

**EXPLANATORY
NOTES**



GEOCHEMICAL MAPPING OF THE SIR SAMUEL 1:250 000 SHEET

by **C. J. KOJAN, J. A. FAULKNER
and A. J. SANDERS**



GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

DEPARTMENT OF MINERALS AND ENERGY



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Contents

Abstract	1
Introduction	1
Setting	2
Access	2
Climate and vegetation	2
Topography and drainage	2
Landforms and regolith development	3
Previous geoscientific investigations and data acquisition	3
Geological mapping	3
Regolith mapping and Cainozoic stratigraphy	3
Rangeland mapping	4
Hydrogeological investigations	4
Mineral-resource and occurrence datasets	4
Geochemical surveys in open-file company reports	4
Topographic and remote-sensing datasets	4
Geology	5
Greenstone belts	5
Agnew – Mount Keith – Perseverance greenstone belt	5
Yandal greenstone belt	5
Dingo Range greenstone belt	6
Granitoid gneiss	6
Granitoid rocks	6
Granitoids of the Southern Cross Province	6
Granitoids of the western Norseman–Wiluna belt	6
Granitoids of the eastern Norseman–Wiluna belt	6
Granitoids east of the Norseman–Wiluna belt	7
Granitoid dykes, and quartz and pegmatite veins	7
Proterozoic mafic dykes	7
Proterozoic sedimentary rocks	7
Permian sedimentary rocks	7
Mineralization	7
Gold	8
Nickel	9
Copper	10
Uranium	10
Regional regolith and geochemical mapping	10
Sampling density	10
Site selection	10
Sample-site form	10
Sampling	10
Regolith-materials mapping	11
Regolith regimes and map units	11
Relict regime	11
Erosional regime	11
Depositional regime	13
Chemical analysis	14
Analytical methods	14
Quality control	14
Analysis of Genalysis standard reference samples	14
Analysis of GSWA standards	15
Repeat analysis by Genalysis	15
Inclusion of duplicate samples from the same sample site	15
Analysis of duplicate samples obtained from archive material: analysis by Analabs and Australian Assay Laboratories	16
Analysis of other components	16
Acidity–alkalinity and conductivity determinations	16
Acidity–alkalinity measurements	16
Conductivity measurements	16
Mineralogical determinations	16
Data presentation	16
Element-distribution maps	18
Special-purpose geochemical maps	18
Acidity–alkalinity and salinity maps	18
Company surface-geochemistry projects — maps and table	18

Results and discussion	18
Mineralogy of selected regolith samples	19
Comparison of regolith units	19
Regolith units derived from greenstone	19
Relict regime	21
Erosional regime	21
Depositional colluvial regime	21
Regolith units derived from granitoid gneiss	21
Regolith units derived from granitoid	21
Relict regime	22
Erosional regime	23
Depositional colluvial regime	23
Regolith units derived from alluvial and lake areas	23
Regional regolith geochemistry	23
Greenstone-belt geochemistry	24
Agnew – Mount Keith – Perseverance greenstone belt	24
Yandal greenstone belt	24
Dingo Range greenstone belt	24
Granitoid and granitoid-gneiss geochemistry	24
Granitoids of the Southern Cross Province	25
Granitoid gneiss of the western Norseman–Wiluna belt	25
Granitoids of the eastern Norseman–Wiluna belt	25
Granitoids east of the Norseman–Wiluna belt	25
Mineralization potential	25
Gold mineralization	25
Greenstone chalcophile-index (gold and VHMS mineralization)	25
Nickel mineralization	26
Uranium mineralization	26
Summary and conclusions	26
References	28

Appendices

1. Production and resources of gold	31
2. Production and resources of nickel, copper and uranium	34
3. Open-file geochemistry surveys	35
4. Sample-site form	62
5. Department of Agriculture site types compared with GSWA regolith units	63
6. Calculation of greenstone chalcophile-index values	66

Plates (in pocket)

1. Regolith-materials map (1:250 000)
2. Sample locations (1:250 000)
3. Company surface geochemistry projects (1:250 000)
4. Company surface geochemistry projects (1:250 000)
5. Sample locations overlay (1:1 000 000)

Figures (from p. 69)

1. Locality plan
2. Generalized regolith
3. Geological interpretation
4. Groundwater salinity
5. Acidity–alkalinity
6. Regolith salinity

Element-distribution maps (7–49)

7. TiO_2
8. Fe_2O_3
9. MnO
10. MgO
11. CaO (other than lake and calcrete samples)
12. CaO (lake and calcrete samples)
13. Na_2O
14. K_2O
15. P_2O_5

16. As
17. Au
18. Ba
19. Bi
20. Ce
21. Co
22. Cr
23. Cu
24. F
25. Ga
26. La
27. Mo
28. Nb
29. Ni
30. Pb
31. Pd
32. Pt
33. Rb
34. S
35. Sb
36. Sc
37. Se
38. Sn
39. Sr
40. Ta
41. Te
42. Th
43. U
44. V
45. W
46. Y
47. Zn
48. Zr
49. Highest values: Ag, Be, Li
50. Contoured gold geochemistry
51. Principal components
52. Greenstone chalcophile-index

Tables

1. Size classification scheme for gold, nickel and uranium mines and deposits	8
2. Historical gold production for SIR SAMUEL	9
3. Regolith codes and descriptions	12
4. Detection limits and number of samples below detection	15
5. XRD mineralogical analysis of selected samples	17
6. Geometric means of analytical results for regolith units derived from greenstone	20
7. Geometric means of analytical results for regolith units derived from granitoid gneiss	21
8. Geometric means of analytical results for regolith units derived from granitoid	22
9. Geometric means of analytical results for regolith units derived from alluvial and lake areas	23

Digital dataset (in pocket)



SIR SAMUEL regional-geochemistry data (SAMCHEM.CSV)

Geochemical mapping of the Sir Samuel 1:250 000 sheet

by

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Abstract

Regolith and geochemical mapping of SIR SAMUEL at 1:250 000 scale is based on field observations and sampling of regolith at a nominal density of one sample per 16 km², followed by chemical analysis of regolith samples. Of the 1026 regolith samples collected on SIR SAMUEL, 397 are samples of stream sediment, 421 are sheetwash samples, 156 are soil samples, and 52 are lake-sediment samples. Each sample has been analysed for 47 elements, pH and conductivity. Forty-four of these elements are shown on 1:1 000 000-scale element-distribution maps. Salinity and pH data are shown as contour maps. The distribution of regolith is shown at 1:250 000 scale. Twenty eight regolith-landform units have been identified, using field observations and remotely-sensed data (Landsat TM, aeromagnetic and radiometric data). In addition, open-file company data involving surface geochemistry have been compiled, along with production figures and in-ground resources for gold, nickel, copper and uranium.

Regolith chemical data clearly distinguish areas of granitoid and greenstone, and also allow subtle distinctions between the different greenstone belts. The distribution of elements such as Cr and Co indicate that mafic and ultramafic rocks are more extensive than indicated by regional mapping of bedrock. Compositional differences between similar regolith-landform units on LEONORA and SIR SAMUEL can be attributed to different bedrock sources, and local variations in conditions of weathering.

Statistical treatment of regolith chemical data (principal-component analysis, and calculation of chalcophile indices over greenstones) has identified areas of potential mineralization. Some of these correspond to areas of known mineral production, yet there are several other locations with anomalous regolith-gold concentrations that warrant further investigation. In addition, chalcophile-index values have outlined several areas of potential gold and base-metal mineralization where regolith values for gold and other pathfinder elements are low.

KEYWORDS: Sir Samuel, Yilgarn Craton, regolith, geochemistry, geochemical maps, regional surveys.

Introduction

Regolith and geochemical maps of the SIR SAMUEL* 1:250 000 map sheet have been prepared as part of the regional regolith and geochemical mapping program of the Geological Survey of Western Australia (GSWA). The aim of this program is to provide information about the geochemistry and distribution of regolith to assist geological mapping, mineral exploration, pastoral and agricultural activities, and environmental monitoring.

The SIR SAMUEL regolith and geochemical mapping project is the fifth in the current series. Previously published projects have covered parts of the northern Yilgarn Craton and Gascoyne Province (MENZIES — Kojan and Faulkner, 1994; LEONORA — Bradley et al., 1995; PEAK HILL — Subramanya et al., 1995; and GLENGARRY — Crawford et al., 1996). SIR SAMUEL is in the northern part

of the highly mineralized Norseman–Wiluna greenstone belt, which is part of the Eastern Goldfields Province (Griffin, 1990) of the Archaean Yilgarn Craton. The Yilgarn Craton consists of discrete belts of greenstone (i.e. metamorphosed volcanic and sedimentary rocks) separated by larger areas of granitoid and gneiss. The SIR SAMUEL, LEONORA and MENZIES regolith and geochemical mapping projects complement geological mapping by GSWA and the Australian Geological Survey Organisation (AGSO) in the Eastern Goldfields, which is part of the collaborative National Geoscience Mapping Accord. This Accord aims to provide remote-sensing datasets, regolith-landform maps and 1:100 000-scale geological maps to support more effective mineral exploration in the northern Eastern Goldfields.

The GSWA regolith and geochemical mapping program involves the description and sampling of regolith from over 1000 sites per 1:250 000 map sheet area (i.e. about one sample per 16 km²) and the analysis of over 40 elements per sample. The regolith comprises clastic and

* Capitalized names refer to standard map sheets.

chemically deposited materials that overlie and commonly conceal bedrock and associated mineralization. The regolith includes both rock that has weathered *in situ*, and debris that has resulted from weathering and transportation. Examples of regolith types in the Yilgarn Craton and adjacent areas include laterite, ferricrete, duricrust, hardpan, lag, silcrete, calcrete, claypan, saltpan, saprolite and sheetwash. The regolith therefore includes a wide variety of relict, erosional, and depositional material.

As a consequence of significant improvements in analytical precision and accuracy, regional-scale geochemical dispersion patterns in regolith, even at such a low sample density as one sample per 16 km², can be related to source rocks and mineralization, or used as the basis for more-detailed surveys. The GSWA program therefore complements both project-scale surveys involving detailed sampling over a limited area, and research-oriented regional-scale regolith mapping surveys based on field observation and remote sensing (e.g. AGSO's regolith-landform maps).

The distribution and chemical composition of regolith on SIR SAMUEL is shown as a regolith-materials map and a series of element-distribution maps. In addition, the pH and conductivity of regolith samples from SIR SAMUEL have been measured. These data are shown as contour maps of acidity-alkalinity (pH) and conductivity (as total dissolved solids — TDS) respectively, along with a contoured groundwater-salinity map using borehole data supplied by the Water and Rivers Commission. Chalcophile-index values for regolith samples derived from greenstone have been used to highlight areas with potential for gold and base-metal mineralization.

Setting

SIR SAMUEL (SG/51-13) lies between latitudes 27°00'S and 28°00'S and longitudes 120°00'E and 121°30'E, and includes parts of the East Murchison and Mount Margaret Goldfields. The map sheet takes its name from the abandoned mining town of Sir Samuel. Mining is currently the main economic activity of the area. Leinster, the largest town on SIR SAMUEL, is located 378 km north of Kalgoorlie, close to the Kalgoorlie–Meekatharra highway. Leinster was established in 1989 to support the Perseverance (Agnew) nickel mine. Examples of other major operating mines on SIR SAMUEL include Mount Keith (nickel), and Bellevue, Darlot and Bronzewing (gold). Gold was formerly mined at the Corboys, Kathleen Valley and New England mining centres (Fig. 1).

The Wanjarri Class A Nature Reserve is located to the east of Kathleen Valley in the centre of SIR SAMUEL. The remainder of the map sheet is covered by pastoral stations engaged in sheep grazing for wool production, although many of these stations are now owned by mining companies. Station homesteads located on SIR SAMUEL are Albion Downs, Leinster Downs, Depot Springs, Yeelirrie, Melrose, Wonganoo, Yandal, Barwidgee, and Yakabindie (Fig. 1).

Access

The Kalgoorlie–Leonora–Wiluna–Meekatharra highway traverses SIR SAMUEL and provides access from Perth via Kalgoorlie. The road is sealed from Kalgoorlie to Mount Keith in the northern part of SIR SAMUEL. A shorter route to Perth can be taken via the unsealed road from Leinster via Agnew (on the adjacent LEONORA; 1:250 000), then to Sandstone, Mount Magnet, and Paynes Find on the Great Northern Highway.

A formed, but unsealed road links Leinster to Bronzewing, to the northeast (Fig. 1). Other unsealed roads link these centres to the former Corboys mining centre and Barwidgee Homestead (to the north), Wonganoo Homestead (to the northeast), and Yandal Homestead and Lake Darlot mining centre (to the southeast). The Lake Darlot mining centre is also accessible by roads connecting with the main Leonora–Leinster road.

Access away from roads is good overall. Although greenstone belts are densely wooded in parts, there is a network of mineral exploration tracks. Most of the remaining areas of granitoid and gneiss are sparsely vegetated, apart from active drainages, and are readily accessible by station tracks and fencelines.

Climate and vegetation

SIR SAMUEL has a semi-arid climate with hot summers and cool to mild winters. January is the hottest month with an average maximum temperature of 36°C and an average minimum temperature of 22°C. July is the coolest month with an average maximum of 18°C. The average annual rainfall is about 215 mm, but this is highly variable and includes both winter showers and heavy falls that may result from cyclonic activity in late summer.

SIR SAMUEL lies within the Eremaean botanical district of Beard (1981). Vegetation is controlled by bedrock, landform, regolith and rainfall. The main vegetation associations are spinifex-hummock grassland on sandplain, mulga woodland on sheetwash areas, scattered mulga, cassia, currant bush and wattle on low greenstone hills, and a halophytic association of saltbush, bluebush and samphire, mainly on saline lowlands. The latter commonly form palaeodrainages, but can also occur below breakaways in areas of greenstone and granitoid outcrop.

Topography and drainage

The terrain on SIR SAMUEL ranges from 437 to 612 m Australian Height Datum (AHD). The lowest point occurs in Lake Darlot in the southeast of the map sheet, and the highest point occurs on the Barr Smith Range, an elevated plateau located in the northwest of the sheet (Fig. 1). Two major drainage divides trending broadly northwest separate three major trunk-valley systems (Bunting and Williams, 1979). Part of a third drainage divide is represented in the northeast corner of the area. The three palaeodrainages on SIR SAMUEL comprise a southerly trending palaeodrainage

located in the southwest corner of the map sheet near Depot Springs Homestead, a southeasterly and easterly trending palaeodrainage that crosses the entire map sheet (including Lakes Miranda and Darlot), and a southeasterly trending palaeodrainage located in the northeast of the map sheet, which includes Lake Maitland. These drainage divides are marked for much of their length by lines of low cliffs, or breakaways, in lateritized bedrock. Breakaways define the edge of an older erosion surface (Jutson, 1934) and are predominantly south or southwest facing. Recent studies by Ollier et al. (1988) and Davy and Gozzard (1995) have demonstrated that much of the ferricrete (duricrust) forming this older erosion surface has been transported and may have been initially deposited on valley floors.

The three palaeodrainage systems (Commander et al., 1991) represent sections of an extensive Cretaceous to Early Tertiary river system that converged and flowed into the sea (now the Eucla Basin) near present-day Ponton Creek on the edge of the Nullarbor Plain (Allen, 1994). The uplift of the older erosion surface in the Eocene initiated the development of the southeasterly drainage pattern. These palaeodrainages contain thick sequences of Cainozoic sediments overlain by areas of sandplain, calcrete and extensive salt lakes or playas.

The main drainage divides and breakaways include the prominent Barr Smith Range, which is underlain by granitoid, and the Bates Range in the eastern part of the map sheet, which is underlain by greenstone. Granitoid commonly outcrops on pediments located below breakaways, whereas greenstone commonly outcrops as low ranges of hills. The orientation of these ranges reflects the predominant northerly or north-northwesterly trending bedrock foliation. Examples include Violet Range, north of Lake Miranda, and Dingo Range in the northeast of the map sheet.

Landforms and regolith development

Regolith includes deeply weathered lateritic profiles consisting of duricrust, saprolite and saprock, and Cainozoic–Recent sediments derived from erosion of weathered rock and underlying bedrock. Regolith also includes eolian deposits of quartz sand and gypsum sand (kopi), and chemical deposits such as calcrete, salt and gypsum. Cainozoic–Recent deposits are commonly thin, however hardpan deposits up to 30 m thick have been intersected in drillholes located north of Lake Darlot, and clay units up to 66 m thick have been intersected within the Lake Darlot palaeodrainage (AFMECO PTY LTD, 1978). Bunting and Williams (1979) reported that calcrete deposits within palaeodrainages range from 15 to 50 m thick, and clay units up to 100 m thick may exist below the larger salt lakes.

Nine major regolith–landform types are recognized on SIR SAMUEL:

- sandplain, with or without dunes, developed on granitoid, lateritized granitoid, sheetwash and alluvial plains,

- granitoid breakaways and plateau areas with silcrete and pisoliths,
- granitoid domes and tors,
- stony plains developed on granitoid,
- colluvial plains and sheetwash derived from granitoid and granitoid gneiss,
- hills and ridges of greenstone,
- stony plains developed on greenstone, including small duricrust-capped hills and ridges,
- colluvial plains and sheetwash derived from greenstone,
- saline alluvial plains, calcrete platforms and salt lakes developed in trunk valleys and on drainage floors.

For the purpose of geochemical interpretation, it is convenient to consider these landforms and their associated regolith units in terms of residual, erosional and depositional regimes as defined by Anand et al. (1993). The term *relict* is used here in lieu of *residual*. The *relict regime* includes upland sandplain, granitoid breakaways and plateau areas, and small duricrust-capped hills and ridges. The *erosional regime* includes granitoid domes and tors, hills and ridges of greenstone, and stony plains developed on greenstone and granitoid. Upslope alluvial and colluvial plains, downslope sheetwash plains, and alluvial, eolian and chemical deposits in trunk valleys and on drainage floors are assigned to the *depositional regime*. The distribution of these three regimes on SIR SAMUEL is summarized in Figure 2, and shown in detail on Plate 1.

Previous geoscientific investigations and data acquisition

Geological mapping

The first edition of the SIR SAMUEL 1:250 000 geological map was compiled by Bunting and Williams (1979). Subsequent 1:100 000-scale geological maps have been produced for SIR SAMUEL (Liu et al., 1996), DARLOT (Wyche and Westaway, 1996), and WANGGANNOO (Lyons, in prep.). Outcrops shown on the accompanying 1:250 000-scale regolith-materials map (Plate 1) have been derived from these geological maps. The geological interpretation map for SIR SAMUEL (Fig. 3) has been compiled by S. Wyche and T. Griffin from published geological maps and a total magnetic intensity image (GSWA, 1996).

Regolith mapping and Cainozoic stratigraphy

AGSO has produced a 1:250 000 regolith–landform map of SIR SAMUEL (Craig and Churchward, 1995), and detailed regolith–landform mapping of selected mining centres on SIR SAMUEL is being undertaken by CSIRO as part of

various AMIRA (Australian Mineral Industries Research Association)-sponsored projects. Glassford (1988) described the Cainozoic stratigraphy of the Yeelirrie district (Plate 2), and Glassford and Semeniuk (1995) argued that much of what was thought to be a lateritic profile developed in situ was transported material.

Rangeland mapping

The rangelands of the northern Eastern Goldfields, covered by the SIR SAMUEL, LEONORA, MENZIES, EDJUDINA, DUKETON and LAVERTON 1:250 000 map sheets, have been mapped by a joint team from the Departments of Agriculture and Land Administration (Pringle et al., 1994). At various sites (termed inventory sites) details of geology, regolith, soil profile, soil pH and vegetation have been recorded. One hundred and forty-three (or 20%) of these inventory sites are located on SIR SAMUEL. Results are presented as 1:250 000 land-system maps, which show the individual sites and site types, the latter representing a unique combination of regolith, soil and vegetation. The relationships between the various site types on SIR SAMUEL and the regolith-landform units of this study (Plate 1) are discussed below.

Hydrogeological investigations

Several regional investigations of groundwater availability, and potential for irrigation and mine development, have been carried out. Sanders (1969) reviewed the potential of calcrete aquifers, and Forbes (1978) and Bestow (1992) reviewed salinity, recharge and groundwater-storage potential in the Eastern Goldfields. In a review of the hydrogeology of the northern Eastern Goldfields, Allen (1994) included descriptions of various aquifer types. Although these studies demonstrated the abundance of groundwater throughout the Eastern Goldfields, they showed that major water supplies were restricted to specific aquifer types, and although water quality varies, it is commonly brackish to hypersaline.

Bestow (1992) reported that groundwater salinity on SIR SAMUEL ranges from 840 mg/L TDS for water from fracture zones in more elevated areas, to 223 000 mg/L for groundwater below Lake Miranda. The total groundwater resource for SIR SAMUEL was estimated at $9581 \times 10^6 \text{ m}^3$ of which $4084 \times 10^6 \text{ m}^3$ was classed as fresh to brackish (<1500 mg/L TDS). Figure 4 shows groundwater salinity for SIR SAMUEL, based on borehole data supplied by the Water and Rivers Commission.

Mineral-resource and occurrence datasets

Mineral-resource data (Appendices 1 and 2) have been compiled from records of past production published in the 'List of cancelled gold mining leases' (Department of Mines, 1954) and updated production records from the Royalties Division of the Department of Minerals and Energy (DME).

Details of in-ground resources were obtained from the GSWA MINEDEX database. The locations of various mines and mineral deposits on SIR SAMUEL were obtained from a variety of sources including TENGRAPH (the graphical database maintained by the Mineral Titles Division of DME), published geological maps, and maps from various geological and mining journals.

Resource figures from the MINEDEX listing for January 1996 are current to at least mid-1995. Production figures are valid to at least December 1994, although more up to date figures have been used where available.

Geochemical surveys in open-file company reports

Company exploration reports are lodged with DME in compliance with the Mining Act (1978). These are listed in the GSWA WAMEX database, as either open-file or confidential reports. Details of open-file company reports that contain surface or near-surface geochemical data are summarized in Appendix 3. For each project, surface geochemical exploration data (including costean and shallow-drilling information) is captured to depths of up to four metres. Projects with less than 30 samples have been omitted.

Each project has been assigned an identification number (ID No. of Appendix 3) and the project boundaries along with the identification number are shown on Plates 3 and 4, providing an overview of surface exploration coverage on SIR SAMUEL. Most projects cover a single area, although some projects cover two or more separate areas.

The projects in Appendix 3 are tabulated in order of increasing M number for the period 1968 to 1994. When reports are released to open-file, the M number is replaced by an Item number, with the highest Item number denoting the most recent release. Gaps in reporting result from either the failure of some tenement holders to lodge reports on their tenements, or on account of mineral-claim holders not being obliged to report all of their exploration results prior to 1978.

The 107 projects listed in Appendix 3 represent a total of 92 638 samples, which have been analysed on average for three elements. The projects are classified according to the targeted mineralization as follows:

Gold	55%
Copper-nickel	25%
Copper-zinc	15%
Uranium	5%

Topographic and remote-sensing datasets

Topographic and remotely sensed data were used in the construction of the regolith-materials map and the geological interpretation map. The topographic datasets

used for this project were supplied by the Australian Land Information Group (AUSLIG).

A total magnetic intensity image (GSWA, 1996) was used by S. Wyche and T. J. Griffin to interpret geological boundaries and structural features shown on Figure 3. Landsat Thematic Mapper scenes were used extensively to identify regolith-landform unit boundaries for the regolith-materials map (Plate 1). Scenes incorporating bands 2, 4, and 7 were obtained from the remote-sensing group of the Department of Land Administration. Both a 1:100 000-scale image for map compilation, and sets of stereoscopic images for three-dimensional viewing were used. The stereoscopic images were computer-derived using a terrain model generated from elevation data. A K-Th-U radiometric image at 1:250 000 scale produced from data supplied by AGSO was used extensively in the interpretation of regolith-unit boundaries.

Geology

The geology of SIR SAMUEL is typical of Archaean granite-greenstone terranes of the Yilgarn Craton (Fig. 3). The map sheet straddles the northern extension of the Mount Ida Fault, which separates the Eastern Goldfields and Southern Cross Provinces (Griffin, 1990). Three north-northwesterly trending greenstone belts (the western Agnew – Mount Keith – Perseverance belt, the centrally located Yandal belt and the eastern Dingo Range belt) are separated by areas of gneiss and larger areas of granitoid. The two western greenstone belts on SIR SAMUEL, and the intervening gneiss and Koonoonooka monzogranite, form part of the highly mineralized Norseman–Wiluna belt.

Bunting and Williams (1979) provided the first comprehensive account of the geology of SIR SAMUEL. They referred to earlier descriptions of old gold mining centres by Reed (1897) for the Lawlers and Sir Samuel districts; Gibson (1907) for the Sir Samuel and Lake Darlot mines; Talbot (1914) for the Mount Keith mines; and Jutson (1914, 1917) and Montgomery (1909, 1928) for the deep lead at Darlot.

Greenstone belts

Bunting and Williams (1979) presented stratigraphic sections and summarized the geology of the Agnew – Mount Keith – Perseverance, Yandal and Dingo Range greenstone belts. Westaway and Wyche (in prep.) and Liu et al. (in prep.) have made significant contributions to further understanding the geology of these greenstones, but the stratigraphy of the Yandal belt and the relationship between the three greenstone belts remain unclear.

Agnew – Mount Keith – Perseverance greenstone belt

Systematic geological mapping of this belt on SIR SAMUEL followed the discovery of major nickel deposits at Perseverance (formerly Agnew) and Mount Keith during

the period 1968–1971. Durney (1972) and Naldrett and Turner (1977) identified two greenstone sequences separated by an unconformity, marked by the Jones Creek Conglomerate. Griffin (1990) distinguished the Agnew belt, consisting of large fold structures, and a more highly deformed Mount Keith – Perseverance belt. Liu et al. (in prep.) retained the Mount Keith – Perseverance and Agnew belts and defined another greenstone belt, which they called the Yakabindie belt.

The Mount Keith – Perseverance and Agnew belts have a common stratigraphy, comprising ultramafic and mafic rocks overlain by felsic volcanic and sedimentary rocks, which are in turn overlain by basalt, minor sedimentary rock and gabbro.

The ultramafic rocks include serpentinized peridotite and dunite, commonly showing olivine cumulate texture, which are interpreted to be part of a thick komatiite flow sequence. This unit occurs intermittently over a distance of 200 km from Weebo on LEONORA (1:250 000), through the Perseverance and Mount Keith areas to beyond Wiluna, and contains several major nickel deposits (Bunting and Williams, 1979). Other spatially related rocks include komatiite with platy olivine-spinifex texture, pyroxenite, tremolite schist, talc schist, basalt, high-Mg basalt, amphibolite, dolerite and gabbro. The fault-bounded Yakabindie greenstone belt contains the layered Kathleen Valley Gabbro and the overlying Mount Goode Basalt.

According to Liu et al. (in prep.) the stratigraphy of the Mount Keith – Perseverance and Agnew belts corresponds to that of the Kalgoorlie Terrane in the southern part of the Norseman–Wiluna belt (Swager et al., 1995). The Jones Creek Conglomerate overlies greenstones, and is equated with the Kurrawang Formation and other stratigraphically equivalent units described from the southern part of the Norseman–Wiluna belt by Hallberg (1985) and Swager et al. (1995).

Yandal greenstone belt

The geology of the Yandal greenstone belt has been summarized by Bunting and Williams (1979). It consists of a thick sequence of mafic volcanic rocks, overlain by calc-alkaline felsic volcanic rocks with subordinate clastic sedimentary rocks (Spring Well volcanic complex). Mafic rocks outcropping at Gipps Hills (Darlot) may be stratigraphically equivalent to similar rocks on the western margin of the Yandal belt. Mafic volcanic rocks are locally interbedded with felsic volcanic rocks, such as those east of Yandal, and mafic intrusive rocks, including gabbro and dolerite, occur within a mixed mafic/felsic sequence in the central part of the belt at Spring Well and Katherine Well. The Yandal belt is bisected by the northerly trending Ockerburry Fault, whereas the Ninnis Fault (formerly known as the Celia Lineament) defines the eastern boundary of much of the Yandal belt. It is also the eastern boundary of the Norseman–Wiluna belt. The western boundary of the Yandal greenstone belt is marked by the Mount McClure Fault (Westaway and Wyche, in prep.).

At granite–greenstone contacts, greenstone is strongly deformed and locally metamorphosed to amphibolite facies, whereas in areas of lower strain, metamorphism has only reached greenschist facies. Westaway and Wyche (in prep.) referred to two major regional deformation episodes, the first characterized by upright folds around north-northwesterly trending axes, and the second by north-northeasterly to north-northwesterly trending shear zones.

There is no stratigraphy applicable to the whole of the Yandal greenstone belt, although Westaway and Wyche (in prep.) described a stratigraphic section from the western boundary, at the Mount McClure Fault, east to the Ockerburry Fault. In this section, mafic and ultramafic rocks with conspicuous interbeds of chert and silicified shales are overlain by sedimentary rocks and mafic volcanic rocks. Overlying these rocks, west of the Ockerburry Fault, is the Spring Well volcanic complex (Giles, 1980, 1982), a well-exposed sequence of rhyolite, dacite, and basaltic andesite lavas, ash and lapilli tuffs, and coarse-grained fragmental rocks. To the north and east of Spring Well, there are poorly exposed felsic volcanic and volcanoclastic rocks, sandstone, conglomerate and tuff. These are locally interbedded with tholeiitic basalts in the Darlot pit and may represent a distal facies of the Spring Well volcanic complex. The sequence has been intruded by gabbroic sills.

By analogy with mineralized Canadian greenstone sequences, Witt et al. (in prep.) suggested that bimodal basalt–rhyolite associations occurring in the eastern part of the Norseman–Wiluna belt are prospective for volcanic-hosted massive sulfide (VHMS) deposits, and epithermal base- and precious-metal mineralization.

Dingo Range greenstone belt

The Dingo Range greenstone belt extends across the northeast corner of SIR SAMUEL (Fig. 3), and consists of a simple sequence of basalt and high-Mg basalt in the core of the north-northwesterly trending Wonganoo Anticline, overlain by a prominent chert and banded iron-formation horizon with interbedded shale and weathered felsic volcanic rocks (Bunting and Williams, 1979). The upper part of the sequence consists of a thick basalt unit containing chert and serpentized peridotite, which is overlain by poorly exposed tuffaceous and shaly sedimentary rocks. The granite–greenstone contacts are typically fault-bounded, and the southwest margin of the belt is defined by a foliated granodiorite (Bunting and Williams, 1979).

Granitoid gneiss

According to Bunting and Williams (1979), these rocks are a mixture of poorly exposed paragneiss, orthogneiss and amphibolite. The extent of granitoid gneiss on SIR SAMUEL (Plate 1) has largely been interpreted from the total magnetic intensity image (GSWA, 1996). Granitoid gneiss in outcrop is a characteristic colour on the radiometric image (prepared from AGSO data). Regolith samples from

these areas are uniformly low in potassium and high in sodium, indicating a granodiorite or tonalite composition.

Liu et al. (in prep.) referred to the belt of granitoid gneiss on the western margin of the Yandal belt as the Cocks–Satisfaction zone, and noted that it consists of deformed granitoid with lenses of mafic rock and more common intercalations of foliated granitoid and greenstone. The granitoid is a foliated and lineated biotite monzogranite. Westaway and Wyche (in prep.) also argued that the Cocks–Satisfaction zone is the strongly deformed and metamorphosed western margin of the Yandal belt.

Granitoid rocks

The geology of undeformed granitoid rocks on SIR SAMUEL has been reviewed by Bunting and Williams (1979), who presented analyses of 35 samples. Liu et al. (in prep.) and Westaway and Wyche (in prep.) included detailed descriptions of granitoid rocks mapped on SIR SAMUEL and DARLOT (1:100 000). The main types of granitoid described from SIR SAMUEL (1:250 000; Fig. 3) are monzogranite, granodiorite, quartz monzonite, quartz syenite and granite, following the nomenclature of Streckeisen (1976). Bunting and Williams (1979) recognized two main phases of granitoid intrusion: an early syntectonic phase and a late post-tectonic phase. Some details of the distribution of the various types of granitoid rocks on SIR SAMUEL are reviewed below in relation to their geological setting.

Granitoids of the Southern Cross Province

Granitoid rocks located west of the northern extension of the Mount Ida Fault (Fig. 3) are included in the Southern Cross Province. Bunting and Williams (1979) state that this zone is occupied by a locally porphyritic batholith of monzogranite, which belongs to a group of major post-tectonic batholiths separating greenstone belts of the Eastern Goldfields and Southern Cross Provinces.

Granitoids of the western Norseman–Wiluna belt

Granitoids of the western Norseman–Wiluna belt, situated east of the Mount Ida Fault and west of the Perseverance Fault, belong to zone 2 of Bunting and Williams (1979). The main granitoid body of this zone outcrops near the Barr Smith Range, which Roddick et al. (1976) included as part of the Mount Keith Granodiorite. The Leinster Monzogranite (Liu et al., in prep.) separates the Agnew and Mount Keith – Perseverance greenstone belts.

Granitoids of the eastern Norseman–Wiluna belt

Granitoids of the eastern Norseman–Wiluna belt are located east of the Perseverance Fault and west of the Ninnis Fault (Fig. 3), and correspond to zone 3 of Bunting and Williams (1979). The main granitoid body is the

Koonoonooka monzogranite (Liu et al., in prep.), which is bounded to the west by the Perseverance Fault and to the east by the Yandal greenstone belt and a zone of granitoid gneiss that may represent the western margin of the Yandal greenstone belt. The marginal zone of the Koonoonooka monzogranite consists of highly deformed and foliated biotite monzogranite with intercalations of greenstone. This marginal zone, and an associated zone of granitoid gneiss, has a combined width ranging from a few hundred metres east of the Perseverance Fault to 13 km west of the Mount McClure Fault. Porphyritic unfoliated biotite monzogranite outcrops in the Koonoonooka Quarry in the central part of the Koonoonooka batholith (Liu et al., in prep.).

A group of smaller granitoid bodies have been mapped in the eastern part of the eastern Norseman–Wiluna belt on SIR SAMUEL where they intrude the Yandal belt. These bodies include the Weebo Granodiorite and a lithologically similar granitoid body that outcrops east of Melrose Homestead (Westaway and Wyche, in prep.). Westaway and Wyche (in prep.) also described a deeply weathered granodiorite body from the Bates Range area, which outcrops as patches of orange clay, quartz and iron-rich rubble. Other granitoid bodies include the Wadarrah Quartz Monzonite, which outcrops northeast of the Darlot mine site, and a poorly exposed monzogranite located in the southeast of the map sheet, west of the Ninnis Fault. The main outcrop east of Melrose Homestead is deeply weathered, foliated and intruded by aplite dykes (Westaway and Wyche, in prep.).

Granitoids east of the Norseman–Wiluna belt

Granitoids located east of the Ninnis Fault and corresponding to zone 4 of Bunting and Williams (1979) lie east of the Norseman–Wiluna belt. The predominant rock type is a pink monzogranite characterized by finely disseminated fluorite and a high K_2O content (4.8–5.8%). Major outcrops occur at Mount Blackburn and west of Wonganoo Homestead. Roddick and Libby (1995) reported a Rb–Sr age of 2480 ± 30 Ma from a similar granitoid (the Mount Boreas Adamellite) on DUKETON and LAVERTON. Quartz syenite has been mapped in areas west of Wonganoo Homestead and southeast of Mount Grey (Fig. 1). At both localities, syenitic rocks are intruded by Mount Boreas-type potassic monzogranite (Bunting and Williams, 1979).

Granitoid dykes, and quartz and pegmatite veins

Bunting and Williams (1979) reported quartz microdiorite dykes, trending at 080° , cutting granitic rocks near Kaluweerie Hill, several kilometres northeast of Depot Springs Homestead. Quartz veins with a similar trend outcrop over distances of 2–6 km in the same area (Plate 1) and may represent a major fault zone. Numerous quartz and pegmatite veins have been reported from SIR SAMUEL by Bunting and Williams (1979). Liu et al. (in prep.) stated that quartz and pegmatite veins are common in both

greenstone and granitoid terrains. Quartz veins commonly trend from east-northeast to west-northwest in both granitoid, granitoid gneiss and greenstone terrains. Some larger veins are associated with sheared contacts between granitoid and greenstone and may carry gold mineralization. The quartz veins are probably of late Archaean age, as they do not cut Proterozoic dykes (Liu et al., in prep.).

Proterozoic mafic dykes

Proterozoic mafic dykes (Fig. 3) are poorly exposed and have been interpreted from aeromagnetic data (GSWA, 1996). They have an easterly or northeasterly trend and have been assigned to the Widgiemooltha dyke suite, with a probable age of 2.4 Ga (Bunting and Williams, 1979; Myers, 1990). Two outcrops of mafic dykes have been reported: an easterly trending dolerite dyke from the Mount Keith area (Burt and Sheppy, 1975), and a dolerite dyke that intrudes granitoids 10 km east of Melrose Homestead (Westaway and Wyche, in prep.). Intermediate to mafic and lamprophyric dykes have been reported from gold deposits in the Mount McClure area of the Yandal greenstone belt. These dykes post-date mineralization (Liu et al., in prep.) but their age is unknown.

Proterozoic sedimentary rocks

A single outlier of conglomerate and lithic arenite near Kaluweerie Hill (Bunting and Williams, 1979), several kilometres northeast of Depot Springs Homestead (Fig. 3), is of Proterozoic age. It forms an easterly trending belt about 15 km long by 1.5 km wide with the southern boundary defined by thick quartz veins that appear to lie in a major fault zone.

Permian sedimentary rocks

Several scattered outliers of Permian sedimentary rocks were described by Bunting and Williams (1979) on SIR SAMUEL (Fig. 3). At Ockerburry Hill, west of Mount Doolette, these rocks comprise conglomerate with clasts of granitoid, vein quartz, quartz-rich sandstone, siltstone and claystone. Elsewhere this unit is represented by extensive cobble scree. Bunting and Williams (1979) argued that these rocks are of glacial origin and can be equated with the Permian Paterson Formation of the Officer Basin.

Mineralization

SIR SAMUEL hosts several of the major gold and nickel deposits that have recently been developed in the Eastern Goldfields, including major nickel mines at Perseverance, Rockys Reward and Mount Keith, and major gold mines at Bronzewing and Mount McClure, Genesis/New Holland (Lawlers), Vivian (Lawlers), Bellevue (Sir Samuel), and Darlot. Other historically important gold mining centres include Kathleen Valley, Corboys and Mount Keith.

Table 1. Size classification scheme for gold, nickel and uranium mines and deposits

	Gold		Nickel		Uranium	
	Cutoff (kg Au)	No. of mines or deposits	Cutoff (t Ni)	No. of mines or deposits	Cutoff (t U ₃ O ₈)	No. of mines or deposits
Major mine or deposit	>10 000	6	>50 000	5	>10 000	0
Mine or deposit	1 000–10 000	13	10 000–50 000	4	1 000–10 000	1
Minor mine or deposit	30–1 000	24	mineralization present	5	250–1 000	1

Nickel mines and deposits are associated with ultramafic volcanic rocks and are confined to the Mount Keith – Perseverance greenstone belt. The gold mines and deposits occur in all greenstone belts on SIR SAMUEL. There are also small deposits of uranium, copper, tin and tungsten, and copper production has been reported from mines at Kathleen Valley and Sir Samuel (Bunting and Williams, 1979).

Gold, nickel and uranium mineralization are classified in this study according to the total contained metal (Au and Ni) or oxide (U₃O₈), which includes metal or oxide data for past production and in-ground resources. Details of the classification scheme and the size distribution of the various mines and deposits on SIR SAMUEL are shown in Table 1.

Gold

According to available data, there are 83 gold-related deposits on SIR SAMUEL, consisting of active gold mines, former gold mines with some recorded production, or prospects with listed resources. In addition, there are 47 former gold mines or prospects for which there are no listed production or resources. The majority of the new prospects are located in the Yandal and Dingo Range greenstone belts.

A summary of historical gold production to the end of 1994, or for some centres to early 1995, is presented in Table 2. Total historical production amounts to about 54 t. The Bronzewing mines are currently producing about 5 t of gold per annum.

A list of individual mines and prospects together with names, and details of location, production and resources is appended (Appendix 1). Individual gold mining centres and mines are shown on all relevant maps accompanying these Notes.

According to the classification scheme (Table 1) and data in Appendix 1 there are six major gold mines, 13 gold mines and 24 minor gold mines on SIR SAMUEL. In addition there is one gold prospect (New Orleans in the Sir Samuel mining centre) that has no mining history but contains a listed resource. Reviews of individual mines and deposits

have been made by Hickman (in prep.) for the Darlot and Bronzewing mines; Australian Resources (1993) for the Lotus and Cockburn Mines; Boxall (1995) for the Genesis and New Holland mines; Brotherton and Wilson (1990) for the Bellevue Mine; and Liu et al. (in prep.) for the Vivian mine.

Major gold mines on SIR SAMUEL can be grouped into two main deposit types, using the criteria of Solomon and Groves (1994). The Bellevue, Darlot, Lotus and Vivian mines consist of shear-zone lodes, whereas the Bronzewing and Cockburn mines consist predominantly of stockworks (also referred to as quartz vein sets). In the shear-zone lode style of deposit, gold is commonly associated with quartz reefs and breccias, whereas in the quartz vein-set style, gold is contained in alteration selvages around the veins. Gold mineralization in both types of deposit is associated with intense alteration zones commonly consisting of pyrite, sericite and ankerite together with pyrrhotite and magnetite. These zones have high concentrations of As, Sb and base metals. The host rocks at Lotus, Bellevue, Darlot, Bronzewing and Vivian consist of basalt and dolerite, whereas the Cockburn mine is set in cherty sedimentary rocks and felsic tuffs. Porphyry and lamprophyre dykes have been reported from several of these mines. At the Genesis/New Holland mines, the mineralization is hosted by quartz-veined and brecciated sandstone. The mine is situated in a shear zone that splays off the northeasterly trending Emu Fault.

Gold also occurs in transported ferruginous detritus near several of the larger primary gold deposits. Hickman (in prep.) noted that the discovery of laterite-hosted gold in the Bronzewing area (Laterite deposit) led to the discovery of the main zones of primary mineralization (Central and Discovery deposits). The Laterite deposit, containing about 500 000 t at 1.5 g/t of gold, was the first ore mined at Bronzewing. The ferruginous detrital colluvial zone ('laterite') at Bronzewing ranges from 8 to 60 m below the surface. The lower part of this zone consists of conglomerate developed on basaltic saprolite, and the laterite zone is overlain by barren pisolitic hardpan. Smaller and shallower laterite-hosted gold deposits have been mined at Lawlers (Waroonga North), Darlot (Monte Christo) and Mount McClure (Lotus West).

Table 2. Historical gold production for SIR SAMUEL prior to 31 December 1994

Goldfield	District	Centre	Ore treated (t)	Contained gold (kg)	Alluvial/dollied (kg)	Total gold recovered (kg)
EAST MURCHISON	LAWLERS	Kathleen Valley	172 538	1 894.8	24.2	1 919.0
		Bronzewing (a)	178 000	298.9	—	298.9
		Mount McClure	1 849 982	6 229.5	—	6 229.5
		Lawlers (part of)	2 701 306	10 116.1	—	10 116.1
		Sir Samuel	2 092 535	22 190.8	11.4	22 202.2
	TOTAL		6 994 361	40 730.1	35.6	40 765.7
	WILUNA	Mount Keith	9 189	236.1	0.3	236.4
		New England	2 998	55.5	—	55.5
		Corboys	10 119	235.5	0.2	235.7
		Bronzewing Reward (including Maitland)	1 279	33.4	—	33.4
		TOTAL	23 585	560.5	0.5	561.0
MOUNT MARGARET	MOUNT MALCOLM	Lake Darlot	2 391 285	12 733.5	183.6	12 917.1
		Hurleys Reward	18	1.2	—	1.2
		TOTAL	2 391 303	12 734.7	183.6	12 918.3

(a) Historical production to 31 March 1995

Nickel

According to the classification scheme (Table 1) and available resource data (Appendix 2), there are five major nickel mines or major deposits on SIR SAMUEL (Mount Keith, Six Mile, Goliath North, Perseverance and Rockys Reward); four deposits with listed resources, and five other deposits for which resource data are unavailable but which contain some nickel sulfide mineralization. Individual nickel mines are shown on all relevant maps accompanying these Notes.

Nickel mining commenced in 1978 at the Perseverance underground mine and was suspended in 1986. Openpit mining commenced in 1989 at Rockys Reward, in 1990 at Perseverance, and in late 1994 at Mount Keith. Total nickel production to the end of 1995 amounted to 246 173 t of nickel comprising 211 480 t from the Perseverance and Rockys Reward mines and 34 693 t from the Mount Keith Mine (Appendix 2).

Marston (1984) and Leshner (1989) reviewed the geology and mineralization of all sixteen nickel deposits on SIR SAMUEL. Reviews of individual deposits have been made by Burt and Sheppy (1975) and Groves and Keays (1979) for Mount Keith; Turner and Ranford (1975), Naldrett and Turner (1977), Hill (1982), and Hill et al. (1987) for Six Mile and Goliath; and Martin and Allchurch (1975), Billington (1984), Hill et al. (1987), and Barnes et al. (1988a,b, 1991) for Perseverance and Rockys Reward.

Olivine-accumulate bodies that host nickel deposits, such as at Mount Keith, are extrusive in origin and form

an integral part of the komatiite lava sequence (Donaldson et al., 1986; Hill et al. 1987). These deposits were referred to as 'intrusive dunite-associated (IDA)' by Marston (1984). However, based on the geology at Perseverance and Rockys Reward, discussed by Hill et al. (1987) and Barnes et al. (1988a,b, 1991), and summarized in Solomon and Groves (1994), the 'volcanic-peridotite associated (VPA)' and 'IDA' deposits may be end members of a continuum of deposits associated with thick komatiitic lava flows that may have both peridotitic and dunitic cumulate zones. Solomon and Groves (1994) used Leshner's (1989) scheme to classify komatiite-associated nickel sulfide deposits. According to this scheme, most nickel deposits on SIR SAMUEL are type IIB deposits, which consist of finely disseminated stratabound sulfides within komatiitic dunites. Nickel grades are typically less than 1% Ni. In contrast, the massive-sulfide orebodies at Rockys Reward and Perseverance are type IA deposits of massive and disseminated stratiform sulfides at the base of komatiitic peridotites. Nickel grades are relatively high (2–4% Ni). In contrast, the nickel content of the unmineralized ultramafic rocks (silicate gangue) is about 0.1% Ni for both classes of deposit.

Primary nickel mineralization in massive-sulfide deposits (type IA) consists of pyrrhotite, pentlandite and pyrite with minor chalcopyrite and magnetite. Primary nickel mineralization in disseminated-sulfide deposits (type IIB) is relatively rich in nickel sulfide minerals and mineralogically more diverse. Disseminated pentlandite in relict dunite alters to pyrrhotite, pyrite and magnetite, and nickel minerals including millerite (NiS), gersdorffite (NiAsS) and cobaltite (Co,Fe)AsS are developed during metamorphism (serpentinization). Chromite and chalco-

pyrite are also present. Primary mineralization is overlain by a supergene zone comprising minerals such as violarite, millerite, pyrite and marcasite. The near-surface or oxidized zone consists of glassy brown jasper.

Copper

Bunting and Williams (1979) reported that 435 t of copper were produced from SIR SAMUEL between 1908 and 1967. Of this, 424 t was produced from three groups of workings in the Kathleen Valley area. An additional 11 t was produced from two other deposits near the Sir Samuel townsite between 1942 and 1967 (Appendix 2). Primary copper mineralization consists of small quartz-rich lodes containing pyrite and chalcopyrite, within northerly or northwesterly trending shear zones in greenstone. Most production comprised cupreous ore and concentrates of secondary and supergene minerals such as malachite, azurite, chrysocolla, bornite, chalcocite and covellite. Gold and silver were recovered from some of the ore, and Gibson (1907) reported that most of the gold orebodies in the Sir Samuel mining centre contained significant amounts of copper.

Uranium

Uranium exploration on SIR SAMUEL has been largely confined to palaeodrainages, which led to the discovery of two small deposits at Lake Maitland in the northeast of the map sheet (Appendix 2). These are similar to the Yeelirrie uranium deposit, discussed by Tingey (1985), which is located 18 km northwest of Yeelirrie Homestead on the adjacent SANDSTONE (1:250 000). At this deposit, a high-grade ore resource of 13 Mt at 0.24% U_3O_8 is accompanied by a halo of lower grade ore of 22 Mt at 0.09% U_3O_8 , with a total contained U_3O_8 resource of 52 500 t. Uranium in palaeodrainages occurs as carnotite, either as partings in salt-lake sediments or as coatings on fracture walls in calcretes. In addition to the Lake Maitland deposits, Butt et al. (1977) described uranium occurrences from four other locations on SIR SAMUEL: at Mount Keith East (Australian Map Grid (AMG) 280300 6996850); Little Well (AMG 222900 6975350); Kaluweerie Hill (AMG 207400 6934350); and Boundary Well (AMG 309500 6927150).

Regional regolith and geochemical mapping

The GSWA regional regolith and geochemical mapping program involves the systematic sampling and description of regolith, the delineation of regolith units using remotely sensed images, and analysis of regolith samples for a variety of elements. These data are summarized on a regolith-materials map, and a series of element-distribution maps.

The fieldwork component of the SIR SAMUEL regolith and geochemical mapping program commenced on 18 March 1995 and was completed on 29 May 1995. The

fieldwork was carried out by C. J. Kojan (GSWA) with assistance from J. J. Bradley (GSWA), and R. Blackmore, B. McCrow, P. Penna, E. Spartali, and G. Tolland (Geochemex Australia).

Sampling density

The GSWA regolith and geochemical mapping program is based on sampling of regolith at a nominal density of one sample per 16 km², which translates to approximately 1000 samples per 1:250 000-scale map sheet. The rationale for this sampling density is discussed in Kojan and Faulkner (1994).

Site selection

The preferred sample medium for geochemical mapping is active-stream sediments, because these are considered to be representative of the surrounding catchment area. However, streams on SIR SAMUEL are largely confined to greenstone belts and it was therefore necessary to sample other media including sheetwash, soil and lake sediments. In all, 1026 sites were sampled on SIR SAMUEL, consisting of 397 stream-sediment samples, 421 sheetwash samples, 156 soil samples, and 52 lake-sediment samples.

Sample sites were selected by superimposing a transparent 4 × 4 km grid over the 1:100 000-scale topographic maps and Landsat images, and selecting a suitable site within each square. The selected sample locations were digitized and assigned site reference numbers and AMG coordinates. The site locations and reference numbers were then printed onto 1:100 000-scale topographic plans. In the field, these sites were located using Garmin 75 Global Positioning System (GPS) units set to the AusGeo84 datum and accurate to ±100 m. The field geologist was allowed some discretion to relocate to an alternative sample site if the proposed site proved to be inaccessible or inappropriate.

Sample-site form

A sample-site form was completed at each site in order to systematically document the regolith at that site, to record the characteristics of the sample collected for subsequent chemical analysis, and to collect information about the surrounding geology and regolith. An example of the form used for SIR SAMUEL is presented in Appendix 4. Particularly important are data dealing with the nature of regolith at each site, as these data are used to assign a regolith code, which in turn forms the basis of the regolith-materials map. The regolith code and regolith characteristics are used to interpret the geochemical data.

Sampling

Two regolith samples were collected at each site, one for geochemical analysis (the analytical sample), and the other as an archive sample. A duplicate analytical sample was collected at every fiftieth site as part of the quality-control

program. Dry samples were sieved in the field, and damp or wet samples were sieved at the analytical laboratory. The analytical samples comprised about 2 kg of -2 mm to +0.45 mm material. This size fraction was chosen to avoid heterogeneity associated with coarse-grained detritus, and to minimize the dilution effects of fine-grained eolian material. An estimate of the amount of material coarser than 2 mm and finer than 0.45 mm was made at each site (% oversize and % undersize on sample-site form; Appendix 4). The archive sample comprised 3–4 kg of the -2 mm fraction.

Prior to sample collection, the top few centimetres of material at each site was removed to avoid incorporation of any windblown sand, vegetation or other organic material. Regolith was then taken from a pit or channel, excavated to a depth of between 10 and 40 cm. Well-defined streams were sampled by channel sampling between and into the stream banks or, in the case of narrow streams, by taking pit samples along the axis of the stream bed. All main channels of a braided drainage were sampled and composited. Soil and lake samples were collected by compositing sample material obtained from three pits spaced 30 to 50 m apart. At sheetwash sites, sample material was composited from three pits set at right angles to the slope direction.

Both the analytical and archive samples were labelled externally with a GSWA sample number. Tags showing the sample number were placed inside each bag. The GSWA sample number was recorded on the sample-site form together with the site reference number, and actual site coordinates. The GSWA number was also written on an aluminium tag that was riveted to a metal stake. The stake was driven into the ground to act as a site marker.

On SIR SAMUEL, a total of 1072 samples were submitted for chemical analysis, consisting of samples from 1026 sites, supplemented by 23 duplicate samples and 23 standards.

Regolith-materials mapping

The 1:250 000-scale regolith-materials map for SIR SAMUEL (Plate 1) is intended to serve as a base map for interpretation of both regional- and project-scale regolith geochemical sampling data. The map was compiled as an overlay on 1:100 000-scale two dimensional (2D) Landsat imagery using the same GSWA regolith classification as for MENZIES (Kojan and Faulkner, 1994). The map unit boundaries were interpreted from map codes recorded on the sample-site forms, published geological maps (Bunting and Williams, 1979; Liu et al., 1996; Wyche and Westaway, 1996; Lyons, in prep.), a K–Th–U radiometric image (produced from AGSO data), and 2D and 3D Landsat images.

Regolith regimes and map units

The GSWA regolith classification scheme used in this study (Plate 1 and Table 3) is based on that of Craig and Anand (1993) for the Kalgoorlie–Kurnalpi regolith-landform map. The landforms and associated regolith

of the Archaean granite–greenstone terrain are described above and can be classified into *residual*, *erosional* and *depositional* regimes (Anand et al., 1993). The term *relict* is substituted for the term *residual* to indicate 'old', and to avoid any genetic connotation. The *relict regime* consists of upland areas that have survived the more recent and continuing period of downcutting and erosion. Granitoid plateaus, areas of extensive ferruginization and silcrete cappings at breakaways, and isolated and duricrust-capped greenstone mesas are assigned to the relict regime. Areas of relatively high relief and stony plains developed on greenstone and granitoid make up the *erosional regime*. In these areas, active erosion is taking place, resulting in a net removal of weathered and eroded material. The remaining landform types, including colluvial plains and sheetwash fans derived from granitoid and greenstone, and saline alluvial plains and sandplains, are assigned to the *depositional regime*. In these areas, aggradation exceeds degradation. On SIR SAMUEL, a wide range of regolith materials are represented, including deeply weathered lateritic profiles consisting of duricrust, saprolite and saprock, and Cainozoic to Recent sediments derived from erosion of lateritic material and underlying bedrock (Plate 1).

Results of the Department of Agriculture's rangeland mapping on SIR SAMUEL (Pringle et al., 1994) are compared with GSWA's regolith-materials mapping (Plate 1) in Appendix 5, and discussed in conjunction with the GSWA scheme in the following section.

