

**EXPLANATORY  
NOTES**



# **GEOCHEMICAL MAPPING OF THE EDMUND 1:250 000 SHEET**

by K. J. Pye, J. Coker, J. A. Faulkner  
and A. J. Sanders

**1:250 000 REGOLITH GEOCHEMISTRY SERIES**



**GEOLOGICAL SURVEY OF WESTERN AUSTRALIA**

**DEPARTMENT OF MINERALS AND ENERGY**



**GEOLOGICAL SURVEY OF WESTERN AUSTRALIA**

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8.  $\text{MnO}$
9.  $\text{MgO}$
10.  $\text{CaO}$
11.  $\text{Na}_2\text{O}$
12.  $\text{K}_2\text{O}$
13.  $\text{P}_2\text{O}_5$
14. LOI
15. Ag
16. As
17. Au
18. Ba
19. Be
20. Bi
21. Cd
22. Ce
23. Co
24. Cr
25. Cu
26. Ga
27. In
28. La
29. Li
30. Mo
31. Nb
32. Ni
33. Pb
34. Pd
35. Pt
36. Rb
37. S
38. Sb
39. Sc
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## Digital dataset (in pocket)

EDMUND regional regolith geochemical data (EDMUND.CSV)



# Geochemical mapping of the Edmund 1:250 000 sheet

by

K. J. Pye, J. Coker, J. A. Faulkner, and A. J. Sanders

## Abstract

Regolith and geochemical mapping of the EDMUND 1:250 000 map sheet has been completed as part of the regional regolith and geochemical mapping program of the Geological Survey of Western Australia. The 1054 regolith samples collected comprised 963 stream-sediment and 90 sheetwash samples, and one soil sample at a nominal sampling density of one sample per 16 km<sup>2</sup>. Each sample has been analysed for 50 components, including pH and total dissolved solids. Results for major-element oxides (except SiO<sub>2</sub>) and trace elements are represented as spot concentration maps. Following statistical treatment, additive index maps have been produced for certain trace-element combinations. Relevant open-file exploration company data have been tabulated.

A regolith-materials map has been produced using sample-site descriptions, Landsat imagery, and aerial photographs. The three-tiered regolith classification system used for this map follows a new scheme designed by the Geological Survey of Western Australia. Regolith on EDMUND is dominated by erosional (66%) and depositional regimes (33%), with relict regimes comprising less than 1% of the area.

Regolith chemistry reflects the underlying bedrock composition. Characteristic associations between regolith chemistry and lithology include high Al<sub>2</sub>O<sub>3</sub> and Ga in the Wyloo Group; high concentrations of Li, Rb, Co, Cu, Ni, Sc, V, Y, As, Cd, and Mo over dolerites and black shales of the lower Edmund Subgroup; elevated Mo, As, S, and Sb in regolith derived from the Discovery Chert; high MnO, Co, Nb, Ta, and Y in the upper Edmund Subgroup; high Ni, Pt, Sn, and W in the Collier Subgroup; and high K<sub>2</sub>O, Rb, Li, Th, and Ce in the Gascoyne Complex. Statistical analysis has identified a number of samples with high concentrations of As, Cd, Mo, Ni, S, Se, Zn, U, Pd, and Pt. Some of these are found in the lower Edmund Subgroup near Muntharra Tabletop, and over granitoids of the Gascoyne Complex.

There is potential for chalcophile-related mineralization in the Discovery Chert, Wyloo Group, and sulfidic black shales of the lower Edmund Subgroup.

**KEYWORDS:** Edmund, Bangemall Basin, Gascoyne Complex, Wyloo Group, regolith, geochemistry, mineralization

## Introduction

Regolith and geochemical mapping of the EDMUND\* 1:250 000 map sheet has been completed as part of the regional regolith and geochemical mapping program of the Geological Survey of Western Australia (GSWA). The regional regolith and geochemical mapping program commenced as part of GSWA's New Initiatives program in 1994, and aims to collect and synthesize regolith chemistry data to assist the mineral exploration industry, pastoralists, and environmental agencies.

Initially, the regolith and geochemical mapping program focused on Archaean granite-greenstones in the

northern part of the Yilgarn Craton, where mineralization potential is well established. More recently, the focus has moved to the less well-explored Proterozoic rocks in the Capricorn Orogen, between the Yilgarn and Pilbara Cratons. The EDMUND regolith maps and explanatory notes extend and complement similar work on adjacent map sheets (Fig. 1), such as PEAK HILL (Subramanya et al., 1995), GLENGARRY (Crawford et al., 1996), ROBINSON RANGE (Bradley et al., 1997), NABBERU (Morris et al., 1997), MOUNT PHILLIPS (Sanders et al., 1997), GLENBURGH (Sanders et al., 1998), MOUNT EGERTON (Morris et al., 1998), and TUREE CREEK (Coker et al., 1998).

Regolith comprises unconsolidated or indurated weathered rock, and includes residual and transported material that can cover and obscure underlying bedrock. In areas of extensive

\* Capitalized names refer to standard 1:250 000 map sheets



regolith cover, an understanding of the distribution of regolith types and their formation processes can offer significant insights into the nature of bedrock, including the presence and extent of mineralization.

## Location and access

The EDMUND 1:250 000 sheet (SF 50-14) lies between latitudes 23°00' and 24°00'S and longitudes 115°30' and 117°00'E (Fig. 2, Plate 1). There are no towns or villages on EDMUND, and mining and pastoral activities predominate in the area. The only permanent settlements on EDMUND are Wanna, Edmund, Mangaroon, Maroonah, Ullawarra, and Mount Augustus Homesteads. Pastoral stations that are partially on EDMUND include Ashburton Downs, Dooley Downs, Glenflorrie, Gifford Creek, Kooline, Lyndon, Minnie Creek, TOWERA, Uuaroo, and Wyloo.

Station roads and tracks provide some access to less rugged areas on EDMUND. During the regolith and geochemical sampling program, the southern half of the map sheet was accessed via well-graded gravel roads. Apart from the Ashburton River and its floodplain, which posed problems during and after floods, the northeastern corner of the map sheet was accessible using well-graded station roads and tracks from the Kooline, Wyloo, and Ashburton Downs Homesteads. There are no roads or tracks on the high ground of the Capricorn Range. Heavily dissected, rugged ranges and peaks make access difficult in the central and northwestern parts of EDMUND.

## Physiography

Daniels (1969) divided EDMUND into three main topographic zones, which are equivalent to the Ashburton Valley, Bangemall, and Maroonah Plains Geomorphological Provinces of Payne et al. (1988). These reflect the underlying rock units and correspond to low-grade metasedimentary rocks of the Wyloo and Bangemall Groups, and igneous and metamorphic rocks of the Gascoyne Complex respectively.

The Ashburton Valley Geomorphological Province occupies a triangular area in the northeastern corner of EDMUND, and consists of undulating low hill country, with sandstones of the Capricorn Formation forming higher ranges and isolated hills. Tertiary and Quaternary alluvium are found along the main river courses (Payne et al., 1988).

The Bangemall Geomorphological Province consists of a broad diagonal strip of northwesterly trending ridges and cuestas across the central part of EDMUND. Muhling and Brakel (1985) noted that prominent ridges and cuestas are formed by chert and sandstone of the Bangemall Group, with less resistant shale, siltstone, and carbonate underlying valleys and scree slopes. This rugged terrain is dissected by creeks, producing steep-sided valleys and gorges. Dolerite dykes and sills intrude the Bangemall Group, forming more-rounded hills and

ridges (Payne et al., 1988). Mount Palgrave (704 m above sea level) is the highest point on the map sheet.

The more subdued topography of the Maroonah Plains Geomorphological Province reflects the underlying granitic and metamorphic rocks of the Gascoyne Complex. Payne et al. (1988) divided this province into two land systems. The first system, called Mundong, consists of erosional surfaces of low granitic hills and broad stony plains, which give way downslope to depositional plains of Tertiary and Quaternary alluvium. The other system, Nadarra, is formed by partially weathered and calcreted Tertiary valley-fill deposits that overlie sedimentary rocks of the Bangemall Group.

The Ashburton River, which flows northwesterly towards the Indian Ocean, is a relatively mature drainage system showing signs of rejuvenation where it dissects areas of calcrete and hardpan (Muhling and Brakel, 1985). The river is flanked by Quaternary alluvial deposits of deep loam and clay soils forming 3–4 km-wide active floodplains (Payne et al. 1988). The southwesterly flowing Lyons River and its tributaries are less deeply incised into the calcrete, and indicate a more mature river system (Muhling and Brakel, 1985). Payne et al. (1988) recognized a number of other land systems adjacent to major rivers. These include low calcrete plateaus and mesas formed by the dissection of partly consolidated or calcrete-rich Tertiary and Quaternary colluvial valley-fill deposits.

According to Payne et al. (1988), major landforms on EDMUND include:

- active alluvial floodplains, and floodplains and banks adjacent to major rivers;
- plains of low to medium relief, including stony plains and outwash plains adjacent to hills, hardpan plains with thin sand cover, gently undulating plains, and calcrete rises;
- plains of highly dissected colluvial hardpan;
- low plateaus, mesas, and buttes of limonite and calcrete with some dissection;
- undulating uplands and low hills of quartzite;
- rough hills of dolerite and shale with saline and non-saline drainage floors;
- granitic hills and undulating stony plains;
- rough hills of dolomite with benched slopes;
- rugged hills, ridges, and mountains of sedimentary rocks.

## Climate

EDMUND experiences an arid climate with annual rainfall between January and May of 200 to 400 mm. In January the mean daily maximum temperature is about 41°C with a mean minimum of about 26°C. In July the mean daily maximum is about 24°C with a mean daily minimum of about 10°C. Mean daily evaporation is about 10 mm per day (3600 mm per year).

## Vegetation and soils

EDMUND lies in the Ashburton Valley District of the Gascoyne Region of the Eremean Botanical Province of Beard (1981). The following description of vegetation is based on observations by Beard (1981).

Vegetation on EDMUND is characterized by areas of spinifex and low woodlands, and shrublands of mulga and snakewood. The highland regions, particularly those occupied by rocks of the Bangemall Group and Capricorn Formation, are host to a variety of spinifex, including *Triodia basedowii* and *Triodia wiseana*. More subdued topography of the Gascoyne Complex supports mulga and snakewood, including *Acacia aneura* and *Acacia xiphophylla*. These species, as well as *Acacia victoriae*, are also found over rocks of the Bangemall and Wyloo Groups. Shale hills of the Wyloo Group support vast areas of dwarf scrub. Alluvial flats surrounding the Ashburton River in the northwestern part of the map sheet are host to wattle scrub.

Predominant soil types on EDMUND are red to reddish brown and uniformly textured. Gradational and duplex soils are restricted to low areas, such as drainage floors (Payne et al., 1988). Due to the arid climate leaching of soils is infrequent, leading to the accumulation of sodium and calcium ions at shallow depths. This results in a down-profile, alkaline reaction trend. Notable exceptions include shallow loams over hardpan, which show uniform acidity throughout their profiles.

## Topographic and remote-sensing datasets

The regolith-materials map for EDMUND (Plate 1) was compiled using Landsat Thematic Mapper (TM) images set to display bands 1, 4, and 7, and 1976 1:50 000 black-and-white aerial photographs. Both datasets were obtained from the Western Australian Department of Land Administration (DOLA). Topographic information was supplied by the Australian Land Information Group (AUSLIG).

## Geology

Early geological investigations on EDMUND were carried out by Woodward (1891), Maitland (1909), and Talbot (1920). The first geological map and accompanying explanatory notes for the map area were compiled by Daniels (1969). More recent regional studies incorporating parts of EDMUND were carried out by Chuck (1984), Muhling and Brakel (1985), Williams (1986), Williams (1990), Tyler and Thorne (1990), Thorne and Seymour (1991), and Cooper et al. (in prep.a).

Three major tectonic units can be recognized on EDMUND: the Palaeoproterozoic Gascoyne Complex and Ashburton Basin, and the Mesoproterozoic Bangemall Basin. Also present is the more restricted Blair Basin.

Table 1. Simplified stratigraphy for EDMUND

Constituent units	Simplified stratigraphy
Dolerite	Dolerite
<b>BANGEMALL GROUP</b>	<b>BANGEMALL GROUP</b>
Collier Subgroup	Collier Subgroup
Kurabuka Formation	
Mount Vernon Sandstone	
Fords Creek Shale	
Edmund Subgroup	Edmund Subgroup
Coordardo Formation	upper Edmund Subgroup
Curran Formation	
Ullawarra Formation	
Devil Creek Formation	
Discovery Chert	Discovery Chert
Jillawarra Formation	lower Edmund Subgroup
Kiangi Creek Formation	
Cheyne Springs Formation	
Gooragoora Sandstone	
Irregully Formation	
Tringadee Formation	
<b>BLAIR BASIN</b>	<b>BLAIR BASIN</b>
Capricorn Formation	Capricorn Formation
<b>GASCOYNE COMPLEX (south) / ASHBURTON BASIN (north)</b>	
Granitoids and metasedimentary rocks	Gascoyne Complex
Ashburton Formation	Wyloo Group
Duck Creek Formation	

For the purposes of geochemical mapping, a simplified geological interpretation map (Fig. 3, Plate 2) has been compiled, based on the work of Cooper et al. (in prep.a). The geology of EDMUND has been classified into the following nine units, which form the basis for the assignment of geological codes in the accompanying datafile:

- Wyloo Group (W);
- Gascoyne Complex metamorphic rocks (Pl);
- Gascoyne Complex granitoids (Pg);
- Capricorn Formation (C);
- lower Edmund Subgroup (PMEI);
- Discovery Chert (PMEs);
- upper Edmund Subgroup (PMEu);
- Collier Subgroup (M);
- dolerites (d).

Cainozoic Geology is represented on the accompanying regolith map (Plate 1). A summary of stratigraphic relationships on EDMUND is provided in Table 1.

## Wyloo Group of the Ashburton Basin

The Capricorn Orogen is an early Palaeoproterozoic collision zone formed by oblique continent–continent

collision of the Pilbara and Yilgarn Cratons at c. 1840–1800 Ma (Tyler and Thorne, 1990, 1994). The Ashburton Basin forms an integral part of the Capricorn Orogen.

The Wyloo Group was deposited within the Ashburton Basin at about 1840 Ma (Tyler and Thorne, 1994). These metasedimentary rocks merge, with increasing metamorphic grade, with rocks of the Gascoyne Complex, where they are intruded by voluminous granitoid plutons (Williams, 1986; Thorne and Seymour, 1991). The Wyloo Group was deposited in a series of environments marking a change from terrestrial and shallow-marine conditions to deep-water sedimentation (Tyler and Thorne, 1990).

The lowest exposed formation of the Wyloo Group on EDMUND is the Duck Creek Dolomite, which is a cream-weathering, well bedded, grey dolomite (Daniels, 1969). The Ashburton Formation, the uppermost unit of the Wyloo Group, conformably overlies the Duck Creek Dolomite (Thorne and Seymour, 1991), but this contact has not been observed on EDMUND (Daniels, 1969). The Ashburton Formation comprises mudstone and immature turbiditic sandstone interbedded with minor amounts of conglomerate, and banded iron-formation (BIF), chert, dolomite, and felsic to mafic volcanic rocks (Thorne and Seymour, 1991).

## Gascoyne Complex

The Gascoyne Complex (Myers, 1990) was previously referred to as the Gascoyne Province by Gee (1979). Williams (1986) described the Gascoyne Complex as the deformed and high-grade metamorphic core of the Palaeoproterozoic Capricorn Orogen.

The Gascoyne Complex consists of metamorphosed and deformed Palaeoproterozoic supracrustal rocks, granitoid batholiths, gneiss domes, and remobilized basement gneiss. Williams (1986) attributed much of the deformation within the complex to the emplacement of mantled gneiss domes and granitoid batholiths and plutons.

Myers (1990) divided the Gascoyne Complex into five zones (A–E) based on the distribution of rock types and structures. From south to north these correspond to the southern foreland thrust belt (A), interleaved basement and cover (B), mantled gneiss domes (C), the Minnie Creek Batholith (D), and granitoid plutons and metasedimentary rocks (E). Gascoyne Complex rocks on EDMUND correspond mostly to zones D and E.

A small area of zone D rocks, forming part of the Minnie Creek Batholith, outcrops in the southwestern corner of EDMUND. This zone consists of a number of elongate plutons that range, with decreasing age, from foliated tonalite and granodiorite to massive undeformed granite (Myers, 1990).

Zone E consists mainly of metasedimentary rocks of the Morrissey Metamorphic Suite, which are extensively intruded by S- and I-type granite plutons. Williams (1986) described the Morrissey Metamorphic Suite as ensialic, geosynclinal shelf and trough sedimentary rocks, which

apparently pass, with decreasing metamorphic grade, into the Wyloo Group (Gee, 1979; Thorne, 1990a,b).

Previous regolith mapping of the Gascoyne Complex on MOUNT PHILLIPS (Sanders et al., 1997) distinguished early- and late-stage granites. However, subsequent mapping has shown that this distinction cannot be made with certainty. For the purpose of regolith and geochemical mapping on EDMUND, these rocks have been grouped as Proterozoic granitoids (unit Pg on EDMUND.CSV). Metasedimentary rocks of the Morrissey Metamorphic Suite have been labelled as Pl. This reclassification accounts for the differences between the simplified geological and regolith-material maps of EDMUND and MOUNT PHILLIPS.

## Blair Basin

The Capricorn Formation was previously mapped as the uppermost unit of the Wyloo Group (Daniels, 1969). However, an unconformity has been recognized between the Capricorn Formation and the underlying Ashburton Formation of the Wyloo Group. The Capricorn Formation was redefined by Thorne and Seymour (1991) and regarded as being deposited within the Blair Basin. It is the sole stratigraphic unit within the Blair Basin and consists of sandstone, greywacke, mudstone, shale, dolomite, and acid volcanic rocks. Thorne and Seymour (1991) recognized three facies associations in the Capricorn Formation, corresponding to braided-fluvial, shallow-marine, and fan-delta environments.

## Bangemall Basin (Bangemall Group)

The Bangemall Group was deposited within and unconformably overlies both the Wyloo Group in the Ashburton Basin and granitoids and metasedimentary rocks of the Gascoyne Complex. The lower part of this intracratonic basin has been dated at 1640 Ma (Nelson, 1995), whereas the upper part was deposited at about 1360 Ma (Williams, 1990). The Bangemall Group consists of sequences of variably deformed terrestrial, alluvial, and shallow- and deep-water sedimentary rocks. Prior to deformation, these sequences were intruded by numerous tholeiitic dolerite sills (Muhling and Brakel, 1985; Vogt, 1995).

The following account of the Bangemall Basin is taken from Daniels (1969), Chuck (1984), Muhling and Brakel (1985), and Williams (1990). Since the Bangemall Basin occupies such an extensive area of EDMUND, this account follows a simplified stratigraphic scheme devised by Morris et al. (1998) for MOUNT EGERTON. The scheme divides Bangemall Basin lithologies into four associations; in ascending order these are the lower Edmund Subgroup, Discovery Chert, upper Edmund Subgroup, and Collier Subgroup.

## Edmund Subgroup

The lower Edmund Subgroup consists of lithologies that outcrop below the Discovery Chert and includes, in



ascending order, the Tringadee Formation, Irregularly Formation, Gooragoora Sandstone, Cheyne Springs Formation, Kiangi Creek Formation, and Jillawarra Formation. These lithologies represent fluvial and lagoonal to shallow-marine deposits with some alluvial-fan deposits along the northern margin of the basin (Williams, 1990). The Cheyne Springs, Kiangi Creek, and Jillawarra Formations have complex gradational relationships and may be laterally equivalent (Chuck, 1984).

Lithological units of the lower Edmund Subgroup have been described by Chuck (1984), Muhling and Brakel (1985), and Williams (1990). The Tringadee Formation is commonly absent from the base of the sequence, but in places is found along the southern margin of the Bangemall Basin. It consists of interbedded and interlaminated, medium- to coarse-grained arenite with subordinate conglomerate, and is probably equivalent to the Mount Augustus Sandstone. The overlying Irregularly Formation consists of dolomite with thin interbeds of quartz arenite, pebble conglomerate, and shale. The Gooragoora Sandstone consists of cross-bedded pyritic sandstone with shale and conglomerate, overlain by dolomite, dololite, dolomitic breccia, and interbedded terrigenous sedimentary rocks of the Cheyne Springs Formation. The Kiangi Creek Formation consists of quartz arenite beds with lesser shale, siltstone, dolomite, and conglomerate. Shale and siltstone with minor amounts of claystone, chert, dolomite, and sandstone make up the Jillawarra Formation. The Jillawarra Formation records a change from an open marine to a restricted and hypersaline depositional environment (Williams, 1990), culminating in the deposition of the Discovery Chert.

On EDMUND the Discovery Chert overlies the Jillawarra Formation and consists of massive, laminated, or fissile chert with localized subordinate shale. The Discovery Chert was formed by chemical precipitation under reducing conditions, in a basinal environment with restricted circulation and low pH (Muhling and Brakel, 1985). Because of its lateral persistence the Discovery Chert is a significant marker horizon in the Bangemall Basin (Williams, 1990).

The Devil Creek Formation, representing the lowermost unit of the upper Edmund Subgroup, conformably overlies the Discovery Chert (Williams, 1990). Chuck (1984) and Muhling and Brakel (1985) observed a gradational boundary between the two units. Williams (1990) and Muhling and Brakel (1985) recognized that the Devil Creek Formation is not laterally persistent, and that in some locations the overlying Ullawarra Formation rests directly on the Discovery Chert. The Devil Creek Formation comprises algal dolomite, dolomitic breccia, turbidite, and parallel-laminated dolomite (Chuck, 1984) intruded by numerous dolerite sills, and represents a return to shallow-marine shelf to basinal conditions (Williams, 1990).

The Ullawarra Formation conformably overlies the Devil Creek Formation, and consists of shale, siltstone, and fine-grained arenite with locally developed beds of

wacke, claystone, dolomite, and chert (Muhling and Brakel, 1985). The formation is extensively intruded by dolerite dykes, which in some areas make up most of the formation's thickness (Williams, 1990). Interfingering is common between the Devil Creek and Ullawarra Formations.

The Curran Formation rests conformably on the Ullawarra Formation and consists of laminated black shale and mudstone with subordinate beds of chert, limestone, dolomite, and fine-grained sandstone (Muhling and Brakel, 1985). It is most probably a pro-delta deposit (Williams, 1990).

The Coodardoo Formation is a sheet-like deposit of sandstone, which outcrops in the axial region of the Bangemall Basin (Chuck, 1984) and rests conformably on the Curran Formation (Williams, 1990). It is the youngest formation of the Edmund Subgroup (Muhling and Brakel, 1985), and consists of a number of depositional cycles comprising quartz arenite, wacke, siltstone, fine-grained mudstone, and shale (Williams, 1990). The Coodardoo Formation was deposited rapidly as a near-shore turbidite (Chuck, 1984; Williams, 1990).

## Collier Subgroup

Previously mapped as the Mucalana Subgroup (a western correlative of the eastern Collier Subgroup), the Fords Creek Shale, Mount Vernon Sandstone, and Kurabuka Formation have now been included in the Collier Subgroup (Thorne, A. M., 1998, pers. comm.). Williams (1990) interpreted the Collier Subgroup as a regressive, linear shoreline sequence.

The Fords Creek Shale is the basal unit of the Collier Subgroup and consists of laminated shale and siltstone with arenite interbeds (Williams, 1990). It rests conformably on the Coodardoo Formation of the upper Edmund Subgroup and is succeeded conformably by the Mount Vernon Sandstone (Chuck, 1984). The Mount Vernon Sandstone consists of massive intraclast-bearing quartz arenites and cross-bedded quartz arenites (Chuck, 1984), with some glauconitic sandstone (Muhling and Brakel, 1985). The conformably overlying Kurabuka Formation forms the uppermost unit of the Bangemall Group, and consists of bright-green to olive shale and mudstone interbedded with fine-grained glauconitic sandstone and carbonate lenses (Williams, 1990).

## Cainozoic geology

Daniels (1969) divided the Cainozoic deposits on EDMUND into two groups. The older group comprises calcrete and partly consolidated colluvium, whereas the younger group comprises unconsolidated colluvium, river sand, and gravel. Extensive calcrete bodies, partly covered by colluvium, are found in the Lyons and Edmund river valleys, with thicknesses locally approaching 30 m (Daniels, 1969). Cainozoic geology is dealt with in more detail in the accompanying regolith-materials map (Plate 1) and later in the text.

## Economic geology and mineralization

EDMUND lies within the Ashburton and Gascoyne Goldfields, areas known primarily for gold and base-metals mineralization with minor occurrences of asbestos, limonite, rare-earth elements, beryllium, manganese, vanadium, and uranium. Muhling and Brakel (1985) proposed that the Bangemall Basin, by analogy with other Proterozoic platform sequences, should be prospective for stratabound Cu–Pb–Zn, and possibly gold and uranium.

Mineral production data prior to June 1997 from 48 individual mineral prospects on EDMUND are tabulated in Appendix 1. This is a collation of all available data as reported to the Department of Minerals and Energy's (DME's) royalties branch and taken from DME's mines and mineral deposits information (MINEDEX) database. The Star of Mangaroon mine is the only site for which a published resource estimate, of measured and indicated status, is available. Resource estimates for copper, lead, and rare-earth oxides are also available in MINEDEX, but as they are only of inferred (or possible) status they have not been included in Appendix 1.

Discussions of mineralization and mineralization styles for EDMUND are provided in Daniels (1969), Blockley (1971), Chuck (1984), and Muhling and Brakel (1985). Details of mineral occurrences are provided in Cooper et al. (in prep.b).

### Gold

Small reef and alluvial gold deposits were worked intermittently from 1895 to 1945 in the Ashburton River area, in the northeastern part of EDMUND (Daniels, 1969). Daniels (1969) reported a 56 oz gold nugget find near Mount Dawson, and recommended a more detailed investigation of the reef gold at the Star of Mangaroon mine. Subsequent work at this mine has defined an epigenetic gold resource of 0.809 t of contained gold in rocks of the Gascoyne Complex. Measured resources are estimated at 270 000 t at 15.9 g/t Au, and indicated resources are estimated at 200 000 t at 19.0 g/t Au. Total gold production on EDMUND prior to 30 June 1997 was 257.25 kg, of which 185.57 kg was mined from the Star of Mangaroon. Production from larger sundry claims include 25.90 kg from the Mangaroon mining centre and 28.46 kg from the Mount Mortimer mining centre.

### Lead–copper–zinc

Total lead production on EDMUND prior to 30 June 1997 was 2687.15 kg, with almost all from deposits in the Kooline mining centre. Significant mines in this area include June Audrey (AMG 443495E, 7443645N), Gift (AMG 445041E, 7443326N), and Bilrose (AMG 444451E, 7443803N), with productions of 434.40, 946.99 and 333.38 t respectively. A total of 957.83 kg of associated silver has been mined in the Kooline area, with

139.6 kg from June Audrey, 260.09 kg from Gift, and 140.08 kg from Bilrose. The June Audrey mine consists of two ore shoots containing galena, cerussite, barite, and traces of copper. Mineralized quartz veins with disseminated galena are found at Gift and galena, cerussite, and barite have been identified in tailings at Bilrose (Blockley, 1971).

A small amount of lead (8.30 t), along with 2.94 kg of silver, has also been mined from the Mangaroon mining centre.

Copper–lead–zinc deposits on EDMUND have been identified at the Bali Hi and Bali Lo prospects, with inferred resources estimated as 0.095 Mt at 2.08% Pb and 0.09 Mt at 1.3% Cu respectively.

Chuck (1984) discussed carbonate-hosted base-metal occurrences from the Joy Helen prospect and Irregully Creek area, in dolomites of the Irregully Formation. The Joy Helen prospect, 33.7 km northeast of Maroonah Homestead (Blockley, 1971), hosts irregular segregations of the secondary copper minerals malachite, azurite, and chrysocolla, with subordinate galena and sphalerite. Galena has been observed outcropping in a small quartz vein in dolomites in the Irregully Creek area. Muhling and Brakel (1985) discussed copper–lead–zinc mineralization in carbonate rocks of the Bangemall Basin, and suggested that these metals were probably concentrated from the surrounding carbonate.

Shale-hosted base metals are found at Mount Palgrave and in the Irregully Creek area (Chuck, 1984). Smith and Davy (1979) and Davy (1980) discussed the low-grade stratiform zinc–copper mineralization at Mount Palgrave. Weak copper and zinc mineralization, consisting mostly of sphalerite with traces of covellite and other copper sulfides (Davy, 1980), is found in black carbonaceous siltstones in the upper part of the Jillawarra Formation (Chuck, 1984). Typical drill results from Mount Palgrave were less than 0.2% Cu and 0.5% Zn (Muhling and Brakel, 1985). Davy (1980) correlated metal abundances in the Jillawarra Formation with carbon and sulfur at Mount Palgrave, but did not consider these deposits economic. Base-metal abundances in the Jillawarra Formation at Mount Palgrave are comparable with those in other shallow-marine, black-shale sequences (Muhling and Brakel, 1985). With no widespread evidence of volcanism during sedimentation, the source of metals in this area is unknown (Muhling and Brakel, 1985).

Chuck (1984) outlined a regional, stream-sediment zinc anomaly in the Irregully area at the northern margin of the Bangemall Basin. In this area drilling by Alcoa intersected a zone of mudstones at 92–108 m depth that averaged 0.12% Zn, 2.3 ppm Ag, 296 ppm Cu, and 0.35% F. There is a possible correlation with a second drillhole 30 km to the northwest, which at depths of 108–126 m averages 0.25% Zn, 2.2 ppm Ag, and 312 ppm Cu, and may indicate the widespread and uniform nature of the anomalous zinc mineralization.

The Discovery Chert contains widespread anomalous concentrations of base metals, particularly copper and zinc (Chuck, 1984). Drill intersections south of Mount

Palgrave yielded the following results for copper: 7.3 m at 3.1%, 11 m at 2.2%, 1.8 m at 6.6%, 16 m at 0.7%, and 18 m at 0.6%Cu. The highest recorded zinc value was 1.8 m at 0.5% Zn.

## Asbestos

Minor amounts of white asbestos are present east of the Maroonah Homestead. Referring to the occurrence of good-quality white asbestos on WYLOO, found at the contact of dolomite and dolerite, Daniels (1969) suggested that this common association in the western Bangemall Group may warrant further investigation on EDMUND.

## Limonite

Small, economically insignificant bodies of limonite are developed in the Henry River region, on the flanks of streams adjacent to the Discovery Chert (Daniels, 1969).

## Rare-earth elements

Rare-earth element deposits are present in carbonatites within the Gascoyne Complex. Resources are of both 'indicated' and 'inferred' status, with estimated grades for indicated resources ranging from 0.830 to 2.2%.

## Other minerals

Small finds of beryllium, manganese, uranium, and vanadium have also been reported from EDMUND, and are available in MINEDEX.

## Geochemical surveys in open-file company reports

To comply with the Mining Act of 1978, mineral exploration companies must lodge reports detailing exploration activities. These are listed in DME's Western Australian Mineral Exploration (WAMEX) database as either open-file or confidential reports. Details of open-file company reports that contain surface or near-surface geochemical data for EDMUND have been summarized as part of a mineral prospectivity program in the Bangemall Basin (Cooper et al., in prep.b) and are presented in Appendix 2. Reports common to a particular exploration project have been grouped and assigned an identification number (ID no.) as shown in Appendix 2 and Plate 3. Most projects cover a single area, although some projects cover two or more distinct areas. Projects with fewer than 30 geochemical samples have been omitted. Gaps in reporting result from the failure of some tenement holders to lodge reports or there being no obligation for mineral-claim holders to report exploration results prior to 1978.

The 58 projects listed in Appendix 2 are classified according to the targeted mineralization. Of these projects

30% targeted copper-lead, 19% targeted uranium, 18% targeted gold, 12% targeted base metals, and 7% targeted gold and base metals. The remaining 14% of projects targeted nickel, antimony, rare-earth elements, tungsten, bismuth, and diamond.

## Regolith sampling

Regolith sampling on EDMUND was carried out in August 1997 by six two-person sampling teams, each of which consisted of a field assistant and a GSWA geologist. Sampling was carried out using two Bell Jetranger helicopters.

The regional regolith geochemical sampling program of GSWA collects regolith samples at a nominal density of one sample per 16 km<sup>2</sup> over a 1:250 000 map sheet, resulting in about 1050 samples. Sampling at this density provides excellent regional background geochemical data and can also detect regional anomalies, according to the classification of geochemical patterns discussed by Xie and Yin (1993). The sampling program fulfils two objectives: firstly, it provides a regolith sample for subsequent multi-element chemical analysis; and secondly, the characteristics of the regolith and surrounding geology recorded at each site are used in the construction of the regolith-materials map (Plate 1).

Sample sites were chosen using a 4 × 4 km grid superimposed on 1:100 000 topographic maps. Within each grid square, the site was chosen with regard to bedrock geology, satellite imagery, topographic data, and access. Site locations were digitized and allocated a unique site-location number, which also served as a reference number for subsequent database storage of site information. A helicopter-mounted global positioning system (GPS) set to the Ausgeo84 datum was used to locate designated sample sites. The geologist was given the discretion to move the site to a more suitable location (e.g. away from standing water or human activity). The actual site location on the ground was determined using a hand-held GPS (either Trimble or Garmin), accurate to ± 100 m. The location of each sample point is listed in AMG coordinates in the accompanying datafile (EDMUND.CSV) and shown on Plate 2.

Stream sediments were the preferred sampling medium and an effort was made to collect samples from first- to third-order streams, as these have been shown to be the ideal medium for regional geochemical surveys (Fordyce et al., 1993; Darnley, 1993). In areas where drainage was lacking or ill defined, sheetwash or soil samples were taken. Areas extensively disturbed by human activity, such as near homesteads, cattle yards, roads, airstrips, and old mining areas, were avoided.

The average flying time between each sample site was about five minutes with about 10–12 minutes spent at each site for sampling and recording site characteristics. About 5 kg of material was composited from either a pit or a trench and sieved on site to less than 6 mm. Each sample was labelled with the site number and a unique GSWA number. At stream sites, samples were either

collected along a trench oriented perpendicular to the stream direction (single-channel streams) or composited from several pits dug in a series of channels (braided-stream systems). Sheetwash samples were collected from three 30 m-spaced pits oriented perpendicular to the slope direction, or from three triangular-oriented pits if no slope was apparent. In all cases (trenches and pits) surface debris was removed prior to excavation. Pits were excavated to between 0.1 and 0.3 m depth. All sites were marked with a plastic pin flag annotated with the GSWA number.

