2
6310G	11075	4250	0-1m	4.02	68.3	197	3.54	51.8	<1	4290	35.1	1.53	<5	4.03	43.1	0.2
6311G	11000	4250	0-1m	3.72	60.4	<100	3.05	73.4	<1	4060	42.7	1.06	11.8	3	40.1	<0.2
6312G	10950	4250	0-1m	4.58	66.4	287	6.06	56.8	<1	4670	37.1	1.29	<5	3.85	44.9	<0.2
6313G	10900	4250	0-1m	4.37	68.2	384	3.32	62	<1	4750	37.1	1.73	<5	3.96	46	<0.2
6314G	10880	4250	0-1m	4.85	67.8	171	3.86	63.2	<1	4820	42.8	1.12	36.2	3.83	44.6	<0.2
6315G	10760	4250	0-1m	4.44	65.2	<100	3.56	64.6	<1	4690	41.9	1.27	<5	4.06	41.7	<0.2
6316G	10700	4250	0-1m	3.79	58.7	158	6.17	75.8	1.5	4030	46.6	1.61	<5	4.08	35.4	<0.2
6317G	10650	4250	0-1m	4.13	63.5	<100	6.29	65	3.26	4450	43.8	1.19	<5	3.52	37.4	<0.2
6318G	10600	4250	0-1m	3.93	66.4	330	4.73	66.2	1.98	4390	43.8	0.72	<5	3.88	38.1	<0.2
6319G	10550	4250	0-1m	3.47	62	244	5.62	66.2	2.37	4010	48.1	0.69	<5	2.85	34.7	<0.2
6324G	10500	4250	0-1m	3.09	60	<100	4.27	48	<1	3880	49.4	1.11	<5	2.23	31.8	<0.2
6326G	10400	4250	0-1m	4.29	64.5	176	4.03	59.5	1.95	5500	47.9	1.1	<5	2.69	38.3	<0.2
6328G	10300	4250	0-1m	5.97	87.4	250	5.68	63.8	1.55	7320	51.8	0.98	<5	3.91	46.4	0.36
6311G	11000	4250	0-1m	3.72	60.4	<100	3.05	73.4	<1	4060	42.7	1.06	11.8	3	40.1	<0.2
6340G	11000	4100	0-1m	3.84	62.7	<100	2.5	45.6	1.62	4390	39.6	1.25	<5	4.12	42.7	<0.2
6341G	11000	4000	0-1m	2.86	58.4	207	2.57	38.7	1.68	3230	41.8	1.01	<5	3.08	33	<0.2
6342G	11010	3900	0-1m	2.89	53.4	<100	3.68	42.6	2.45	3150	43.3	1.15	<5	3.52	32.5	<0.2
6343G	11000	3800	0-1m	3.67	105	276	7.63	38.4	<1	1870	21.5	1.33	<5	4.24	39.6	<0.2
6344G	11000	3700	0-1m	3.35	55.2	298	4.44	51.8	<1	2840	29.1	1.39	<5	4.58	42.8	<0.2
6346G	11000	3600	0-1m	3.29	67.4	490	4.1	57.2	1.62	3510	33.9	1	<5	4.56	51.1	<0.2
6348G	11000	3500	0-1m	3.35	57.7	679	7.54	40.1	<1	2470	28	0.95	<5	4.22	41.2	<0.2
6350G	11000	3400	0-1m	2.9	54.7	120	8.49	36.6	<1	1320	18.5	1.15	16.6	4.01	35	<0.2
6352G	11000	3300	0-1m	1.75	52.2	<100	6.5	31.7	<1	1450	31.1	0.70	72.6	2.77	20.9	<0.2
6354G	11000	3200	0-1m	1.42	48	1020	10.2	16.5	2.26	924	37.4	0.55	46.2	3.03	17.6	<0.2
6345G	11000	3700	1-1.5m	2.42	39.7	288	3.82	44.2	<1	2030	22.3	1.12	<5	2.35	29.2	<0.2
6347G	11000	3600	1-1.5m	3.93	68.5	606	3.41	48.7	2.36	3610	28.9	1.1	<5	5.47	51.2	<0.2
6349G	11000	3500	1-1.5m	0.9	23.4	323	4.36	8.63	<1	477	14.3	<0.5	<5	1.67	10.2	<0.2
6351G	11000	3400	1-1.5m	1.68	34	<100	14.1	26.4	<1	840	13.6	0.66	36.1	3.31	20	<0.2
6353G	11000	3300	1-1.5m	1.05	32.3	<100	5.01	33.3	<1	519	31.4	0.77	92.4	4.18	12.6	<0.2
6355G	11000	3200	1-1.5m	0.77	42.1	<100	6.64	7.39	2.12	238	36.1	0.77	17.9	2.35	9.74	<0.2

Table A12.2: Elemental abundances at Steinway for 2-4mm material sieved from 0-1m and 1-1.5m composites.
Analyses in ppm unless otherwise stated.
Ir(20ppb), Mo(5ppm), Se(5ppm) and Ag(5ppm) are below detection (in brackets) for all samples.