Relict regime

The relict regime is subdivided into four map units: R1, R2, R3 and R4 (Table 3). R1 consists of ferruginous pisolites and nodules, whereas R3 consists of silcrete and includes silica-cemented R1 material. Both R1 and R3 cap plateaus and breakaways developed on granitoid and granitoid gneiss, and both show strong thorium enrichment on the radiometric image. Compared to the Department of Agriculture's rangeland-mapping classification (Appendix 5), R3 and R1 comprise breakaway mixed shrublands (BRXS) and stony plain acacia shrublands (SAES). R4 consists of upland sandplain overlying R1 and R3 material on granitoid plateau areas and is commonly indistinguishable in the field from D9 (sandplain). Both R4 and D9 comprise sandplain spinifex hummock grasslands (SASP) and sandplain acacia shrublands (SACS; Appendix 5). R2 (iron-rich duricrust) forms isolated mesas and plateau remnants within greenstone belts. R2 is commonly represented by Cz1 on 1:100 000-scale geology maps (Liu et al., 1996; Wyche and Westaway, 1996).

Erosional regime

The erosional regime is subdivided into ten map units: E1g, E1m, E1v, E2g, E2m, E2s, E2v, E4g, E4m and E4v (Table 3). E1 corresponds to saprolite, E2 corresponds to outcrop and E4 corresponds to lag or very coarse-grained detritus. Suffixes denote the source rock: g — granitoid; m — granitoid gneiss; s — sedimentary rock; v — greenstone.

Table 3. Regolith codes and descriptions

<i>Regolith code</i>	<i>Description</i>
RELICT REGIME	
R1	Ferruginous pisolites and nodules, locally reworked and cemented; derived from granitoid and gneissic rock
R2	Iron-rich duricrust; over volcano-sedimentary rock (greenstone)
R3	Silcrete, including silica-cemented R1 material; derived from granitoid and gneissic rock
R4	Quartz-rich sand and silt over R1–R3 material
EROSIONAL REGIME	
E1g	Mottled zone and saprolite over poorly exposed granitoid rock
E1m	Mottled zone and saprolite over gneissic rock
E1v	Mottled zone and saprolite over volcano-sedimentary rock (greenstone)
E2g	Outcrop of granitoid saprock and bedrock
E2m	Outcrop of gneissic saprock and bedrock
E2s	Outcrop of sedimentary saprock and bedrock
E2v	Outcrop of volcano-sedimentary saprock and bedrock (greenstone); includes ferruginous bedrock
E4g	Lag of locally derived granitoid detritus in a sandy or sandy clay matrix; associated with actively eroding outcrop/subcrop
E4m	Lag of locally derived gneissic detritus in sandy or sandy clay matrix; associated with actively eroding outcrop/subcrop
E4v	Lag of locally derived highly ferruginous detritus in a sandy clay matrix; associated with actively eroding volcano-sedimentary rock (greenstone)
q, p	Quartz and pegmatite veins
DEPOSITIONAL REGIME	
	Dominantly colluvial
DC1g	Predominantly medium-grained detritus derived from granitoid rock; most clasts 2–25 mm in sandy clay matrix; feldspar rich
DC1q	Medium- to coarse-grained quartz detritus — derived from quartz vein
DC1s	Predominantly medium-grained detritus derived from sedimentary rock; most clasts 2–25 mm in sandy or sandy clay matrix
DC1v	Medium- to coarse-grained detritus derived from volcano-sedimentary rock (greenstone); most clasts >25 mm and of lithic or ferruginized lithic origin in a red sandy clay matrix
DC2g	Fine-grained detritus derived from granitoid rock; most clasts 2–5 mm in a sandy clay matrix
DC2v	Fine- to medium-grained detritus derived from volcano-sedimentary rock (greenstone); most clasts 2–25 mm and of ferruginized lithic origin in a red sandy clay matrix
DC3	Colluvium or sheetwash of sand or clay (with or without feldspar); clasts generally absent
DC3f	Fine-grained colluvium or sheetwash of 2–5 mm ferruginous clasts (buckshot gravel) in a red clay matrix
	Dominantly alluvial
DA4	Gravelly sands and sandy clays of active alluvial channels with ferruginous and variably altered lithic clasts
DA5	Sand- or clay-rich alluvium and colluvium on broad drainage floors; often accompanied by calcrete fragments; includes overbank and terrace alluvium and small non-saline claypans
DA6	Saline or highly gypsiferous playa-lake sediments
DA7v	Valley calcrete
	Dominantly eolian
D8	Gypsiferous and calcareous sand dunes adjacent to playa lakes
D9	Quartz-rich sand overlying bedrock, colluvium or alluvium; sandplain

E1g (saprolitic granitoid) is commonly exposed below breakaways, and also occurs in association with E2g (granitoid outcrop) and E4g (granitoid detritus) in areas of dissected granitoid terrain in the southern part of SIR SAMUEL. Individual areas of E1g are typically too small to portray at the map scale, so this unit was commonly included in E2g and appears to correspond to the stony bluebush mixed shrublands (SBMS) site type of Pringle et al. (1994), with a soil consisting of shallow duplex loam on clay (Appendix 5). E1m (saprolitic gneiss) is similar to E1g and occurs in association with E2m and E4m in areas of granitoid-gneiss outcrop. These granitoid-gneiss units correspond to a distinctive colour on the radiometric image. E1v (saprolitic greenstone) has been mapped using 2D Landsat images and is commonly indistinguishable from E2v (greenstone outcrop). It is commonly represented by SBMS developed on clay (Appendix 5). E1v and E4v are commonly represented on geological maps as Czf (Liu et al., 1996; Wyche and Westaway, 1996).

The distribution of E2g (granitoid outcrop), E2m (granitoid-gneiss outcrop), E2s (sedimentary rock outcrop) and E2v (greenstone outcrop) has been taken from published geological maps (Bunting and Williams, 1979; Liu et al., 1996; Wyche and Westaway, 1996), although some boundaries have been modified following examination of Landsat and radiometric images. E2g, together with E2m, comprises seven different Department of Agriculture rangeland-mapping site types, of which sandy granitic acacia shrublands (SGRS), SBMS, and SAES are the best represented (Appendix 5). E2v comprises five different site types, of which stony iron mulga shrublands (SIMS), SBMS and lateritic hardpan plain mulga shrubland (LHMS) are the best represented (Appendix 5). E2s includes a large outlier of Proterozoic sandstone and conglomerate mapped in the Kaluweerie Hill area, northeast of Depot Springs Homestead. The remaining areas of E2s comprise small outliers of Permian sedimentary rocks. E4v (ferruginous lag) occurs in erosional areas of moderate relief, downslope from greenstone outcrop. E4v commonly overlies greenstone but can occur on granitoid or granitoid gneiss adjacent to greenstone. Samples designated E4v typically contain greater than 30% Fe_2O_3 and the main corresponding Department of Agriculture site types are SIMS and LHMS. E4g (granitoid detritus) occurs in association with E2g in granitic pediment areas and comprises mainly SAES.

Depositional regime

The depositional regime is subdivided into 14 map units (Table 3). DC1g, DC1q, DC1s, DC1v, DC2g, DC2v, DC3, and DC3f are predominantly colluvial in origin, whereas DA4 and DA5 consist mainly of alluvial material, and DA6 and DA7v consist of mixed chemical deposits and alluvial sediments. D8 and D9 are largely of eolian origin. The greenstone-sourced colluvial units DC1v, DC2v and DC3f can be distinguished from colluvial units sourced from granitoid and granitoid gneiss using radiometric imagery. The greenstone-sourced units produce a characteristic pattern reflecting enhanced uranium and thorium contents. Granitoid-derived colluvial units give rise to mulga wanderrie grass shrublands in the

Department of Agriculture rangeland-mapping classification, whereas greenstone-derived colluvial units give rise to lateritic mulga wanderrie shrubland (MUWA and LMWS respectively; Appendix 5).

DC1g and DC1v represent coarse-grained colluvium deposited close to its source. These units commonly occur as footslopes surrounding erosional regime units and are commonly associated with active drainage channels (DA4). The regolith material is immature and closely reflects the source material. DC1g (including similar regolith from granitoid and granitoid gneiss) is feldspathic and has a high K_2O content in comparison to samples of DC2g and DC3. DC1v (greenstone-sourced DC1) is ferruginous and has 10–30% Fe_2O_3 . Greenstone clasts, some of which have been ferruginized, are transported farther from their source than is the case with granitoid clasts. As a consequence, areas of DC1v are commonly more extensive. DC1s is represented by one area in the vicinity of Ockerburry Hill.

DC2g and DC2v represent fine- to medium-grained colluvium derived from the further breakdown of DC1g or DC1v material. These units commonly occur as colluvial plains and sheetwash, and may be associated with active alluvial channels (DA4). DC2g (granitoid and granitoid gneiss derived from DC1) carries less feldspar and has a lower K_2O content than DC1g. DC2g also occurs directly downslope and adjacent to granitoid outcrops, indicating very rapid weathering. DC2v (greenstone-sourced DC2) contains ferruginous clasts and at least 10% Fe_2O_3 .

DC3 derived from granitoid and granitoid gneiss consists of sand- or clay-rich colluvium. DC3f (greenstone-sourced DC3) contains fine-grained ferruginous detritus commonly referred to as buckshot gravel, and samples commonly contain at least 10% Fe_2O_3 . These units occur as broad sheetwash fans that terminate at major alluvial floodplains (DA5).

The alluvial units comprise DA4 (alluvial channels) and DA5 (alluvial plains). DA4 comprises gravelly sands and clays of active alluvial channels and includes some of the larger claypans on alluvial plains. DA5 consists of sand- or clay-rich sediment on wide alluvial plains, which border and locally make up the major drainage floors or palaeodrainages, and may be associated with sand dunes. Calcrete nodules are common, and calcrete or calcreted hardpan may occur under a shallow sand cover. DA5 is commonly associated with valley calcrete deposits (DA7v) and playa-lake sediments (DA6) and gives rise to a wide range of Department of Agriculture site types of which plain mixed halophyte shrublands and sago bush low shrublands are the most common (PXHS and PSAS respectively; Appendix 5). DA6 (playa-lake sediments) consists of either saline or highly gypsiferous silt and clay. The gypsiferous lake sediments are designated DA6g in the datafile accompanying these notes (SAMCHEM.CSV). DA7v (calcrete) consists of exposed calcrete platforms exhibiting typical karst morphology and commonly gives rise to calcrete platform shrublands (CAPW; Appendix 5). DA6 corresponds to unit Czp and DA7v corresponds to Czk on 1:100 000-scale geological maps (Liu et al., 1996; Wyche and Westaway, 1996).

Eolian sediments comprise D8 (gypsiferous and calcareous sand dunes) and D9 (undifferentiated sandplain). D8 is confined to major drainage floors, and is closely associated with gypsiferous lakes. The main Department of Agriculture site type is samphire low shrublands, but kopi dune woodlands are probably more typical (SAMP and KOPI respectively; Appendix 5). D9 and R4 are indistinguishable in the field and comprise SASP and SACS (Appendix 5). D8 corresponds to unit Czd and D9 corresponds to Czs on 1:100 000-scale geological maps (Liu et al., 1996; Wyche and Westaway, 1996).

Chemical analysis

All regolith samples were analysed by Genalysis Laboratory Services, Maddington, Perth. Following drying at 105°C, a 150 g split was pulverized to a nominal 90% minus 75 µm in a zirconia ring mill, and analysed for SiO₂, TiO₂, Al₂O₃, Fe₂O₃, MnO, MgO, K₂O and Cr. The remainder of the sample was pulverized to a nominal 90% minus 75 µm in a chrome-steel jumbo ring-mill, and analysed for 39 components comprising CaO, Na₂O, P₂O₅, Ag, As, Au, Ba, Be, Bi, Ce, Co, Cu, F, Ga, In, La, Li, Mo, Nb, Ni, Pb, Pd, Pt, Rb, S, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, U, V, W, Y, Zn and Zr. Loss on ignition (LOI) was determined for 10% of the samples.

Check analyses of fifteen samples were carried out by Analabs and Australian Assay Laboratories in Perth.

Analytical methods

Seven different analytical methods were used:

- *Inductively coupled plasma optical emission spectroscopy (ICP-OES) using combined hydrofluoric/multi-acid digestion (Genalysis code A/OES)*: The pulverized sample was digested in a hydrofluoric/perchloric/nitric acid mixture for at least 24 hours, evaporated to fume dryness and leached in a dilute hydrochloric/nitric acid mixture. The following element and oxide concentrations were then read using ICP-OES: CaO, Na₂O, P₂O₅, Cu, Ni, S, Sc, V and Zn.
- *Inductively coupled plasma mass spectrometry (ICP-MS) using combined hydrofluoric/multi-acid digestion (Genalysis code A/MS)*: The pulverized sample was digested in a hydrofluoric/perchloric/nitric acid mixture for at least 24 hours, evaporated to fume dryness and leached in a dilute hydrochloric/nitric acid mixture. The following element concentrations were then read using ICP-MS: Ag, As, Ba, Be, Bi, Ce, Co, Ga, In, La, Li, Mo, Nb, Pb, Rb, Sb, Sn, Sr, Ta, Te, Th, U, W, Y and Zr.
- *Inductively coupled plasma optical emission spectroscopy (ICP-OES) using an alkaline oxidative fusion with sodium peroxide in a zirconium crucible (Genalysis code D/OES) followed by leaching with dilute acid*: The concentrations of SiO₂, TiO₂, Al₂O₃, Fe₂O₃, MnO, MgO, K₂O and Cr were analysed by this method.

- *Fire assay lead collection and ICP-MS (Genalysis code FA*MS)*: Elements analysed by this method were Au, Pd and Pt.
- *Low-level fluorine determination (Genalysis code DH/SIE)*: The sample was fused with a mixture of sodium carbonate, potassium carbonate and zinc oxide, dissolved in water, and the fluorine level was read with a specific-ion electrode.
- *Selenium determination (Genalysis code AP/MS)*: Selenium was determined by precipitation of selenium metal followed by aqua regia digestion and ICP-MS analysis.
- *Loss on ignition gravimetric determinations (Genalysis code GRAV)*.

Detection limits and the number of samples with values below detection are shown in Table 4.

Quality control

Quality-control procedures are designed to monitor the variability associated with sampling and geochemical analysis in order to ensure that the results reflect genuine geochemical variations and are not artefacts of the analytical technique or sampling method. Reproducible results should normally be obtainable from the same sample site. Similarly, individual analytical determinations should be reproducible within set limits, except that variability will inevitably increase close to the detection limit. Five main quality-control procedures were adopted for the sampling and analysis of the geochemistry samples collected on SIR SAMUEL:

- analysis of standard reference samples supplied by Genalysis;
- analysis of standard reference samples included by GSWA in each of the seven batches submitted to Genalysis;
- analysis of duplicate samples by Genalysis;
- inclusion by GSWA of duplicate samples collected at the same site;
- analysis of splits from archive samples, by Analabs and Australian Assay Laboratories.

Analysis of Genalysis standard reference samples

Seven batches of samples were supplied to Genalysis Laboratories. During the course of analysis, 40 determinations of five different standards were made. The standards included the international reference materials SYS (CANMET), MRG-1, and SO-2 (KGV), and the two Genalysis in-house standards PCO2 and PCO3. In addition, two standards with high levels of Au, Pd, and Pt (SARM7.2 and ETAO4) were analysed 34 times.

Precision and accuracy were assessed using the mean, standard deviation, percent relative standard deviation (RSD%), and range of acceptable values for each group of standards. Precision was considered acceptable if the

Table 4. Detection limits and number of samples below detection

Element	Detection limit	Number of values below detection limit
Percent		
SiO ₂	0.01	0
TiO ₂	0.01	0
Al ₂ O ₃	0.01	0
Fe ₂ O ₃	0.01	0
MnO	0.01	42
MgO	0.01	2
CaO	0.01	5
Na ₂ O	0.01	1
K ₂ O	0.01	0
P ₂ O ₅	0.01	3
Parts per million		
Ag	0.5	960
As	2	223
Au	0.001	657
Ba	1	0
Be	0.1	0
Bi	0.5	868
Ce	0.1	0
Co	1	0
Cr	20	8
Cu	1	0
F	50	282
Ga	1	0
In	0.1	692
La	0.1	0
Li	0.5	0
Mo	0.5	13
Nb	0.5	0
Ni	1	0
Pb	2	7
Pd	0.001	793
Pt	0.001	697
Rb	0.2	0
S	10	9
Sb	0.2	129
Sc	2	132
Se	0.2	229
Sn	1	381
Sr	0.1	0
Ta	0.2	53
Te	0.5	834
Th	0.1	0
U	0.1	0
V	2	0
W	1	695
Y	0.1	0
Zn	1	0
Zr	1	0

RSD% for an element was less than 20. Precision was good for all major elements, with RSD% less than 10 for most elements, apart from MnO (25–35). Precision was good overall (RSD <20%) for all trace elements that had concentrations greater than ten times the detection level.

Accuracy was considered acceptable if the mean values for an element lay within $\pm 10\%$ of the recommended value. Accuracy was excellent for all major elements apart from

MnO, which was 10–12% higher than the recommended standard values. Accuracy was acceptable for all trace elements at levels greater than ten times the quoted detection levels (Table 4). Precision and accuracy were poor for Ag, As, Mo, Se, Ta and Te at concentrations near the detection level. Precision and accuracy for Au, Pd and Pt were excellent at high concentrations (i.e. for standards SARM7.2 and ETAO4) but could not be assessed for other standards, which were not measured for these elements.

Analysis of GSWA standards

Twenty-three analyses of four GSWA in-house standards were made (IQC-45, IQC-47, GRA2 and DOLERITE1). The precision and accuracy were assessed in the same manner as for the Genalysis standards discussed above, although recommended values are unavailable for Ta and Te, and recommended values for some other elements are based on a limited number of determinations.

Precision and accuracy were good for major elements at concentrations well above the detection level, although K₂O determinations for two standards slightly exceeded the accuracy limits. Results at very low concentrations (<0.1%) were commonly within or close to the acceptable limits. Precision and accuracy were commonly acceptable for all trace elements at higher levels of concentration, but were outside acceptable limits for Cr, Cu, Zn and Zr for specific standards. Results for Ag, As, Au, Pd, Pt, Se, Ta, Te and W were outside acceptable limits at low levels of concentration (<10 × detection level).

Repeat analysis by Genalysis

Genalysis reported duplicate analyses of 45 samples spread over the seven batches submitted for analysis. The precision of these repeat analyses was assessed by expressing each pair of results as a quotient in percent with the highest value as the denominator and subtracting the result from 100. Duplicate pairs that showed less than 20% variation for elements with concentrations greater than ten times the detection limit (Table 4) were considered satisfactory. All major elements agreed within 20%, apart from K₂O, which varied from 20 to 27%. Results were not assessed for P₂O₅ as most values were close to detection level. Results were within 20% for all trace elements except Zn, for which seven pairs of analyses produced variations ranging from 20 to 33%. Silver, As, Au, Bi, F, In, Pd, Pt, Sb, Se, Sn, Ta, Te and W were too close to detection levels to assess.

Genalysis also reported separate repeat analyses for Au, Pd and Pt for 34 samples, including most samples with Au values greater than 5 ppb. There were no significant differences between repeat analyses of the same sample.

Inclusion of duplicate samples from the same sample site

Duplicate analytical samples were collected at 23 sites, corresponding to about one duplicate for every 50 samples collected. These samples were used to assess within-

sample variability. Each duplicate was assigned a GSWA number and submitted separately, and not necessarily in the same batch as the original sample. The precision for duplicate samples was assessed by calculating the percent difference for each pair of element determinations, as described above. Results were within 20% for all major elements except for TiO_2 (24–32% variation) in four pairs, and K_2O (20–28% variation) in four pairs. The results for P_2O_5 were not assessed because most values were close to the detection level. Results of duplicate analyses agreed to within 20% for Be, Cr, Ga, Mo, Sr, U and Y at higher concentrations. Results for duplicate analyses of Ba, Ce, Cu, La, Nb, Ni, Pb, Rb, Th and V were within limits for most samples at higher concentration, but results for S, Zn, and Zr exceeded the limits for several pairs of determinations. Silver, As, Au, Bi, F, In, Pd, Pt, Sb, Sc, Se, Sn, Ta, Te and W were not assessed because the concentrations of these elements were all near detection level.

Analysis of duplicate samples obtained from archive material: analysis by Analabs and Australian Assay Laboratories

Fifteen archive samples were coned, quartered and sieved to the -2 mm +450 μm size fraction. Two quarters, each weighing 350–500 g, were bagged, labelled, and assigned new GSWA numbers. One set of sample splits was submitted to Analabs and the second set was submitted to Australian Assay Laboratories. Most of the fifteen samples contained anomalous amounts of Au, Pd and Pt and some contained anomalous amounts of Ni, As and Cr, according to Genalysis determinations.

The total of SiO_2 , TiO_2 , Al_2O_3 , Fe_2O_3 , MnO, MgO, CaO, Na₂O, K_2O , P_2O_5 , SO_3 , LOI, Cr_2O_3 , BaO and V_2O_5 from samples analysed by Genalysis (including all results from the six batches for which an LOI determination was made) ranges from 97.5% (mean for batch 2895) to 100.8% (mean for batch 3001), with standard deviations ranging from 2.34% (batch 3291) to 3.80% (batch 2895). In contrast, the mean and standard deviation for samples analysed by Analabs are 99.85% and 0.28% respectively. Genalysis results for major elements generally do not agree well with those obtained from the other two laboratories: most SiO_2 and K_2O results are higher and most TiO_2 , Al_2O_3 and Fe_2O_3 results are lower. For Au, Pd and Pt, results from Genalysis and Analabs agree well, whereas those from Australian Assay Laboratories tend to be high. For other trace elements, Genalysis determinations agree well with the other laboratories for As, Ba, Be, Bi, Co, Mo, Ni, Sb, Sc, Ta and Th, satisfactorily for Ce, Ga, Pb, Rb, Sr, V and Zr, and poorly for Cr, Cu, Rb and Zn. It was not possible to assess Ag, F, In, La, Li, Nb, Se, Sn, Te, U, W and Y as all these elements occurred at low concentrations in the samples.

Analysis of other components

All regolith samples were measured for acidity–alkalinity (pH; Fig. 5) and conductivity (a measure of the TDS

content; Fig. 6). Mineralogical determinations (by x-ray diffraction — XRD) were made on 14 samples.

Acidity–alkalinity and conductivity determinations

Acidity–alkalinity (pH) and conductivity measurements were made by thoroughly mixing approximately 20 g of archive material with 90 ml of deionized water and allowing it to stand for at least 30 minutes. The pH and conductivity of the solution were then determined.

Acidity–alkalinity measurements

Acidity–alkalinity measurements were made using a 3050 Portable Jenway pH meter, following calibration using three buffer solutions with pH values of 4, 7 and 10. The electrode was rinsed with deionized water before measurement of the first test suspension, and between measurements of unknown samples. Sample number and pH reading were recorded for each test suspension and the pH values were entered into the SIR SAMUEL datafile (SAMCHEM.CSV).

Conductivity measurements

Conductivity measurements were made using a TD SCAN4 conductivity meter. The meter was calibrated against a buffer solution with a conductivity value of 12.9 mS/cm. The electrodes were rinsed with deionized water before measurement of the first test suspension, and between measurements of unknown samples. Sample number, conductivity and temperature were recorded for each test suspension and the conductivity values in mS/m, adjusted to equivalent readings at 20°C (see below), were entered into the datafile (SAMCHEM.CSV).

Mineralogical determinations

The mineralogy of fourteen samples representing various regolith types was determined by powder X-ray diffraction methods (XRD) at CSIRO, Floreat Park, Western Australia, following the method described by Hart and Nickel (1995). The minerals present were determined by evaluating peak heights of certain diagnostic reflections. Following this, chemical data were used to calculate theoretical mineral abundances (Table 5). LOI, MnO and P_2O_5 were not included in these calculations. Two samples containing substantial amounts of MgO were further investigated using a scanning-electron microscope.

Data presentation

The main products of the regolith geochemical mapping of SIR SAMUEL are a regolith-materials map (Plate 1), a sample-site location map (Plate 2), plans and tables showing details of company geochemical surveys (Plates 3 and 4 and Appendix 3), element-distribution maps (Figs 7–49), a map of contoured gold geochemistry and gold deposits (Fig. 50), and the digital datafile

Table 5. XRD mineralogical analysis of selected samples

GSWA no.	Regolith unit	Sample type	Quartz	Kaolinite	Allophane	K-feldspar	Plagioclase	Goethite	Hematite	Anatase	Amphibole	Chlorite	Saponite	Halite	Gypsum	Total
131002	DC1g	stream	43	—	8	21	16	2	—	—	—	—	—	—	—	90
131023	DC1v	shtwh	55	29	—	5	—	10	—	1	—	—	—	—	—	100
131035	DC1g	shtwh	65	24	—	7	1	4	—	1	—	—	—	—	—	102
131141	R3	stream	79	13	—	2	1	4	—	—	—	—	—	—	—	99
131154	E4v	stream	39	12	—	1	1	47	—	1	—	—	—	—	—	101
131156	DC1	stream	67	10	—	4	5	12	—	—	—	1	—	—	—	99
131199	DC1v	shtwh	38	29	—	4	—	28	—	1	—	—	—	—	—	100
131256	DA6	lake	16	20	—	8	—	6	—	1	—	—	16	6	2	75
131404	DC1	stream	37	17	—	10	14	27	—	1	—	—	—	—	—	106
131447	E4v	stream	32	20	—	3	1	20	20	—	—	—	1	—	—	97
131553	DA5	lake	65	9	—	6	2	2	—	—	—	—	14	—	5	103
131597	DC1	stream	60	12	—	8	5	11	—	—	3	—	—	—	—	99
131733	DC1g	stream	54	6	—	24	12	1	—	—	—	—	—	—	—	97
131809	DC3	stream	74	7	—	7	2	—	6	—	—	—	—	—	—	96

shtwh — sheetwash

(SAMCHEM.CSV). All GSWA regolith and geochemistry maps are produced from digital data, and these data can be purchased from the DME. Data from the sample sites are stored in the Departmental geochemical ORACLE database and are available for inspection on request.

Element-distribution maps

The concentrations of 44 elements or oxides (TiO_2 , Fe_2O_3 , MnO , MgO , CaO , Na_2O , K_2O , P_2O_5 , As, Ag, Au, Ba, Be, Bi, Ce, Co, Cr, Cu, F, Ga, La, Li, Mo, Nb, Ni, Pb, Pd, Pt, Rb, S, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, U, V, W, Y, Zn and Zr) on SIR SAMUEL for a total of 1026 samples are shown in Figures 7–49. CaO values for lake- and calcrete-derived samples are shown separately from samples derived from other sources (Figs 11 and 12). Higher values for Ag, Be and Li are shown in Figure 49, because in most samples concentrations of these elements are low or (in the case of Ag) below detection level.

On some element-distribution maps, the complete range of concentrations is represented by circles, with the diameter proportional to the concentration. However, for element-distributions that have a strong positive skew, the highest values are represented by stars. This facilitates comparison of lower values, which might otherwise appear as very small circles. The cutoff values between circles and stars are similar to those for the adjacent LEONORA map sheet. In fact, the individual element statistics for MENZIES, LEONORA and SIR SAMUEL are very similar.

The precise value for a specific element at a particular site can be determined by identifying the GSWA number from the sample-site location plan (Plate 2), then referring to the digital datafile (SAMCHEM.CSV). This file contains analytical data for all samples, along with details of sample type, geology (granitoid, greenstone, gneiss, calcrete, lake, or mixed), regolith code (Table 3 and Plate 1), and AMG coordinates.

Special-purpose geochemical maps

The results of comparative and statistical treatments of regolith chemical data for SIR SAMUEL are shown in Figures 50, 51, and 52. In Figure 50, prospective areas for gold mineralization are highlighted by comparing contoured gold concentrations with known locations of gold mineralization (Appendix 1). Principal-component analysis has been used to examine element associations in relation to geology (Fig. 51), and prospective areas for gold and base-metal mineralization have been identified using greenstone chalcophile-index values (Fig. 52 and Appendix 6). Greenstone chalcophile-index values are based on the concept that high concentrations of chalcophile and associated elements in lateritic material may indicate areas of mineralization (Smith et al., 1989). The development and application of such an index to mixed regolith materials derived from greenstones is described by Kojan et al. (in prep.).

Acidity–alkalinity and salinity maps

Acidity–alkalinity (Fig. 5) is shown as a contoured plot of pH values obtained by testing regolith samples from each site. Individual pH values are listed in the datafile (SAMCHEM.CSV). The regolith-salinity map (Fig. 6) is a contoured plot of TDS, calculated from conductivity values measured for regolith samples. The individual conductivity values in mS/cm corrected to a standard temperature of 20°C are listed in the datafile (SAMCHEM.CSV). These have been calculated from the formula:

$$k_{20} = k \times 100 / (1 + 0.022(T - 20)),$$

where k is the measured conductivity in mS/cm recorded at temperature $T^\circ\text{C}$. The TDS values (mg/L) are calculated from the formula:

$$\text{TDS} = 4.437 \times (k_{20})^{1.066}.$$

Both formulas are similar to those of Kevi (1988), used for calculation of TDS values from resistivity measurements. Figure 4 is a contoured plot of groundwater salinity (TDS), using waterbore data supplied by the Water and Rivers Commission. An average salinity value was calculated for those sites where multiple salinity values were quoted.

Company surface-geochemistry projects — maps and table

Two maps at 1:250 000 scale (Plates 3 and 4) show the locations of all company surface-geochemistry projects that have been carried out on SIR SAMUEL. Details of individual projects are listed in Appendix 3.

Results and discussion

Each sample in the datafile (SAMCHEM.CSV) is classified in terms of sample type, regolith code and geology. Four different sample types have been distinguished on SIR SAMUEL. Sheetwash samples comprise colluvial material in areas where a slope is apparent. Most sheetwash samples on SIR SAMUEL are from colluvial regolith units (DC1, DC2, and DC3). In contrast, most soil samples were obtained from sandplain areas (R4 and D9), or alluvial units on drainage floors (DA5 and DA7v). Stream-sediment samples were obtained from a wide variety of regolith types, but typically from erosional and proximal colluvial units (E2, E4 and DC1). Some lake-sediment samples were obtained from areas of standing water. Not all lake-sediment samples are designated DA6, as some samples obtained from lake margins were derived from greenstone colluvium (DC3f).

Two extensive units (DA4 and D8) in Table 3 and on Plate 1 do not appear in the list of regolith codes in the datafile (SAMCHEM.CSV). In these cases a regolith

code was assigned that reflected the source material and not the sample medium. On the map, DA4 represents major active channels and claypans on drainage floors, and consists of stream-sediment or freshwater-lake clays. D8 represents gypsiferous dunes on playa-lake margins. These dunes were included in DA6 on MENZIES (Kojan and Faulkner, 1994) and LEONORA (Bradley et al., 1995) and were not sampled on SIR SAMUEL. The approach on SIR SAMUEL was to map the more distinctive units that occur on drainage floors, such as valley calcrete (DA7v), gypsiferous dunes (D8), and playa lakes (DA6), and assign the surrounding less distinctive alluvial regolith to DA5.

Regolith codes shown on the sample forms have been checked against the analytical results to ensure that the most appropriate regolith codes and regolith source material are assigned to each sample. The most useful data for distinguishing codes and regolith source-material are those for SiO_2 , Fe_2O_3 , K_2O , Na_2O , CaO , S, pH and conductivity. In some cases it was necessary to assign a code on the basis of discriminant analysis. The six main source types recognized on SIR SAMUEL are granitoid, greenstone, gneiss, lake, calcrete and mixed. Regolith units derived from greenstone are relatively high in iron ($>10\%$ Fe_2O_3), with some units, such as E4v and R2, commonly exceeding 30% Fe_2O_3 . Granitoid-sourced regolith units commonly have less than 10% Fe_2O_3 , and SiO_2 contents are highly variable, but typically less than 85% SiO_2 for erosional and colluvial units and greater than 85% SiO_2 for relict units (R1, R3 and R4). Regolith derived from gneiss has unusually high Na_2O and low K_2O contents compared to regolith derived from granitoid. The two sources can also be distinguished using discriminant analysis. Two types of lake geochemistry are indicated in the datafile. Samples from saline lakes (DA6) have greater than 2% Na_2O (as sodium salts) and greater than 1200 mS/cm conductivity, whereas those from gypsiferous lakes (DA6g) have greater than 4% S (as gypsum). The samples derived from calcrete (DA7v) have greater than 1% CaO and are highly alkaline (pH >8.5).

A comparison of Department of Agriculture site types with GSWA regolith units is made above, and is summarized in Appendix 5. Results indicate that the regolith within outcrop areas (E2v, E2m, E2s and E2g) mapped on Plate 1 is much more diverse than shown, and commonly contains clays, hardpan and ferruginous lag. In contrast, the other regolith units correlate well with the site types described by Pringle et al. (1994).

Mineralogy of selected regolith samples

Table 5 summarizes the results of mineralogical analysis of 14 samples from SIR SAMUEL. The minerals identified by XRD analysis (Hart and Nickel, 1995) are expressed as theoretical mineral abundances calculated from chemical data. The main minerals identified were quartz, kaolinite, and iron oxides. Iron oxide is largely confined to samples wholly or partly derived from greenstones, and typically occurs as goethite. Samples 131447 (Dingo Range greenstone belt) and 131809

(northern Mount Keith – Perseverance greenstone belt) also contain hematite. Iron formation and ultramafic rocks occur in both areas. Other minerals present are K-feldspar, plagioclase, amphibole, chlorite, halite, gypsum and a magnesium-rich aluminosilicate tentatively identified as a form of saponite. Gypsum, halite and saponite are largely confined to lake samples, which also contain significant amounts of K-feldspar. Samples with plagioclase and higher concentrations of K-feldspar are confined to DC1g and DC2g. Remnant primary minerals are dispersed throughout SIR SAMUEL, indicating that mechanical erosion of relatively unweathered rock has been a significant process, especially in granitoid terrain.

Comparison of regolith units

Samples have been grouped according to source (greenstone, granitoid, gneiss, lake and calcrete) and further subdivided according to regolith code. Descriptive statistics have been produced for each of these regolith subdivisions and the element geometric means of the regolith units are compared in Tables 6–9. Separate statistics have been produced for regolith unit DA5 (sand- or clay-rich alluvium on broad drainage floors) because it is not possible to assign a source lithology to most of the DA5 samples. Statistics have not been produced for the 128 samples of mixed source, which include 61 of the 67 DA5 samples. The remaining samples consist of colluvium (DC1, DC2 and DC3) containing a mixture of granitoid-, gneiss- and greenstone-derived detritus.

Element geometric means for different regolith units for samples derived from granitoids, granitoid gneiss, greenstones and alluvial and lake areas are shown in Tables 6–9. Elements with a large number of values close to or below detection level have been omitted. Samples of mixed origin are omitted from these tables, but the raw chemical data are included in the SAMCHEM.CSV datafile, and shown on the element-distribution maps. As for MENZIES (Kojan and Faulkner, 1994) and LEONORA (Bradley et al., 1995), geometric means are used to compare the geochemical characteristics of the different units in order to minimize the effect of extreme values.

Regolith units derived from greenstone

Geometric-mean values, and numbers of samples for units R2, E4v, E1v, E2v, DC1v, DC2v and DC3f are listed in Table 6.

Most regolith samples derived from greenstone belong to the erosional and depositional colluvial regimes (Table 3). In contrast, many of the samples derived from granitoid were obtained from the relict and depositional eolian regimes. A more realistic comparison between samples derived from greenstone and those derived from granitoid can be made by excluding relict samples over granitoid (R1, R3 and R4), and sandplain (D9). On this basis, regolith samples derived from greenstone have higher geometric-

Table 6. Geometric means of analytical results for regolith units derived from greenstone

Regolith unit No. of samples	R2 n=10	E2v n=13	E1v n=5	E4v n=89	DC1v n=84	DC2v n=63	DC3f n=16
Percent							
SiO ₂	43.4	75.3	71.6	43.3	65.1	65.7	68.2
TiO ₂	0.93	0.42	0.45	0.90	0.60	0.63	0.55
Al ₂ O ₃	11.4	8.9	8.8	9.0	9.5	9.6	9.3
Fe ₂ O ₃	35.14	7.24	10.27	38.00	15.53	14.66	13.23
MnO	0.05	0.06	0.03	0.07	0.07	0.05	0.04
MgO	0.15	0.43	0.19	0.18	0.23	0.14	0.16
CaO	0.04	0.70	0.13	0.07	0.15	0.07	0.07
Na ₂ O	0.05	0.49	0.28	0.07	0.15	0.10	0.12
K ₂ O	0.36	1.21	0.95	0.33	0.74	0.73	0.77
P ₂ O ₅	0.09	0.04	0.05	0.09	0.06	0.06	0.06
Parts per million (a)							
As	30.9	6.3	12.4	31.2	13.6	11.8	11.7
Au (ppb)	1.0	1.5	0.8	1.2	1.2	1.0	0.8
Ba	115	294	321	204	209	233	242
Be	1.1	0.7	0.7	1.0	0.9	0.8	0.8
Bi	0.5	0.3	0.3	0.4	0.4	0.4	0.4
Ce	20	21	23	21	22	25	22
Co	28	15	9	30	19	12	12
Cr	1 395	179	233	1 062	496	457	444
Cu	71	33	34	82	52	34	33
F	80	88	87	58	72	74	81
Ga	30	13	15	28	17	20	18
La	10	10	12	10	11	13	12
Li	6	8	6	5	7	8	7
Mo	3	2	3	3	2	2	3
Nb	5	4	4	5	5	5	6
Ni	112	44	48	97	70	44	43
Pb	22	16	14	21	18	18	17
Pd (ppb)	1.4	0.8	0.8	1.1	0.8	0.8	0.7
Pt (ppb)	6.5	0.9	1.7	5.1	1.7	1.4	1.3
Rb	18	53	37	15	37	37	36
S	162	55	97	210	92	108	171
Sb	1.3	0.5	0.5	2.2	0.8	0.8	0.7
Sc	26	9	9	26	14	13	12
Se	1.7	0.5	0.6	1.9	1.0	0.9	1.2
Sn	1.4	1.0	0.9	1.4	1.3	1.4	1.3
Sr	15	67	47	22	32	30	34
Ta	0.6	0.4	0.5	0.5	0.6	0.6	0.7
Te	0.7	0.3	0.3	0.9	0.5	0.4	0.4
Th	14	6	7	14	9	12	11
U	2.0	1.2	1.2	2.0	1.7	1.9	2.0
V	588	115	129	605	238	250	221
W	1.0	0.9	0.6	1.3	1.2	1.1	1.0
Y	10	8	9	11	10	9	8
Zn	63	46	51	80	62	45	46
Zr	81	48	90	80	63	72	65

(a) except where noted otherwise

mean values than those derived from granitoid for Fe₂O₃ (20.0 vs 2.5%), TiO₂ (0.7 vs 0.3%), MnO (0.06 vs 0.01%), MgO (0.19 vs 0.08%), P₂O₅ (0.07 vs 0.03%), As (17 vs 2 ppm), Co (19 vs 4 ppm), Cr (600 vs 90 ppm), Cu (52 vs 11 ppm), Ni (67 vs 16 ppm), Pt (2.3 vs <1 ppb), S (128 vs 49 ppm), Sc (16 vs 3 ppm), Se (1.2 vs 0.2 ppm), Y (10 vs 5 ppm) and V (318 vs 39 ppm).

There are major differences between soil and sheetwash samples, and stream- and lake-sediment samples

derived from greenstone. The geometric-mean for SiO₂ is 63.0% for soil and sheetwash compared to 54.4% for stream- and lake-sediment samples. Stream- and lake-sediment samples have geometric means that are between 60–80% higher for Fe₂O₃, MnO, MgO, As, Co, Ni and V than those of soil and sheetwash samples. The geometric mean for Cr in stream and lake sediments is about 20% higher than that for soil and sheetwash samples. Stream-sediment samples include a larger proportion of the highly ferruginous E4v unit.

Table 7. Geometric means of analytical results for regolith units derived from granitoid gneiss

Regolith unit No. of samples	E4m n=7	E1m n=2	E2m n=2	DC1g (a) n=2	DC2g (a) n=2
Percent					
SiO ₂	80.1	82.0	79.9	80.0	83.0
TiO ₂	0.32	0.31	0.13	0.42	0.23
Al ₂ O ₃	9.1	8.5	10.3	10.3	7.2
Fe ₂ O ₃	3.53	3.48	1.40	3.62	2.37
MnO	0.03	0.02	0.02	0.03	0.02
MgO	0.10	0.45	0.10	0.12	0.08
CaO	0.18	0.98	0.77	0.35	0.20
Na ₂ O	0.45	1.22	1.85	0.50	0.42
K ₂ O	1.12	0.91	1.52	0.92	0.93
P ₂ O ₅	0.03	0.02	0.02	0.04	0.02
Parts per million (b)					
As	3.7	4.1	1.5	3.3	3.7
Au (ppb)	0.8	2.7	0.5	0.5	0.7
Ba	316	527	326	294	253
Be	0.7	0.6	0.9	0.7	0.5
Bi	0.3	0.3	0.4	0.3	0.3
Ce	23	15	15	31	17
Co	5	6	3	8	4
Cr	132	170	98	101	85
Cu	15	10	10	17	18
F	54	42	55	90	59
Ga	12	11	13	14	9
La	13	9	8	18	10
Li	7	6	10	9	6
Mo	3	1	4	1	4
Nb	4	3	5	7	3
Ni	24	36	11	22	19
Pb	14	11	15	16	15
Pd (ppb)	0.6	0.5	0.5	0.5	0.7
Pt (ppb)	0.7	0.7	0.5	0.5	0.5
Rb	45	26	68	40	41
S	52	983	7	227	35
Sb	0.2	0.3	0.1	0.2	0.3
Sc	4	4	3	5	4
Se	0.4	0.2	0.1	0.3	0.1
Sn	0.9	0.5	0.7	1.1	0.8
Sr	51	129	143	81	47
Ta	0.4	0.4	0.7	0.7	0.5
Te	0.3	0.3	0.3	0.3	0.3
Th	7	7	4	9	6
U	1.5	1.0	0.8	1.6	1.1
V	58	57	29	55	38
W	0.6	0.5	0.5	0.5	0.5
Y	7	4	5	9	5
Zn	29	18	21	33	30
Zr	56	51	46	76	44

(a) DC1g and DC2g samples derived from granitoid gneiss
 (b) except where noted otherwise

Relict regime

The relict regime is typically preserved in greenstone terrains. Ten samples of duricrust (R2) were obtained from this regime including samples from the Perseverance and Leinster Downs areas (Agnew and Mount Keith – Perseverance greenstone belts) and the Bates Range area (Yandal greenstone belt). These samples carry high Fe₂O₃ values, and the highest geometric-mean values for Cr, Ni, Pd and Pt.

Erosional regime

The erosional regime in areas of greenstone is represented by E2v, E1v and E4v. Although E2v represents greenstone outcrop, the geometric-mean values for CaO, MgO, MnO and Na₂O are lower and SiO₂ higher than average values for greenstone (Morris, 1993), indicating some weathering. Compared to results for LEONORA (Bradley et al., 1995), SiO₂ values for E2v are much higher (20–25% SiO₂) and Fe₂O₃ values much lower (10–15% Fe₂O₃) on SIR SAMUEL. A comparison of the geometric means for these three units indicates consistent trends moving downslope from the source (E2v through E1v to E4v) or conversely, up the laterite profile, with progressive depletion of CaO and MgO and enrichment in Fe₂O₃, TiO₂, As, Cr, Cu, Ni, Pt, S and V.

Depositional colluvial regime

The depositional colluvial regime is represented by units DC1v, DC2v and DC3f with increasing distance from the source and progressive reduction in the size and quantity of clasts. In comparison with the results obtained for LEONORA (Bradley et al., 1995), SiO₂ values are higher (5–10% SiO₂) and Fe₂O₃ values for DC1v and DC2v are correspondingly lower. A comparison of geometric-mean values for SIR SAMUEL shows small but consistent depletions in components such as MnO, CaO, As, Co, Cr, Cu, Ni and Sc, and corresponding increases in SiO₂, Ba, S and U. Other elements show little variation.

Regolith units derived from granitoid gneiss

A comparison of geometric means for samples derived from granitoid gneiss with samples derived from granitoid indicates some small but significant differences. Samples derived from granitoid gneiss have higher values for MnO (0.03 vs 0.01%), MgO (0.12 vs 0.08%), CaO (0.31 vs 0.10%), Na₂O (0.62 vs 0.39%), As (3.3 vs 2 ppm), Cr (119 vs 90 ppm), Ni (22 vs 16 ppm) and V (49 vs 39 ppm). The geometric means for 15 samples from five different regolith units are shown in Table 7. A detailed comparison of geometric-mean values between regolith types is not possible because of the low number of samples for each regolith type. However, high values of MgO, CaO, and Na₂O occur in E2m and E1m, but these oxides are relatively depleted in E4m, DC1g and DC2g. Arsenic, Ba, Cr and Ni show relatively high values in E1m, which is also ferruginous. The high sulfur values indicate that some samples include small amounts of gypsum.

Regolith units derived from granitoid

Ten different regolith units derived from granitoid are recognized on SIR SAMUEL. Geometric-mean values and numbers of samples are listed in Table 8. Compared to soil and sheetwash samples derived from granitoid, the geometric-mean values for stream-sediment samples derived from granitoid are higher for CaO (0.18 vs 0.05%), Na₂O (0.83 vs 0.15%), K₂O (2.4 vs 1.6%), Ba (576 vs 364 ppm), and Rb (87 vs 72 ppm), and lower for As (1.8

vs 2.6 ppm), Cu (10 vs 13 ppm), Cr (69 vs 104 ppm), Ni (14 vs 18 ppm) and V (29 vs 44 ppm).

Relict regime

The relict regime includes three regolith units (R1, R3 and R4). D9 (lowland sandplain) is included with these units for convenience, as it is indistinguishable in the field from R4 (upland sandplain), but in some areas appears to grade into granitoid sheetwash (DC3). Results (Table 8)

show that D9 and R4 are compositionally similar, although D9 has higher K₂O and Ba values, consistent with higher K-feldspar contents. R1 (ferruginous pisolites and nodules) is less siliceous than R3 (silcrete) but otherwise very similar. The Fe₂O₃ content of R1 and R3 (about 3%) is low, particularly for a ferruginous unit. Both R1 and R3 are locally reworked and cemented. R1 shows slightly higher values for Cr, Ni and V in comparison to the other relict units. Most trace-element values are uniformly low.

Table 8. Geometric means of analytical results for regolith units derived from granitoid

Regolith unit No. of samples	D9 n=75	R4 n=25	R1 n=20	R3 n=28	E4g n=46	E1g n=1	E2g n=46	DC1g n=84	DC2g n=105	DC3 n=121
Percent										
SiO ₂	89.8	90.4	82.6	87.2	78.0	79.0	79.9	81.1	82.5	82.9
TiO ₂	0.18	0.19	0.31	0.22	0.21	0.39	0.19	0.23	0.26	0.29
Al ₂ O ₃	4.5	4.4	7.1	6.5	9.5	11.5	9.8	9.2	8.3	7.2
Fe ₂ O ₃	1.76	1.91	3.38	2.13	2.27	2.96	2.04	2.10	2.49	3.13
MnO	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.01
MgO	0.04	0.03	0.04	0.05	0.09	0.05	0.09	0.07	0.07	0.06
CaO	0.02	0.02	0.02	0.06	0.19	0.06	0.22	0.13	0.07	0.04
Na ₂ O	0.04	0.02	0.02	0.13	0.79	0.22	1.09	0.57	0.22	0.08
K ₂ O	0.77	0.32	0.41	0.92	2.15	1.44	2.95	2.53	1.98	1.15
P ₂ O ₅	0.01	0.01	0.02	0.02	0.02	0.04	0.02	0.02	0.02	0.03
Parts per million (a)										
As	1.8	1.8	3.3	2.0	2.1	3.3	1.8	2.0	2.4	2.9
Au (ppb)	0.6	0.5	0.8	0.6	0.7	0.5	0.6	0.6	0.6	0.7
Ba	194	65	98	237	550	449	599	574	438	274
Be	0.3	0.2	0.3	0.4	0.8	0.7	0.9	0.7	0.6	0.4
Bi	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ce	9	8	12	14	25	29	26	26	21	17
Co	2	2	3	3	4	5	3	3	4	4
Cr	93	99	150	77	83	135	67	67	89	127
Cu	8	9	10	9	12	16	10	11	13	13
F	32	33	39	43	62	80	59	56	59	53
Ga	6	6	10	9	13	17	13	12	11	10
La	5	4	6	8	14	17	14	15	12	10
Li	4	4	6	5	6	9	6	6	7	6
Mo	2	2	2	2	2	3	2	2	2	2
Nb	3	3	4	4	4	6	4	4	5	4
Ni	14	14	18	13	18	17	13	14	17	18
Pb	11	8	10	14	19	25	25	22	21	14
Pd (ppb)	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5
Pt (ppb)	0.5	0.5	0.6	0.5	0.6	0.5	0.6	0.5	0.6	0.5
Rb	34	15	21	37	82	67	117	102	82	50
S	36	39	55	44	39	50	44	47	47	60
Sb	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.3
Sc	2	2	4	2	3	6	2	3	4	4
Se	0.2	0.2	0.4	0.2	0.3	0.4	0.2	0.2	0.2	0.4
Sn	0.6	0.6	0.9	0.7	0.8	1.5	0.7	0.9	1.0	0.9
Sr	22	9	12	30	100	58	99	82	53	33
Ta	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.5	0.5	0.4
Te	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Th	5	5	8	7	8	11	9	10	9	7
U	0.8	0.7	0.9	1.1	1.4	2.0	1.7	1.6	1.5	1.3
V	29	30	59	35	36	51	28	31	40	49
W	0.6	0.5	0.6	0.5	0.6	0.5	0.6	0.5	0.6	0.6
Y	3	2	3	3	5	8	5	5	6	5
Zn	15	14	15	17	24	34	22	22	25	23
Zr	38	35	52	53	61	76	61	63	62	52

(a) except where noted otherwise

Erosional regime

The erosional regime is represented by E4g, E1g and E2g. E1g (saprolite) and is more extensive than indicated on Plate 1, but is difficult to portray on account of its patchy distribution. The three units are compositionally very similar (Table 8). SiO₂ values are lower than those reported on LEONORA (Bradley et al., 1995) and K₂O, Na₂O, Ba, Rb, Sr, Cr and Th values are higher.

Table 9. Geometric means of analytical results for regolith derived from alluvial and lake areas

Regolith unit No. of samples	DA5 n=67	DA6 n=11	DA6g n=24	DA7v n=15
Percent				
SiO ₂	82.4	59.9	33.9	68.6
TiO ₂	0.32	0.42	0.17	0.29
Al ₂ O ₃	6.7	8.5	3.6	6.7
Fe ₂ O ₃	3.11	3.89	1.85	2.73
MnO	0.02	0.03	0.02	0.03
MgO	0.19	4.66	1.69	2.82
CaO	0.09	1.99	14.40	4.55
Na ₂ O	0.11	2.51	0.42	0.19
K ₂ O	1.06	1.44	0.54	0.89
P ₂ O ₅	0.03	0.05	0.04	0.04
Parts per million (a)				
As	2.9	5.2	2.8	3.0
Au (ppb)	0.6	1.4	1.2	1.1
Ba	259	250	125	202
Be	0.5	0.7	0.3	0.6
Bi	0.3	0.3	0.3	0.3
Ce	20	24	11	22
Co	5	7	5	6
Cr	110	104	72	90
Cu	15	19	9	18
F	70	328	104	384
Ga	9	13	5	10
In	0	0	0	0
La	11	13	6	12
Li	8	10	6	9
Mo	2	2	1	2
Nb	4	6	2	4
Ni	20	21	12	23
Pb	15	14	9	13
Pd (ppb)	0.5	0.7	0.6	0.5
Pt (ppb)	0.5	0.8	0.6	0.5
Rb	50	59	31	44
S	106	12 073	82 037	545
Sb	0.3	0.3	0.2	0.3
Sc	5	7	3	5
Se	0.2	0.5	0.4	0.2
Sn	1.0	1.3	0.7	1.1
Sr	37	321	554	114
Ta	0.4	0.6	0.3	0.5
Te	0.3	0.3	0.3	0.3
Th	7	7	4	7
U	2.1	8.3	4.0	3.0
V	47	82	30	44
W	0.6	0.7	0.6	0.8
Y	6	8	4	7
Zn	30	36	18	35
Zr	52	65	28	54

(a) except where noted otherwise

Depositional colluvial regime

The depositional colluvial regime comprises DC1g, DC2g and DC3. Results (Table 8) show that there is a systematic variation in composition downslope (E2g to DC1g to DC3), with increases in SiO₂, Fe₂O₃, TiO₂, As, Cr, Ni and V, and decreases in Al₂O₃, CaO, Na₂O, K₂O, Ba, Be, Ce, Pb, Rb, Sr and U. DC1g is compositionally similar to E4g, with a higher K₂O content than E4g, but lower levels than E2g.

Regolith units derived from alluvial and lake areas

Alluvial and lake areas contain regolith from lakes and calcrete (DA6, DA6g, and DA7v), and sand and clay (DA5) that surround lake and calcrete units on major drainage floors. The sand and clay that constitutes DA5 is commonly assigned a mixed source in the datafile (SAMCHEM.CSV). Analytical results (Table 9) show that DA5 is compositionally similar to DC3g. In DA5, Na₂O, CaO, MgO and U are slightly higher than in DC3g, probably due to the presence of small amounts of halite, calcrete and magnesium-rich clay. DA6 represents saline lakes, which by definition contain greater than 2% Na₂O as halite. DA6 is also enriched in CaO, S, MgO, K₂O, Sr, F, Li and U (Table 9). CaO and S occur as gypsum. Results of mineralogical investigations on a DA6 sample from SIR SAMUEL (GSWA 131256, Table 5) indicate that the MgO occurs as a magnesium-rich aluminosilicate referred to as saponite and the K₂O occurs as K-feldspar. DA6g (only listed in SAMCHEM.CSV) represents gypsiferous lakes, which by definition carry greater than 4% S as gypsum. This unit is also enriched in CaO, MgO, Na₂O, Sr, F and U (Table 9). DA7v represents valley calcrete, which by definition contains at least 1% CaO and is highly alkaline with a pH greater than 8.5. Analytical results in Table 9 show that this unit is also enriched in MgO, K₂O, F, S, Sr and U.

Regional regolith geochemistry

Regolith units derived from greenstone on SIR SAMUEL have higher SiO₂ and lower Fe₂O₃, MgO and CaO contents compared to equivalent regolith units described for LEONORA (Bradley et al., 1995). In contrast, regolith units derived from granitoid on SIR SAMUEL have lower SiO₂, and higher K₂O, Na₂O and Ba contents in comparison to the equivalent units on LEONORA. These differences can be attributed to compositional differences in greenstones and granitoids on the two map sheets, and to localized differences in conditions of weathering and erosion. Most of the greenstones on LEONORA are situated west of the Keith-Kilkenny transition zone and consist predominantly of mafic and ultramafic rocks, which can be correlated with similar rocks on SIR SAMUEL (Liu et al., in prep.). In contrast to LEONORA, the most extensive greenstone terrain on SIR SAMUEL is the Yandal greenstone belt, which is situated east of the Keith-Kilkenny transition zone and the Perseverance Fault (Fig. 3) and consists of mafic volcanic rocks overlain by felsic volcanic rocks (Westaway and Wyche, in prep.). Bradley et al. (1995) argued that different processes of weathering and erosion have

occurred on LEONORA, and that west of a line from Leonora to Agnew, colluvial sediments consist mainly of broken-down rock formed through mechanical erosion, whereas east of this line chemical weathering has been the dominant process.