## Sample recording form

The sample recording form used on EDMUND is shown in Appendix 3. At each site, the samples AMG coordinates (Ausgeo84 grid) read from the GPS, the sample site number (incorporating an abbreviation of the 1:100 000 sheet name and a numerical identifier), GSWA number, sampling date, sampler's initials, and nature of sample (e.g. stream, sheetwash, channel, or pit) were recorded. The cross section was used to record the position of the sample in an idealised landform profile. The composition of the regolith was recorded in terms of iron-rich, lithic, and non-lithic components using a series of letters signifying abundance (i.e. Abundant: >30%; Common: 5–30%; Rare: 1–5%; and Trace: <1%). Within each category, the relative abundance of each component was ranked using a numerical system, with 1 being the most abundant and numbers greater than 1 becoming less abundant. Fresh bedrock-fragment types, if present, were recorded in the same way. Fields also exist for recording the nature of the surrounding regolith, grain coatings, the nature of fine-grained material, the nature and distribution of bedrock and secondary units, and characteristics of the stream site (if appropriate). A free-form section (Remarks) allows for specific entries pertinent to the site that are not covered in the preceding sections.

Sample-form data were collated and the site locations entered into a digital master database. Checks were made between the designated and actual site locations to check for any data-entry or GPS errors.

## Regolith-materials mapping

The regolith-materials map of EDMUND follows the revised version of the regolith classification scheme employed by GSWA, and as adopted on the MOUNT EGERTON, TUREE CREEK, and GLENBURGH regolith maps. The revised scheme is still based on the RED scheme (Anand et al., 1993; Anand and Smith, 1994) used on previous maps produced by GSWA's regional regolith and geochemical mapping program. In the RED scheme, regolith is classified according to its nature and position in an idealised landform profile as relict (R), erosional (E), or depositional (D). Relict regimes are usually areas of higher topographic elevation (e.g. upland surfaces and plateaus), including areas of siliceous and ferruginous duricrust ('laterite'). The erosional regime includes areas of outcrop or subcrop where there is a net loss of material caused by weathering and downslope transport. The

depositional regime includes areas of net gain of material, and has been expanded to include areas of colluvium, sheetwash, active alluvial channels, and overbank deposits.

The reasons for changing the approach to the classification of regolith are detailed in Morris et al. (1998). The new scheme has been developed in an attempt to produce a simplified and standardized regolith classification scheme capable of being used by both regolith and bedrock mappers in the GSWA. It is broadly based on the RED scheme, with an expanded number of primary codes reflecting the need to cover a wider range of environments (Table 2). The secondary codes (Table 2) have been chosen to reflect the composition of the regolith, and depart from the scheme used in earlier explanatory notes of the regional regolith and geochemical mapping program in that actual compositions, rather than rock types, are used. Thus, granitoids and felsic gneisses both use the suffix 'g' (quartzofeldspathic), and sedimentary rocks derived from a mafic protolith and regolith derived from basalt would both use the suffix 'm' (ferromagnesian). This approach is necessary to identify rock composition where rock type cannot be identified. This is a common problem in sheetwash and alluvial areas where the broad composition of the material can be identified (e.g. quartzofeldspathic, ferromagnesian), but the rock type from which the regolith is derived is unclear. In situations where the rock type from which regolith has been derived can be identified, a second suffix (tertiary code) can be used (Table 2), designating a specific rock type or composition.

In designing the new scheme, an important consideration was the ability to make a direct conversion from one regolith type to another, and in most cases this is possible. However, there are some exceptions. For example, erosional-regime regolith derived from siliceous sedimentary rocks of the Discovery Chert (E2s or E4s in the old scheme) would be designated Eqs in the new scheme (reflecting its quartz-rich nature), yet E2s and E4s units (such as the Wylloo Group rocks) in the old scheme would be designated Egs in the new scheme, reflecting their quartzofeldspathic origin. A comparison of the original and new schemes is shown in Table 3.

A regolith-materials map (Plate 1) has been produced for EDMUND using Landsat TM imagery, aerial photographs, magnetic and radiometric data, and field observations recorded at each sample site. In some cases the scale difference between field-recorded data and remotely sensed mapping causes discrepancies between the regolith code assigned by the sampling geologist and the unit shown on the interpreted regolith-materials map. This may affect the expected chemistry of a sample, particularly if two quite different regolith units are in contact (e.g. calcrete next to an erosional breakaway). The assigned regolith codes for each sample are listed in the accompanying datafile (EDMUND.CSV). A simplified version of the regolith-materials map appears as Figure 4.

Erosional-regime regolith is predominant on EDMUND, with only a thin veneer of depositional and relict regolith (Table 4).

Table 2. Primary, secondary, and tertiary codes used in the new regolith-materials classification scheme

Regolith code		Description
<b>Primary codes — environment</b>		
Depositional	R	relict Relicts of an ancient land surface. Includes overlying and proximal reworked material
	E	erosional Exposed rock, saprock, saprolite, with thin locally derived debris
	C	colluvial Proximal mass-wasting products grading into sheetwash. Noticeable slope
	W	diluvial Distal sheetwash; minimal gradient; poorly defined drainage
	A	alluvial Alluvium in fluvial channels, and distal floodplain deposits with recognizable drainage systems
	O	overbank Overbank alluvial deposits
	L	lacustrine Inland lakes, associated dunes, and playa deposits, and some coastal lakes (not formed by coastal barring). Includes saline and freshwater playas and eolian deposits (e.g. gypsiferous dunes) associated with such lake systems
	S	eolian Eolian dunes and sandplains, including interdunes
	B	beach Deposits at or above high water mark, adjacent to marine and tidal-related areas
	T	tidal Deposits found between high- and low-water marks
	M	marine Sea-bed deposits, extending from below wave base. Includes reefs
<b>Secondary codes — composition</b>		
	b	black soil, gilgai
	c	clay-mineral rich
	e	evaporite
	f	iron rich (ferruginous)
	g	quartzofeldspathic
	h	hardpan
	k	carbonate rich (including calcrete)
	m	ferromagnesian
	q	quartz rich
	r	carbonaceous
	u	ultramafic
	w	compacted and/or weakly cemented material (includes consolidated colluvium)
	x	mineral-rich material
	y	gypsiferous
	z	siliceous (including silcrete)
<b>Tertiary codes — rock qualifiers and specified compositional qualifiers</b>		
	m	metamorphic
	p	plutonic
	v	volcanic
	s	sedimentary
	h	halite
	a	aluminous
	n	magnesite

## Relict regime (R)

Relict-regime regolith, which accounts for less than 1% by area of the total regolith on EDMUND (Table 4), is made up of siliceous caprock (Rz) and quartz- and feldspar-rich material developed over sedimentary rocks (Rgs). Other 'relict' areas, especially of Rz, were noted in the course of mapping and regolith interpretation, but were too small for representation at the 1:250 000 scale of the regolith-materials map. Those areas labelled as Rgs, which comprises most of the relict-regime regolith, are confined to the southeastern corner of EDMUND, where they form relict surfaces over sandstones of the Kurubuka Formation of the Collier Subgroup.

## Erosional regime (E)

Erosional-regime regolith is the most extensively developed regolith regime on EDMUND, covering 66% of the area (Table 4). It predominates in the central part of

EDMUND, where it corresponds to the high ground of the Bangemall Geomorphological Province (Payne et al., 1988) underlain by the Bangemall Basin. Large areas of erosional regolith are also found over rocks of the Gascoyne Complex, Wyloo Group, and Capricorn Formation in the Ashburton Valley and Maroonah Plains Geomorphological Provinces (Payne et al., 1988).

Fifty-eight percent of erosional-regime regolith consists of quartzofeldspathic sediments (Egs) derived from sedimentary rocks of the Bangemall Group, Wyloo Group, and Capricorn Formation. About 19% of erosional regolith comprises material derived from granites (Egp) and metasedimentary rocks (Egm) of the Gascoyne Complex, in the southwestern corner of EDMUND. Bedrock in this area includes granite, monzogranite, gneiss, amphibolite, migmatitic paragneiss, calc-silicate gneiss, quartz-muscovite schist, muscovite schist, and phyllite.

Carbonate rocks (Eks) of the Irregularly Formation, Devil Creek Formation, and Duck Creek Dolomite make up almost 13% of erosional regolith.

Table 3. Comparison of the new regolith classification scheme for EDMUND with the old scheme for ROBINSON RANGE

EDMUND		ROBINSON RANGE	
New code	Description	Old code	Description
<b>Relict regime</b>			
–	Not present	R1	Ferruginous pisolites and nodules
–	Not present	R2	Iron-rich duricrust forming remnant land surfaces
Rz	Silcrete, sometimes weakly ferruginized, forming remnant land surfaces (may include chalcidonic capping on calcrete)	R3	Silcrete (often weakly ferruginized) and silicified rock
–	Not present	R4	Quartz-rich sand overlying presumed or known R1–R3 material
Rgs	Silicified capping on sandstone, usually horizontally bedded; forming mesas	–	Not present
<b>Erosional regime</b>			
Ef	Outcrop of saprock, bedrock, and subcrop with locally derived sand and sandy clays; coarse bouldery lag may be present adjacent to prominent ranges; derived from ferruginized rock	–	Not present
–	Not present	E1	Mottled zone and saprolite
–	Not present	E2v	Outcrop of saprock and bedrock; areas of subcrop with locally derived sandy clays; coarse (bouldery) lag may be present adjacent to prominent ranges; derived from greenstones and other mafic rocks
Egs	As for Ef; derived from quartzofeldspathic sedimentary rock	E2s	E2v derived from sedimentary rocks
Egm	As for Ef; derived from quartzofeldspathic metamorphic rock	E2m	E2v derived from metamorphic rocks, predominantly granitoid gneiss
–	Not present	E2a	E2v derived from amphibolite
–	Not present	E4	Lag of locally derived ferruginous $\pm$ lithic fragments $\pm$ feldspar in a sandy clay to sand-rich matrix associated with actively eroding outcrop or subcrop
–	Not present	E4v	E4 derived from greenstones and other mafic rocks
Egs	See above	E4s	E4 derived from sedimentary rocks
Egm	See above	E4m	E4 derived from metamorphic rocks, predominantly granitoid gneiss
–	Not present	E4a	E4 derived from amphibolite
Egp	As for Ef; derived from quartzofeldspathic plutonic rock	–	Not present
Eks	As for Ef; derived from carbonate-rich sedimentary rock	–	Not present
Emp	As for Ef; derived from coarse-grained ferromagnesian rock	–	Not present
Eqs	As for Ef; derived from quartz-rich sedimentary rock	–	Not present
<b>Depositional regime — colluvial</b>			
C	Unconsolidated and semi-consolidated sand, silt, gravel, and rubble (derived from various sources)	DC1	Medium to coarse detritus, mainly of lithic or ferruginized lithic clasts (mostly >25 mm), in colluvium with a sand or sandy clay matrix
–	Not present	DC1v	DC1 derived from greenstones
Cgs	As for C, derived mainly from quartzofeldspathic sedimentary rock	DC1s	DC1 derived from sedimentary rocks
Cgm	As for C, derived mainly from quartzofeldspathic metamorphic rock	DC1m	DC1 derived from metamorphic rocks, predominantly granitoid gneiss
–	Not present	DC1a	DC1 derived from amphibolite
C	See above	DC2	Fine to medium detritus (clasts 4–25 mm) mainly of lithic or ferruginized lithic origin, in a red sandy clay colluvial matrix, or quartz in a sandy clay matrix
Cgs	See above	DC2s	DC2 derived from sedimentary rocks
Cgm	See above	DC2m	DC2 derived from metamorphic rocks, predominantly granitoid gneiss
Cw	Consolidated to semi-consolidated sand, silt, gravel, and rubble	DC3	Sand- or clay-dominated colluvium or sheetwash ( $\pm$ feldspar); merges into alluvial plains (DA5)
Ch	Consolidated to semi-consolidated sand, silt, gravel, and rubble; often deeply incised; may include areas of hardpan	DC3h	Consolidated colluvium (hardpan) with a ferruginous or silica-rich cement; reddish brown and poorly bedded
Cf	As for C, derived from strongly ferruginized rock	–	Not present
Cg	As for C, derived mainly from quartzofeldspathic rocks	–	Not present
Cgp	As for C, derived mainly from quartzofeldspathic plutonic rock	–	Not present
Ck	As for C, derived mainly from calcrete	–	Not present
Cks	As for C, derived mainly from carbonate-rich sedimentary rock	–	Not present
Cqs	As for C, derived mainly from quartz-rich sedimentary rock	–	Not present
Cmp	As for C, derived mainly from coarse-grained ferromagnesian rock	–	Not present
<b>Depositional regime — alluvial</b>			
A	Cobbles, gravel, sand, silt, and clay in active alluvial channels; commonly flanked by steep-sided colluvial slopes	DA4	Gravelly sands and clays of active alluvial channels with mixtures of lateritic, non-lateritic, and variably altered lithic clasts
O	Overbank deposits, sand-, or clay-rich alluvium and colluvium on floodplains. Includes calcrete fragments and non-saline claypans	DA5	Sand or clay-rich alluvium and colluvium on broad drainage floors, including overbank alluvial deposits and terraces; includes non-saline claypans; calcrete fragments
–	Not present	DA7	Saline clays and sandy clays of playa lakes; usually lacking vegetation
Ok	Valley calcrete, silicified in places	DA8	Extensive and continuous calcrete outcrop in broad drainage floors (valley calcrete)
W	Sand- and clay-dominated colluvium or sheetwash with indistinct alluvial channels; may be scattered with small lakes	–	Not present
–	Not present	D9	Sandplain, eolian in origin. May form dunes to thin sheets

SOURCE: Bradley et al. (1997) for ROBINSON RANGE data

Table 4. Regolith materials unit area and number of samples

Regime	Regolith code	No. of samples	% of regolith	% of regime
Alluvial (Overbank)	A	87	3.83	25.52
	O	33	2.99	19.90
	Ok	45	3.98	26.49
	(Sheetwash) W	40	4.20	28.09
	Total		15.00	
Colluvial	C	69	5.20	27.96
	Cf	—	0.14	0.74
	Cg	1	0.03	0.14
	Cgm	16	1.13	6.07
	Cgp	17	0.99	5.30
	Cgs	91	5.58	30.02
	Ch	1	0.08	0.45
	Ck	—	0.04	0.21
	Cks	10	0.90	4.87
	Cmp	5	0.48	2.56
	Cqs	4	0.34	1.84
	Cw	42	3.69	19.85
	Total		18.59	
Erosional	Ef	—	0.12	0.19
	Egm	49	5.43	8.21
	Egp	57	7.22	10.91
	Egs	352	38.47	58.16
	Eks	78	8.39	12.68
	Emp	35	3.76	5.68
	Eqs	22	2.76	4.17
	Total		66.15	
Relict	Rgs	—	0.26	98.77
	Rz	—	0.00	1.23
	Total		0.26	

Smaller areas of ferromagnesian detritus (Emp) derived from dolerites, scattered throughout the Bangemall Group and Collier Subgroup, comprise almost 11% by area of the erosional regolith. Thin bands of the Discovery Chert erode to produce quartz-rich regolith, comprising just over 4% of the erosional material.

Less than one percent of erosional regolith consists of ferruginized material. Small areas of apparently ferruginized material were interpreted from Landsat TM imagery, but were not extensive enough for expression at 1:250 000 scale.

## Depositional regime (C, W, A, O)

Depositional-regime regolith forms about 33% of regolith on EDMUND (Table 4) and can be divided into two subgroups: alluvial and colluvial.

Alluvial regolith (15% of the total regolith) consists of four subdivisions: alluvial (A), overbank (O), sheetwash (W), and calcrete (Ok). All four are extensively developed on or adjacent to the Ashburton and Lyons river drainages and comprise 25.5%, 19.9%, 26.5%, and 28.1% respectively, of alluvial depositional material on EDMUND.

Alluvial regolith (A), which includes the material within active alluvial channels (e.g. gravelly sand and

sandy clay), corresponds to major drainage systems and their tributaries. These include the Ashburton River in the northeast, the Lyons and Edmund river tributaries in the south, and the Henry and Yannarie river tributaries in the west.

The most expansive areas of overbank material (O) on EDMUND correspond to broad floodplains flanking the Ashburton River system. Smaller pockets of overbank material are found adjacent to the Lyons River in the south.

Large areas of sheetwash (W) are present in the distal parts of the floodplains along the Ashburton River. These overlie rocks of the Wyloo Group in the northeastern part of the map sheet. Sheetwash is also extensively developed where the Lyons River catchment drains the high ground underlain by the Bangemall Group (especially adjacent to the Edmund River). Sheetwash is not usually assigned secondary or tertiary qualifiers because it contains a range of source material of variable provenance.

Calcrete, which can be up to 30 m thick, is extensively developed in the drainage of the Lyons River and its tributaries. It is also well developed in the western part of EDMUND, along tributaries of the Henry and Yannarie Rivers.

Colluvial-regime regolith (C), which accounts for about 18% of the total regolith, is best developed over the Gascoyne Complex, Wyloo Group, and Capricorn Formation. It is derived from a variety of sources, and is mostly found in the upper reaches of the main drainage systems. Colluvial regolith is poorly developed over the Bangemall Group, which corresponds to areas where erosion is the predominant process. In many areas, it was not possible to assign specific parentage (secondary and tertiary qualifiers) to colluvium because of its numerous sources. Areas of mixed colluvium (C), including consolidated to semi-consolidated colluvium (Cw) and hardpan (Ch), are best developed within major drainage systems. In areas where a particular rock type contributed significantly to the colluvium, the appropriate secondary and tertiary qualifiers (Table 2) were used.

Areas of Cgp and Cgm are derived from granitic and metamorphic rocks respectively, of the Gascoyne Complex. Lesser areas of Cg consist of material from both rock types.

Colluvial regolith derived from quartzofeldspathic sedimentary rocks (Cgs) is the most extensive type of colluvial regolith (30% by area), and is associated with sedimentary rocks of the Wyloo Group, Capricorn Formation, and, to a lesser extent, the Bangemall Group. Small areas of Cks surround erosional outcrops of carbonate rocks in the Irregularly Formation, Devil Creek Formation, and Duck Creek Dolomite. Lesser areas of Cmp and Cqs are derived from outcrops of dolerite and the Discovery Chert respectively.

A small area of colluvium derived from calcrete is found on the banks of the Lyons River. Where colluvium has been strongly ferruginized, regolith has been assigned the code Cf.



## Chemical analysis

The 1054 regolith samples from EDMUND were analysed in six separate batches by Genalysis Laboratories in Perth. The samples comprised 963 stream-sediment samples, 90 sheetwash samples, and one soil sample. In addition, analyses of 21 duplicates and 14 analyses of three in-house GSWA standards were carried out, along with analyses of duplicates and standards supplied by Genalysis.

All regolith samples were oven dried at GSWA's Carlisle base. About 2 kg of each sample (either sieved to <2 mm or to <6 mm) was supplied to Genalysis. Following oven drying, an aliquot of each sample was sieved to between 2 and 0.45 mm. This material was pulverized to <75 µm in a zirconia ring mill (for analysis of SiO<sub>2</sub>, TiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, MnO, MgO, K<sub>2</sub>O, and Cr) or a chrome-steel jumbo ring mill (for analysis of CaO, Na<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>, Ag, As, Ba, Be, Bi, Cd, Ce, Co, Cu, Ga, In, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, U, V, W, Y, Zn, and Zr).

Fifty components were measured for each sample, comprising 10 oxides in weight percent (SiO<sub>2</sub>, TiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, MnO, MgO, CaO, Na<sub>2</sub>O, K<sub>2</sub>O, and P<sub>2</sub>O<sub>5</sub>), 33 trace elements as parts per million (Ag, As, Ba, Be, Bi, Cd, Ce, Co, Cr, Cu, Ga, In, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, U, V, W, Y, Zn, and Zr), three ultra-trace elements as parts per billion (Au, Pd, and Pt), one anion as percent (S), loss on ignition (LOI) as percent, as well as pH and total dissolved solids. These data are contained on the accompanying floppy disk as a comma-separated file (EDMUND.CSV).

## Analytical methods

Six different analytical methods were used:

- Silver, As, Ba, Be, Bi, Cd, Ce, Co, Ga, In, La, Li, Mo, Pb, Rb, Sb, Sn, Sr, Ta, Te, Th, U, W, and Y were analysed by inductively coupled plasma mass spectrometry (ICP-MS) following a combined hydrofluoric–multi-acid digestion. The pulverized sample was digested in a hydrofluoric–perchloric–nitric–hydrochloric acid mixture for at least 24 hours, evaporated to fume dryness, and leached in a dilute hydrochloric–nitric acid mixture (Genalysis code A/MS).
- MnO, Na<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>, Cr, Cu, Ni, Sc, V, and Zn were analysed by inductively coupled plasma optical emission spectrometry (ICP-OES) following a combined hydrofluoric–multi-acid digest. The pulverized sample was digested in a hydrofluoric–perchloric–nitric–hydrochloric acid mixture for at least 24 hours, evaporated to fume dryness, and leached in a dilute hydrochloric–nitric acid mixture (Genalysis code A/OES).
- SiO<sub>2</sub>, TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, MgO, CaO, K<sub>2</sub>O and S were analysed by ICP-OES following an alkaline oxidative fusion with sodium peroxide in a nickel crucible, and leaching with hydrochloric acid to dissolve the melt (Genalysis code DX/OES).

- Niobium and Zr were analysed by ICP-MS following an alkaline oxidative fusion with sodium peroxide in nickel crucibles, and leaching with hydrochloric acid to dissolve the melt (Genalysis code DX/MS).

- Gold, Pd, and Pt were analysed by ICP-MS following fire-assay lead collection (Genalysis code FA\*/MS).

Selenium was analysed by ICP-MS following precipitation and aqua-regia digestion (Genalysis code A\*/MS).

- Loss on ignition (LOI) was determined by gravimetric means (Genalysis code GRAV).

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

## Quality control

The aim of quality control is to assess precision (i.e. closeness of agreement of independent tests under prescribed conditions) and accuracy (i.e. closeness of agreement between the result of a measurement and the true value — Thomson and Ramsey, 1995). The precision and accuracy of analysis have been assessed using a series of standard samples, blanks, and duplicates, which were analysed, along with unknowns, in six batches. Standard samples comprise laboratory and international reference standards (BCS348, ETA04, MRG1, SO2, SY3, SY4, TKC1, SARM 7.2 and SARM 7.5) and GSWA reference standards (amphibolite IQC-42, laterite IQC-47, and gossan IQC-45).

A duplicate of every fiftieth sample was taken prior to sieving, given a separate GSWA number, and submitted as an unknown to check for replication. Laboratory-supplied blank samples were run prior to and during the end of analytical runs.

Due to a variation in the order of analysis of samples, some GSWA duplicates and in-house standards were not analysed in their intended batches. This resulted in batches four and five not containing any GSWA duplicates or reference standards.

The following criteria were used to assess precision and accuracy:

- standard data to agree within 20% of consensus values, provided the analyte concentration is more than 10 times the detection level;
- duplicates to agree within 20%, provided the analyte concentration is more than 10 times the detection level;
- blank values not to exceed three times the detection level;
- the relative standard deviation percent (RSD% = (standard deviation/mean) × 100) for multiply analysed samples should not exceed 20.



## Analysis of GSWA reference standards

Three GSWA reference standards were analysed along with unknowns from EDMUND (Appendix 4). These comprised amphibolite IQC-42 (n=5), gossan IQC-45 (n=4), and laterite IQC-47 (n=5). As there are no consensus values for these standards at present, it is not possible to assess accuracy. With one minor exception (Ta in IQC-42 at 35% RSD) the analyses of standards between batches are within acceptable limits for precision.

## Analysis of GSWA duplicates

Duplicates of 22 GSWA samples were assigned separate GSWA numbers and analysed as unknowns. The original sample and its duplicate are taken as showing good agreement if the analyte concentration agrees to within 20%, provided the concentration is more than 10 times the detection limit. In the case of CaO, Ag, As, Au, Cd, In, Mo, Pb, Pd, Pt, S, Sc, Se, and Te for the duplicate samples, most values are less than 10 times the detection limit, so precision cannot be assessed.

All major-element oxides (except CaO, which is less than 10 times the detection limit) and Ba, Bi, Ce, Co, Cr, Cu, Ga, La, Li, Nb, Ni, Rb, Sn, Sr, Th, U, V, W, Y, and Zr show good agreement where the analyte concentration is more than 10 times the detection limit. For these elements only three of the 22 duplicates vary more than 20% from the original sample. In cases where there is variation, it is usually at very low values and close to the threshold of more than 20% variance and 10 times the detection limit. Of the duplicate pairs that exceed threshold values for acceptable replication, Be (4 pairs), Sb (4 pairs), and Zn (5 pairs) show good agreement. Again, almost all of these values are at low concentrations and close to threshold values. Tantalum shows the greatest variation when re-analysed, with 15 samples (out of 22) exceeding the set threshold for acceptable replication. Overall, values for Ta are low and in many cases are only just over the 10 times detection threshold. Individual samples with relatively poor duplication include GSWA 151377 for Zn (155 versus 94 ppm; batch 3), GSWA 151627 for Zr (107 versus 78 ppm; batch 6), and GSWA 152031 for Pb (49 versus 34 ppm; batch 6). Morris et al. (1998) suggested that poor duplication could in part be attributed to difficulty in dissolving some mineral phases, such as zircon. Assessment of data shows that there is no indication of batch control on replication.

## Analysis of laboratory blanks

There were 47 blank analyses spaced over the six analytical batches. Most blank analyses are within acceptable values of less than three times the detection level for the respective analytes. Two Zr blanks assayed 5 ppm (detection limit of 1 ppm) and a Ce blank assayed 0.05 ppm (detection limit of 0.01 ppm) in batch 2.

## Analysis of laboratory reference standards

Reference standards used by Genalysis include BCS348, ETA04, MRG1, SARM 7.2, SARM 7.5, SO2, SY3, SY4, and TKC1. Standards were checked against their consensus values to gauge accuracy. Precision within batches was determined by computing the relative standard deviation in percent (RSD%) where there were multiple runs of a standard in a batch (Appendix 4). Where average analyte values agreed to within 20% of consensus values and the RSD% was less than 20 (and provided the analyte concentration was at least 10 times the detection level) that analysis was deemed to be acceptable in terms of precision and accuracy. Apart from samples that are very close to the acceptable cutoff values or at low levels, all standards are within acceptable levels. The only major discrepancy is Sr in standard SO2 (batch 4), which assayed 88 ppm compared to a certified value of 334 ppm.

## Analysis of laboratory duplicates

Agreement between laboratory duplicate pairs is of a good standard. The main exception is for Zn in three duplicates from batch 3 (106 versus 155 ppm, 47 versus 36 ppm, and 31 versus 22 ppm), and one duplicate from batch 6 (24 versus 11 ppm).

## Check analyses of anomalous samples

Fifteen samples with anomalous values were submitted to Amdel Laboratories in Perth for reanalysis. The analytical techniques used by Amdel are described in Morris et al. (1998). Pulps were used for repeat analysis of samples, with the archive sample also analysed in the case of anomalous gold. Six samples had significant inter-laboratory variations and were resubmitted for further analysis. In these cases the archived sample was sent to both Genalysis and Amdel laboratories.

Elements that show the greatest variation between analyses include Au, Cr, and Nb. Morris et al. (1998) discussed possible reasons for the poor agreement of Cr and Nb during reanalysis. Variations in Au are most likely due to nugget effects. Gold, Cr, and Nb results for the four samples with anomalous Au are shown in Appendix 4. Platinum and Pd are not included because values are close to detection limits in all cases.

The values incorporated into the geochemical database (EDMUND.CSV) represent either a consensus value or the most conservative value derived from multiple analyses.

## Determination of regolith pH and total dissolved solids

The acidity-alkalinity (pH) and total dissolved solids (TDS) of each regolith sample collected on EDMUND have been measured and the results are included in the digital

dataset (EDMUND.CSV). All measurements were made on oven-dried samples. For both types of measurements, a sub-sample was mixed with deionized water in the ratio of 1:5, then shaken vigorously. After standing overnight the pH was measured using a portable Jenway pH meter, which was calibrated using standards solutions of pH=4 and pH=7. The electrode was rinsed in deionized water between each regolith sample measurement. The conductivity of each sample (i.e. a measure of the total dissolved solids) was made using a SCAN4 conductivity meter, calibrated using a buffer solution of 11.67 millisiemens/centimetre (mS/cm).

## Element-distribution maps

The results of the geochemical survey on EDMUND are represented as a series of spot concentration maps (Figures 5–51). These maps are ordered in terms of major-element oxides and loss on ignition (LOI), followed alphabetically by trace elements. They show individual element concentrations for each sample (SiO<sub>2</sub> has been omitted due to consistently high values). Circles of various diameters are used to show the relative concentration of an element from an individual sample site. The diameter of the circle corresponds to the concentration of the element. Where the element concentration is more than 2.5 standard deviations above the mean, a star symbol is used (i.e. anomalous value). Exact element values can be obtained by identifying the relevant GSWA sample number from Plate 2 and then referring to the attached digital dataset (EDMUND.CSV).

Bedrock composition, structure, and physical and chemical weathering control the regolith chemistry on EDMUND. Element associations and concentrations are discussed below in terms of the geological units. The terms high, moderate, and low applied to a given element refer to the concentration relative to the average for the whole map sheet, independent of the absolute values present.

The chemistry of regolith on EDMUND is discussed in terms of statistically determined element associations, determined using the Spearman's rank correlation approach. This involves ranking the data then determining correlation coefficients between elements. Rock (1988) discussed the advantages of calculating correlations based on ranked data, and these include simplicity of calculation and the relatively low impact of outlying values. The Spearman's rank correlation coefficient  $\rho$  (rho) has been calculated for elements according to different geological groupings. Significant element correlations are discussed under the relevant subgroups, where the level of significance varies according to the population size. The Pearson linear correlation coefficient  $r$  (Pearson  $r$ ) was used as a guide for selecting significant correlation values between elements. The lower the sample number the higher the correlation value must be to be significant. A positive correlation of 70% was set as the absolute minimum in order to indicate significant correlation between elements in individual subgroups.

Where examples of samples with high concentrations of multiple elements are given, they are based on the

10 highest values for each element over the entire map sheet. Established geochemical associations, such as those discussed by Levinson (1974) were also used as a guide for identifying element associations on EDMUND.

Well-developed element associations on EDMUND include Al<sub>2</sub>O<sub>3</sub> with Ga, K<sub>2</sub>O with Rb and Li, Ce with La, and MnO with Co. A less well-developed association is TiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, MnO, MgO, P<sub>2</sub>O<sub>5</sub>, Co, Cu, In, Nb, Ni, Sc, V, Y, Zn, and Zr. This is similar to the common element associations in mafic rocks, apart from the addition of Nb and Zr, which may result from incorporation of such resistate phases as rutile and zircon. The association of MnO, P<sub>2</sub>O<sub>5</sub>, Co, Cu, Cr, In, Sc, V, Y, and Zn with Fe<sub>2</sub>O<sub>3</sub> during weathering could also be a factor, while other elements are linked with this group by virtue of mechanical dispersion of their host minerals, such as rutile and zircon.

The highest Cr values in regolith are found in detritus sourced from the Discovery Chert, with other high values in sheetwash on the Edmund River floodplain. There is no clear association of Cr with Ni in areas underlain by mafic rocks. The highest values of Cr are quite separate from those of Ni, and neither are high enough to suggest the presence of any ultramafic rocks on the sheet.

## Wyloo Group

Regolith over the Wyloo Group shows a more uniform composition than regolith over most other units (Figs 5–51). It is characterized by elevated Bi (although the 0.5–1.5 ppm absolute values are not high) and high values of Sb.

Regolith over the Wyloo Group has similarities with parts of the Bangemall Group (the upper part of the Edmund and Collier Subgroups) in having high Al<sub>2</sub>O<sub>3</sub> and Ga (probably as illite and mica). The Wyloo Group contains all the anomalous Al<sub>2</sub>O<sub>3</sub> values, which are mostly concentrated just south of the Bali Hi and Bali Lo prospects (GSWA 151351, 20.78%; GSWA 151030, 18.28%; GSWA 151140, 18.15%; GSWA 151350, 18.11%; and GSWA 151129, 18.11%). One other anomalous value (GSWA 152031, 18.48%) is found north of Greggs Find near the eastern edge of the map sheet. High K<sub>2</sub>O and Li over the Wyloo Group serve to distinguish this regolith from the Edmund Subgroup, whilst the high Bi and Sb content distinguish it from the Collier Subgroup.

Significant element associations in the Wyloo Group, determined using the Spearman's rank correlation coefficients, include Al<sub>2</sub>O<sub>3</sub>, Ga, Sn ( $\rho > 0.90$  between all three), and Rb ( $\rho > 0.80$ ); TiO<sub>2</sub> and V ( $\rho = 0.93$ ); K<sub>2</sub>O and Rb ( $\rho = 0.96$ ); and Ce, La, and Th ( $\rho > 0.90$ ).

Relatively high values of Sc and Ni in the regolith suggest a possible contribution from mafic rocks, although other components normally associated with mafic rocks (such as TiO<sub>2</sub> and V) are quite low.

Slight variations in the distributions of Li, U, Sb, and Bi suggest possible chemical subgroups within the Wyloo

Group. In particular, all anomalous Sb values (except one) fall within a 20 km zone parallel to the southern contact of the group.

The Wyloo Group can also be characterized on the basis of the highest overall concentrations of Au in regolith. The two highest Au results for regolith on EDMUND are found in the Wyloo Group, and include GSWA 151752 (9 ppb) from west of Peak Edgar Well and GSWA 151809 (9 ppb) from near The Gorge.

Seven samples showed multi-element associations at high concentrations: GSWA 152044 (2.18 ppm Bi, 15.75 ppm Sb, 4.1 ppm W); GSWA 152031 (3.3 ppm Be, 57.8 ppm Li); GSWA 151767 (2.61 ppm Bi, 19.21 ppm Sb); GSWA 151351 (3.4 ppm Be, 242.45 ppm Rb); GSWA 151131 (95 ppm As, 59.43 ppm La, 299 ppm Pb); GSWA 151129 (56.4 ppm Li, 13.99 ppm Sb); and GSWA 151028 (2.01 ppm Bi, 18.63 ppm, 9.77 ppm U). Sample GSWA 151131 is from an area adjacent to the Bali Lo Cu-Pb-Zn prospect.

## Capricorn Formation

The spot concentration maps show relatively uniform regolith composition over the Capricorn Formation, with levels very similar to those for the encompassing Wyloo Group. Bismuth and Sb are slightly lower over the Capricorn Formation compared with the Wyloo Group.