Sample	La	Lu	Rb	Sm	Sc	Na%	Ta	Th	W	U	Yb	Zn
6301G	27.2	0.2	<20	4.88	39.3	0.1	<1	22.6	15.3	5.56	1.97	<100
6303G	27.9	0.2	<20	4.54	37.4	0.1	1.59	20.7	23.4	2.16	1.94	<100
6306G	28.4	0.2	<20	4.27	37.8	0.1	1.04	20	14.5	3.4	1.64	<100
6308G	26.9	0.3	21.5	4.36	36.4	0.1	1.29	19	8.85	2.73	1.65	112
6309G	33.4	0.30	38.8	5.34	43.5	0.2	<1	18.1	11.9	<2	2.38	133
6310G	27.5	0.30	55	5	43.1	0.1	1.83	17.3	10.6	<2	2.26	129
6311G	37.2	0.31	38	5.56	42.5	0.2	<1	16.6	6.97	<2	2.42	140
6312G	28.6	0.3	25.8	4.73	43.5	0.1	1.35	18.6	8.01	<2	2.28	131
6313G	36.4	0.29	32.4	5.63	45.7	0.1	<1	19.3	7.63	<2	2.22	126
6314G	33.2	0.3	<20	4.84	45.5	0.1	<1	17	15.7	<2	2.43	<100
6315G	37.4	0.31	25.8	5.78	44.8	0.1	1.43	16.5	12.3	<2	2.36	152
6316G	37.9	0.29	39.9	5.22	40.5	0.2	2.1	15	7.18	<2	2.23	137
6317G	33.4	0.32	<20	4.59	43	0.2	<1	15.7	9.83	<2	2.22	132
6318G	31.9	0.3	<20	4.31	41.1	0.2	<1	14.9	17.1	<2	2.01	138
6319G	27.7	0.2	44.6	3.78	39.3	0.2	1.65	13.6	10.7	<2	1.89	152
6324G	28.8	0.3	25.6	4.72	41.7	0.34	2.33	12.5	6.87	<2	2.22	162
6326G	35.3	0.28	45.2	5.09	41.8	0.2	1.52	14	5.86	<2	2.3	140
6328G	39.3	0.29	28.8	5.32	47.6	0.1	<1	16.9	7.29	<2	2.39	119
6311G	37.2	0.31	38	5.56	42.5	0.2	<1	16.6	6.97	<2	2.42	140
6340G	27.9	0.3	40.6	4.77	46.2	0.1	<1	17.6	12.5	<2	2.5	113
6341G	24.2	0.3	24.9	4.21	41.3	0.35	2	13.5	9.82	<2	2.37	133
6342G	28.4	0.31	21.6	5.02	42	0.32	<1	12.2	9.25	<2	2.57	148
6343G	20.7	0.3	45.5	4.42	46.6	0.1	<1	16.4	32.1	<2	2.26	101
6344G	33.7	0.3	36	5.4	39.8	0.1	2.11	17.6	13	<2	2.31	<100
6346G	26.2	<0.2	28.4	3.84	43.5	0.1	1.87	20.9	17.8	3.99	2.11	107
6348G	23.4	<0.2	<20	3.47	37.4	0.1	2.14	17.1	13.4	4.09	1.96	102
6350G	24.7	<0.2	33.3	3.89	31.5	0.1	<1	13.1	10.2	<2	1.75	<100
6352G	17.6	<0.2	24.3	2.72	25.1	0.2	1.31	8.67	8.16	2.31	1.65	<100
6354G	9.41	<0.2	<20	1.89	23.6	0.2	<1	6.14	6.34	3.23	1.23	119
6345G	29	<0.2	<20	4.35	28.5	0.1	<1	12.1	10.9	<2	1.52	<100
6347G	27.2	0.23	26	4.17	45.5	0.108	1.95	21	15.3	4.87	1.83	<100
6349G	3.74	<0.2	<20	0.74	10.6	0.058	<1	3.97	2.96	<2	0.6	<100
6351G	14.4	<0.2	<20	2.54	24.6	0.132	<1	8.42	7.32	<2	1.39	<100
6353G	11	0.21	<20	2.26	20.5	0.222	<1	5.17	10.4	3.64	1.47	<100
6355G	4.2	0.22	<20	1.96	16.4	0.376	<1	2.73	2.33	3.28	2	<100

Table A12.2 (continued).

Sample	Sample id	Depth	size fraction	% size	Sb	As	Ba	Br	Ce	Cs	Cr	Co	Eu
09-2040	L40-A	10-30cm	>710um	8.4	5.23	68	330	8.17	58	<2	4820	34.9	1.13
09-2040	L40-B	10-30cm	710-250	5.6	0.95	23.6	230	4.5	34.7	<1	1340	26.2	0.9
09-2040	L40-C	10-30cm	250-53	26.6	0.56	9.9	214	<2	13.5	1.4	541	10.4	<0.5
09-2040	L40-D	10-30cm	<53	59.4	0.36	12.7	153	26.1	56.6	6.94	445	31.6	1.33
09-2047	L40-E	150-170cm	>710um	10.6	4.41	68.1	292	6.57	98.8	<2	5080	73.5	3.55
09-2047	L40-F	150-170cm	710-250	4.2	2.34	32.7	551	2.21	78	<2	2040	97.7	1.73
09-2047	L40-G	150-170cm	250-53	27.2	0.39	8.65	205	<2	30.1	1.16	563	48.7	<0.5
09-2047	L40-H	150-170cm	<53	63	0.78	12.6	272	22.1	133	6.67	673	62.2	2.09

Sample id	Au ppb	Hf	Fe%	La	Lu	K %	Rb	Sm	Sc	Na%	Ta	Th	W
L40-A	56.4	3.42	43.6	30.1	0.24	0.28	41	4.72	51.7	0.125	3.55	17.9	11.7
L40-B	71.7	3.34	11.6	16.3	<0.2	0.31	33	2.64	16.8	0.221	<1	10	5.1
L40-C	33.9	2.15	4.33	7.03	<0.2	0.39	<20	1.18	7.28	0.308	<1	4.78	<2
L40-D	304	3.95	4.63	26.4	0.3	0.83	49.7	5.5	22.8	0.531	1.31	10.6	<2
L40-E	452	4.68	43.8	50.8	0.62	<0.2	39.7	12.5	51.2	0.137	<1	18.7	15.1
L40-F	117	1.98	18.7	32.9	0.54	0.29	45	8.21	18.8	0.185	2.3	10.6	5
L40-G	15.4	1.56	4.46	10.2	<0.2	0.21	<20	2.51	5.69	0.3	<1	4.49	2.05
L40-H	364	4.72	6.45	31.2	0.49	0.38	39.4	7.42	31.5	0.855	<1	12.1	4.51

Sample id	U	Yb	Zn
L40-A	<4	2.17	247
L40-B	4.92	1.28	241
L40-C	<2	0.69	<100
L40-D	<2	2.15	158
L40-E	4.86	4.86	146
L40-F	5.33	3.94	302
L40-G	2.84	1.16	<100
L40-H	4.73	3.38	151

Table A12.3: Elemental abundances at Steinway for 4 size fractions sieved from two soils (10810E 4250N).
Analyses in ppm unless otherwise stated.
Ir(20ppb), Mo(5ppm), Se(5ppm) and Ag(5ppm) are below detection (in brackets) for all samples.