A principal-component analysis (Rock, 1988) of the SIR SAMUEL data highlights the main element associations, and can also be used to produce a geochemical map of the granitoid-greenstone terrane (Fig. 51). The method of deriving a principal-component value for each sample is described by Bradley et al. (1995). Principal Component 1 (PC1) uses Fe_2O_3 , TiO_2 , MnO , P_2O_5 , As, Co, Cr, Cu, Ga, Ni, Pd, Pt, Sb, Sc, Se, Te, V, Y and Zn; Principal Component 2 (PC2) uses Al_2O_3 , K_2O , Be, Ce, La, Li, Rb and Zr. Since all factor loadings for PC1 are positive and all factors for PC2 are negative, addition of the two components produces a single set of numbers that places each sample point on a greenstone – alkali granitoid continuum. The numerical values are then contoured to produce the final map (Fig. 51). The areas of erosional regime for greenstone and granitoid rocks are clearly defined.

Greenstone-belt geochemistry

Geometric-mean values for samples derived from the three main greenstone belts (Fig. 3) show some between-belt compositional differences. The Agnew – Mount Keith – Perseverance belt has relatively high MgO , CaO , Co, Cr, Ni and W, whereas the Yandal belt has high Fe_2O_3 , Ba, Ga, Mo, V and Zr. Greenstones of the Dingo Range belt have high SiO_2 , K_2O and Rb. Three elements (Bi, Pt and Pd) have similar values for the Agnew – Mount Keith – Perseverance and Yandal belts that are higher than in the Dingo Range belt. Cerium, La and Nb are similar in the Yandal and Dingo Range belts, where they are higher than in the Agnew – Mount Keith – Perseverance belt. The concentration of the remaining elements (TiO_2 , MnO , Na_2O , Cu, Pb, Se, Sc, Sn, Ta, Th, Y and Zn) are similar in all three belts.

These differences probably reflect small differences in bedrock geochemistry, although elements such as Mg and Ca may be influenced by weathering effects because both MgO and CaO are in high concentrations in playa lakes and on surrounding drainage floors.

Agnew – Mount Keith – Perseverance greenstone belt

High values for MgO , CaO , Co, Cr, Cu, Ni, Pd, Pt and Se correspond to areas of mafic and ultramafic rocks in the Agnew – Mount Keith – Perseverance greenstone belt. The high values for W (≥ 13 ppm) correspond to the gold mining areas south of Leinster and north of Bellevue mine. A third high value for W is located near the Perseverance nickel mine. In addition to high W, the area south of Leinster has high Au (up to 730 ppb), As (up to 450 ppm), Sb and Te, and the area north of the Bellevue mine has elevated As, Au, Nb, Ta, Sn and Zn. The Perseverance nickel mine area has high Au, Bi, Te and Zn, and an area near Mount Keith has high As, Sn, Te and Zn values.

Yandal greenstone belt

The high geometric-mean values for Fe_2O_3 and V indicate that the central part of the Yandal greenstone belt contains a higher proportion of mafic volcanic rocks than suggested by regional mapping (Bunting and Williams, 1979; Wyche and Westaway, 1996). Regolith geochemistry has defined three extensive areas with high Co, Cr, Cu, Se, Pd, Pt and V values. One of these areas is located east of the Mount McClure gold mines and corresponds to an ultramafic unit mapped by Wyche and Westaway (1996). A second area is located in the eastern part of the belt between Mount Grey outcrop and Yandal Homestead, in an area of very poor bedrock exposure. The third group of high values is located in the Ockerburry Hill area, and corresponds to an area of exposed and interpreted mafic volcanic rocks. A high Co, Cu and V association is located in an area of outcropping mafic volcanic rocks near Darlot mine.

High values for Ba (up to 3302 ppm) and Ga (up to 76 ppm) are mostly confined to the Spring Well felsic volcanic complex, which also has anomalous values for As, Mo, Sn, Sb, Te and Zn. Other areas with possibly significant concentrations of gold and chalcophile and pathfinder elements include the Yandal Homestead area (As, Au, Mo, Pb, Sn, Te and W), the Bronzewing area (Bi, Mo, Nb, Sn, Ta and W), the Mount McClure area (As, Au, Cu, Pb, Te and Zn), and the Darlot mine area (Au, Ba, Sn and Te).

Dingo Range greenstone belt

Three groups of samples from the Dingo Range greenstone belt with high values for Co, Cr, Cu, V, Pd and Pt correspond to areas of mafic and ultramafic rocks mapped in the Mount Harold, Dingo Range and Wonganoo Homestead areas respectively. Chalcophile and pathfinder elements show high values in the Mount Harold area (Cu, Mo, Nb, Sn, Te and W), Dingo Range area (As, Cu, Sb, Sn, Te, W and Zn), and Wonganoo Homestead area (Te and Zn). A single sample with high values for Nb, Pd, Pt and Sn is located close to the northern boundary of the map sheet.

Granitoid and granitoid-gneiss geochemistry

Samples derived from granitoid on SIR SAMUEL have a low geometric-mean value for SiO_2 , and high values for K_2O , Na_2O , Ba, and Rb compared to samples from LEONORA (Bradley et al., 1995). In contrast to the LEONORA granitoids, K_2O , Na_2O , Ba and Rb values on SIR SAMUEL are consistently high in areas of granitoid outcrop (Figs 13, 14, 18 and 33). This suggests that granitoids on SIR SAMUEL are undergoing active erosion, and there is relatively little saprolitic or silicified material. The distribution of Na_2O values reflects the distribution of granodiorite, specifically the Mount Keith Granodiorite; the small granodiorite body south of Bates Range; and the granitoids mapped in the southeast of the

map sheet by Wyche and Westaway (1996). Scattered high Na_2O values also occur in areas of granitoid-gneiss outcrop. Most of the remaining granitoid areas on SIR SAMUEL consist of monzogranite, which is high in Ce, Nb, Sn, Th and Y relative to granodiorite.

Granitoids of the Southern Cross Province

A few samples of granitoid with unusual trace-element concentrations were taken from three locations in the Southern Cross Province on SIR SAMUEL. A lake sample from 11 km northwest of Yeelirrie Homestead has an anomalously high U content (32 ppm), in addition to high values for the pegmatite-related elements Be, Ce, La, Li, Nb, Sn, Th and Y. Two stream-sediment samples from 22 km south of Yeelirrie Homestead have high Ce, La, Nb, Ta, Th and Y concentrations, and a soil sample from a site 32 km north of Depot Springs Homestead contains 20 ppm Mo.

Granitoid gneiss of the western Norseman–Wiluna belt

Several samples with high values for Mo and W (Figs 27 and 45) are located in the northern section of the granitoid-gneiss belt that forms the western margin of the Norseman–Wiluna belt on SIR SAMUEL.

Granitoids of the eastern Norseman–Wiluna belt

Three locations in the eastern Norseman–Wiluna belt on SIR SAMUEL contain one or more samples showing unusually high element concentrations. A lake sample 11 km east of the Bellevue mine contains high Sn (Fig. 38), Be, Ce, La, Li, Nb and Y concentrations. A linear association of soil and sheetwash samples located several kilometres west of Barwidgee Homestead includes one sheetwash sample with high Se (Fig. 37), and several samples with high values for Sn, Y and Zn. These samples are located along an inferred north-northwesterly trending fault. The sheetwash samples may be derived from the adjacent WILUNA (1:250 000). A soil sample located in an area of quartz veining 14 km west-southwest of Barwidgee Homestead has high Cu (Fig. 23), Ni, Pb and Zn values.

Granitoids east of the Norseman–Wiluna belt

Two locations east of the Norseman–Wiluna belt on SIR SAMUEL contain one or more samples showing unusually high element concentrations. A group of lake- and stream-sediment samples sampled east of Lake Darlot has high values for Ce, La, Li, Mo, Nb, Sn (Fig. 38) and Y. A similar association has been described from the Yeelirrie and Lake Miranda areas. A soil sample from 10 km north of Wonganoo Homestead has a high Se concentration (Fig. 37).

Mineralization potential

The above review deals with the chemistry of regolith derived from either greenstone or granitoid and has revealed high values for a wide range of elements. The high values for pegmatite-related, rare-earth and base-metal elements in areas of granitoid and granitoid gneiss warrant further investigation. High values for pegmatite and chalcophile elements in greenstone belts are mainly of interest as pathfinders or indicators of gold and volcanic-hosted massive sulfide (VHMS) deposits. SIR SAMUEL has further potential for gold, VHMS, nickel and uranium mineralization, which is discussed below with reference to the appropriate element-distribution maps and a greenstone chalcophile-index map.

Gold mineralization

The distribution of gold in regolith samples on SIR SAMUEL is shown in Figure 17. The same data are contoured and shown together with known gold mines and prospects, and gold resources, on Figure 50 (data in Appendix 1). These data show that the majority of significant gold mines and prospects are located within the areas of high gold values (≥ 2 ppb Au). The exceptions include the Lotus, Cockburn, Parmelia and Challenger deposits (Mount McClure), the Bronzewing group of deposits (Central, Discovery, etc.), and the Hurleys Reward deposit. Regolith mapping and the results of Hickman (in prep.) indicate that the Bronzewing, Lotus and Cockburn deposits are concealed by barren pisolitic hardpan: thus surface geochemical sampling for gold is unlikely to be successful in these areas. However, there are eleven locations where several samples have gold values greater than or equal to 3 ppb, which warrant further investigation. These include the Langfords Find and Popes Patch prospects near Yandal (Au >10 ppb), and nine 'greenfields' localities: Dingo Range; Rosewood Fault northeast of Darlot; Spring Well north of Ockerburry Hill; three locations west, south and north of Yandal Homestead; the Eleven Mile Fault area; the Rockys Reward area; and a granitoid location northeast of Perseverance mine. Some of these locations also have high Te, and two other locations (Wonganoo Homestead and Mount Grey areas) have high Te but low Au. Tellurium values up to 30 ppm are associated with gold mineralization at the old Bronzewing Reward mine (Hickman, in prep.). Low-level Au values in Lake Darlot and the lake southeast of Lake Maitland reflect the low-level Au concentrations of the regolith in the adjacent greenstone terrain. A highly anomalous Au value of 15 ppb near the Lake Darlot road crossing is the result of contamination from rockfill used to maintain the causeway.

Greenstone chalcophile-index (gold and VHMS mineralization)

The concept of using pathfinder elements and additive indices to highlight areas of potential gold and VHMS mineralization in the Yilgarn Craton was proposed by Smith and Perdix (1983). A CHI*6 index (Smith et al., 1989) was used by Bradley et al. (1995) to highlight chalcophile associations on LEONORA. A greenstone

chalcophile-index (Kojan et al., in prep.), specifically applied to greenstone-sourced regolith samples, includes correction factors for downslope weathering effects. A greenstone chalcophile-index value has been calculated for each regolith sample derived from greenstone. These values represent the sum of the standard scores calculated for As, Bi, Mo, Sb, Se, Sn and W, using the procedure described in Appendix 6.

Greenstone chalcophile-index values are listed in the datafile (SAMCHEM.CSV) and positive values are presented in Figure 52. High index values are associated with most gold mining centres, with the exception of Darlot and Mount Keith. Gold deposits that have low regolith-Au values (such as the Bronzewing group, and Lotus and Cockburn), are associated with a cluster of higher chalcophile-index values. High chalcophile-index values also occur in areas of low-level Au and Te, including Mount Doolette, Mount Sir Samuel, Six Mile (Yakabindie) and the northern Perseverance Fault (south of Nuendah). Several of these chalcophile/gold anomalies also contain anomalous base-metal values, with a maximum value for Cu of 201 ppm and Zn of 249 ppm from Mount McClure; Cu and Zn of 237 ppm from Spring Well and Ockerburry Hill; Pb of 158 ppm from near Yandal Homestead; Cu of 253 ppm from the Mount Harold area; and Cu of 188 ppm and Zn of 210 ppm from Dingo Range.

Nickel mineralization

Details of nickel mines and deposits on SIR SAMUEL are listed in Appendix 2. Nickel concentrations in regolith (Fig. 29) relate to areas of ultramafic rocks, which carry up to 0.1% Ni as silicate minerals. High values (Ni >540 ppm) in greenstone belts cannot be regarded as direct evidence of nickel sulfide mineralization. The relatively low nickel values obtained in the Mount Keith area and Yandal and Dingo Range greenstone belts reflect more intense weathering and leaching of nickel. Relatively high levels of Co, Cr, Pd and Pt indicate that mafic and ultramafic rocks are much more widespread in the Yandal and Dingo Range belts than indicated by geological mapping. A soil sample from an area of quartz-veined granitoid 14 km west southwest of Barwidgee Homestead has anomalous Cu (255 ppm), Ni (174 ppm), Pb (146 ppm) and Zn (106 ppm).

Uranium mineralization

High U values (Fig. 43) relate to concentrations of secondary uranium minerals, such as carnotite, in playa-lake sediments and calcrete deposits. Butt et al. (1977) described five such occurrences from SIR SAMUEL, one of which (Lake Maitland) was found to consist of two uranium deposits (Appendix 2). There are 12 separate locations on SIR SAMUEL where one or more samples contain 7.5 ppm or more U (Fig. 43). Four of these locations (Lake Maitland; Kaluweerie, north of Depot Springs; Little Well, east of Yeelirrie Homestead; and Boundary Well near Ockerburry Hill) correspond to uranium occurrences described by Butt et al. (1977). Other anomalous areas include one site 11 km northwest of

Yeelirrie Homestead, and another site several kilometres east of the main Yeelirrie uranium deposit that contains elevated U as well as high values for a range of pegmatite-related and rare-earth elements. This uranium, pegmatite-related, and rare-earth element association is also evident at a single site 18 km east of the Bellevue mine (32 ppm U), and a group of sites located close to the Ninnis Fault east of Lake Darlot (U up to 28 ppm).

Summary and conclusions

The SIR SAMUEL regolith mapping and geochemistry program has examined 1026 regolith samples, collected at a sampling density of one sample per 16 km². These samples comprise 397 stream-sediment, 421 sheetwash, 156 soil and 52 lake-sediment samples. Forty-seven elements have been measured for each sample and 44 of these are featured on element-distribution maps.

The regolith-materials map delineates 28 different regolith units. Four correspond to a relict regime, ten to an erosional regime, and fourteen to a depositional regime. Relict, erosional and depositional colluvial units have been classified according to their source lithology, degree of weathering, and proximity to source. These parameters have been determined from a combination of field observations, interpretation of available imagery, and inspection of the analytical results.

Results of a comparison of Department of Agriculture site types with GSWA regolith units mapped on SIR SAMUEL indicate that the regolith within the outcrop areas (E2v, E2m, and E2g) is much more diverse than shown, and commonly contains clays, hardpan and ferruginous lag. In contrast, the other regolith units correlate well with the site types.

Regolith derived from granitoid can be compared to that derived from greenstone by excluding the numerous silica-rich samples from the relict and depositional eolian regimes from the granitoid dataset. Greenstone-sourced samples have much higher geometric-mean values for Fe₂O₃, TiO₂, MnO, MgO, P₂O₅, As, Co, Cr, Cu, Ni, Pt, Sc, Se, Y and V, and lower values for SiO₂, K₂O, Na₂O, Ba and Rb compared to granitoid. Other elements have similar geometric means.

Stream and lake samples derived from greenstone-sourced regolith have geometric-mean values for Fe₂O₃, MnO, MgO, As, Co, Cr, Cu, Ni and V that are between 20 and 80% higher than the corresponding values for soil and sheetwash samples. These differences are reflected on the regolith map and in the datafile, where a much higher proportion of stream-sediment samples are classified E4v (ferruginous lag) or R2 (duricrust) with a minimum of 30% Fe₂O₃.

Granitoid-sourced stream-sediment samples have geometric-mean values for CaO, Na₂O, K₂O, Ba and Rb that are up to five times higher than the corresponding values for soil and sheetwash samples (excluding samples from the relict regime or sandplain). Again, the differences are reflected on the regolith map and in the datafile, where

a higher proportion of stream-sediment samples are classified as erosional (E2g or E4g) or proximal colluvial (DC1g) on account of their relatively high K_2O content.

A comparison of geometric-mean values for regolith units derived from greenstone belts reveals two separate trends. The first trend from E2v (outcrop) through E1v (saprolite) to E4v (ferruginous lag) shows progressive depletion of CaO , Na_2O , K_2O and MgO , and progressive enrichment in Fe_2O_3 , TiO_2 , As , Co , Cr , Cu , Ga , Ni , Pt and V . DC1v is similar to E4v in that it is relatively enriched in Fe_2O_3 and associated elements compared to E2v. The second trend (from DC1v (proximal colluvium) through DC2v to DC3f) shows small but consistent depletions in a wide range of components including Fe_2O_3 , CaO , Na_2O , K_2O , MgO , MnO , As , Co , Cu , Ni , Sc , V and Zn .

A comparison of geometric-mean values for regolith units derived from granitoids shows that R4 (upland sandplain) and D9 (general sandplain) are compositionally very similar and that R1 (ferruginous pisolites and nodules) is similar to R3 (silcrete). Results show that the three erosional regime units (E1g, E2g, and E4g) are compositionally very similar. There is a systematic downslope variation from E2g through DC1g to DC3, with an increase in SiO_2 , Fe_2O_3 , TiO_2 , As , Cr , Ni and V , and a decrease in Al_2O_3 , CaO , Na_2O , K_2O , Ba , Be , Ce , Pb , Rb , Sr , Th and U . DC1g is compositionally similar to E4g with a higher K_2O content than E4g, but a lower K_2O content than E2g.

A review of geometric-mean values for regolith units situated in alluvial and lake areas shows that DA5 (alluvial sands and clays of mixed origin) is compositionally similar to DC3 (distal colluvium of granitoid or mixed origin). DA6 (saline lakes) has anomalously high Na_2O values; both DA6 and DA6g (gypsiferous lakes) have high CaO , MgO , Na_2O , K_2O , S , Sr , F and U concentrations. DA7v (valley calcrete) is enriched in CaO , MgO , K_2O , F , S , Sr and U , and is highly alkaline.

Concentrations of SiO_2 and Fe_2O_3 on SIR SAMUEL are significantly higher in regolith derived from greenstone compared to equivalent units on LEONORA, whereas MgO and CaO are lower. In contrast, granitoid-derived regolith on SIR SAMUEL has a lower SiO_2 and higher K_2O , Na_2O , Ba and Rb content in comparison to the equivalent units on LEONORA. This suggests that granitoids on SIR SAMUEL are undergoing active erosion, and that, in contrast, the greenstones on large parts of SIR SAMUEL have been subjected to intensive silicification and ferruginization.

Comparison of geometric-mean values for samples derived from the three main greenstone belts shows that overall differences are small. Compared to the other belts the Agnew – Mount Keith – Perseverance greenstone belt is slightly enriched in MgO , CaO , Co , Cr , Ni and W , whereas the Yandal greenstone belt is slightly enriched in Fe_2O_3 , Ba , Ga , Mo , V and Zr . The Dingo Range greenstone belt is high in SiO_2 , K_2O and Rb . Other elements (TiO_2 , MnO , Na_2O , Cu , Pb , Sc , Se , Sn , Ta , Th , Y and Zn) are evenly distributed throughout all three belts.

The high geometric-mean values for Fe_2O_3 and V for the Yandal greenstone belt indicate a higher proportion of

mafic volcanic rocks than is suggested by geological maps. Regolith geochemistry has defined three large areas with high values for Co , Cr , Cu , Pd , Pt , Se and V , and one additional area with high Co , Cu and V only. One of the large anomalous areas for Cr and associated elements is located in the eastern part of the belt in an area of very poor bedrock exposure.

The distribution of Na_2O reflects the distribution of granodiorite. Most of the remaining granitoid areas on SIR SAMUEL consist of monzogranite and on this map sheet have high concentrations of Ce , Nb , Sn , Th and Y relative to granodiorite.

There are a range of regolith samples from SIR SAMUEL that were derived from greenstone and granitoid that have anomalously high trace-element values. Six high-value occurrences for pegmatite-related and rare-earth elements in granitoid and granitoid-gneiss areas warrant further investigation. At least three of these high-value occurrences are associated with anomalous U in lake sediments. There are nine other anomalous uranium occurrences, including the uranium deposits at Lake Maitland. A single site situated in an area of quartz veining west of Barwidgee Homestead shows highly anomalous Cu , Ni , Pb and Zn concentrations.

Gold geochemistry results show that the majority of significant gold mines and prospects on SIR SAMUEL are located within the areas of high gold values (≥ 2 ppb Au), apart from several deposits in the Mount McClure and Bronzewing areas, and the Hurleys Reward deposit. In addition, there are 12 locations where several regolith samples have gold values of 3 ppb or more, which warrant further investigation. These include two old prospects in the Yandal greenstone belt, and ten underexplored areas, nine of which are located in areas of greenstone. Some of these locations also have anomalous Te values, and two other locations have high Te but low Au values.

Greenstone chalcophile-index values, calculated for all greenstone-derived regolith samples, are high over most gold mining centres. However, in other areas, (e.g. Bronzewing group and at Lotus and Cockburn), high chalcophile-index values are not accompanied by high Au concentrations.

High chalcophile-index values occur in underexplored areas where both Au and Te concentrations are low. Four such areas have been identified. Six areas with Au and chalcophile-index anomalies also have anomalous base-metal values.

Regolith with high Ni concentrations corresponds to areas of ultramafic rocks. The relatively low nickel values obtained in the Mount Keith area and Yandal and Dingo Range greenstone belts reflect more intense weathering and leaching of nickel. Results for Co , Cr , Pd and Pt indicate that mafic and ultramafic rocks are much more widespread in the Yandal and Dingo Range belts than is indicated by geological mapping. These areas warrant investigation for nickel sulfide mineralization.

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Appendix 1

Production and resources of gold to 31 December 1994

Mining centre	Name	Total gold produced (kg)	Resources gold (kg)	Total gold (t)	Location (AMG)		
					Easting	Northing	
EAST MURCHISON GOLDFIELD							
LAWLERS DISTRICT							
Kathleen Valley	Abbotts (Mount Pascoe)	11.2	—	11.2	263100	6956400	
	McFarlanes Find (Betheno)	20.5	—	20.5	260450	6968600	
	Mossbecker, Hidalgo, Kathleen	20.7	1 971.0	1 991.7	260050	6952850	
	Carriport	11.0	360.0	371.0	259750	6953250	
	Nil Desperandum, Pascoe Pride, Roderick Dhu	318.3	670.0	988.3	259650	6954250	
	Yellow Aster, Yellow Aster North	1 133.5	2 259.0	3 392.5	259850	6954650	
	Main Road	270.0	154.0	424.0	258600	6952200	
	Sulphide King	5.9	—	5.9	257000	6952750	
	Mount Harris	11.2	—	11.2	257200	6947800	
	Kathleen Consols	4.9	—	4.9	259300	6951500	
Bronzewing	Discovery	—	23 960.0	23 960.0	302600	6968750	
	Western	—	5 680.0	5 680.0	302200	6969150	
	Anzac	—	450.0	450.0	302450	6970400	
	Laterite	—	750.0	750.0	303000	6970500	
	Central	—	41 640.0	41 640.0	302600	6969650	
	Bobs	—	—	—	303700	6972000	
Mount McClure	Anomaly 55	—	—	—	293900	6968300	
	Lotus	2 329.0	6 404.0	8 733.0	295100	6966550	
	Cockburn	280.0	22 201.0	22 481.0	296000	6965250	
	Karra Creek	—	—	—	297900	6963000	
	Anxiety North	—	—	—	298400	6958900	
	Anxiety South	—	—	—	298650	6956900	
	Success	865.0	—	865.0	296400	6954800	
	Parmelia	1 625.0	—	1 625.0	297400	6952800	
	Challenger	329.0	—	329.0	299400	6949100	
	Dragon	1 308.0	—	1 308.0	302800	6942500	
Lawlers	Dobra Serica, Admiral Dewey, Try It,						
	Kiora, Lone Hand, Moa	76.0	76.0	152.0	253900	6900500	
	Glasgow Lass, Lillian, Lillian Lass, Boomer	87.1	165.0	252.1	253750	6900300	
	Waroonga	—	477.0	477.0	253900	6902200	
	New Holland	4 279.0	1 309.0	5 588.0	253750	6901700	
	Genesis	1 432.0	1 739.0	3 171.0	253650	6902550	
	Cinderella, King Edward	—	—	—	254000	6901000	
	Kanmuntoo, Trump, Victor	83.7	—	83.7	254150	6900900	
	Rajah, Rajah extended, Woroonga extended	37.9	—	37.9	254750	6900200	
	Melbourne	1.8	—	1.8	259600	6902250	
	Return	1.1	—	1.1	261300	6901450	
	Vivian	2 418.5	7 430.0	9 848.5	260750	6903000	
	Vivian Gem	98.8	—	98.8	260000	6904800	
	Dalmatia	2.0	2.0	4.0	265500	6912650	
	Caroline Baker	0.3	—	0.3	265050	6915550	
	Leinster	831.2	—	831.2	264200	6917200	
	Brilliant	273.9	—	273.9	269000	6904650	
	Cams	—	463.0	463.0	257550	6930150	
	Scorpion	—	—	—	257900	6929900	
	Maria	—	547.0	547.0	259750	6920200	
	north of Brilliant	—	—	—	267500	6907800	
	south of Leinster mine	—	—	—	264900	6916700	
	Sir Samuel	Bellevue	21 882.6	4 420.0	26 302.6	258900	6940200
		Condor, Dedong, Canberra, Calliope	32.0	—	32.0	259200	6940400
		Isidore, Carbine, Dollypot	65.5	—	65.5	258650	6941150
Dreamland, Camperdown		6.0	—	6.0	258700	6942100	
Cardiganshire		1.5	—	1.5	258700	6941650	
Vanguard		164.9	—	164.9	259400	6942250	
Westralia		46.7	—	46.7	259200	6941000	
Goodenough		1.6	—	1.6	258650	6943000	
Palmyra		0.9	—	0.9	258000	6946000	
New Orleans		—	1 058.0	1 058.0	260850	6941800	

Appendix 1 (continued)

Mining centre	Name	Total gold produced (kg)	Resources gold (kg)	Total gold (t)	Location (AMG)	
					Easting	Northing
Miscellaneous	Gum Well	–	–	–	307100	6935300
	Hartwell Bore	–	–	–	305550	6916350
	Toms Well	–	–	–	300000	6916000
WILUNA DISTRICT						
Mount Keith	Waldecks, Wiluna South	17.2	–	17.2	254200	6996400
	Comtesse	3.0	–	3.0	254100	6995150
	Jessie May	1.7	1.7	3.4	255100	6994500
	Queen of Scots, Gem, Winifred, Starlight	8.6	–	8.6	254850	6991450
	Aurora, Chicone, Dunbar	121.6	–	121.6	255200	6990900
	Miss Deal, Grand Schlam, Little Schlam, Talbings	84.0	–	84.0	256000	6989650
New England	Auckland, Empire, Glennis	27.3	–	27.3	298000	7011200
	Longshoot	7.2	–	7.2	298000	7008700
	Lowlands, Eric	21.0	454.0	475.0	307900	7006500
Corboys	Merrington Consols, North End	2.9	–	2.9	297250	7005450
	Waratah leases	73.0	–	73.0	297900	7004050
	Corboys Reward North, Yandal 2	90.3	1 167.0	1 257.3	298150	7003100
	Toscana	69.3	–	69.3	298750	7000150
	Alta Gorfoquana	2.7	–	2.7	299500	7000550
Bronzewing	Bronzewing Reward, Kirkpatricks (Hawk),					
	Malbie, Lucky	15.8	–	15.8	301200	6976850
	(Maitland), Gem, Ethelstone, Wandilla	17.6	–	17.6	305600	6983400
	Mount Joel	–	–	–	306300	6985700
	Sundown	–	–	–	306400	6974850
	Anomaly 63	–	–	–	291800	6975700
	Anomaly 60	–	–	–	293250	6973600
	Anomaly 57	–	–	–	295000	6970900
MOUNT MARGARET GOLDFIELD						
MOUNT MALCOLM DISTRICT						
Darlot	Amazon, East End	201.3	–	201.3	332200	6909600
	Ballingarry	98.1	–	98.1	333300	6908050
	Blue Spec	1.8	–	1.8	328800	6914400
	Boomerang	2.9	–	2.9	330700	6912550
	British King	387.5	690.0	1 077.5	326850	6908250
	British King North	0.4	–	0.4	327350	6909500
	Darlot, Zangbar, Monte Cristo, Filbandint,					
	Afrikander	11 142.6	10 030.0	21 172.6	329500	6913850
	Furmans	–	–	–	325750	6911800
	Homeward Bound, Balmoral	6.9	–	6.9	328300	6906800
	King of the Hills	65.2	–	65.2	331300	6912750
	Morning Light	14.3	–	14.3	334150	6911000
	Mystery	0.8	–	0.8	334900	6908000
	New Year's Gift	14.7	–	14.7	327500	6907150
	Pride of Darlot, A1	12.7	–	12.7	327100	6906300
	Rise and Shine, Lass O'Gowrie	28.5	–	28.5	330650	6913100
	Rose, Sylvia, Kyneton	2.1	–	2.1	326000	6907800
	Rosewood	3.0	–	3.0	335400	6916850
	Royal Welshman, Wee Jim	2.0	–	2.0	328800	6909650
	St George, Brown Hill, Iron Clad	351.0	–	351.0	330900	6913700
	The Dragon	17.2	–	17.2	335450	6914500
	Waikato	163.3	–	163.3	328100	6911750
	Weebo, Lot of Bother, New Discovery	26.7	–	26.7	325600	6906850
	Darlot Deep Lead	–	–	–	328800	6912350
	Maryland	–	–	–	328500	6916250
	unnamed	–	–	–	324700	6915000
	unnamed	–	–	–	322500	6913600
	Fisher Well	–	–	–	331000	6914550
	unnamed	–	–	–	335300	6912100
	Cornucopia	–	–	–	330600	6911800
	Dead Horse	–	–	–	328300	6910100
	Larrys	–	–	–	328600	6910800
	Cemetery	–	–	–	331600	6910900
	Woodarra	–	–	–	332150	6809650
	Woodarra North	–	–	–	331650	6910250

Appendix 1 (continued)

Mining centre	Name	Total gold produced (kg)	Resources gold (kg)	Total gold (t)	Location (AMG)	
					Easting	Northing
Miscellaneous	Hamster	—	—	—	308500	6952950
	Griffin Well	—	—	—	324550	6939700
	Popes Patch	—	—	—	313000	6929550
	Langfords Find (Yandal)	—	—	—	319950	6952250
	Waterloo	—	—	—	321300	6911750
	Mandilla Well	—	—	—	312700	6938000
	Lily Well	—	—	—	313150	6954800
	Lily Well North	—	—	—	313500	6954800
	Boundary	—	—	—	345350	6971150
	Stirling	—	—	—	346050	6969650
	Hurleys Reward	1.2	120.0	121.2	348050	6969250
	Bungarra Flat	—	—	—	349150	6967000
	Kennys Find	—	—	—	350100	6965850
	Freemans Find/Trondy	4.0	—	4.0	347500	6963700
	Red Cloud	—	—	—	348700	6962050
	Nuggets	—	—	—	345000	6963700

Appendix 2

Production and resources of nickel, copper and uranium to 31 December 1995

Mine or prospect	Production to end 1995 (t)	Resources		Total metal or oxide (t)	Location (AMG)	
		Ore	Contained		Easting	Northing
		Mt × grade (%)	metal or oxide (t)			
NICKEL						
Mount Keith	34 693	236.2 × 0.6	1 417 200	1 451 893	257500	6985200
Mount Keith: Cliffs – Charterhall	–	confidential	–	–	257000	6977000
Betheno	–	no data	–	–	259400	6967000
Six Mile	–	151 × 0.6	906 000	906 000	260350	6963650
David	–	2.3 × 0.5	11 500	11 500	260650	6962500
Goliath North	–	45.2 × 0.63	284 760	284 760	261200	6961800
Goliath South	–	no data	–	–	261200	6959950
Serpentine Hill	–	3.0 × 0.8	24 000	24 000	260300	6960500
Mount Goode	–	no data	–	–	260252	6943964
Sir Samuel	–	1.5 × 2.0	30 000	30 000	268700	6933600
Leinster Downs	–	no data	–	–	271050	6929100
Rockys Reward and Perseverance		5.4 × 2.4	129 600		273000	6923600
		132.6 × 0.65	861 900		273700	6920900
		54.8 × 1.93	1 057 640			
Subtotal	211 480		2 049 140	2 260 620		
Melon, Eleven Mile Well		6.0 × 0.8	48 000	48 000	276650	6915700
Total	246 173		4 770 600	5 016 773		
COPPER						
Kathleen Valley	–	no data	–		258300	6954100
	–	no data	–		257400	6957600
	–	no data	–		258100	6958600
Subtotal	424		0	424		
Sir Samuel	–	no data	–		258400	6942500
	–	no data	–		257600	6946300
Subtotal	11		0	11		
Total	435		0	435		
URANIUM						
Lake Maitland	–	1.25 × 0.04	500	500	311455	6996712
Lake Maitland (Mount Joel)	–	11.6 × 0.051	5916	5 916	311163	6992367
Total		0	6 416	6 416		

Appendix 3

Open-file geochemistry surveys

KEY	
ID No.	Project reference number — allocated for these notes.
Map sheet	1:100 000 sheet number(s) to aid in project location (Plates 1 and 2).
Area (sq km)	Project area. When the project extends outside SIR SAMUEL the area is not stated.
Company	The company that carried out the geochemical exploration.
M No.	GSWA project reference number.
Item No.	DME library reference number for a group of related open-file reports on microfiche; the Item number replaces the M number for project identification.
A No.	GSWA report reference number.
Yr	The year that the report was written.
Medium	How the sample was obtained RAB: Rotary air blast drilling RC: Reverse circulation drilling
No./Ag to Zn	The number of samples from the medium indicated, and each element determined marked 'X' or 'x'. The 'x' means that this element was not determined for the entire number of samples listed. If more than one analytical method is used for a group of samples from a particular medium, a new line is taken to identify the elements relevant to each method.
Method/Analyst	Blanks occur in these columns if the information is not given in the company report. AAS: Atomic absorption spectroscopy BLEG: Bulk leach extractable gold ETA: Electrothermal absorption GTA: Graphic Tube Atomization gen: generation ICP: Inductively coupled plasma MS: Mass spectroscopy OES: Optical emission spectroscopy XRF: X-ray fluorescence AAL: Australian Assay Labs ARA: Assay Research Australia AS: Analytical Services AustS: Australian Selection CC: Classic Comlabs Clas: Classic KML: Kalgoorlie Metallurgical Labs PL: Pilbara Labs PML: Kalgoorlie Metallurgical Labs RW: Rapley Wilkinson TEL: Trace Element Labs
DD	'Y' marked in this column indicates deep drilling activity.
Comments	Further sample details with regards to collection and analysis. D: Depth DL: Detection limit — only correlates to gold analyses

Notes: For public use all open-file company reports are provided on microfiche in the Department of Minerals and Energy (DME) library at Mineral House. To locate a particular report on microfiche, the relevant Item number and A number are required.

Appendix 3

Sir Samuel 1:250 000 open-file

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
1	3043 3143	906	CRA Exploration	169	253 "	1527 1529	68	Soil	1434					X	X	X
2	2942 3042		Seltrust Mining Corp	252/2	3837 " " " " " "	10145-47 10151-52 10155 10157-60 10166 10168 10172-73 10177	79	Auger Percussion Rock Chip Soil	4020 270 430 8200							X X X X
3	3042 3043	26	Aust Selection Seltrust Mining Corp BP Minerals Aust	252/8	3840 3840 3840	5633 11586 15418	75 82 85	Percussion Rock Chip " Percussion Rock Chip "	10 12 4 24		X X	X	X X	X X	X X	X X
4	3042		BP Minerals Aust	252/17	3841	26852	89	Percussion " Rock Chip " Stream	3 64 25	X X	X	X X	X X	X X	X X	X X
5	3042		Aust Selection Aust Selection Aust Selection Western Selcast	252/18	6181 6181 6181 6181 " "	1321 2298 1327 2674-75 2677-83 2685-86	68 70 71 72	Soil Soil Soil Diamond Gossan Percussion Soil	810 7790 600 31 134 479 10330					x		X X X X X X
6	3142 3143		Amalgamated Petroleum Amalgamated Petroleum Amalgamated Petroleum Amalgamated Petroleum Amalgamated Petroleum	289	371 371 371 371 371	160 161 162 1 4221	69 70 70 71 73	Soil Percussion Soil Stream Grab RAB	320 3 500 16 1420 12		x			x		X X X X X
7	3142		Western Mining Corp	500	2815	1811	71	Rock/ Soil	200	X				X		X

[illegible]

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
8	3043	8	McIntyre Mines	558	2416	811	71	Percussion	103					X	X	X
					"	1727										
			Falconbridge Aust		2416	4562-65	73	Ironstone	358						X	X
					"	4567		Percussion	97						X	X
								RAB	83						X	X
								Soil	1 238						X	X
9	2943 3043		Western Mining Corp	593	1188	1793-94	71	Percussion	10						X	X
					"	1798		Soil	1 190							X
					"	1804										
					"	1806										
10	2943	35	Jododex Aust	639	2881	2010-13	71	Auger	4 300					X		X
								RAB	14					X		X
11	3042	9	Hawkstone Minerals	661	2806	2075	70	Gossan	25		x			x		X
			Hawkstone Minerals		2806	3490	72	Rock	70						x	X
								Rock /Soil	110							X
								Soil	45							X
								Vacuum	183							X
12	3043	4	Carr Boyd Minerals	679	1081	2128	71	Soil	560							X
13	3143	9	SAMAUST	881	1847	2611	72	Diamond	1							X
								Percussion	23							X
								Rock	252							X
14	3142	14	Kennecott Exploration Aust	912	2374	2723	71	Soil	545							X
			Kennecott Exploration Aust		2374	3151	72	Percussion	13							X
15	2942	24	Kennecott Exploration Aust	913	1083	3595	72	Rock /Soil	110							X
								Soil	850					X		X
16	3142 3143	12	SAMAUST	922	1495	2739-40	71	Gossan	33							X
								Percussion	4							X
17	3042		Amax Exploration Aust	1150	624	3534-36	73	Percussion	100					X	X	X
18	3143	30	Asarco Aust	1162	7580	3586-87	73	Auger	75							
			Carpentaria Exploration Co		7580	5701	75	Auger	33							
			Carpentaria Exploration Co		7580	8928	79	RC	320							
			Carpentaria Exploration Co		7580	9465	80	Auger	10							

(cont)

Fe	Mn	Mo	Ni	Pb	Sb	Sn	Zn	Method	Analyst	DD	Comment on Samples
			X					AAS	TEL	Y	D:0-3m composite
	X		X				X			Y	D:0-3m composite
			X								D:0-4m composite
			X								Fractional analysis, Recon, D:0.15m
			X								
			X				X			Y	D:0-1.5m
			X				x				
			X				X			Y	D:0.5m
			X				X				D:0-1.5m
			X								
			X				x		Geomin	Y	D:0-4m composite
			X						"		D:0-4m composite
			X								D:0-4m composite
			X						Amdel		D:0-4m composite
			X								
			X								D:0.1m
			X				X	AAS	Geomin	Y	D:0-3.5m
			X				X	AAS	"		D:1.5-3m
			X				x	AAS	"		
			X					Perchloric /AAS			480 samples just outside tenement boundaries
			X					Perchloric /AAS		Y	D:0-3m composite
			X					Perchloric /AAS			D:1.5m
				X				Perchloric /AAS	Sampey		D:0.15m, Results as profiles
			X				X	AAS	Geomin	Y	
			X				X	AAS	"		D:0-1.5m
			X				X	AAS	Geomin	Y	D:2-4m composite
								Bromo-Pedap	AS /Sheen	Y	Also U, D:0-2m
								Bromo-Pedap	Analabs	Y	Also U, D:0-3m composite
								XRF	Analabs	Y	Also U, D:0-1m
								XRF		Y	Also U, D:0-1m

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
19	3142	156	Asarco Aust	1166/2	1496	10329	80	Diamond	3	X						X
								Gossan	80	X						X
								Percussion	2	X						X
20	3042	12	Kennecott Exploration	1284	2531	3861	73	Rock	24							X
								Soil	428							
			Western Seicast		2531	6500-2	75	Auger	44							X
								Diamond	10							X
								Percussion	31							X
21	3143	21	Amax Exploration Aust	1337	1859	3959-60	73	Auger	295					X	X	X
								Percussion	10					X	X	X
								Soil	2 700							X
22	3042 3142	12	Consol Gold Fields Aust	1352	1860	4009-10	71	Soil	4 380							X
23	3042	1	Yellow Aster Mines	1677/1	1358	6630	76	Percussion	44			X				
								Rock	9			X				
24	3042 3043	5	Yellow Aster Mines	1677/2	574	6823	76	Rock	219			X				
								Stream	19			X				
25	3142	19	CRA Exploration	1724	535	5731	75	Diamond	1	X						X
					"	6287		Percussion	2							X
								RAB	233	X	x	X		X	X	X
			CRA Exploration		535	6286	76	Gossan	75	X	x	X		X	X	X
26	3142 3143	200	Esso Exploration Aust	1727	244	6262-63	76	Gossan	750	X				X		X
27	3143	8	International Nickel Aust	1744	480	5818	75	Auger	58							X
					"	6312		RAB	30							X
								Rock	86							X
28	3142	200	Esso Aust	1828	657	6850	77	RAB	60							
			Esso Aust		657	7377	78	Rock	23	X						X
29	3142	121	Esso Aust	1881	133	6534	75	Gossan	236	X				X		X
								RAB	16	X						X

(cont)

<i>Fe</i>	<i>Mn</i>	<i>Mo</i>	<i>Ni</i>	<i>Pb</i>	<i>Sb</i>	<i>Sn</i>	<i>Zn</i>	<i>Method</i>	<i>Analyst</i>	<i>DD</i>	<i>Comment on Samples</i>
				X			X			Y	D:0-3m composite
				X			X		Analabs		
				X			X				D:0-3m composite
			X						MGV Labs		
			X								350 samples just outside tenement boundaries
			X							Y	D:0-3m composite
			X				X				D:0-3m composite
			X				X	Multi-acid /AAS			D:0-2m
			X				X				
			X				X				
			X								
			X								D:0.15m
									KML	Y	D:1.5-3m
								Fire assay	KML		Over 5m diameter or 10-20m across units, Random
								Fire assay	KML		Wt:7-10kg
	X			X			X			Y	D:0-2m
				X			X		Analabs		D:0-2m
	X	x	x	X			X				D:0-3m composite
	X	x	x	X			X	AAS	Analabs		
			X	X			X				Over 2m intervals
			X				X	Perchloric /AAS		Y	D:0-4m
			X				X	Perchloric /AAS			D:0-3m composite
			X				X	Perchloric /AAS			
									Analabs	Y	D:0-4m composite, Also U
			X				X				
			X	X			X	AAS	Analabs	Y	
			X	X			X	AAS			D:0-2m

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
30	3043 3143		Western Mining Corp	2136/1	2205	7935	78	Ironstone	300	X				X	X	X
								RAB	60	X		x			x	X
								Rock	32	X					X	X
31	3042 3043 3142	5	Western Mining Corp	2195	2493	10250	81	Rock	41	X	x	x		x	x	X
			Western Mining Corp		2493	10682-83	82	Diamond	2	X	X					X
								Percussion	19	X	X					X
			Western Mining Corp		2493	12608	83	Diamond	2	X	X		X			X
								Soil	1 491	X	X	x	X			X
32	3142	11	Hampton Areas Aust	2268	924	7744	75	Percussion	18	X		x				X
								Rock	54	x						X
								Soil	1 020	X						X
33	3142	11	Abminco	2303	3007	7899	78	Ironstone	120	X						X
34	3142	28	Abminco	2305	3009	7901	78	Ironstone	182	X						X
35	3142 3143	112	Abminco	2388	2651	8105	79	Gossan	49							X
36	3142	34	Otter Exploration	2400	1863	9556-57	77	Rock	20	X						X
								"	39	X						X
37	3042	27	Otter Exploration	2401/1	2162	8132	77	Rock	33	X						X
38	3142	34	Aust Selection	2436	2652	8233	79	RAB	127		X					X
39	2942		Western Mining Corp	2448	684	8254	79	Auger	77							
								Percussion	12							
40	3142	28	Aust Selection	2474/1	2472	8359	79	Percussion	2							X
			Seltrust Mining Corp		2472	13020	83	Rock	33	X	X					X
								"	10			X				
										X	X		X	X	X	X
41	3143	1	Seltrust Mining Corp	2474/2	2471	9648	80	Gossan	64	X	X	x	X	x	x	X
								Percussion	4	X	X		X	X	X	X
42	3042 3142	34	AMAX Iron Core Corp	2667	3047	10322-23	80	Percussion	6	X					X	X
								Rock	238	X		x	X	x	X	X

(cont)

<i>Fe</i>	<i>Mn</i>	<i>Mo</i>	<i>Ni</i>	<i>Pb</i>	<i>Sb</i>	<i>Sn</i>	<i>Zn</i>	<i>Method</i>	<i>Analyst</i>	<i>DD</i>	<i>Comment on Samples</i>
X	X		X	X			X			Y	
X	x		X	X			X				D:0-1.5m
x			X	X			X				
	X		X	X		x	X	AAS			10-20 pieces per sample
X	X	X		X			X	AAS		Y	D:0-2m
X	X	X		X			X	AAS			D:0-2m
		X		X		X	X				D:0-2m
X	X	x		X			X				Surface
				X			X	AAS	TEL	Y	D:0-2m
				X			X				
				X			X				D:0.15m, 63 samples fractional analysis
				X			X	Perchloric /AAS			
				X			X	Perchloric /AAS			
				X			X				
				X			X		PL		
				X			X		Analabs		
				X			X		Analabs		
				X			X			Y	D:0-4m composite, Also K ₂ O
										Y	D:0-1.5m, For U ₃ O ₈
											D:0-1.5m, For U ₃ O ₈
	X		X	X			X			Y	D:0-2m
X				X		X	X	HF digest	AS		
X	X	X	X	X		X	X	ICP			Also Be, Ce, La, Sr, V, Y, Zr & oxides
	x	x	X	X		X	X	ICP	AS	Y	Also Be, La, Sr, V & oxides
	X	X	X	X		X	X	ICP	"		D:0-2m, Also Be, La, Sr, V & oxides
			X	X			X			Y	D:0-4m composite
	x	x	X	X		x	X				Also Cd, Hg

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
43	3043	11	Asarco Aust	2777/2	2573	14417	84	Rock	235			X				
								"			X					
								"		X						X
44	3042		Seltrust Mining Corp	3061	3607	11820	83	RAB	6	X	X			X	X	X
					"	11822		Rock	3	X	X			X	X	X
			BP Minerals Aust		3607	19056	86	Percussion	4			X				
								"	5	X	X		X	X	X	X
								Rock	25			X				
								"		X	X		X	X	X	X
			BP Minerals Aust		3607	26004	88	RC	11			X				
45	3142		Esso Exploration Aust Inc	3134/2	3013	12345	83	Ironstone	63	X	X			X		X
46	3042	32	AMAX Aust	3150	5492	12399-400	83	Gossan	496			x				
								"		x	X			X	X	X
								Percussion	14			X				
								"		X	X				X	X
47	3142 3143	25	BHP Minerals	3449	3049	13781	82	RAB	5		X					X
			BHP Minerals		3049	14313	84	Gossan	79			X				
								"		X			X			X
48	3042	24	Asarco Aust	3622/2	4774	32800	90	Lag	358			X				
								RAB	17		X	X		X		X
			Asarco Aust		4774	32961	91	Lag	725			X				
49	3042	31	Asarco Aust	3622/5	5992	35465	92	Lag	6709			X				
								Rock	5		X	X		X		X
50	3042		Asarco Aust	3622/6	5993	14426-27	84	Rock	19			X				
								"		X			X	X		X
								"			X					
			Asarco Aust		5993	22962	88	Lag	200			X				
								RAB	52			X				
								"			X					
								"								X
			Asarco Aust		5993	35467	92	RAB	48			X				
								"			X			X		X
								RC	8			X				
								Rock	6			X				

(cont)

<i>Fe</i>	<i>Mn</i>	<i>Mo</i>	<i>Ni</i>	<i>Pb</i>	<i>Sb</i>	<i>Sn</i>	<i>Zn</i>	<i>Method</i>	<i>Analyst</i>	<i>DD</i>	<i>Comment on Samples</i>
								Aqua regia /AAS	AS		DL: 0.1ppm
								ICP-OES	"		
				X			X	AAS	"		
X	X		X	X			X	ICP		Y	D:0-3m composite, Also oxides
X	X		X	X			X	ICP			Also oxides
									BP	Y	DL: 0.02ppm
X	X	X	X	X		X	X	ICP	"		Also Be, Ce, Sr, V, Y, Zr & oxides
									"		DL: 0.02ppm
X	X	X	X	X		X	X	ICP	"		Also Be, Ce, Sr, V, Y, Zr
									BP	Y	D:0-2m, DL: 0.02ppm
				X			X		Analabs		
	x		X	X			X	Aqua regia /AAS	Analabs	Y	DL: 0.02ppm, Wt:0.5-1kg
								Perchloric /AAS	"		Also Pd & Pt by fire assay / AAS
								Aqua regia /AAS	"		DL: 0.02ppm, D:0-2m, Wt:0.5kg
				X	X		X	Perchloric /AAS	"		
				X			X			Y	D:4m
						X		XRF	Analabs		DL: 0.05ppm
				X			X	Perchloric /AAS	"		
			X	X			X	Aqua regia /ETA		Y	Mesh:-7+2mm, DL:1ppb
								AAS			D:0-4m
								Aqua regia /ETA			Mesh:-7+2mm, DL:1ppb
								Aqua regia /ETA			Mesh:-7+2mm, DL:1ppb
								Aqua regia /ETA			Mesh:-7+2mm, DL:1ppb
			X	X			X				
								Fire assay /AAS	AS		
			X	X	X			AAS	"		Also Cd, K, Na
X		X						ICP-OES	"		Also Ca, Mg, Se, Si, Te, V
								Fire assay /ICP-MS	AS	Y	Mesh:-6+2mm, DL:1ppb
								50g fire assay /AAS	"		D:0-4m composite, Wt:2kg
								Acid digest /ICP-MS	"		
			X					AAS	"		
								30g fire assay /AAS		Y	D:0-4m composite, Wt:2-4kg
				X			X	AAS			
								30g fire assay /AAS			D:0-2m, Wt:2-4kg
											DL:8ppb

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu	
51	2942 3042		Asarco Aust	3622/8	6119	35468	92	Lag	1567			X					
			Asarco Aust		6119	35472	92	Lag	172			X					
			Asarco Aust		6119	35475	92	Lag	145			X					
52	3042		Asarco Aust	3622/9	6289	36985	92	Lag	1021			X					
			Asarco Aust	3622/10	6709	37379	92	Lag	282			X					
			Asarco Aust		6709	37380	92	Lag	17			X					
			Asarco Aust	3622/11	7073	38876	92	Lag	1011			X					
53	3142	56	Kinex	3863	5637	15876	85	Auger	28			X					
								RAB	79		x	X				x	
								Rock	26	x		X				x	
								Soil	15	x		X				x	
54	3142	96	Hawk Investments	3904/2	2669	18405	86	Rock	45			X					
								"				x					
55	3142	77	Sundowner Minerals	3904/3	6689	37741	93	Stream	56			X					
56	3142	6	Sundowner Minerals	3904/4	6928	33697	91	RAB	76			X					
												X			X	X	X
			Sundowner Minerals		6928	35408	92	RAB	98			X					
57	3043	13	Inter Copper	4025	3429	16465	85	Rock	35	X	X	X	X				
								Soil	198	X	X	X	X				
								Vacuum	987			X					
58	3042 3142	112	Pancontinental Mining	4036	2841	16500	85	Rock	78			X					
								"				x					x
								Stream	21			X					
59	3042 3142	112	Golden Plateau	4188/1	5052	19485	86	Rock	19		X	X					
									Stream	196			X				
				Valiant Consolidated		5052	22207	87	Soil	237			X				
							Stream	96			X						

(cont)

Fe	Mn	Mo	Ni	Pb	Sb	Sn	Zn	Method	Analyst	DD	Comment on Samples
								Aqua regia /ETA		Y	Mesh:-6.5+2mm
								Aqua regia /ETA			Mesh:-7+2mm
								Aqua regia /ETA		Y	Mesh:-7+2mm
										Y	Mesh:-6.5+2mm, DL:1ppb
										Y	DL:1ppb
										Y	DL:1ppb
											DL:1ppb
										Y	D:0-1m
				x			x				D:0-1m
				x			x				
				x			x				
								Fire assay XRF			
								BLEG	ARA		Mesh:-40um, Wt:1-2kg, DL:1ppb
X			X				X	ETA AAS	Genalysis "	Y	D:0-4m composite, DL:1ppb, 400x200m grid
								ETA	Genalysis	Y	D:0-4m composite, DL:1ppb
	X				X				Analabs		Also W, DL:12ppb, 500x50m grid
	X				X				"		Also W, DL:12ppb, 500x50m grid D:0-0.5m, DL:20ppb
								50g fire assay	AAL		
				x			x	AAS	"		
								AAS /BLEG	"		Wt:5kg, DL:0.02ppb
											DL:1ppb Bulk, DL:1ppb
								BLEG /fire assay	PML/Amdel		Wt:2.5kg, DL:0.01ppb
								BLEG /fire assay	"		Wt:5kg, Mesh:-6mm, DL:0.01ppb

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
59	3042	112	Spargos Exploration		5052	25704-5	88	RAB	54			X				
cont	3143							"			X					
								"								X
								RC	13	X	X	X				X
								Rock	143			X				
								"			X					
								"								X
								Soil	295			X				
			Spargos Exploration		5052	24757	88	Rock	10			X				
								"			X					
								"								X
60	3142		Epoch Minerals Exploration	4211	4412	19191	86	Rock	22			X				
	3143				"	19548		"								x
			Epoch Minerals Exploration		4412	22891	87	RAB	17			X				
								Rock	10			X				
								Soil	39			X				
61	3143	16	Esso Exploration Aust Inc	4289/2	5056	18875	86	Rock	45	x	X	X	x	X	x	
62	3142	330	Electrolytic Zinc Co	4706/3	5548	21227	87	Rock	124	X	X	X	X			X
	3143															
			Norgold		5548	24839-40	88	Auger	278			X				
								"			X					X
								Rock	39			X				
								"			X					X
								Soil	586			X				
								"			X					X
								Stream	37	X		X				X
			Electrolytic Zinc Co		5548	27180	89	Rock	1			X				
								"		X	X					X
								Soil	35			X				
								Stream	3	X		X				X
			Norgold		5548	28122-23	89	Auger	638			X				
								"		X	X					X
								RC	31			X				
								"			X					
								"		X						X
								Soil	424			X				
								"		X	X					X
			Geopeko		5548	30576	90	Auger	444			X				
								"			X					X
								Soil	911			X				
								"			X					X
								Stream	39			X				
			Geopeko		5548	33731	91	RAB	128			X				
								"			X					X

(cont)