Spearman's  $\rho$  between components of the regolith over the Capricorn Formation shows good correlation between  $\text{Al}_2\text{O}_3$ ,  $\text{K}_2\text{O}$ , Ga, and Rb and to a lesser degree Nb, Sc, and Sn. The Capricorn Formation does not contain any samples with high multi-element associations. Sample GSWA 151243, from west of the Bali Hi and Bali Lo prospects, assayed the highest overall concentration of Sn (8.1 ppm). West of this, GSWA 151343 assayed 130.73 ppm Ce.

## Lower Edmund Subgroup

Spearman's  $\rho$  for components of the regolith over the lower Edmund Subgroup highlight three main groups of associated elements:  $\text{MgO}$ ,  $\text{CaO}$ , and  $\text{Na}_2\text{O}$ ;  $\text{P}_2\text{O}_5$ , Cu, Ga, In, Nb, Ni, and Mo with less  $\text{TiO}_2$ ,  $\text{Al}_2\text{O}_3$ , and  $\text{Fe}_2\text{O}_3$ ; and As, Mo, and Sb. However, the element concentration plots (Figures 5–51) indicate a wide variation in absolute values over this unit. For many elements, values range from very high (anomalous values) to very low. The clay content, represented by  $\text{Al}_2\text{O}_3$  and Ga, is much lower than over the Wyloo Group or upper Edmund Subgroup, except in the area between the northern margin of the Discovery Chert and the southern margin of the Wyloo Group (near Muntharra Tabletop), and west of Mount Palgrave.

The northwesterly trending tract of lower Edmund Subgroup rocks that lies between the southern margin of the Wyloo Group and the northern margin of the Discovery Chert has yielded significant values for many elements. In the following text it is referred to as the Muntharra Tabletop region.

The presence of dolerites is reflected by patchy distribution of high  $\text{Fe}_2\text{O}_3$ ,  $\text{CaO}$ ,  $\text{MgO}$ ,  $\text{TiO}_2$ , Cu, Ni, Sc, and V near known mafic rocks. In the Muntharra Tabletop region and at Mount Palgrave high values for these elements not only reflect mafic rocks but also sulfidic shales. These were described in the Mount Palgrave area by Davy (1980) and noted in the Muntharra Tabletop region by A. M. Thorne (1998, pers. comm.). Different dolerite compositions are suggested by variations in regolith composition near mafic rocks (c.f. dolerite-derived regolith in the Muntharra Tabletop region with that east of Wannery Creek). In the northern part of the lower Edmund Subgroup outcrop in the Wongida Creek drainage and in nearby areas, the regolith becomes more siliceous with low values of Cr,  $\text{MgO}$ , and  $\text{Na}_2\text{O}$ , and low to moderate  $\text{Fe}_2\text{O}_3$  and  $\text{Al}_2\text{O}_3$ .

Trace elements tend to be higher over dolerites and black shales than over sedimentary rocks, particularly for As, Co, Cu, Li, Ni, Rb, Sc, Sb, U, V, and Y. There are several anomalous values in the Muntharra Tabletop region, particularly for As, Cd, Mo, Ni, S, Se, U, and Zn. Platinum and Pd also display higher values in this region, but their absolute concentrations are close to detection limits.

In general, Ba concentrations are lowest in regolith over the lower Edmund Subgroup, but there are higher Ba and Pb values in the western part of the area, north and south of Mount Padbury.

The lower Edmund Subgroup contains numerous samples that display multi-element associations at high concentrations. At least seven samples in the Muntharra Tabletop region contain high concentrations of more than one element. From southeast to northwest these include: GSWA 151139 (79 ppm As, 2.1 ppm Cd, 7.66 ppm U, 466 ppm Zn); GSWA 151035 (167 ppm Cu, 122 ppm Ni, 3 ppb Pd, 7 ppb Pt); GSWA 151346 (78 ppm As, 383 ppm Zn); GSWA 151234 (100 ppm As, 2.9 ppm Cd, 17.3 ppm Mo, 0.68% S, 5.2 ppm Se, 7.68 ppm U, 438 ppm Zn); GSWA 151942 (3.4 ppm Be, 0.34% S); and GSWA 151852 (24.1 ppm Mo, 6.24 ppm U). Towards the western part of the lower Edmund Subgroup, three samples south of Mount Padbury display high multi-element concentrations: GSWA 150953 (131 ppm Ni, 48 ppm Sc); GSWA 150940 (126.45 ppm Ce, 270 ppm Pb); and GSWA 150967 (1342.4 ppm Ba, 129.13 ppm Ce, 101.7 ppm Co). The strip of lower Edmund Subgroup between the Barlee Range and the Gascoyne Complex, which displays numerous anomalous concentrations of Cr in regolith, is host to the following samples with high concentrations of multiple elements (from south to north): GSWA 151387 (50.5 ppm Nb, 35.36 ppm Th); GSWA 151169 (739 ppm Cr, 37.3 ppm Ga, 0.22 ppm In, 34.99 ppm Th, 1189 ppm V); GSWA 151690 (33.4 ppm Ga, 0.18 ppm In, 1087 ppm V); GSWA 151688 (591 ppm Cr, 28.7 ppm Ga); GSWA 151405 (329.82 ppm Rb, 36.2 ppm Th); and GSWA 150989 (25.8 ppm Mo, 6 ppm Se). High concentrations of Rb and Th in GSWA 151405 most probably relate to its proximity to rocks of the Gascoyne Complex.

## Upper Edmund Subgroup

This subgroup is exposed in two main areas on EDMUND: as a synclinal succession between the Minierra and Barlee Ranges, and forming the High Range in the western part of the sheet. Spearman's  $\rho$  highlights correlations between elements such as MgO, CaO, and Na<sub>2</sub>O, and As, Mo, and Sb, and is consistent with the expected associations of Ce and La, MnO and Co, and K<sub>2</sub>O and Rb. Regional variations are indicated by the element concentration maps (Figs 5–51).

The few regolith samples in the High Range area have similar composition to regolith over the lower part of the succession (mostly the Ullawarra Formation) in the main synclinal area. Regolith samples over these areas have the highest Zr content on EDMUND.

Throughout the upper Edmund Subgroup, but particularly in the lower part, mafic igneous rocks are interbedded with sedimentary rocks. This is reflected in the regolith composition, with regolith over the lower part of the subgroup having moderate to high values of TiO<sub>2</sub>, MgO, CaO, MnO, P<sub>2</sub>O<sub>5</sub>, Nb, Sc, V, and Co relative to regolith over the upper part of the subgroup. Elements that have a relatively uniform distribution include Li, Rb, Cu, In, Ni, Ta (the highest overall values for the sheet), U, Ce, La, Ba, and Be. Regolith over the upper part of the subgroup appears more siliceous, but shows slightly higher values for Bi, Cr, and Th relative to regolith over the lower part. These higher values are found near the central part of the main synclinal feature. Relative to the rest of the map sheet, regolith over the upper Edmund Subgroup contains some of the highest values for MnO, Co, Nb, Ta, and Y.

The lower part of the upper Edmund Subgroup, in particular the Ullawarra Formation, contains samples with high concentrations of several elements: GSWA 151392 (228.23 ppm Sr, 44.68 ppm Y); GSWA 151378 (945.2 ppm Ba, 96.8 ppm Co); GSWA 151051 (41.6 ppm Nb, 1010 ppm V); GSWA 151360 (65.5 ppm Co, 4.62 ppm Ta); GSWA 151158 (55.8 ppm Nb, 1102 ppm V, 413 ppm Zr); GSWA 151059 (43.1 ppm Nb, 48.83 ppm Y, 359 ppm Zr); and GSWA 151592 (128.16 ppm Ce, 155 ppm Cu, 43.9 ppm Nb, 59.32 ppm Y, 451 ppm Zr).

## Discovery Chert

Some of the highest values of a number of elements of economic interest are found in regolith close to the Discovery Chert. As the Discovery Chert is usually located in topographically high areas, high values, such as Cr and Ag that may relate to this unit, may be in regolith downslope overlying the lower Edmund Subgroup.

As very few samples were obtained from the Discovery Chert, only very high correlations of elements should be considered. Elements that display high correlation include MnO, MgO, CaO, and Co; As and Sb; K<sub>2</sub>O and Rb; and Mo and Se. Samples found to have high concentrations of multiple elements include GSWA

151283 (40.2 ppm Nb, 32.19 ppm Th); GSWA 151279 (17 ppm Mo, 0.6% S); and GSWA 151171 (20.8 ppm Mo, 0.38% S, 4.3 ppm Se).

## Collier Subgroup

This unit consists of sedimentary rocks intruded by mafic igneous rocks. According to Spearman's  $\rho$ , significant correlations include MgO, CaO, Na<sub>2</sub>O, Co, Nb, Sr, and Y; Al<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, Li, and Rb; and P<sub>2</sub>O<sub>5</sub> and Cu. However, the spot concentration plots (Figs. 5–51) reveal wide variations over different parts of the Collier Subgroup.

Compared to regolith over the underlying Edmund Subgroup, regolith over the Collier Subgroup contains higher concentrations of K<sub>2</sub>O, Rb, and Li. In areas where sedimentary rocks dominate, there is less TiO<sub>2</sub>, MgO, CaO, Na<sub>2</sub>O, Cr, In, Ni, Sc, Ta, and V. However, where mafic rocks are prominent, concentrations of these components are similar over both the Collier Subgroup and upper Edmund Subgroup rocks. The Collier Subgroup contains samples with some of the highest values for Ni, Pt, Sn, and W. Sample GSWA 151209, in the far southeastern corner near Koorabooka Bore, contains 170 ppm Cu and 361 ppm Zr.

Zirconium levels are similar in the Collier and upper Edmund Subgroups. High values of Pt and Pd in regolith over the Collier Subgroup are spatially related to dolerites. Some higher Mo values over dolerite in the Collier Subgroup may indicate the development of sulfides in dolerite.

## Gascoyne Complex

For the purpose of analysis and discussion, rocks of the Gascoyne Complex are divided into two groups: metasedimentary rocks and granitoids.

Metasedimentary rocks of the Gascoyne Complex, consisting of migmatitic paragneiss, schist, and phyllite, are found in two main areas on EDMUND — in the northwestern corner of the map sheet and in a north-westerly trending area south of, and parallel to, the High Range. There are other minor exposures east of the Edmund River and north of Maroonah Homestead. Southeast of Two Peaks, part of the Gascoyne Complex is covered by calcrete.

Absolute element values in regolith associated with metasedimentary rocks of the Gascoyne Complex are characterized by moderate to low Al<sub>2</sub>O<sub>3</sub> and Ga, and moderately high K<sub>2</sub>O, Li, and Rb. The regolith also contains low CaO (with the exception of some samples over calcrete, such as GSWA 151300 with 12.31% CaO) and MgO. Regolith in the northwestern and southwestern parts of the map sheet contain moderate to low values of Na<sub>2</sub>O, but regolith in a small area east of the Edmund River has high Na<sub>2</sub>O values. Elements usually associated with the presence of mafic rocks are not present in high concentrations and the overall composition is consistent with a quartzofeldspathic source.

Regolith over the larger southern part of the Gascoyne Complex commonly has higher Ba, Ce, La, Th, Sr, and Zr but lower W, Bi, and Ta than regolith in the northern part. Two samples in the southern area have high concentrations of more than one element: GSWA 151611 (136.87 ppm Ce, 67.45 ppm La) south of Two Peaks; and GSWA 150915 (150.59 ppm Ce, 78.21 ppm La, 38.16 ppm Th) near the Star of Mangaroon mine.

Four main areas of granitoid are shown in the simplified geological map (Plate 2, Fig. 3). These areas are referred to, from north to south, as: Henry River, Maroonah, Mangaroon, and Yangibarra (east of the Edmund River, in the central-southern part of the map sheet). The regolith over the Edmund River floodplain, which overlies rocks of the Gascoyne Complex, is considered separately.

Spearman's  $\rho$  highlights very few significant element correlations, other than the expected ones of Ce and La, and  $K_2O$  and Rb. High values for  $Fe_2O_3$ , Cu, In, Sc, and V may relate to the inclusion of samples from the Edmund River drainage in the dataset. Element concentration maps suggest that there are at least four distinct plutons of variable composition present in the granitoids. These can be defined in terms of their  $K_2O$ , CaO, and  $Na_2O$  contents.

The Henry River granitoid is characterized by high  $K_2O$ , high  $Na_2O$ , low CaO, and some high Rb values.

The Maroonah granitoid contains high  $K_2O$ , particularly east of Two Peaks where there are four anomalous values, but in general, the  $Na_2O$  content is lower. The Rb content, though high, appears slightly lower than over the Henry River granitoid. Again there is low CaO, but Sr values south of Maroonah Homestead are reasonably high.

The Mangaroon granitoid has high values of CaO, very high values of Sr and  $Na_2O$ , with relatively low  $K_2O$ .

The Yangibarra granitoid has high  $Na_2O$  and  $K_2O$ , moderate values of Rb, moderate to high values of Sr, and low values of CaO.

Further differences between the granitoids are shown by Nb (relatively high in the Yangibarra granitoid, quite low in the Mangaroon granitoid) and Ce, La, and Th (with two very high values for each over the Yangibarra granitoid and low values for Th and Ce, in particular, over the Mangaroon granitoid). Regolith over the Mangaroon granitoid lacks significant U. Barium values are high over the Maroonah and Yangibarra granitoids, slightly lower over the Mangaroon granitoid, and relatively low over the Henry River granitoid.

Regolith over granitoids of the Gascoyne Complex displays some of the highest overall values for  $Fe_2O_3$ , CaO,  $Na_2O$ , Ba, Ce, Ga, In, La, Sr, and particularly  $K_2O$  and Rb. The Yangibarra granitoid contains two samples with very high values of multiple elements: GSWA 150999 (300.49 ppm Ce, 144.84 ppm La, 44.94 ppm Th) and GSWA 151078 (905.6 ppm Ba, 162.29 ppm Ce, 75.24 ppm La). Two samples from the Maroonah granitoid also contain high multi-element concentrations: GSWA 151609 (215.71 ppm Ce, 110.22 ppm La,

52.38 ppm Th) and GSWA 151405 (329.82 ppm Rb, 36.2 ppm Th).

## Dolerite

Dolerites contain some of the highest overall concentrations of MgO, Cu, Cd, Mo, Ni, S, Se, Sr, U, Zn, and  $TiO_2$ . Spot concentration maps (Figures 5–51) appear to highlight compositional differences in the dolerites, and this is discussed further in the section on statistical analysis.

Several samples with high concentrations of multiple elements are located in three areas of dolerite. Such samples from the Collier Subgroup, in the far south-eastern corner of EDMUND, are GSWA 151314 (0.6 ppm Ag, 208 ppm Cu, 1.28% S, 294.22 ppm Sr, 11.47 ppm U); GSWA 151010 (2 ppb Pd, 7 ppb Pt); and GSWA 150114 (187 ppm Cu, 5 ppb Pt, 1084 ppm V). Samples from the Muntharra Tabletop region, between the Wyloo Group and the Discovery Chert, are GSWA 151333 (1.9 ppm Cd, 0.36% S, 348 ppm Zn); GSWA 151064 (126 ppm As, 2.7 ppm Cd, 31.7 ppm Mo, 0.98% S, 7 ppm Se, 10.91 ppm U, 438 ppm Zn); and GSWA 151332 (2.7 ppm Cd, 148 ppm Ni, 494 ppm Zn). One sample from west of the Edmund River drainage, near the Discovery Chert, with high values is GSWA 151580 (171 ppm Cu, 38.6 ppm Mo, 8.1 ppm Se, 6.82 ppm U).

## Calcrete

There are two large areas and several smaller areas with calcrete in drainages. The two largest areas are between Carinna Hill and Maroonah Homestead (overlying the Irregularly Formation in the lower part of the Edmund Subgroup) and in the Lyons River drainage (at the southern edge of the map sheet) extending a little way back into the Edmund River drainage.

The main areas of calcrete display isolated high values of CaO but little or no MgO, indicating that dolomite is minor or absent. Samples from calcrete areas do not have particularly high CaO, and this may be due to a later episode of silicification. In many cases the values recorded are consistent with those from nearby alluvium and colluvium and relate, at least in part, to underlying bedrock.

Of particular interest is the presence of Pb at the 50–100 ppm level over calcrete southeast of Maroonah Homestead. This appears to reflect the Irregularly Formation bedrock, as other samples over this formation south of this occurrence also show elevated Pb.

## Edmund River floodplain

The Edmund River is a tributary of the Lyons River and drains the upper part of the Edmund Subgroup, including the Discovery Chert, before passing over rocks of the lower part of the Edmund Subgroup and granitoids of the Gascoyne Complex. Some calcrete is present in the lower part of this system.

Samples taken from this drainage system do not reflect the composition of the underlying lithologies. This is shown by higher  $\text{Fe}_2\text{O}_3$ , Cr, In, Sc, V, and Zr and to a lesser degree by  $\text{TiO}_2$ ,  $\text{P}_2\text{O}_5$ , Ag, Cu, Ni, U, and Y. It can also be discerned by higher MnO and Co, and Ga, which is present in disproportionately high concentrations in this drainage basin. Some of the highest Ga values on the sheet are present here and are separated from, and enriched relative to,  $\text{Al}_2\text{O}_3$ . This phenomenon has been reported in laterites (Davy et al., 1991a), but is rare elsewhere.

The samples collected in this drainage come from a low-angle outwash fan, with material derived mostly from the upper Edmund Subgroup, which forms the high ground of the Barlee Range.

## Statistical treatment of regolith chemical data

Spot concentration maps (Figs 5–51) permit visual comparison of regolith chemistry with regolith unit and bedrock geology. However, in order to determine quantitatively any significant differences in regolith composition (e.g. between geological or regolith units), it is necessary to compare groups of data statistically.

Numerous statistical tests are available for comparing groups of data, provided these data are normally distributed. Unfortunately, many geological datasets (including regolith chemistry on EDMUND) follow a nonnormal distribution, in that the majority of element concentrations are low and only a few are high, giving a positive skew to the distribution (Koch and Link, 1970). The nonnormally distributed data must be transformed so that parametric tests of population difference can be applied. The most common transformation involves adding a constant to each value then log-transforming it (i.e.  $y = \log(x + C)$ , where  $x$  is the original element concentration and  $C$  is a constant, e.g. 10; Rock, 1988).

The Tukey's HSD (Honestly Significant Difference) test has been used for comparing multiple populations on EDMUND (Miller and Kahn, 1962; Rock, 1988). Tukey's HSD was carried out at the 95% confidence level. Elements at concentrations less than 10 times the detection limit are not discussed statistically, due to complications introduced at low levels. The arithmetic mean and standard deviation have also been determined for raw datasets, to be used in conjunction with log-normalized results from Tukey's HSD.

Spot concentration maps indicate that there may be two or more chemically distinct groups of dolerites on EDMUND. To confirm this, principal component analysis was applied to all regolith samples taken from areas of erosional dolerites (Emp). Before this, elements in the dolerites at concentrations less than 10 times the detection limit were removed from the dataset. Factor analysis of the dolerite dataset resolved the chemistry into two principal components: factor 1 —  $\text{SiO}_2$ ,  $\text{K}_2\text{O}$ , Be, Rb, Th, and U; and factor 2 —  $\text{P}_2\text{O}_5$ , Cu, Sn, Y, Zn, and Zr. On EDMUND, these dolerite groups do not appear to follow any stratigraphic division, and the factor analysis may

be influenced by surrounding non-doleritic rock types, indicated by the influence of  $\text{SiO}_2$ . Further work is recommended to chemically define and spatially locate these different groups of dolerites. Compositional differences were also identified between dolerites on MOUNT EGERTON (Morris et al., 1998).

Several geological units and regolith types have been tested in order to compare:

- element concentrations in erosional, colluvial, sheetwash, and overbank material from the Wyloo Group;
- element concentrations in erosional regolith from the Bangemall Group;
- erosional regolith over granitoids (Egp) and quartzofeldspathic metamorphic rocks (Egm) of the Gascoyne Complex.
- **Comparison between element concentrations in erosional, colluvial, sheetwash, and overbank material from the Wyloo Group**

In order to examine downslope changes in regolith chemistry, erosional (Egs), colluvial (Cgs), sheetwash (W), and overbank (O) regolith material from the Wyloo Group were statistically compared. The arithmetic mean and standard deviation for each regolith grouping are shown in Table 5.

Tukey's HSD highlighted statistically significant differences at the 95% confidence level, between two or more of the regolith regimes, for  $\text{SiO}_2$ ,  $\text{TiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ , MgO, CaO,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ,  $\text{P}_2\text{O}_5$ , Ag, Ba, Be, Bi, Cd, Ce, Cr, Cu, Ga, La, Nb, Rb, S, Sb, Sn, Sr, Ta, Th, U, V, Y, Zn, and Zr. The other elements were either too close to the detection limit or displayed no statistically significant difference between regolith regimes.

Erosional regolith over the Wyloo Group can be distinguished from other regolith on the basis of higher relative concentrations of  $\text{Al}_2\text{O}_3$ ,  $\text{K}_2\text{O}$ , As, Ba, Be, Bi, Ce, Ga, La, Nb, Rb, Sb, Sn, Th, and U. This is similar to the result for analysis of erosional-regime regolith over the Wyloo Group on TUREE CREEK (Coker et al., 1998). It is probable that some of these elements, particularly  $\text{Al}_2\text{O}_3$ , Ga, and  $\text{K}_2\text{O}$ , are contained in clay-rich rocks derived from argillaceous sedimentary rocks of the Wyloo Group. The highest overall concentrations for  $\text{Al}_2\text{O}_3$  in the Wyloo Group on EDMUND also support this observation.

Colluvium (Cgs) and sheetwash (W) are less easily distinguished from erosional and overbank regolith. Although between them they have the highest relative concentrations of  $\text{SiO}_2$ , MnO, CaO, As, and Pb, these elements are found at low levels and do not serve to distinguish Cgs and W either from each other or from erosional and overbank material. Colluvium (Cgs) in the Wyloo Group displays the lowest concentrations of MgO and Ba relative to the other regimes, an observation also made on TUREE CREEK (Coker et al., 1998). The breakdown of primary silicate minerals results in rapid downslope depletion of MgO (especially in colluvium), and its subsequent accumulation in regimes such as

Table 5. Mean and standard deviation for regolith-materials units Egs, Cgs, W, and O over the Wyloo Group

	Egs (n=82)		Cgs (n=25)		W (n=14)		O (n=33)	
	Mean	$\sigma$	Mean	$\sigma$	Mean	$\sigma$	Mean	$\sigma$
<b>Percentage</b>								
SiO <sub>2</sub>	68.02	4.96	75.46	6.29	71.26	9.17	66.92	6.77
TiO <sub>2</sub>	0.64	0.13	0.53	0.19	0.65	0.36	0.82	0.21
Al <sub>2</sub> O <sub>3</sub>	14.02	2.90	9.68	3.16	10.24	3.05	12.11	2.59
Fe <sub>2</sub> O <sub>3</sub>	8.23	1.83	7.49	1.74	8.78	3.59	9.14	1.51
MnO	0.129	0.068	0.133	0.067	0.134	0.061	0.120	0.035
MgO	1.19	0.35	0.96	0.33	1.14	0.59	1.53	0.50
CaO	0.26	0.34	0.21	0.30	0.79	1.09	0.74	0.54
Na <sub>2</sub> O	0.249	0.092	0.203	0.104	0.265	0.144	0.322	0.126
K <sub>2</sub> O	3.11	0.76	2.04	0.67	1.94	0.70	2.08	0.35
P <sub>2</sub> O <sub>5</sub>	0.059	0.014	0.052	0.018	0.072	0.038	0.088	0.034
LOI	3.80	0.79	2.96	0.94	4.44	3.18	5.28	1.65
<b>Parts per million</b>								
Ag	0.2	0.1	0.2	0.1	0.2	0.1	0.2	—
As	11	14	8	6	11	7	9	2
Au (ppb)	2	1	2	2	2	1	2	1
Ba	417.1	95.8	340.0	62.7	342.4	66.8	350.4	56.0
Be	2.3	0.5	1.7	0.5	1.7	0.5	1.7	0.4
Bi	0.90	0.38	0.67	0.30	0.69	0.39	0.44	0.20
Cd	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Ce	83.15	17.36	65.09	11.01	58.11	13.13	63.16	11.02
Co	18.2	5.1	17.6	6.9	17.8	4.9	20.8	6.0
Cr	93	21	81	25	98	29	110	20
Cu	37	14	31	9	37	11	46	14
Ga	19.1	4.0	13.4	4.5	14.3	4.4	17.0	3.8
In	0.06	0.02	0.04	0.01	0.05	0.02	0.06	0.02
La	40.77	8.62	30.35	6.55	28.20	6.69	30.49	4.70
Li	24.2	12.6	18.5	5.9	20.6	9.1	24.2	6.6
Mo	0.6	0.8	0.5	0.2	0.8	0.5	0.9	0.2
Nb	12.6	2.5	9.2	2.5	9.5	2.8	11.6	2.1
Ni	50	11	45	11	47	12	49	9
Pb	24	33	26	20	20	6	20	4
Pd (ppb)	—	1	—	—	—	1	1	1
Pt (ppb)	1	1	—	1	1	1	1	1
Rb	161.93	39.56	110.97	37.21	105.01	41.32	109.53	22.56
S (%)	0.02	0.01	0.02	0.01	0.02	0.02	0.04	0.04
Sb	5.21	4.19	3.46	1.92	3.56	2.02	3.78	8.92
Sc	15	3	11	4	12	4	16	4
Se	0.1	0.2	—	—	0.1	0.2	—	0.1
Sn	2.9	0.6	2.1	0.7	2.1	0.6	2.3	0.5
Sr	37.52	12.83	26.46	11.08	40.99	18.53	48.03	14.50
Ta	0.56	0.34	0.39	0.14	0.54	0.25	0.66	0.33
Te	0.1	0.1	0.1	0.1	0.1	0.1	—	0.1
Th	16.84	3.45	12.25	2.65	11.55	2.94	12.18	1.75
U	2.88	0.98	2.04	0.38	2.12	0.43	2.16	0.64
V	104	26	88	30	118	65	141	36
W	1.6	0.7	1.4	0.5	1.3	0.4	1.3	0.4
Y	13.67	3.05	11.90	4.59	13.98	5.53	17.71	5.04
Zn	71	34	59	13	68	25	73	16
Zr	150	25	136	39	143	54	187	45

NOTES: Trace elements in parts per million unless otherwise specified  
 n: number of samples  
 $\sigma$ : standard deviation  
 —: less than detection limit

Regolith-materials units:  
 Egs: outcrop, subcrop, and bouldery lag derived from quartzofeldspathic sedimentary rock  
 Cgs: colluvium derived from quartzofeldspathic sedimentary rock  
 W: distal sheetwash; minimum gradient; poorly defined drainage  
 O: overbank alluvial deposits

hardpan and alluvium. This appears to be the case on EDMUND, with the highest concentrations of MgO found in overbank material (Sanders et al., 1997). Sheetwash material, along with overbank material, contains the highest concentrations of CaO, which is most probably derived from calcrete.

Overbank regolith material in the Wyloo Group can be characterized by higher relative concentrations of TiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, MgO, Na<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub>, Cr, Cu, S, Sc, Sr, Ta, V, Y, Zn, and Zr. It is likely that many of these elements are locked up in detrital minerals, or have accumulated with Fe<sub>2</sub>O<sub>3</sub> in colluvium. The presence of



**Table 6. Mean and standard deviation for erosional regolith over the Edmund Subgroup, Collier Subgroup, and Discovery Chert**

	<i>Collier</i> ( <i>n</i> =49)		<i>Discovery</i> ( <i>n</i> =9)		<i>LESG</i> ( <i>n</i> =144)		<i>UESG</i> ( <i>n</i> =130)	
	<i>Mean</i>	<i>σ</i>	<i>Mean</i>	<i>σ</i>	<i>Mean</i>	<i>σ</i>	<i>Mean</i>	<i>σ</i>
<b>Percentage</b>								
SiO <sub>2</sub>	64.25	6.91	62.89	8.13	71.00	12.56	57.33	9.88
TiO <sub>2</sub>	1.49	1.15	1.69	1.02	1.17	1.19	2.74	1.43
Al <sub>2</sub> O <sub>3</sub>	12.50	1.87	11.66	1.15	7.96	3.01	11.08	2.02
Fe <sub>2</sub> O <sub>3</sub>	11.55	3.94	11.47	3.33	10.10	5.99	14.64	3.83
MnO	0.144	0.082	0.204	0.189	0.199	0.176	0.329	0.224
MgO	1.45	0.78	2.00	1.27	1.69	1.69	2.56	1.26
CaO	1.10	1.32	1.80	1.39	1.96	2.51	3.56	2.27
Na <sub>2</sub> O	0.320	0.339	0.343	0.293	0.419	0.538	0.804	0.505
K <sub>2</sub> O	2.80	0.79	2.21	0.33	1.59	0.93	1.75	0.65
P <sub>2</sub> O <sub>5</sub>	0.104	0.076	0.151	0.046	0.102	0.064	0.191	0.068
LOI	4.40	0.71	5.37	1.16	3.80	1.92	4.94	1.39
<b>Parts per million</b>								
Ag	0.2	0.1	0.4	0.2	0.3	0.2	0.2	0.1
As	8	5	29	18	16	17	8	6
Au (ppb)	1	1	1	1	1	1	1	1
Ba	482.3	88.4	344.6	120.5	366.6	170.1	471.6	133.1
Be	2.3	0.5	2.0	0.5	1.5	0.6	1.6	0.4
Bi	0.40	0.15	0.43	0.17	0.36	0.48	0.21	0.14
Cd	0.1	0.2	0.5	0.3	0.3	0.5	0.1	0.1
Ce	76.50	12.76	76.00	10.55	63.67	19.56	77.42	18.05
Co	23.1	9.8	28.6	20.8	26.1	17.6	40.4	15.0
Cr	118	52	113	40	83	71	88	50
Cu	52	40	96	24	53	35	77	29
Ga	18.7	2.9	17.5	2.0	12.4	5.4	17.9	3.4
In	0.07	0.02	0.08	0.01	0.05	0.03	0.07	0.02
La	34.09	5.40	37.69	7.20	27.21	9.00	33.53	7.27
Li	25.8	8.6	22.3	3.8	18.7	8.9	14.7	4.0
Mo	1.3	1.9	9.5	7.0	3.7	4.5	1.7	1.3
Nb	15.8	4.6	17.5	4.9	11.8	6.0	21.2	7.7
Ni	52	20	74	27	47	23	65	18
Pb	23	6	24	5	32	28	19	12
Pd (ppb)	—	—	—	1	—	1	—	—
Pt (ppb)	1	1	1	1	1	1	1	1
Rb	150.56	44.46	102.16	17.54	75.08	48.42	76.91	32.26
S (%)	0.03	0.03	0.14	0.21	0.05	0.09	0.02	0.03
Sb	0.87	0.42	3.74	2.16	2.30	2.11	0.90	1.00
Sc	16	5	17	4	13	9	20	6
Se	0.4	0.5	2.6	2.1	0.8	1.1	0.5	0.6
Sn	2.6	0.8	2.2	0.2	1.7	0.6	2.3	0.7
Sr	52.62	36.50	94.99	28.58	62.58	48.82	116.15	50.28
Ta	0.97	0.56	0.80	0.46	0.65	0.43	1.35	0.72
Te	—	0.1	0.1	0.1	0.1	0.1	—	0.1
Th	13.53	2.91	9.90	2.40	9.43	4.73	7.95	3.09
U	2.50	0.80	3.08	1.17	2.26	1.39	1.57	0.52
V	238	161	379	116	256	215	428	181
W	1.5	1.0	1.1	0.3	0.9	0.5	1.1	0.5
Y	20.50	6.32	22.98	6.00	17.50	7.49	30.32	10.36
Zn	97	31	168	107	99	83	103	31
Zr	183	40	190	40	151	62	221	57

NOTES: This table does not include any Emp-derived regolith  
Trace elements in parts per million unless otherwise specified  
n: number of samples  
σ: standard deviation  
—: less than detection limit

Collier: Collier Subgroup  
Discovery: Discovery Chert  
LESG: lower Edmund Subgroup  
UESG: upper Edmund Subgroup

mafic elements in regolith of the Wyloo Group may be related to the presence of mafic volcanic rocks, as observed by Thorne and Seymour (1991), or it may indicate derivation from mafic-rich sedimentary rocks.

#### • Comparison between element concentrations from erosional regolith from the Bangemall Group

Statistical comparison of geological units using only samples of erosional regolith minimizes the compos-



itional variations due to weathering and transportation. The arithmetic mean and standard deviation of erosional units from the lower Edmund Subgroup, upper Edmund Subgroup, Discovery Chert, and Collier Subgroup are presented in Table 6.

Despite the small sample population (n=9), statistical analysis of erosional regolith over the Discovery Chert indicates that it contains significantly higher concentrations of a number of elements, relative to other erosional regolith in the Bangemall Group. These elements include As, Cu, Mo, Ni, Sb, Se, U, and Zn, and may indicate mineralization potential. High concentrations of Bi, Cr, and Rb are also found, but these tend to be high in the Collier Subgroup also. In addition, regolith over the Discovery Chert displays high Sr, a characteristic it shares with regolith over the upper Edmund Subgroup.

Regolith over the Collier Subgroup can be distinguished from other geological groupings on the basis of higher relative concentrations of  $\text{Al}_2\text{O}_3$ ,  $\text{K}_2\text{O}$ , Ba, Be, Cr, Ga, Li, Th, W, and particularly Rb. In a statistical analysis of erosional-regime regolith over the Edmund and Collier Subgroups on MOUNT EGERTON, Morris et al. (1998) also reported higher concentrations for most of these elements over the Collier Subgroup.

Regolith derived from the lower Edmund Subgroup displays the highest relative concentrations of  $\text{SiO}_2$ , and in this regard is significantly different from regolith over the upper Edmund Subgroup, Collier Subgroup, and Discovery Chert. Surprisingly, the Discovery Chert regolith has the second lowest mean concentration of  $\text{SiO}_2$  at 62.89%, a result that may reflect the low sample population. The lower Edmund Subgroup regolith also displays the highest values of Pb, with a mean concentration of 32 ppm.

Chemically distinguishing characteristics of regolith derived from the upper Edmund Subgroup include high relative concentrations of  $\text{Fe}_2\text{O}_3$ ,  $\text{TiO}_2$ , MnO, MgO, CaO,  $\text{Na}_2\text{O}$ ,  $\text{P}_2\text{O}_5$ , Co, Nb, Sc, Ta, and particularly Sr, V, Y, and Zr. The prevalence of these elements almost certainly relates to the presence of numerous dolerite dykes and sills in this subgroup. In addition, some of these elements are commonly found in detrital minerals (e.g. Nb and Zr).