Sample	Depth	Sb	As	Ba	Br	Ca%	Ce	Cs	Cr	Co
2039	0-10cm	1.41	23.6	208	5.29	1.8	46.7	2.87	1520	28.6
2040	10-30cm	1.02	18.2	196	18.1	6.5	46.6	3.6	960	28.9
2041	30-50cm	1.07	17.3	149	20.2	5.6	49.5	3.69	995	29.3
2042	50-70cm	0.95	17.2	228	22.7	5.5	50.7	4.65	962	31.3
2043	70-90cm	1.05	16.8	253	16.4	4.5	50.2	5.09	1020	32.6
2044	90-110cm	0.83	14.9	207	16.7	4.1	52.9	5.08	952	33.3
2045	110-130cm	0.89	17	296	16.6	2.7	54.8	4.96	1070	35.5
2046	130-150cm	0.99	22	298	15.1	2.1	68.2	5.13	1280	48.9
2047	150-170cm	1.26	21.2	283	18.5	0.2	105	5.65	1270	67.3
Sample	Eu	total Au	Hf	Fe%	K %	La	Lu	Mg%	Rb	Sm
2039	1.15	106	3.4	14.6	0.33	23.2	0.27	0.38	28.6	4.34
2040	0.98	239	3.55	8.71	0.66	22.6	0.26	0.74	49	4.43
2041	1.17	208	3.97	9.24	0.58	23.3	0.25	0.71	32.5	4.61
2042	1.12	208	3.62	9.15	0.59	24	0.27	0.72	39.7	4.65
2043	0.95	206	3.7	9.44	0.43	24.2	0.29	0.65	33.8	4.82
2044	1.08	222	3.67	8.81	0.1	23.7	0.25	0.58	40.4	4.71
2045	1.26	257	3.68	9.84	0.48	30	0.29	0.54	32.8	5.7
2046	1.56	297	3.7	11.5	0.55	33.7	0.35	0.50	33.6	6.33
2047	2.01	323	4.14	11.6	0.45	32.7	0.45	0.39	10	7.97
Sample	Sc	Na%	Ta	Th	W	U	Yb	Zn		
2039	25.7	0.24	1.24	11	<2	<2	1.87	156		
2040	21.5	0.47	0.5	9.93	<2	<2	1.86	166		
2041	23	0.56	1.04	10.1	<2	<2	1.85	165		
2042	22.9	0.56	1.76	10.6	<2	2.69	2.02	152		
2043	24.2	0.61	1.58	10.8	<2	<2	2.08	154		
2044	24.5	0.65	0.5	11	4.66	2.34	2.11	158		
2045	26.4	0.68	0.5	11.6	<2	<2	2.47	165		
2046	28.4	0.68	1.11	11.9	<2	<2	2.69	159		
2047	28.6	0.73	0.5	12.5	<2	<2	3.57	181		
Sample	org. C %	moist. %	water Au	iodide Au	cyanide Au	residue Au				
2039	0.30	4.25	17.28	54	14.28	6.8				
2040	0.23	5.66	25.48	136.8	50	16.7				
2041	0.18	6.11	15.84	132.4	15.32	13.8				
2042	0.21	6.50	13.36	139.6	13.56	12.3				
2043	0.11	6.83	7.64	151.6	6.84	9.3				
2044	0.10	7.59	7.08	170.4	21	11.6				
2045	0.11	7.67	6.04	179.2	21.36	15.1				
2046	0.08	7.97	6.76	169.2	34.52	20.4				
2047	0.08	7.94	3.94	201.6	27.72	23.6				

Table A12.4: Elemental abundances at Steinway for soil profile (10810E 4250N).
Analyses in ppm unless otherwise stated. Au is in ppb.
Ir(20ppb), Mo(5ppm), Se(5ppm) and Ag(5ppm) are below detection (in brackets) for all samples.

Sample	Easting	Northing	Sample Description	total Au	water Au	iodide Au	org. C %	Mg %	Ca %
6071	10500	4250	clay, lag, carbonate	11.4	0.5	8.1	1.4	0.21	0.76
6067	10550	4250	clay, lag, carbonate	15.6	1.5	9.4	0.8	0.27	3.45
6065	10600	4250	clay, lag, carbonate	10.9	1.6	9.2	0.6	0.26	3.00
6063	10650	4250	clay, lag, carbonate	10.3	1.4	7.8	0.4	0.23	2.25
6061	10700	4250	clay, lag, carbonate	13.8	1.9	11.1	0.8	0.23	2.98
6059	10750	4250	clay, lag, carbonate	19.6	1.3	10.4	2.6	0.24	0.67
6057	10800	4250	clay, lag, carbonate	93	9.7	85.2	0.6	0.22	2.80
6046	10835	4250	clay, lag, carbonate	36	1.9	15.4	2.0	0.21	1.60
6051	10835	4250	clay, lag, carbonate	35.4	1.3	20.6	1.6	0.16	0.86
6073	10900	4250	clay, lag, carbonate	11.2	4.9	16.0	0.9	0.16	0.14
6098	10950	4250	clay, lag, carbonate	14.7	2.8	8.1	0.6	0.22	0.45
6077	11000	4250	clay, lag, carbonate	19.6	4.0	7.9	0.5	0.27	0.87
6079	11050	4250	clay, lag	15.1	3.6	14.4	0.5	0.21	0.49
6081	11100	4250	clay, lag, carbonate	15.7	0.4	7.7	2.1	0.20	0.33
6083	11150	4250	clay, lag	13	1.7	10.5	0.6	0.28	0.45
6096	11200	4250	clay, lag, carbonate	9.3	0.9	5.4	1.1	0.55	3.18
6088	11250	4250	clay, lag	11	0.2	2.0	1.0	0.09	0.15
6090	11300	4250	clay, lag, carbonate	12	2.3	10.8	0.6	0.62	3.80
6092	11350	4250	clay, lag, carbonate	9.8	0.7	4.4	1.3	0.33	3.73

Table A12.5: Elemental abundances at Steinway for soils (0-0.1m).
Au analyses in ppb.