Fe	Mn	Mo	Ni	Pb	Sb	Sn	Zn	Method	Analyst	DD	Comment on Samples
								50g fire assay /AAS	AS	Y	D:0-4m composite, DL:0.01ppm
								Single acid /ICP-OES	"		
			X	X			X	Single acid /AAS	"		
				X			X	AAS			D:0-1m, DL:0.01ppm
								Aqua regia /AAS	AS		DL:0.01ppm
								Single acid /ICP-OES	"		
			x	X			X	Single acid /AAS	"		
								BLEG /ICP-MS	"		Wt:5kg, Surveyed grid, DL:0.2ppb
								Aqua regia /AAS	AS		DL:0.01ppm
								Single acid /ICP-OES	"		
				X			X	Single acid /AAS	"		
								50g fire assay	SGS		DL:0.01ppm, Also some for Pd, Pt
			x							Y	D:0-4m composite
								Fire assay			
			x	X	x	x	x	AAS	Genalysis	Y	DL:0.01ppm, Also W (colourimetry)
			X		X	X		Multi acid /AAS	Genalysis		Wt:2.5kg, DL:0.01ppm
								Aqua regia /AAS	Genalysis		D:0.3m & 2m, 5 traverses
							X	Mixed acid /AAS	"		
								Aqua regia /AAS	"		400m intervals
							X	Mixed acid /AAS	"		
								Aqua regia /ETA	"		Recon, Wt:5kg, D:0.2-0.3m
							X	Mixed acid /AAS	"		
								BLEG /AAS	PML/Amdel		Wt:5kg, Mesh:-6mm
								Aqua regia /AAS	Genalysis		Composite
			X	X	X		X	Mixed acid /AAS	"		
								Aqua regia /ETA	"		Recon, Wt:5kg, D:0.2-0.3m
								BLEG /AAS	PML/Amdel		Wt:5kg, Mesh:-6mm
								ETA	Genalysis	Y	Wt:2kg, D:0-2m, Density:400x40m, DL:1ppb
								AAS	"		
								Aqua regia /AAS	SGS		D:0-4m composite, 8 traverses, DL:0.01ppm
								Mixed acid /AAS	"		
				X			X	Aqua regia /ETA	"		
								Mixed acid /AAS	Genalysis		Wt:2.5kg, Mesh:-6mm, D:0.2-0.3m, DL:1ppb
									"		
								Aqua regia /ETA	Genalysis		Wt:2kg, D:4m, 12 traverses, 40m intervals, DL:1ppb
								Mixed acid /AAS	"		
								Aqua regia /ETA	"		Recon & infill, Wt:5kg, Mesh:-6mm, D:0.2-0.3m
							X	Mixed acid /AAS	"		
								BLEG	ARA		Wt:5kg, Mesh:-6mm, DL:0.1ppb
								Aqua regia /ETA	Genalysis	Y	D:0-4m composite, DL:1ppb
								Mixed acid /AAS	"		

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu				
63	3143		Norgold	4706/4	3934	21613	87	Rock	66	X	X	X	X		X	X				
			Norgold		3934	24841	88	Soil	27			X								
			"						X					X						
			Norgold		3934	24842	88	Soil	355			X								
					"				X							X				
								Stream	27	X		X				X				
64	3142 3143		Norgold	4706/5	3972	26382	89	Auger	1380			X								
								"		X	X					X				
								Rock	56	X	X	X	X		x	X				
								Soil	237			X								
								"			X					X				
								Stream	27	X		X				X				
								Norgold	3972	29318	89	Rock	1	X	X	X	X		X	X
												Soil	56			X				
			"				X									X				
			Stream		8	X						X				X				
			65		3042 3043	10	CRA Exploration	4838	4077	21718	87	Rock	28			X				
												"			x		x			
"		x												x	x	x				
Soil	47											X								
"				X									X				X			
66	3142 3143	176	Western Mining Corp	4569	4978	22217	87	Lag	19		X	X				X				
			Rock					5			X									
			Western Mining Corp		4978	32612	91	Lag	5544			X								
								"			X		X			X				
								RC	37			X								
67	3043	6	Audimco	5009	3779	22233	87	Rock	49		x	X				x				
68	3043	16	Great Victoria Gold	5012	4647	22478	88	RAB	257		X	X				X				
								Rock	148		X	X				X				
								Soil	572		X	X				X				
69	3142		Hill Minerals	5019	4171	31034	82	RAB	13			X			X	X				
			A. J. Flavelle		4171	22370	87	Costean	18			X								
			"						X											
			"					X												

(cont)

Fe	Mn	Mo	Ni	Pb	Sb	Sn	Zn	Method	Analyst	DD	Comment on Samples
		X		X			X	AAS	Genalysis		Wt:2.5kg, DL:10ppb, Also W(colourimetry)
								Aqua regia /ETA	Genalysis		Recon, Wt:5kg, D:0.2-0.3m, 800x800m triangular grid
				X			X	Mixed acid /AAS	"		
								Aqua regia /ETA	Genalysis		Recon, Wt:5kg, D:0.2-0.3m, 800x800m triangular grid
				X			X	Mixed acid /AAS	"		
								BLEG /AAS	PML /Clas		Wt:5kg, Mesh:-6mm, DL:0.01ppb,
								Aqua regia /ETA	Genalysis		Wt:2kg, D:0-2m, 400x400m triangular grid
								Mixed acid /AAS	"		
	X			X	x		x	Mixed acid /AAS	"		DL:0.01ppm, Also W(fusion /colourimetry)
								Aqua regia /ETA	"		Recon, Wt:5kg, D:0.2-0.3m, 800x800m triangular grid
				X			X	Mixed acid /AAS	"		
								BLEG /AAS	PML /Clas		Wt:5kg, Mesh:-6mm, DL:0.01ppb,
	X			X				Multi acid /AAS	Genalysis		DL:0.01ppm, Also W
								Aqua regia /ETA	"		Recon, Wt:5kg, D:0.2-0.3m, 800x800m triangular grid
				X			X	Mixed acid /AAS	"		
								BLEG /AAS	PML /Clas		Wt:5kg, Mesh:-6mm, DL:0.01ppb,
								50g fire assay /AAS	SGS		DL:0.01ppm
					x	x		XRF	"		Also some Ba, Ti, W, Zr
			x	x			x	Mixed acid /AAS	"		
								Aqua regia /ETA	"		DL:2ppb, D:0.2m, 3 traverses, 200x20m grid
								XRF	"		Also Pd(50g fire assay /AAS)
			X	X			X	Mixed acid /AAS	"		
X	X		X	X	X		X		WMC		DL:1ppb
									"		DL:1ppb
								25g aqua regia /AAS	WMC	Y	Mesh:-6+2mm, 153 traverses
			X				X	AAS	"		
									"		D:0-1m, DL:0.02ppm
											DL:0.01-0.02ppm
									Genalysis	Y	D:2m
											DL:0.02ppm
								AAS	Genalysis		Wt:2kg, D:0.05-0.15m, DL:0.01ppm
			X					AAS	Genalysis	Y	D:0-4m composite, DL:0.01ppm
								Fire assay /ICP-OES	AS		D:1.5m, 4x40m trench, DL:0.01ppm, Also Pd, Pt
								Single acid /ICP-OES	"		
								Single acid /AAS	"		

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
70	2942	200	Minsaco Resources	5267	4591	22988	87	Rock	8		X	X				
			Minsaco Resources		4591	22989	88	Ironstone	94			X				
								Rock	19		X	X				
								Soil	518		X	X	X			
71	3042 3142	54	Western Reefs	5586/2	6082	28819	89	Rock	18			X				
							"				X					
							"									X
			Western Reefs	6082	28895	89	Rock	18			x	X				x
							Soil	558				X				
			Western Reefs	5586/2	6082	30857	90	Soil	593			X				
							"				x					
							"				x					x
72	3402 3142	77	Spargos Mining	5586/3	6328	36506	92	RAB	36		X	X				
								Soil	989			X				
								Stream	9			X				
73	3042 3142	126	BP Minerals Aust	5630/2	4287	24370	88	Lag	80		X	X				
								Rock	1		X	X				
								Soil	48			X				
								"		X	X			X	X	
								Stream	46			X				
			BP Minerals Aust	4287	27986	89	Rock	34				X				
							"				X		X	X	X	X
							Soil	600				X				
							Stream	60				X				
			Forsayth	5630/1	5762	34502	90	Rock	19			X				
							"				X					
							Soil	113				X				
							"				X					
							Stream	8				X				
			Forsayth	5762	34501	91	Rock	53				X				
							"				X					X
							Soil	3				X				
74	3142	5	K. J. Shorto	5664	4136	23850	88	Rock	19			X				
								Soil	28			X				
75	2943 3043		Chevron Exploration Corp	5678	6405	27661	89	Rock	22			X				
								Soil	7			X				
								Stream	17			X				

(cont)

Fe	Mn	Mo	Ni	Pb	Sb	Sn	Zn	Method	Analyst	DD	Comment on Samples
				X					Amdel		DL:0.02ppm, Also W
						X			Amdel		DL:0.02ppm DL:1ppb
								Aqua regia /AAS	AS		DL:0.01ppm
								Single acid /ICP-OES	"		
				X			X	Single acid /AAS	"		
				x			x	AAS			DL:0.01ppm
								BLEG /ICP-MS	AS		Wt:5kg, D:0.15m, 500x100m grid, DL:1ppb
								BLEG /ICP-MS	AS /Sheen		Wt:5kg, 500x100m /200x50m grids, DL:1ppb
								Single acid /ICP-OES	"		
				x			x	AAS			
								AAS	Genalysis	Y	D:0-2m composite, DL:0.01ppm
								BLEG	AS /Sheen		Wt:5kg, D:0.2m, 500x50m /500x100m grids Recon, Wt:10kg
X		X			X		X	ICP	Analabs		DL:1ppb
								BLEG	"		Also Ba, Th, W
									"		Wt:5kg, Mesh:-4mm, DL:0.05ppb
								Aqua regia /AAS	BP		DL:0.02ppm
X	X	X	X	X				ICP	"		Also La, Sr, V, Y & oxides
								Aqua regia /ETA			Grid 320x40m, DL:1ppb, Data in M5630/1 A34502
								BLEG	Analabs		
								ETA	Genalysis		Wt:2kg, DL:0.1ppb
								AAS	"		
								ETA	"		Wt:0.4kg, Mesh:-2mm, DL:0.1ppb
								AAS	"		
								BLEG	"		Wt:4kg, Mesh:-2mm, DL:0.1ppb
								ETA	Genalysis		DL:1ppb
				X	X	X	X	AAS	"		
								ETA	"		Mesh:-1mm, DL:1ppb
								AAS	Genalysis		Surface outcrops, DL:0.01ppm
								BLEG /AAS	"		Wt:12-15kg, D:0.15m, DL:0.1ppb
								ETA, BLEG			DL:1ppb
								ETA, BLEG			DL:1ppb

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
76	3043	7	Antico Mines	5695/1	4095	23877-78	88	Rock	134			X				
								"			X					
			Antico Mines		4095	27756	89	Soil	49			X				
								"			X					
77	3042	11	Antico Mines	5695/2	5283	23880-81	88	Rock	177		X	X				
								Soil	227		X	X				
			Antico Mines		5283	27760	88	Rock	8			X				
								"		X	X					
			Antico Mines		5283	27758-59	89	Soil	148			X				
								"			X					
78	3042 3043	102	Antico Mines	5695/4	4954	26787	89	Soil	32			X				
								"			X					
79	3143		Antico Mines	5696/2	5556	23888-90	88	Rock	6			X				
								"			X					
								Soil	92			X				
								"			X					
80	2942		Aust Ores and Minerals	5811	3637	25181	88	RC	20	X	X	X				X
								Rock	45		X	X				
								Stream	11		X	X				
81	3042	2	Forsayth	5848/3	5290	27941	89	Costean	10			X				
								Laterite	42			X				
								RC	11			X				
								Rock	13			X				
								Soil	14	X		X				X
82	2942 3043		Forsayth	5848/7	6278	27246	88	Stream	37			X				
83	3043 3143	200	Antico Mines	5898/1	4615	25823	88	Rock	92	x	X	X				x
								Soil	149			X				
								"			X					
84	3042-43 3142-43	128	Antico Mines	5898/2	6475	25824-25	88	Rock	40	x	X	X				x
								Soil	161		X	X				
85	3042	7	Chevron Exploration Corp	6009	5809	27062	89	RAB	111		X	X				
			Dalrymple Resources		5809	29729	90	Soil	5			X				

(cont)

Fe	Mn	Mo	Ni	Pb	Sb	Sn	Zn	Method	Analyst	DD	Comment on Samples
								Aqua regia /ETA AAS	Genalysis "		
								Aqua regia /ETA AAS	Genalysis "		Wt:0.5kg, D:0.15m, DL:1ppb, 7 traverses
									Genalysis "		
								Fire assay /AAS AAS	Genalysis "		DL:0.01ppm, Also W (fusion /colourimetry)
								Aqua regia /ETA AAS	Genalysis "	Y	Wt:0.5kg, D:0.1m, DL:1ppb
								ETA AAS	Genalysis "		DL:1ppb
								Aqua regia /ETA Aqua regia /AAS Aqua regia /ETA Aqua regia /AAS			Wt:1kg, DL:1ppb Wt:0.2kg, D:0.1m, Mesh:-10mm, DL:1ppb
			X	X			X	AAS	Genalysis	Y	D:0-4m composite, DL:0.01ppm, Also W Also W Also W
								ETA ETA, Aqua regia /AAS	RW RW	Y	5 trenches, D:1.1m, DL:1ppb, Poor sample location D:0.3-3m, 500x400m grid, DL:1ppb D:0-4m composite Recon, DL:1ppb
								BLEG	RW		DL:0.01ppb
								BLEG			Wt:5kg, Mesh:-1mm, 2-3 samples /sqkm, DL:1ppb
				x			x	Aqua regia /ETA Aqua regia /AAS	Genalysis " "		DL:0.01ppm Wt:0.5kg, D:0.15m, 100x80m /200x40m grids, DL:0.01ppm
				x			x		Genalysis "		DL:0.01ppm Wt:0.5-1.2kg, D:0-0.01m, Intervals 40-80m, DL:1ppb
								Aqua regia /AAS ETA	Genalysis	Y	D:0-4m composite, DL:0.01ppm, Data in A29729 DL:1ppb

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
86	3143		Minsaco Resources	6040	4105	27833-35	89	Pisolite	79			X				
								RC	31			X				
								Rock	35			X				
								Rock /Soil	10			X				
								Soil	692			X				
			Minsaco Resources		4105	27620	89	RAB	22			X				
87	2943	15	Asarco Aust	6054	4732	26409	89	Lag	761			X				
88	3042 3142	150	Metana Minerals	6272	5322	28105	89	Rock	78			X				
								Stream	44			X				
								Stream	42			X				
89	3142		Western Mining Corp	6498/2	4751	33183-4	91	Lag	2948			X				
								"			x		X			
								"								x
								RC	4			X				
			Western Mining Corp	6498/3	6628	34513	91	Soil	42			X				
								"			X		X			
								"								X
								Lag	169			X				
			Western Mining Corp		6628	36810	92	Lag	549			X				
			Western Mining Corp	6498/5	7296	40321	94	Lag	298			X				
90	3042		Placer Exploration	6555	6104	33206	91	Lag	50							
								"						X	X	X
								Rock	9							
								"						X	X	X
91	3142	24	Asarco Aust	6589	4025	30367	90	Lag	830			X				
92	3042	200	Asarco Aust	6590	4539	30364	90	Lag	1207			X				
93	3042		Western Mining Corp	6674/3	6315	36549	92	Lag	215			X				
								"			X					
								"						X	X	X
94	3042		Western Mining Corp	6674/5	6894	33914	91	Lag	294			X				
95	3043	16	Kismet Gold Mining	6693	5593	30933	90	Rock	7			X				X
								Soil	175			X				
								"								X

(cont)

<i>Fe</i>	<i>Mn</i>	<i>Mo</i>	<i>Ni</i>	<i>Pb</i>	<i>Sb</i>	<i>Sn</i>	<i>Zn</i>	<i>Method</i>	<i>Analyst</i>	<i>DD</i>	<i>Comment on Samples</i>
								Fire assay	CC	Y	400x400m grid, DL:1ppb
								Fire assay			D:0-1m
											DL:1ppb
											D:0-1m
								BLEG	AS		Wt:0.5kg, 200x200m grid, DL:1ppb
								Fire assay /AAS	Genalysis	Y	D:0-2m composite, DL:0.01ppm
								30g aqua regia /ETA			Mesh:-6+2mm, 11 traverses, 400x50m grid, DL:1ppb
								Aqua regia			DL:0.01ppm, 4 for 17 rare earth elements, 11 traverses
								GTA			
								BLEG			DL:0.01ppb
								25g aqua regia /AAS	WMC	Y	Recon, 200x100m grid, Mesh:-6+2mm, DL:1ppb
								Hydride gen /AAS	"		
				x			x	Multi acid /AAS	"		
											D:0-1m composite, DL:0.02ppm
								25g aqua regia /AAS	WMC		400x50m grid, Mesh:-6+2mm, DL:1ppb
								Hydride gen /AAS	"		
				X			X	Multi acid /AAS	"		
								25g aqua regia /AAS	"		Mesh:-6+2mm, DL:1ppb
											Recon, 400x100m grid, Mesh:-6+2mm, DL:1ppb
								25g aqua regia /AAS	"		Recon, 400x100m grid, Mesh:-6+2mm, DL:1ppb
X								Aqua regia /AAS	Analabs		100x25m grid, 50m composite, D:0.05m, Mesh:-4+1.7mm
	X			X	X		X	Perchloric /AAS	"		
X								Aqua regia /AAS	Analabs		
	X			X	X		X	Perchloric /AAS	"		
								30g aqua regia /ETA	Analabs		200x50m grid, Wt:0.1-0.15kg, Mesh:-6.5+2mm, DL:1ppb
								30g aqua regia /ETA	Analabs		400x50m grid, Mesh:-6.5+2mm, DL:1ppb
								25g aqua regia /AAS	WMC		400x100m grid, Mesh:-6+2mm, DL:1ppb, 75% just
								Hydride gen /AAS	"		outside project boundaries
X	X			X			X	0.2g multi acid /AAS	"		
								25g aqua regia /AAS	WMC		14 traverses, Wt:0.03kg, Mesh:-6+2mm, DL:1ppb
				X	X		X	AAS	Genalysis		DL:0.01ppm
								BLEG	"		500x250m grid, D:0.15m, Mesh:-10+2mm, DL:1ppb
				X	X		X	AAS	"		

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
96	3142	49	Sundowner Minerals	6718	4369	31220	90	Soil	70			X				
								"						X	X	X
								Stream	14			X				
								"						X	X	X
97	3142	4	S. Partyka	6730	7060	31705	90	Rock	17			X				
								"		X						X
								Rock	39			X				
								Soil	14			X				
			S. Partyka		7060	33954	91	Rock	1			X				
98	3042	1	Spargos Mining	6836/1	4638	32110	90	Rock	17	X	X	X			X	X
								Soil	19			X				
99	3042	10	Spargos Mining	6836/2	6439	32794	90	Rock	23	X	X	X			X	X
								Soil	145			X				
			Spargos Mining		6439	36663	92	Soil	38			X				
100	3142	61	Mt Edon Gold Mines	6888/2	7532	41871	94	Soil	30			X				
			Plutonic Operations		7532	41770	94	RAB	132		X	X				
101	3042	51	Placer Exploration	6993/2	6896	33423-24	91	Lag	543							
								"						X	X	X
								Rock	31			X				
								"							x	X
			Placer Exploration		6896	35565	92	Lag	761			X				
								"								X
								Rock	38			X				
								"		X	x			x	X	X
								Soil	50	X		X				X
								Soil	101			X	X			
								"								
								"			X					X
								Stream	24	X		X				X
102	3042 3142	52	Cambridge Mining Services	7031	6515	33942	90	Soil	197			X				
103	3142	290	Stockdale Prospecting	7354	6297	35617	92	Stream	100			X			X	X
								Stream	70			X				

(cont)

<i>Fe</i>	<i>Mn</i>	<i>Mo</i>	<i>Ni</i>	<i>Pb</i>	<i>Sb</i>	<i>Sn</i>	<i>Zn</i>	<i>Method</i>	<i>Analyst</i>	<i>DD</i>	<i>Comment on Samples</i>
	X		X				X	ETA AAS	Genalysis "		200m composite, 50m intervals, Mesh:-1mm, DL:1ppb
	X		X				X	ETA AAS	" "		Mesh:-1mm, Wt:2kg, DL:1ppb
								50g aqua regia /AAS Multi acid /AAS 50g fire assay 50g aqua regia /AAS 50g fire assay	SGS " " " SGS		DL:0.01ppm DL:0.01ppm DL:2ppb DL:0.01ppm
	X	X	X		X		X	AAS BLEG /ICP-MS	Sheen AS		DL:0.01ppm 1 traverse, Wt:5kg, D:0.15-0.25m, DL:1ppb
				X			X	AAS BLEG /ICP-MS ETA	Sheen AS Sheen AS Genalysis		DL:0.01ppm Recon, 4 traverses, D:0.1-0.3m, Wt:4-5kg, DL:1ppb Infill, 2 traverses, 50m intervals, D:0.1-0.3m, DL:1ppb
								Aqua regia /ETA ETA	Genalysis Genalysis		400x25m grid, 100m composite, DL:1ppb Y 800x200m grid, D:0-4m composite, DL:1ppb
X								Aqua regia /AAS Perchloric /AAS 30g aqua regia /ETA Perchloric /AAS 30g aqua regia /ETA Perchloric /AAS AAS, ETA Perchloric /AAS BLEG Fire assay /AAS Hydroxide gen /AAS Perchloric /AAS BLEG	Analabs " " " Analabs " ARA Analabs " ARA		100x25m grid, 50m composite, D:0.05m, Mesh:-4+1.7mm DL:1ppb Y 200x25m grid, 50m composite, Mesh:-5+2mm, DL:1ppb Grab, DL:5ppb, 1ppb Orientation, 50m composite, 25m interval, DL:0.1ppb 25m interval, Fractional analysis, DL:5ppb Wt:5kg, DL:0.1ppb
								BLEG /ICP-MS	Sheen AS		Infill, 200x50m grid, D:0.15-0.3m, Wt:4-5kg, DL:1ppb
X	X	X	X		X		X	BLEG	Analabs "		Mesh:-0.3mm, Wt:0.5kg, DL:1ppb Mesh:-2mm, Wt:5kg, DL:0.2ppb

Appendix 3

ID No.	Map Sheet	Area sqkm	Company	M No.	Item No.	A No.(s)	Yr	Medium	No.	Ag	As	Au	Bi	Co	Cr	Cu
104	3143		Asarco Aust	7368/2	6250	35815	92	Lag Stream	490 23			X X				
								"			X				X	X
								"						X		
								"								
105	3042	2	Spargos Mining	7524	7372	35615	92	Soil	192			X				
			Spargos Mining		7372	37637	93	RAB Stream	24 420		X	X X				X
106	3042	7	Spargos Mining	7591	6471	36664-5	92	Rock Soil	16 514	X	X	X X				X
								"			x					
107	3142 3143	187	Hunter Resources	7737	6433	37234	92	Lag	115			X				
												X				

SOURCE: Department of Minerals and Energy, WAMEX database, 2 August 1995

(cont)

<i>Fe</i>	<i>Mn</i>	<i>Mo</i>	<i>Ni</i>	<i>Pb</i>	<i>Sb</i>	<i>Sn</i>	<i>Zn</i>	<i>Method</i>	<i>Analyst</i>	<i>DD</i>	<i>Comment on Samples</i>
								Aqua regia /ETA	Analabs		DL:1ppb
								Fire assay /ETA	"		Mesh:-5+0.5mm, Wt:0.15kg, DL:1ppb
								Perchloric /AAS	"		
X			X	X			X	ICP-OES	"		Also Ba
		X			X	X		ICP-MS	"		Also Rb, W
								BLEG	ARA		3 traverses, Mesh:-1.6mm, D:0.15m, Wt:2kg, DL:0.1ppb
			X	X			X		Sheen	Y	D:0-4m composite, DL:1ppb
								BLEG	ARA		Mesh:-1.6mm, D:0.15m, 25m interval, DL:0.1ppb
							X	AAS	Genalysis		DL:0.01ppm
								ETA	"		200x50m grid, D:0.1-0.3m, Wt:0.2kg, DL:1ppb
								AAS	"		
								50g fire assay /AAS	SGS		Fragment size 1-50mm, DL:5ppb
								XRF	"		

Appendix 5

Department of Agriculture site types compared with GSWA regolith units

Landform and regolith code	No. sites on map	Agriculture Department site acronym	Site-type name	Site-type number	Soil	Dominant plants			
						Tree	Tall shrub	Mid-low shrub	Grasses
Granitoid breakaways R1, R3	0	BRXS	Breakaway mixed shrublands	26	Lithosols	None		<i>Scaevola spinescens</i>	<i>Aristida</i> sp.
	5	SAES	Stony plain <i>acacia eremophila</i> shrublands	27	Shallow red earth on rock	Rare	<i>Acacia aneura</i> <i>Callitris collumellaris</i> <i>A. aneura</i> <i>A. pruinocarpa</i>	<i>Dodonea viscosa</i> <i>A. tetragonophylla</i> <i>Eremophila</i> sp.	<i>Eriachne</i> sp. Rare
Granitoid and gneiss outcrops E2g, E2m (E1g)	4	SGRS	Sandy granitic acacia shrublands	24	Shallow red sand on rock	None	<i>A. aneura</i> <i>A. quadrimarginea</i>	<i>A. tetragonophylla</i> <i>Eremophila</i> sp.	None
	0	GRHS	Granite hill mixed shrublands	25	Sand pockets	None	<i>A. quadrimarginea</i> (scattered)	<i>Cassia</i> sp. <i>Eremophila</i> sp.	None
	5	SBMS	Stony bluebush mixed shrublands	22	Shallow duplex loam on clay	Rare	<i>A. aneura</i> <i>Hakea preissii</i>	<i>A. tetragonophylla</i> <i>Maireana</i> sp.	None
	1	USBS	Upland small bluebush species shrublands	23	Shallow red earth (hardpan)	Rare	<i>A. aneura</i> <i>H. preissii</i>	<i>Maireana</i> sp. <i>Ptilotus obovatus</i>	None
	7	SAES	see above						
	2	HMCS	Mulga shrublands with chenopod shrubs	19	Duplex or red earth on hardpan	<i>A. aneura</i> (scattered)	<i>A. aneura</i>	<i>A. tetragonophylla</i> <i>Maireana</i> sp.	<i>Stipa</i> sp. <i>Eragrostis</i> sp.
	1	PXHS	Plain mixed halophyte shrublands	9	Saline duplex on hardpan on granitoid	None	<i>A. aneura</i> <i>H. preissii</i>	<i>Cratystylis</i> sp. <i>Maireana</i> sp.	<i>Stipa</i> sp.
Greenstone hills and ridges E2v (E1v)	1	GHAS	Greenstone hill acacia shrublands	29	Lithosols	None	<i>A. aneura</i> <i>A. quadrimarginea</i>	<i>Cassia</i> sp. <i>Ptilotus obovatus</i>	None
	3	SIMS	Stony ironstone mulga shrublands	28	Shallow red earths	None	<i>A. aneura</i> (scattered)	<i>Scaevola spinescens</i> <i>P. obovatus</i>	None
	2	SBMS	see above						
	2	LHMS	Lateritic hardpan plain mulga shrubland	31	Red earth and lag on greenstone	Rare	<i>A. aneura</i>	<i>Eremophila</i> sp. <i>S. spinescens</i>	<i>Eragrostis</i> sp.
	1	LMWS	Lateritic mulga wanderrie shrublands	4	Deep red earth	Rare	<i>A. aneura</i> <i>A. linophylla</i>	<i>A. ramulosa</i> <i>Eremophila</i> sp.	<i>Eragrostis</i> sp. <i>Eriachne</i> sp.
Stony plains on granitoid and gneiss E4g, E4m	10	SAES	see above						
	1	PXHS	see above						
	1	MUWA	Mulga wanderrie grass shrublands	3	Deep earthy red sand	<i>A. aneura</i>	<i>A. aneura</i>	<i>A. linophylla</i> <i>Eremophila</i> sp.	<i>Eragrostis</i> sp. <i>Eriachne</i> sp.
	1	HPMS	Hardpan plain mulga shrublands	30	Clay loam over hardpan	<i>A. aneura</i>	<i>A. aneura</i> <i>A. ramulosa</i>	<i>A. tetragonophylla</i> <i>Eremophila</i> sp.	<i>Eragrostis</i> sp.
	1	USBS	see above						
Stony plains on greenstone E4v	1	SGRS	see above						
	5	SIMS	see above						
	4	LHMS	see above						
	1	HMCS	see above						
	1	LMWS	see above						

Appendix 5 (continued)

Landform and regolith code	No. sites on map	Agriculture Department site acronym	Site-type name	Site-type number	Soil	Dominant plants			
						Tree	Tall shrub	Mid-low shrub	Grasses
Sheetwash plains from granitoid DC1g, DC2g, DC3	21	MUWA	see above						
	3	HPMS	see above						
	3	SAES	see above						
	1	HMCS	see above						
	1	WABS	Wanderric bank mulga shrublands	5	Red sand or red earth over clay	Rare	<i>A. aneura</i>	<i>Eremophila</i> sp.	<i>Eragrostis</i> sp.
	5	PXHS	see above						
	1	SBMS	see above						
	0	CBKW	Creek bank woodlands/shrublands	35	Clay loam over hardpan	<i>E. camaludensis</i>	<i>A. aneura</i> <i>A. burkittii</i>	<i>E. serrulata</i> <i>Pluchea squarrosa</i>	<i>Themeda australis</i>
Sheetwash plains from greenstone DC1v, DC2v, DC3f	12	LMWS	see above						
	4	MUWA	see above						
	2	LHMS	see above						
	1	DRMS	Drainage tract mulga shrublands	33	Deep red earth	<i>A. aneura</i>	<i>A. aneura</i>	<i>A. tetragonophylla</i> <i>P. obovatus</i>	<i>Eragrostis</i> sp.
	2	PXHS	see above						
	1	SAES	see above						
	0	DMCS	Mulga drainage line shrublands chenopod understoreys	20		<i>A. aneura</i>	<i>A. burkittii</i> <i>A. tetragonophylla</i>	<i>Eremophila glabra</i> <i>Cratystylis</i> sp.	
	0	GRMU	Mulga groves on hardpan plains	32	Red earths	<i>A. aneura</i>	<i>A. aneura</i>	<i>Eremophila</i> sp. <i>P. obovatus</i>	<i>Eragrostis</i> sp.
Alluvial plains DA5	0	CPMG	Mulga shrublands with claypan grass understorey	34	Clay		<i>A. aneura</i>	<i>Cassia nemophila</i> <i>Cratystylis</i> sp.	<i>Eriachne flaccida</i>
	6	PXHS	see above						
	2	MHHS	Mixed chenopod mulga shrublands	18	Saline duplex on hardpan	Rare	<i>A. aneura</i>	<i>Cratystylis</i> sp. <i>Maireana</i> sp.	Rare
	2	BLSS	Bladder saltbush low shrublands	15	Saline duplex	None	None	<i>Atriplex vesicaria</i> <i>Cratystylis</i> sp.	None
	2	HMCS	see above						
	1	FRAN	Frankenia low shrublands	14	Red sand on clay (saline duplex)		None	Rare	<i>Frankenia</i> sp.
	4	PSAS	Sago bush low shrublands	17	Red sand on clay (saline duplex)		Rare	<i>A. aneura</i>	<i>M. pyramidata</i>
	1	MUWA	see above				<i>H. preistii</i>	<i>M. sedifolia</i>	
None	0	SBLS	Sandy bank lake shrubland	12	Sand	<i>A. aneura</i>	<i>A. aneura</i> <i>A. tetragonophylla</i>	<i>Lycium australe</i> <i>Atriplex bunburyana</i>	<i>Eragrostis</i> <i>Eriopoda</i>
	2	CAPW	Calcrete platform woodlands/ shrublands	8	Calcareous red earth on calcrete	<i>Casuarina cristata</i> <i>E. clelandii</i>	<i>A. tetragonophylla</i> <i>A. aneura</i>	<i>Eremophila</i> sp. <i>Maireana</i> sp.	<i>Stipa</i> sp.
	1	MHHS	see above						
	1	PXHS	see above						
	1	SSAS	Silver saltbush low shrublands	16	Red sand on clay (saline	Rare	Rare	<i>A. bunburyana</i>	<i>Stipa</i> sp.
Valley calcrete DA7v	2	CAPW	Calcrete platform woodlands/ shrublands	8	Calcareous red earth on calcrete	<i>Casuarina cristata</i> <i>E. clelandii</i>	<i>A. tetragonophylla</i> <i>A. aneura</i>	<i>Eremophila</i> sp. <i>Maireana</i> sp.	<i>Stipa</i> sp.
	1	MHHS	see above						
	1	PXHS	see above						
	1	SSAS	Silver saltbush low shrublands	16	Red sand on clay (saline	Rare	Rare	<i>A. bunburyana</i>	<i>Stipa</i> sp.

	0	CCAS	Calcephytic casuarina acacia woodlands	7	duplex) Calcareous red earth on calcrete	<i>C. cristata</i>	<i>A. aneura</i> <i>A. burkittii</i>	<i>C. nemophila</i> <i>P. obovatus</i>	<i>Enteropogon</i> sp. <i>Stipa</i> sp.
Gypsiferous dunes D8	2	SAMP	Samphire low shrublands	11	Red sand on clay (saline duplex)	None	None	<i>Halosarcia</i> sp.	None
	1	BLSS	see above						
	0	KOPI	Kopi dune woodlands	13	Gypsiferous sand	<i>E. striatocalyx</i>	<i>Grevillea sarissa</i>	<i>A. oswaldii</i>	<i>Eragrostis</i> sp.
Sandplain D9, R4	0	SASP	Sandplain spinifex hummock grasslands	1	Deep earthy red sands	<i>A. aneura</i> (mulga) <i>E. gongylocarpa</i> <i>A. aneura</i> <i>Bursaria occidentalis</i> (scattered)	<i>A. coolgardiensis</i> <i>E. kingsmillii</i> <i>A. linophylla</i> <i>A. ramulosa</i>	<i>Baeckea</i> sp. <i>Leptosema</i> sp. <i>Eremophila forrestii</i> <i>Maireana georgei</i>	<i>T. basedowii</i> <i>T. irritans</i> <i>Amphipogon</i> sp. <i>Eragrostis</i> sp.
	0	SACS	Sandplain acacia shrublands	2					

Appendix 6

Calculation of greenstone chalcophile-index values

Greenstone chalcophile-index values are calculated specifically for greenstone or part greenstone-sourced samples. Each major greenstone belt or group of belts is assumed to contain a distinctive suite of greenstone rocks. Greenstone chalcophile-index values are calculated with reference to the host greenstone belt (or group of belts) with the aim of better defining anomalous zones within that belt.

Data relating to a specific greenstone belt or group of belts form part of the GSWA regolith geochemistry dataset for the northern Eastern Goldfields, which is a composite dataset representing about 3100 samples collected and analyzed in the course of the MENZIES, LEONORA and SIR SAMUEL regional regolith geochemical mapping projects. Each listed sample in the dataset has a unique GSWA sample number and separate fields describing geology (greenstone, granitoid, etc.), regolith unit (E2v, E4v, DC1v, etc.), sample type (sheetwash, stream sediment, etc.), and the results of the analysis for 47 elements.

The dataset includes sample data obtained from seven different greenstone belts (or groups of belts) comprising the Barlee Terrane, Kalgoorlie Terrane, Gindalbie Terrane, Yandal greenstone belt, Dingo Range greenstone belt, Transitional Zone of the Keith–Kilkenny lineament, and the Minerie Terrane.

The three major greenstone belts or groups of belts represented on SIR SAMUEL are the Agnew – Mount Keith – Perseverance greenstone belt, the Yandal greenstone belt, and the Dingo Range greenstone belt. Separate datasets for each of the greenstone belts were extracted from the main dataset using Arc-Info, but the Yandal and Dingo Range datasets were subsequently combined on account of the small size of the Dingo Range dataset. Standard scores and chalcophile-index values were calculated for the two resulting datasets using the following procedures.

To compensate for downslope variation between regolith units (attributable to weathering effects), the raw values for each element within each regolith unit were multiplied by a correction factor (CF) to make the values analogous to the parent (E2v) material:

$$CF = \frac{\text{geomean } \sum \text{element_value (E2v)}}{\text{geomean } \sum \text{element_value (regolith_unit)}} \quad 1.$$

For example, the correction factor for As in E4v is obtained as follows:

$$CF = \frac{\text{geomean } \sum \text{As(E2v)}}{\text{geomean } \sum \text{As(E4v)}}$$

The corrected element-value is then obtained by multiplying the individual element values by the appropriate correction factor:

$$\text{corrected_element_value} = \text{element_value} \times CF \quad 2.$$

For example, the corrected As value in E4v is obtained as follows:

$$\text{corrected_As(E4v)} = \text{As(E4v)} \times CF(\text{As(E4v)})$$

The corrected element-value is then expressed as a logarithm in order to approximate a normal distribution.

$$\log(\text{corrected_element_value}) \quad 3.$$

For example, the corrected value for As is expressed as its logarithm:

$$\log(\text{corrected_As})$$

Standard scores for each element included in the calculation of the final greenstone chalcophile-index value are then derived for the corrected and log-transformed data for each element using the 'standardize' function in Microsoft Excel. Standard scores (S) are used in preference to element values: the score is an expression in standard deviations of the value of a particular element in relation to the overall distribution of values. This allows an As score, for example, to be directly compared with an Sb score. Similarly, scores for different elements can be combined in an additive index, with equal weighting being accorded to each element irrespective of the absolute range of values of that element.

$$S = \frac{\log(\text{corrected_element_value}) - \text{mean } \sum \log(\text{corrected_element_value})}{\text{standard deviation } \sum \log(\text{corrected_element_value})} \quad 4.$$

For example, the standard score for As is expressed as:

$$S(\text{As}) = \frac{\log(\text{corrected_As}) - \text{mean } \sum \log(\text{corrected_As})}{\text{standard deviation } \sum \log(\text{corrected_As})}$$

The Greenstone Chalcophile-Index value (GCIV) attributable to each greenstone sourced sample was then obtained by simple addition of the appropriate element scores:

$$GCIV = S(\text{element 1}) + S(\text{element 2}) + S(\text{element 3}) \dots 5.$$

For example, the Greenstone Chalcophile-Index value applied to the GSWA data is:

$$GCIV = S(\text{As}) + S(\text{Bi}) + S(\text{Mo}) + S(\text{Sb}) + S(\text{Se}) + S(\text{Sn}) + S(\text{W})$$

This chalcophile index differs from the CHI6*X index (Smith et al., 1989) in that Ag was excluded because the Ag values are typically too close to the detection level to be meaningful.

Two sets of standard scores and GCIVs were obtained corresponding to the Agnew – Mount Keith –

Perseverance greenstone belt and the Yandal and Dingo Range greenstone belts. The samples and GCIVs corresponding to SIR SAMUEL were extracted, these datasets were combined, and the values transferred to the datafile that accompanies these notes (SAMCHEM.CSV). These values were used to construct the greenstone chalcophile-index map (Fig. 52).

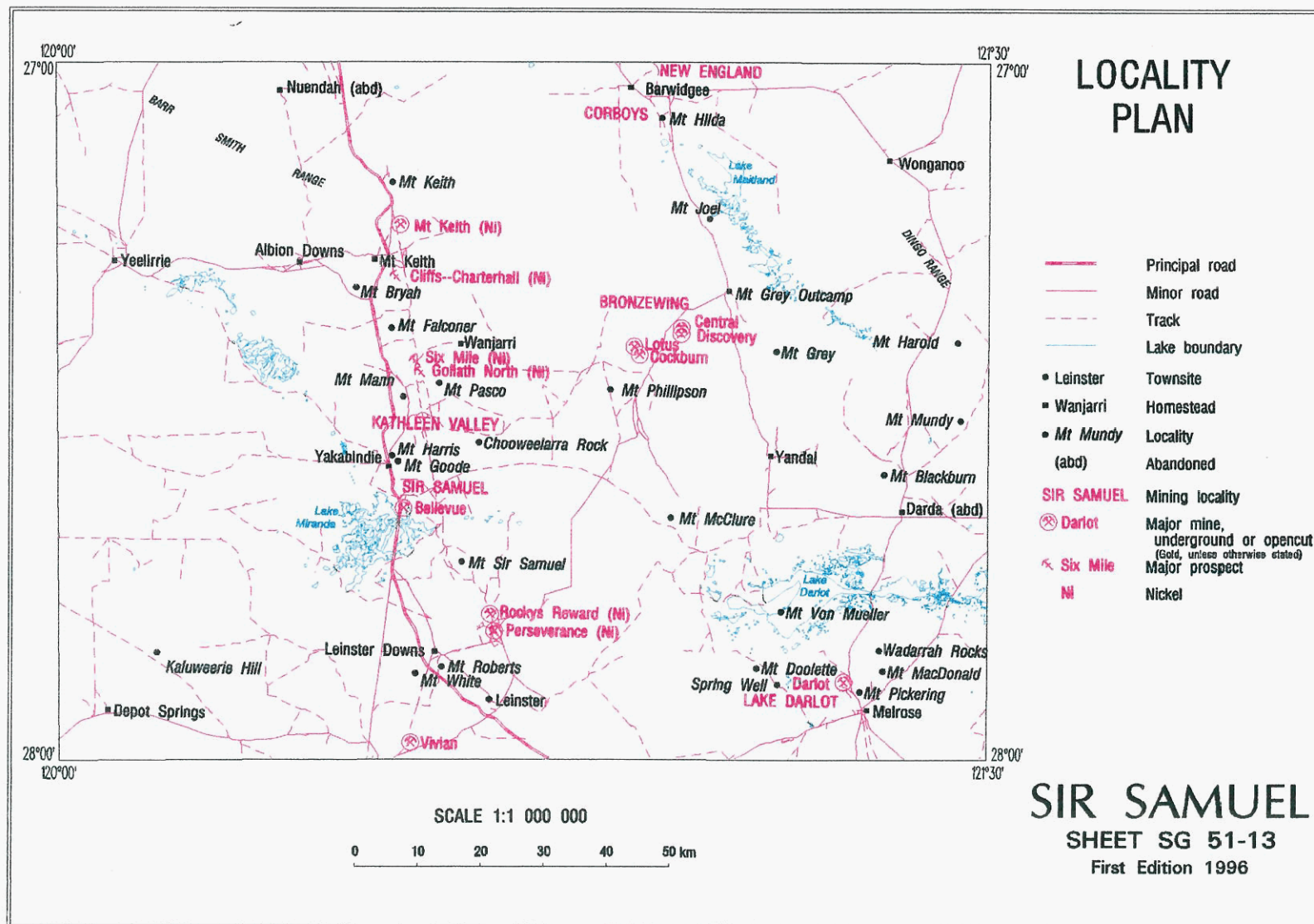
Figures

1. Locality plan
2. Generalized regolith
3. Geological interpretation
4. Groundwater salinity
5. Acidity-alkalinity
6. Regolith salinity

Element-distribution maps (7–49)

7. TiO_2
8. Fe_2O_3
9. MnO
10. MgO
11. CaO (other than lake and calcrete samples)
12. CaO (lake and calcrete samples)
13. Na_2O
14. K_2O
15. P_2O_5
16. As
17. Au
18. Ba
19. Bi
20. Ce
21. Co
22. Cr
23. Cu
24. F
25. Ga
26. La
27. Mo
28. Nb
29. Ni
30. Pb
31. Pd
32. Pt
33. Rb
34. S
35. Sb
36. Sc
37. Se
38. Sn
39. Sr
40. Ta
41. Te
42. Th
43. U
44. V
45. W
46. Y
47. Zn
48. Zr
49. Highest values: Ag, Be, Li
50. Contoured gold geochemistry
51. Principal components
52. Greenstone chalcophile-index

Figure 1.



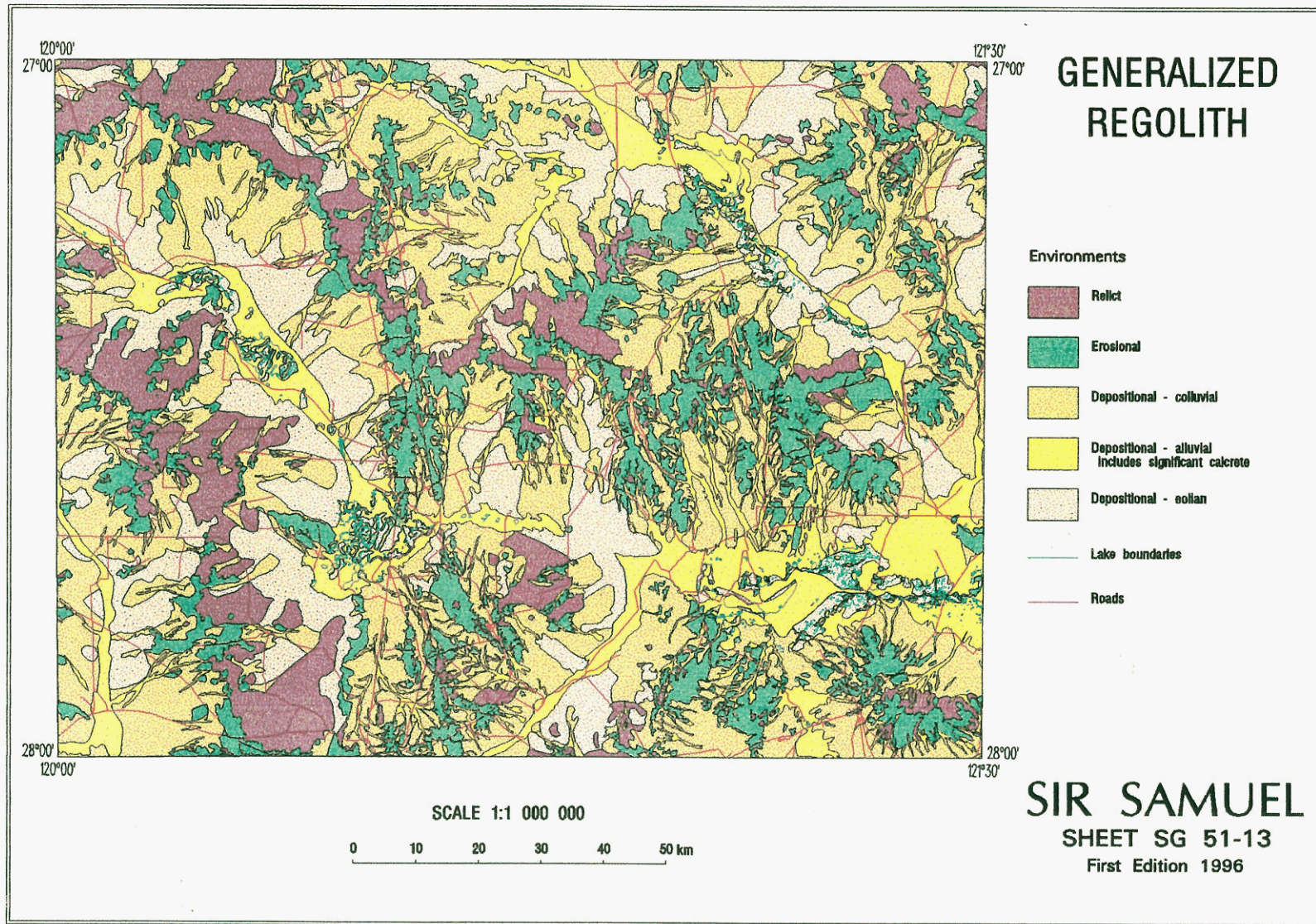


Figure 2.

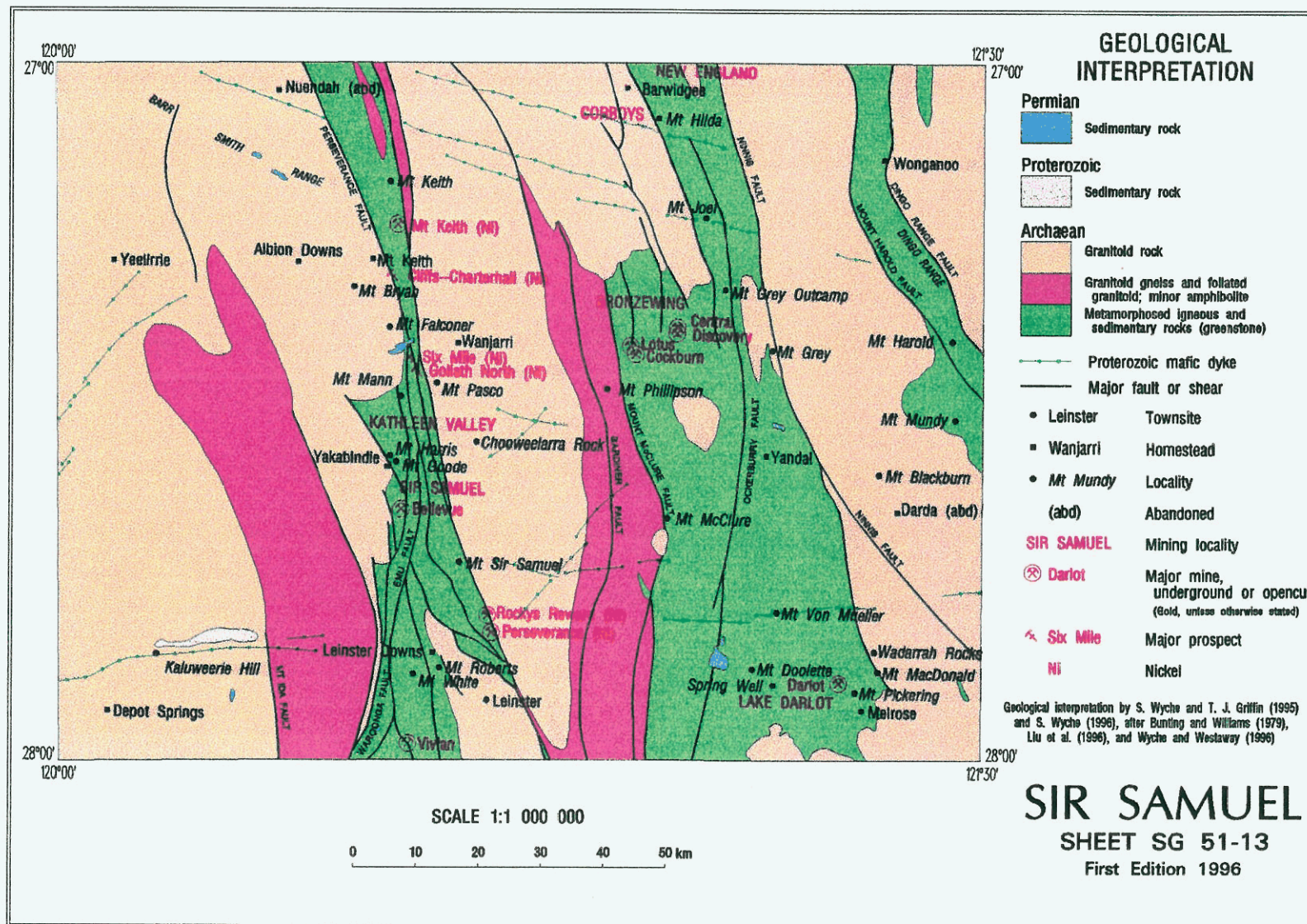


Figure 3.

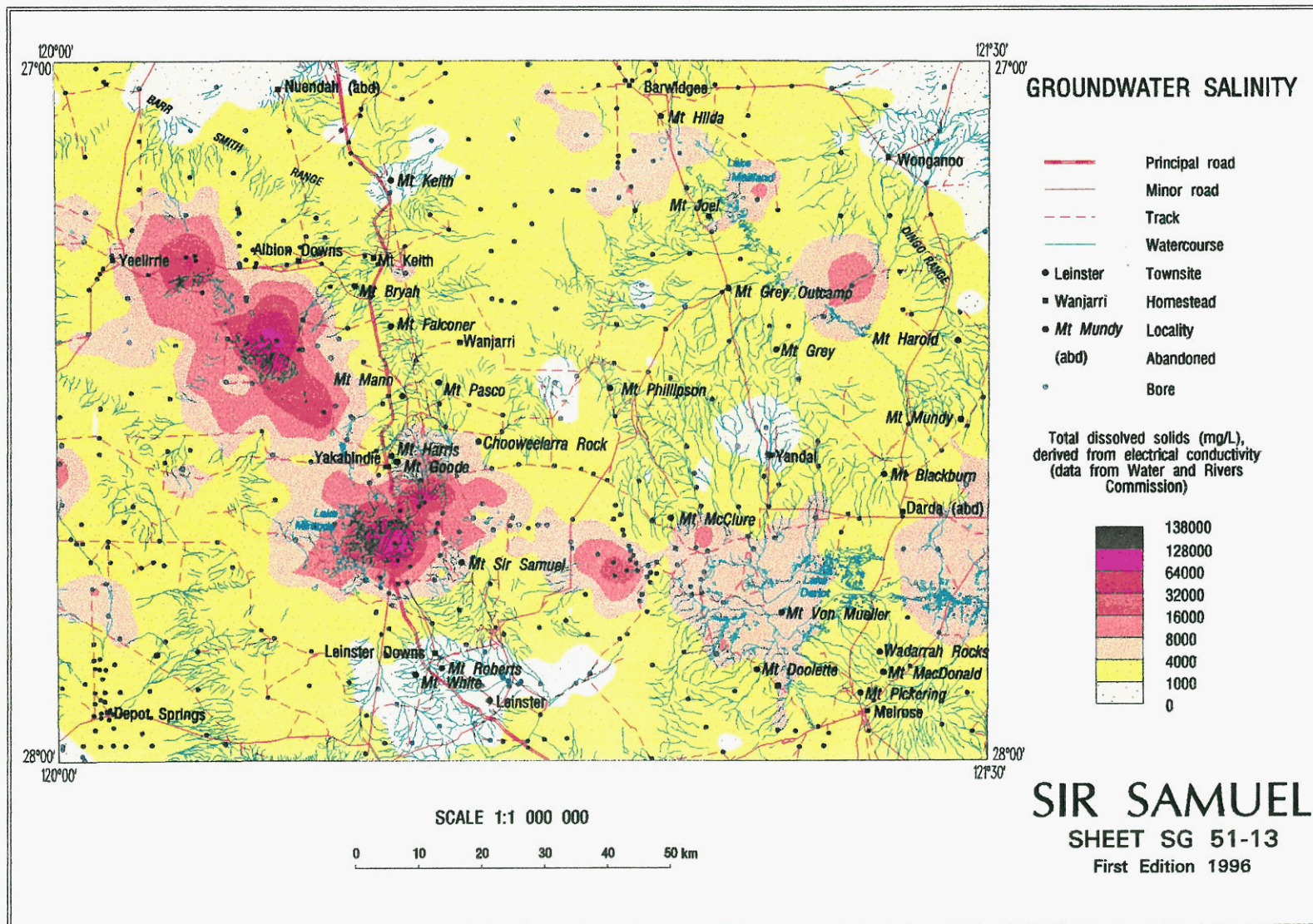


Figure 4.