#### • Comparison between erosional regolith over granitoids (Egp) and quartzofeldspathic metamorphic rocks (Egm) of the Gascoyne Complex

Statistical comparison of regolith over granitoids and metasedimentary rocks of the Gascoyne Complex has yielded some distinctive compositional differences (Table 7). Regolith derived from granitoid is characterized by higher  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ , Ba, Rb, and Sr, and to a lesser degree by higher  $\text{Al}_2\text{O}_3$  and CaO.

Metasedimentary rocks produce regolith with higher MnO, MgO, Cr, Ni, Ta, W, and Y. Although these plot as significantly different according to Tukey's HSD, concentrations are either close to detection level or similar to those in the granitoids.

**Table 7. Mean and standard deviation for erosional regolith over Gascoyne Complex rocks**

	Egm		Egp	
	Mean	$\sigma$	Mean	$\sigma$
<b>Percentage</b>				
$\text{SiO}_2$	82.20	3.18	80.30	3.66
$\text{TiO}_2$	0.38	0.22	0.30	0.16
$\text{Al}_2\text{O}_3$	8.41	1.65	9.34	1.61
$\text{Fe}_2\text{O}_3$	2.96	1.11	2.91	2.32
MnO	0.057	0.041	0.037	0.018
MgO	0.55	0.18	0.44	0.18
CaO	0.64	0.57	0.92	0.78
$\text{Na}_2\text{O}$	0.856	0.398	1.290	0.506
$\text{K}_2\text{O}$	2.68	0.81	3.53	1.09
$\text{P}_2\text{O}_5$	0.037	0.013	0.043	0.017
LOI	1.45	0.78	1.27	0.66
<b>Parts per million</b>				
Ag	0.2	0.1	0.1	0.1
As	1	2	1	1
Au (ppb)	1	1	1	1
Ba	423.1	120.8	573.7	177.1
Be	1.4	0.5	1.6	0.6
Bi	0.25	0.24	0.18	0.23
Cd	—	—	—	—
Ce	53.06	37.39	46.46	41.98
Co	6.8	6.1	5.2	3.3
Cr	28	13	22	25
Cu	10	5	9	4
Ga	10.0	2.2	10.7	2.2
In	0.02	0.01	0.02	0.01
La	25.89	18.85	22.70	19.98
Li	14.5	4.4	13.8	5.4
Mo	0.4	0.9	0.3	0.3
Nb	8.6	4.3	9.2	7.2
Ni	14	4	12	12
Pb	22	7	25	8
Pd (ppb)	—	—	—	—
Pt (ppb)	—	—	—	—
Rb	117.68	38.58	148.42	63.38
S (%)	0.01	0.01	0.01	0.01
Sb	0.20	0.40	0.14	0.14
Sc	5	2	4	2
Se	—	0.1	—	0.1
Sn	1.8	0.5	1.6	0.6
Sr	67.72	35.76	116.84	59.84
Ta	1.06	0.55	0.80	0.58
Te	—	—	—	—
Th	13.44	8.66	11.58	8.14
U	1.89	0.59	1.74	0.65
V	48	28	51	55
W	1.5	0.8	1.2	0.7
Y	8.126	4.236	6.648	2.146
Zn	25	8	21	7
Zr	92	32	80	27

NOTES: Trace elements in parts per million unless otherwise specified

$\sigma$ : standard deviation

—: less than detection limit

Regolith-materials units:

Egm: Outcrop, subcrop, and bouldery lag derived from quartzofeldspathic metamorphic rock

Egp: Outcrop, subcrop, and bouldery lag derived from quartzofeldspathic plutonic rock

Comparison of the chemistry of the regolith overlying different granitoid bodies, as identified in the discussion on the spot concentration plots, has not been carried out, but provides scope for further study.

## Speciality maps

### Regolith pH and total dissolved solids

A contoured map of regolith pH is presented as Figure 52. Results from total dissolved solids (TDS) determinations have not been contoured, as almost all were below detection level. Actual results for pH and TDS for each sample site are included with the digital datafile (EDMUND.CSV).

Areas of consistently acidic pH are found in regolith over the Wyloo Group and, to a lesser extent, the Gascoyne Complex. A small area of alkaline regolith in the Gascoyne Complex corresponds to sheetwash and calcrete adjacent to the Lyons River drainage. Areas of more neutral pH in the Wyloo Group correspond to the Ashburton River floodplain, which consists of large areas of overbank and sheetwash material. Acid regolith is also found in parts of the Collier Subgroup and south of the Barlee Range in the lower Edmund Subgroup. More neutral to alkaline pH is identified in regolith of the upper Edmund Subgroup and parts of the lower Edmund Subgroup (especially in the Muntharra Tabletop region).

### Element-index maps

Smith and Perdrix (1983) and Smith *et al.* (1989) showed how pathfinder elements and additive indices could be used to highlight areas of mineralization in arid terrains of the Yilgarn Craton. Although they concentrated on limited types of sample media (predominantly ferruginized duricrust or laterite), the use of additive indices here has been adapted and extended to include all media types sampled in the GSWA regional regolith and geochemical mapping program. For example, Kojan *et al.* (1996a,b) showed how a greenstone chalcophile index could be used to identify areas of known and potential gold mineralization on SIR SAMUEL. Indices are usually additive (i.e. element a + element b + element c), but account must be taken of the relative concentration and concentration range of each element. The first step is to log-transform the data, which reduces the effect of extremely high or low values. The transformed data are then standardized, which involves expressing each value as a standard normal deviate, thus allowing direct comparison of elements regardless of concentration (Rock, 1988). The geologically standardized scores are then summed to create an elemental association suite.

Four element-index plots have been compiled for EDMUND. These consist of a base-metals index (Fig. 53), chalcophile index (Fig. 54), ferro-alloy index (Fig. 55), and a metalliferous black-shale index (Fig. 56).

### Base-metals index

Summed standard scores for base metals (Cu + Pb + Zn + Sb + As + Bi) are contoured in Figure 53. As expected, the index plot shows lowest values over regolith of the Gascoyne Complex. The small sliver of Bangemall Group

rocks in the High Range area, within Gascoyne Complex rocks, is clearly delineated by this plot. As with several other spot maps, the Edmund River drainage is clearly highlighted. High values are present in a line north and south of the Mount Palgrave area (known to be associated with Cu and Pb mineralization) and in the Muntharra Tabletop region. Other high values are found in dolerite over the Collier Subgroup (especially in the far southeastern corner) and over the lower Edmund Subgroup, south of the Barlee Range area. The base-metals index plot does not appear to highlight any areas with strong associations of these elements in the upper Edmund Subgroup.

### Chalcophile index

A contoured chalcophile index plot (Fig. 54) summarizes summed standard scores for As, Ag, Bi, Cd, Sb, Mo, Se, and W. There is good correlation between characteristic elements for regolith in the Muntharra Tabletop region. This index plot further highlights this area, which is found between the Wyloo Group and the Discovery Chert. It also highlights areas of dolerite, particularly in the lower Edmund Subgroup and in the Collier Subgroup in the far southeastern corner of EDMUND. These elements may provide a clue as to the composition of different groups of dolerites on EDMUND, as this index plot does not highlight the dolerites in the upper Edmund Subgroup. Relative to the remainder of the Gascoyne Complex, slightly higher values for the summed elements are displayed in the Mangaroon and Yangibarra granitoids. The remainder of the Gascoyne Complex, particularly the metasedimentary rocks and the Henry River granitoid, display consistently low values for the summed elements.

### Ferro-alloy index

The ferro-alloy index plot (Fig. 55) summarizes summed standard scores for Ni, Cr, Mo, Co, and V. It shows consistently high values in regolith over rocks of the Edmund Subgroup and is most probably related to the numerous dolerite dykes and sills that intrude it. Particularly high values for this index plot are displayed in the Muntharra Tabletop region and over dolerite of the Collier Subgroup, in the far southeastern part of the map sheet. This plot suggests that there may be subtle compositional differences between dolerites within the Collier Subgroup. Dolerites between the Kenneth and Godfrey Ranges have higher values than dolerites south of the Minierra Range. The area south of the Barlee Range, in the central-southern region of EDMUND, also has high values for the ferro-alloy elements. This is probably influenced by the highest overall values for Cr being in this area, although all the other elements also show fairly high values. Ferro-alloy elements commonly show low values over the Wyloo Group and even lower values over the Gascoyne Complex.

### Metalliferous black-shale index

Highest overall values for summed standard scores for black-shale elements (V + Cr + Co + Ni + Cu + Zn + Ag

+ Cd + Pb + U + As + Se + Sb + Ti + Ba + Na + La + Ce + Zr) are found in regolith in the Muntharra Tabletop region, an area that is host to strongly sulfidic black shale and dolerite (Fig. 56). High values are also displayed over the upper Edmund Subgroup (particularly the Ullawarra Formation) and in the area of dolerite between the Kenneth and Godfrey Ranges in the Collier Subgroup. Lower values correspond to the Wyloo Group, lower parts of the lower Edmund Subgroup, and the Gascoyne Complex.

## Mineralization potential

Various mines, prospects, and mineral occurrences are reported on EDMUND, and the area has a long history of base-metal and gold production, highlighted by total production of almost 2700 t of Pb, and 260 kg of Au (Appendix 1). Sites of high production include the Kooline Lead Field, and the Star of Mangaroon mine (Blockley, 1971). Thus, EDMUND has demonstrated base-metal and gold potential, which will be discussed in terms of several element associations.

### S, Se, As, Cd, Zn, Mo, Ag

The element concentration maps for S and Se (Figs. 37 and 40) indicate the presence of substantial amounts of sulfides, particularly in the Discovery Chert, lower Edmund Subgroup, and over dolerites. Some areas of regolith with high S also have elevated concentrations of As, Cd, Zn, Ag, and Mo. In particular, the areas near Muntharra Tabletop and Mount Palgrave must be considered prospective.

### Lead

Although high Pb in regolith does not coincide with elevated S, there are several areas (such as the Kooline mines) where small, rich lead lodes are developed. Regolith chemistry (Fig. 33) has found elevated Pb values at Kooline in the Wyloo Group, as well as a higher value of 299 ppm in GSWA 151131 from the southern end of the Capricorn Range near Bali Hi. Other high values northeast of Edgar Peak may correspond to more extensive Kooline-type veins in the Wyloo Group.

Lead values in regolith are not high near other known prospects, such as the Star of Mangaroon, Joy Helen, and Monte Carlo. However, there are elevated Pb values in a north-south line over the Irregularly Formation (in the western part of the map sheet, east of the Henry River) extending south of the Mount Padbury area. As noted previously, Pb is also present in calcrete southwest of Mount Padbury.

Other isolated high Pb values east of Muntharra Tabletop and southeast of Wanna Hill, in the southernmost part of EDMUND, may also reflect mineralized veins.

### Gold

Traces of gold have been found at various prospects on EDMUND, but the absolute values determined by this study

are a maximum of 9 ppb. There is a tendency for higher values to be present in the Wyloo Group (Fig. 17).

## Copper

There are several copper prospects on Edmund (such as Star of Mangaroon, Bali Hi, and Bali Lo), but in these areas Cu is commonly low in regolith (Fig. 25). The maximum value of Cu on EDMUND is 208 ppm and most high values appear to be related to dolerites, although Cu values exceeding 100 ppm are found in regolith over black shales in the Muntharra Tabletop region.

### Cr, Ni, Pd, Pt

Elevated values for these elements in regolith are usually found near areas of mafic rocks, with maximum values for Cr, Ni, Pd, and Pt being 739 ppm, 156 ppm, 3 ppb, and 7 ppb respectively. On the southern side of the Barlee Range a zone of higher Cr values (between 500 and 740 ppm) is present in regolith possibly derived from the Discovery Chert (Fig. 24). The origin of these high values is unclear, although they may reflect metasomatically derived Cr or silicification of mafic to ultramafic rocks within the Discovery Chert.

### Ce, La, Th, U

A large number of rare-earth element prospects are reported in the Yangibarra granitoid, and two regolith samples (GSWA 150999 and 151078) from this area have anomalous concentrations of Ce (Fig. 22) and La (Fig. 28). Samples GSWA 150999 and 151281 also have high Th (Fig. 45).

The maximum concentration of U is 11.5 ppm (Fig. 46), but it is not commonly associated with Ce, La, or Th. Four high values for U are present in the Muntharra Tabletop region, between the Wyloo Group and the Discovery Chert, and may represent U trapped in reducing conditions in association with sulfides.

## Other elements

There are anomalous values of Sb (maximum of 52 ppm; Fig. 38) and Bi (maximum of 4.2 ppm; Fig. 20), with the highest values found in regolith over the Wyloo Group. These elements are associated with the Pb and Cu mineralization of the Wyloo Group (Blockley, 1971; Marston, 1980; Davy et al., 1991b) and the highest values in the regolith may indicate the presence of mineralized veins. The two anomalous Bi values (4.23 ppm, GSWA 150938; 3.18 ppm, GSWA 151425) in the Telfer River catchment (west of the Henry River granitoid) are associated with higher W values (Fig. 48), and may indicate a mineralized contact.

The highest Ta values (more than 3 ppm and a maximum of 4.9 ppm; Fig. 43) are found in regolith of the upper Edmund Subgroup, usually associated with

dolerite. Elevated Ta in regolith is usually associated with high Nb. Tellurium is highest (0.5 ppm) in samples with elevated chalcophile-element abundances.

Maximum values for Sn and W (8.1 and 5.9 ppm respectively) are very low, and variations in these elements can be interpreted in lithological terms, in that Sn is commonly higher in regolith over the Wyloo Group and upper Edmund Subgroup.

## Discussion

Regional-scale regolith and geochemical mapping on EDMUND involved the collection of 1054 regolith samples representing a nominal sample density of one sample per 16 km<sup>2</sup>. Each sample has been analysed for 50 components (major-element oxides and trace elements), acidity-alkalinity (pH), and total dissolved solids. These data are presented as either spot concentration or contour maps.

EDMUND is one of the latest regolith-materials maps to employ a new regolith classification scheme. The three-tiered scheme firstly divides regolith on the basis of relict, erosional, or expanded depositional regimes. Secondary and tertiary qualifiers are then used to further subdivide the regolith according to composition and rock type (e.g. ferromagnesian, plutonic). Erosional-regime regolith, consisting mostly of eroded quartzofeldspathic sedimentary rocks (Egs), is predominant on EDMUND, occupying 66% of the map sheet area. Depositional-regime regolith comprises 33% of regolith on EDMUND, with large areas corresponding to the Ashburton and Lyons river drainages. Less than one percent of the map sheet is covered by relict-regime regolith.

Quality control on regolith chemical data included the analysis of a number of GSWA reference standards and duplicates with each batch of samples. Laboratory standards and duplicates were also repeatedly analysed in each batch. Fifteen samples with anomalous results were sent to a second laboratory for reanalysis. Where there was significant inter-laboratory disagreement, samples were reanalysed. Precision and accuracy are shown to be within acceptable limits, except for Zn values in laboratory duplicates and for Sr in one laboratory standard.

Chemical analysis of regolith shows very strong correlation with the underlying bedrock. High Al<sub>2</sub>O<sub>3</sub>, Ga, Bi, and Sb characterize rocks of the Wyloo Group of the Ashburton Basin. The Wyloo Group also has a high proportion of regolith samples with Au concentrations above the detection limit. The Capricorn Formation of the Blair Basin is compositionally very similar to the Wyloo Group, although it can be distinguished on the basis of lower Sb and Bi concentrations.

Regolith derived from the lower Edmund Subgroup in the Bangemall Basin displays a wide range of element concentrations due to its diverse lithological composition.

It commonly has much lower clay content than the Wyloo Group, represented by low Al<sub>2</sub>O<sub>3</sub> and Ga. A tract of sulfidic black shales and dolerites between the southern margin of the Wyloo Group and the northern margin of the Discovery Chert (Muntharra Tabletop region) contains high concentrations of Li, Rb, Co, Cu, Ni, Sc, V, Y, As, Cd, and Mo. Trace elements over this area, and over other areas of dolerite, tend to be higher than over purely sedimentary rocks. Numerous sample sites with high concentrations of multiple elements have also been identified in the lower Edmund Subgroup, many of which are in the Muntharra Tabletop region. Barium is commonly lowest in regolith over the lower Edmund Subgroup. The Discovery Chert, at the base of this subgroup, contains several samples with high concentrations of a number of elements of economic interest, including Mo, S, As, and Sb.

The upper Edmund Subgroup is intruded by numerous dolerite dykes and sills and this is strongly reflected in the regolith chemistry. Relative to other units on EDMUND, the upper Edmund Subgroup commonly contains the highest values of MnO, Co, Nb, Ta, and Y. The lower part of this subgroup (corresponding to the Ullawarra Formation) displays moderate to high values of TiO<sub>2</sub>, MgO, CaO, MnO, P<sub>2</sub>O<sub>5</sub>, Nb, Sc, V, and Co relative to the overlying units. Elements showing relatively uniform distribution over this subgroup include Li, Rb, Cu, In, Ni, Ta, U, Ce, La, Ba, and Be.

Compared with the Edmund Subgroup, regolith over the Collier Subgroup contains higher K<sub>2</sub>O, Rb, and Li. Regolith over mafic intrusive rocks is similar to regolith over the upper Edmund Subgroup. Some of the higher values for Ni, Pt, Sn, and W are found in the Collier Subgroup.

Regolith over the Gascoyne Complex highlights areas of both metasedimentary rocks and granitoids. Moderate to low Al<sub>2</sub>O<sub>3</sub> and Ga, and moderately high K<sub>2</sub>O, Li, and Rb characterizes regolith over metasedimentary rock. Four chemically distinct granitoid plutons have been identified.

Spot concentration maps, factor analysis of chemical data, and the element-index maps have highlighted what may be a compositional difference in dolerites.

Base-metal, chalcophile, ferro-alloy, and metalliferous black-shale additive index plots closely resemble the chemistry of the underlying bedrock, and can be useful in identifying areas of potential mineralization. All four index plots highlight an area of strongly sulfidic black shales and dolerites in the lower Edmund Subgroup. Other areas with anomalous element concentrations, such as areas of high Nb, Th, Cr, Ga, In, V, Mo, and Se south of the Barlee Range area, return high values in the index plots.

Spot concentration maps have been used in conjunction with statistical analysis of regolith chemical data and element-index plots to highlight areas of potential

mineralization in the Discovery Chert (As, Cd, Zn, Mo), as well as small-scale Pb mineralization, similar to the Kooline lodes, in the Wyloo Group, and Pb and Cu in the Wyloo Group. There is further possibility of Pb mineralization north and south of the Joy Helen prospect, and in calcrete south of this area. Copper ( $\pm$  Pb  $\pm$  Zn) and U are found in black shales between the southern margin of the Wyloo Group and the northern margin of the Discovery Chert (Muntharra Tabletop region).

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## Appendix 1

# Production from mines and prospects on EDMUND prior to 30 June 1997

Table 1.1. Lead production from EDMUND prior to 30 June 1997

Mining centre	Year	Mine/prospect or owner	Tenements	WAMIN deposit number	Location (AMG)		Production		
					Easting	Northing	Ore & conc (t)	Metal (t)	Silver (kg)
Kooline	1948	Hamilton, Dunlop, & Camp	PA 8/200	256	442798	7444245	28.0	21.13	6.33
	1951–53	Beadon	ML 8/140		442798	7444245	104.1	69.67	17.91
	1948–49	A. C. Bellchambers	PA 8/232 <sup>1</sup>		445100	7443600	7.8	5.49	4.45
	1948–49	Camp & Dunlop	MC 8/03	253	442351	7443402	16.3	11.10	3.77
	1951–58	Dingo	ML 8/143		442351	7443402	293.7	212.74	72.11
	1948–52	Bandys Peak	ML 8/119	259	443384	7443326	57.3	46.32	5.79
	1948–52	Silver King	ML 8/124	260	443344	7442348	36.8	24.78	5.46
	1948–54	South Kooline	ML 8/121	257	445171	7443807	95.0	61.53	18.56
	1948–54	Kooline Queen	ML 8/120	258	444195	7443999	81.2	59.52	14.04
	1948–49	Bagoes Syndicate	PA 8/213	251	443495	7443645	20.3	13.78	7.40
	1949	F. Holden & Party	PA 8/213		443495	7443645	27.1	18.43	7.25
	1949–55	June Audrey	ML 8/135		443495	7443645	595.9	434.40	139.67
	1957–58	Redcraze	ML 8/163		443495	7443645	58.7	45.41	12.28
	1948–57	Gift	ML 8/122	250	445041	7443326	1 234.2	946.99	260.09
	1948–59	Bilrose	ML 8/118	252	444451	7443803	466.4	333.38	140.08
	1949	Carnegie	ML 8/127 <sup>1</sup>		446700	7442900	1.8	1.28	0.47
	1949	E. Shanks	PA 8/239 <sup>1</sup>		451000	7447900	9.8	5.90	3.10
	1949	Ballard & Carson	PA 8/240 <sup>1</sup>		445200	7446700	6.5	4.74	1.74
	1949	E. Reck	PA 8/244 <sup>1</sup>		448400	7443200	1.4	1.04	0.32
	1953	Ballard, Shanks, & Howie	PA 8/297		448400	7443200	2.2	1.62	0.34
	1949–50	V. P. Joy & M. Brennan,	PA 8/230		nd	nd	24.9	16.98	6.11
	1949–50	Mount Conspicuous	ML 8/133,142	264	446246	7441946	2.7	1.82	0.57
	1949	M. Brennan	PA 8/233 <sup>1</sup>		448100	7443400	8.0	5.54	2.14
	1951	J. E. Illingsworth	PA 8/262		448100	7443400	7.2	5.77	1.25
	1949–53	Phar Lap	ML 8/123	263	442005	7443645	15.8	10.42	137.16
	1949–57	Ridge	ML 8/126,155	254	441416	7445844	268.1	208.40	60.18
	1950	Iverson & Crossley	PA 8/260		nd	nd	1.9	1.22	0.30
	1950–52	Big Chief	ML 8/136		459062	7436120	22.5	8.04	0.40
	1951–56	Roebuck	ML 8/156	249	445301	7443999	42.6	29.70	9.45
	1957	Roebuck Lead Mine	PA 8/315		445301	7443999	34.8	26.25	7.90
	1952	A. J. Jenkin	PA 8/270		447800	7443900	2.1	1.60	0.51
	1952	J. D. Downie	Crown Land		na	na	2.2	1.33	0.36
	1952–53	Rainbow	ML 8/138	261	444997	7442522	8.3	6.14	1.86
	1957	Campsite	ML 8/161		444997	7442522	8.8	6.20	1.85
	1953	Jenson & Jacobson	PA 8/283 <sup>1</sup>		448400	7442900	5.3	3.46	0.68
	1954	E. Green & D. Woddsbey	PA 8/300 <sup>1</sup>		429900	7456200	27.0	19.17	4.96
	1957–58	F. A. Griffiths	PA 8/316 <sup>1</sup>		431500	7455300	10.5	7.56	0.99
Mangaroon	1956, 60	Bohan & McDonald	MC 49/04	233	371521	7360951	11.4	8.30	2.94
Monte Carlo	1948	McConnell & Moore	MC 8/1	242	351197	7449988	4.4	2.41	2.160
	1949	E. Shanks	ML 8/111		351197	7449988	13.8	8.35	2.490
<b>Total</b>							<b>3 666.5</b>	<b>2 697.91</b>	<b>965.42</b>

**SOURCE:** DEPARTMENT OF MINES, 1954, List of cancelled gold mining leases which have produced gold: Perth, Western Australia, 271p  
Appendix 1 is a collation of all available data from published and unpublished sources, as reported to the Department of Minerals and Energy's (DME's) royalties branch

**NOTES:** <sup>1</sup> Coordinates determined from public plan SP127(2); the accuracy of some tenement locations is uncertain  
nd: not determined  
na: not applicable  
conc: concentrate  
The coordinates identify the centre of the tenement(s) listed, determined from survey diagrams, mining registers, tenement applications, public plans, and TENGGRAPH (Department of Minerals and Energy's electronic tenement-graphics system). Localities are specified by the Australian Map Grid (AMG) standard reference system  
Where a WAMIN deposit number has been listed against the tenement(s), the location information has been taken from the Western Australia Mineral Occurrence (WAMIN) database



Table 1.2. Gold production from EDMUND prior to 30 June 1997

Mining centre	Year	Mine/prospect or owner	Tenements	WAMIN deposit number	Location (AMG)		Production		Total metal (kg)	Silver (kg)
					Easting	Northing	Ore & conc (t)	Metal (t)		
Mangaroon	1961–83	Star of Mangaroon <sup>2</sup>	GML 9/46	232	372172	7359679	4 742.0	185.57	185.57	3.20
	1980	Popeye	GML 9/71		nd	nd	–	–	0.08 <sup>3</sup>	–
	1981–82	Diamonds	GML 9/72	1402	354200	7358600	211.0	2.44	2.44	–
	1983	A. P. McDonald	M 9/02		373130	7360490	25.0	0.13	0.13	–
	1987	Ashburton Mining Corp	M 9/02		373130	7360490	–	–	0.04 <sup>3</sup>	–
	1983–85	North Star	GML 9/70		371610	7360970	189.0	1.71	5.02 <sup>3</sup>	0.07
	1989	E. J. Kempton	M 9/50		367470	7366840	–	–	4.63 <sup>3</sup>	0.63
	1960–88	Sundry claims			na	na	418.8	16.47	25.90 <sup>3</sup>	2.17
Mount Mortimer	1995–96	Mount Mortimer	M 8/66,71,105		455810	7431060	–	–	4.98 <sup>3</sup>	–
	1928–88	Sundry claims			na	na	45.0	1.25	28.46 <sup>3</sup>	2.48
	<b>Total</b>						<b>5 630.8</b>	<b>239.88</b>	<b>257.25</b>	<b>8.55</b>

**SOURCE:** DEPARTMENT OF MINES, 1954, List of cancelled gold mining leases which have produced gold: Perth, Western Australia, 271p  
Appendix 1 is a collation of all available data from published and unpublished sources, as reported to the DME royalties branch.

**NOTES:** <sup>2</sup> Has a measured and indicated resource of 0.047 Mt and 0.809 t contained gold

<sup>3</sup> Includes alluvial/dollied gold

conc: concentrate

nd: not determined

na: not applicable

The coordinates identify the centre of the tenement(s) listed, determined from survey diagrams, mining registers, tenement applications, public plans, and TENGGRAPH (Department of Minerals and Energy's electronic tenement-graphics system). Localities are specified by the Australian Map Grid (AMG) standard reference system

'Sundry claims' refers to prospects and small deposits that were permitted to treat a maximum of 50 tonnes of ore per annum.

Where a WAMIN deposit number has been listed against the tenement(s), the location information has been taken from the Western Australia Mineral Occurrence (WAMIN) database



## Appendix 2

## Open-file geochemical surveys

## KEY

<b>ID no.</b>	Project reference number allocated for these notes (see Plate 3)
<b>M no.</b>	Geological Survey of Western Australia project reference number. An asterisk beside the M number indicates that not all the samples for the listed activities fall within EDMUND, that is, the total number of samples includes some from adjacent sheets. The projects are tabulated in order of increasing M number and cover the period 1965 to 1997. When reports are released to open-file, the M number is replaced by an Item (I) number, with the highest Item number denoting the most recent release
<b>Year</b>	The year that the report was written
<b>I no.</b>	The Item number or the Department of Minerals and Energy's (DME's) library reference number for a group of related open-file reports on microfiche. The Item number replaces the M number for project identification
<b>A no.</b>	Geological Survey of Western Australia (GSWA) report reference number
<b>Activity ID</b>	The number allocated by GSWA's spatial index (SPINDEX) database to identify exploration activities within projects
<b>Activity type</b>	The geochemical exploration activity (drilling details are only included if analytical samples are taken within 0–4 m depth): DIAM: diamond drilling NGRD: includes rock chip, lag, costean (up to 4 m depth) and grab samples RAB: rotary air blast drilling RC: reverse circulation drilling SOIL: surface or shallow soil samples SSED: stream-sediment samples
<b>Description</b>	Includes a list of the elements analysed for, the analytical methods used, the total number of samples taken, and various other sample details, depending on the information provided in the report. When these details are provided in italics, the exploration activity has not been used to compile the exploration activity areas on Plate 3. This is usually due to poor sample location in the report. AAS: atomic absorption spectroscopy #: appearing after an element symbol indicates anomalously high analytical results. (1:2 400): scale of the maps presented in the company reports

**SOURCE:** Department of Minerals and Energy's Western Australian Mineral Occurrence (WAMEX) and spatial index (SPINDEX) databases, February 1998

**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 2. Open-file surface geochemistry surveys for EDMUND as at February 1998

ID no.	M no.	Year	I no.	A no.	Activity ID	Activity type	Description
1A	62*	1965–7	3227	572 572 980, 571 1539 1595, 3335	1060 1061 1050 1056 1047	RC NGRD SSED SSED SSED	43 holes totalling 1436 m. Sampled at 2 m intervals. Cu# Zn# (1:1 200; 1:2 400) Grab sampling. Cu# Zn# (1:600) Mesh -80 fraction. Cu# Pb Zn Ni, 8200 samples (1:12 000; 1:10 200; 1:47 520; 1:2 400) Sampled dry beds close to confluence. Analysed -80 mesh fraction. Cu# Zn# Pb Ni (1:39 600) Only a plan is provided. Ni Zn, 137 samples (1:39 600)
1B							
2	115/2	1966	69/B	1632 1632	1816 1817	NGRD SSED	Gossan. Ni# Co Zn# Pb, 6 samples (1:63 360) Major streams sampled at 500–100 m intervals. Assayed by AAS. Most assays <65 ppm. 3 samples with 100–150 ppm Pb. Cu Pb# Zn Ni Co, 180 samples.
3	136	1966–7	37	1690  1690	1850  1851	SSED  NGRD	An area of 6 400 km <sup>2</sup> was covered with an average density of 1 sample per sq.km. Non-magnetic fraction of -80 mesh analysed for total Cu Pb Zn and cold extractable Cu Pb Zn. Two major anomalous areas. Cu# Pb Zn# As Co Ag P <sub>2</sub> O <sub>5</sub> , 288 samples (1:23 760) Cu# Pb Zn As# (1:1 200)
4	153	1966	111	1639	2302	SSED	Mild anomalism noted at old workings. Cu Ni Co Ag Mo Zn Pb, 281 samples (1:9 600; 1:63 360)
5	306	1970–1	1046	39 39 437 437 437, 2266 2266	1818 1819 1822 2574 2575 1824	SSED NGRD SOIL NGRD NGRD RC	Orientation surveys around Joy Helen Mine. Mesh -80 and -60 fractions analysed; sampling at 600 m intervals. Cu Pb# Zn#, 1699 samples (1:40 000) Random chip sampling. Cu Pb Zn. No plans Sampling over stream-sediment anomaly on 62 x 152 m grid. Mainly B horizon was sampled. Cu# Pb# Zn, 362 samples (1:12 000) Sampling over soil anomaly at Middle Bore. Cu# Pb# Zn (1:12 000) Bulk rock sampling. Cu Pb# Zn# (1:12 000) 10 holes totalling 297 m. Drilled over Middle Bore geochemical anomaly. Sampled at 1.5 m intervals Results showed surface enrichment of Pb Zn Cu; variable thickness of 1.5–14 m
6	315	1970	1047	715 716	2303 2305	SSED NGRD	Mesh -80 fraction collected at 610 m intervals. Weak anomalism. Cu Pb# Zn, 3000 samples (1:40 000) Grab sampling at random. Assayed by AAS for Cu Pb Zn Ag and XRF for Ba. Cu# Pb# Zn Ag# Ba, 11 samples (1:40 000)
7	391*	1969–71	1048	1099–100 1100, 1986 1100, 1986	1826 1828 1829	SSED NGRD SSED	Collected at 600 m intervals from streams draining selected portions of Irregularly Formation. Mesh -80 fraction. Cu Pb Zn#, 500 samples (1:40 000) Bulk rock sampling mostly from silcrete cappings. Cu Pb# Zn#, 62 samples (1:40 000) Finest deposit from active stream bed. Mesh -80 fraction. Cu Pb Zn Ni, 376 samples (1:40 000)
8	467	1970	1049	1893 1893	1831 2238	NGRD NGRD	Continuous chip sampling at 1.5 m intervals. Cu# (1:300) Grab sampling. Assayed by AAS. Cu# Pb Zn# Ni# Ag# (1:2400)
9	741	1972	1051	2282	1834	NGRD	Reconnaissance grab sampling. Cu# Pb# Zn# Co, 63 samples
10A	990	1972–9	2364	5388	2648	NGRD	Trenching and channel sampling. 7 costeans in the main shear zone and 3 prospect pits in the 'PC' prospect. Depth varied from 0.5 to 3.3 m. 7 cm samples over a width of 1.2 m were taken at 1.8 m intervals. U <sub>3</sub> O <sub>8</sub> # Cu# Pb# Au, 8 samples
10B				5986–7, 7239	2653	RC	Percussion drilling of 75 holes totalling 1341 m. Sampled at 1.5 m intervals. 404 samples assayed for U and other elements. Drilling program indicated that no U mineralization is associated with Cu and that these U-bearing horizons were thin. Intersection in PHD4V of 0–3 m at 186 ppm U (1:2 400; 1:6 000)
10C				5986–7 10597	2654 2667	NGRD RC	Gossan sampling. No survey details recorded other than a map. Cu Pb# Zn U Mn, 12 samples (1:1 200) Inclined percussion drilling conducted at 30–50m line spacing. 11 holes totalling 512 m. Sampled at 2 m intervals and assayed by AAS for Cu Pb Zn Ag, and by fluorometry for U <sub>3</sub> O <sub>8</sub> . Good intersections in many holes with high Pb and Ag values (1:500; 1:10 000)
11	1194	1973	6	4049	2293	NGRD	Fresh rock sampling on traverses 300 m apart. U Th Cu Pb Zn Ag As, 181 samples (1:50 000)
12	1327	1973	26	4220 4220	2285 2286	SSED NGRD	Panned concentrates collected in arid conditions. Samples were checked for fluorescence before analysis. W (1:37 736) Grab sampling. Highest values were 2430 ppm W and 300 ppb U (1:1 163 )
13	1367	1973	1013	4068 4068	1842 1843	NGRD RC	Costean and bulk sampling (1:4 800) Percussion drilling of 6 holes totalling 181 m. Sampled at 1.5 m intervals. Cu Pb Zn Ni, 30 samples (1:240; 1:1 200)
14	1434*	1974	2237	5177	2582	NGRD	Grab sampling. Mainly of granitic composition and few gossan and dolerite samples. U Th Cu# Pb Ag# Ba#, 280 samples (1:42 000; 1:20 000)
15	1471/1*	1968–78	1282	1124 1125 4392	2271 2272 2274	SSED DIAM NGRD	An area of 38 sq.m was covered to establish threshold and anomalous values. Cu# Pb# Zn# Ni As, 432 samples (1:47 520) 1 hole of 75 m. Sampled at 3 m intervals Cu# Pb# Zn#, 23 samples (1:240) Grab and chip sampling. U Th Cu Pb Zn Bi Ag As Au Mn Fe, 40 samples. U <sub>3</sub> O <sub>8</sub> # Cu# Pb# Zn# Ag# As, 9 samples. U <sub>3</sub> O <sub>8</sub> # Cu# Pb# Zn# Ag# As, 31 samples
	1471/3	1982–9	5944	13008	2309	NGRD	Grab sampling and composite channel sampling. U <sub>3</sub> O <sub>8</sub> # Th Cu# Pb# Zn# Ni Co Ag# Au Bi Sb As, 24 samples (1:20 000)
	1471/3	1982–9	5944	23608	2313	NGRD	Channel and chip sampling. Continuous channel samples at 2 m interval on 7 grid lines. Weak Au and Ag anomalism in Stockyard Creek. Ag anomalism at Bali South E. Au# Cu# Pb# Zn# Ag#, 100 chip samples. Au# Cu# Pb# Zn# Ag#, 9 samples (1:500)