Sample id	Sample	Hole ID	Easting	Northing	Depth(m)	Type	Al2O3	CaO	Fe
e	6173	not known	10501	4800	6.5	Fe nodules	nd	nd	29.7
f	6034/35/36	not known	10835	4250	13-16	Fe nodules + some low Fe nodules	nd	nd	24.1
a	6002	not known	10820	4250	9.5	Fe nodules	nd	nd	33.8
d	6007/8	not known	10820	4250	17-19	Fe nodules + some low Fe nodules	nd	nd	26.9
b	6002	not known	10820	4250	9.5	Fe nodules + some low Fe nodules	nd	nd	13.2
c	6179/80	not known	10501	4800	16-19	Fe nodules - some pisolitic	nd	nd	43.5
1	PF17	not known	11400	3200	18	ferruginous saprolite	16.86	0.04	11.20
2	C001	not known	10485	4764	76.8-77.8	partially weathered andesite	17.16	4.21	4.93
3	C002	not known	10485	4764	88.4-89.3	andesite	16.57	4.15	4.90
4	C003	not known	10485	4764	120-121	andesite	16.43	4.50	3.50
5	C007	not known	10485	4764	141.7-142.8	andesite	16.76	4.31	6.74
6	C008	not known	10485	4764	163.65-164.7	andesite	14.16	7.72	12.00
7	C009	not known	10485	4764	198.7-199.9	andesite	15.82	6.80	4.48
8	st1-32	st-1	10808	4250	31.5		17.15	2.96	5.24
9	C011	not known	10485	4764	226-227	andesite	16.64	6.41	6.83
10	PF1	not known	11525	3200	23	mottled clays	25.96	0.04	1.12
11	PF2	not known	11525	3200	22	mottled clays	20.85	0.04	1.39
12	C004	not known	10485	4764	136-137	andesite	15.88	5.30	8.35
13	PF4	not known	11525	3200	20	micaceous clays	26.06	0.03	1.44
14	st1-30	st-1	10808	4250	29.5	saprolite	16.60	1.94	7.59
15	st1-56	st-1	10808	4250	55.5	saprolite	15.00	2.87	5.29
16	st1-48	st-1	10808	4250	47.5	saprolite	17.21	3.66	4.75
17	C010	not known	10485	4764	200-201	andesite	18.79	5.99	6.13
18	C006	not known	10485	4764	140.6-141.7	andesite	14.77	6.14	10.10
19	6194	not known	10501	4800	44-45	saprolite	4.30	0.43	1.73
20	PF3	not known	11525	3200	21	micaceous clays	9.96	0.03	1.12
21	st1-38	st-1	10808	4250	37.5	saprolite	15.27	1.74	9.18
22	st1-52	st-1	10808	4250	51.5	saprolite	15.92	2.99	6.20
23	st1-36	st-1	10808	4250	35.5	saprolite	18.75	2.60	7.79
24	st1-44	st-1	10808	4250	43.5	saprolite	16.49	3.11	5.77
25	st1-40	st-1	10808	4250	39.5	saprolite	16.42	3.11	5.99
26	C012	not known	Penfold	Penfold	75.5-76.5	core	13.39	7.88	10.40
27	6017	not known	10820	4250	34-35	saprolitic clay	15.78	2.61	5.28
28	C005	not known	10485	4764	137-138	core-andesite	15.68	5.88	7.26
29	6018	not known	10820	4250	36-37	saprolitic clay	18.51	3.23	7.14
30	C013	not known	Penfold	Penfold	81.0-82.0	core	13.41	3.90	6.21
31	6202	not known	10501	4800	60-61	saprolite	13.68	1.35	3.72
32	st1-34	st-1	10808	4250	33.5	saprolite	18.55	2.68	6.98
33	6016	not known	10820	4250	32-33	saprolitic clay	15.22	2.20	6.80

Table A12.6: Elemental abundances at Steinway for regolith and bedrock samples.
Majors are in %, traces in ppm, Au and Ir in ppb.
nd not determined.