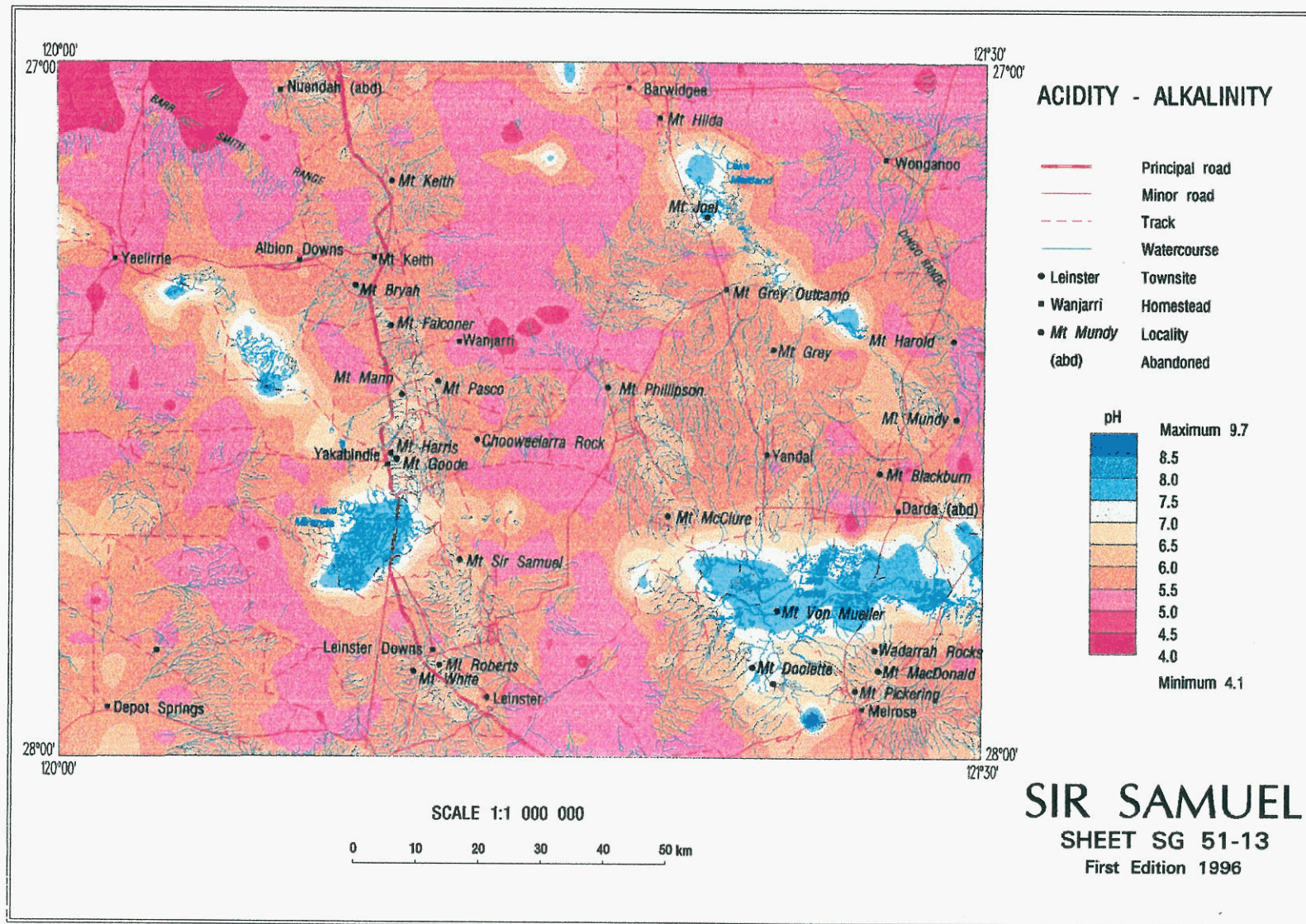


Figure 5.

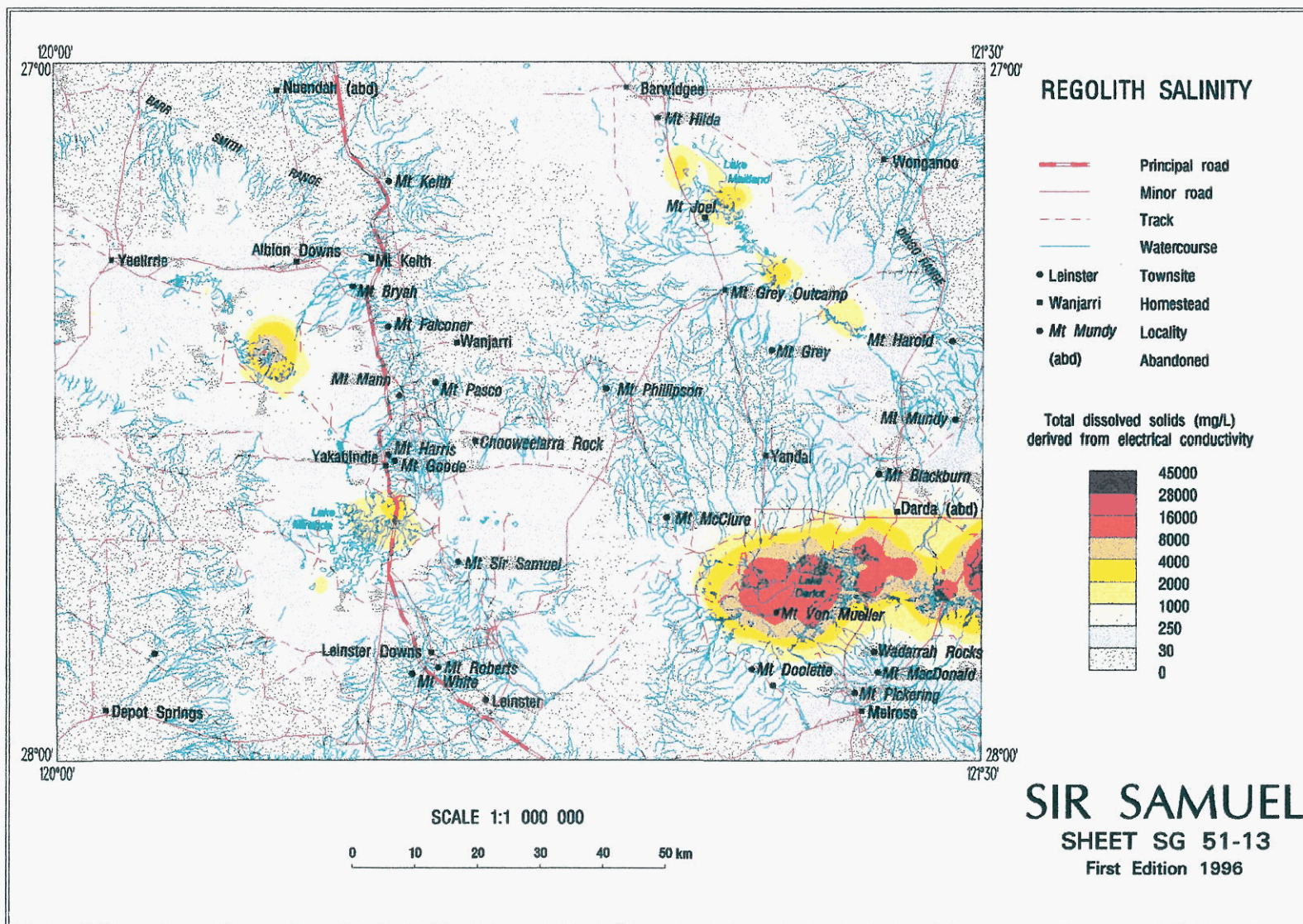
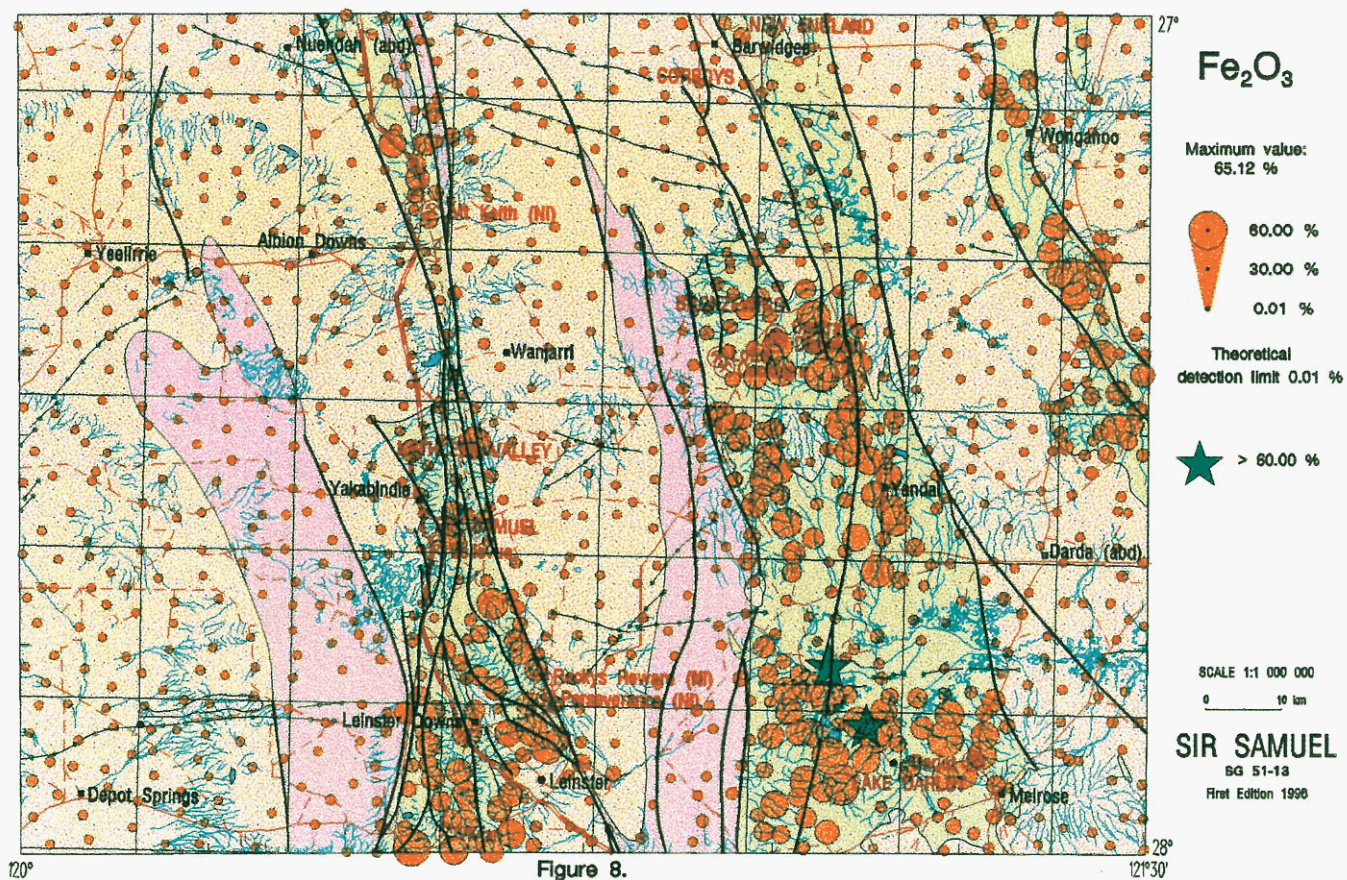
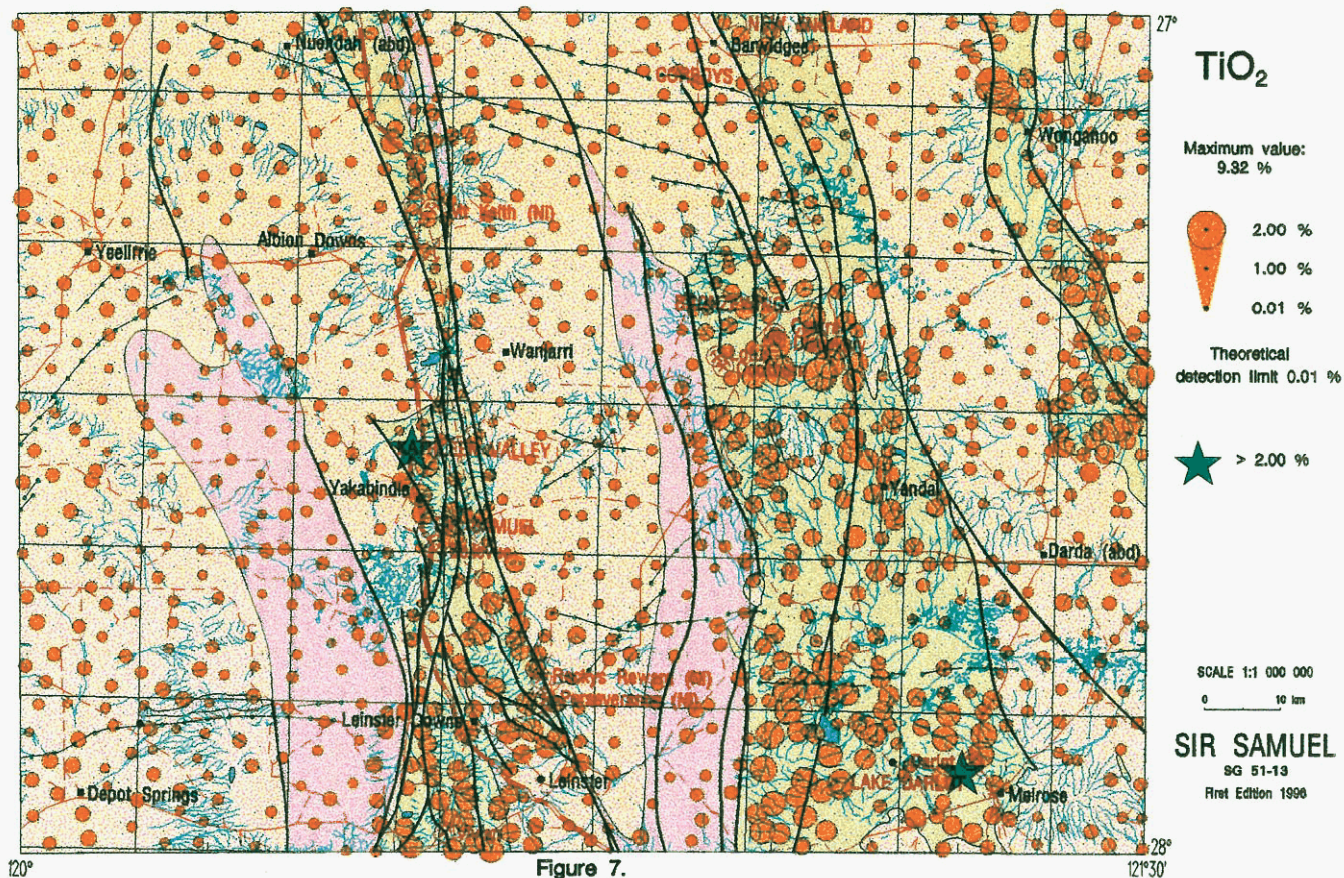
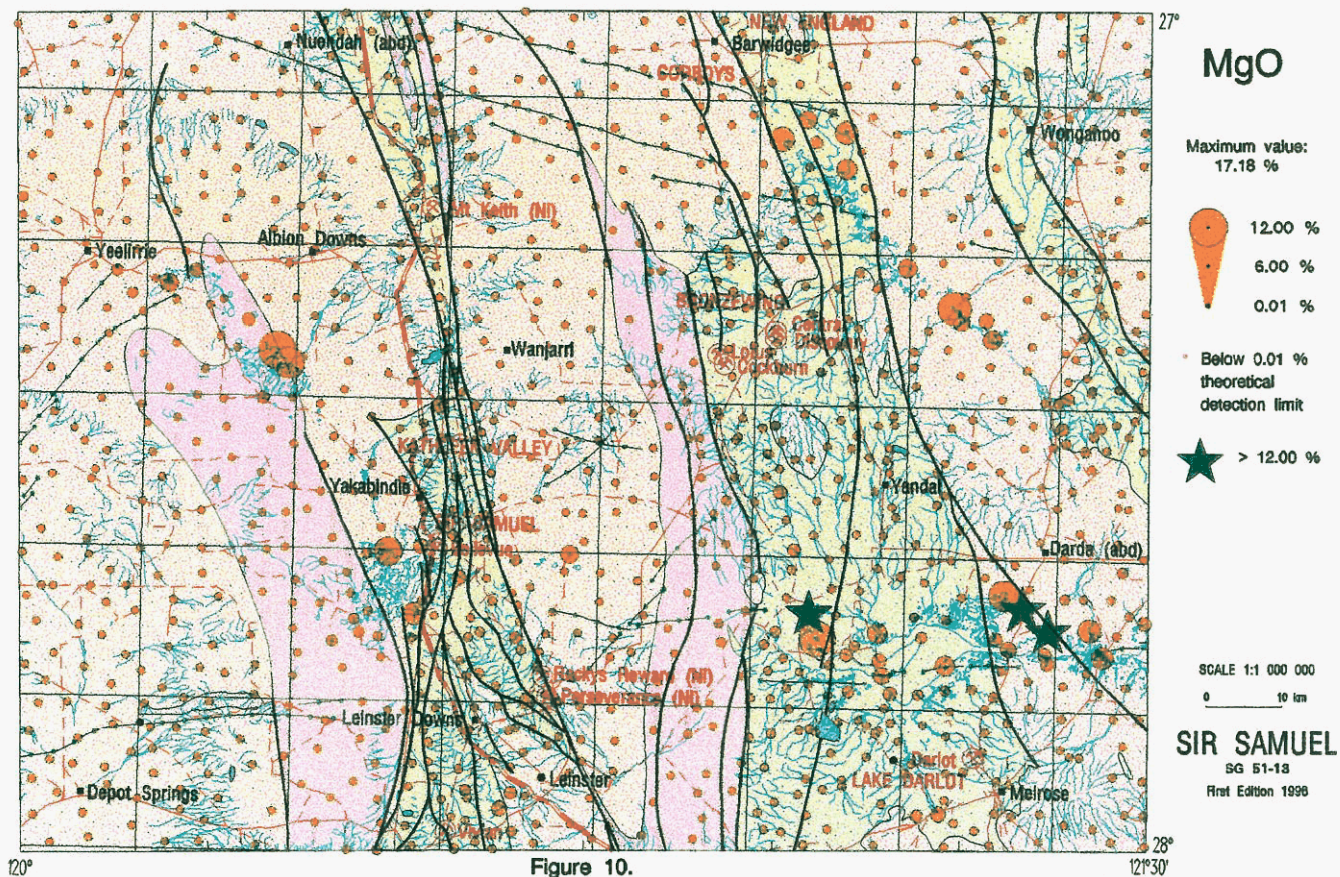
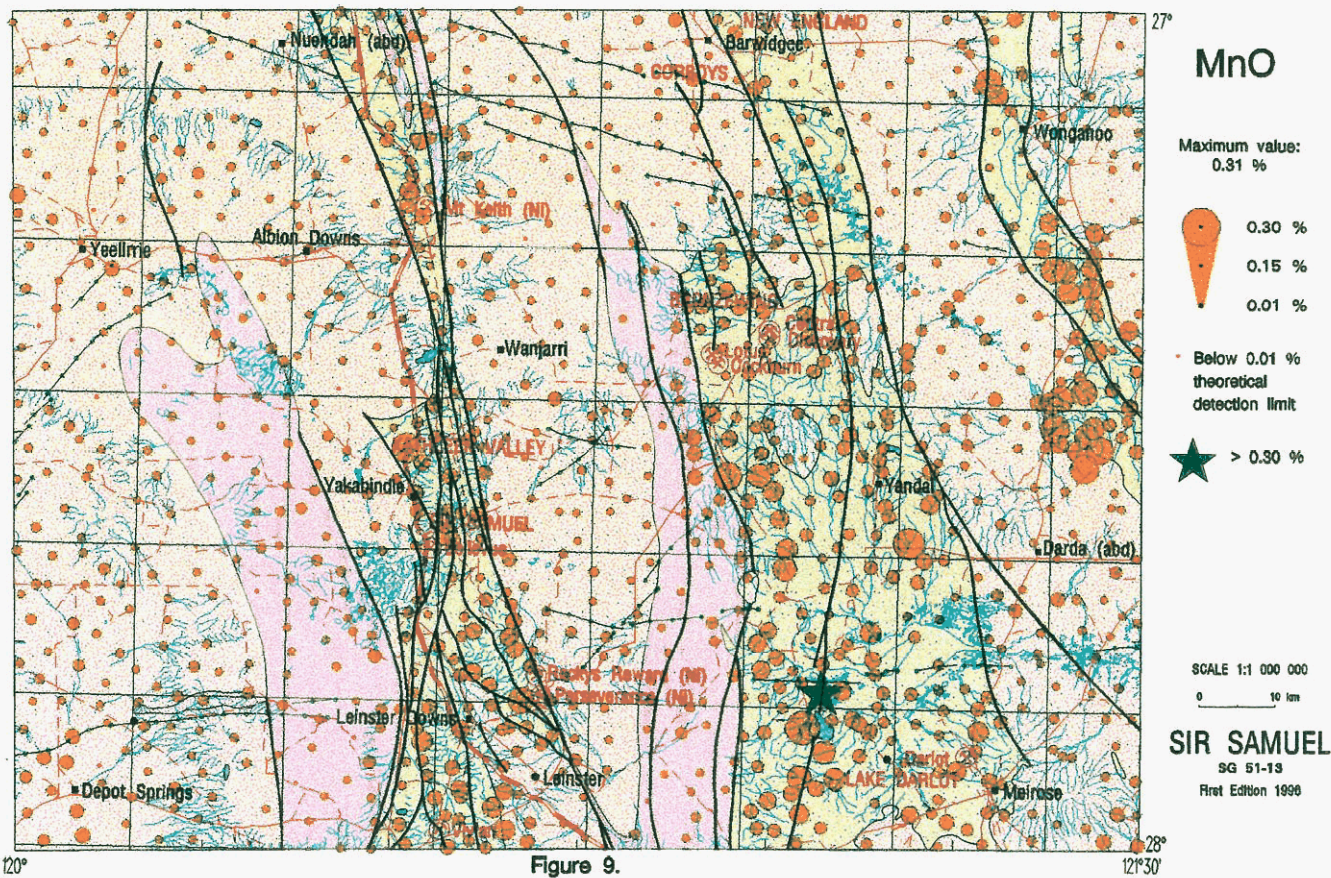
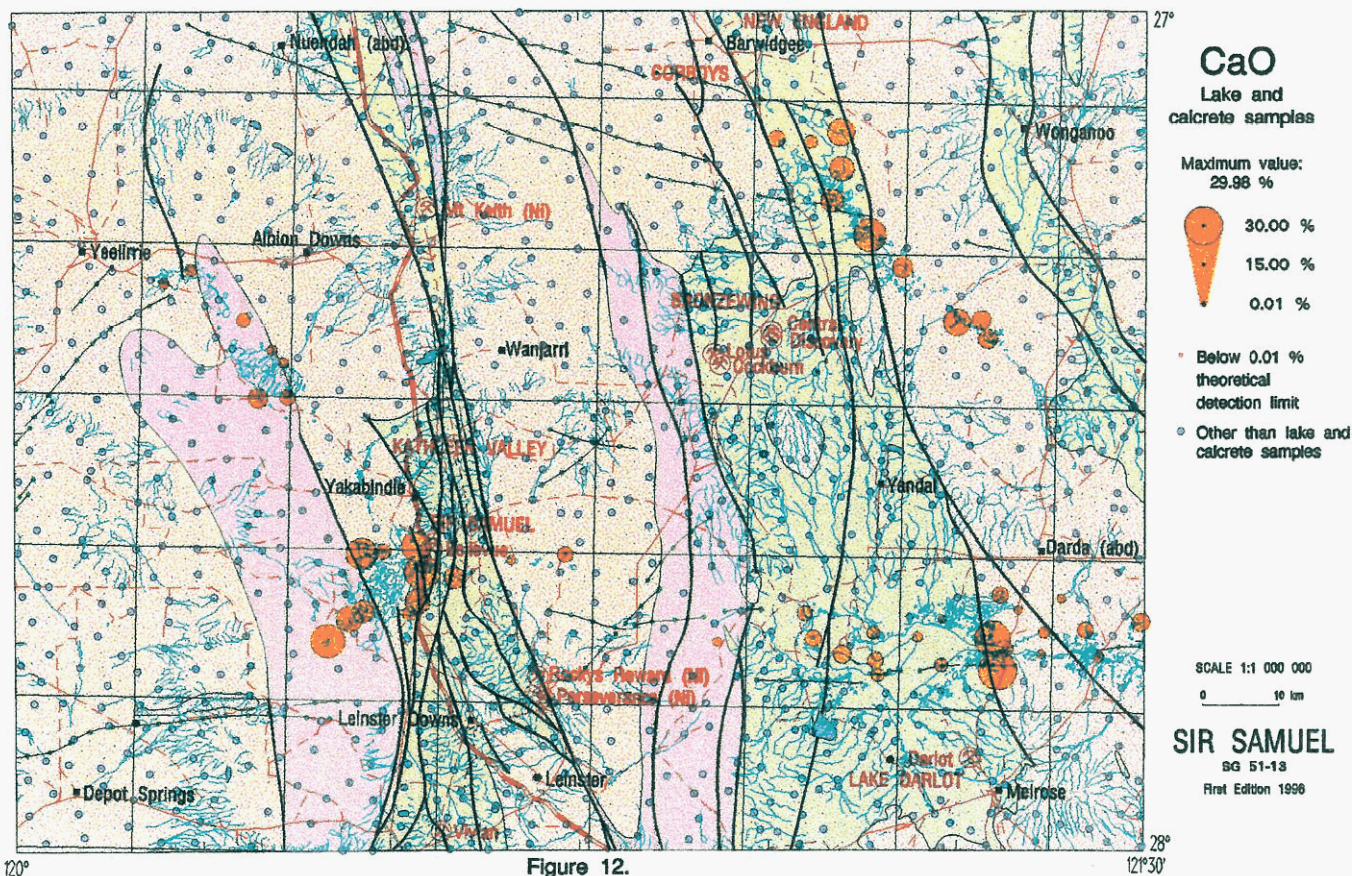
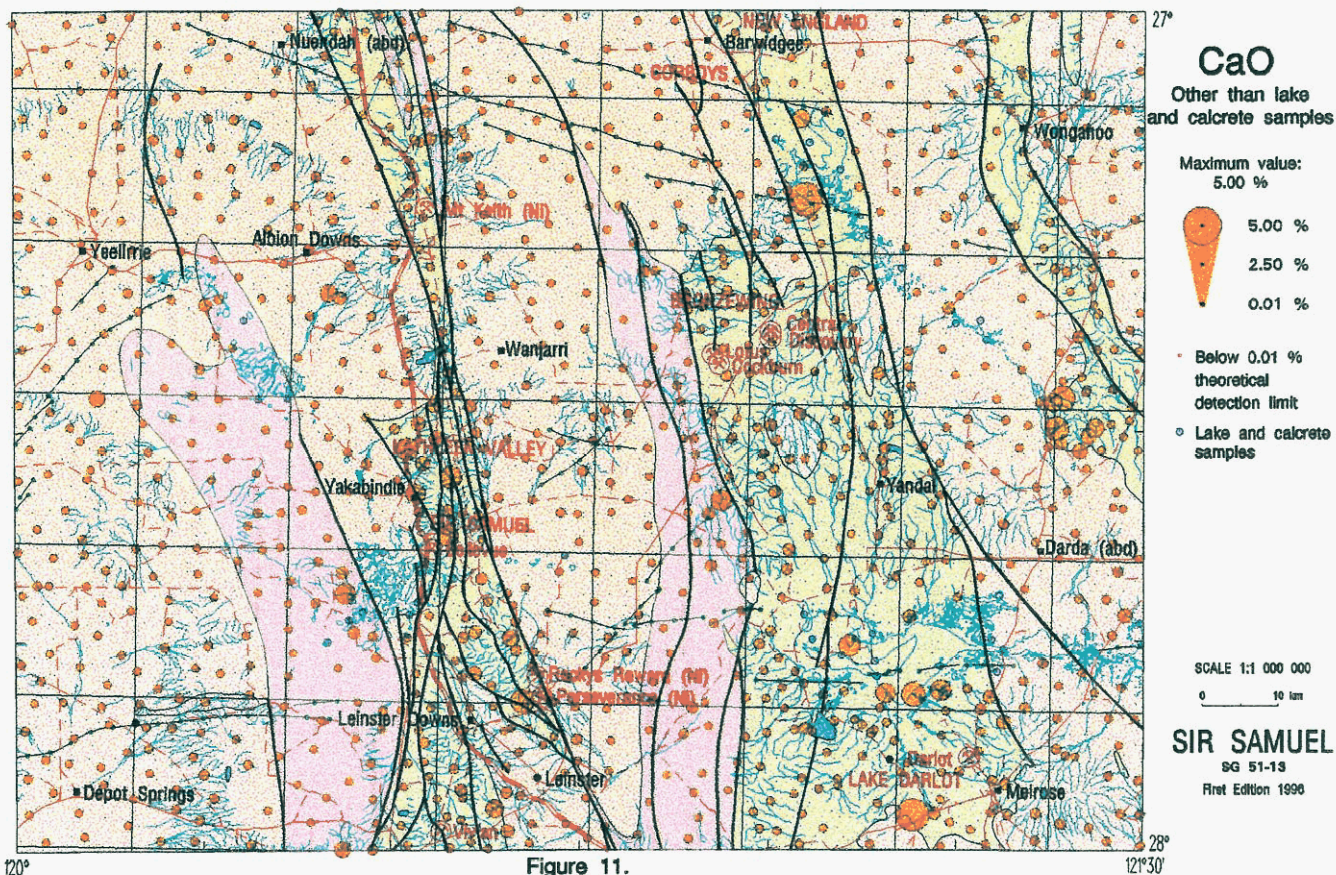
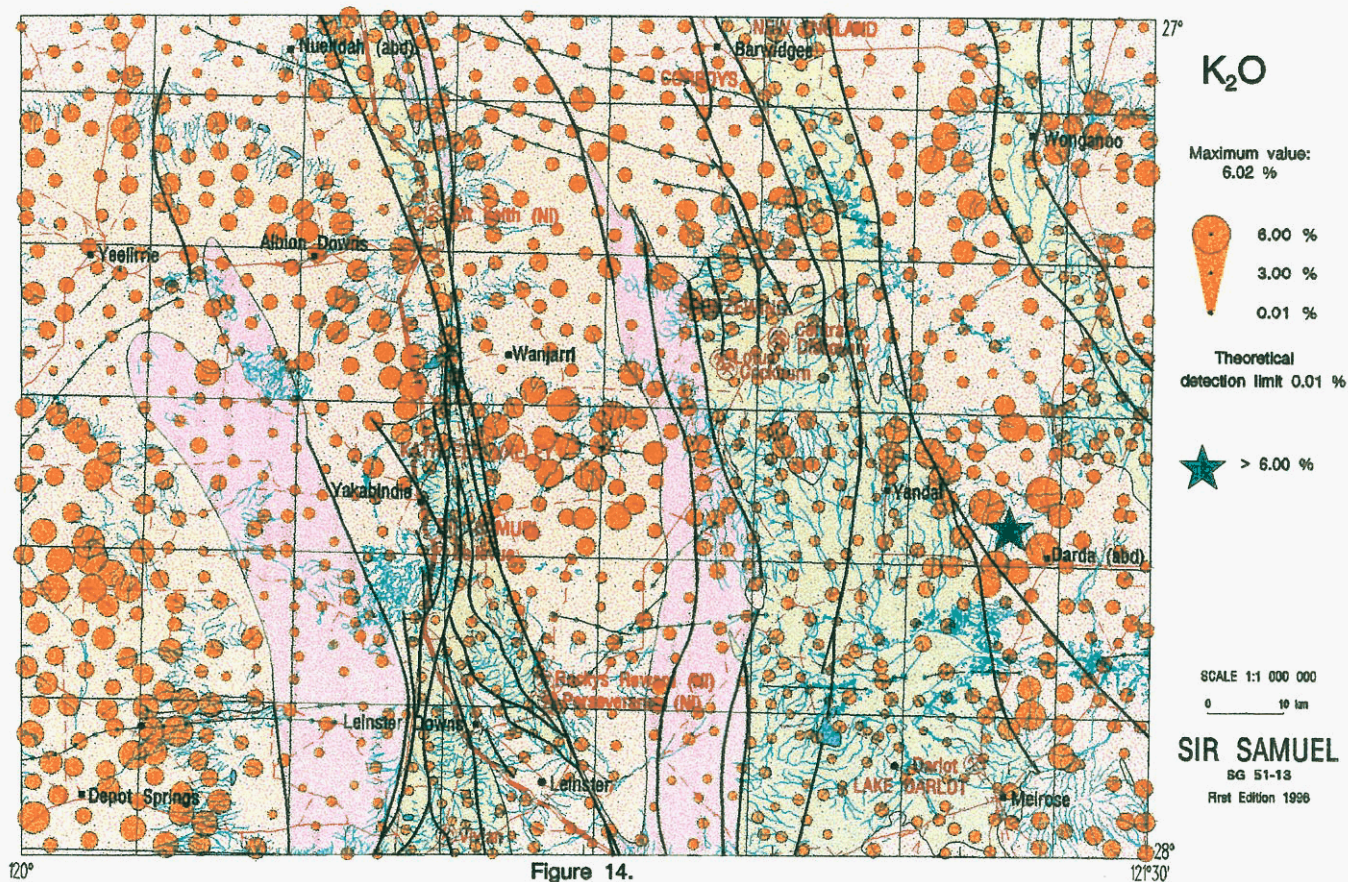
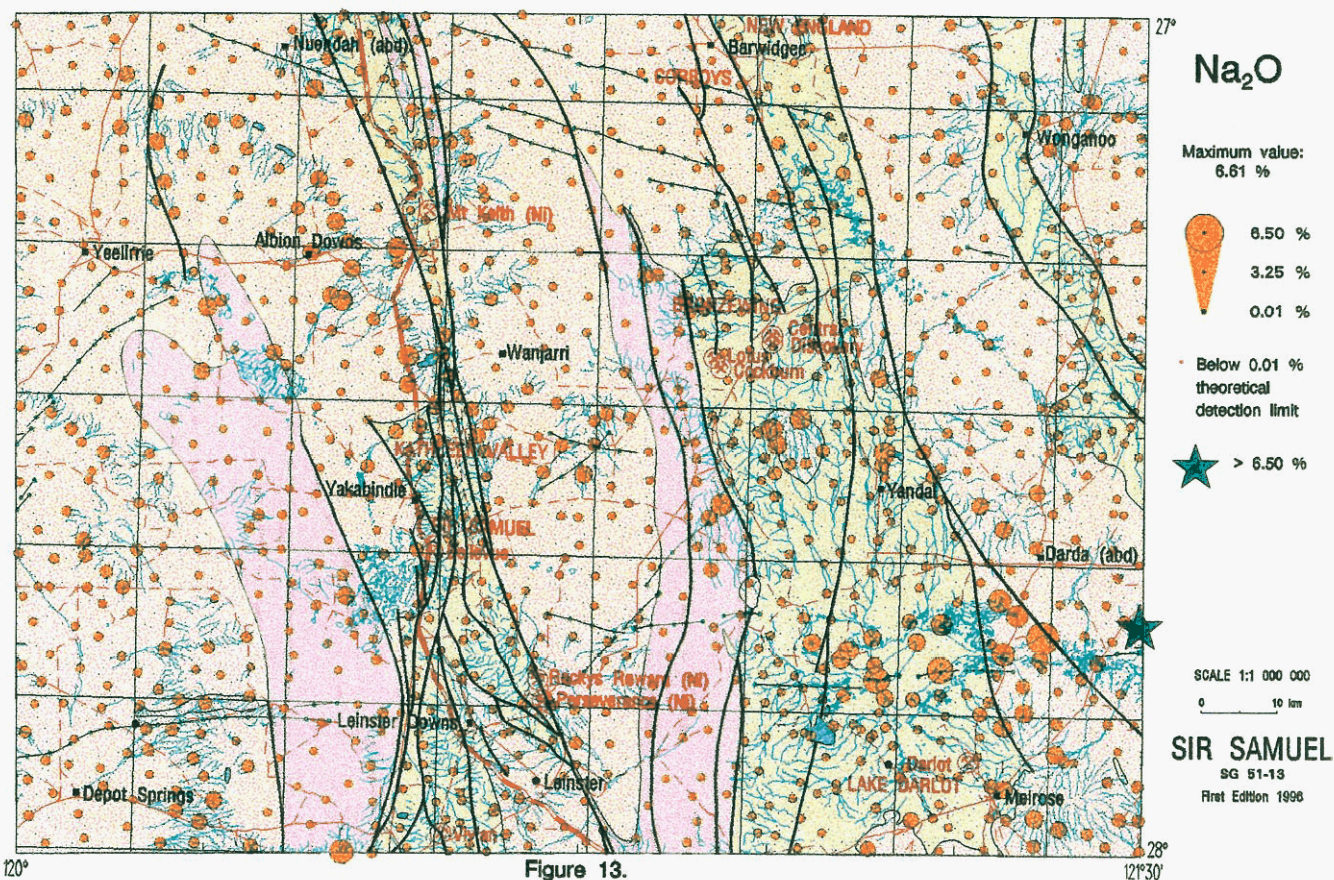


Figure 6.









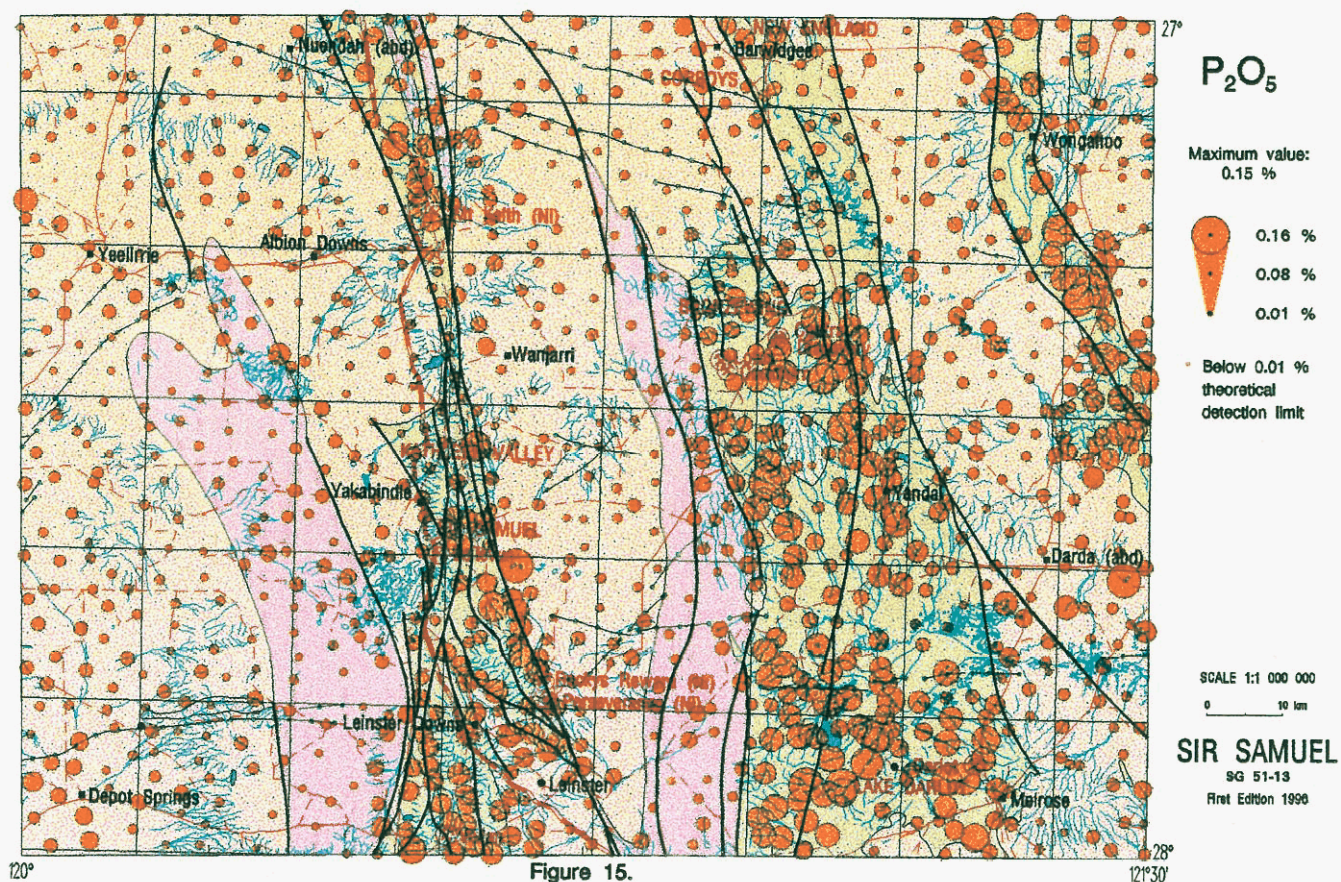


Figure 15.