## Appendix 2 (continued)

ID no.	M no.	Year	I no.	A no.	Activity ID	Activity type	Description
15 (cont.)				31452	2503	RC	4 holes totalling 380 m. Sampled at 2 m intervals. Au Ag Cu Pb Zn. Weak Ag anomaly is associated with shear zone
				31453	2505	RAB	47 holes totalling 1266 m. Sampled at 2 m intervals. Au Cu Pb Zn As. Weak Au mineralization associated with Pb As# Zn# Pb# Cu# (1:2 000)
				31453	2511	NGRD	Channel sampling along shear extension using kango hammer. Chip samples at 1 m intervals Cu# Pb# Au# Ag Zn (1:2 000)
				31453	2512	SOIL	Sampled at 5 m intervals along lines of variable spacing. Residual soil sieved to -80 mesh Assayed for Au Zn As# Cu# Pb#, 24 samples (1:2 000)
16	1519	1974-81	1108	4603, 9751-2	1853	NGRD	3 costeans about 40 m long and 4 m wide to cut across Cu mineralization. Sampled at 2 m intervals using continuous channels. Co Cu Zn Pb by AAS, 65 samples
				9751-2	1857	SSED	Stream beds sampled across at 3 m intervals where wider than 7 m, or at 1 m intervals if <7 m. Sieved at site and composite representative samples made from each sieve fraction. Banks sampled where recognizable colluvial slope or deposit with -85 mesh fraction. Cu Pb# Zn#, 641 samples (1:20 000)
17	1525/1	1974-6	415/A	4634	1862	NGRD	Grab sampling. U <sub>3</sub> O <sub>8</sub> Th#, 1 sample. Th up to 9900 ppm, U <sub>3</sub> O <sub>8</sub> 420 ppm. U <sub>3</sub> O <sub>8</sub> Th#, 2 samples (1:10 000)
				5695	1863	NGRD	Costeaining 3 trenches of width 3.2 m and depths varying from 0.6-1.05 m. U# Th, 10 samples (1:10 000; 1:100)
				5695	1865	DIAM	3 holes totalling 211 m. Sampled at 1.5 m intervals and assayed by XRF. U Th, 42 samples (1:10 000)
				5695	2595	NGRD	Grab sampling. 11 samples. U Th by XRF. High Th values up to 4515 ppm in 2 samples and 411 ppm U. Not located on maps
				6343	1866	RC	Percussion drilling of 6 holes totalling 148 m. Sampled at 1 m intervals. Assayed by XRF. No anomalism for U. U <sub>3</sub> O <sub>8</sub> Th Cu Pb Ni Zn, 19 samples (1:100)
18	1525/2	1974-6	415/B	4637	1870	NGRD	Costeaining. 5 trenches and two pits were dug over ground radiometric anomalies. Continuous chip sampling was done in trenches. Showed minor amounts of secondary U mostly associated with clayey calcareous material. U <sub>3</sub> O <sub>8</sub> # Th V <sub>2</sub> O <sub>5</sub> Cu Zn, 11 samples
				4637	1871	RAB	Auger drilling of 7 holes totalling 43 m. Holes at 10-75 m intervals. Sampled at 30 cm intervals. Assayed by XRF for U <sub>3</sub> O <sub>8</sub> . Highest assay was 350 ppm U <sub>3</sub> O <sub>8</sub> , 17 samples
				5694	1879	NGRD	Costeaining. 9 trenches excavated to depths of 1.08-1.72 m. Continuous sampling, U <sub>3</sub> O <sub>8</sub> , 16 samples. Grab sampling, U <sub>3</sub> O <sub>8</sub> , 3 samples (1:10 000; 1:100)
				6344-5	1874	RC	Percussion drilling of 88 holes totalling 1965 m. Drilling at 25-50 m intervals. Sampled at 0.5 m intervals over PDH50 anomaly and 1 m intervals at Zone 4 anomaly. Assayed by XRF for U <sub>3</sub> O <sub>8</sub> Th, 307 samples (1:10 000)
				6344-5	1876	NGRD	Continuous channel sampling and grab sampling from costeans. Assayed by XRF. U <sub>3</sub> O <sub>8</sub> # Th, 6 samples (1:10 000)
19	1526/2	1973-5	2514	4635	1885	NGRD	Rock chip, 125 samples. Grab, 8 samples. Assayed for Cu by AAS and for U by XRF. Cannot be located as local grid was not tied to a reference point
				6348	2598	NGRD	4 trenches blasted. Assayed for Cu by AAS and for U by XRF. U <sub>3</sub> O <sub>8</sub> # Th Cu#, 7 samples. Approximate location (1:10 000)
20	1529	1974	416	4642, 4729	2572	RAB	100 holes totalling 676 m. Auger drilling using Gemco rig to check extent and subsurface geochemistry of calcrete. Samples of 1.5-2.5 kg weight collected at 0.5 m intervals in calcrete horizons and at 1 m intervals outside calcrete. Assayed for U Th by XRF and other elements by AAS. All samples were tested for radioactivity using McPhar TV-3B scintillometer. Best intersections: Gum Creek Well, hole #G52, 2.5 m (0.5-3.0 m) at 341 ppm U; Pooranoo Well prospect, hole #G53, 2 m (0.5-2.5 m) at 262 ppm U. U# Th Cr Cu Ni CaO MgO, 131 samples (1:10 000)
21	1530	1973-5	423	4643-4, 4727	1889	NGRD	Costeaining and grab sampling. Cu Pb Zn U, 25 samples (1:20 000)
				4644, 4728	1892	SSED	U V Cu Pb Zn, 41 samples
				4644, 4728	1893	NGRD	Surface sampling (rock chip, gossan, grab, & costeaining). U V Cu Pb Zn, 76 samples (1:20 000)
				5681	1897	NGRD	Chip sampling. U Th Cu Pb Zn Ag, 31 samples
22A	1531*	1974-5	420	4645	1905	NGRD	Costeaining, Cu Mn Pb Zn# V U Th Au, 68 samples. Surface, Cu Mn Pb Zn# V, 9 samples (1:20 000)
22B				5682	1907	NGRD	Grab sampling. U Th, 49 samples
23	1573	1975	420	5058	2599	SSED	Orientation survey. Sampling at known copper occurrences. Mesh -80, -20,+80 fraction. Assayed by AAS for Cu# Zn# Pb, 100 samples
				5058	2600	NGRD	Rock chip sampling at known Cu occurrences. Assayed by AAS. Cu Pb Zn# Mn Co, 11 samples (1:4 800)
				5058	2601	SSED	Sample density of 1.3 samples per sq.km Analyses returned low values. Analysed mesh -80 fraction by AAS for Cu Pb Zn, 461 samples (1:36 000)
24	1625	1974	410	5279	2263	NGRD	Rock chip and gossan sampling. Sample types were not separately identified. U#, 48 samples (1:2 000)
25	1697	1975	656	5622	1918	NGRD	Rock chip and grab sampling (1:12 500)
26	1713	1975	364	5688	2335	NGRD	Gossan sampling. Some samples were taken at 50-100 m intervals. Cu Pb# Zn# Ag Ba Mn U Au, 38 samples (1:2 000; 1:1 270; 1:80 000)
27	2096	1978	519	7397	1919	SOIL	1000 x 20 m reconnaissance grid and mesh -80 fraction assayed for Cu Pb Zn Ag. No anomalism. Cu Pb Zn Co Mn As, 437 samples (1:50 000)
				7397	1920	REGO	Ironstone sampling conducted during reconnaissance traversing of the favourable contact. Ni Cu Co Ag Pb Zn, 84 samples (1:50 000)
				7397	1921	SSED	High-density sampling at NE quarter of the Temporary Reserve to test limits of the ironstone dispersion halos. Mesh -10 and +36 fraction. Ni Cu Co Cr Ag Mn Pb Zn As, 104 samples
				7397	2603	NGRD	Costeans sampled at 2+ m intervals. Cu Co Ag Pb Zn, 25 samples (1:100)

## Appendix 2 (continued)

ID no.	M no.	Year	I no.	A no.	Activity ID	Activity type	Description
28	2356/2*	1980	2039	(9238-40	1922	SSED	The survey was conducted in 1978 but data is in this report. Panned concentrates were collected at stream trap sites. Mesh -20 and +80 fraction
	2356/3*	1979	2553	16567-9			Sample density 1 sample per 3 sq.km. Cu Pb Zn# Co# Ni# Mn Au U
	2356/4*	1978	3275	16694)	1923	SOIL	Sampling of mesh -80 fraction at 25 m intervals on lines spaced at 100 m intervals. Line spacing of 25 m across drainages. Cu Pb Zn Ag Cd Co Ni (1:2 000; 1:5 000)
					1924	NGRD	Rock-chip and grab sampling. Cu Pb Zn
29	2383/2	1979	808	8091	2758	NGRD	Costean on radiometric anomalies. U# Th (1:2 000)
30	2459	1979-81	2746	8873-5	1926	SSED	Panned concentrate. Orientation and detailed sampling of magnetite. Cu# Pb Zn Co# Ni W Nb Ta Sn U As Bi Mo Au Ag Cd Sb Y. Minor anomalism (1:5 000)
				8873-5	1927	NGRD	Grab, chip, and channel sampling. 2 m intervals. Cu Pb Zn Ta Mo W Sn Au (1:50 000)
				8873-5	1929	SOIL	100 x 25 m grids. Mesh -80 fraction. Cu Pb Zn Co Ni W Nb Ta Sn U As Bi Mo Au Ag Cd Sb Y. No anomalism (1:5 000)
				10660	1937	NGRD	Continuous rock chip sampling at 2 m intervals. Cu# Pb# Zn Mn As Sb. Highest values: 2700 ppm Cu, 2.3% Pb (1:10 000)
				10660	1938	SOIL	Cu Pb Zn (1:5 000)
31A	2475	1980-3	2697	9151	1942	NGRD	Gossan, Cu Ni Pb Zn Ag U Au, 24 samples. Rock chip, Cu Ni Pb Zn Ag U Au, 22 samples (1:20 000)
31B				9461	1946	NGRD	Rock chip and gossan sampling from radiometric anomalies U Cu Pb Zn Ni Au (1:20 000)
31C				12925	1952	NGRD	Costeans. Strongly radioactive rocks sampled. U Ni Cu Zn Pb, 7 samples (1:10 000)
32	2517	1979	934	8699	1956	SSED	Mesh -20 fraction. Cu Pb Zn Mn, 117 samples. No anomalism (1:40 000)
				8699	1957	NGRD	Chip sampling over gossans and ferruginous horizons. Cu Pb Zn Mn, 62 samples (1:40 000)
33	2539	1980-1	1297	9332	2389	SSED	Panned heavy concentrates. 5-40 kg sample panned to 50-200 g. Checked for visible Au and for scheelite using UV. Magnetic fraction separated and assayed for Nb Mo Sn Ta W Bi, 383 samples (1:40 000)
				9332	2390	SSED	Mesh -80 fraction collected at sites of panned samples. Cu Pb Zn Ni, 164 samples (1:40 000)
				9332	2391	NGRD	Rock chip sampling. 10-15 chips of 1-2 kg weight. Cu# Zn# Pb# W# Au# , 29 samples (1:40 000)
				10280-1	2394	NGRD	Rock chips samples of 1-2 kg collected within and outside tenement. No location map included. Cu Pb# Zn Ag Au# W#, 72 samples
34	2605/1	1981-3	1469	9680-2	1377	SOIL	Sampling on 50 m spaced lines. Mesh -40 fraction. Cu Pb Zn, 3127 samples (1:20 000)
				9680-2	1378	NGRD	Rock chip sampling. Petrography, 8 samples. Cu Pb Zn, 273 samples (1:10 000; 1:20 000)
				10618-19	1380	NGRD	Chip and lag samples. Cu Pb Zn Fe Mn Ag Co F Ba, 38 samples (1:20 000)
				11351	1384	NGRD	Cu Pb Zn Fe Mn, 10 samples (1:10 000)
				12226	1389	NGRD	Costean samples, Cu Pb# Zn# Ba Mn Ag Au Fe, 2 samples. Chip samples, Cu Pb Zn Ba Ag Au Fe, 2 samples.
35	2725	1980-2	2568	10422	1357	SSED	Mesh -80 fraction; mesh +80 and -40 fractions. Cu Pb# Zn Ni Co Ag Cr Mn Mo As U, 64 samples (1:50 000)
				10422	1358	NGRD	Lag. Cu Pb# Zn# Ni Co Ag Cr Mn Mo As U Au, 63 samples. Not all analyses presented. Selected samples indicate high values (1:10 000)
				10422	1359	NGRD	Grab and chip sampling. Cu Pb# Zn# Ni Co Ag Cr Mn Mo As U Au, 134 samples. High Pb at 1000 ppm (1:10 000)
				10756, 10422	1364	RAB	Percussion drilling of 7 holes totalling 459 m. Sampled at 1 m intervals. Pb# Zn Cu Ni Co Mn Cr Ag Mo U As Fe Ba Au, 362 samples (1:10 000)
36	2817/2*	1982-3	1638	11763, 11765	2348	SSED	Mesh -20, -20+80, -80 fraction and panned magnetic mesh -20 fractions were analysed during orientation and detailed phases of sampling. Cu# Pb Zn U# Th As Ni Mo Co Bi# Sb W K, 2575+ samples. 15 anomalous areas were identified as a result of the survey (1:20 000)
				11763, 11765	2349	NGRD	Rock chips, fault breccias, gossans, and ironstones collected during geological mapping. Cu Pb Zn U Th W Mo Fe Mn Bi Ce La Nb Sb Se Sn Au Ag P As Bi Ni Co Ca Cr Mg Al Ti Ba Sr. Poorly presented analytical data (1:20 000)
				12165, 12168-70	2366	SOIL	Collected over regional geochemical anomalies at 25 m sampling interval. Mesh -80 fraction. U <sub>3</sub> O <sub>8</sub> Cu Pb Zn Ni Co Bi. No anomalism (1:20 000)
				12165, 12168	2367	DIAM	6 holes totalling 556 m. 0.9-2 m sampling intervals. Minor U mineralization. Plotted using local grid. Bi Ni Cu Co Zn Mn Cr Pb Ag Fe Cr Mg Al Ti V Ba Sr Mo
				12385	2369	SSED	Mesh -20 and magnetic fractions. Pb Zn Cu Ag Ba U Ni Co As Sr, 331 samples (1:20 000)
				12385	2370	NGRD	Chip sampling. Pb Zn Cu Ag Ba U Ni Co Sr Mn Fe Cr Ca Mg Al V Ti Mo Au As, 12 samples (1:20 000)
37	2820*	1982	2704	11188	2262	SSED	From gravel bars up to 4 km downstream. Density of 1 sample per sq.km. Mesh -10 fraction, 1kg heavy mineral concentrate. Au# Cu# Pb# Zn# As, 1026 samples (1:50 000)
38	2962	1982	1710	11438	2359	SSED	Mesh -10 fraction, 1 kg heavy mineral concentrates by heavy-media separation. Density 1 sample per 3 sq.km. Au As Cu Pb Zn, 18 samples (1:40 000)
				11438	2360	NGRD	Rock chip sampling. Au Cu Zn As Ag W Pb, 10 samples
39	2966	1982-3	2482	11529, 12564	1366	SSED	Collected mesh -80 fraction at 800 m intervals. At anomalous points mesh -20+40 fraction was sampled at 100 m intervals. Cu Pb Zn# Ba#, 360 samples (1:25 000)
40	3071	1982	4471	11921	2517	NGRD	Rock chip sampling. Au Cu Pb Zn Ag Bi Sn Ce La Y Eu Nb Be (1:10 000)

## Appendix 2 (continued)

ID no.	M no.	Year	I no.	A no.	Activity ID	Activity type	Description
41	3560	1984	3180	14209	1370	SSED	As Ba Cu Au Pb Mn Zn, 31 samples (1:64 516)
				14209	1371	SOIL	As Ba Cu Au Pb Mn Zn, 107 samples (1:64 516)
				14209	1372	NGRD	As Ba Cu Au Pb Mn Zn, 12 samples (1:64 516)
42	3805/2	1985	4402	15621	1353	RAB	Percussion drilling of 59 holes totalling 3194 m. Sampled at 2 m intervals. Cu Pb Zn Mn Fe Co Ni As Ag, 155 samples (1:50 000)
43	5383	1988	3746	23240	2320	NGRD	Chip and channel sampling; 400 x 800 m grid; 200 g of mesh -80 fraction sampled. Assayed for Au by fire assay, As Cu Ag Pb Zn by AAS, and B by ICAu# As# Cu# Pb# Ag# Zn# B, 98 samples (1:10 000; 1:1000)P.
				23240	2321	SSED	Mesh -20+80 fraction. Au Cu Pb# Zn As#, 22 samples (1:1 000)
44	5479	1988	5271	23584	2449	NGRD	Grab and gossan sampling delineated 4 anomalous areas. 51.07–81.97% Fe <sub>2</sub> O <sub>3</sub> , 0.11–10.7% TiO <sub>2</sub> , 0.06–8.41% MnO, 1010 ppm – 2.04% Ba, high REE, 47–1620 ppm La, 51–8084 ppm Ce, 16–1886 ppm Pr. Whole rock. V# Cr Co Ni Cu Zn As Sr Y Zr Nb# Mo Ag# Sn Ba# La# Ce# Pr# Nd Sm Eu# Gd# Yb Lu Pb Th# U#, 21 samples (1:40 000)
				23584	2450	NGRD	Grab sampling of granitic rocks. Display considerable variation in composition in relation to location of gossan. Whole rock. V Cr Co Ni Cu Zn As# Sr Y Zr Nb# Mo Ag Sn Ba# La# Ce# Pr Nd Sm Eu Gd Yb Lu Pb Th U, 20 samples (1:40 000)
45	5523*	1987	4835	23712	2315	NGRD	Grab sampling. Cu# Ag# Au# Pb# U#, 29 samples (1:250 000)
				23713	2316	NGRD	Grab sampling, Pt# Pd# Cu# Ag# Au# Pb# U, 27 samples (1:250 000)
46	5629/2	1988–9	5806	25520	2403	SSED	Sample density 1 sample per 1.8 sq.km. 5.5 kg of -2 mm fraction. Highest Au of 1.27 ppb. Au# Ni Cu Zn Pb As Mn Cr Fe Co Bi V Mo Sr La Y Be Ce Zr Sn, whole rock, 142 samples
				28889	2405	SSED	BLEG bulk sampling. 5.5 kg. Analysed about 500 g of -2 mm fraction for multi-elements. Highest Au of 2 ppb. Au#, 52 samples (1:40 000)
47	5629/3*	1988–9	5807	25522	2681	SSED	Reconnaissance sampling. Sample density of 1 sample per 1.5 sq.km. 5.5 kg of -2mm fraction. Highest value of 1.51 ppb Au. Follow up did not upgrade the result. Assayed with ICP. Au# Ni Cu Zn Pb As Mn Cr Fe, whole rock, Co Bi V Mo Sr La Y Be Ce Zr Sn Ag, 163 samples (1:40 000)
				28539	1215	SSED	BLEG samples. Au#, 54 samples. Ni Cu Zn Pb As Mn Cr Fe Al <sub>2</sub> O <sub>3</sub> MgO CaO Na <sub>2</sub> O K <sub>2</sub> O TiO <sub>2</sub> P <sub>2</sub> O <sub>5</sub> Ag Co Bi V Mo Sr La Y Be Ce Zr Sn, 54 samples (1:40 000)
				28539	2684	SSED	Reconnaissance and follow up. 5.5 kg of -2 mm fraction. Analysed for multi-elements by ICP and by BLEG for Au. Highest value of 1.02 ppb Au. Assays confirmed high values and enhanced anomalies. Whole rock, Ni Cu Zn Pb As Mn Cr Fe Ag Co Bi V Mo Sr La Ce Zr Sn, 23 samples (1:40 000)
48	6248/1	1990–2	7778	32019	2668	SSED	Co Sr Y Nb Ba La Ce Ta Mg K Ca Ti V Cr Ni Zr, 160 samples (1:20 000; 1:10 000)
				32019	2670	NGRD	Co Sr Y Nb Ba La Ce Ta Mg K Ca Ti V Cr Ni Zr (1:5 000)
				37344	1255	SOIL	Loam. Spinel, garnet. Mg K Ca Ti V Cr Co Ni Sr, 38 samples (1:500; 1:10 000; 1:20 000)
49	6637/1	1990–3	6874	21069	2371	SSED	2 kg BLEG samples collected from active channel. Au# Ag Cu, 9 samples (1:20 000)
				32960	2376	SOIL	2 kg BLEG samples at 50 m intervals. Mesh -80 fraction. Au# Pb# As#, 70 samples (1:10 000)
				32960	2377	NGRD	Chip sampling. Au# As# Cu# Pb# Zn#, 15 samples (1:20 000)
				35441	2231	NGRD	Chip sampling. Au Cu Pb Zn Ag As, 3 samples
				35441	2747	NGRD	Chip sampling. Au Cu Pb Zn Ag As, 3 samples
				35441	2233	SSED	Au, 2 samples
				38237	2380	SSED	BLEG samples from active channel, -6 mm fraction. Samples come from a domal structure seen on airphotos. Highest values for Au of 4.2 ppb. Au#, 10 samples (1:20 000)
				38237	2381	NGRD	Chip sampling from a steam-sediment anomaly. No anomalism. Au Cu Pb Zn Ag As, 4 samples (1:20 000)
				35441	2382	NGRD	Chip sampling of a Landsat anomaly. Highest Au value of 0.86 ppm. Cu Pb Zn Ag As, 4 samples (1:20 000)
				35464	2383	SSED	2 kg BLEG samples collected from active channel, -6 mm fraction. No anomalism. Au, 5 samples (1:20 000)
50	6641	1990	5405	21454	2461	NGRD	Rock chip sampling to identify BLEG anomalies. Highest values at Greggs Find of 7.74 ppm Au. Au# Ag Cu# Pb Zn# As#, 1 sample (1:20 000)
				21454	2462	SSED	2 kg BLEG samples from active channel, -3 mm fraction. Maximum value of 35.9 ppb Au. Au# Ag# Pb#, 101 samples (1:20 000)
51	6783/1*	1991	6438	32886–8	1307	SSED	Orientation sampling, -6 mm, mesh -80+200, +20, -20+80 fractions. The -80+200 fraction had elevated Au values. Au# Cu Zn Pb Mo As MgO Al <sub>2</sub> O <sub>3</sub> SiO <sub>2</sub> Ga Y Zr Nb La Ce Pr Nd Eu Tb Gd Dy Ho Er Tm Yb Lu Hf Ta Th U Fe Sc, 430 samples (1:50 000)
				32886–8	1309	SOIL	Lag. Au# Cu Zn Pb Mo As MgO Al <sub>2</sub> O <sub>3</sub> SiO <sub>2</sub> Ga Y Zr Nb La Ce Pr Nd Eu Tb Gd Dy Ho Er Tm Yb Lu Hf Ta Th U Fe Sc, 38 samples (1:50 000; 1:100 000)
				32886–8	1310	NGRD	Bulk rock. Au Ni Cu Zn Mo As MgO Al <sub>2</sub> O <sub>3</sub> SiO <sub>2</sub> Ga Y Zr Nb La Ce Pr Nd Eu Sm Tb Gd Dy Ho Er Tm Yb Lu Ta Th U Fe Sc, 130 samples (1:50 000; 1:100 000)
				35093	1319	SSED	2 samples collected from each sample point as 4kg of -4 mm sample and 100–200 g of mesh -80 fraction sample. Au P K Sc Ti Cr Mn Fe Co Ni Cu Zn Pb Bi As Se Br Rb Mo Ag Sb Cs Ba Ce Sm Eu Yb Lu Hf Ta W Ir Th U, 70 samples (1:100 000)

## Appendix 2 (continued)

ID no.	M no.	Year	I no.	A no.	Activity ID	Activity type	Description
51 (cont.)			35093		1320	SOIL	2 samples collected from each sample point as 4 kg of -4 mm sample and 100–200 g of mesh -80 fraction sample. Au Fe Ni Cu Zn As Mo Ag Sb Te Pb Bi, 41 samples (1:100 000)
			35093		2627	NGRD	Detailed deflation lag sampling in Boogardi, Contesis, and Cardibar prospects. Samples of bedrock and alluvial fragments coated with iron, -2 mm fraction. Assayed by AAS for Au Ni Cu Pb Zn Te Pb Bi Fe As Mo Sb Ag (1:10 000)
			36887		1314	SSED	Bulk sampling trap sites. Panned heavy concentrates were sieved to -1 mm and -5+1 mm fractions. 2 kg samples were collected from sluice and assayed for Au# Pt# Pd#, 37 samples. Prospectivity for Au in the tenement area is low (1:100 000)
			36888		1315	NGRD	Rock chip reconnaissance. Duplicates collected for all samples. Assayed by AAS. P K Sc# Ti# Cr Mn# Fe Ce Ni Cu# Zn# As Se Br Rb Mo Ag Sb Cs Ba La Ce# Sm Eu Yb Lu Hf Ta W Ir Au# Pb# Th U, 28 samples
			36888		1316	SSED	2 samples collected at each site. 100–200 g of mesh -20+40 and -80 fractions. Mesh -80 samples assayed by AAS and mesh -20+40 samples assayed by neutron activation. P K Sc Ti Cr Mn Fe Ce Ni Cu Zn As Se Br Rb Mo Ag Sb Cs Ba La Ce Sm Eu Yb Lu Hf Ta W Ir Au Th U, 92 samples (1:50 000)
			36888		2621–2	SSED	BLEG samples. 4 kg of -4 mm fraction. All Au values were below or at detection level of 0.001 ppm. Au, 176 samples (1:50 000)
	6783/2*	1992	6069	(34993,	1965	NGRD	Chip sampling at previous anomalous sampling points. Some samples from quartz outcrops. Assayed by neutron activation. Al Sb As# Ba Br Ce Cr Co Cu# Dy Er Eu Gd Ga Au Hf Ho Ir Fe La Pb# Lu Mg Mn Mo# Nb Ni# Nb Pd P Pt K Pr Rb Sm Sc Se Si Ag Na Ta Tb Th Tu Ti W U Yb Y Zn# Zr, 33 samples
	6783/1*	1991	6438	35093)			Chip sampling. Al Sb As# Ba Br Ce Cr Co Cu# Dy Er Eu Gd Ga Au Hf Ho Ir Fe La Pb# Lu Mg Mn Mo# Nb Ni# Nb Pd P Pt K Pr Rb Sm Sc Se Si Ag Na Ta Tb Th Tu Ti W U Yb Y Zn# Zr, 37 samples (1:50 000)
	6783/2*	1992	6069	(34993,	1966–7	NGRD	Chip sampling. Al Sb As# Ba Br Ce Cr Co Cu# Dy Er Eu Gd Ga Au Hf Ho Ir Fe La Pb# Lu Mg Mn Mo# Nb Ni# Nb Pd P Pt K Pr Rb Sm Sc Se Si Ag Na Ta Tb Th Tu Ti W U Yb Y Zn# Zr, 37 samples (1:50 000)
	6783/1*	1991	6438	35093)			
52	6946/1	1991–3	7995	33095	2422	SSED	2 kg BLEG from active channels, -3 mm fraction. Highest Au of 12.2 ppb. Follow up sampling did not detect anomaly. Au# Ag# Cu, 86 samples (1:20 000)
				33095	2423	NGRD	Rock chip sampling. Au by fire assay, Cu Pb Zn Ag by AAS, As by hydride. Highest Au of 5.35 ppm. Cu# Pb Zn# Au#, 73 samples (1:20 000)
				35367	2431	NGRD	Continuous channel sampling on quartz grit unit at 10 m intervals on approximately 100 m spaced lines. Highest Au of 4.29 ppm. Au by fire assay, Cu Pb Zn Ag by AAS. Au# As# Cu Pb Zn Ag, 28 samples (1:2 500)
				35367	2432	NGRD	Grab sampling over quartz grit unit. Highest Au of 3.72 ppm. Au by fire assay, Cu Pb Zn Ag by AAS. Au# As# Cu# Pb# Zn#, 27 samples (1:2 500)
				35367	2433	NGRD	Trenching. Composite grab samples over 5 m intervals. Au by fire assay. Au Cu Pb Zn As (1:2 500)
				38149	2425	NGRD	Continuous chip and grab sampling of outcrops of quartz-veined grit and arenite. Highest Au of 14 ppm. Au by fire assay, Cu Pb Zn Ag by AAS. Au# As# Cu# Pb# Zn#, 40 samples. Au#, 81 samples (1:20 000)
				38149	2426	RC	Drilled over geochemical anomaly; 10 holes totalling 438 m. Assayed 4 m composite samples and 1 m samples when Au > 0.2 ppm. Au by fire assay. Revealed only weak mineralization. Anomalous results in 5 holes (1:1 000)
	6946/3	1994	7550	40927	2489	NGRD	Reconnaissance rock chip sampling along with geological mapping. Assayed for Au by fire assay, Cu Pb Zn Ag by AAS, As by hydride. Maximum Au value of 1.33 ppm. Au# Cu Pb As Zn#, 101 samples (1:20 000)
				40927	2490	SSED	2 kg samples from active channel, sieved to -6 mm fraction. Assayed for Au Ag Cu by BLEG. Anomalous zone 5 km long with peak value of 12.2 ppb Au. Infill sampling did not upgrade the anomaly. Source not traced. Au# Ag Cu#, 93 samples (1:20 000)
53	6965	1990	4879	33317	1324	SSED	Collected mesh -80 fraction from major junctions and smaller tributaries. Assayed for Cu Pb Zn Ag by AAS. Cu Pb Zn Ag, 64 samples (1:41 667)
				33317	1325	NGRD	Sampled a variety of material ranging from gossan to rock chips. Assayed by AAS. Au Cu Pb Zn#, 10 samples (1:41 667)
54	7180	1991	5865	34702	1328	SSED	2 samples from each site. 4 kg of -4 mm fraction and 150–200 g of -20+40 fraction. Both from stream bed, bank to bank. Assayed by neutron activation for Au Ag As Ba Ce C Cr Cs Eu Fe Hf Ir La Lu Mo Rb Sb Se Sm Ta Th U W Yb Zn; and by ICP for Cu Zn Pb Y Nb Zr Ti Mn P K Ni Ag Mo Au Na P K Sc Ti Cr Mn Fe Co Ni Cu Zn As# Se Br Mo Ag Rb Sb Cs Ba La Ce S Eu Yb Lu Hf Ta W Ir Bi Pb# Th U Zr Nb, 12 samples (1:20 000)
				34702	1329	NGRD	Chip sampling. Assayed by neutron activation for Au Ag As Ba Ce C Cr Cs Eu Fe Hf Ir La Lu Mo Rb Sb Se Sm Ta Th U W Yb Zn; and by ICP for Cu Zn Pb Y Nb Zr Ti Mn P K Ni Ag Mo. No anomalism. Au Na P K Sc Ti Cr Mn Fe Co Ni Cu Zn As Se Br Mo Ag Rb Sb Cs Ba La Ce S Eu Yb Lu Hf Ta W Ir Bi Pb Th U Zr Nb, 5 samples (1:25 000)
				34702	1330	SOIL	2 samples collected at each site. 4 kg of -4 mm fraction and 150–200 g of -20+40 mesh fraction. Depth 0–4 cm in a circle of 3 m radius. Assayed by neutron activation for Au Ag As Ba Ce C Cr Cs Eu Fe Hf Ir La Lu Mo Rb Sb Se Sm Ta Th U W Yb Zn; and by ICP for Cu Zn Pb Y Nb Zr Ti Mn P K Ni Ag Mo. No anomalism. Au Na P K Sc Ti Cr Mn Fe Co Ni Cu Zn As Se Br Mo Ag Rb Sb Cs Ba La Ce S Eu Yb Lu Hf Ta W Ir Bi Pb Th U Zr Nb, 5 samples (1:25 000)
				34702	2617	NGRD	Lag. 200 g of -7+2.5 mm fraction. Consisted mainly of Fe pisolites, some of which were magnetic. Assayed by neutron activation for Au Ag As Ba Ce C Cr Cs Eu Fe Hf Ir La Lu Mo Rb Sb Se Sm Ta Th U W Yb Zn; and by ICP for Cu Zn Pb Y Nb Zr Ti Mn P K Ni Ag Mo. No anomalism. Au Na P K Sc Ti Cr
55	7881/3	1993	7183	38880	1162	SOIL	No details of sampling methods were reported. Cr Mn Fe Cu As Mo Sb Au Bi, 14 samples (1:50 000)
	7881/5	1995	8604	45941	2409	SSED	10–50 kg silt collected from restricted drainage. ICP-MS. Au below detection limit. Cr Mn Fe Ni Cu As Mo Sb Au Bi, 8 samples (1:100 000)
	7881/10	1994–6	8942	41641	3898	SOIL	Infill at 50 m spacing on 16 lines for a total of 17 line kilometres. Ba Cd, 356 samples (1:10 000)
				47975	3900	SOIL	From depth of 10–20 cm, mesh -2 mm fraction. Collected at 50 m intervals, composited over 100 m. Cd Cu, 904 samples (1:40 000)