Sample id	K	MgO	Mn	Na	P2O5	S	SiO2	TiO2	Ag	As	Au	Ba	Bi	B	Ce	Cl	Co
e	0.24	nd	nd	0.23	nd	nd	nd	0.61	<5	54.5	<5	238	5	14.7	9.18	nd	26.2
f	0.56	nd	nd	0.59	nd	nd	nd	0.69	<5	84.9	<5	534	2	17.4	8.55	nd	11.9
a	<0.2	nd	nd	0.09	nd	nd	nd	0.92	<5	81	<5	<100	2	30.1	6.06	nd	11.2
d	<0.2	nd	nd	0.07	nd	nd	nd	1.04	<5	199	<5	776	2	6.68	30.4	nd	60.7
b	<0.2	nd	nd	0.13	nd	nd	nd	1.22	<5	31.1	11.1	<100	1	18.5	3.7	nd	14.8
c	<0.2	nd	nd	0.12	nd	nd	nd	0.67	<5	97.9	17	1520	4	5.64	92.2	nd	61
1	0.59	0.29	13	0.09	0.020	530	57.74	0.61	<5	7.01	<5	290	nd	17.7	14.9	230	2.45
2	1.44	2.44	160	4.12	0.147	2310	58.79	0.89	<5	5.27	<5	788	nd	1	40.3	170	21.6
3	1.48	1.46	119	3.41	0.146	2460	63.44	0.85	<5	1.55	<5	410	nd	1	33.4	60	16.3
4	1.31	1.21	87	4.58	0.141	3070	62.17	0.85	<5	304	<5	619	nd	1	31.1	160	18.5
5	1.07	1.40	112	4.01	0.158	1320	61.19	0.86	<5	3.47	<5	523	nd	1	36.6	340	16.3
6	0.58	1.95	308	2.05	0.121	1940	53.60	0.74	<5	4.59	<5	580	nd	1	37.8	150	22.8
7	1.73	2.32	98	2.53	0.064	520	59.30	1.27	<5	102	<5	669	nd	1	25	10	35.4
8	0.70	1.13	221	3.53	0.024	400	59.62	1.38	<1	48.7	<5	270	2	10.3	127	3920	60.7
9	0.81	2.19	118	2.52	0.084	1260	59.12	1.27	<5	52	9.2	566	nd	1	23.9	15	52.4
10	0.95	0.33	4	0.07	0.036	170	61.06	0.87	<5	0.5	9.3	547	nd	1	174	110	1.87
11	0.38	0.24	14	0.16	0.035	260	67.31	1.36	<5	1.41	10.4	387	nd	3.37	103	820	2.66
12	1.03	1.76	136	3.76	0.150	1850	57.16	0.82	<5	5.61	11.9	341	nd	1	37.5	60	17.9
13	0.55	0.32	28	0.08	0.114	270	57.97	2.94	<5	2.86	14	691	nd	3.43	244	10	4.93
14	0.59	1.04	96	2.78	0.030	690	56.90	1.33	1	74.6	14.8	50	<1	17.4	149	5910	42.6
15	0.39	1.18	55	3.84	0.120	160	63.80	1.28	<1	32.8	44.8	407	1	5.14	24.2	2270	46.7
16	1.19	1.29	53	4.51	0.091	340	60.11	1.43	<1	38.4	70	531	<1	15.3	23	6730	52.6
17	1.46	2.37	91	3.68	0.131	4250	54.47	1.55	<5	194	87.2	458	nd	1	29	40	532
18	0.77	1.83	221	3.21	0.133	3830	56.78	0.77	<5	4.88	141	196	nd	1	38.1	10	15.2
19	0.41	0.44	840	1.18	0.015	240	88.65	0.33	<5	63	146	624	nd	18	14.5	3870	79.6
20	0.10	0.14	26	0.03	0.040	130	82.86	2.15	<5	3.67	195	260	nd	1	99.3	60	3.56
21	0.94	1.88	77	2.36	0.064	290	52.55	1.3	<1	52.7	215	455	<1	8.69	25.3	1420	67.9
22	0.93	1.42	59	3.91	0.109	220	59.21	1.34	3	47.9	247	392	<1	8.2	17.1	3190	60.5
23	1.33	1.86	92	2.76	0.041	260	52.03	1.55	1	48.4	336	532	<1	8	59.6	3110	62.1
24	1.14	1.35	62	4.47	0.096	280	59.60	1.43	<1	35.1	345	470	<1	9.2	26.4	3910	63.9
25	0.77	1.07	55	4.25	0.091	220	59.56	1.37	3	43.1	350	329	<1	5.75	22.1	2320	56.6
26	1.99	2.61	233	3.41	0.056	10180	47.55	1.2	<5	3.45	358	874	nd	1	17.8	120	50.6
27	0.25	0.95	51	3.87	0.073	530	52.74	1.3	<5	82.8	359	531	nd	20.8	232	4820	49.6
28	1.55	1.51	159	3.92	0.147	2550	57.49	0.81	<5	11.1	374	609	nd	1	35.9	40	15.7
29	0.25	1.71	78	3.62	0.080	500	29.72	1.57	<5	90.3	1040	260	nd	35.6	51.3	7410	52.9
30	1.15	1.25	143	4.02	0.072	6690	62.84	1.19	<5	19.5	1290	562	nd	1	19.4	330	50.6
31	0.45	1.22	34	4.70	0.056	910	65.08	1.13	<5	410	1810	141	nd	58.6	13.2	24420	23.4
32	1.35	1.51	64	3.27	0.030	320	55.63	1.55	<1	44.8	8420	186	<1	6.99	30	2520	58.8
33	0.25	0.83	40	3.90	0.065	590	61.65	1.26	<5	109	21400	186	nd	15.9	87.1	4180	44.4

Table A12.6 (continued).