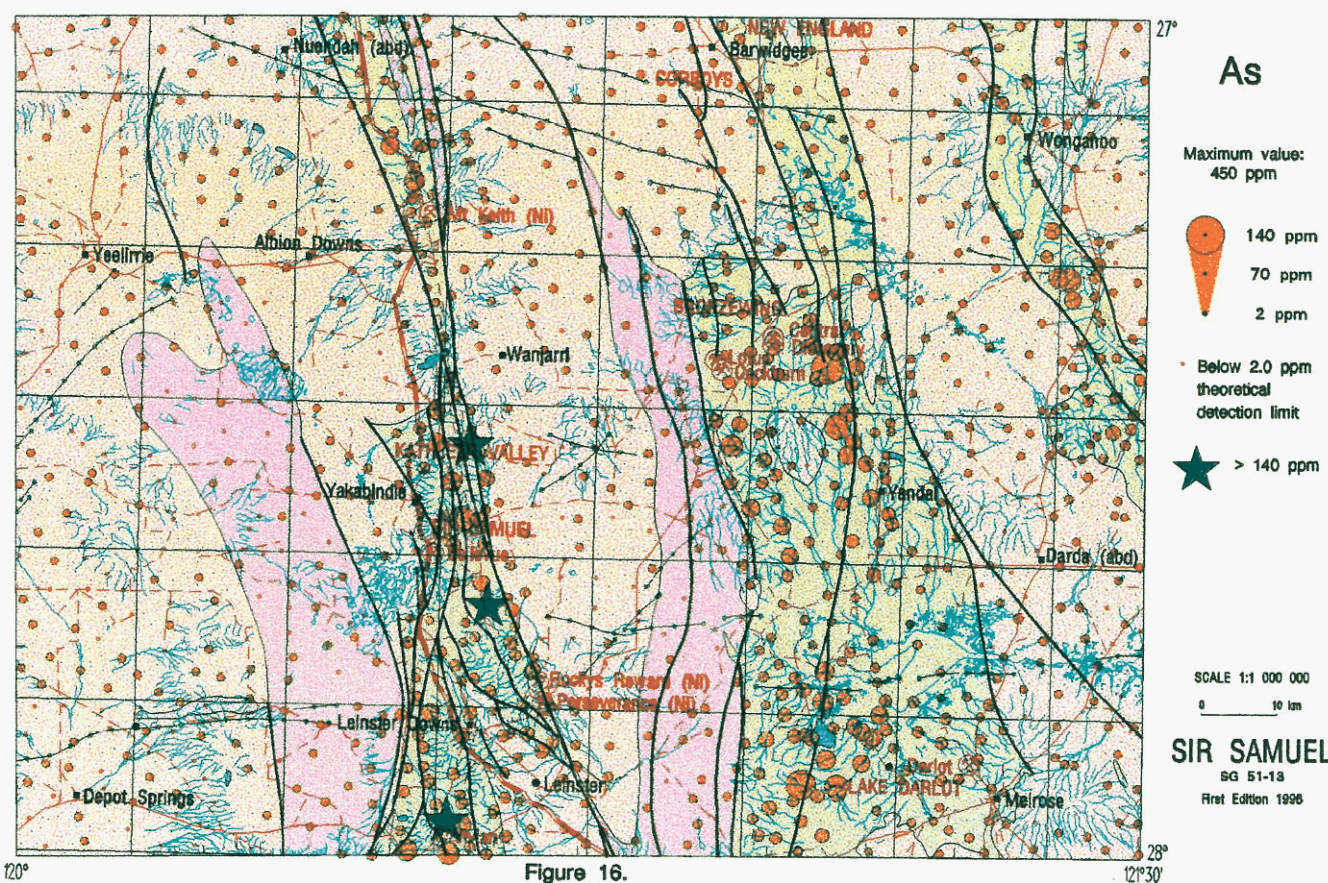
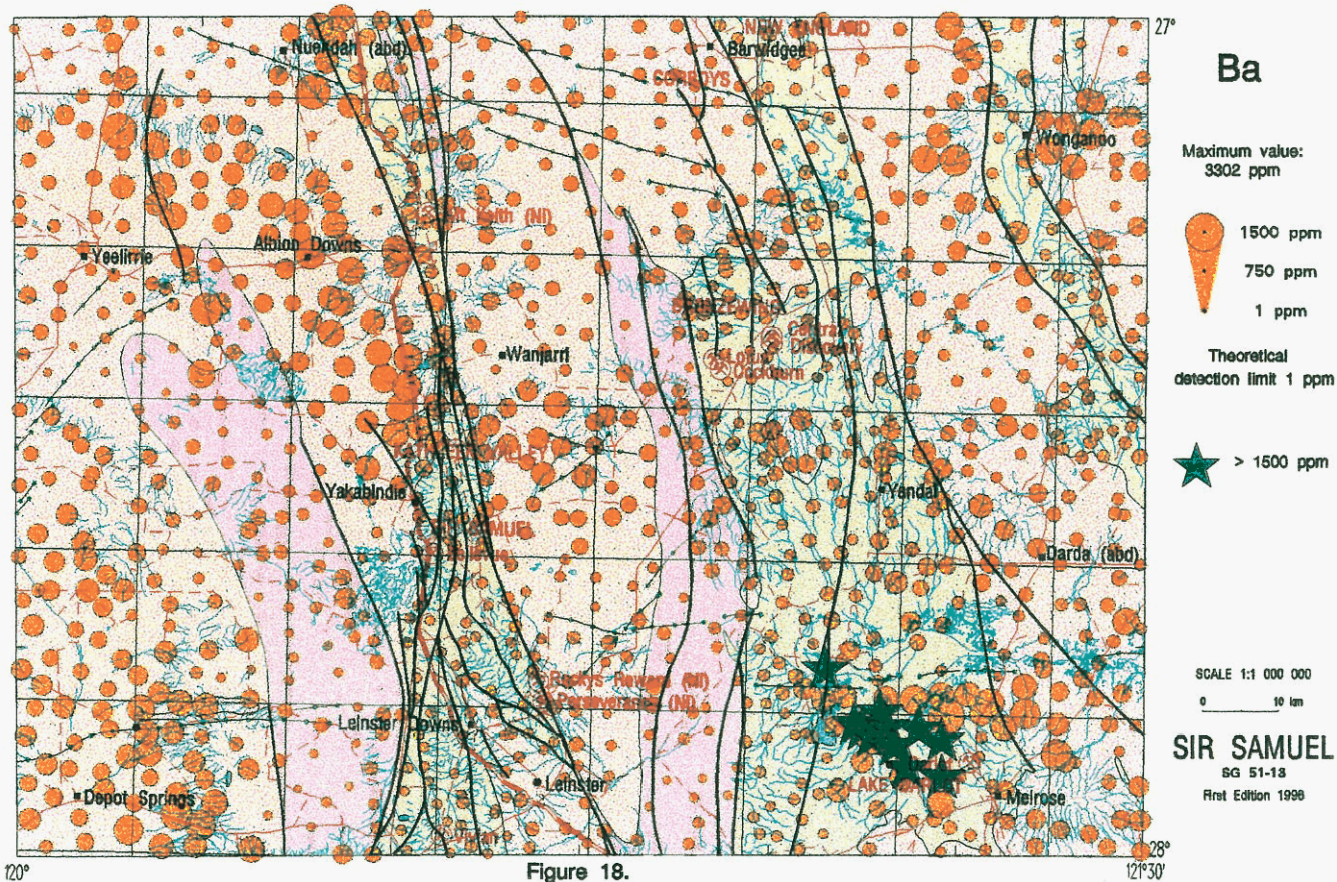
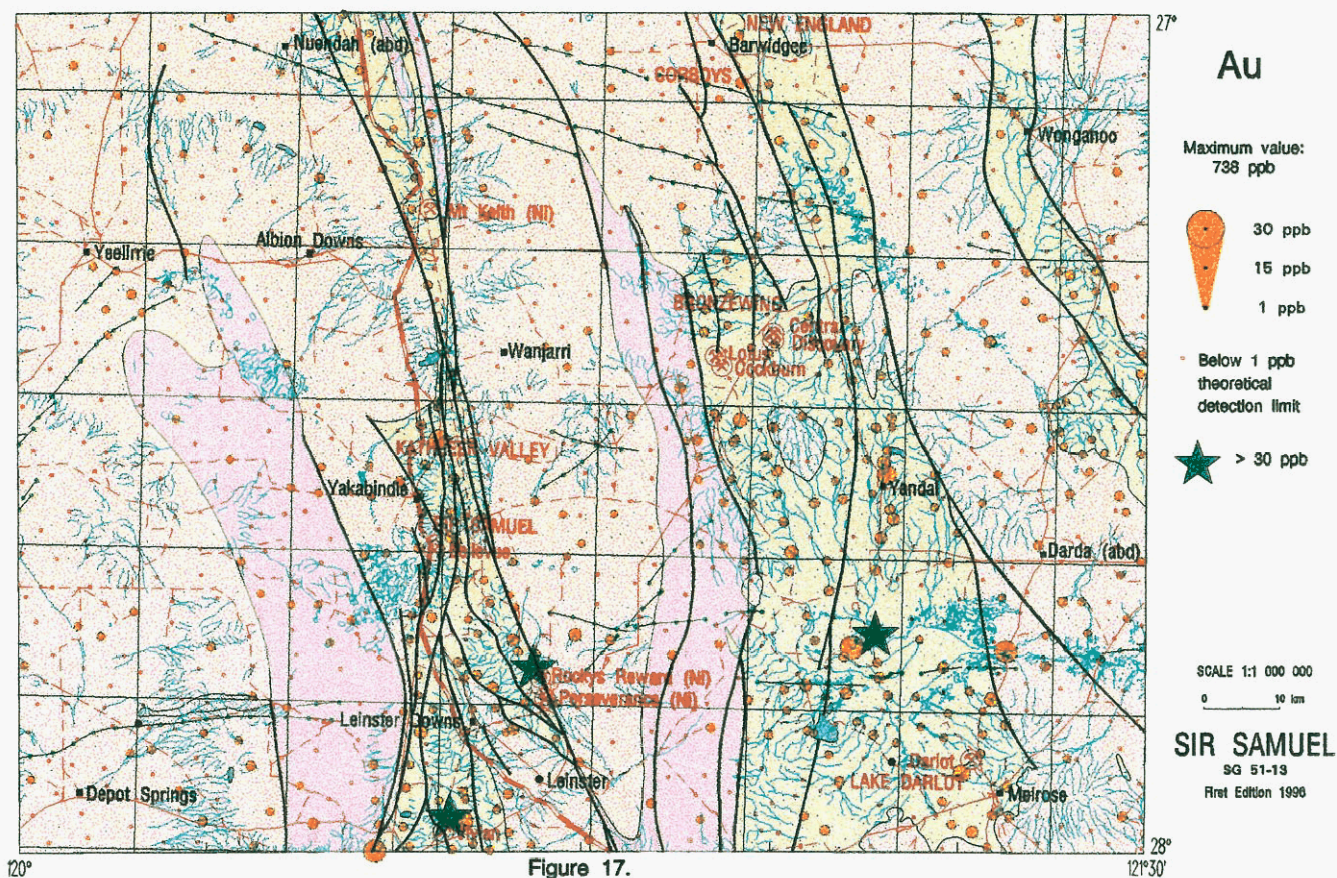
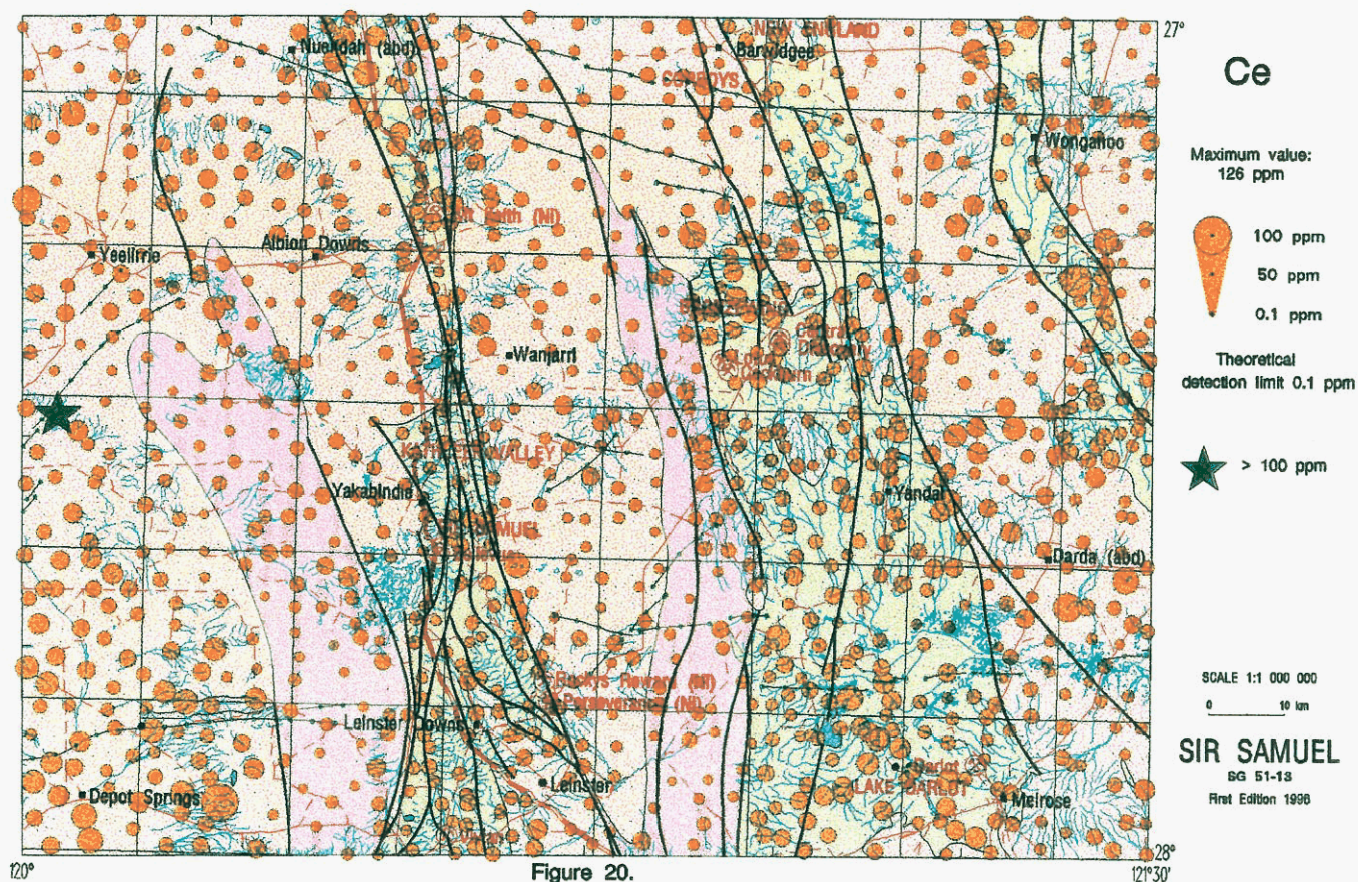
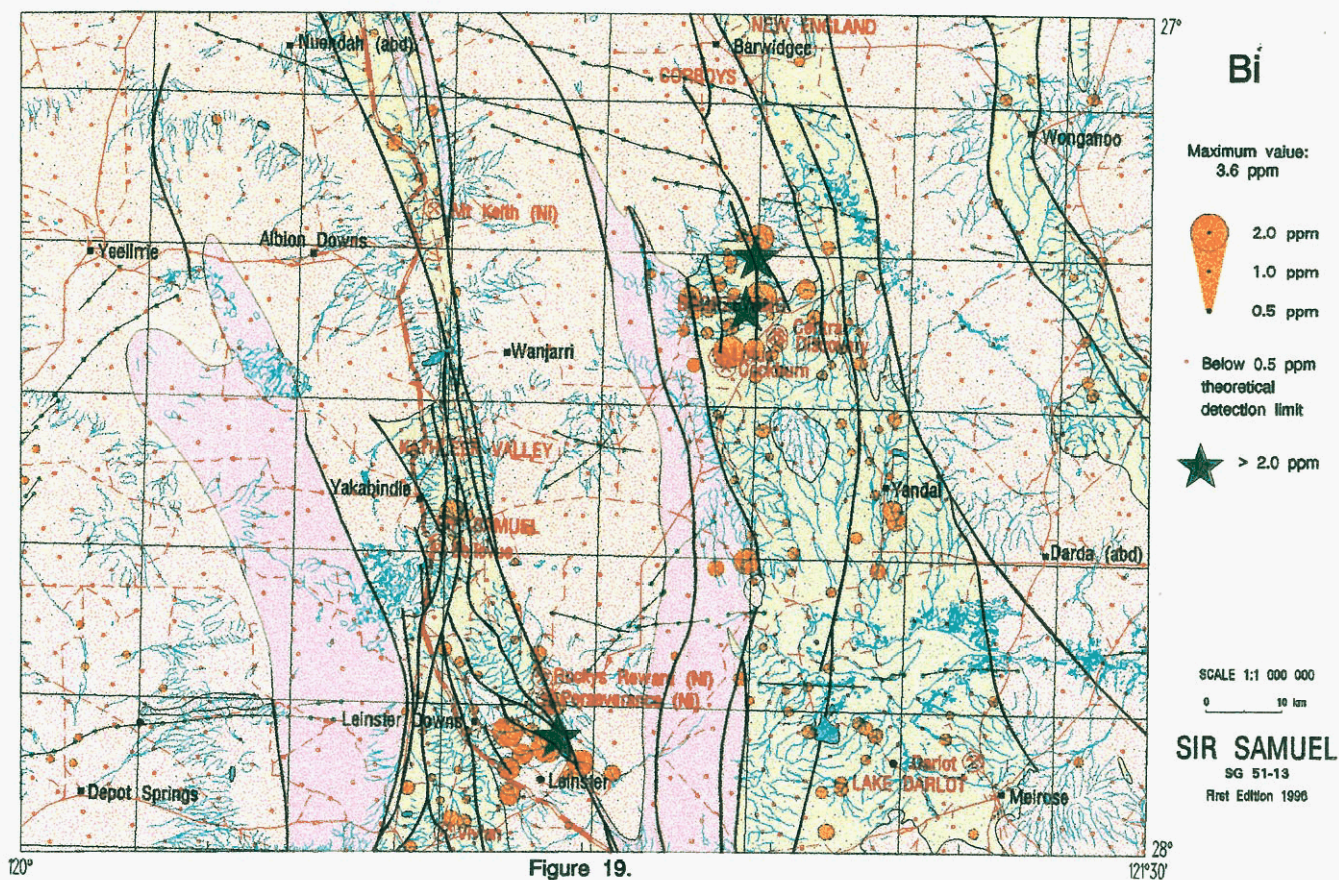
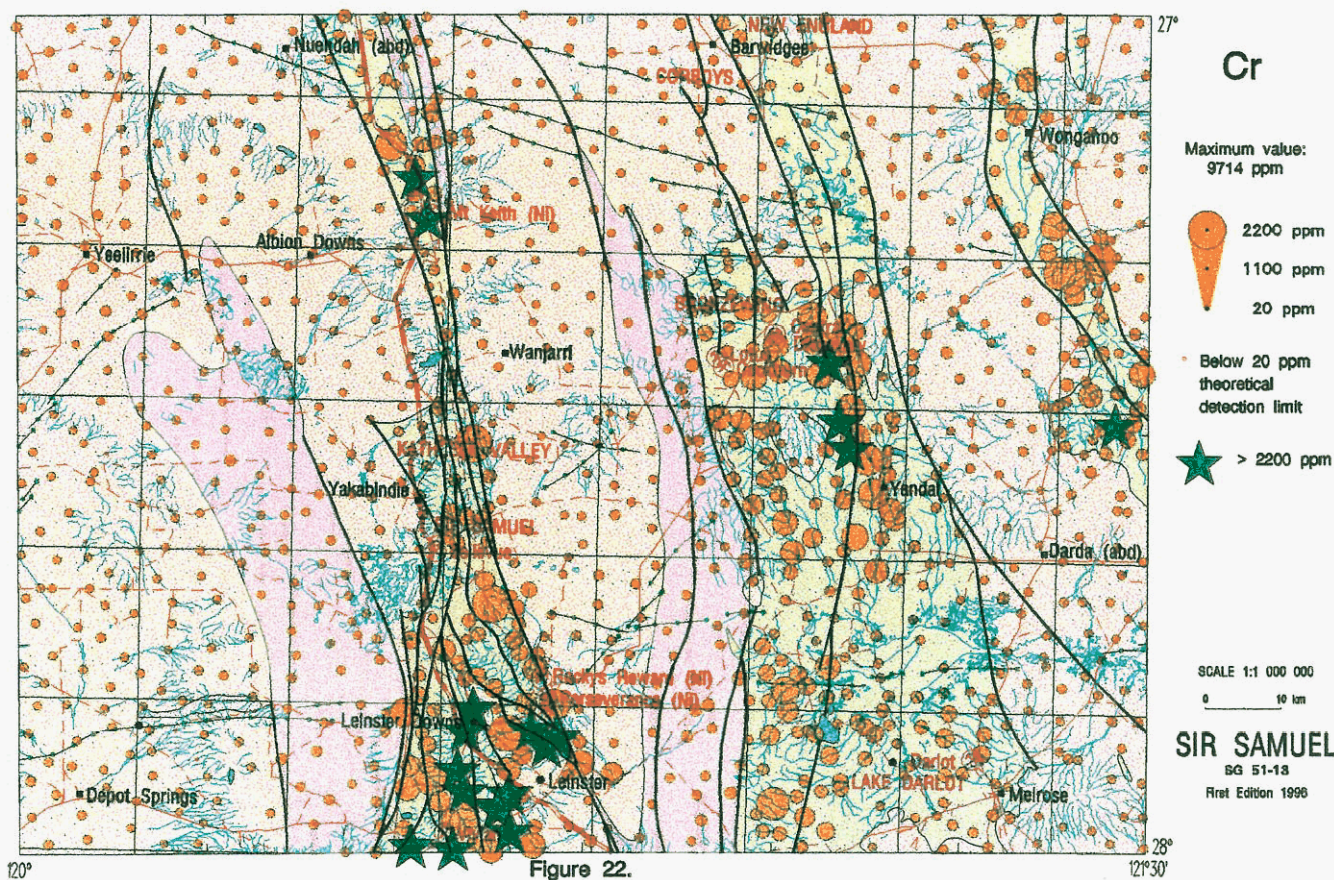
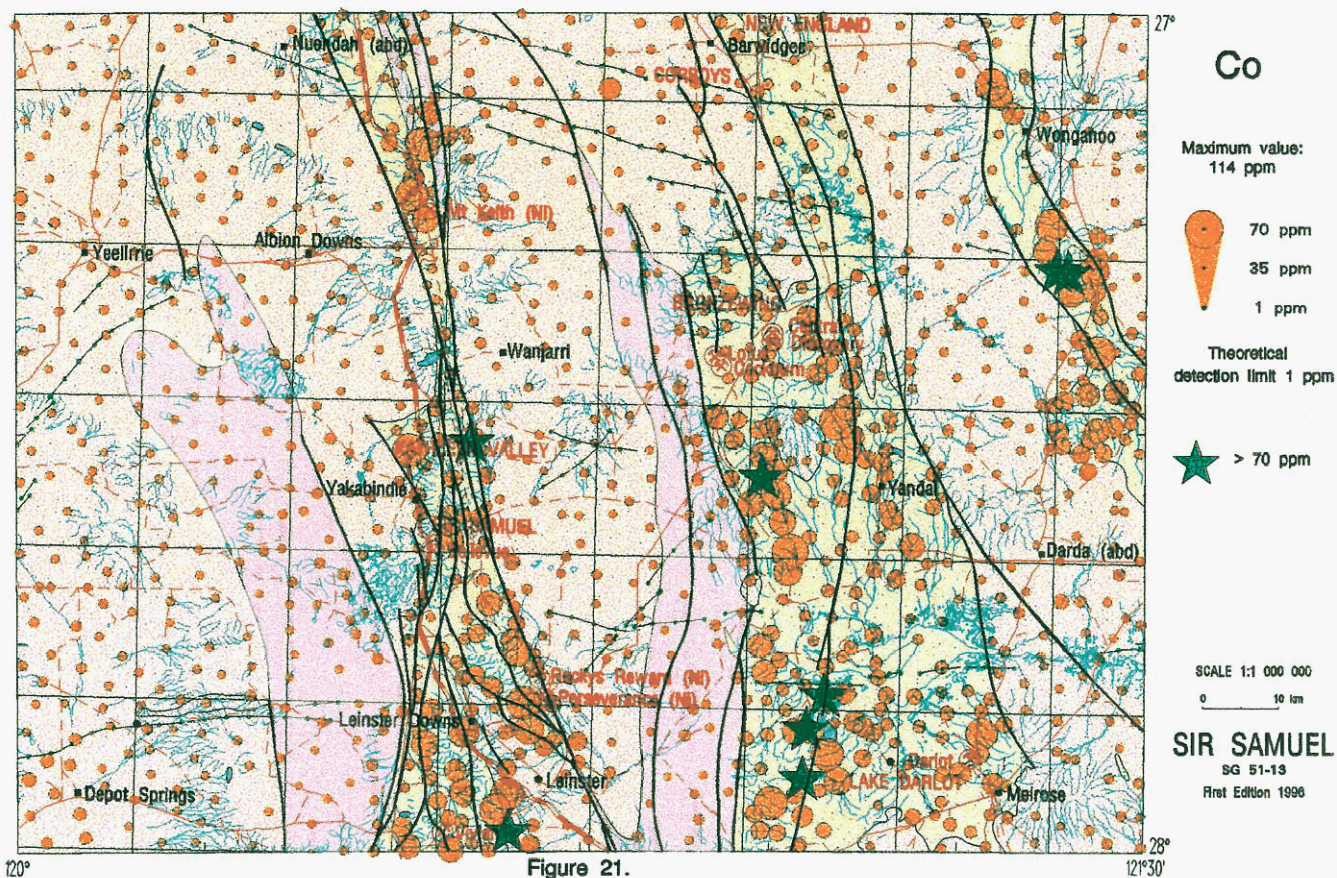
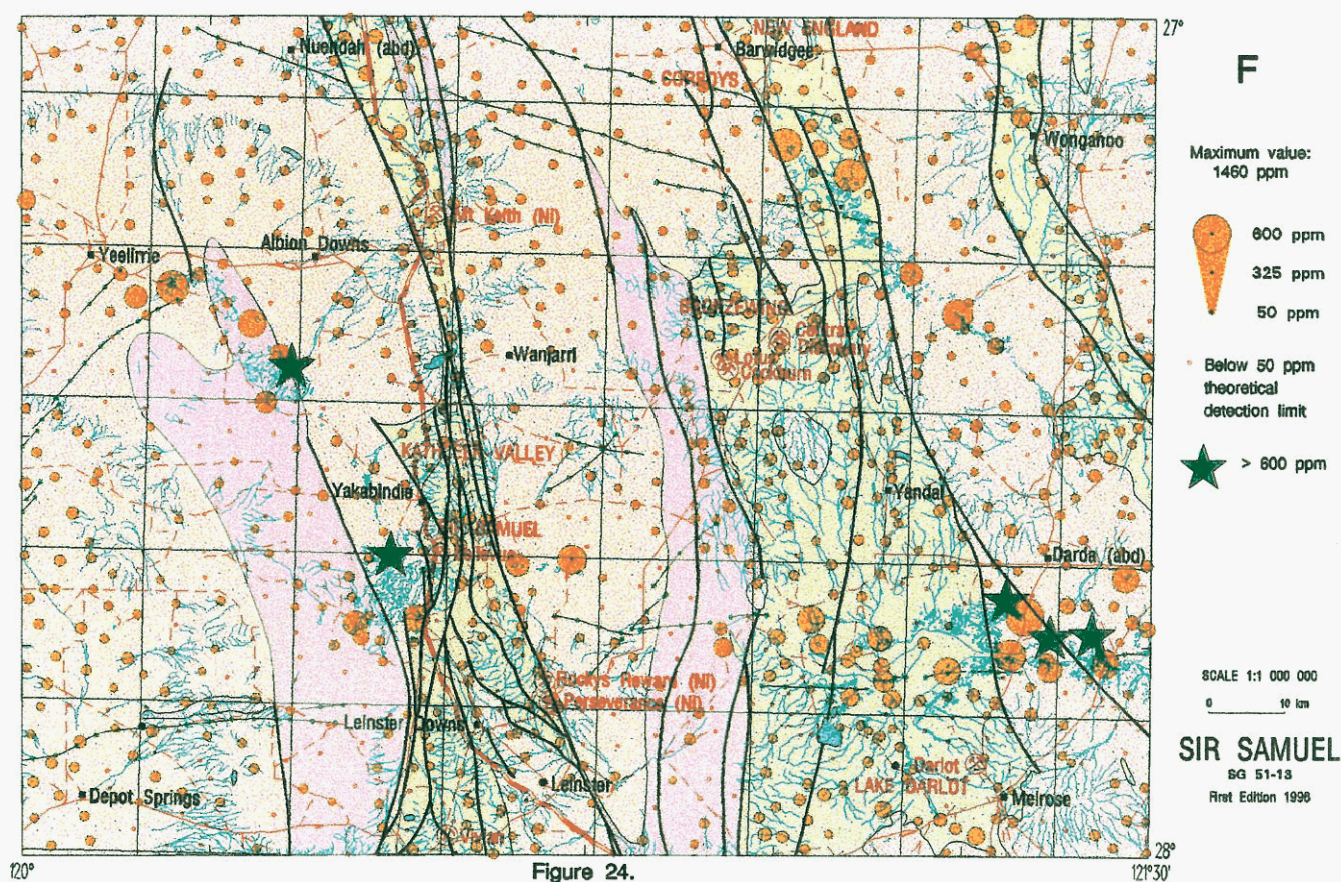
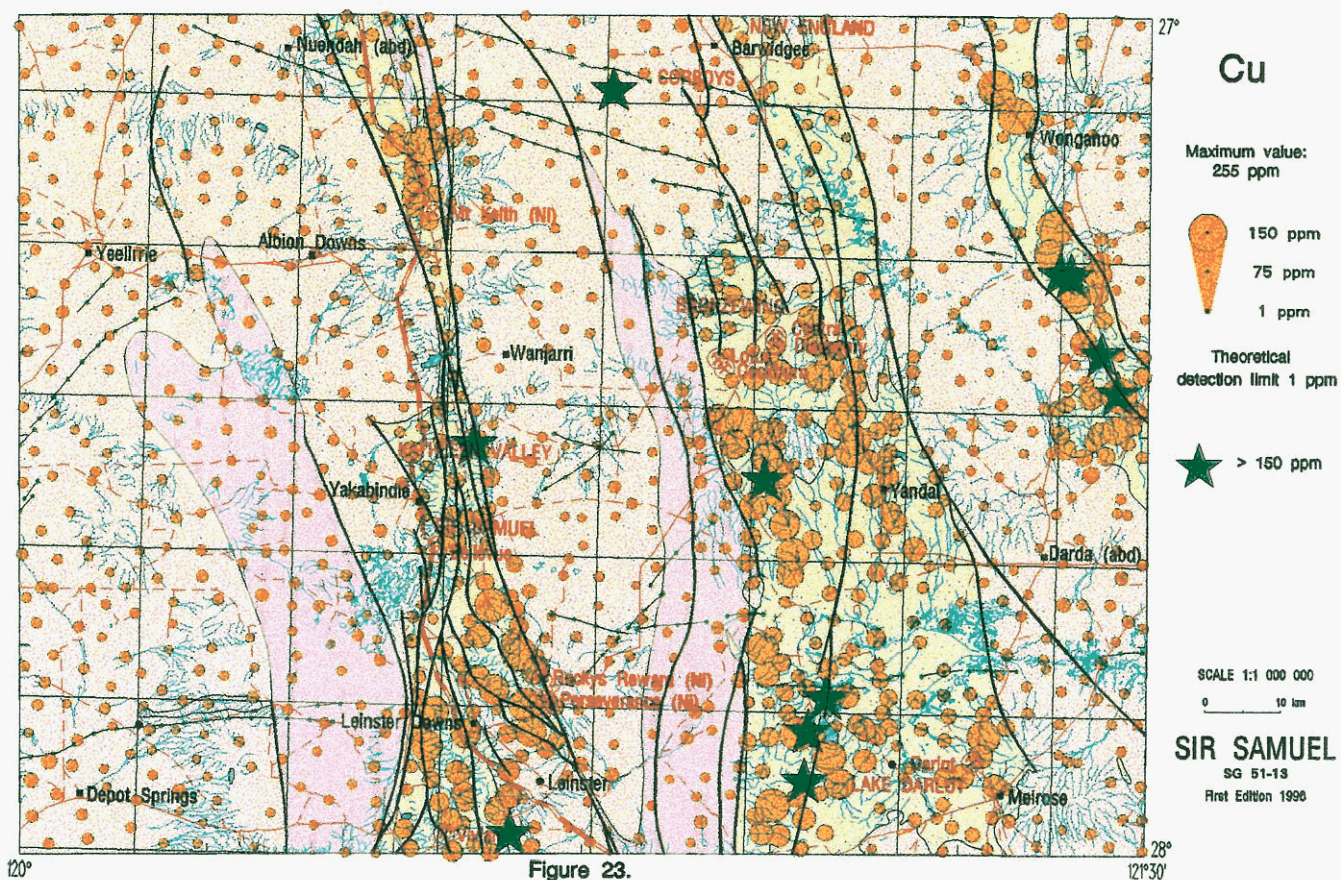


Figure 16.









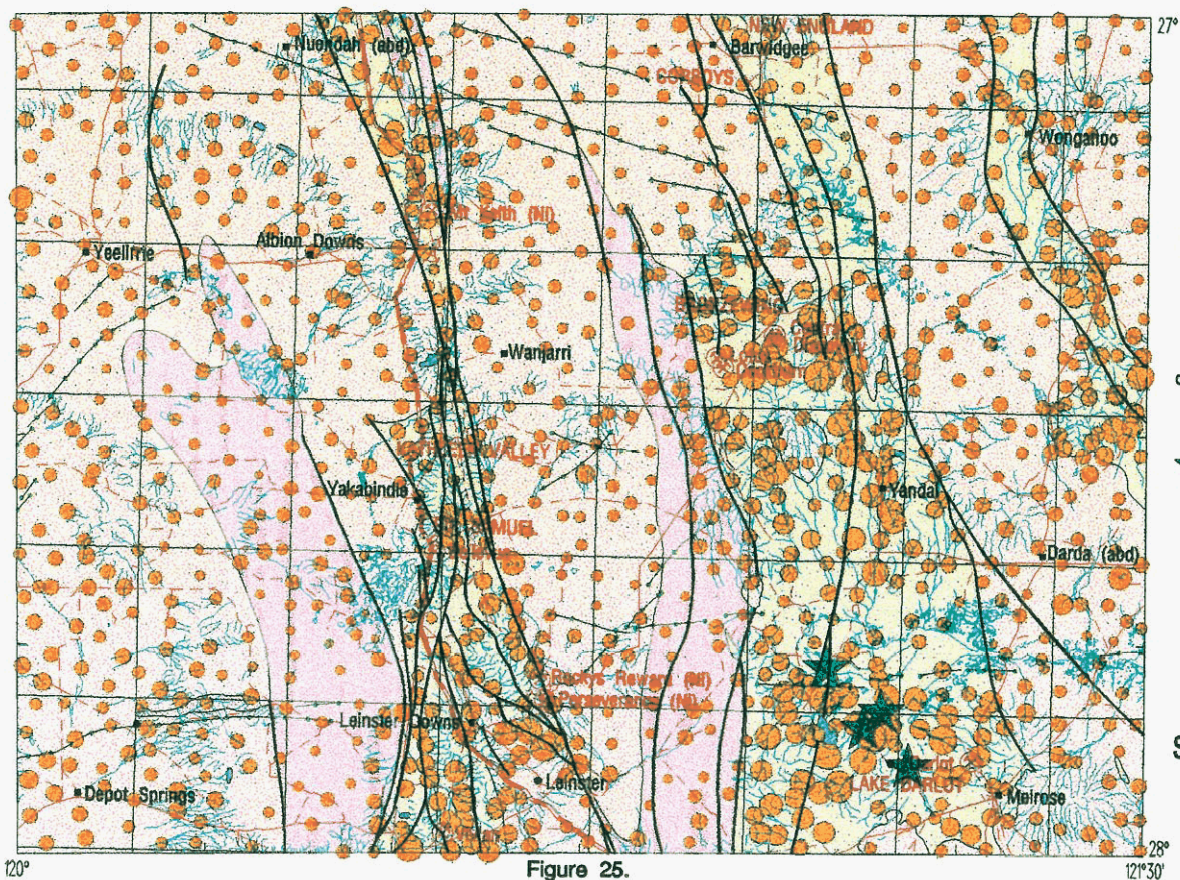


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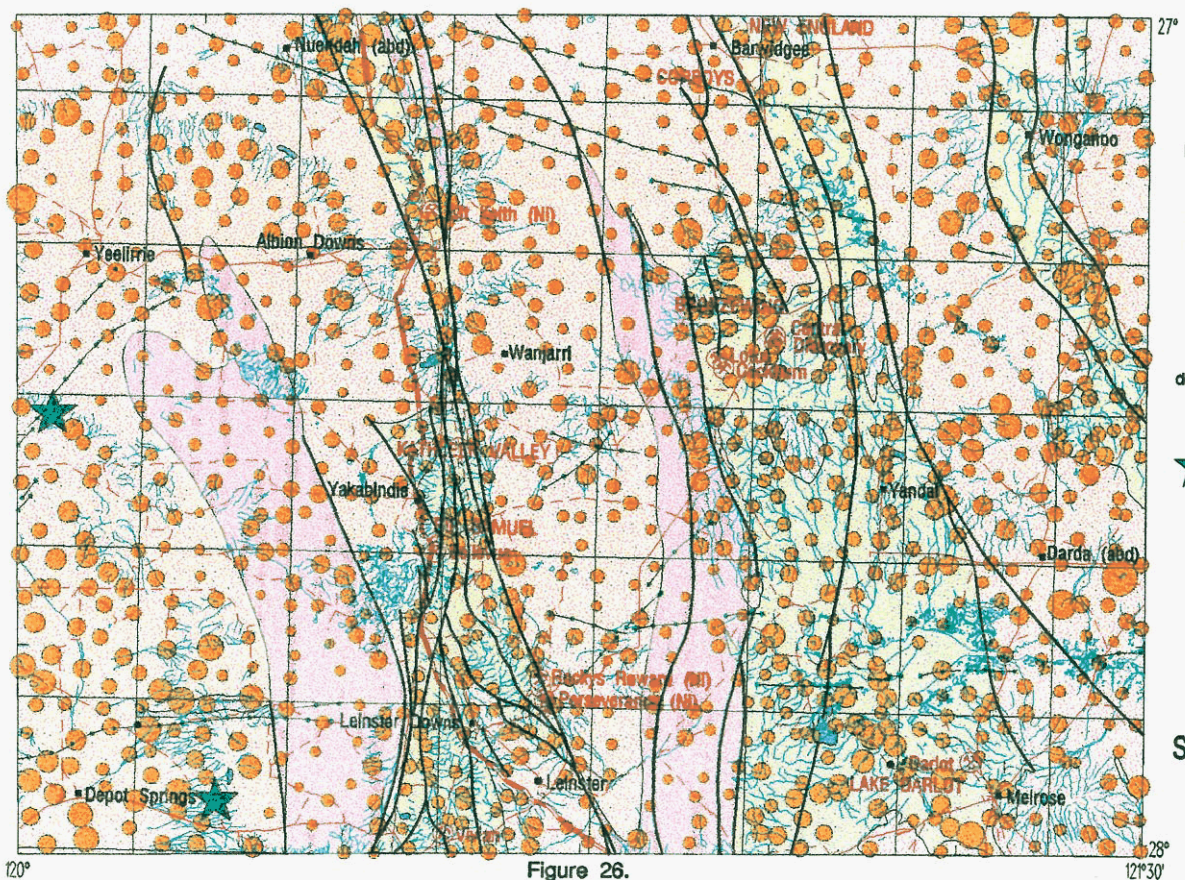


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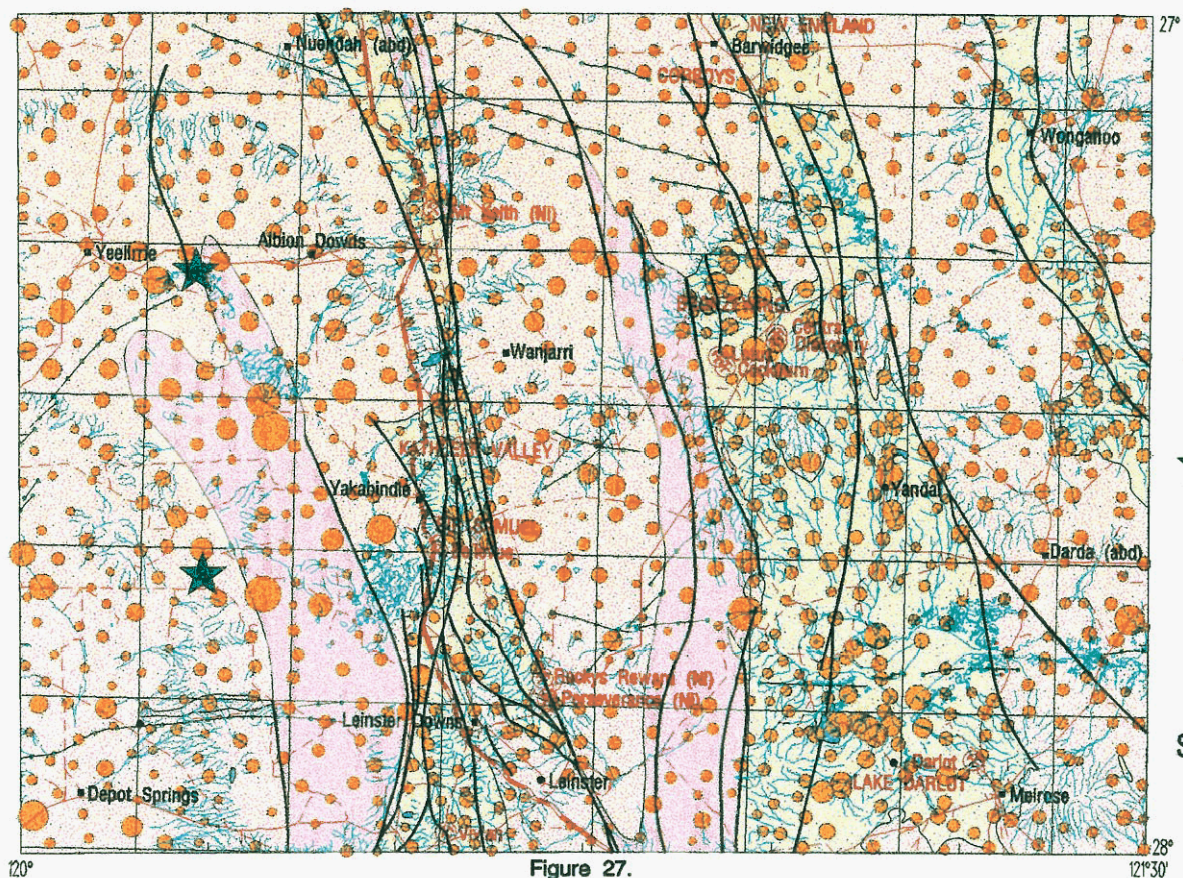


Figure 27.

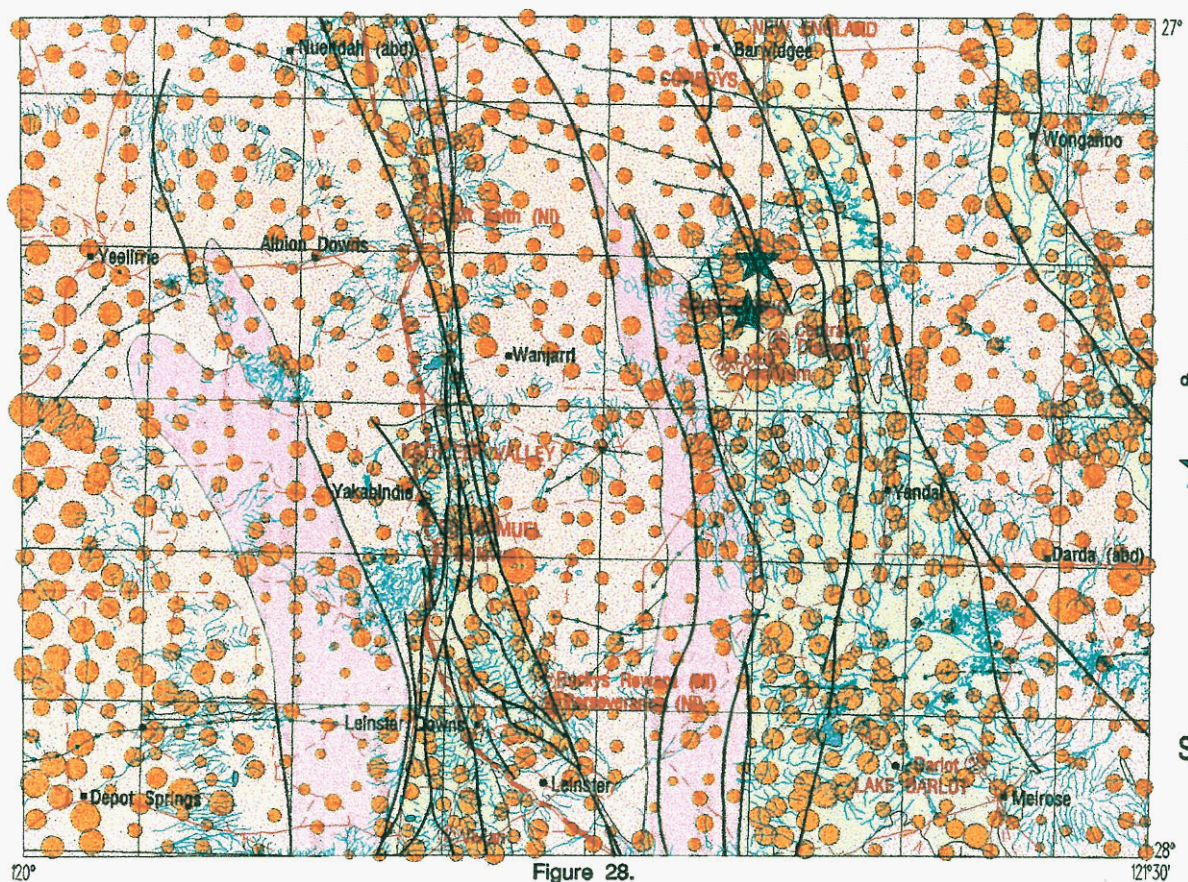
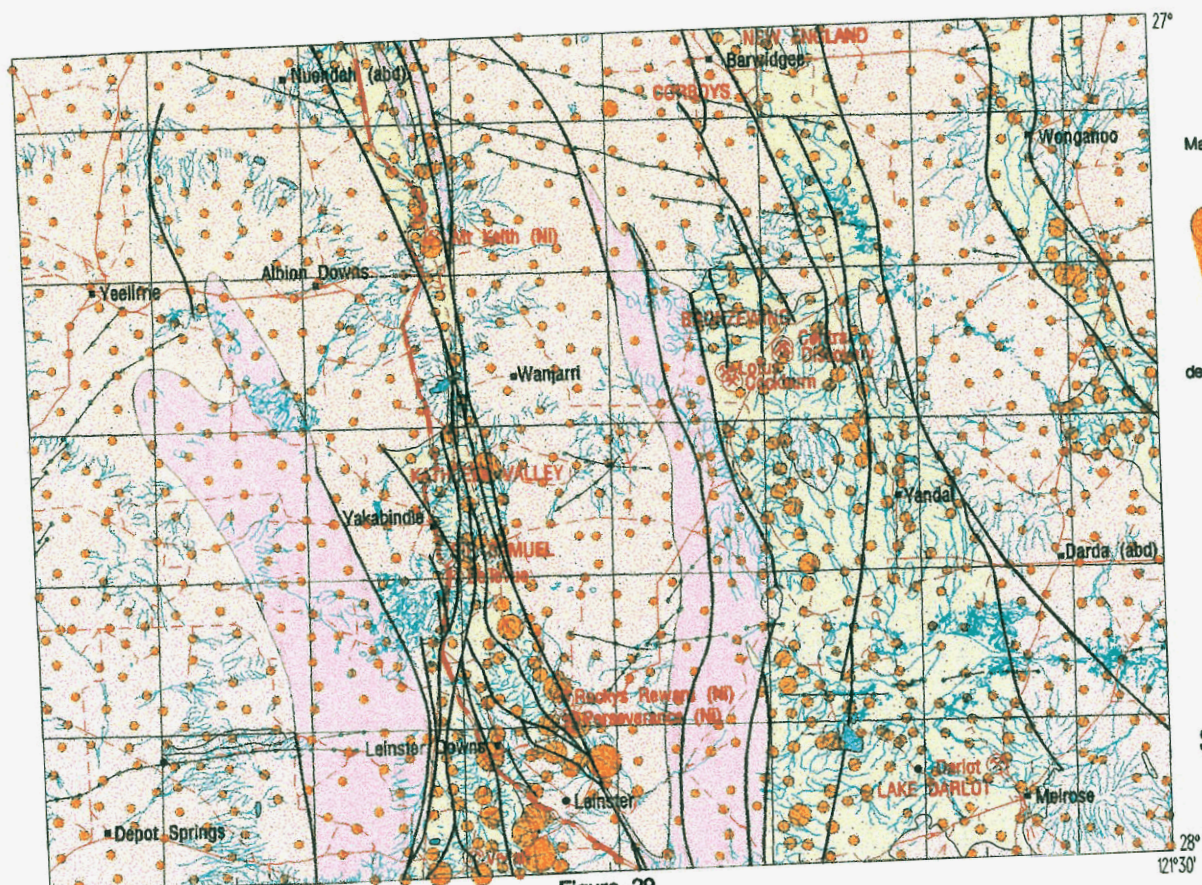


Figure 28.



Ni

Maximum value:
541 ppm

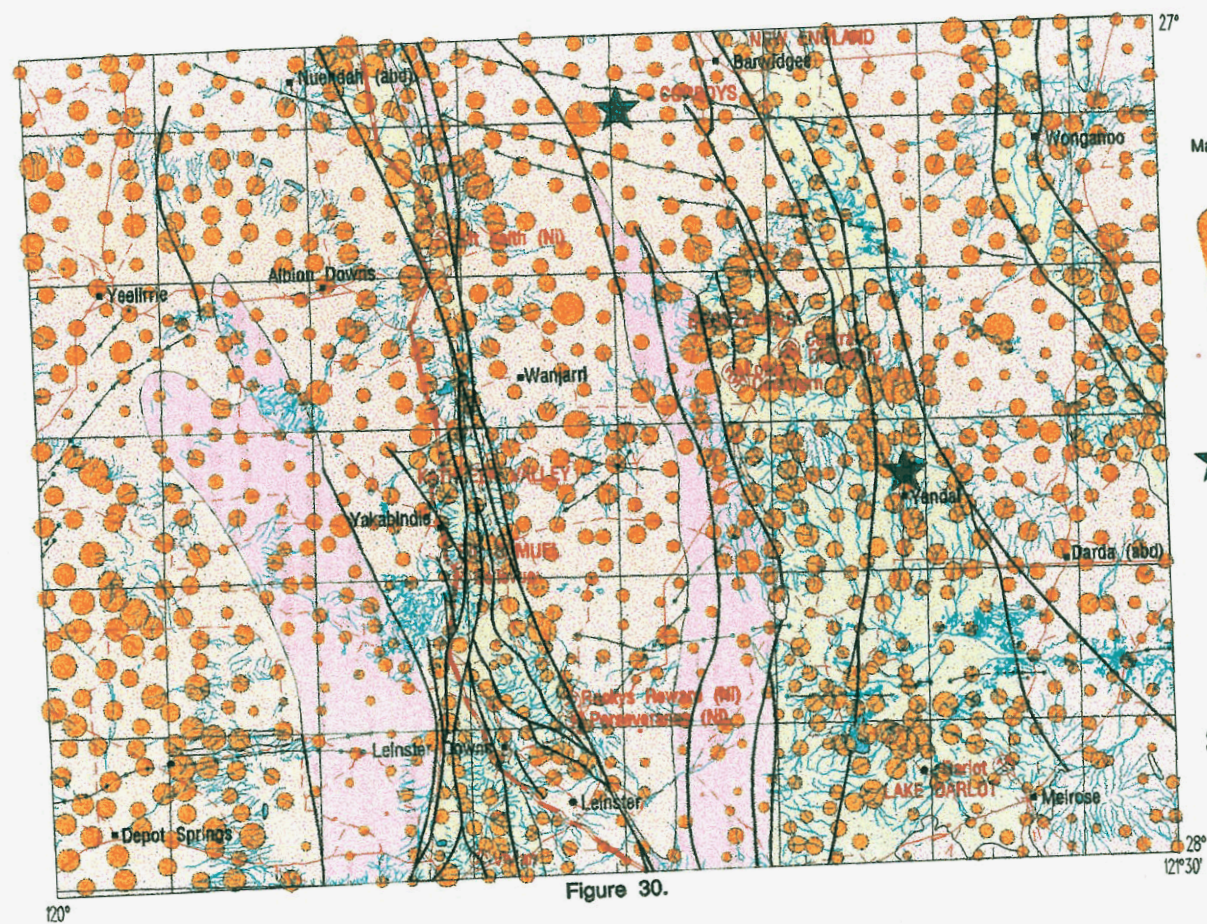


Theoretical
detection limit 1 ppm

SCALE 1:1 000 000
0 10 km

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Figure 29.



Pb

Maximum value:
158 ppm



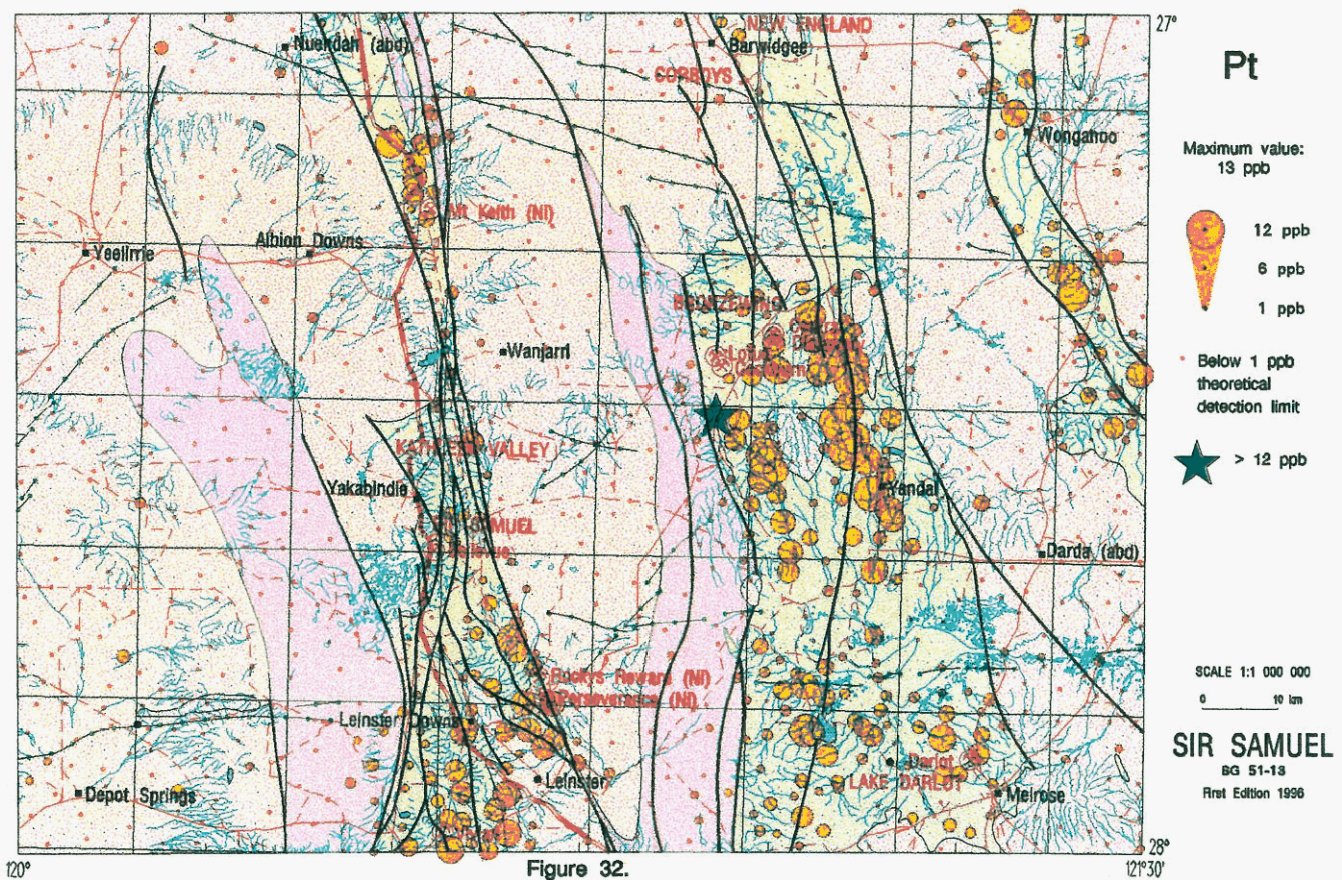
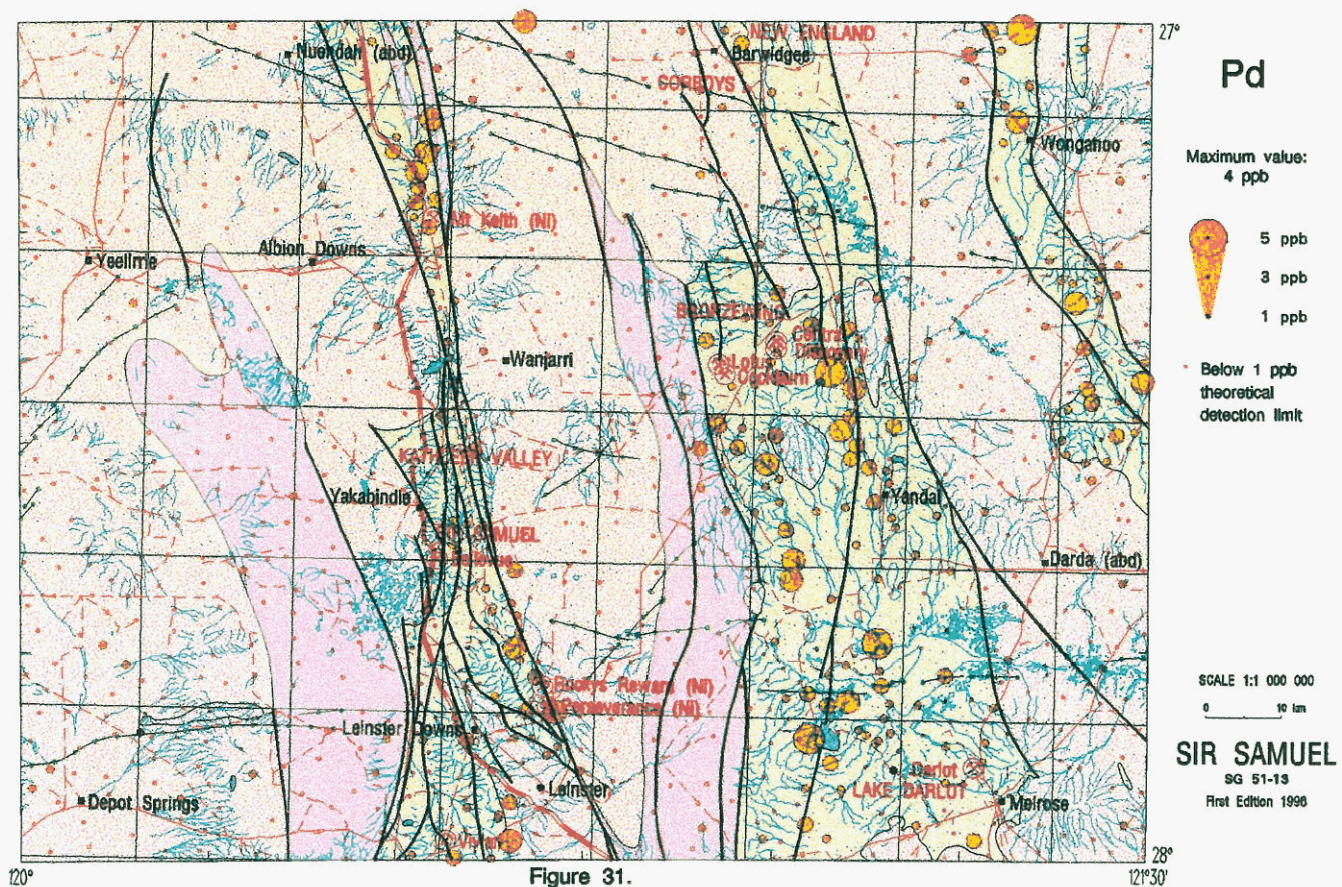
Below 2 ppm
theoretical
detection limit

★ > 60 ppm

SCALE 1:1 000 000
0 10 km

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Figure 30.



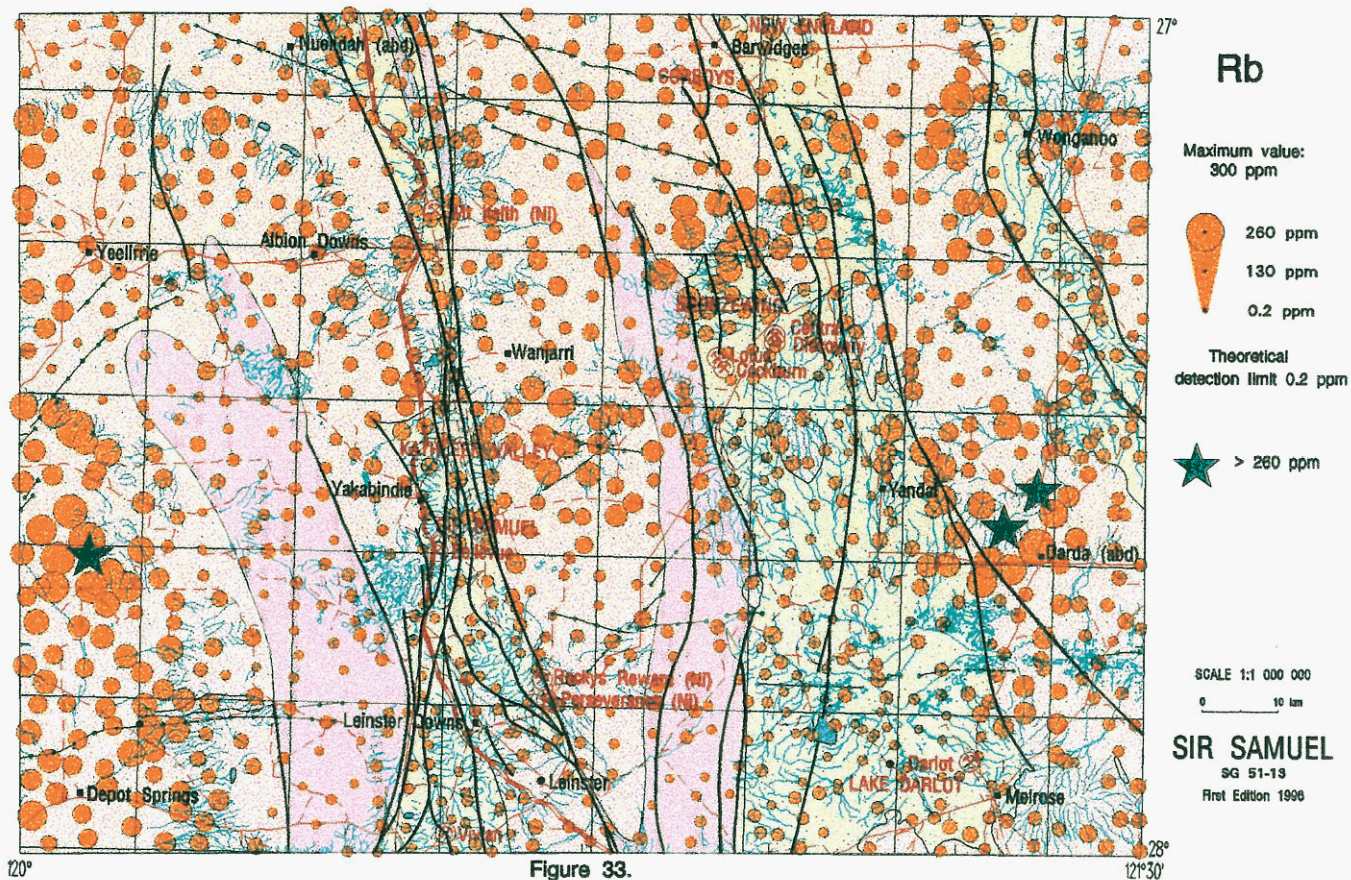


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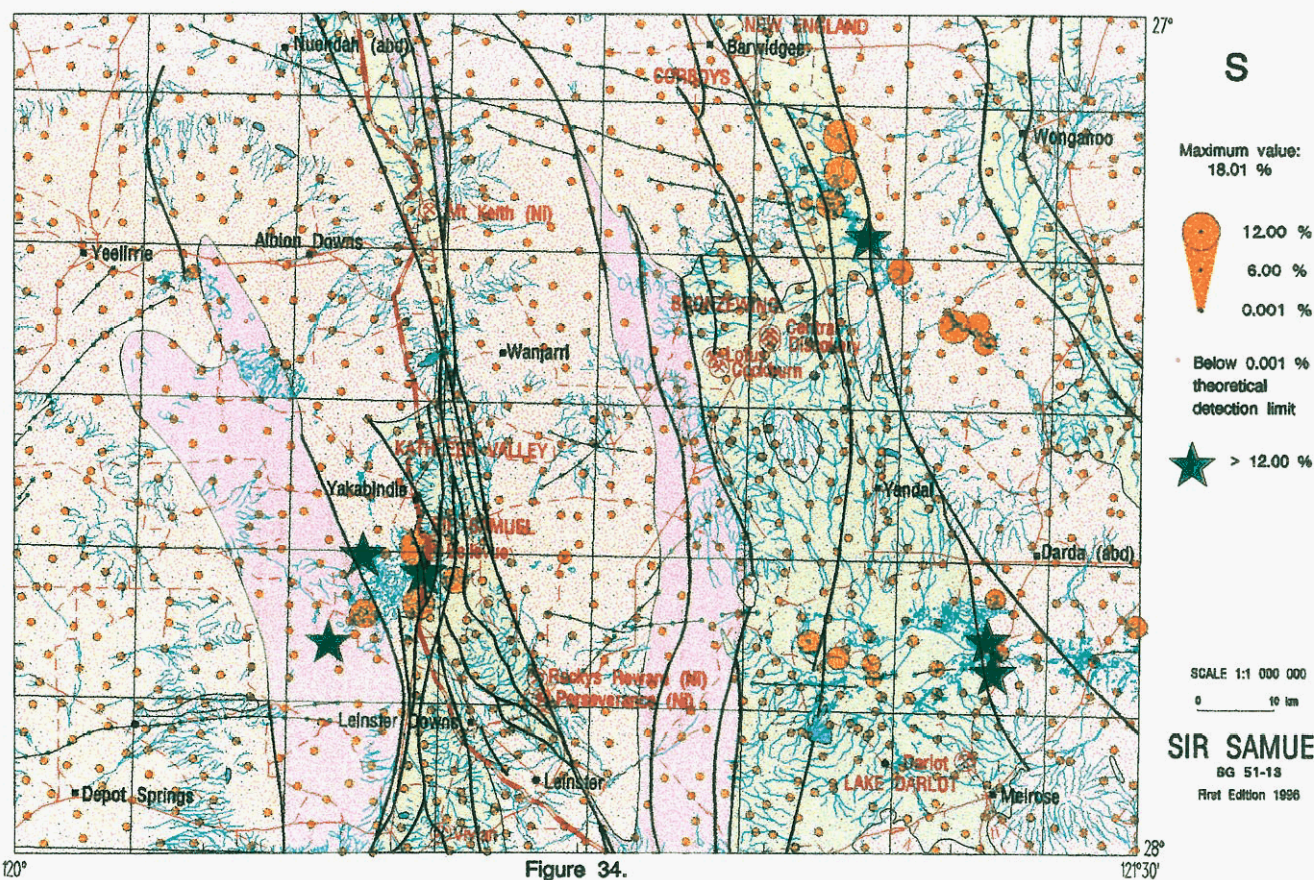
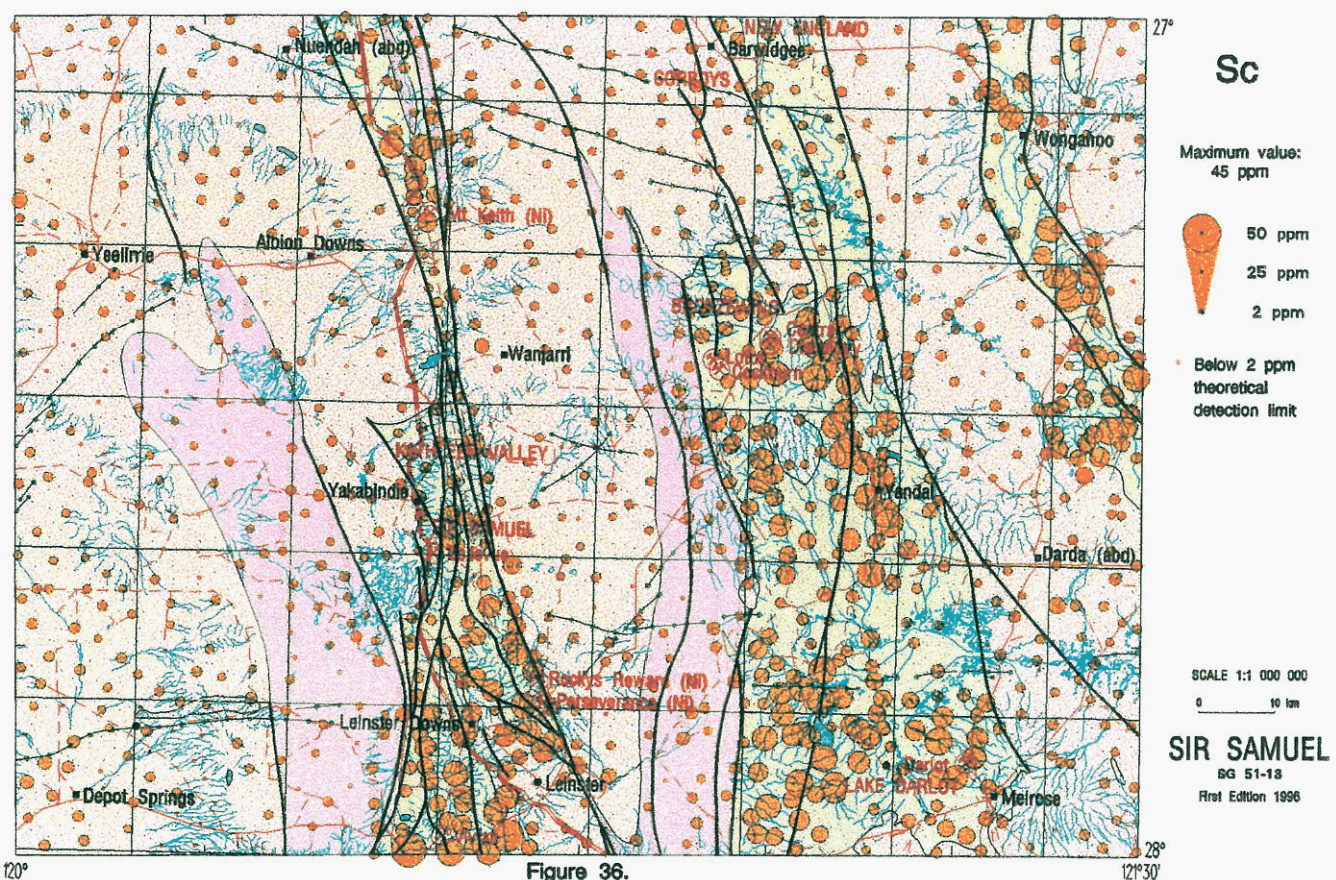
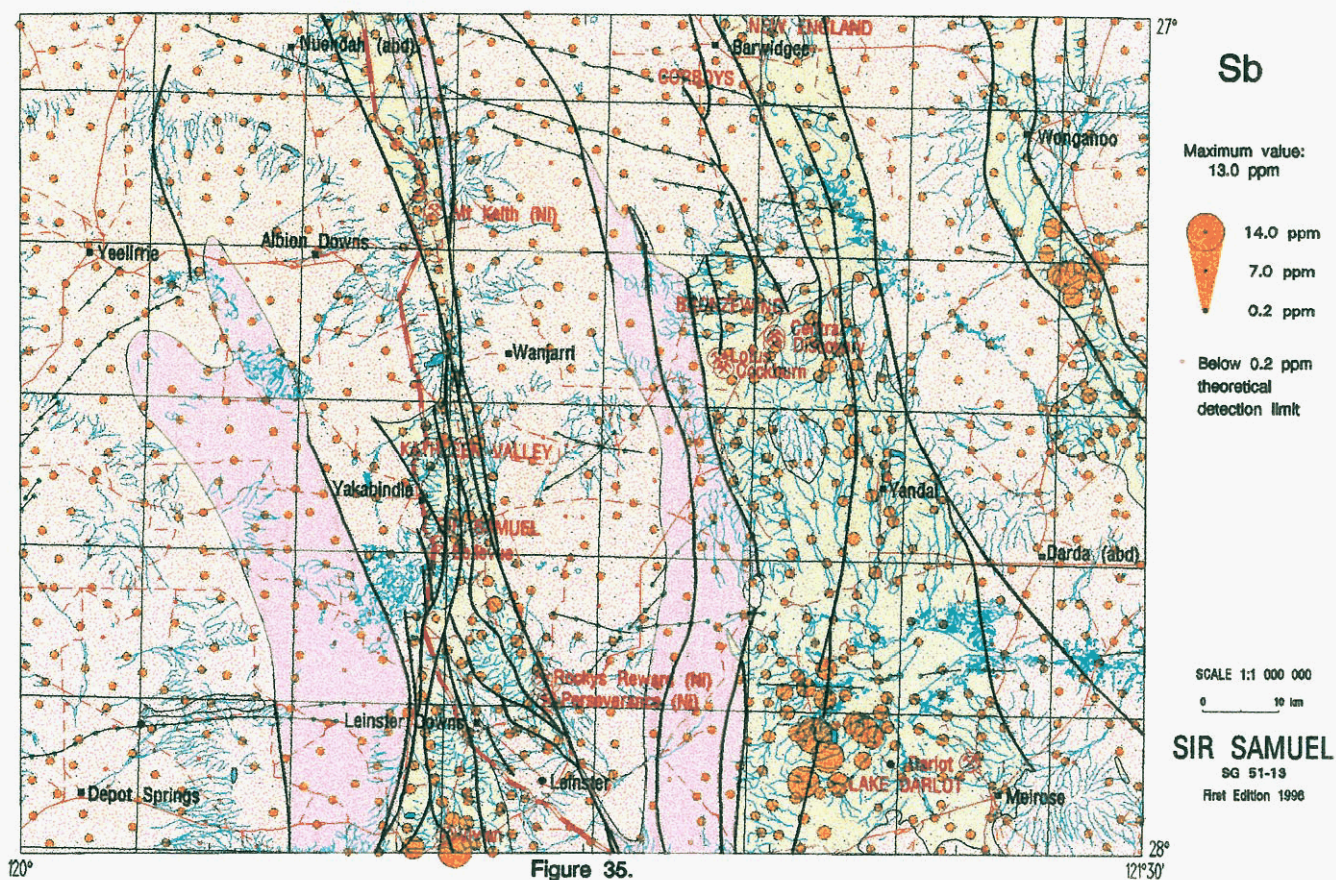


Figure 34.