## Appendix 2 (continued)

<i>ID no.</i>	<i>M no.</i>	<i>Year</i>	<i>I no.</i>	<i>A no.</i>	<i>Activity ID</i>	<i>Activity type</i>	<i>Description</i>
56	7992	1993	6991	38235	2416	SSED	2 kg BLEG samples from active channels. Sieved to -6 mm fraction. Detected 2 anomalies associated with massive grit ridges and quartz-sericite rocks. Au values up to 5.5 ppb. Au#, 84 samples (1:20 000)
				38235	2417	NGRD	Taken during reconnaissance geological mapping and follow up of anomalous stream-sediment samples. No anomalism. Au Ag Cu Pb Zn, 5 samples (1:20 000)
57	8271	1994	7710	42131	1340	SSED	Mesh -80 fraction, collected by helicopter. No anomalism related to precious metals. Assayed by ICP-MS for Ag Ba Bi; by AAS for Cu Pb Zn Co Cr Fe Mn Ni; and by fire assay for Au Pt Pd. Ag Au Ba Co Cr Cu Fe Mn Ni# Pb Pd Pt Zn, 70 samples (1:50 000)
				42131	1341	NGRD	Ag As Al Au Ba Bi Ca Ce Co Cr Cu Fe K La Mg Mn Mo Na Nb Ni P Pb Pd Pt Th U V Zn Zr, 7 samples
58	10330	1997	9140	49908	3747	SSED	Mesh -2 mm fraction and -80 fraction. Au Mg P Ca Ti V Cr Mn Fe Co Ni Cu Zn As Zr Nb Mo Pd Ag Sn Sb Ba La Ce W Pt Pb Bi Th U, 41 samples (1:100 000)
				49908	3749	NGRD	Rock grab samples. Au Ni Co Mg P Ca Ti V Cr Mn Fe, 10 samples. Mn Fe Co Ni Cu Zn As Se Br Mo Ag Rb Sb Cs Ba La Ce S Eu Yb Lu Hf Ta W Ir Bi Pb Th U Zr Nb, 11 samples (1:25 000)



## Appendix 3

## Sample-site form

Sheet _____	Zone _____	Loc/n No _____	GSWA No _____
Site Ref _____	E _____	N _____	Date _____
Photo Y/N (Describe) _____			
Channel <input type="checkbox"/> Pit/Hole <input type="checkbox"/> Single point <input type="checkbox"/> Multipoint <input type="checkbox"/> Shtwash <input type="checkbox"/> Creek <input type="checkbox"/> Soil <input type="checkbox"/> Lake <input type="checkbox"/>			
CLASTS		Surrounding Regolith Code: Left _____ Right _____	
Gravel (2-5mm) <input type="checkbox"/> Stones (5-64mm) <input type="checkbox"/> Cobbles (64-256mm) <input type="checkbox"/> Boulders (>256mm) <input type="checkbox"/>		Regolith Description:	
Abundant : >30%    Common : 5-30%    Rare : 1-5%    Trace : <1%			
Iron-rich Abnt/Comn/Rare/Tr <input type="checkbox"/> Lithic Abnt/ Comn / Rare/ Tr <input type="checkbox"/>			
<input type="checkbox"/> Pisoliths <input type="checkbox"/> Saprolite fragments <input type="checkbox"/> Nodules <input type="checkbox"/> Ferrug. granules <input type="checkbox"/> Ferruginous Saprolite frag's <input type="checkbox"/> Ferrug. duricrust <input type="checkbox"/> Saprock Fragments <input type="checkbox"/> Gossan fragments <input type="checkbox"/> Fresh B'rock frag's (below) <input type="checkbox"/> Ferrug lithic fragments <input type="checkbox"/> Vein quartz <input type="checkbox"/> Other Silica			
Non-Lith Abnt/Comn/Rare/Tr <input type="checkbox"/>		Clast Lithology	
<input type="checkbox"/> Quartz (sand) <input type="checkbox"/> Feldspar		<input type="checkbox"/> Mafic	<input type="checkbox"/> BIF
<input type="checkbox"/> Calcrete		<input type="checkbox"/> Ultramafic	<input type="checkbox"/> Sandstone
<input type="checkbox"/> Hardpan		<input type="checkbox"/> Felsic	<input type="checkbox"/> Ark / Gwk
<input type="checkbox"/> MnO <sub>2</sub>		<input type="checkbox"/> Granite	<input type="checkbox"/> Shale/Siltstone
<input type="checkbox"/> SILCRETE <input type="checkbox"/> OTHER _____		<input type="checkbox"/> Quartzite	<input type="checkbox"/> Chert
Secondary coating		<input type="checkbox"/> Fe / Mn	<input type="checkbox"/> Siliceous
		<input type="checkbox"/> Calcareous	<input type="checkbox"/> Clay
- 2 mm Material <input type="checkbox"/> Sand (0.1 - 2mm) <input type="checkbox"/> Clay <input type="checkbox"/> Other _____ Colour _____			

Rock O/c	Dist.	Dir.	Secondary Units Nearby	Heading _____ Width: _____ m
1. _____ m			Hardpan <input type="checkbox"/> Consolidated Collvm <input type="checkbox"/>	<input type="checkbox"/> Single <input type="checkbox"/> Braided <input type="checkbox"/> Incised
2. _____ m			Calcrete <input type="checkbox"/> Duricrust <input type="checkbox"/>	Seived to Size Y/N   Depth- _____
3. _____ m			Mot Zone <input type="checkbox"/> Saprolite <input type="checkbox"/> Saprock <input type="checkbox"/>	Osize - _____ %   Usize - _____ %
4. _____ m			Gyps Dune <input type="checkbox"/> Sand Dune <input type="checkbox"/> Salt <input type="checkbox"/>	

REMARKS

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**Appendix 4**

**GSWA and laboratory standard data  
and quality control data**

**Table 4.1. Detection limits and number of samples below detection level**

<i>Element</i>	<i>Detection limit</i>	<i>n &lt; DL</i>
<b>Percentage</b>		
SiO <sub>2</sub>	0.1	0
TiO <sub>2</sub>	0.05	0
Al <sub>2</sub> O <sub>3</sub>	0.02	0
Fe <sub>2</sub> O <sub>3</sub>	0.01	0
MnO	0.001	0
MgO	0.01	0
CaO	0.1	69
Na <sub>2</sub> O	0.002	0
K <sub>2</sub> O	0.02	0
P <sub>2</sub> O <sub>5</sub>	0.002	0
LOI	0.01	0
<b>Parts per million</b>		
Ag	0.1	3
As	1	92
Au (ppb)	1	121
Ba	0.1	0
Be	0.1	1
Bi	0.01	5
Cd	0.1	371
Ce	0.01	0
Co	0.1	0
Cr	2	0
Cu	1	0
Ga	0.1	0
In	0.01	8
La	0.01	0
Li	0.1	0
Mo	0.1	0
Nb	0.5	0
Ni	1	0
Pb	2	0
Pd (ppb)	1	802
Pt (ppb)	1	595
Rb	0.05	0
S (%)	0.01	279
Sb	0.05	4
Sc	2	8
Se	0.5	645
Sn	0.1	0
Sr	0.05	0
Ta	0.01	1
Te	0.1	666
Th	0.01	0
U	0.01	0
V	2	0
W	0.1	1
Y	0.05	0
Zn	1	0
Zr	1	0

**NOTES:** Trace elements in parts per million unless otherwise specified  
n: number of samples  
DL: detection limit

Table 4.2. Analyses of GSWA standards: amphibolite (IQC-42), gossan (IQC-45), and laterite (IQC-47)

	Amphibolite (IQC-42)								Gossan (IQC-45)								Laterite (IQC-47)							
	1	2	3	6	6	Mean	σ	RSD%	1	2	3	6	Mean	σ	RSD%	1	2	3	6	6	Mean	σ	RSD%	
Percentage																								
SiO <sub>2</sub>	51.8	52.5	52.6	51.8	51.6	52.1	0.5	0.9	42.1	42.6	42.8	42.3	42.5	0.3	0.7	87.1	87.3	87.6	86.3	86.7	87.0	0.5	0.6	
TiO <sub>2</sub>	0.39	0.37	0.41	0.37	0.37	0.38	0.02	4.68	0.17	0.18	0.12	0.12	0.15	0.03	21.71	<0.05	0.02	0.01	0.01	0.01	0.01	0.01	40.00	
Al <sub>2</sub> O <sub>3</sub>	5.92	6.17	5.96	6.02	6.03	6.02	0.10	1.58	2.34	2.31	2.28	2.27	2.30	0.03	1.37	0.68	0.63	0.67	0.65	0.65	0.66	0.02	2.97	
Fe <sub>2</sub> O <sub>3</sub>	8.14	8.64	8.42	8.4	8.44	8.41	0.18	2.12	45.10	45.28	46.05	45.48	45.48	0.41	0.91	8.41	8.58	8.53	8.35	8.32	8.44	0.11	1.34	
MnO	0.326	0.294	0.341	0.356	0.351	0.334	0.025	7.472	0.070	0.067	0.075	0.070	0.071	0.003	4.704	0.066	0.072	0.074	0.073	0.072	0.071	0.003	4.384	
MgO	13.81	13.67	13.97	14.24	14.28	13.99	0.27	1.90	0.16	0.17	0.15	0.13	0.15	0.02	11.20	0.42	0.33	0.34	0.32	0.32	0.35	0.04	12.19	
CaO	4.1	4.26	4.21	4.13	4.09	4.16	0.07	1.78	0.20	0.19	0.13	0.13	0.16	0.04	23.23	0.20	0.06	0.05	0.05	0.05	0.08	0.07	80.62	
Na <sub>2</sub> O	0.251	0.25	0.256	0.25	0.253	0.252	0.003	1.012	0.01	0.01	0.01	0.01	0.01	0.00	22.22	0.04	0.04	0.03	0.03	0.03	0.03	0.01	20.00	
K <sub>2</sub> O	3.23	3.32	3.29	3.27	3.21	3.26	0.04	1.36	0.37	0.35	0.35	0.31	0.35	0.03	7.29	0.07	0.06	0.04	0.05	0.05	0.05	0.01	21.11	
P <sub>2</sub> O <sub>5</sub>	0.026	0.023	0.024	0.023	0.024	0.024	0.001	5.103	0.636	0.613	0.655	0.665	0.642	0.023	3.567	0.004	0.005	0.005	0.004	0.003	0.004	0.001	19.920	
LOI	4	3.5	3.3	3.4	3.4	3.5	0.3	7.9	6.8	6.8	6.6	6.6	6.7	0.1	1.7	2.6	2.3	2.3	2.3	2.3	2.3	0.1	5.4	
Parts per million																								
Ag	5	4.9	5.2	5.3	5.2	5.1	0.2	3.2	0.6	0.6	0.6	0.8	0.7	0.1	15.4	0.2	0.3	0.2	0.4	0.4	0.3	0.1	33.3	
As	360	363	372	367	365	365	5	1	425	423	431	435	429	6	1	6	8	7	7	7	7	1	10	
Au (ppb)	143	146	146	149	147	146	2	1	37	33	38	35	36	2	6	8	10	10	10	10	10	1	9	
Au-Rp1 (ppb)	148	140	149	-	-	146	5	3	30	36	33	-	33	3	9	9	7	9	-	-	8	1	14	
Ba	44.9	42.5	46.2	47.3	46.1	45.4	1.8	4.0	168.0	174.7	174.2	170.5	171.9	3.2	1.8	147.3	148.0	154.8	152.9	159.3	152.5	5.0	3.3	
Be	45.9	53.4	48.2	46.3	48.3	48.4	3.0	6.2	4.7	5.1	4.8	4.9	4.9	0.2	3.5	0.1	0.2	0.2	0.2	0.2	0.2	0.0	24.8	
Bi	87.73	85.66	90.78	87.08	87.36	87.72	1.88	2.14	182.91	178.12	175.86	171.67	177.14	4.68	2.64	0.60	0.86	0.88	0.91	0.86	0.82	0.13	15.30	
Cd	0.5	0.5	0.6	0.6	0.6	0.6	0.1	9.8	0.2	0.2	0.2	0.2	0.2	-	-	-	-	-	-	-	-	-	-	
Ce	3.6	3.55	3.78	3.48	3.5	3.6	0.1	3.4	68.3	64.3	65.6	64.5	65.7	1.8	2.8	5.6	5.9	6.2	6.1	6.1	6.0	0.2	4.1	
Co	52.8	53.5	54.4	52.3	51.9	53.0	1.0	1.9	16.2	15.9	17.6	17.3	16.8	0.8	4.9	181.2	178.3	181.1	187.9	188.1	183.3	4.4	2.4	
Cr	1 596	1 591	1 550	1 576	1 560	1 575	20	1	157	170	161	161	162	6	3	1 188	1 268	1 331	1 241	1 280	1 262	53	4	
Cu	79	85	90	89	91	87	5	6	1 608	1 620	1 583	1 548	1 590	32	2	11	15	16	18	18	16	3	18	
Ga	17.7	17.6	18	17.6	17.3	17.6	0.3	1.4	5.5	5.7	6.2	6.1	5.9	0.3	5.6	1.1	0.9	1.6	1.6	1.6	1.4	0.3	24.7	
In	0.03	0.03	0.04	0.03	0.03	0.03	0.00	13.98	0.9	1.0	0.9	1.0	1.0	0.1	6.4	0.2	0.2	0.3	0.3	0.3	0.2	0.0	17.3	
La	1.43	1.4	1.46	1.44	1.44	1.43	0.02	1.53	27.72	24.62	26.29	26.80	26.36	1.30	4.93	1.57	1.68	1.78	1.70	1.70	1.69	0.08	4.47	
Li	355.4	260.7	357.6	351.9	350.4	335.2	41.7	12.5	2.5	2.3	2.6	2.8	2.6	0.2	8.2	3.6	3.3	3.9	4.2	3.8	3.8	0.3	8.9	
Mo	231.6	218.6	225.6	218	221.3	223.0	5.7	2.5	31.7	32.4	33.0	32.2	32.3	0.5	1.7	1.2	1.2	1.5	1.5	1.5	1.4	0.2	11.9	
Nb	2.7	2.8	3.2	2.5	2.4	2.7	0.3	11.5	2.4	2.8	3.3	2.5	2.8	0.4	14.7	0.6	1.1	0.7	0.6	0.6	0.7	0.2	30.1	
Ni	425	415	429	432	429	426	7	2	75	74	77	73	75	2	2	2 100	2 234	2 205	2 196	2 192	2 185	50	2	
Pb	102	98	105	109	107	104	4	4	463	454	437	441	449	12	3	11	10	12	12	12	11	1	8	
Pd (ppb)	7	7	7	7	7	7	-	-	2	2	2	4	3	1	40	5	4	7	6	6	6	1	20	
Pd-Rp1 (ppb)	6	7	7	-	-	7	1	9	3	3	3	-	3	-	-	5	6	7	-	-	6	1	17	
Pt (ppb)	9	8	7	8	8	8	1	9	7	7	7	8	7	1	7	5	4	4	5	5	5	1	12	
Pt-Rp1 (ppb)	7	8	8	-	-	8	1	8	9	9	7	-	8	1	14	5	5	5	-	-	5	-	-	
Rb	798.19	787.59	765.8	766.85	762.04	776.09	15.88	2.05	15.31	14.46	15.63	15.79	15.30	0.59	3.88	1.14	1.18	1.38	1.42	1.36	1.30	0.13	9.78	
S(%)	2.85	2.93	2.85	2.94	2.92	2.90	0.04	1.53	0.01	0.02	0.03	0.02	0.02	0.01	40.82	-	0.01	0.02	0.01	0.01	0.01	0.01	0.01	40.00
Sb	152.14	155.4	158.24	156.09	156.54	155.68	2.24	1.44	0.99	0.94	1.02	1.03	1.00	0.04	4.06	0.56	0.66	0.71	0.65	0.69	0.65	0.06	8.82	
Sc	18	17	18	18	18	18	-	3	52	54	53	53	53	1	2	6	6	6	6	6	6	-	-	
Se	0.7	0.7	0.9	1.2	0.9	0.9	0.2	23.3	3.2	2.8	2.2	2.4	2.7	0.4	16.7	-	-	0.6	0.5	0.5	0.5	0.1	10.8	
Sn	4.8	4.6	5.3	5.1	5.2	5.0	0.3	5.8	1.0	1.1	1.2	1.2	1.1	0.1	8.5	1.6	0.9	1.2	1.3	1.3	1.3	0.3	19.9	
Sr	28.36	27.37	28.8	29.03	28.55	28.42	0.64	2.25	14.34	13.11	14.25	14.50	14.05	0.64	4.52	5.79	6.15	6.31	6.40	6.50	6.23	0.28	4.46	
Ta	0.12	0.2	0.12	0.24	0.26	0.19	0.07	34.96	0.32	0.47	0.42	0.49	0.43	0.08	17.87	0.02	0.04	0.03	0.03	0.02	0.03	0.01	29.88	
Te	1.9	0.5	0.1	0.1	0.1	0.5	0.8	144.4	0.6	0.8	0.5	0.5	0.6	0.1	23.6	-	-	-	-	-	-	-	-	
Th	0.16	0.15	0.2	0.17	0.21	0.18	0.03	14.54	9.04	8.80	7.91	8.30	8.51	0.51	5.95	0.61	0.67	0.77	0.79	0.79	0.73	0.08	11.26	
U	0.39	0.37	0.45	0.45	0.44	0.42	0.04	8.91	467.64	466.30	454.28	454.20	460.61	7.37	1.60	0.72	0.84	0.63	0.61	0.57	0.67	0.11	16.00	
V	150	147	157	151	154	152	4	3	134	132	127	129	131	3	2	27	31	30	30	27	29	2	6	
W	1 600	1 585.5	1 617.9	1 618.8	1 620.4	1 608.5	15.3	1.0	2.6	2.6	2.7	2.5	2.6	0.1	3.1	1.6	1.1	1.5	1.5	1.5	1.4	0.2	13.5	
Y	7.42	7.54	7.5	7.67	7.81	7.59	0.15	2.02	121.9	118.0	122.3	121.3	120.9	1.9	1.6	2.8	2.6	3.1	2.5	2.6	2.7	0.2	9.0	
Zn	136	136	135	133	135	135	1	1	196	192	198	205	198	5	3	25	23	27	27	26	26	2	7	
Zr	39	39	42	40	41	40	1	3	35	29	23	27	29	5	18	11	11	9	8	9	10	1	14	

NOTES: Trace elements in parts per million unless otherwise specified; numbers in heading refer to batches;  $\sigma$ : standard deviation; RSD%: percentage relative standard deviation

Table 4.3. Analyses of standards MRG1, SO2, SY3, SY4, and TKC1

	Detection limit	Certified value	MRGI								
			Batch 1		Batch 2		Batch 3	Batch 4	Batch 5		Batch 6
			Mean	RSD%	Mean	RSD%	Mean	Mean	Mean	RSD%	Mean
Percentage											
SiO <sub>2</sub>	0.1	39.40	39.93	1.88	40.27	2.09	39.40	40.13	39.73	2.42	39.31
TiO <sub>2</sub>	0.05	3.69	3.73	2.32	3.87	0.55	3.69	3.74	3.70	0.57	3.67
Al <sub>2</sub> O <sub>3</sub>	0.02	8.5	8.23	3.09	8.61	1.89	8.34	8.11	8.28	2.56	8.47
Fe <sub>2</sub> O <sub>3</sub>	0.01	17.83	16.96	2.38	17.94	1.85	17.83	17.73	17.50	2.55	17.82
MnO	0.001	0.168	0.153	—	0.153	0.924	0.168	0.154	0.158	1.347	0.162
MgO	0.01	13.5	13.65	2.16	13.57	3.02	13.50	13.43	13.69	3.00	13.54
CaO	0.1	14.8	15.07	0.77	14.69	3.27	14.80	14.77	14.70	0.38	14.40
Na <sub>2</sub> O	0.002	0.714	0.710	0.299	0.712	1.292	0.714	0.717	0.730	1.162	0.714
K <sub>2</sub> O	0.02	0.22	0.20	2.84	0.22	—	0.18	0.20	0.20	—	0.18
P <sub>2</sub> O <sub>5</sub>	0.002	0.060	0.054	3.965	0.054	2.619	0.064	0.055	0.058	1.230	0.057
LOI	0.01	—	—	—	—	—	—	—	—	—	—
Parts per million											
Ag	0.1	0.14	0.2	—	0.2	—	0.1	0.2	0.2	—	0.1
As	1	0.65	—	—	1	—	—	—	1	—	—
Au (ppb)	1	—	—	—	—	—	—	—	—	—	—
Ba	0.1	49	49.7	1.3	48.1	1.3	48.9	51.2	49.6	3.4	49.7
Be	0.1	0.2	0.3	38.5	0.4	—	0.3	0.3	0.3	—	0.2
Bi	0.01	0.2	0.25	4.62	0.15	30.12	0.18	0.15	0.21	27.49	0.20
Cd	0.1	0.1	0.2	38.5	0.1	—	0.1	0.2	0.2	—	0.1
Ce	0.01	25.6	28.42	2.01	26.41	0.31	25.36	28.84	26.11	0.20	25.62
Co	0.1	87	87.2	2.5	85.1	0.3	87.2	84.8	87.9	4.6	87.2
Cr	2	420	385	—	418	2	420	411	400	2	415
Cu	1	135	129	3	128	3	135	125	131	2	130
Ga	0.1	16	18.4	0.6	17.4	1.7	16.3	18.3	17.9	2.3	16.3
In	0.01	<0.5	0.08	—	0.07	—	0.10	0.08	0.08	—	0.09
La	0.01	10	10.30	1.40	9.24	2.44	10.27	10.68	9.21	0.75	10.02
Li	0.1	4	3.6	—	3.3	1.7	3.8	3.2	3.7	7.9	4.2
Mo	0.1	0.8	1.1	5.5	1.0	5.6	0.9	1.1	0.9	—	0.8
Nb	0.5	20	22.3	0.3	22.7	3.1	19.6	21.5	20.8	7.5	19.8
Ni	1	195	186	3	191	—	197	187	182	1	196
Pb	2	10	8	14	8	—	10	8	9	7	9
Pd (ppb)	1	—	—	—	—	—	—	—	—	—	—
Pt (ppb)	1	—	—	—	—	—	—	—	—	—	—
Rb	0.05	8	7.96	3.48	7.38	3.13	8.03	8.71	7.63	6.51	7.98
S (%)	0.01	0.06	0.05	—	0.07	10.88	0.06	0.04	0.06	—	0.06
Sb	0.05	0.42	0.51	5.72	0.47	2.44	0.42	0.48	0.47	2.46	0.42
Sc	2	48	49	1	47	2	46	48	50	—	51
Se	0.5	0.19	—	—	—	—	—	0.5	—	—	—
Sn	0.1	3.3	3.6	8.1	3.3	1.8	3.3	3.3	3.7	4.7	3.3
Sr	0.05	270	287.88	2.59	273.67	0.09	271.69	281.47	272.48	0.45	270.75
Ta	0.01	2	1.89	1.83	1.87	0.31	1.96	1.00	1.74	1.33	1.80
Te	0.1	—	—	—	—	—	—	0.1	—	—	—
Th	0.01	1	0.88	5.25	0.80	7.19	0.98	0.88	0.87	8.68	0.97
U	0.01	0.28	0.27	2.18	0.24	—	0.28	0.28	0.26	2.26	0.28
V	2	520	519	2	509	2	516	519	532	1	524
W	0.1	0.54	0.4	—	0.4	—	0.5	0.4	0.4	16.5	0.5
Y	0.05	11.8	12.93	1.88	11.66	0.05	11.76	12.42	12.05	2.01	11.79
Zn	1	190	172	2	184	1	187	178	183	4	187
Zr	1	105	105	4	108	3	103	108	108	2	108

NOTES: Trace elements in parts per million unless otherwise specified  
RSD%: percentage relative standard deviation  
Where only one standard was analysed in a batch, RSD% was not calculated  
—: less than detection limit



Table 4.3 (cont.)

		SO2					
	Detection limit	Certified value	Batch 1 Mean	Batch 2 Mean	Batch 3 Mean	Batch 4 Mean	Batch 5 Mean
Percentage							
SiO <sub>2</sub>	0.1	53.47	52.50	52.81	53.39	51.43	53.29
TiO <sub>2</sub>	0.05	1.42	1.38	1.41	1.42	1.37	1.40
Al <sub>2</sub> O <sub>3</sub>	0.02	15.16	14.21	14.85	15.27	14.15	14.82
Fe <sub>2</sub> O <sub>3</sub>	0.01	7.97	7.60	7.92	7.88	7.78	7.67
MnO	0.001	0.090	0.092	0.087	0.093	0.077	0.089
MgO	0.01	0.90	0.96	0.93	0.90	0.94	0.96
CaO	0.1	2.70	2.70	2.81	2.68	2.95	2.67
Na <sub>2</sub> O	0.002	2.510	2.516	2.392	2.489	2.131	2.434
K <sub>2</sub> O	0.02	2.94	2.77	2.68	2.94	2.70	2.86
P <sub>2</sub> O <sub>5</sub>	0.002	0.690	0.699	0.698	0.683	0.610	0.705
LOI	0.01	—	—	—	—	—	—
Parts per million							
Ag	0.1	—	0.1	0.1	—	0.1	0.3
As	1	1.22	—	2	1	2	1
Au (ppb)	1	—	—	—	—	—	—
Ba	0.1	980	942.9	968.7	980.3	923.3	984.2
Be	0.1	1.7	1.6	1.6	1.8	1.6	1.8
Bi	0.01	0.03	0.03	0.04	0.03	0.17	0.04
Cd	0.1	0.13	0.1	0.1	0.1	0.1	0.1
Ce	0.01	111	121.71	114.91	111.63	108.46	110.06
Co	0.1	8.2	7.6	7.8	8	9.3	7.3
Cr	2	14	11	10	14	18	14
Cu	1	6.6	5	4	7	8	5
Ga	0.1	25	26.6	24.3	25.9	22.9	26.7
In	0.01	—	—	0.02	—	0.01	0.1
La	0.01	46.1	48.48	44.25	46.16	49.55	43.45
Li	0.1	8.4	9	10.4	8.6	9.2	9.2
Mo	0.1	2.6	1.9	2.3	2.6	2.5	2.4
Nb	0.5	—	—	0.6	—	—	—
Ni	1	10	8	8	9	15	8
Pb	2	20	19	18	20	22	18
Pd (ppb)	1	—	—	—	—	—	—
Pt (ppb)	1	—	—	—	—	—	—
Rb	0.05	79	73.22	74.16	78.88	85	73.54
S (%)	0.01	0.041	0.03	0.02	0.04	0.04	0.05
Sb	0.05	0.08	0.09	0.07	0.09	0.09	0.09
Sc	2	11.4	11	10	12	10	10
Se	0.5	0.47	—	0.5	—	0.5	—
Sn	0.1	2.02	1.8	1.9	2	1.9	2.1
Sr	0.05	334	342.76	323.19	340.78	87.96	324.52
Ta	0.01	1.15	1.14	1.21	1.15	1.05	1.04
Te	0.1	—	—	—	—	—	—
Th	0.01	4.1	3.55	4.34	4.1	4.19	3.83
U	0.01	0.96	0.87	0.74	0.95	1.05	0.92
V	2	62	69	64	62	70	66
W	0.1	0.4	0.3	0.3	0.4	0.5	0.3
Y	0.05	37.2	37.67	35.86	36.83	35.93	36.34
Zn	1	122	114	120	119	120	112
Zr	1	790	804	783	791	769	807

Table 4.3 (cont.)

Detection limit	SY3											
	Certified value	Batch 1		Batch 2	Batch 3		Batch 4		Batch 5		Batch 6	
		Mean	RSD%		Mean	RSD%	Mean	RSD%	Mean	RSD%		
Percentage												
SiO <sub>2</sub>	0.1	59.7	59.95	0.59	58.46	59.58	0.19	60.61	1.10	59.85	2.03	59.71
TiO <sub>2</sub>	0.05	0.15	0.19	3.82	0.18	0.15	—	0.19	7.44	0.17	0.00	0.16
Al <sub>2</sub> O <sub>3</sub>	0.02	11.79	11.37	2.86	11.53	11.76	0.36	11.28	6.52	11.44	2.29	11.70
Fe <sub>2</sub> O <sub>3</sub>	0.01	6.42	6.36	0.89	6.47	6.48	1.64	6.62	1.28	6.32	0.67	6.37
MnO	0.001	0.323	0.313	4.970	0.317	0.324	0.436	0.309	1.831	0.308	2.755	0.321
MgO	0.01	2.67	2.75	0.26	2.63	2.65	1.07	2.71	5.74	2.67	0.27	2.66
CaO	0.1	8.3	8.30	0.00	8.60	8.27	1.37	8.43	4.28	8.27	0.09	8.33
Na <sub>2</sub> O	0.002	4.17	4.143	6.606	3.928	4.141	1.110	4.030	0.597	4.039	2.189	4.162
K <sub>2</sub> O	0.02	4.2	4.08	0.35	4.19	4.17	0.51	4.16	2.72	4.15	1.70	4.09
P <sub>2</sub> O <sub>5</sub>	0.002	0.527	0.508	3.062	0.523	0.521	0.814	0.518	0.546	0.527	0.268	0.526
LOI	0.01	—	—	—	—	—	—	—	—	—	—	—
Parts per million												
Ag	0.1	0.02	—	—	—	—	—	—	—	—	—	—
As	1	19	21	3	20	18	4	17	4	18	4	17
Au (ppb)	1	—	—	—	—	—	—	—	—	—	—	—
Ba	0.1	430	426.2	2.9	418.1	432.1	0.4	433.3	1.3	424.5	1.4	429.5
Be	0.1	23	21.2	8.4	22.7	23.0	0.9	22.8	2.5	20.8	5.4	23.0
Bi	0.01	0.27	0.30	2.40	0.29	0.27	10.48	0.29	12.41	0.27	2.67	0.27
Cd	0.1	0.2	0.3	47.1	0.1	0.3	28.3	0.2	—	0.2	—	0.2
Ce	0.01	2 340	2 393.95	0.40	2 331.10	2 325.55	0.40	2 407.40	1.06	2 314.20	0.53	2 327.2
Co	0.1	11	9.5	1.5	9.9	10.7	4.0	10.3	2.1	9.7	0.7	9.4
Cr	2	10	6	47	8	10	—	8	—	8	—	10
Cu	1	17	20	—	22	17	4	19	4	18	4	17
Ga	0.1	27	27.2	0.3	25.0	26.3	1.3	28.0	0.3	28.2	6.0	28.8
In	0.01	<0.5	0.10	—	0.11	0.12	6.15	0.11	12.86	0.10	7.44	0.11
La	0.01	1 330	1 398.00	3.64	1 326.60	1 325.05	0.47	1 371.65	0.94	1 329.05	1.23	1 320.50
Li	0.1	92	88.5	1.2	91.9	92.5	0.8	89.4	3.1	86.1	0.2	95.4
Mo	0.1	0.6	0.7	20.2	0.9	0.7	10.9	0.6	—	0.5	—	0.6
Nb	0.5	200	206.3	3.3	202.9	199.3	0.6	207.9	1.0	209.0	1.5	201.7
Ni	1	11	10	7	10	10	—	9	16	10	—	10
Pb	2	135	150	—	138	136	1	142	1	146	3	134
Pd (ppb)	1	—	—	—	—	—	—	—	—	—	—	—
Pt (ppb)	1	—	—	—	—	—	—	—	—	—	—	—
Rb	0.05	208	217.67	3.13	209.77	206.55	0.47	214.51	1.83	204.82	2.59	206.80
S(%)	0.01	0.05	0.04	—	0.06	0.05	—	0.04	20.20	0.06	—	0.02
Sb	0.05	0.44	0.39	5.51	0.42	0.44	1.63	0.40	1.79	0.40	—	0.42
Sc	2	11	14	—	12	12	6	12	—	12	—	12
Se	0.5	0.015	—	—	—	—	—	—	—	—	—	—
Sn	0.1	5.5	6.1	—	5.8	5.8	6.1	5.9	3.6	5.9	1.2	5.5
Sr	0.05	306	312.62	1.18	301.22	305.75	0.10	313.08	1.73	294.63	1.08	306.84
Ta	0.01	30	28.25	1.25	28.66	30.15	2.77	27.50	0.82	29.75	0.69	29.21
Te	0.1	—	—	—	—	—	—	—	—	—	—	—
Th	0.01	990	1 089.70	0.82	1 003.00	1 002.30	0.01	1 044.95	5.96	982.27	0.74	991.20
U	0.01	650	702.64	0.76	657.71	657.29	0.18	704.85	4.35	644.40	0.10	700.79
V	2	51	56.5	1.3	53.0	51.5	1.4	55.5	3.8	56.0	—	52.0
W	0.1	1.3	1.1	12.9	1.8	1.3	—	1.1	—	1.1	6.7	1.4
Y	0.05	685	703.57	1.47	660.85	706.53	1.85	707.03	1.41	657.16	1.49	679.02
Zn	1	240	230	6	232	236	—	222	4	223	2	236
Zr	1	320	354	2	339	322	—	334	1	338	—	320

Table 4.3 (cont.)