Sample id	Cr	Cs	Cu	Eu	Ga	Ge	Hf	Ir	La	Lu	Mo	Nb	Nd.p	Ni	Pb	Rb	Sb	Sc	Se
e	2600	3.66	81	<0.5	nd	nd	3.33	<20	5.47	<0.2	<5	nd	nd	189	18	43.1	2.75	28.5	<5
f	228	<1	29	<0.5	nd	nd	4.63	<20	4.87	<0.2	<5	nd	nd	44	36	<20	1.55	13.7	<5
a	1510	1.61	10	<0.5	nd	nd	4.25	<20	3.15	<0.2	<5	nd	nd	38	10	<20	1.88	10.2	<5
d	247	1.86	65	1.18	nd	nd	4.72	<20	18	<0.2	<5	nd	nd	45	40	<20	2.57	8.27	<5
b	672	1.03	12	<0.5	nd	nd	6.55	<20	1.62	<0.2	<5	nd	nd	77	4	<20	1.83	12.2	<5
c	3620	2.42	62	2.61	nd	nd	3.54	<20	30.3	0.28	<5	nd	nd	219	62	<20	3.82	32.2	<5
1	82.7	<1	16	0.5	29	nd	6.2	<20	8.0	0.1	<5	3	nd	60	18	27	1.1	10	<5
2	<5	2.1	23	1.8	24	nd	3.5	<20	19.6	0.2	<5	4	nd	311	16	69	<0.2	9	<5
3	<5	1.8	66	1.7	21	nd	3.8	<20	16.5	0.2	<5	3	nd	269	7	55	<0.2	8	<5
4	<5	2.7	16	1.3	22	nd	3.6	<20	15.7	0.2	<5	<1	nd	62	12	54	<0.2	8	<5
5	5.3	1.6	24	1.7	21	nd	3.7	<20	18.2	0.2	<5	<1	nd	348	13	36	0.9	11	<5
6	<5	1.6	43	1.8	19	nd	3.5	<20	18.5	0.4	<5	2	nd	140	10	34	1.8	14	<5
7	140	2.4	55	1.4	21	nd	2.1	<20	11.8	0.1	<5	1	nd	207	11	69	0.7	23	<5
8	136	6.3	106	1.2	26	1	2.0	nd	14.1	0.1	nd	3	20	101	3	49	1.0	20	nd
9	117	1.8	81	1.2	23	nd	2.6	<20	11.0	0.3	<5	2	nd	206	9	38	1.0	20	<5
10	55.4	2.0	39	2.8	33	nd	8.5	<20	106.0	0.2	<5	5	nd	277	31	28	2.5	10	<5
11	52.1	2.0	10	1.8	29	nd	10.3	<20	72.4	0.2	<5	8	nd	128	35	<20	2.3	9	<5
12	<5	2.2	34	1.7	22	nd	6.5	<20	18.7	0.3	<5	6	nd	219	6	28	0.8	12	<5
13	67.3	1.0	12	3.9	42	nd	19.6	<20	209.0	0.4	<5	22	nd	224	56	<20	4.7	14	12.4
14	126	8.3	89	0.6	22	1	2.0	nd	11.3	0.1	nd	5	8	108	15	44	1.2	26	nd
15	123	2.2	101	1.1	20	1	2.0	nd	7.6	0.1	nd	3	7	122	3	23	1.0	15	nd
16	148	1.9	87	1.2	24	1	2.2	nd	9.8	0.2	nd	6	14	105	<1	31	1.3	18	nd
17	165	2.4	80	1.7	25	nd	2.9	<20	12.6	0.2	<5	<1	nd	222	10	55	0.6	23	<5
18	<5	1.1	33	1.7	20	nd	3.6	<20	19.0	0.3	<5	3	nd	77	9	20	1.2	13	<5
19	42.2	<1	78	0.6	6	nd	0.7	<20	8.0	0.1	<5	1	nd	32	8	<20	<0.2	5	<5
20	43.3	<1	10	1.9	20	nd	14.2	<20	74.2	0.3	<5	12	nd	237	26	<20	3.0	9	<5
21	139	2.2	96	1.9	25	<1	2.2	nd	15.5	0.5	nd	5	22	194	1	31	1.5	28	nd
22	143	2.1	78	1.2	21	<1	2.2	nd	7.3	0.2	nd	4	4	135	2	34	1.5	20	nd
23	151	5.0	125	4.2	28	1	2.3	nd	89.6	0.6	nd	7	91	209	1	39	1.4	30	nd
24	131	2.4	89	1.4	23	<1	2.1	nd	10.6	0.3	nd	4	13	148	<1	33	1.5	17	nd
25	143	2.5	110	1.8	24	1	2.2	nd	13.0	0.4	nd	5	15	138	3	27	1.5	17	nd
26	115	4.9	54	1.0	20	nd	2.0	<20	8.1	0.1	<5	3	nd	297	6	64	0.5	24	<5
27	111	2.5	57	11.8	20	nd	2.7	<20	237.0	0.7	<5	1	nd	110	9	<20	1.2	15	<5
28	<5	1.8	20	1.7	22	nd	3.5	<20	18.0	0.3	<5	1	nd	134	7	67	0.5	11	<5
29	178	3.7	59	4.2	29	nd	2.3	<20	52.0	0.6	<5	1.5	nd	166	11	41	1.3	23	<5
30	114	2.4	61	1.2	19	nd	2.2	<20	8.9	0.2	<5	1	nd	145	15	45	0.4	20	<5
31	99.1	1.5	57	1.0	17	nd	1.6	<20	4.7	0.1	<5	2	nd	110	15	37	0.2	13	<5
32	171	5.0	147	1.5	27	<1	<1	nd	22.4	0.3	nd	3	24	150	<1	77	0.9	26	nd
33	144	3.5	76	4.5	20	nd	1.9	<20	62.2	0.3	<5	0.5	nd	143	10	27	1.7	16	<5

Table A12.6 (continued).

Sample id	Sm	Sr	Ta	Th	U	V	W	Y	Yb	Zn	Zr
e	1.19	13	<1	13.5	2.4	nd	4.31	nd	0.95	39	110
f	1.1	320	<1	15.6	2.41	nd	6.3	nd	0.7	0	168
a	1.15	0	<1	10.8	<2	nd	4.98	nd	0.84	6	150
d	3.77	17	<1	11.9	2.87	nd	8.89	nd	0.94	14	191
b	0.79	0	<1	11.4	3.05	nd	7.79	nd	0.89	5	158
c	8.7	24	<1	26.8	5.15	nd	4.73	nd	1.88	30	134
1	1.4	18	<1	22.1	2.89	138	12	9	0.7	21	240
2	5.4	228	1.1	3.2	4.74	49	<2	19	1.8	51	114
3	4.6	234	1.1	3.0	<2	43	<2	17	1.5	56	109
4	4.6	235	<1	3.1	<2	52	4	17	1.6	33	103
5	5.1	278	1.4	3.1	<2	51	<2	19	1.9	189	111
6	5.8	343	1.5	2.7	<2	60	<2	30	2.7	93	100
7	4.1	444	<1	1.4	<2	161	<2	14	1.3	212	63
8	3.9	308	<1	1.7	nd	206	6	11	1.4	160	68
9	4.0	460	<1	1.6	<2	139	8	19	2.0	126	79
10	12.9	45	1.1	23.0	2.79	86	3	15	1.4	22	266
11	7.8	63	<1	19.2	2.52	67	7	17	1.6	21	380
12	5.2	333	1.1	2.9	<2	53	8	23	2.2	175	114
13	18.2	168	2.0	40.4	4.32	89	19	27	2.5	47	685
14	1.9	205	1.7	2.0	nd	204	7	10	1.2	183	65
15	3.3	265	<1	0.8	nd	169	<2	15	1.3	103	65
16	4.0	334	<1	1.4	nd	197	<2	18	1.8	122	69
17	5.1	417	1.4	1.5	<2	186	12	18	1.6	186	77
18	5.8	303	2.2	3.2	<2	57	6	27	2.6	170	105
19	2.1	105	<1	0.6	<2	47	10	9	0.5	35	16
20	6.9	79	<1	17.4	3.61	63	14	17	1.8	25	512
21	6.2	206	1.3	1.5	nd	222	5	27	3.1	211	72
22	3.2	257	1.1	0.8	nd	151	6	17	1.7	121	66
23	16.4	285	1.1	1.0	nd	253	7	33	3.9	194	74
24	4.4	264	1.9	1.3	nd	175	8	26	2.0	166	73
25	5.6	215	<1	1.4	nd	194	7	28	2.8	155	74
26	3.9	391	1.2	1.0	<2	160	27	18	2.0	117	56
27	46.0	193	2.0	1.0	<2	134	23	42	5.0	136	58
28	4.9	307	1.9	3.1	<2	53	41	19	2.1	137	107
29	13.3	301	<1	1.4	<2	167	8	30	4.1	158	70
30	3.9	303	2.2	1.8	<2	157	27	18	1.9	97	52
31	2.5	293	2.4	1.7	<2	122	58	14	0.9	68	52
32	6.3	323	1.4	1.8	nd	241	<2	22	2.2	187	74
33	17.2	193	<1	1.4	<2	165	11	18	2.0	132	62

Table A12.6 (continued).