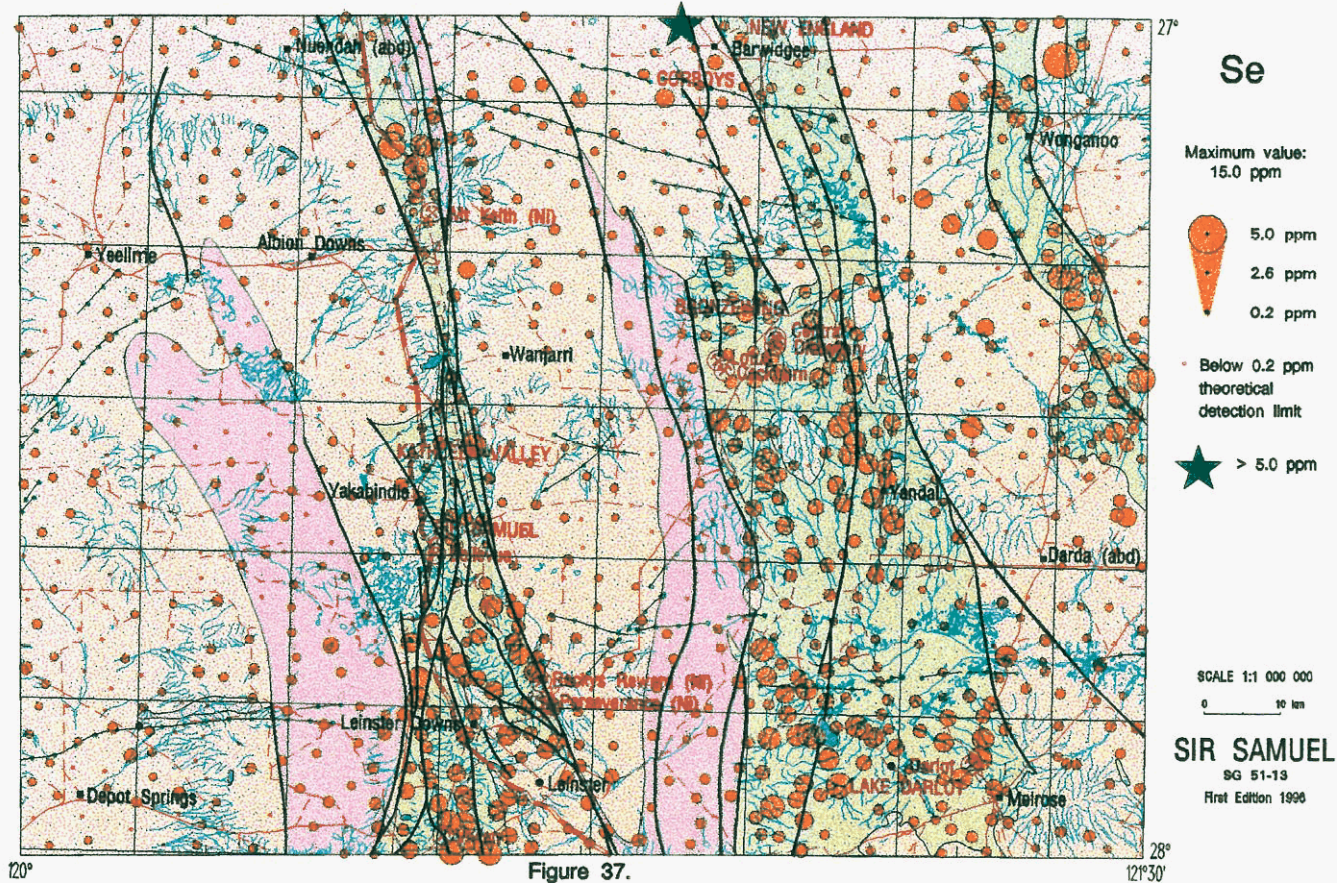


Figure 37.

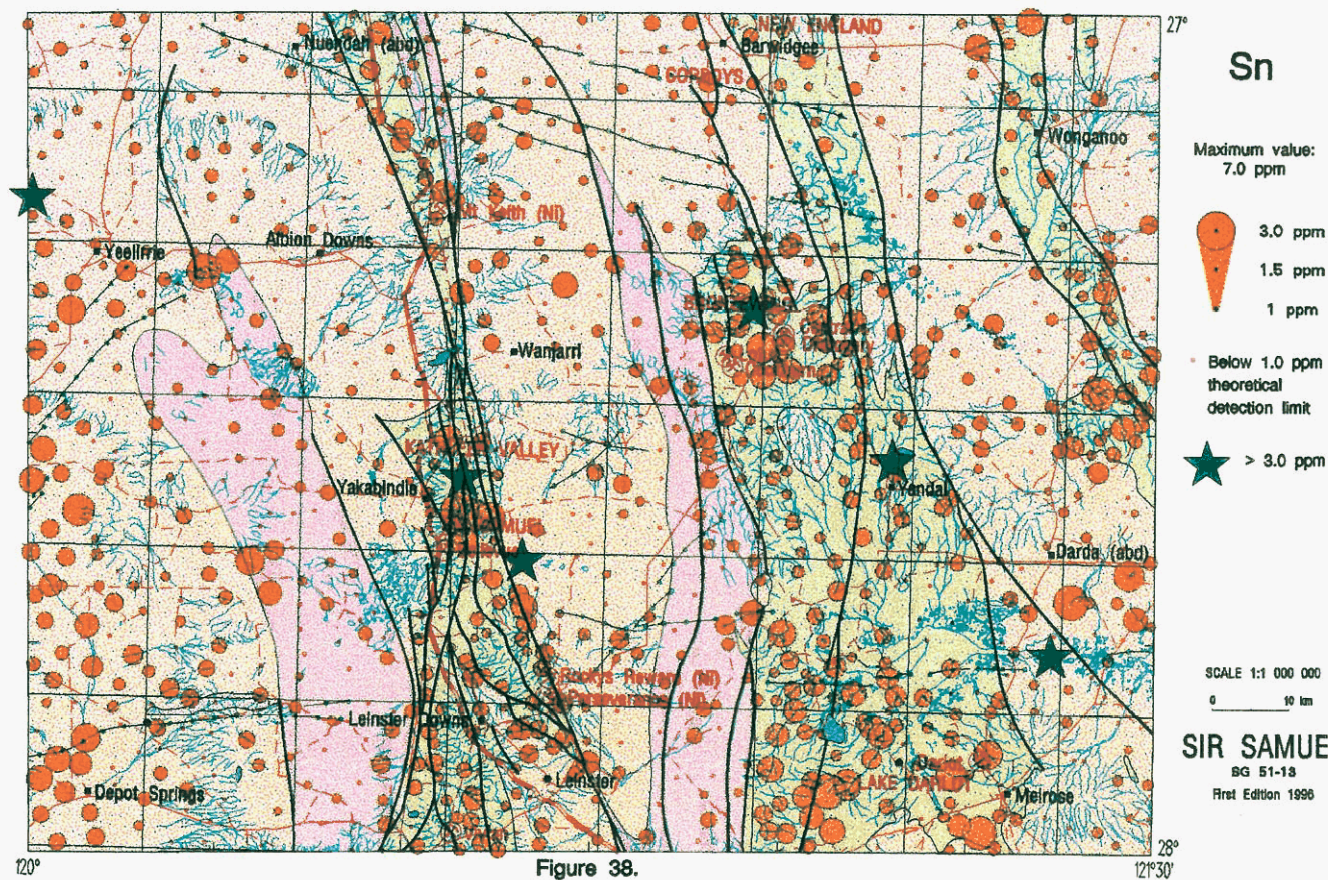
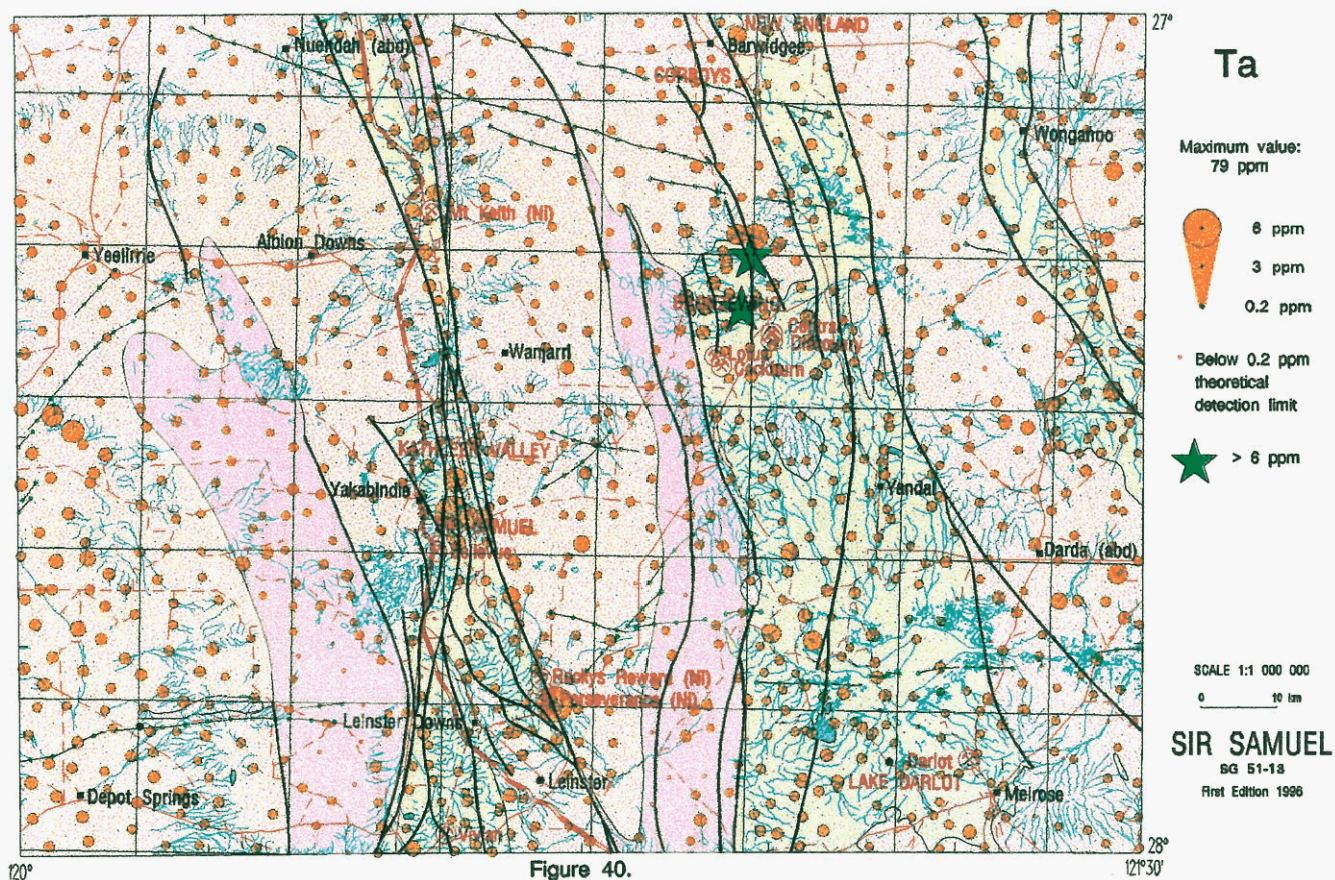
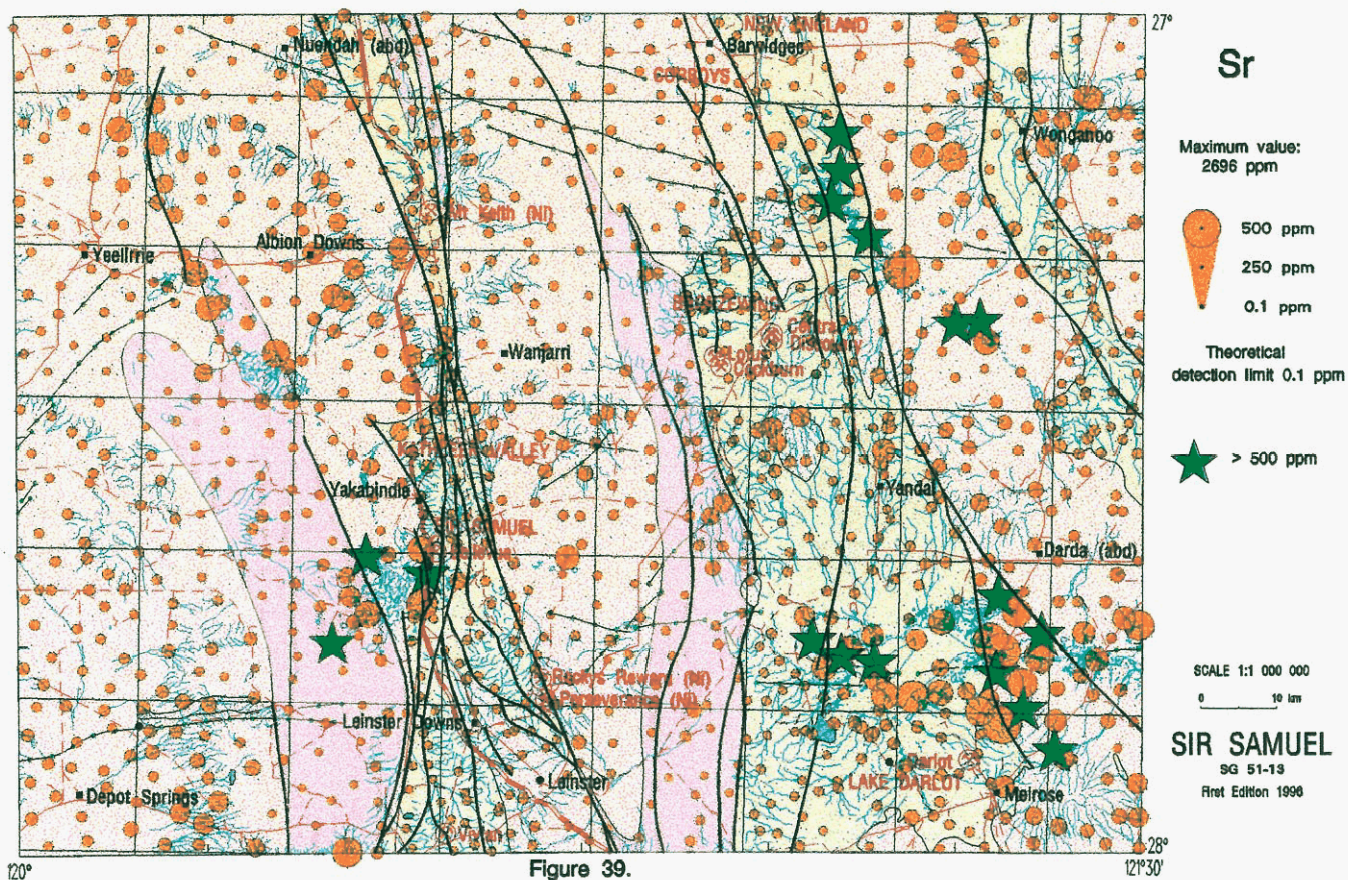
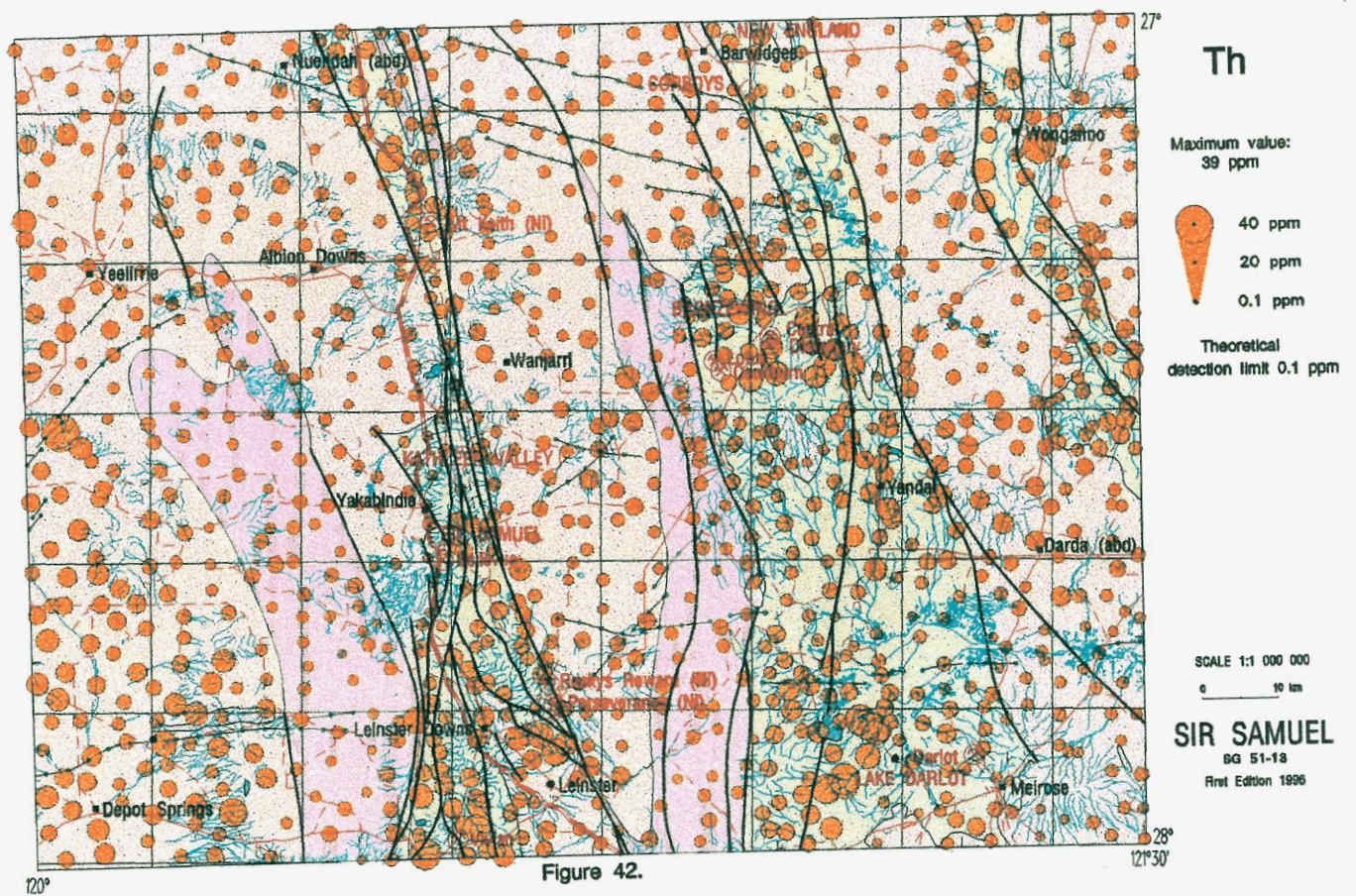
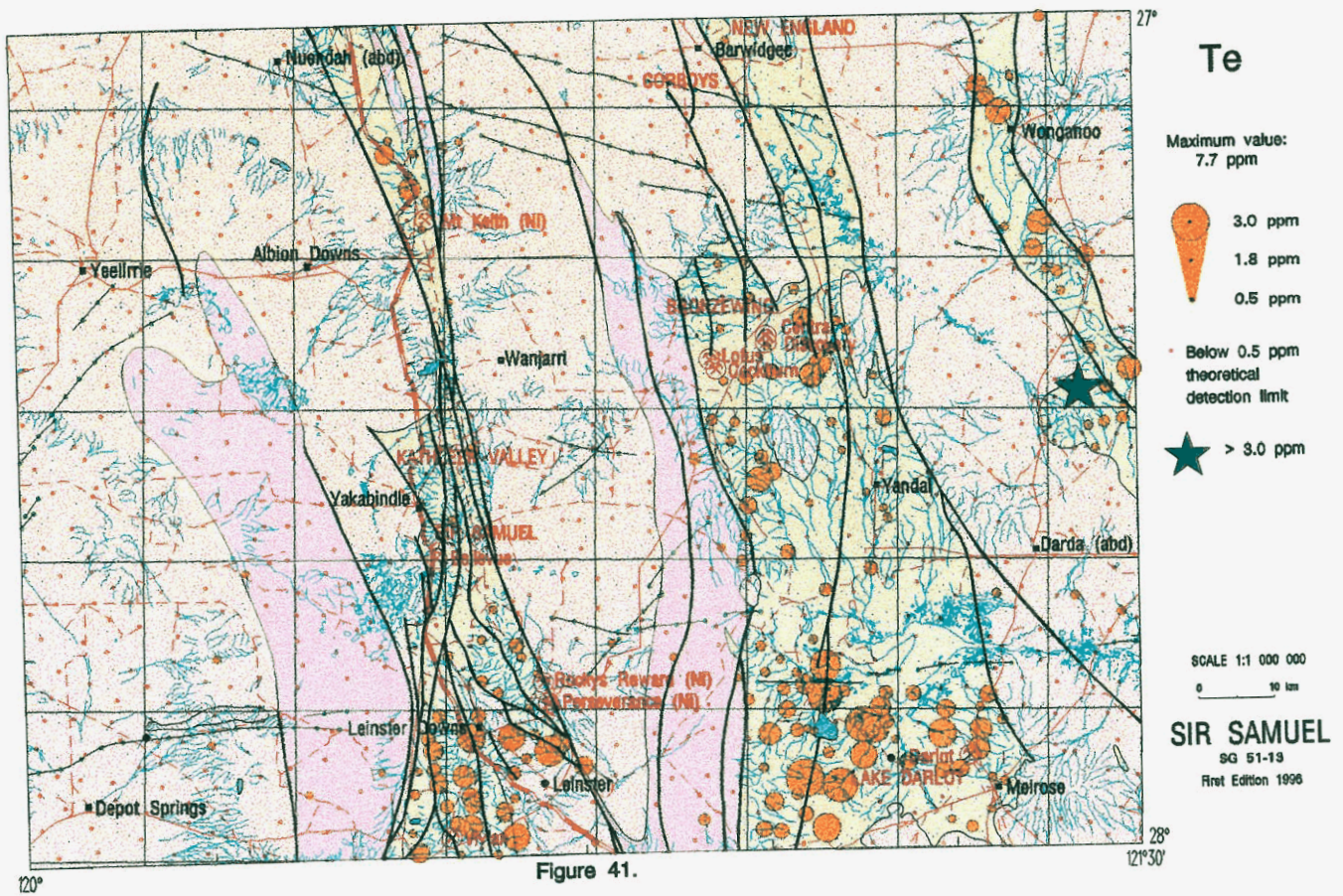
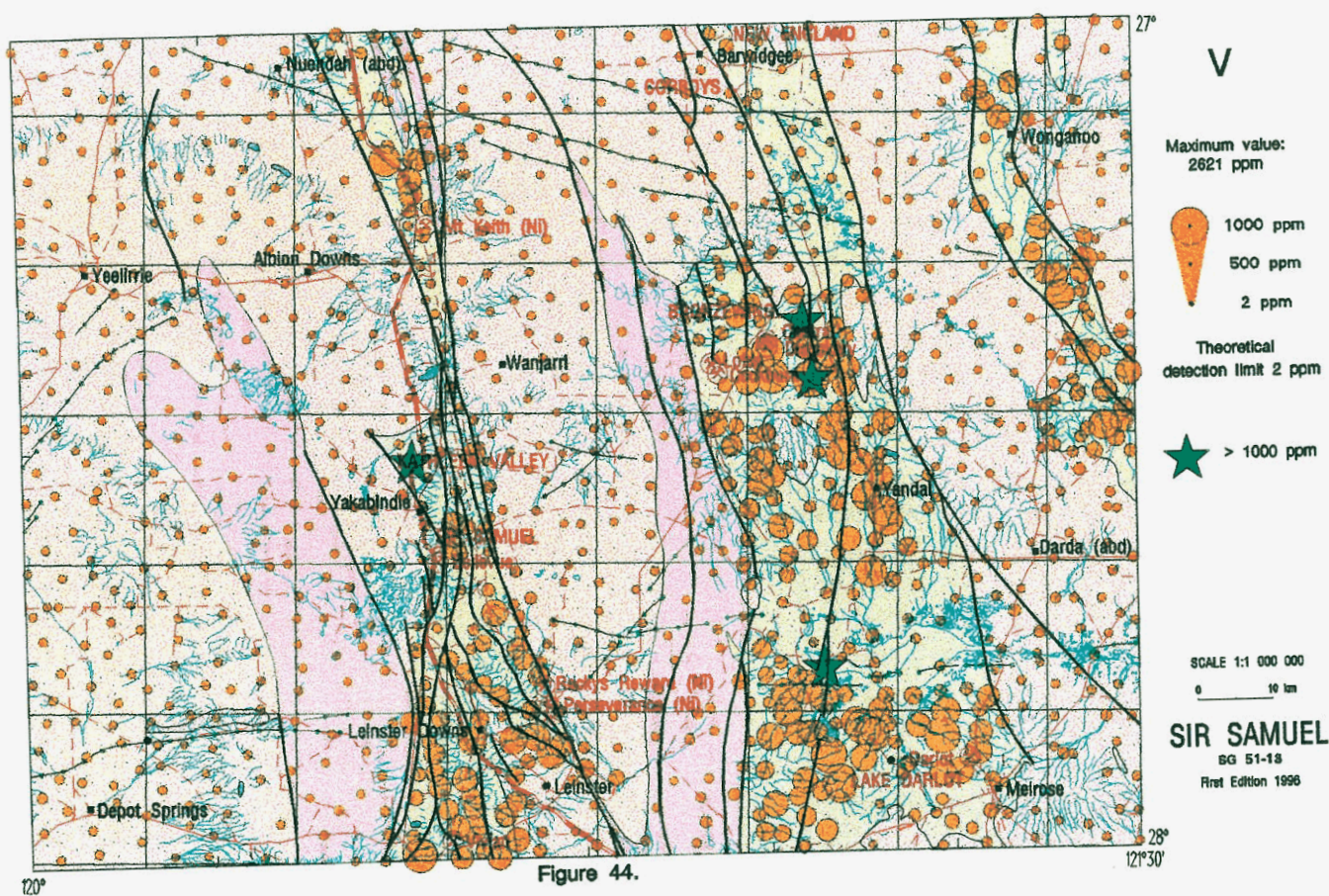
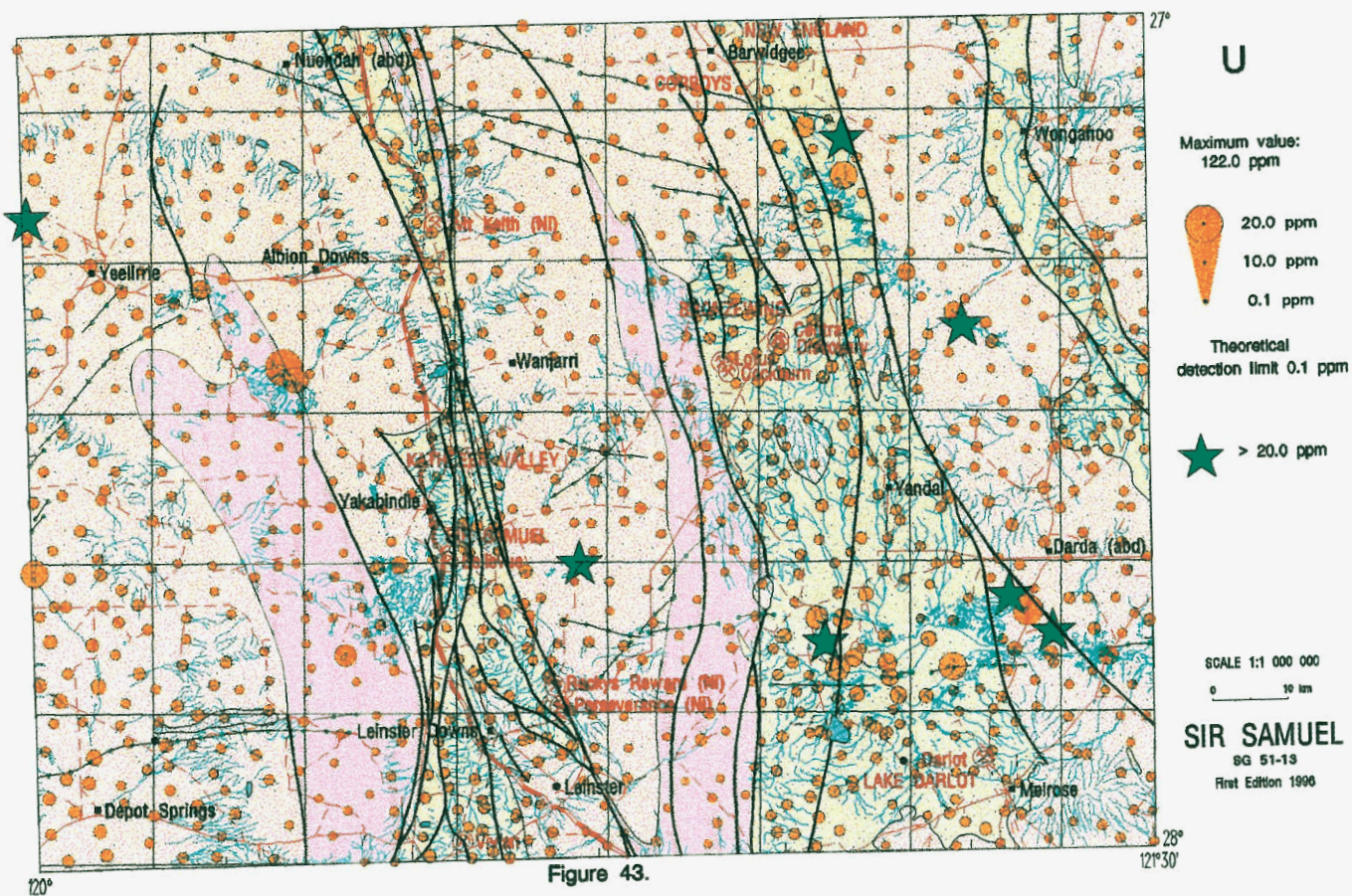
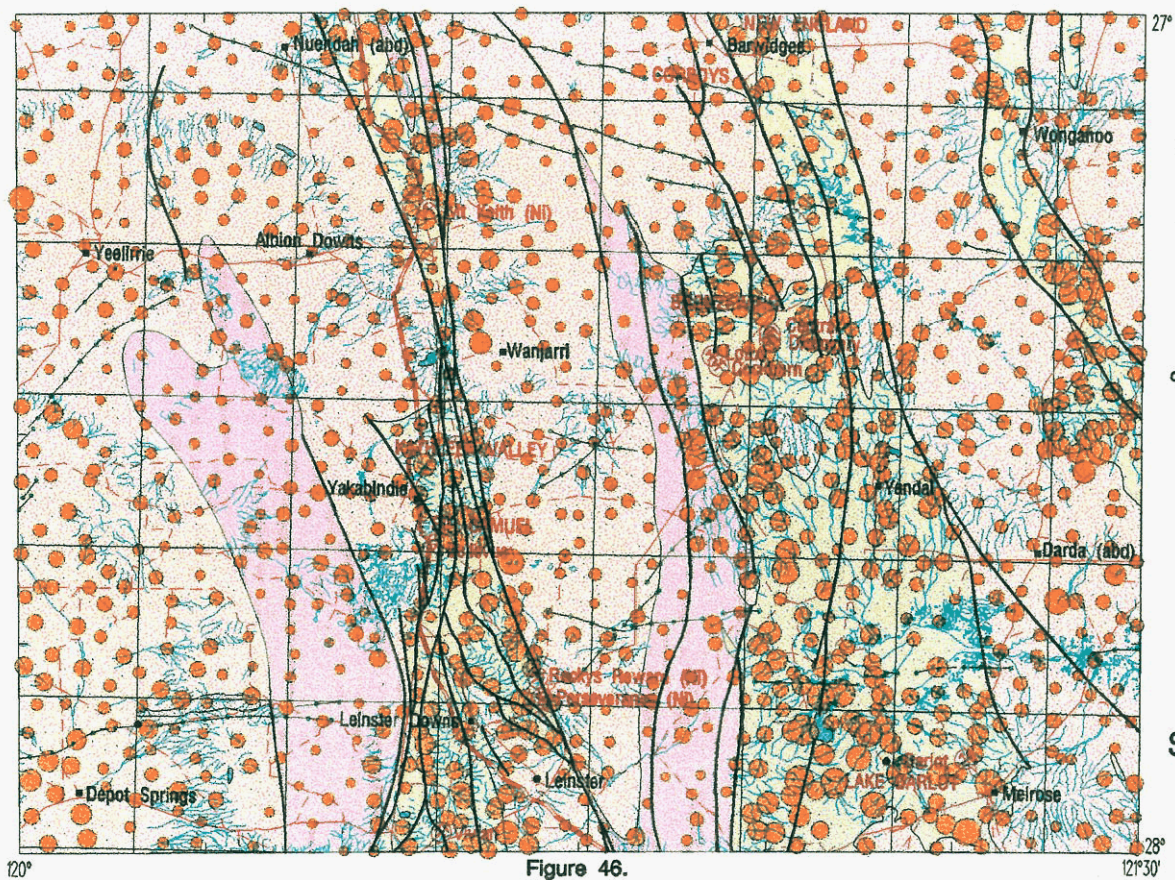
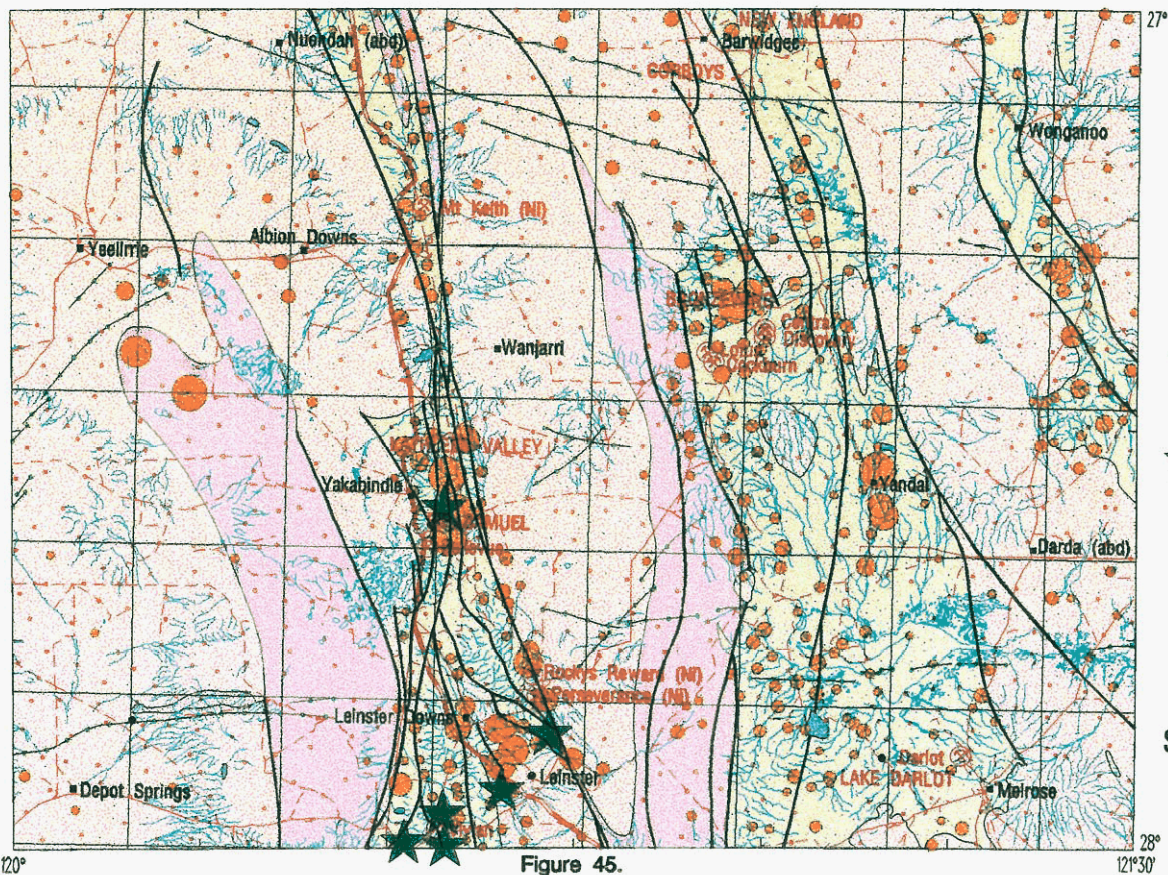


Figure 38.









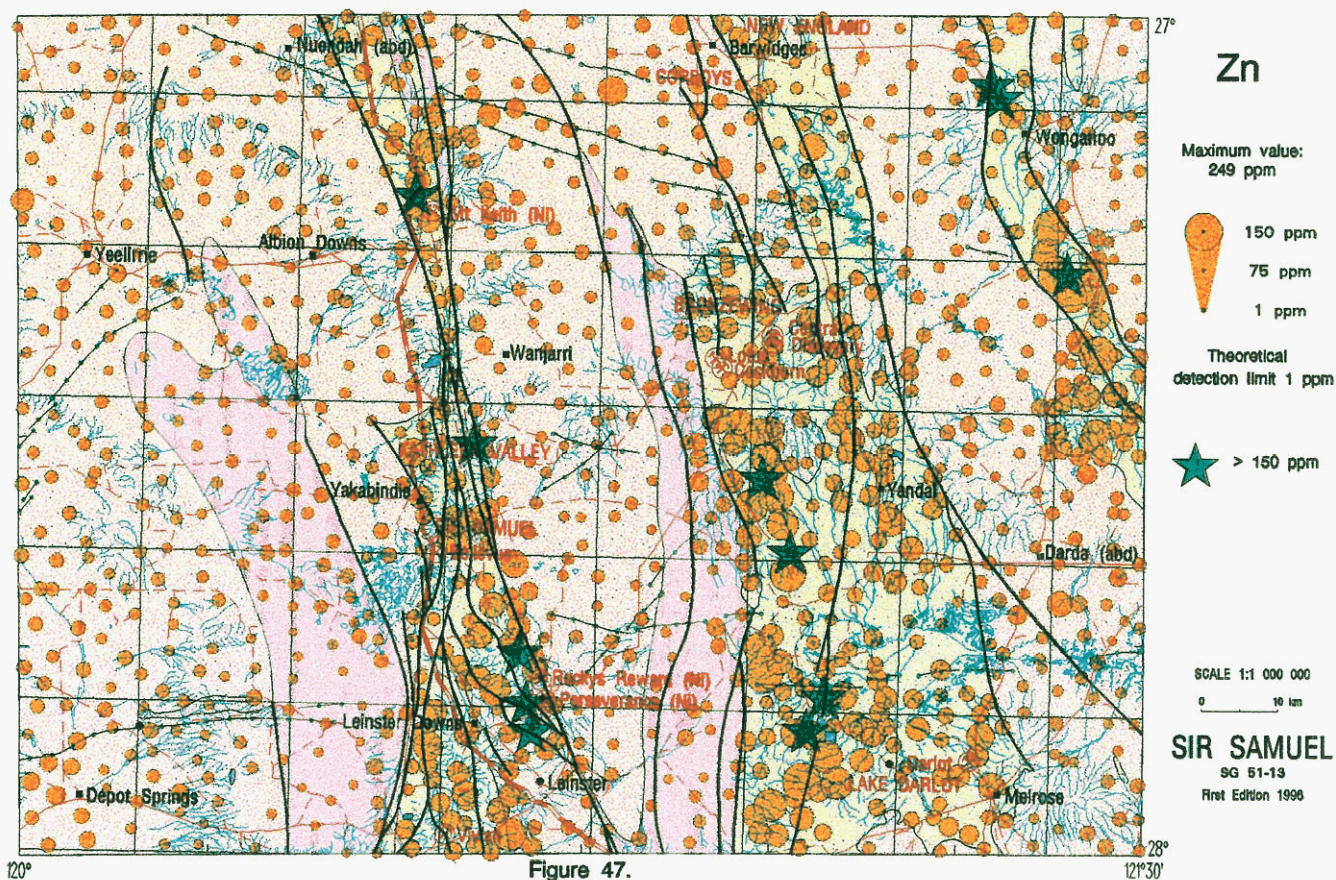


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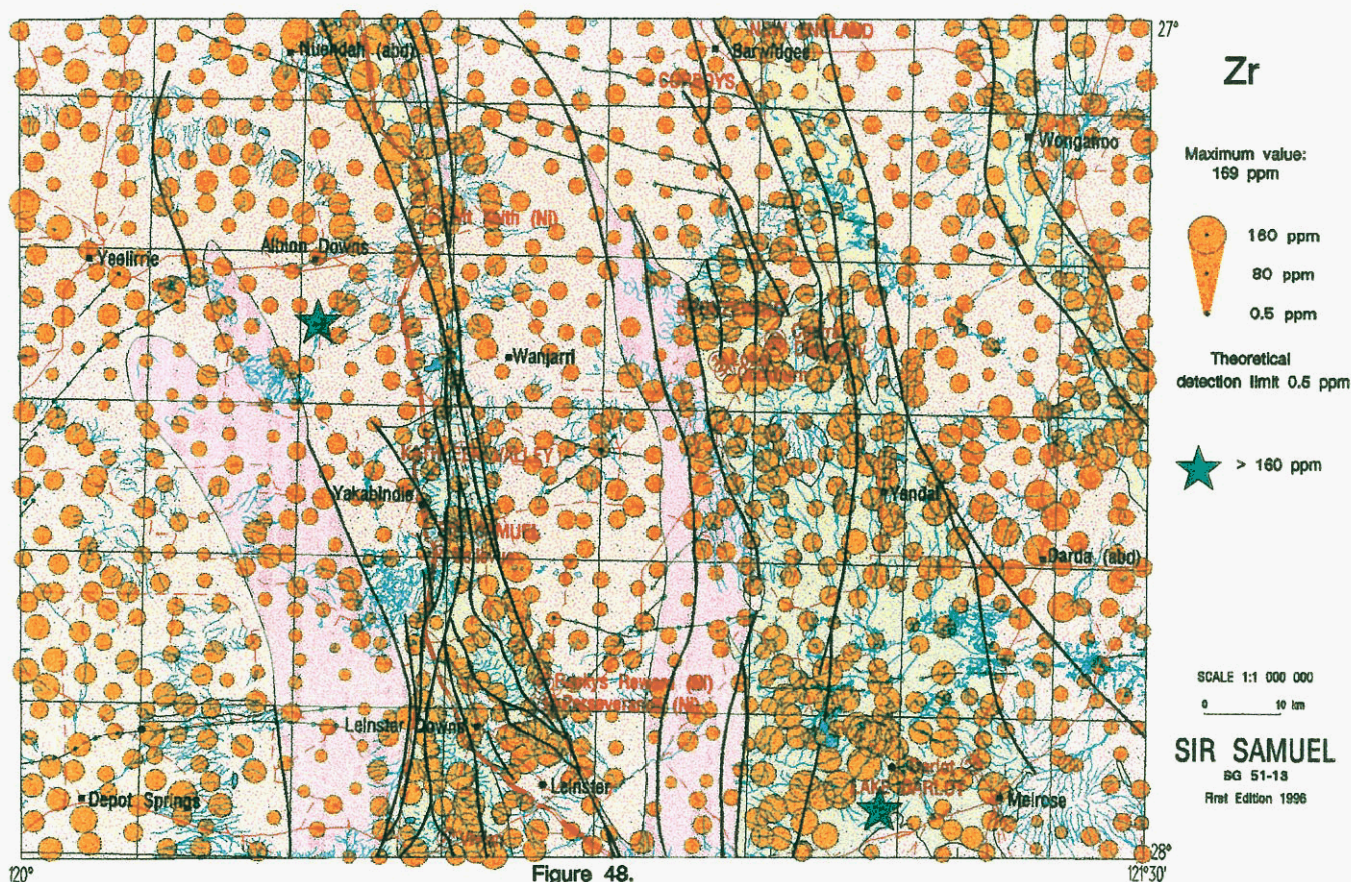


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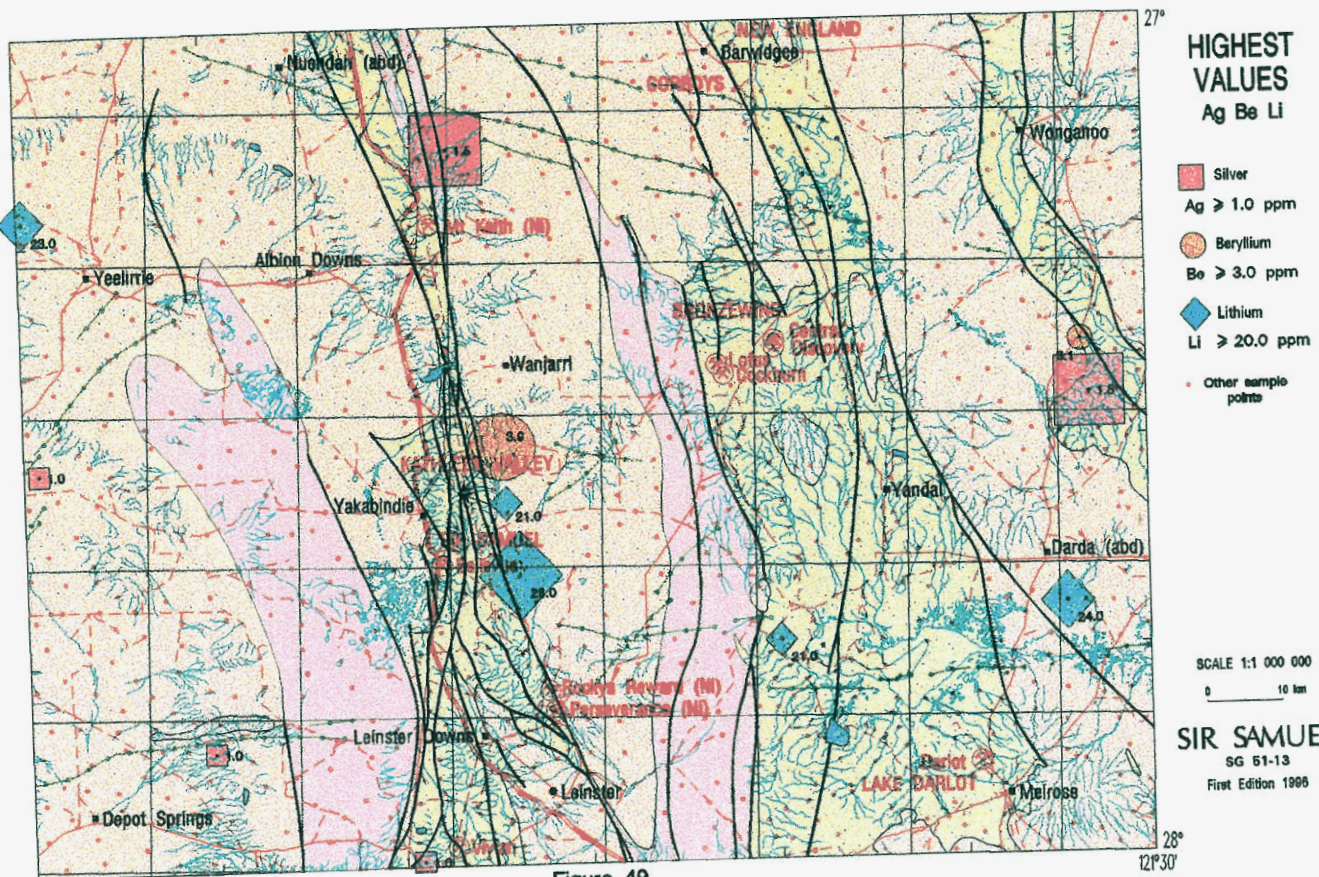
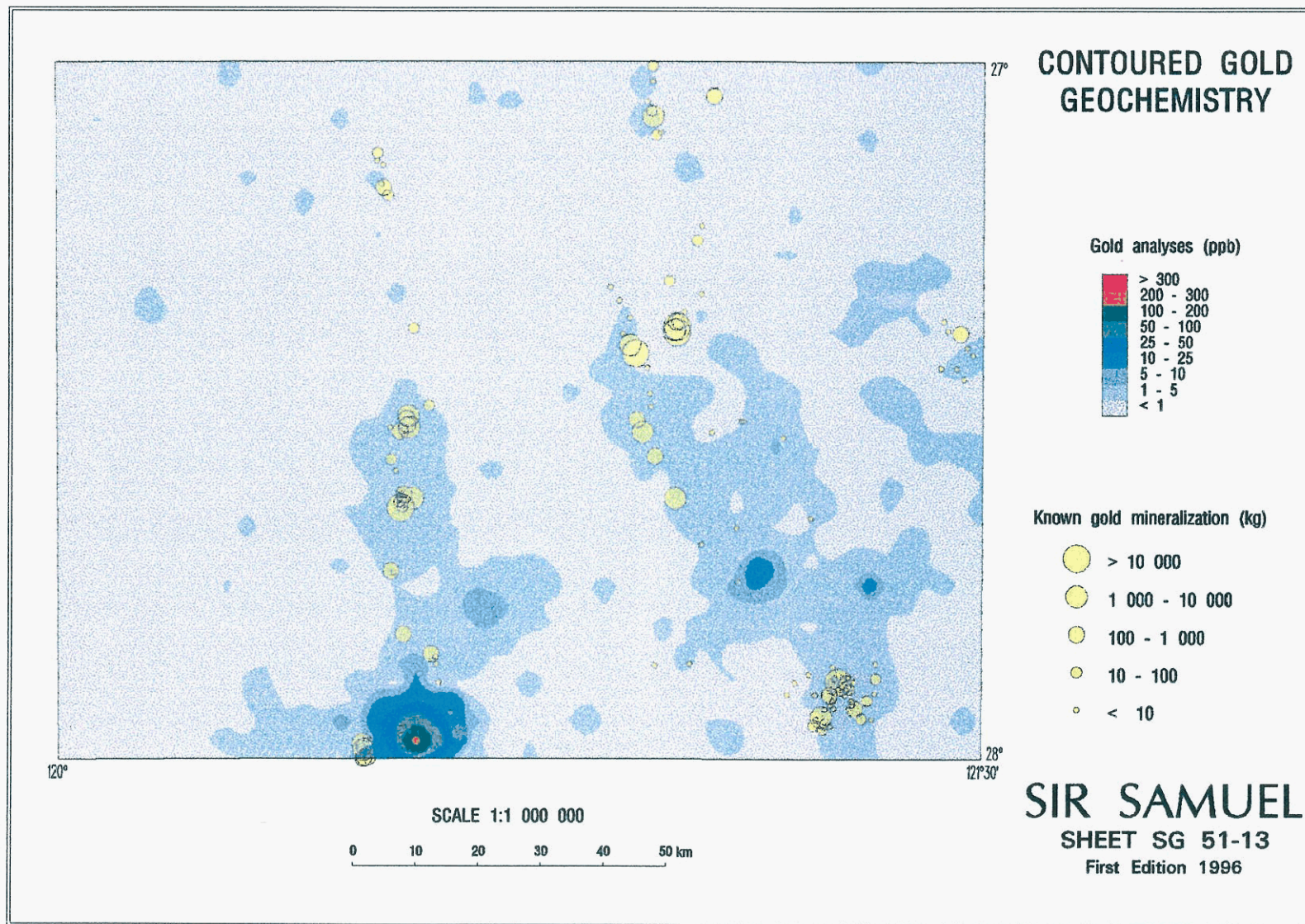


Figure 49.