Detection limit	Certified value	SY4								
		Batch 1		Batch 2 Mean	Batch 3 Mean	Batch 4 Mean	Batch 5		Batch 6 Mean	
		Mean	RSD%				Mean	RSD%		
Percentage										
SiO <sub>2</sub>	0.1	49.9	49.65	5.55	50.44	49.87	51.36	49.73	2.92	49.80
TiO <sub>2</sub>	0.05	0.28	0.32	4.42	0.28	0.28	0.30	0.30	2.40	0.27
Al <sub>2</sub> O <sub>3</sub>	0.02	20.7	19.94	6.77	20.62	20.59	20.96	19.87	2.31	20.41
Fe <sub>2</sub> O <sub>3</sub>	0.01	6.21	6.16	2.87	6.54	6.22	6.28	6.02	0.47	6.14
MnO	0.001	0.106	0.102	—	0.103	0.103	0.099	0.099	2.154	0.102
MgO	0.01	0.54	0.60	—	0.60	0.56	0.60	0.59	1.21	0.56
CaO	0.1	8.05	7.95	2.67	7.88	8.04	8.50	8.02	0.09	7.99
Na <sub>2</sub> O	0.002	7.1	7.031	0.965	7.019	7.107	6.919	7.000	0.556	7.102
K <sub>2</sub> O	0.02	1.66	1.64	3.89	1.63	1.64	1.73	1.66	2.99	1.55
P <sub>2</sub> O <sub>5</sub>	0.002	0.133	0.122	1.746	0.120	0.128	0.121	0.127	2.795	0.133
LOI	0.01	—	—	—	—	—	—	—	—	—
Parts per million										
Ag	0.1	0.6	0.4	—	0.3	0.6	0.5	0.4	—	0.6
As	1	1	1	—	1	1	1	—	—	1
Au (ppb)	1	—	—	—	—	—	—	—	—	—
Ba	0.1	340	334.7	0.9	337.0	345.4	330.4	326.7	1.0	338.3
Be	0.1	2.6	2.8	12.9	2.8	2.8	2.7	2.6	2.8	2.6
Bi	0.01	0.2	—	—	0.11	0.20	—	—	—	0.19
Cd	0.1	1	0.5	110.0	0.9	0.9	0.8	0.2	47.1	0.9
Ce	0.01	122	134.16	6.53	122.39	123.48	129.91	116.08	0.07	123.25
Co	0.1	2.8	2.9	2.5	3.1	3.0	2.8	2.5	—	2.8
Cr	2	12	10	—	10	10	10	10	—	12
Cu	1	7	5	—	5	7	6	4	61	6
Ga	0.1	35	37.8	4.1	36.0	35.4	35.6	35.8	3.8	35.3
In	0.01	—	—	—	0.03	—	0.01	0.01	—	0.03
La	0.01	58	61.90	2.02	57.12	58.21	61.20	53.75	0.78	57.32
Li	0.1	37	35.2	6.0	38.0	36.3	35.4	36.4	7.0	38.2
Mo	0.1	1.5	1.0	—	1.1	1.5	1.2	1.2	—	1.5
Nb	0.5	13	14.0	3.5	14.1	13.6	15.3	14.6	4.8	15.1
Ni	1	9	10	14	8	10	9	9	8	9
Pb	2	10	11	7	9	9	11	11	7	10
Pd (ppb)	1	—	—	—	—	—	—	—	—	—
Pt (ppb)	1	—	—	—	—	—	—	—	—	—
Rb	0.05	55	58.05	8.42	56.42	54.87	54.08	51.61	0.90	54.72
S (%)	0.01	0.015	—	—	0.02	0.01	—	0.02	—	0.01
Sb	0.05	0.1	—	—	—	0.10	0.05	0.07	—	0.12
Sc	2	1.1	—	—	—	—	—	2	—	—
Se	0.5	2	1.3	21.8	1.5	2.0	2.0	1.5	—	2.0
Sn	0.1	7.1	7.3	1.9	7.4	7.0	7.3	7.4	1.9	7.1
Sr	0.05	1 191	1 252.40	3.24	1 187.30	1 200.40	1 185.80	1 126.50	5.77	1 184.90
Ta	0.01	0.9	1.00	—	0.97	0.95	1.03	0.77	—	0.92
Te	0.1	—	—	—	—	—	—	—	—	—
Th	0.01	1.4	1.26	9.58	1.71	1.35	1.17	1.17	15.17	1.36
U	0.01	0.8	0.83	35.78	0.86	0.80	0.67	0.70	15.26	0.73
V	2	8	10	—	11	8	10	11	7	8
W	0.1	7	6.2	4.6	5.0	7.0	6.0	6.1	2.3	7.1
Y	0.05	119	123.75	5.99	115.11	118.68	122.92	110.84	2.35	118.41
Zn	1	93	84	2	88	93	92	85	5	93
Zr	1	517	546	3	539	513	521	525	—	517

Table 4.3 (cont.)

	Detection limit	Certified value	TKC1							
			Batch 1		Batch 2		Batch 3	Batch 4	Batch 5	
			Mean	RSD%	Mean	RSD%	Mean	Mean	Mean	RSD%
Percentage										
SiO <sub>2</sub>	0.1	57.8	59.65	1.30	57.81	0.60	57.80	58.05	57.71	0.06
TiO <sub>2</sub>	0.05	0.684	0.74	5.73	0.72	0.99	0.70	0.73	0.71	1.99
Al <sub>2</sub> O <sub>3</sub>	0.02	11.34	11.18	1.96	11.54	0.31	11.40	10.83	11.21	1.70
Fe <sub>2</sub> O <sub>3</sub>	0.01	8.58	8.70	2.85	8.63	1.47	8.61	8.58	8.51	1.00
MnO	0.001	0.245	0.220	2.899	0.231	0.612	0.247	0.218	0.227	1.561
MgO	0.01	2.82	2.95	1.92	2.84	3.24	2.89	2.77	2.88	0.98
CaO	0.1	2.7	2.75	2.57	2.83	1.00	2.68	2.83	2.68	–
Na <sub>2</sub> O	0.002	1.82	1.682	2.270	1.774	0.797	1.826	1.753	1.746	1.053
K <sub>2</sub> O	0.02	1.9	1.94	0.73	1.99	4.97	1.83	2.00	1.94	1.83
P <sub>2</sub> O <sub>5</sub>	0.002	0.149	0.135	6.285	0.141	2.006	0.147	0.135	0.146	0.969
LOI	0.01	–	–	–	–	–	–	–	–	–
Parts per million										
Ag	0.1	15	14.8	–	14.5	3.9	15.3	14.4	14.4	0.5
As	1	700	679	3	679	2	697	681	687	–
Au (ppb)	1	–	–	–	–	–	–	–	–	–
Ba	0.1	850	825.6	2.3	830.1	0.3	852.5	837.8	838.3	0.7
Be	0.1	52	46.9	3.5	51.2	4.7	52.1	50.1	48.9	1.6
Bi	0.01	25	27.40	1.88	25.93	0.11	25.98	27.87	23.89	1.63
Cd	0.1	8	7.0	2.0	7.7	4.6	7.7	7.4	6.9	2.05
Ce	0.01	565	540.37	4.19	546.20	0.23	508.63	564.32	520.48	1.62
Co	0.1	33	31.4	2.9	31.9	0.2	33.1	31.9	31.6	0.4
Cr	2	1 800	1 706	1	1 787	–	1 801	1 753	1 790	–
Cu	1	1 880	1 871	–	1 889	1	1 874	1 840	1 817	4
Ga	0.1	24	23.7	2.4	22.6	0.9	24.0	23.6	23.5	2.4
In	0.01	5.6	5.62	3.15	5.17	–	5.60	5.66	5.18	0.55
La	0.01	300	297.85	3.82	290.73	2.16	297.35	299.90	287.76	0.14
Li	0.1	58	58.1	8.1	58.0	3.4	60.3	59.3	57.0	4.1
Mo	0.1	30	29.5	4.3	27.9	4.6	31.3	29.7	29.6	2.6
Nb	0.5	65	63.5	0.9	67.5	1.8	65.1	68.9	68.4	2.8
Ni	1	1 850	1 840	3	1 866	2	1 852	1 725	1 886	1
Pb	2	1 950	1 987	2	1 924	–	1 941	1 957	1 922	–
Pd (ppb)	1	–	–	–	–	–	–	–	–	–
Pt (ppb)	1	–	–	–	–	–	–	–	–	–
Rb	0.05	580	560.78	1.03	551.60	0.79	590.33	575.22	521.22	0.94
S (%)	0.01	1.03	1.05	4.04	1.05	1.35	1.02	0.97	1.02	1.39
Sb	0.05	185	176.27	5.09	180.80	1.96	184.45	179.23	176.43	1.42
Sc	2	49	48	–	48	–	47	43	47	3
Se	0.5	71	67.0	3.8	66.5	3.2	69.9	66.0	67.7	0.9
Sn	0.1	5	5.5	14.3	5.9	13.3	5.0	4.7	5.0	7.1
Sr	0.05	700	710.12	0.47	684.95	0.88	719.33	692.05	657.46	0.75
Ta	0.01	100	97.00	1.46	113.81	21.11	101.49	101.50	91.12	3.20
Te	0.1	–	11.7	2.4	10.9	2.0	10.8	11.0	11.6	2.4
Th	0.01	137	136.59	6.97	135.18	1.44	137.92	134.25	130.04	1.68
U	0.01	11	10.60	5.14	10.28	0.34	11.16	11.10	10.54	1.48
V	2	185	183	–	185	1	185	177	181	1
W	0.1	67	63.3	7.4	64.7	1.3	66.3	62.7	63.8	2.3
Y	0.05	24	24.09	3.14	23.12	0.12	24.60	28.64	23.24	2.04
Zn	1	2250	2 167	–	2 214	–	2 242	2 168	2 161	2
Zr	1	300	344	1	358	11	301	310	307	2

Table 4.4. Analyses of laboratory standard BCS348

DL	Certified value	BCS348									
		Batch 1	Batch 1	Batch 2	Batch 2	Batch 3	Batch 3	Batch 4	Batch 4	Batch 5	Batch 5
		Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%
Percentage											
LOI	0.01	11.80	11.87	1.19	11.74	1.90	11.73	0.88	11.93	0.87	11.60

NOTES: DL: detection level  
RSD%: percent relative standard deviation  
Where less than two standards were analysed, %RSD was not calculated

Table 4.5. Analyses of laboratory standard SARM 7.2

DL	Certified value	SARM 7.2											
		Batch 1	Batch 1	Batch 2	Batch 2	Batch 3	Batch 3	Batch 4	Batch 4	Batch 5	Batch 5	Batch 6	Batch 6
		Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%
Parts per billion													
Au	1	62	58	3	61	5	61	2	60	–	60	4	62
Pd	1	306	286	2	297	2	304	1	295	1	297	1	303
Pt	1	748	713	1	736	2	746	1	731	2	732	3	741

NOTES: DL: detection level  
RSD%: percent relative standard deviation  
Where less than two standards were analysed, %RSD was not calculated  
–: below detection limit

Table 4.6. Analyses of laboratory standard ETA04

DL	Certified value	ETA04											
		Batch 1	Batch 1	Batch 2	Batch 2	Batch 3	Batch 3	Batch 4	Batch 4	Batch 5	Batch 5	Batch 6	Batch 6
		Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%	Mean	RSD%
Parts per billion													
Au	1	230	208	3	228	7	227	1	210	–	218	1	229
Pd	1	178	161	1	167	1	177	1	169	4	169	3	178
Pt	1	45	40	–	45	4	44	1	42	2	42	3	45

NOTES: DL: detection level  
RSD%: percent relative standard deviation  
Where less than two standards were analysed, %RSD was not calculated  
–: below detection limit

Table 4.7. Comparison of analytical results for anomalous gold samples

Sample	GSWA 151805					GSWA 151809					GSWA 151810					GSWA 151752				
'Round'	1	2	2	3	3	1	2	2	3	3	1	2	2	3	3	1	2	2	3	3
Laboratory	G	A	A	A	G	G	A	A	A	G	G	A	A	A	G	G	A	A	G	G
Type	arch	pulp	arch	arch	arch	arch	pulp	arch	arch	arch	arch	pulp	arch	arch	arch	arch	pulp	arch	arch	arch
Parts per billion																				
Au	14	7	1	2	<sup>(a)</sup> 2	32	<sup>(a)</sup> 9	3	9	6	74	84	–	2	<sup>(a)</sup> 3	<sup>(a)</sup> 9	2	6	12	6
Au-Rp1	6	2	–	2	–	401	11	–	2	–	68	70	–	1	–	40	–	5	9	–
Au-Rp2	25	–	–	–	–	11	–	–	–	–	–	–	–	–	–	39	–	–	10	–
Au-Rp3	–	–	–	–	–	84	–	–	–	–	–	–	–	–	–	12	–	–	–	–
Cr	82	120	<sup>(a)</sup> 100	105	77	<sup>(a)</sup> 77	70	220	305	70	<sup>(a)</sup> 73	70	190	59	56	78	80	241	330	<sup>(a)</sup> 83
Nb	<sup>(a)</sup> 13.7	23	23.4	22.2	12.21	<sup>(a)</sup> 13.3	20.9	18	10.5	7.93	<sup>(a)</sup> 13.2	19.6	18	9.2	7.72	<sup>(a)</sup> 10	14.9	14.9	–	–

NOTES: (a) incorporated into the database  
A: Amdel Laboratories  
G: Genalysis Laboratories  
arch: archive  
–: less than detection limit

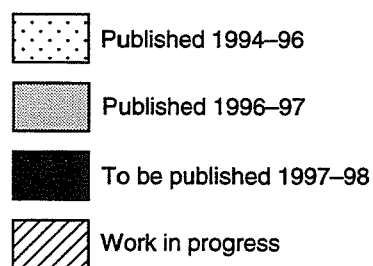
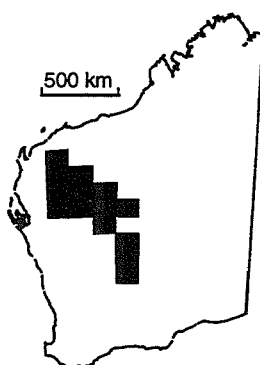
## Figures

1. Status of regional regolith and geochemical mapping program maps and explanatory notes
2. Simplified locality plan
3. Simplified geological interpretation
4. Generalized regolith map

### Element-distribution maps

5.  $\text{TiO}_2$
6.  $\text{Al}_2\text{O}_3$
7.  $\text{Fe}_2\text{O}_3$
8.  $\text{MnO}$
9.  $\text{MgO}$
10.  $\text{CaO}$
11.  $\text{Na}_2\text{O}$
12.  $\text{K}_2\text{O}$
13.  $\text{P}_2\text{O}_5$
14. LOI
15. Ag
16. As
17. Au
18. Ba
19. Be
20. Bi
21. Cd
22. Ce
23. Co
24. Cr
25. Cu
26. Ga
27. In
28. La
29. Li
30. Mo
31. Nb
32. Ni
33. Pb
34. Pd
35. Pt
36. Rb
37. S
38. Sb
39. Sc
40. Se
41. Sn
42. Sr
43. Ta
44. Te
45. Th
46. U
47. V
48. W
49. Y
50. Zn
51. Zr
52. Contoured regolith pH
53. Base-metals index ( $\text{Cu} + \text{Pb} + \text{Zn} + \text{As} + \text{Sb}$ )
54. Chalcophile index ( $\text{As} + \text{Ag} + \text{Bi} + \text{Cd} + \text{Sb} + \text{Mo}$ )
55. Ferro-alloy index ( $\text{Ni} + \text{Cr} + \text{Mo} + \text{Co} + \text{V}$ )
56. Metalliferous black-shale index ( $\text{V} + \text{Cr} + \text{Co} + \text{Ni} + \text{Cu} + \text{Zn} + \text{Ag} + \text{Cd} + \text{Pb} + \text{U} + \text{As} + \text{Se} + \text{Sb} + \text{Ti} + \text{Ba} + \text{Na}_2\text{O} + \text{La} + \text{Ce} + \text{Zr}$ )

JURABI POINT	ONSLOW	YARRALLOOLA	PYRAMID	MARBLE BAR	NULLAGINE	PATERSON RANGE
NINGALOO	YANREY	WYLOO	MOUNT BRUCE	ROY HILL	BALFOUR DOWNS	RUDALL
MINILYA	WINNING POOL	EDMUND	TUREE CREEK	NEWMAN	ROBERTSON	GUNANYA
QUOBBA	KENNEDY RANGE	MOUNT PHILLIPS	MOUNT EGERTON	COLLIER	BULLEN	TRAINOR
SHARK BAY	WOORAMEL	GLENBURGH	ROBINSON RANGE	PEAK HILL	NABBERU	STANLEY
EDELL	YARINGA	BYRO	BELELE	GLENGARRY	WILUNA	KINGSTON
ZUYTDORP	AJANA	MURGOO	CUE	SANDSTONE	SIR SAMUEL	DUKETON
HOUTMAN ABROLHOS	GERALDTON	YALGOO	KIRKALOCKA	YOUANMI	LEONORA	LAVERTON
ZEEWYJK	DONGARA	PERENJORI	NINGHAN	BARLEE	MENZIES	EDJUDINA
	HILL RIVER	MOORA	BENCUBBIN	JACKSON	KALGOORLIE	KURNALPI



PAM128A

04.05.98

**Figure 1. Status of regional regolith and geochemical mapping program maps and explanatory notes**



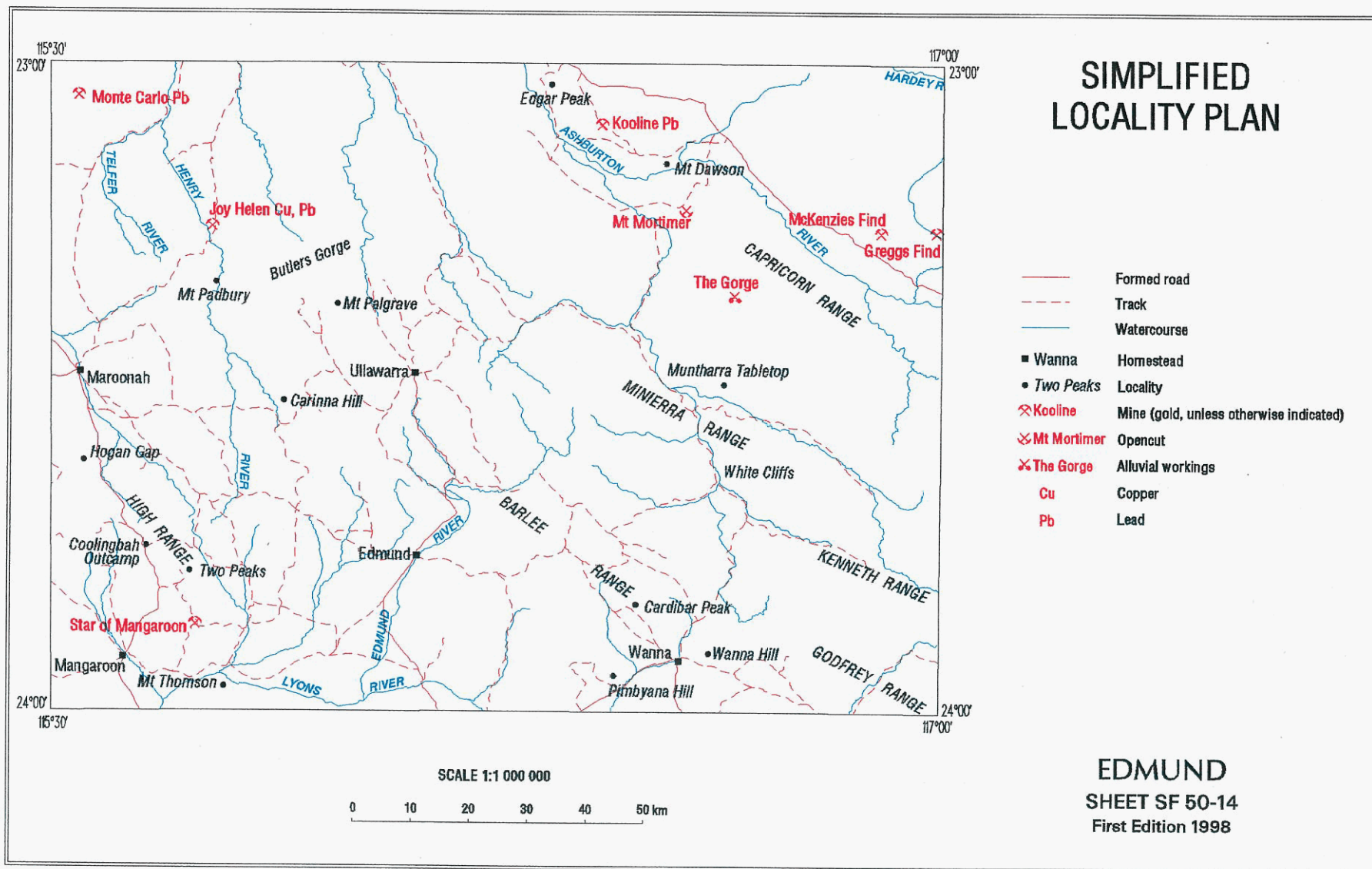


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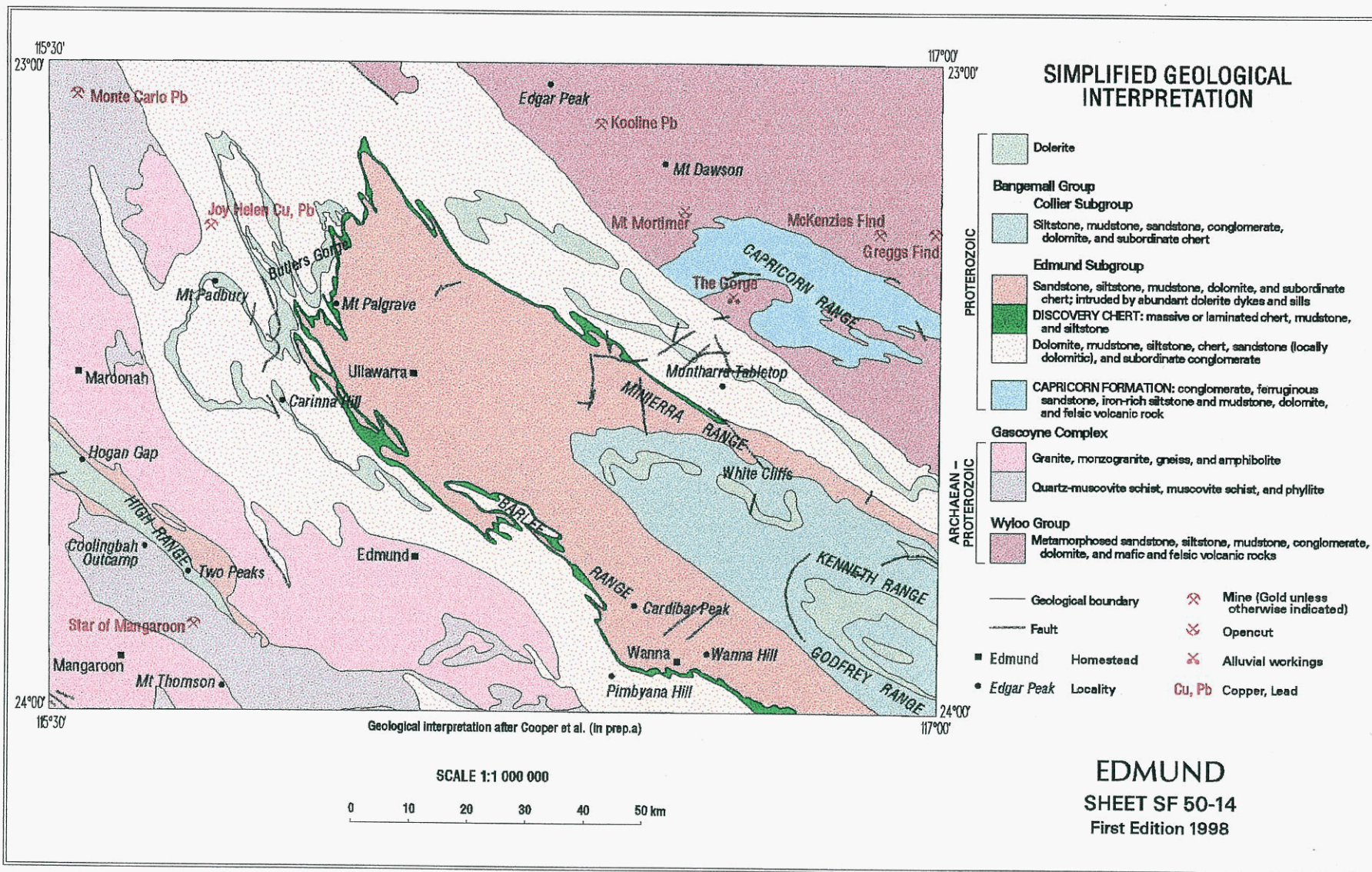


Figure 3



115°30'  
23°00'

117°00'  
23°00'

24°00'  
115°30'








24°00'  
117°00'

SCALE 1:1 000 000

0 10 20 30 40 50 km

## GENERALIZED REGOLITH MAP

### Environment

-  Relict
-  Erosional
-  Depositional - colluvial
-  Depositional - alluvial
-  Watercourse
-  Road or track
-  Regolith boundary

EDMUND  
SHEET SF 50-14  
First Edition 1998

Figure 4



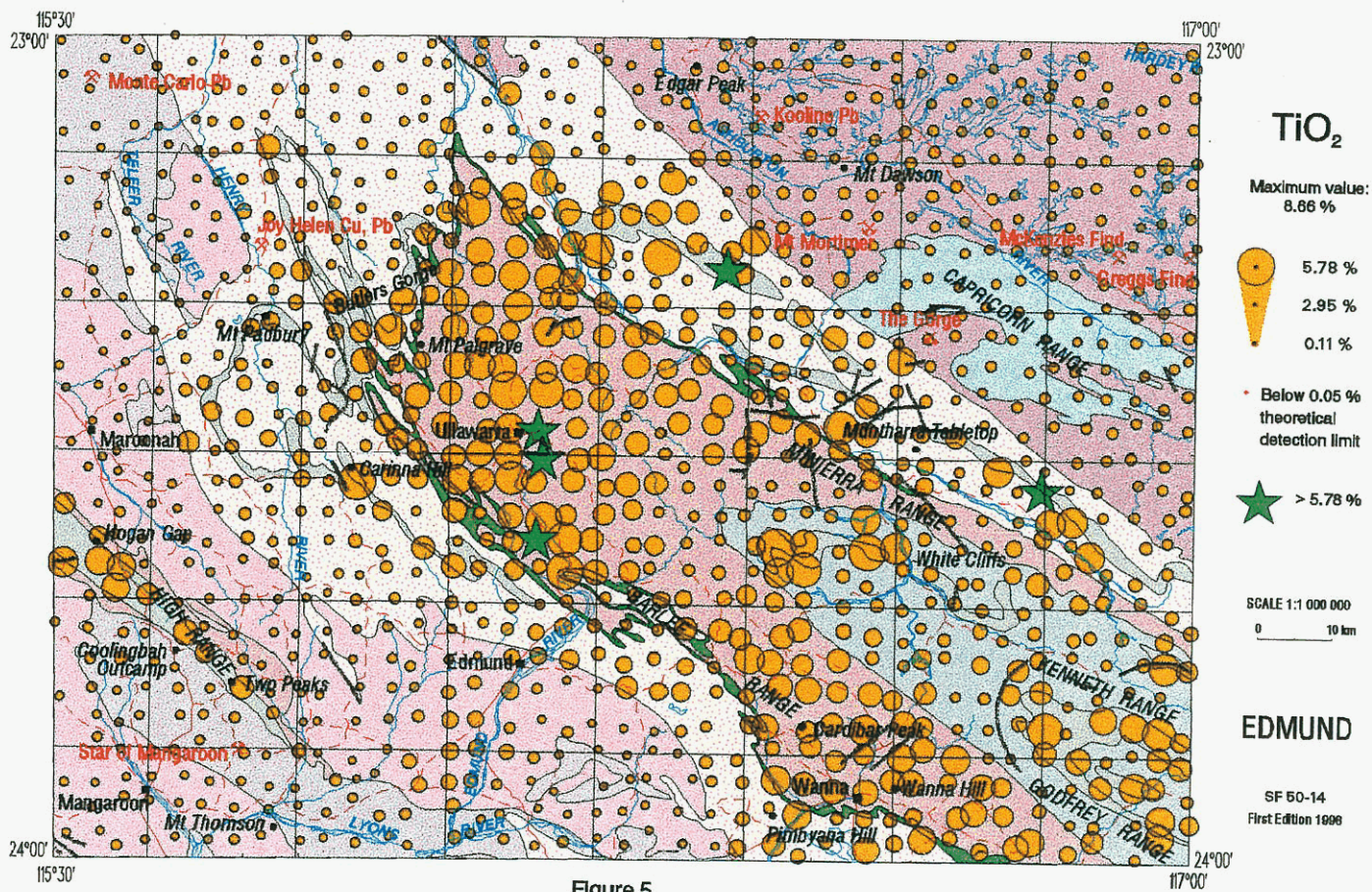


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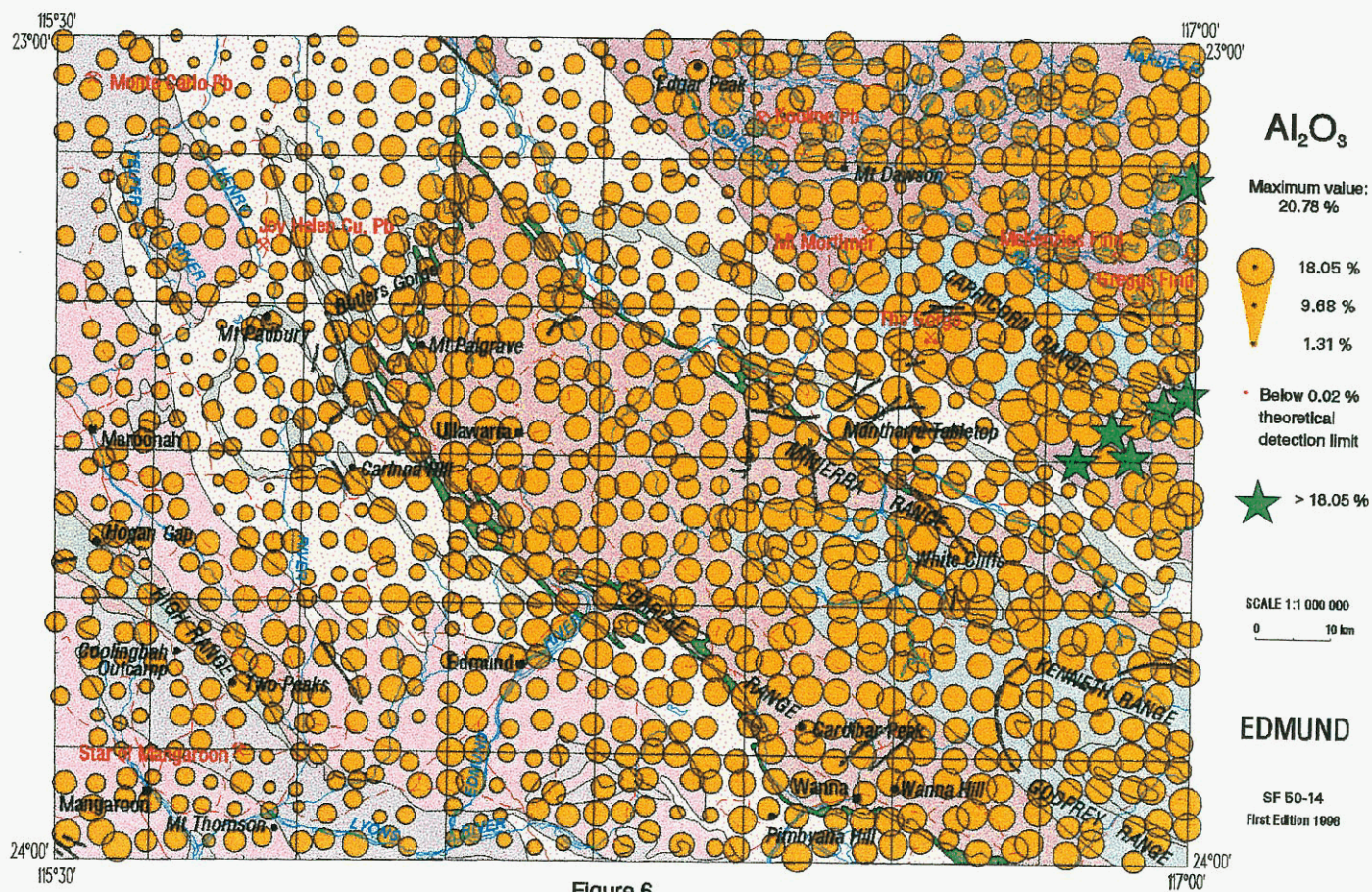


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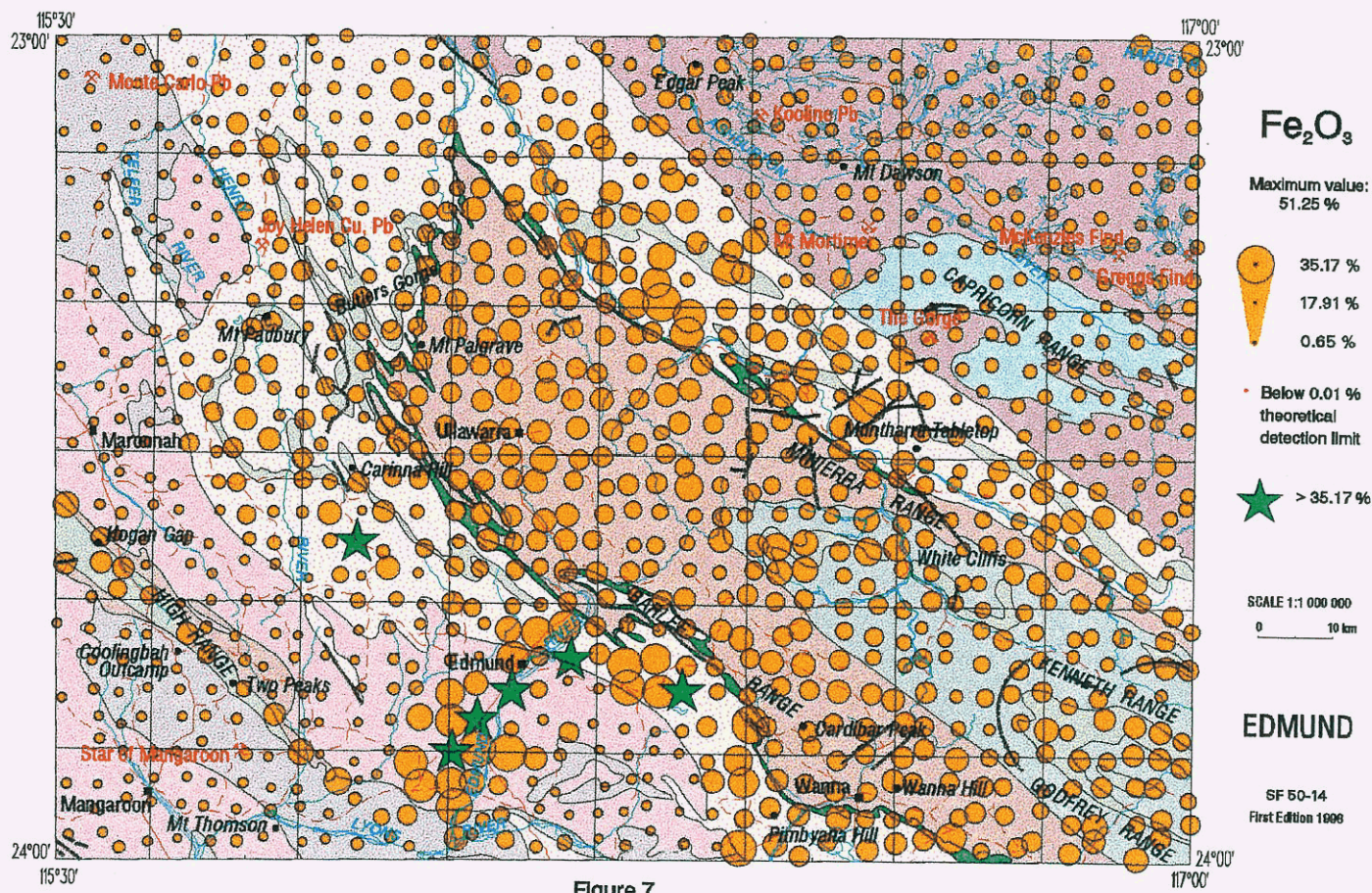