Sample	Depth(m)	Al2O3	CaO	Fe2O3	K	MgO	MnO	Na	P2O5	S	SiO2	TiO2	Ag	As	Au
st1-1	0.5	10.45	7.43	10.99	0.86	2.25	0.142	0.63	0.025	0.97	49.97	0.71	2	15.1	191
st1-2	1.5	12.57	3.61	13.91	0.84	1.97	0.111	0.92	0.018	0.726	51.16	0.8	3	19.5	212
st1-3	2.5	14.07	0.36	12.85	0.29	1.56	0.056	1.01	0.015	0.813	56.36	0.86	1	17.9	169
st1-4	3.5	13.91	0.15	14.88	0.12	1.19	0.024	0.82	0.011	0.675	54.39	1	1	19.9	68.8
st1-5	4.5	12.98	0.07	14.31	0.34	0.97	0.018	0.66	0.011	0.1	55.87	1.17	<1	18.6	15.4
st1-6	5.5	15.9	0.04	12.43	0.29	0.94	0.016	0.62	0.008	0.092	53.91	1.16	<1	15.4	6.1
st1-8	7.5	16.83	0.03	22.03	0.12	0.76	0.021	0.44	0.009	0.093	43.93	1.29	<1	25.2	2.5
st1-10	9.5	18.2	0.13	9.23	0.12	0.62	0.012	0.58	0.007	0.244	55.57	1.6	3	13.2	11.8
st1-12	11.5	27.4	0.13	7.54	0.12	0.36	0.008	0.50	0.005	0.703	46.82	1.52	<1	11.8	15.7
st1-14	13.5	32.05	0.02	3.99	0.12	0.27	0.001	0.57	0.004	0.257	44.24	1.2	<1	6.23	13.3
st1-16	15.5	32.32	0.08	4.91	0.99	0.22	0.003	1.52	0.013	6.428	29.46	1.26	<1	19.3	85
st1-18	17.5	30.33	0.04	12.93	0.12	0.22	0.004	0.58	0.009	1.304	37.63	1.54	<1	48.2	11.9
st1-20	19.5	23.27	0.03	3.19	0.34	0.21	0.014	0.44	0.018	1.881	58.93	1.6	<1	32.1	63.6
st1-22	21.5	9.84	0.02	1.32	0.46	0.1	0.020	0.22	0.011	0.665	82.72	0.84	<1	7.39	10.1
st1-24	23.5	21.3	0.03	1.63	0.12	0.17	0.033	0.50	0.004	0.413	65.6	0.96	<1	5.72	13.4
st1-26	25.5	19.19	0.08	19.46	0.12	0.97	0.036	1.12	0.015	0.891	40.74	1.43	<1	77.7	2.5
st1-28	27.5	17.95	0.19	14.59	0.47	0.97	0.030	1.28	0.017	0.698	49.87	0.64	<1	60.7	2.5
st1-30	29.5	16.6	1.94	10.86	0.59	1.04	0.124	2.78	0.03	1.169	56.9	1.18	1	74.6	14.8
st1-32	31.5	17.15	2.96	7.50	0.70	1.13	0.285	3.53	0.024	0.347	59.62	1.34	<1	48.7	2.5
st1-34	33.5	18.55	2.68	9.99	1.35	1.51	0.083	3.27	0.03	0.567	55.63	1.51	<1	44.8	8420
st1-36	35.5	18.75	2.6	11.14	1.33	1.86	0.119	2.76	0.041	0.931	52.03	1.6	1	48.4	336
st1-38	37.5	15.27	1.74	13.12	0.94	1.88	0.099	2.36	0.064	0.29	52.55	1.38	<1	52.7	215
st1-40	39.5	16.42	3.11	8.57	0.77	1.07	0.071	4.25	0.091	0.496	59.56	1.48	3	43.1	350
st1-44	43.5	16.49	3.11	8.25	1.14	1.35	0.080	4.47	0.096	0.307	59.6	1.29	<1	35.1	345
st1-48	47.5	17.21	3.66	6.80	1.19	1.29	0.069	4.51	0.091	0.22	60.11	1.29	<1	38.4	70
st1-52	51.5	15.92	2.99	8.87	0.93	1.42	0.076	3.91	0.109	1.109	59.21	0.96	3	47.9	247
st1-56	55.5	15	2.87	7.57	0.39	1.18	0.071	3.84	0.12	0.137	63.8	1.33	<1	32.8	44.8