Figure 50.



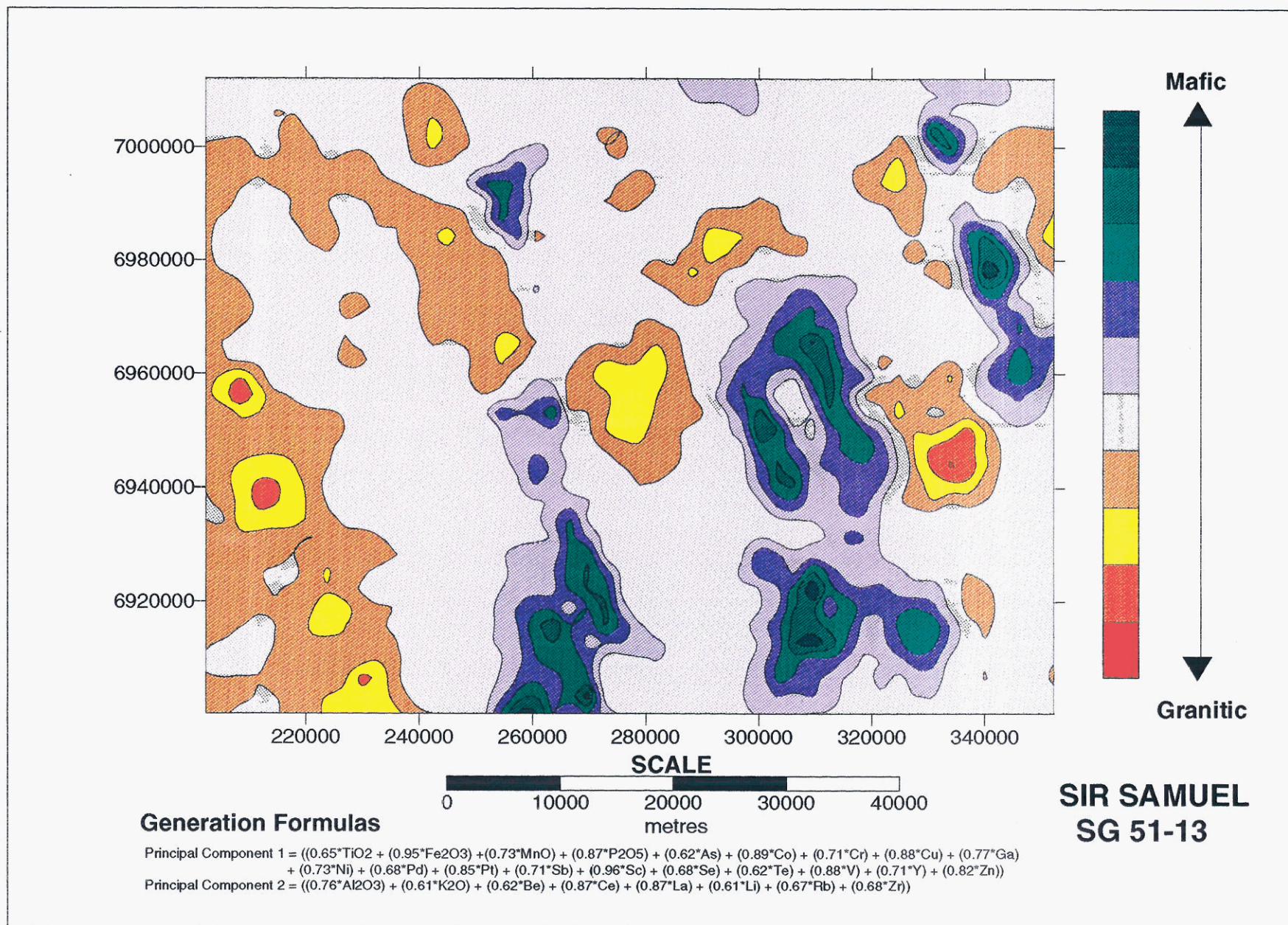


Figure 51. Plot of Principal Component 1 + Principal Component 2

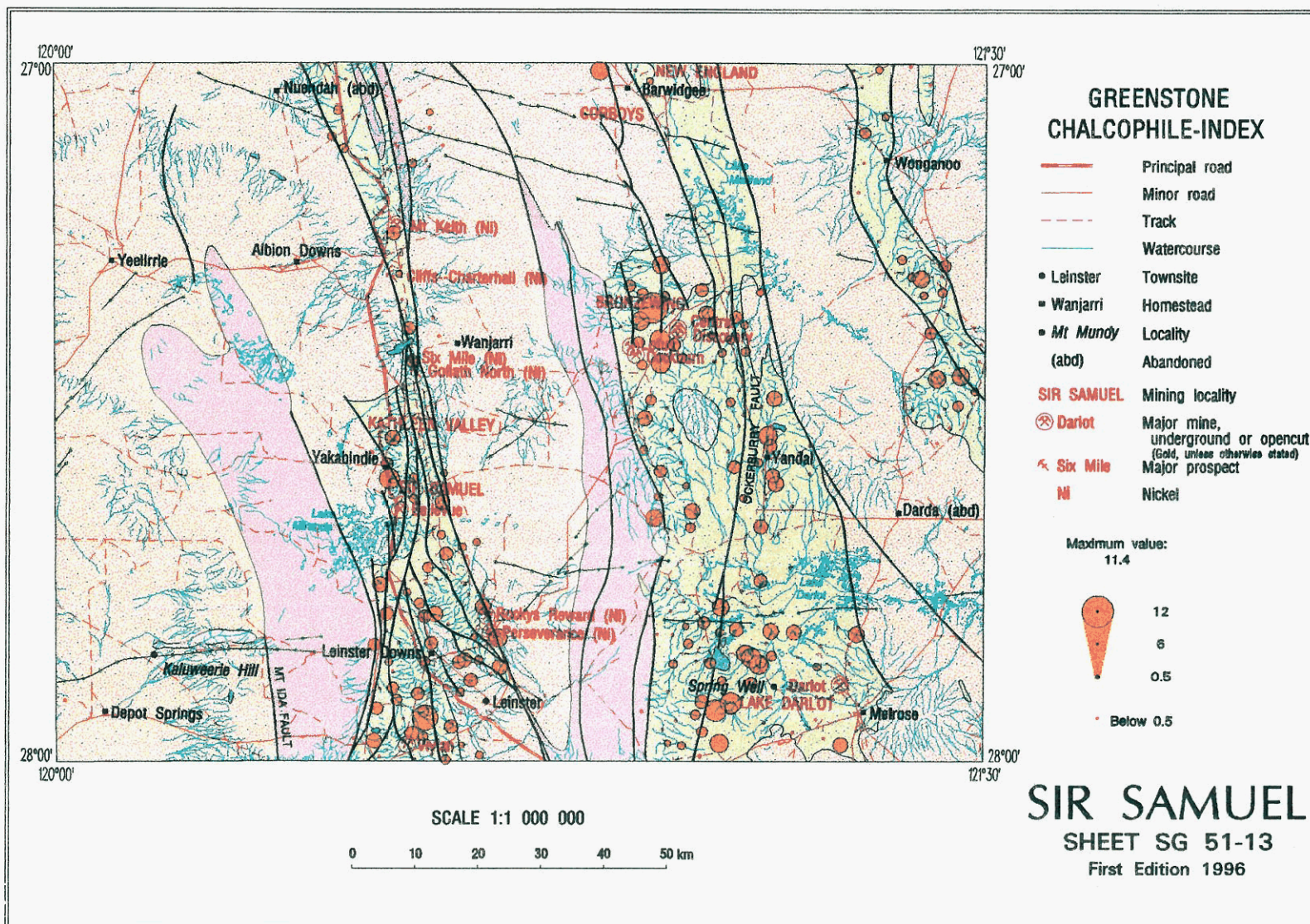
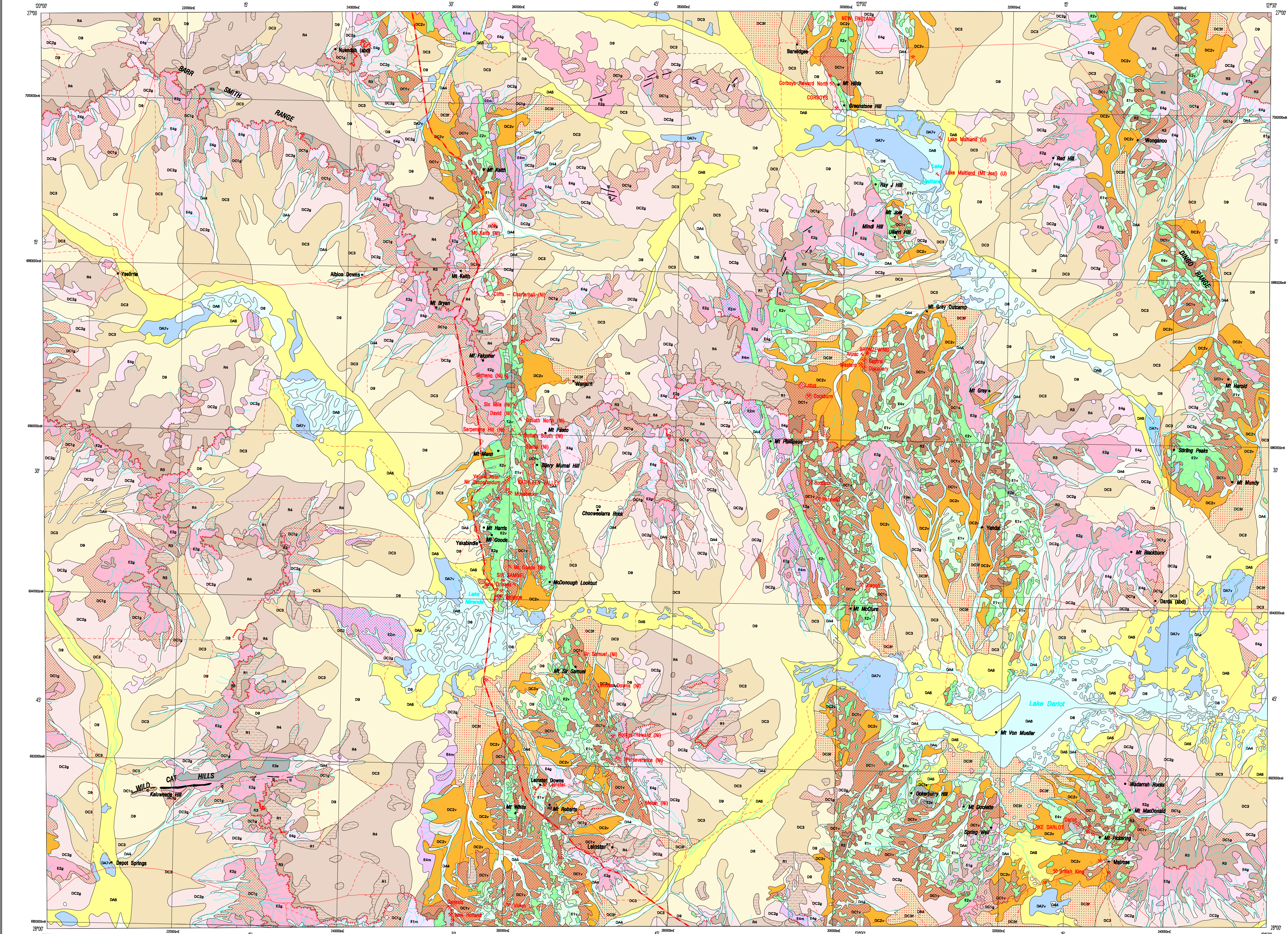


Figure 52.



RELICT REGIME

R1	Ferrous platties and nodules, locally reworked and cemented; derived from granitoid and gneissic rock
R2	Iron-rich duricrust over volcano-sedimentary rock (greenstone)
R3	Siltstone, including silica-cemented R1 material; derived from granitoid and gneissic rock
R4	Quartz-rich sand and silt over R1-R3 material

EROSIONAL REGIME

E1g	Mottled zone and saprolite over poorly exposed granitoid rock
E1m	Mottled zone and saprolite over gneissic rock
E1v	Mottled zone and saprolite over volcano-sedimentary rock (greenstone)
E2g	Outcrop of granitoid saprock and bedrock
E2m	Outcrop of gneissic saprock and bedrock
E2s	Outcrop of sedimentary saprock and bedrock
E2v	Outcrop of volcano-sedimentary saprock and bedrock (greenstone); includes ferrous bedrock
E4g	Lag of locally derived granitoid detritus in sandy or sandy clay matrix; associated with actively eroding outcrops/subcrops
E4m	Lag of locally derived gneissic detritus in sandy or sandy clay matrix; associated with actively eroding outcrops/subcrops
E4v	Lag of locally derived highly ferrous detritus in sandy clay matrix; associated with actively eroding volcano-sedimentary rock (greenstone)

DEPOSITIONAL REGIME

DOMINANTLY COLLUVIAL

DC1g	Prodominantly detritus derived from granitoid rock; most clasts 2-25 mm in sandy or sandy clay matrix; bedrock-rich
DC1q	Medium- to coarse-grained quartz detritus derived from quartz vein
DC1s	Prodominantly medium-grained detritus derived from sedimentary rock; most clasts 2-25 mm in sandy or sandy clay matrix
DC1v	Medium- to coarse-grained detritus derived from volcano-sedimentary rock (greenstone); most clasts > 25 mm and of ferruginous lithic origin in a red sandy clay matrix
DC2g	Fine-grained detritus derived from granitoid rock; most clasts 2-5 mm in a sandy clay matrix
DC2v	Fine- to medium-grained detritus derived from volcano-sedimentary rock (greenstone); most clasts 2-25 mm and of ferruginous lithic origin in a red sandy clay matrix
DC3	Colluvium or sheetwash of sand or clay (with or without bedrock); clasts generally absent
DC3f	Fine-grained colluvium or sheetwash of 2-5 mm ferrous clasts (bedrock grains) in a red clay matrix

DOMINANTLY ALLUVIAL

DA	Gravelly sands and sandy clays of active alluvial channels with ferruginous and variably altered lithic clasts
DAS	Sand- or clay-rich alluvium and colluvium on broad drainage floors; often accompanied by calcrete fragments; includes overbank and terrace alluvium and small non-rolling channels
DAB	Saline or highly gypsiferous playa-like sediments
DA7v	Valley calcrete

DOMINANTLY EOLIAN

D8	Gypsiferous and calcareous sand dunes adjacent to plays lakes
D9	Quartz-rich sand overlying bedrock, colluvium, or alluvium; sandpans

REFERENCE

CBRO (1)	CBRO (2)	AGRO
LT1	R2	NC40
LT2	R1	DS41
BR2	-	DS60
LS4	D9	WR22

SP1, SP4	E3	WR11-14
SP5	E4	
SP1, SP4	E3	WR11-14
SP5	E4	
SP1-5	E3	WR11-14
	E4	
BR2	E3	WR12
BR2	E4	
BR2	E3	WR12
BR2	E4	
BR2	E3	WR12
BR2	E4	
BR1, BR3	SR1	ES-9
SR1		WR12
SS5, SS6	LI1-5	-
SS5, SS6	LI1-5	WR21
SS5, SS6	LI1-5	-
SS5, SS6	LI1-5	WR21
LA1-6	MI1-5	E1
MI1-5		WR21
-	-	-

CS3, CS4	LI1-5	-	SC01, SC04
LI1-5			SC05
LI4	-		SC01
CS3, CS4	LI1-5	-	SC01, SC04
LI1-5			SC05
CS3, CS4	LI1-5	-	SC01, SC04
LI1-5			SC05
CS3, CS4	LI1-5	-	SC04
LI1-5			SC05
CS1-4	LI1-5	-	SC04
LI1-5			SC05
AS3	CS1-4	D2	SC06
AS2, CS1-2	MI1-2	D2	SC06
MI1-2			SC06
LS1-5	D1		SA01
AS1-4	D5		SA02
AS3	AS4	D6	EV01, EV02
SL00			
-	-	-	DS60
ES1	D7		EV02
SD00			
ES1-2	D9		SD01

CBRO (1) regolith codes: R.S. Aspell et al., 1988
CBRO (2) regolith codes: R.S. Aspell et al., 1988
AGRO regolith codes: C. Pels et al., 1991

SYMBOLS

Regolith boundary	—	Abandoned	—
Principal road	—	Mining locality	—
Minor road	—	Major mine	—
Track	—	Minor mine	—
Breakaway	—	Prospect	—
Watercourse, ephemeral	—	Nickel	—
Townsite	—	Uranium	—
Homestead	—	Mining area, made ground	—
Locality	—		

GEOLOGICAL INTERPRETATION

Permian	Sedimentary rock
Proterozoic	Sedimentary rock
Archaean	Granitoid rock
	Granitoid gneiss and foliated gneiss; minor amphibolite
	Metamorphosed igneous and sedimentary rocks (greenstone)
	Proterozoic mafic dyke
	Major fault or shear

Geological Interpretation by S. Wyche and T. J. Griffin (1995) and S. Wyche (1996), after Bunting and Williams (1979), Liu et al. (1996), and Wyche and Westaway (1996)

SHEET INDEX

GLENGARRY SG 50-12	WILUNA SG 51-9	KINGSTON SG 51-10
SANDSTONE SG 50-16	SIR SAMUEL SG 51-13	DUKETON SG 51-14
YUAMMI SH 50-4	LEONORA SH 51-1	LAVERTON SH 51-2

Edited by: C. Strong and G. Loan

Cartography by: G. Jose and D. Ladbroke

Topography from Australian Surveying and Land Information Group Sheet SG 51-13 and roads modified from geological field survey (1985)

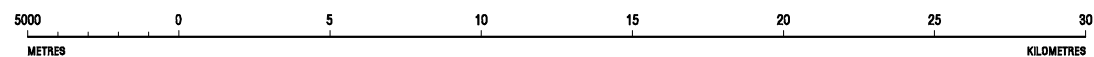
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MINISTER FOR MINES
K.A. PERRY, DIRECTOR GENERAL

SCALE 1:250 000



TRANSVERSE MERCATOR PROJECTION

Grid lines indicate 20 000 metre interval of the Australian Map Grid Zone 51



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DIRECTOR, GEOLOGICAL SURVEY
OF WESTERN AUSTRALIA

Compiled by: C.J. Kojan and A.J. Sanders (GSWA)

Field observations by: C.J. Kojan, J.J. Bradley (GSWA), R. Blackmore, B. McCrow, P. Penna, E. Spertall and G. Tolland (Geochemex Australia) 1995

The recommended reference for this map is: KOJAN, C.J., SANDERS, A.J., 1996, Sir Samuel, W.A.: Western Australia Geological Survey, 1:250 000 Regolith Materials Series, Plate 1

REGOLITH MATERIALS SERIES

SIR SAMUEL

SHEET SG 51-13

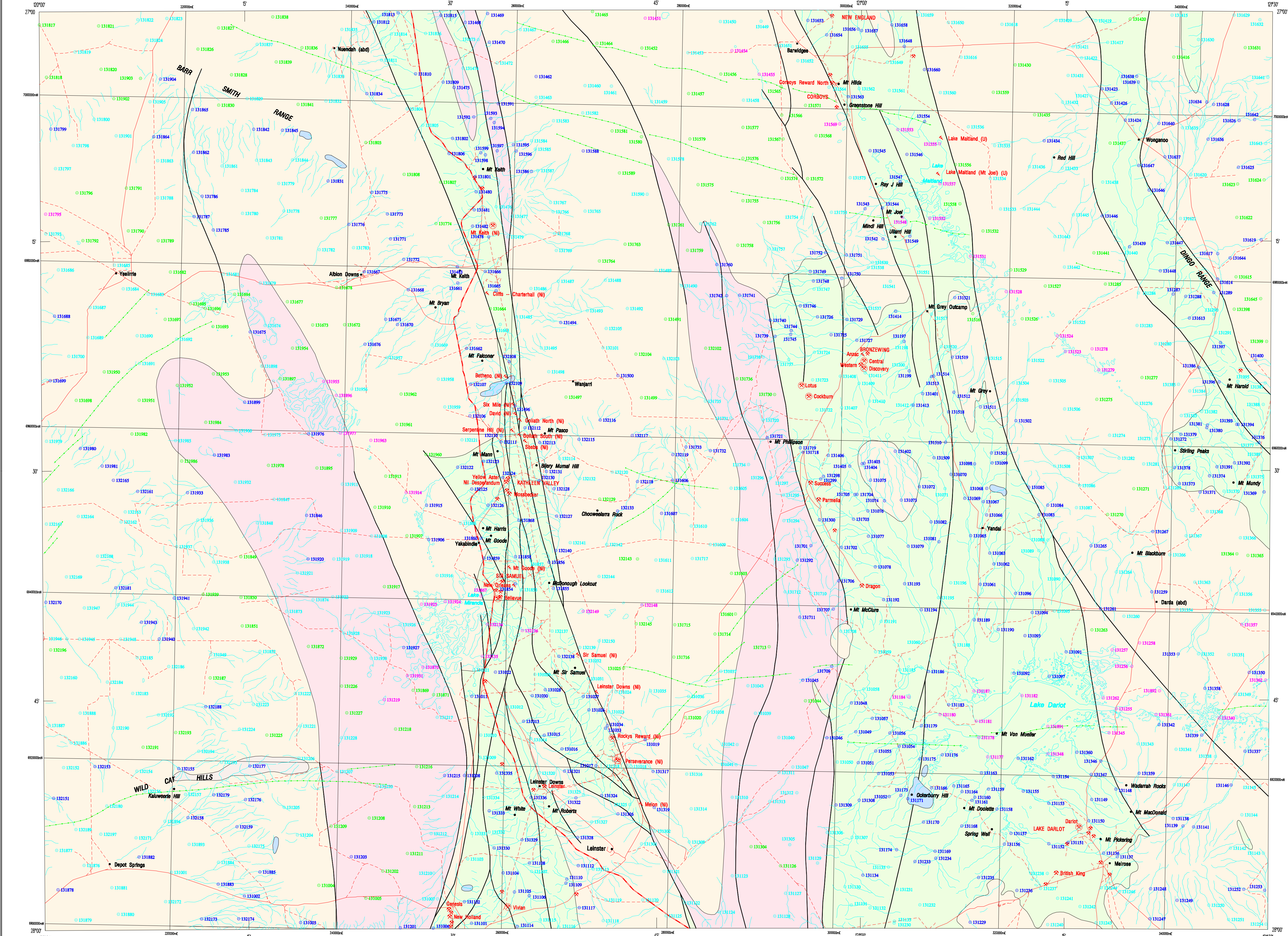
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GLENGARRY SG 50-12	WILUNA SG 51-9	KINGSTON SG 51-10
SANDSTONE SG 50-16	SIR SAMUEL SG 51-13	DUKETON SG 51-14
YUAMMI SH 50-4	LEONORA SH 51-1	LAVERTON SH 51-2

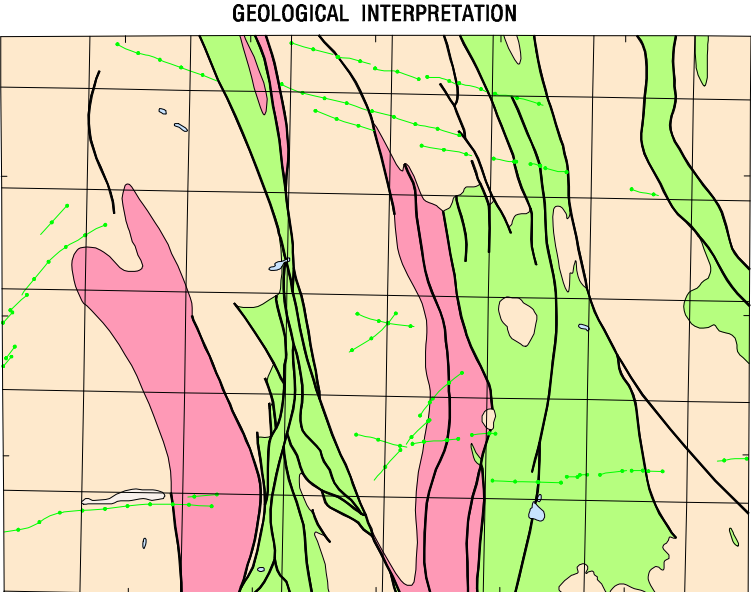
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SAMPLE LOCATIONS

- Sample point references

 - 131222 Lake sample
 - 131222 Stream sample
 - 131222 Soil sample
 - 131222 Sheetwash sample
- Principal road
 - Minor road
 - Track
 - Watercourse and lake boundaries
 - Leinster Townsite
 - Wanjarri Homestead
 - Mt Mundy Locality
 - (abd) Abandoned
 - SIR SAMUEL Mining locality
 - Darlot Major mine, underground or opencut (cont. unless otherwise indicated)
 - Success Mine
 - Minor mine
 - Six Mile Prospect
 - Ni Nickel
 - U Uranium



Geological interpretation by S. Wyche and T. J. Griffin (1995) and S. Wyche (1996), after Bunting and Williams (1979), Liu et al. (1996), and Wyche and Westaway (1996)



SHEET INDEX		
GLENGARRY SG 50-12	WILUNA SG 51-9	KINGSTON SG 51-10
SANDSTONE SG 50-16	SIR SAMUEL SG 51-13	DUKETON SG 51-14
YUWANMI SH 50-4	LEONORA SH 51-1	LAVERTON SH 51-2

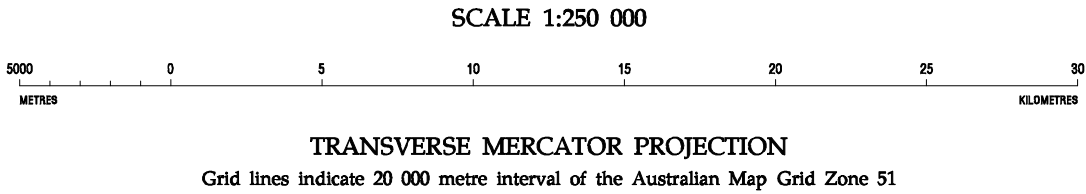
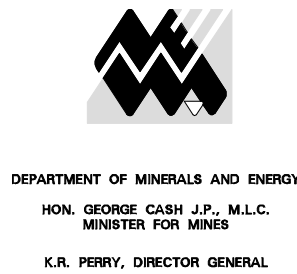
SAMPLE LOCATIONS

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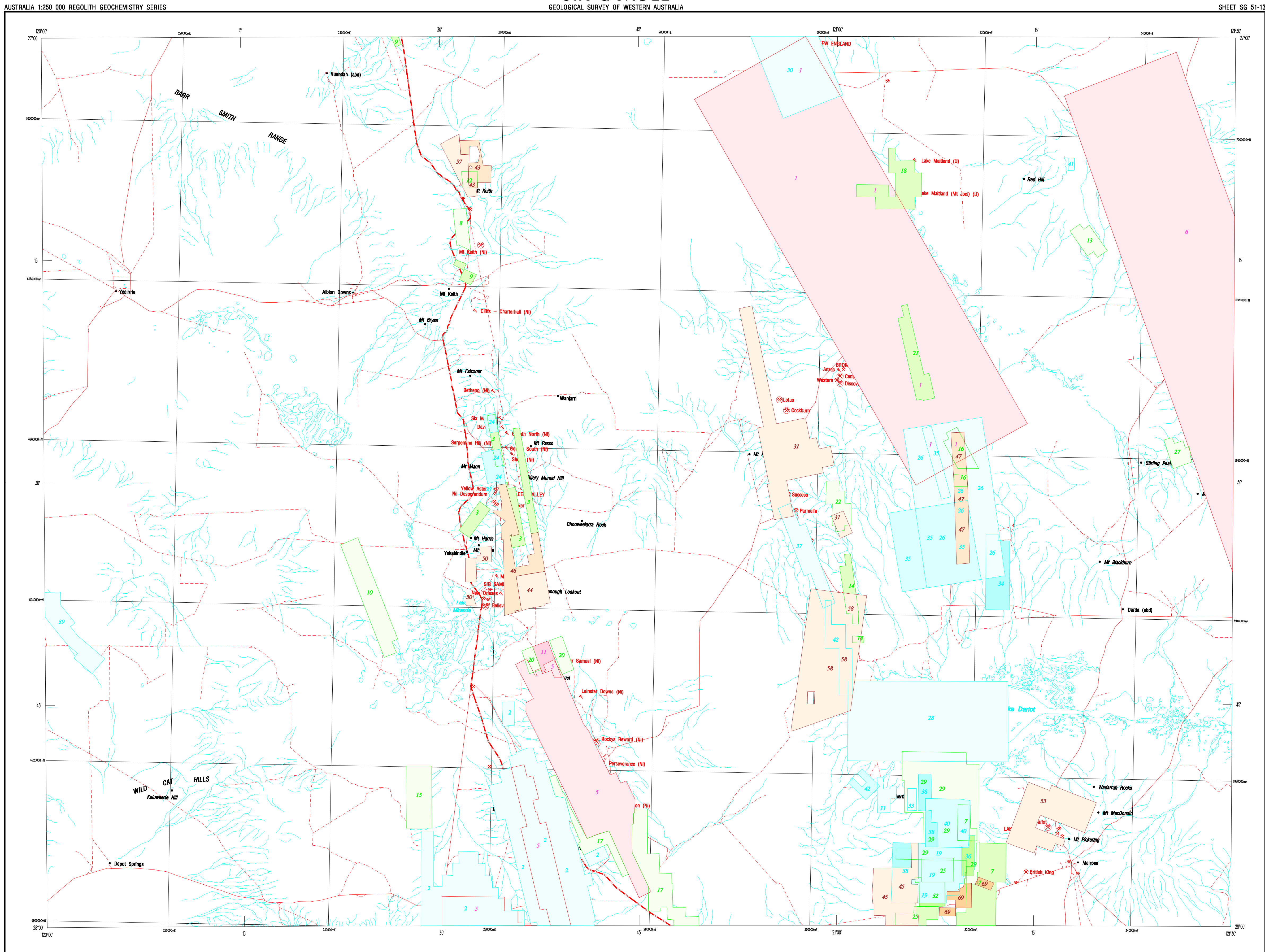
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Cartography by: G. Jose
Topography from Australian Surveying and Land Information Group Sheet SG 51-13 and roads modified from geological field survey (1985)
This map was compiled digitally from the geochemical database held by Geological Survey Western Australia and stored in the ORACLE database management system; compiled and produced using a Geographic Information System, Arc/INFO
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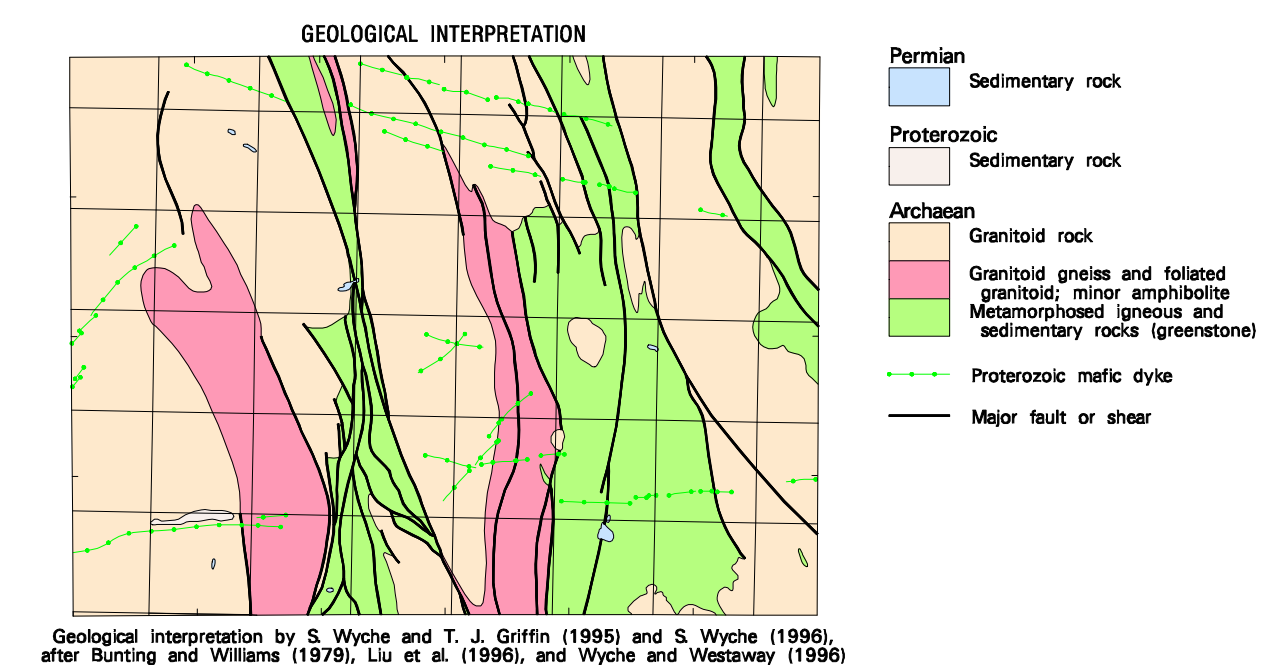
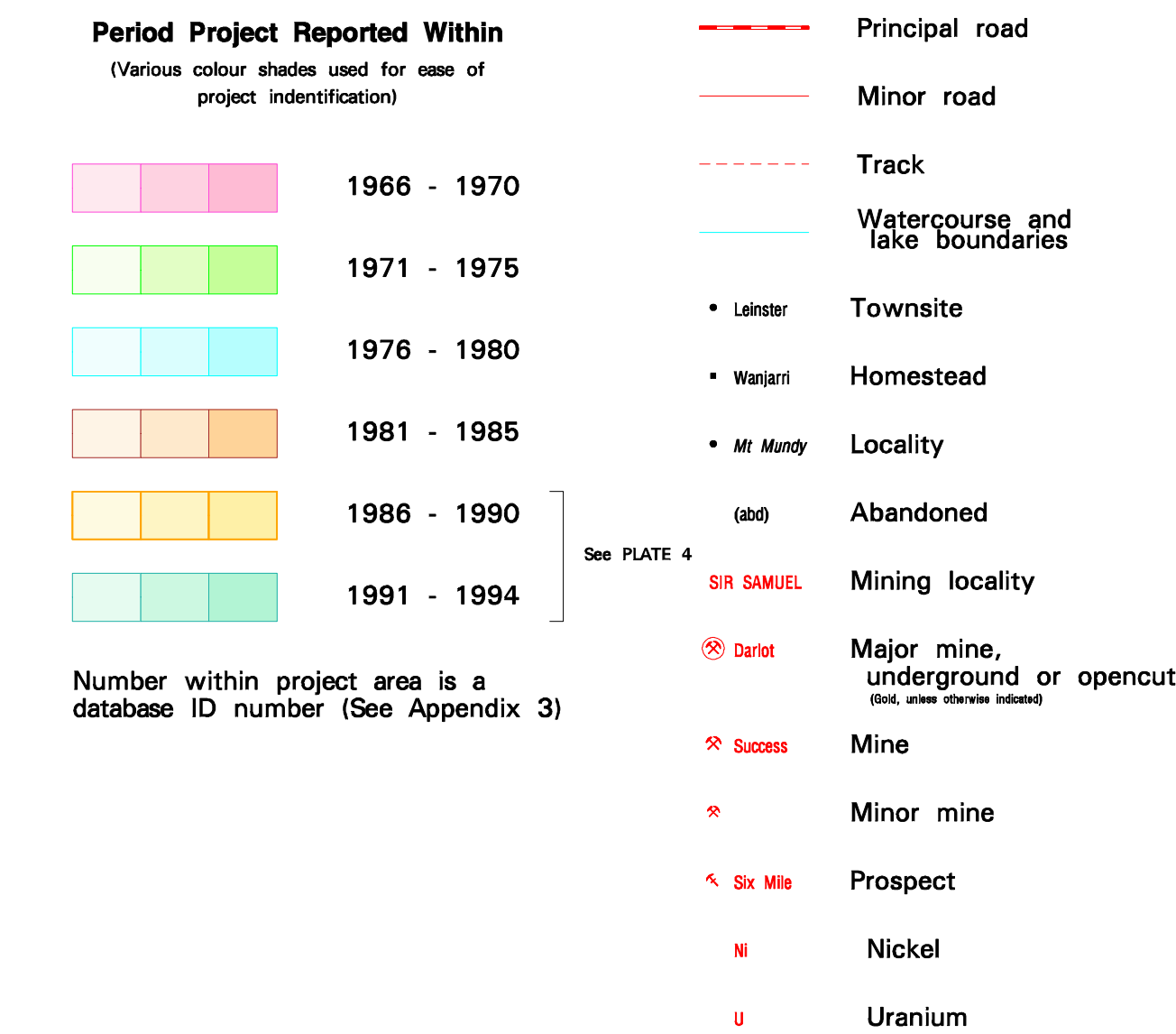
Sampling by: C. J. KOJAN, (GSWA) with assistance from J.J. Bradley (GSWA), R. Blackmore, B. McCrow, P. Penna, E. Spatali, and G. Tolland (Geochem Australia) 1995
Total sample sites: 1026; 420 sheetwash sediment, 398 stream sediment, 52 lake sediment, and 156 soil
Analyst: Genalysis Laboratory Services. Minimum sample size: 1.5 kg. Fraction of soil, sheetwash sediment, stream sediment and lake sediment samples analysed: ~2mm+0.45mm
The recommended reference for this map: KOJAN, C.J., FAULKNER, J.A., and SANDERS, A.J., 1996, Sir Samuel, W.A. -- Sample locations: Western Australia Geological Survey, 1:250 000 Regolith Geochemistry Series, Plate 2

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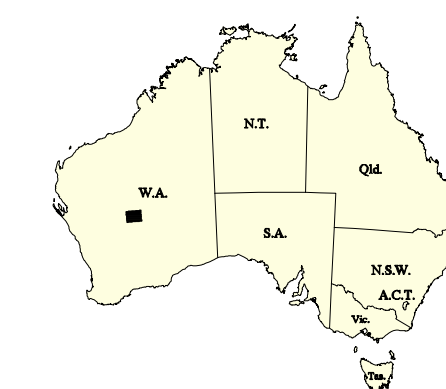


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SHEET INDEX		
GLENGARRY SG 50-12	WILUNA SG 51-9	KINGSTON SG 51-10
SANDSTONE SG 50-16	SIR SAMUEL SG 51-13	DUKETON SG 51-14
YOUANMI SH 50-4	LEONORA SH 51-1	LAVERTON SH 51-2



INDEX TO 1:100 000 MAP SHEETS WITHIN SIR SAMUEL 1:250 000		
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DEPOT SPRINGS 2942	SIR SAMUEL 3042	DARLOT 3142

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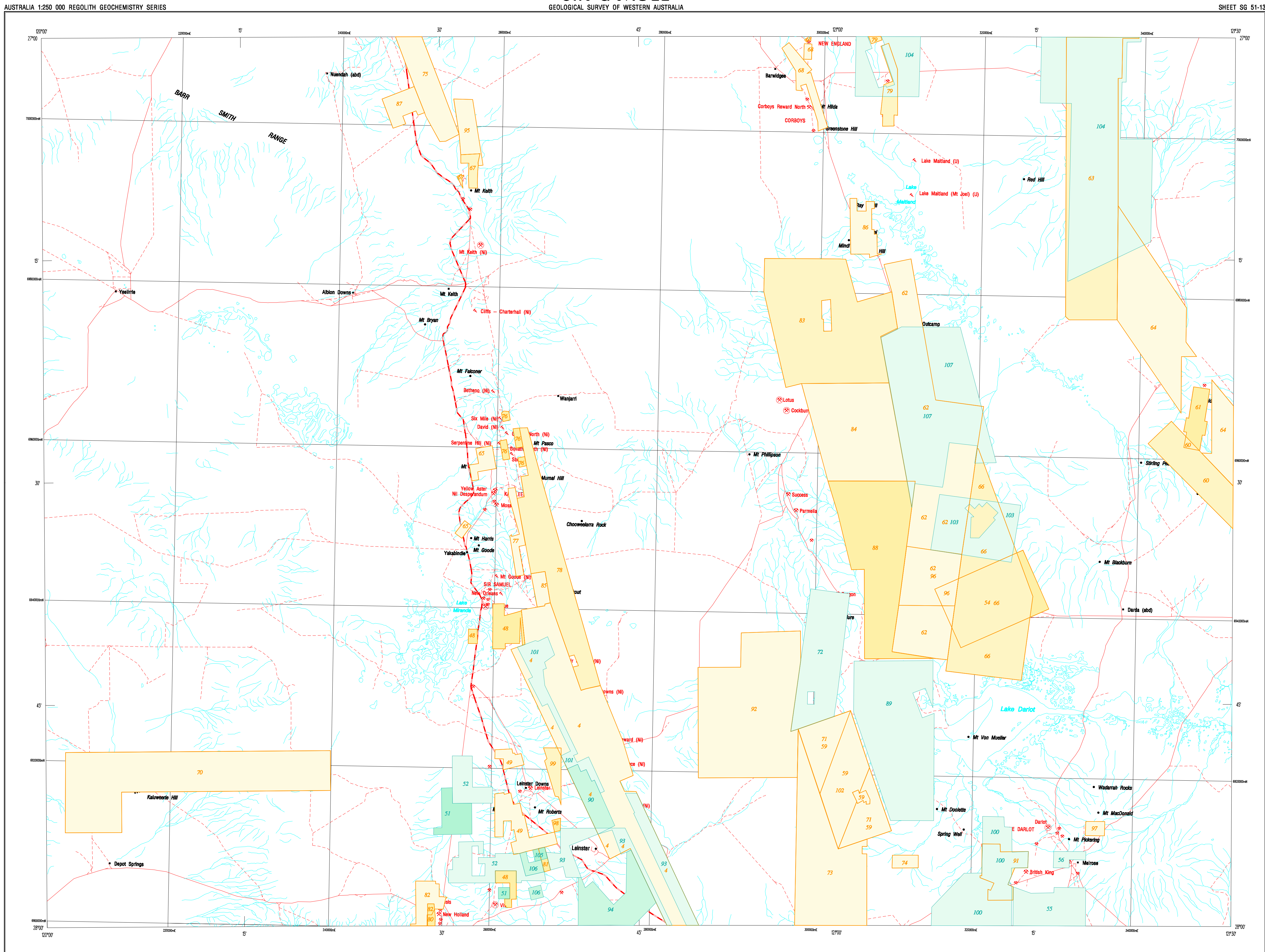
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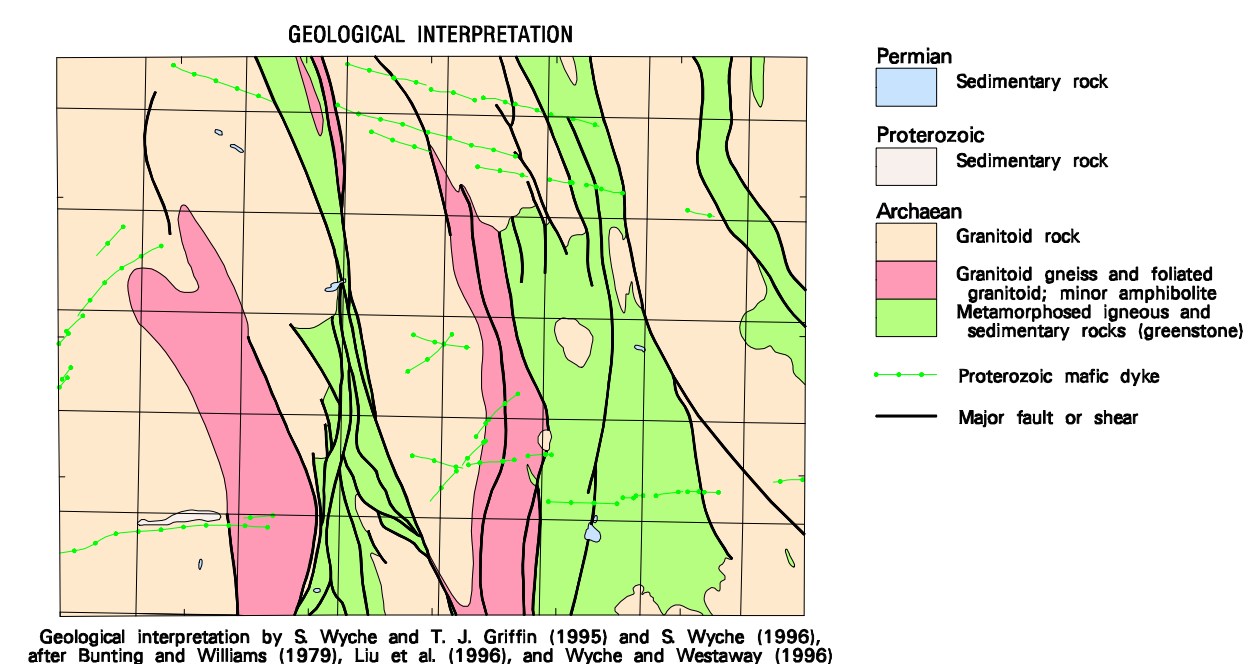
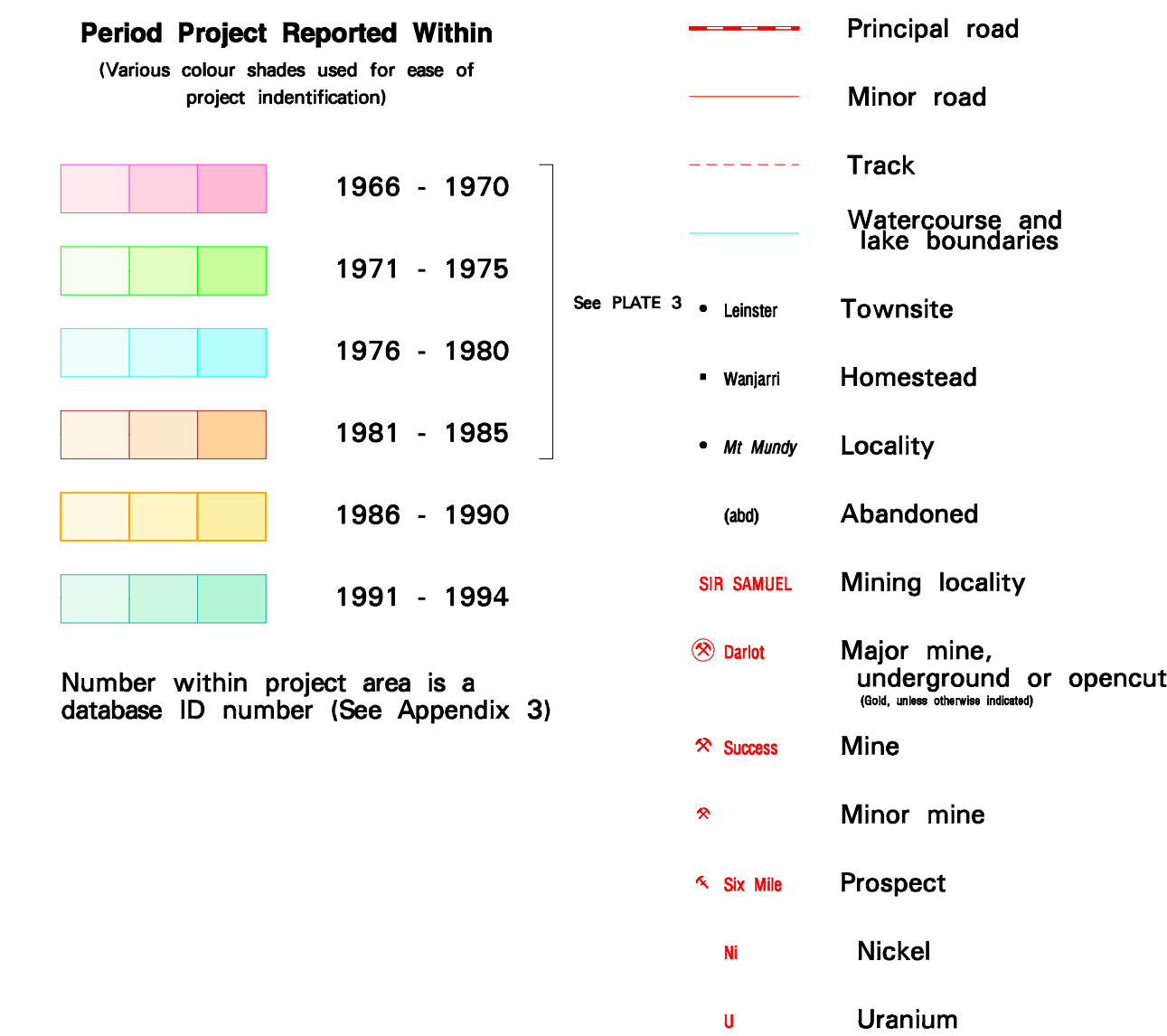
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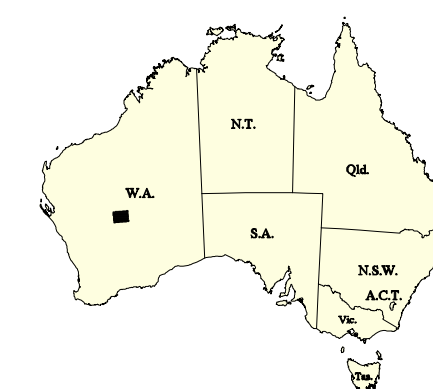


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GLENGARRY SG 50-12	WILUNA SG 51-9	KINGSTON SG 51-10
SANDSTONE SG 50-16	SIR SAMUEL SG 51-13	DUKETON SG 51-14
YOUANMI SH 50-4	LEONORA SH 51-1	LAVERTON SH 51-2



INDEX TO 1:100 000 MAP SHEETS WITHIN SIR SAMUEL 1:250 000		
YEELIRRIE 2943	MOUNT KEITH 3043	WANGGANNOO 3143
DEPOT SPRINGS 2942	SIR SAMUEL 3042	DARLOT 3142

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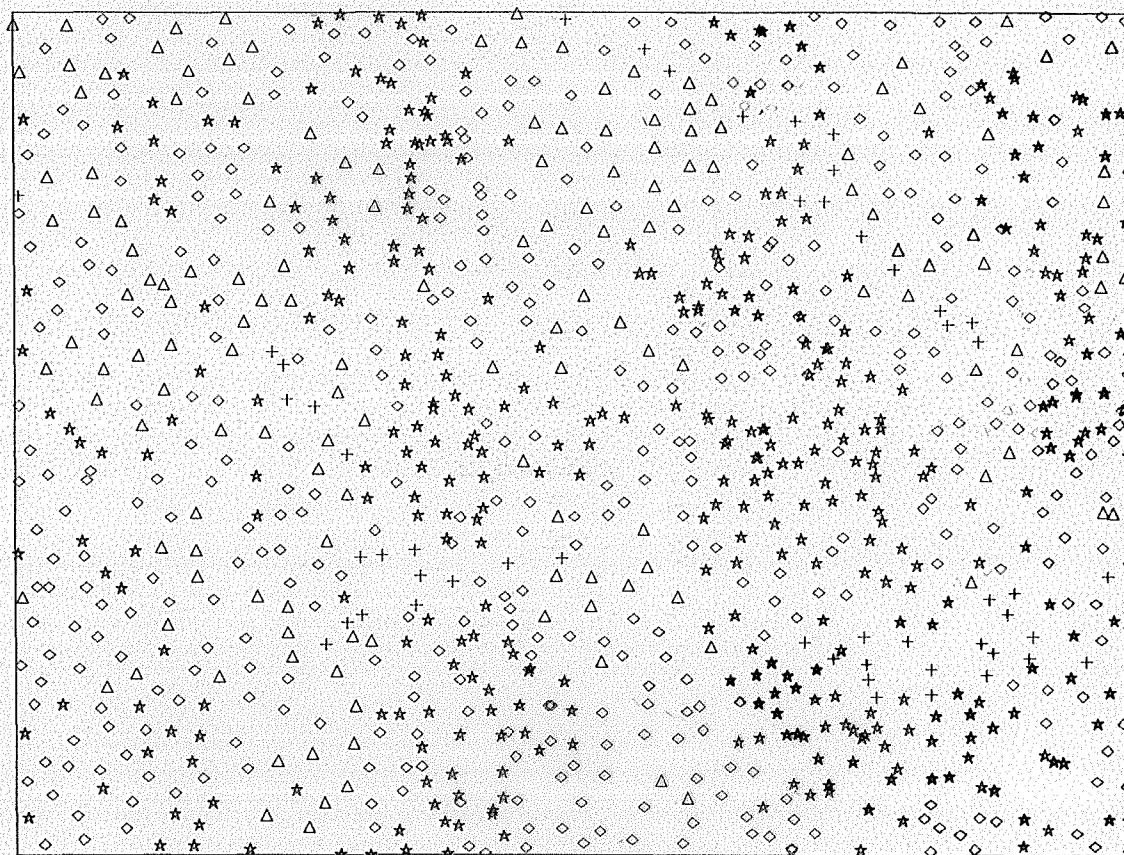
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SAMPLE LOCATIONS

SAMPLE TYPE

- △ Soil
- + Lake
- ★ Stream
- ◇ Sheetwash



SCALE 1:1 000 000

0 10 20 30 40 50 km

SIR SAMUEL
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