Sample	Ba	Bi	Br	Ce	Cl	Co	Cr	Cs	Cu	Eu	Ga	Ge	Hf	La	Lu
st1-1	205	1	17.1	46.6	1740	28	883	4.29	78	0.92	16	<1	3.52	21.7	0.25
st1-2	137	1	17.9	45.4	3380	30.7	1230	5.14	73	0.97	20	2	3.43	21.5	0.27
st1-3	274	<1	27	49.3	3300	35	988	5.31	68	0.81	19	2	3.97	16.7	0.26
st1-4	108	1	37.9	8.3	2690	12.9	1180	2.69	68	<0.5	24	1	4.43	5.67	<0.2
st1-5	153	1	37.3	5.02	2070	9.85	1110	2.89	61	<0.5	30	1	5.33	3.71	<0.2
st1-6	172	1	34	5.78	900	13	1080	2.65	60	<0.5	29	1	4.49	3.01	<0.2
st1-8	251	<1	29.6	7.34	690	18.1	1850	1.46	52	<0.5	33	1	5.08	3.96	<0.2
st1-10	130	<1	30	4.03	1660	17	949	1.33	37	<0.5	35	3	5.64	2.35	<0.2
st1-12	124	<1	27.8	6.42	1810	19	465	<1	15	<0.5	43	2	6.32	2.1	<0.2
st1-14	<100	<1	26.5	4.78	4330	15.5	184	<1	3	<0.5	47	2	6.52	1.83	<0.2
st1-16	441	1	35.6	5.61	5500	14.6	156	<1	46	<0.5	48	2	5.27	3.93	<0.2
st1-18	<100	<1	23.2	11.6	4100	26.3	143	<1	9	<0.5	54	2	6.04	5.16	<0.2
st1-20	115	<1	18.1	28.9	2520	15.5	161	3.21	20	0.99	37	2	7.92	23.4	<0.2
st1-22	106	<1	7.59	22.7	940	3.35	72.3	<1	12	0.54	11	1	5.04	16.9	<0.2
st1-24	<100	<1	19.6	23	3010	3.08	115	<1	40	<0.5	22	2	3.9	3.94	<0.2
st1-26	<100	<1	23.4	23.2	7160	28	191	5.14	191	<0.5	29	<1	3.16	3.81	<0.2
st1-28	1330	<1	37.3	22.6	12350	30.1	161	9.77	157	<0.5	20	1	2.31	4.6	<0.2
st1-30	<100	<1	17.4	149	5910	42.6	126	8.29	89	0.63	22	1	2	11.3	<0.2
st1-32	270	2	10.3	127	3920	60.7	136	6.32	106	1.2	26	1	2.01	14.1	<0.2
st1-34	186	<1	6.99	30	2520	58.8	171	4.96	147	1.49	27	<1	2	22.4	0.32
st1-36	532	<1	8	59.6	3110	62.1	151	4.95	125	4.16	28	1	2.32	89.6	0.6
st1-38	455	<1	8.69	25.3	1420	67.9	139	2.19	96	1.87	25	<1	2.21	15.5	0.45
st1-40	329	<1	5.75	22.1	2320	56.6	143	2.54	110	1.84	24	1	2.19	13	0.4
st1-44	470	<1	9.2	26.4	3910	63.9	131	2.36	89	1.42	23	<1	2.14	10.6	0.27
st1-48	531	<1	15.3	23	6730	52.6	148	1.91	87	1.2	24	1	2.18	9.75	0.23
st1-52	392	<1	8.2	17.1	3190	60.5	143	2.09	78	1.23	21	<1	2.19	7.3	0.21
st1-56	407	1	5.14	24.2	2270	46.7	123	2.16	101	1.13	20	1	1.97	7.62	<0.2

Table A12.7: Elemental abundances at Steinway for drill hole ST-1 (10808E 4250N). Majors are in %, traces in ppm and Au in ppb. Results from Gardiner (1993).

Sample	Nb	Nd	Ni	Pb	Rb	Sb	Sc	Sm	Sr	Ta	Th	V	W	Y	Yb	Zn	Zr
st1-1	7	24	198	12	31	0.87	20	4.56	192	1.16	9.4	216	<2	17	1.81	87	123
st1-2	7	19	211	16	41.4	1.13	27	4.54	170	1.42	10.3	273	<2	17	1.96	88	131
st1-3	11	14	184	14	34.6	0.92	28	3.95	108	1.19	10.9	240	3.61	15	1.72	80	148
st1-4	9	<1	130	6	<20	0.98	30	1.04	66	1.11	10.4	303	<2	5	0.92	65	175
st1-5	11	<1	112	4	<20	0.97	28	0.7	31	1.66	8.58	330	3.71	4	0.86	52	193
st1-6	12	<1	146	4	<20	0.94	30	0.64	16	1.43	7.5	280	4.41	5	0.89	53	203
st1-8	11	<1	209	6	<20	1.92	38	0.94	11	1.89	9.75	458	4.64	4	0.95	26	194
st1-10	11	1	203	5	<20	0.98	25	0.62	14	1.14	7.6	201	8.75	6	0.9	18	234
st1-12	16	<1	134	2	<20	1.1	16	0.94	11	1.11	11.8	145	4.54	8	1.09	8	265
st1-14	10	6	74	4	<20	0.88	11	0.97	8	1.01	14.5	70	2.98	8	0.93	1	278
st1-16	10	3	83	44	<20	1.1	18	0.94	702	1.16	11	90	5.22	5	0.74	4	230
st1-18	13	5	114	10	<20	1.46	10	1.57	30	1.12	13.9	219	6.45	10	0.99	6	253
st1-20	22	18	47	13	<20	1.91	9	3.16	44	1.44	11.1	102	13.7	11	1.19	22	392
st1-22	8	8	17	10	<20	0.94	6	2.03	66	<1	4.72	45	24.1	8	0.84	13	238
st1-24	4	2	11	1	<20	1.37	12	0.71	13	<1	6.2	82	32.4	6	0.91	17	145
st1-26	2	7	78	4	<20	4.06	40	1.29	20	<1	5.19	540	60.7	6	0.58	93	126
st1-28	1	2	70	4	33.8	2	25	1.26	36	<1	2.28	246	22.3	4	0.77	93	82
st1-30	5	8	108	15	44.4	1.21	26	1.91	205	1.68	1.99	204	7.2	10	1.18	183	65
st1-32	3	20	101	3	48.5	1.03	20	3.91	308	<1	1.66	206	6.36	11	1.38	160	68
st1-34	3	24	150	<1	77.4	0.89	26	6.27	323	1.36	1.8	241	<2	22	2.24	187	74
st1-36	7	91	209	1	38.7	1.38	30	16.4	285	1.06	0.97	253	6.92	33	3.89	194	74
st1-38	5	22	194	1	30.8	1.53	28	6.17	206	1.25	1.47	222	5.44	27	3.05	211	72
st1-40	5	15	138	3	27.4	1.51	17	5.55	215	<1	1.36	194	7.05	28	2.76	155	74
st1-44	4	13	148	<1	33.3	1.51	17	4.44	264	1.88	1.28	175	7.63	26	1.96	166	73
st1-48	6	14	105	<1	30.7	1.31	18	3.98	334	<1	1.35	197	<2	18	1.78	122	69
st1-52	4	4	135	2	34.1	1.48	20	3.15	257	1.13	0.82	151	5.91	17	1.67	121	66
st1-56	3	7	122	3	22.9	0.98	15	3.28	265	<1	0.79	169	<2	15	1.29	103	65

Table A12.7 (continued),