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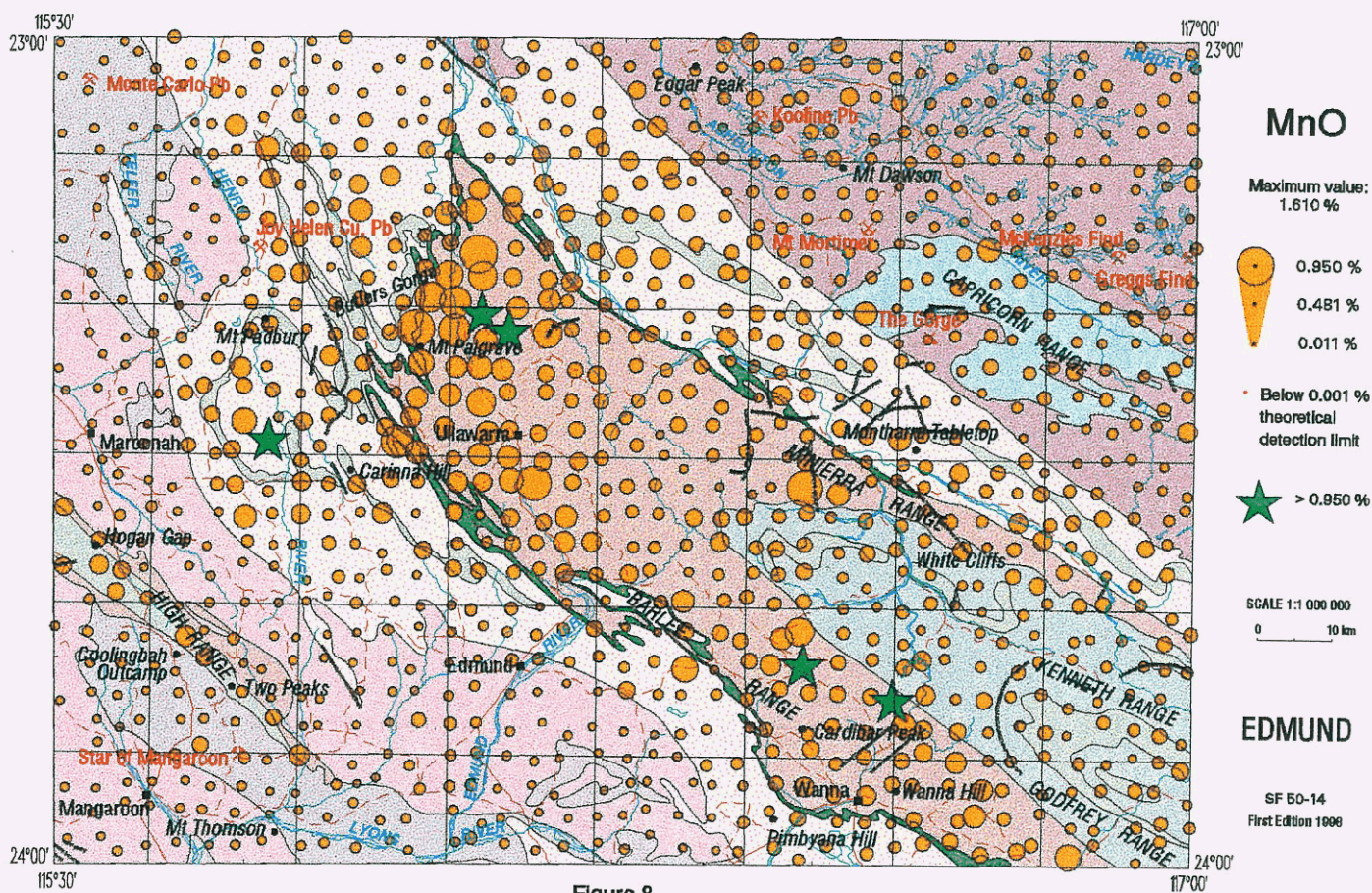


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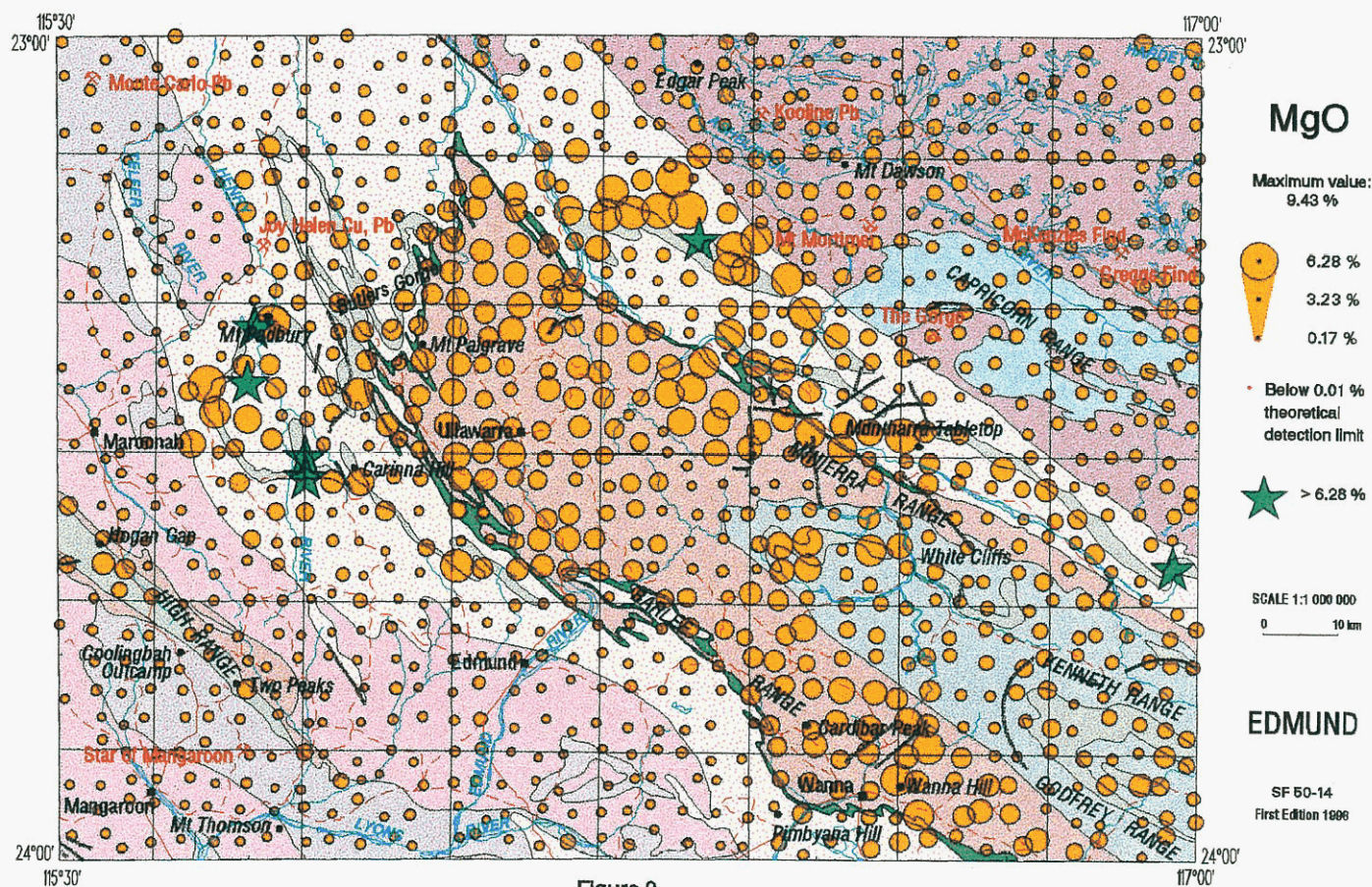


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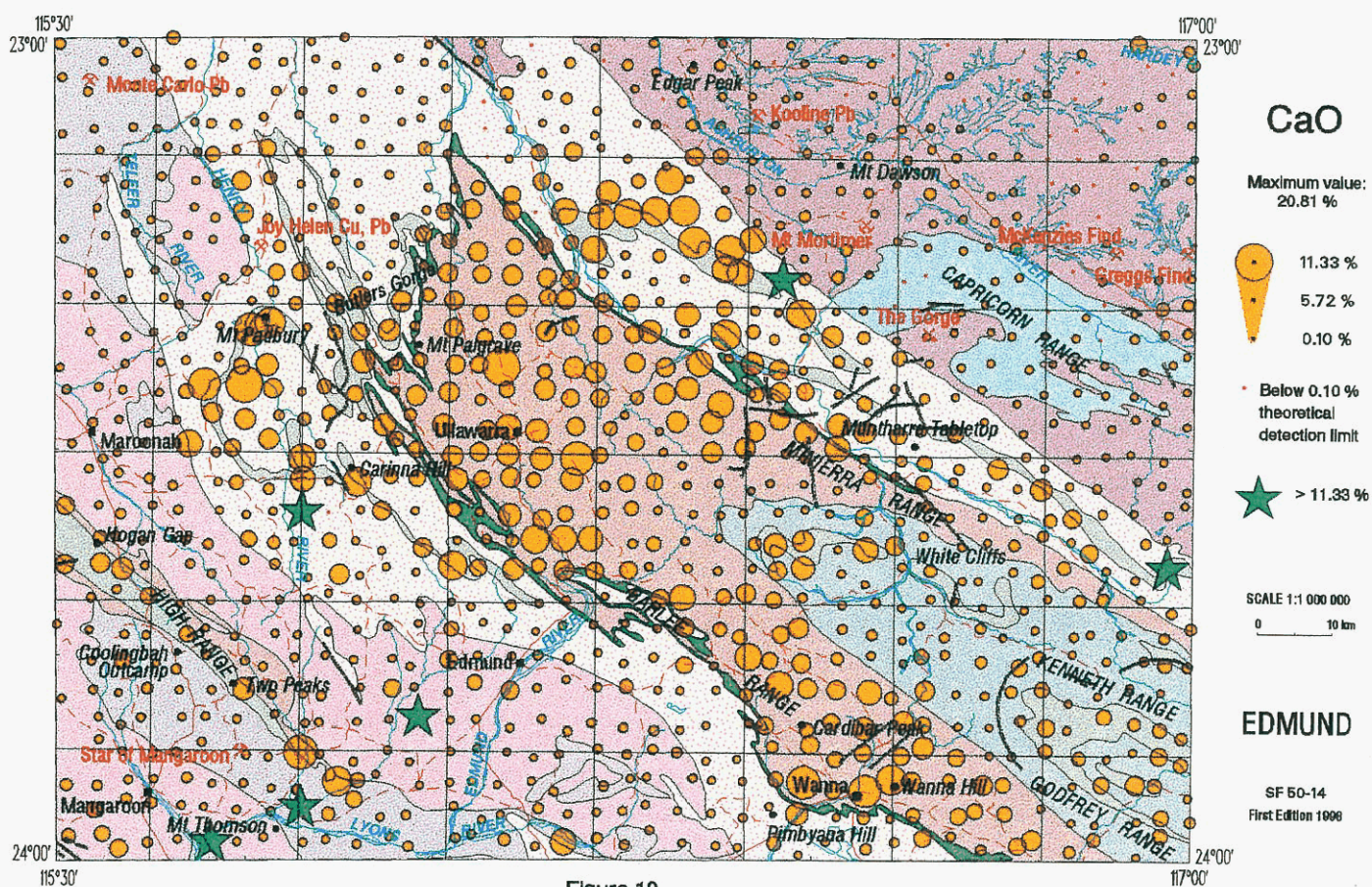


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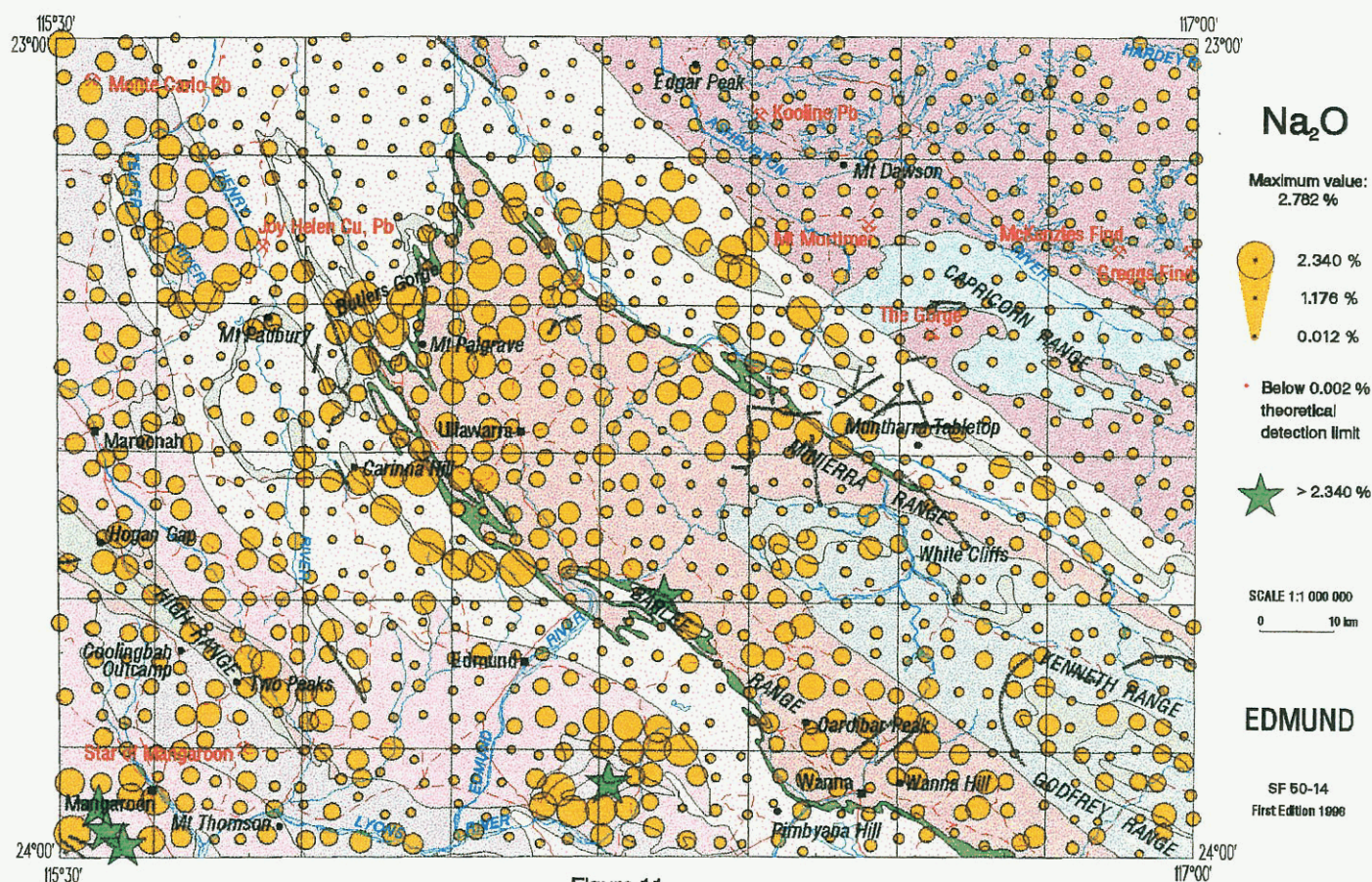


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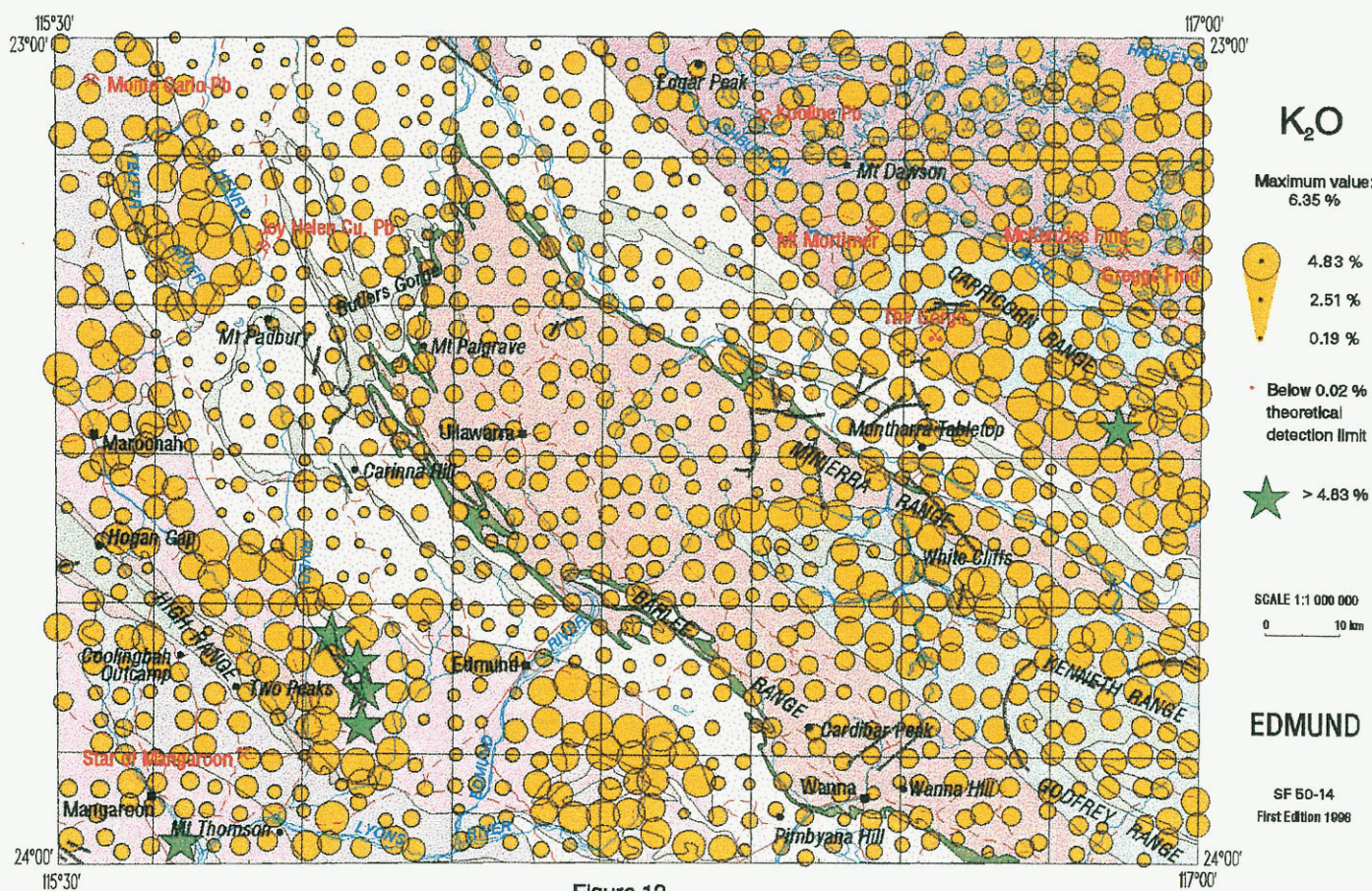


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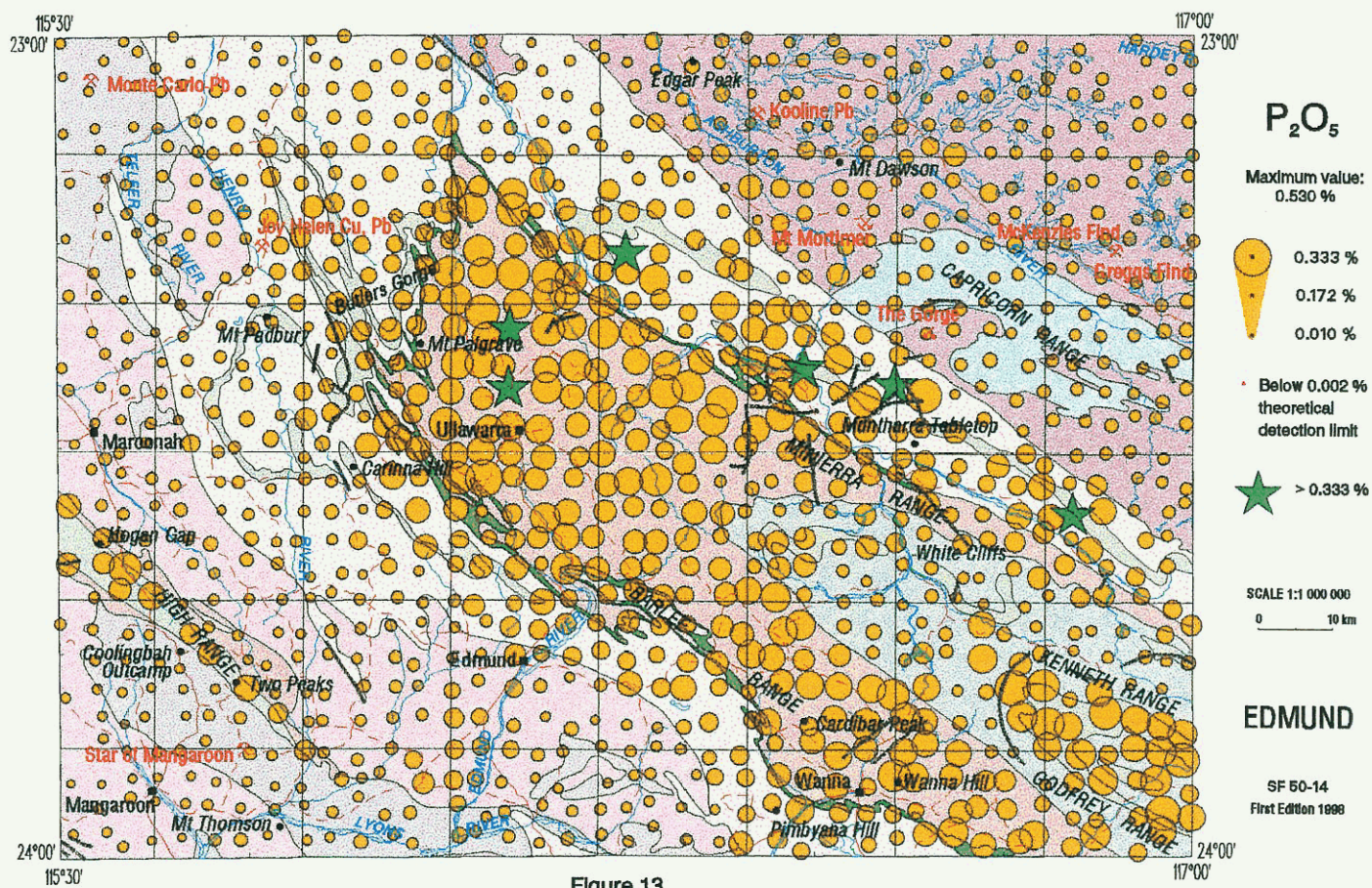


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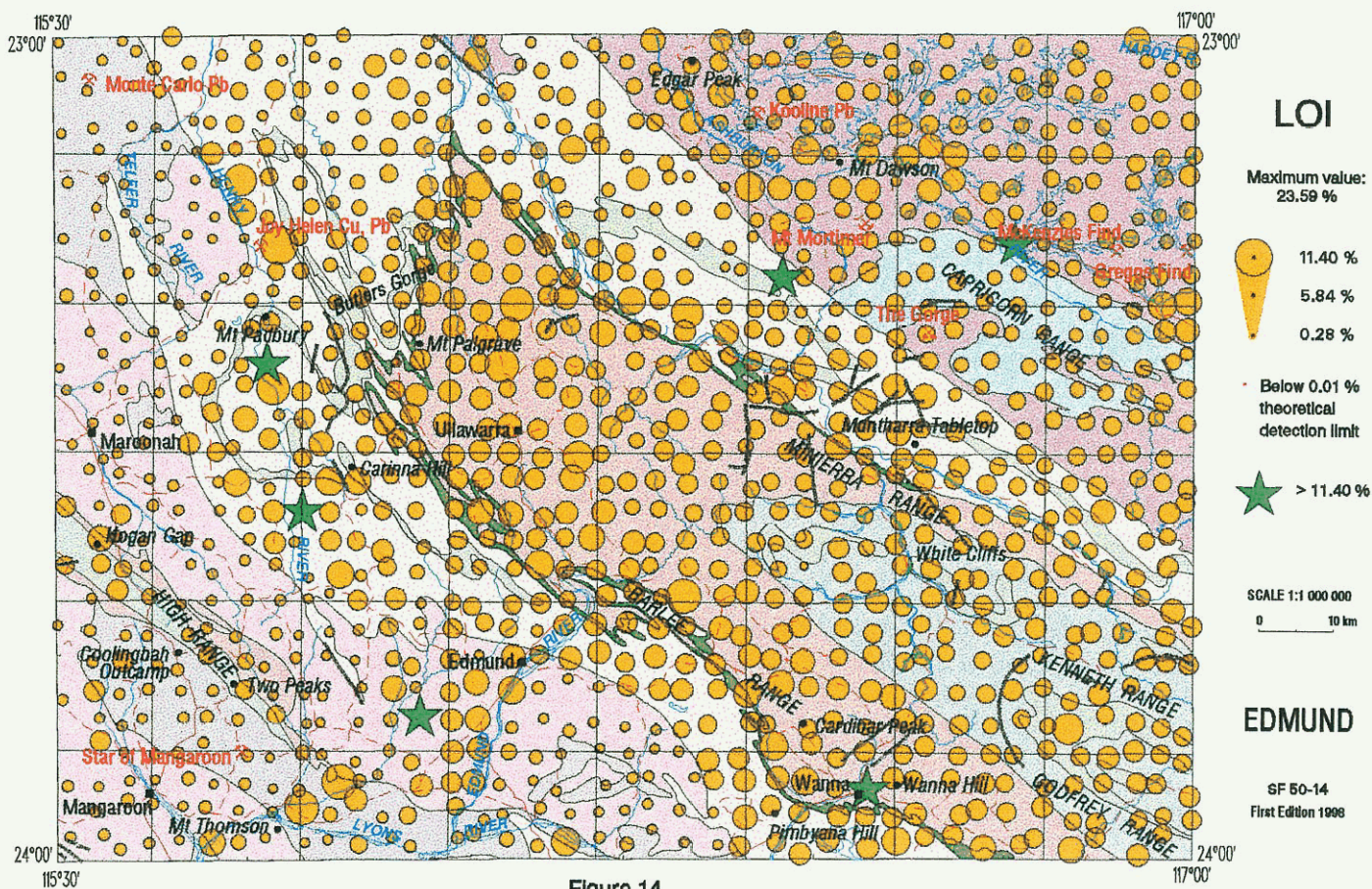


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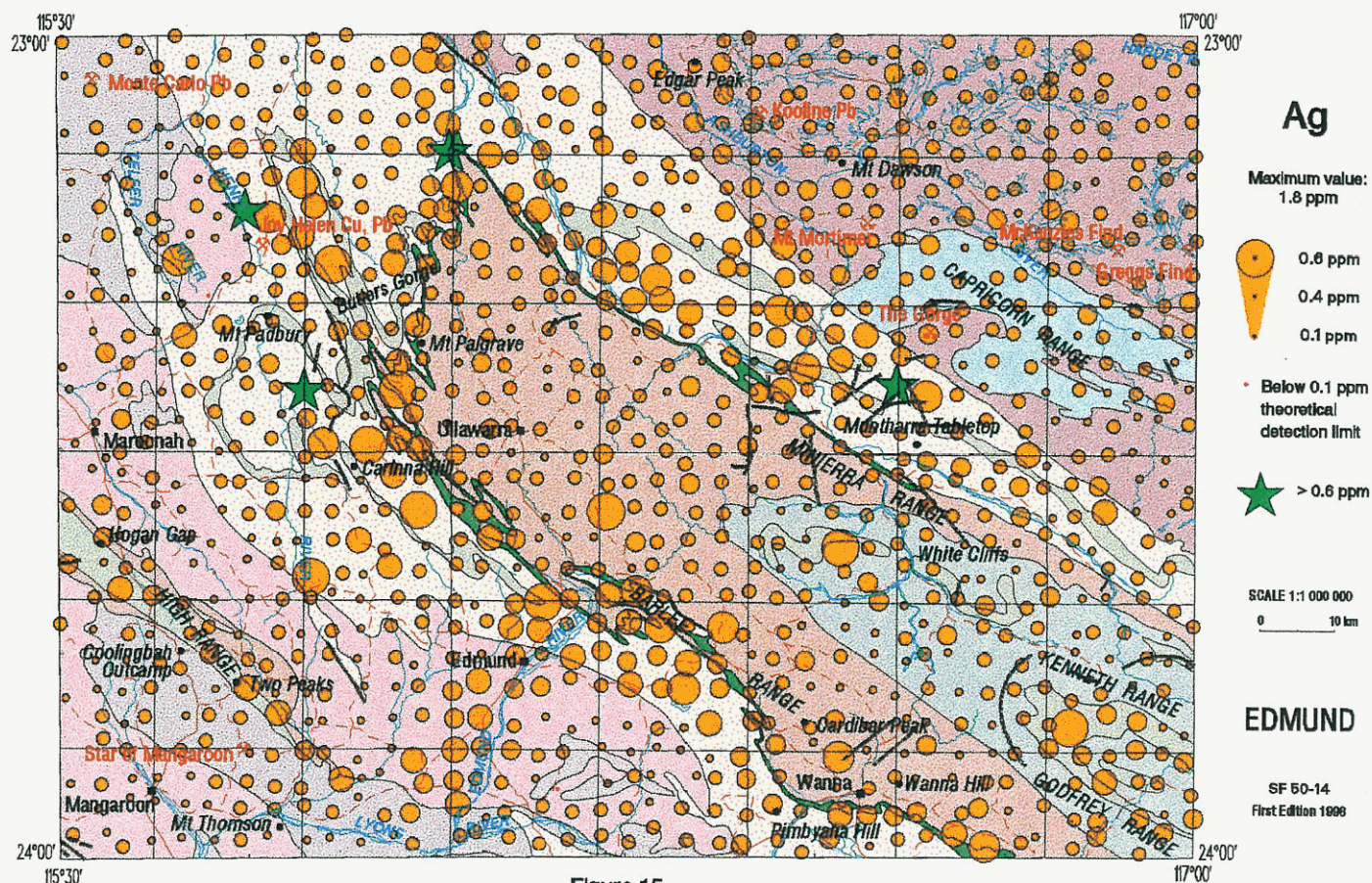


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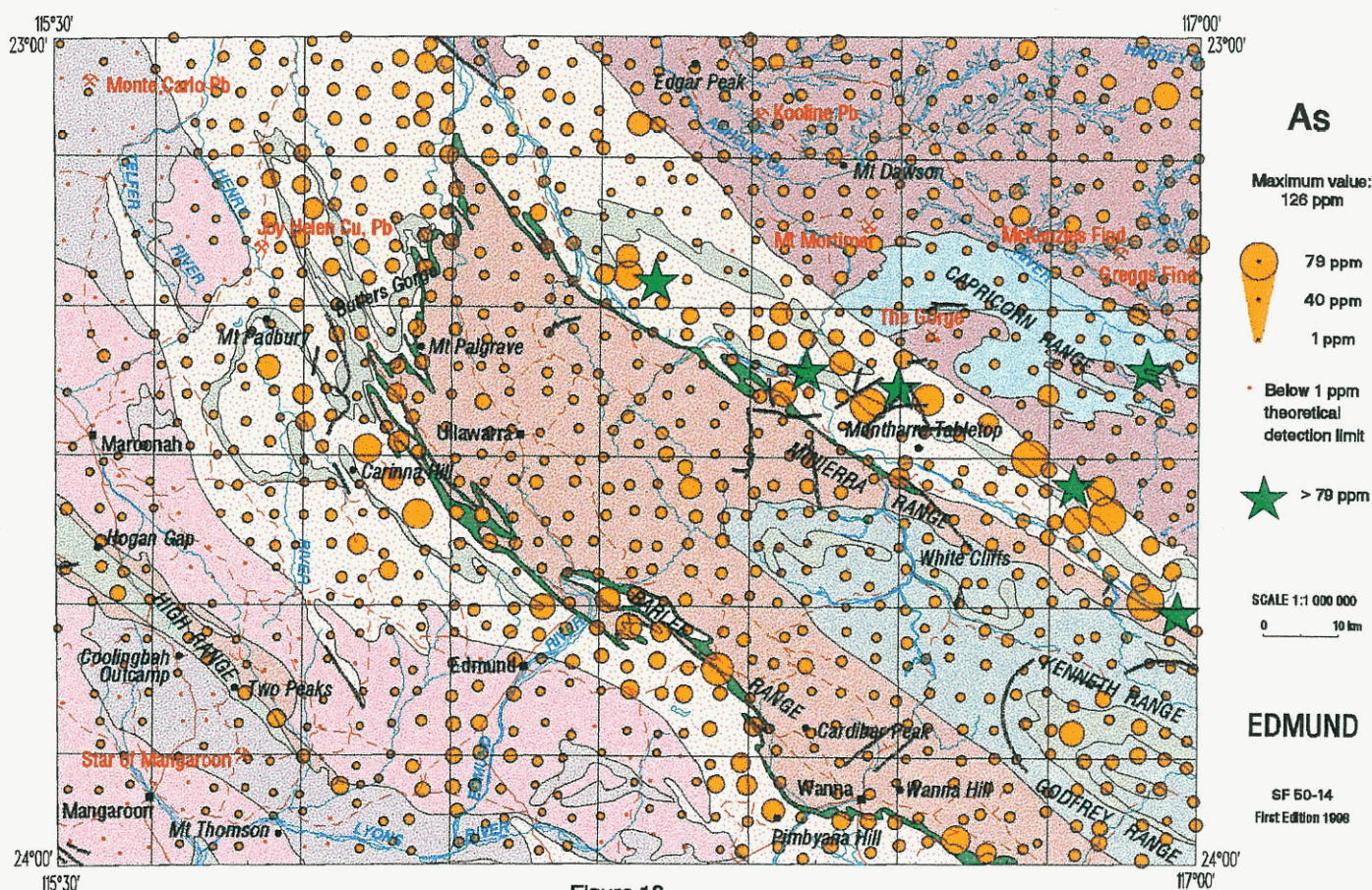


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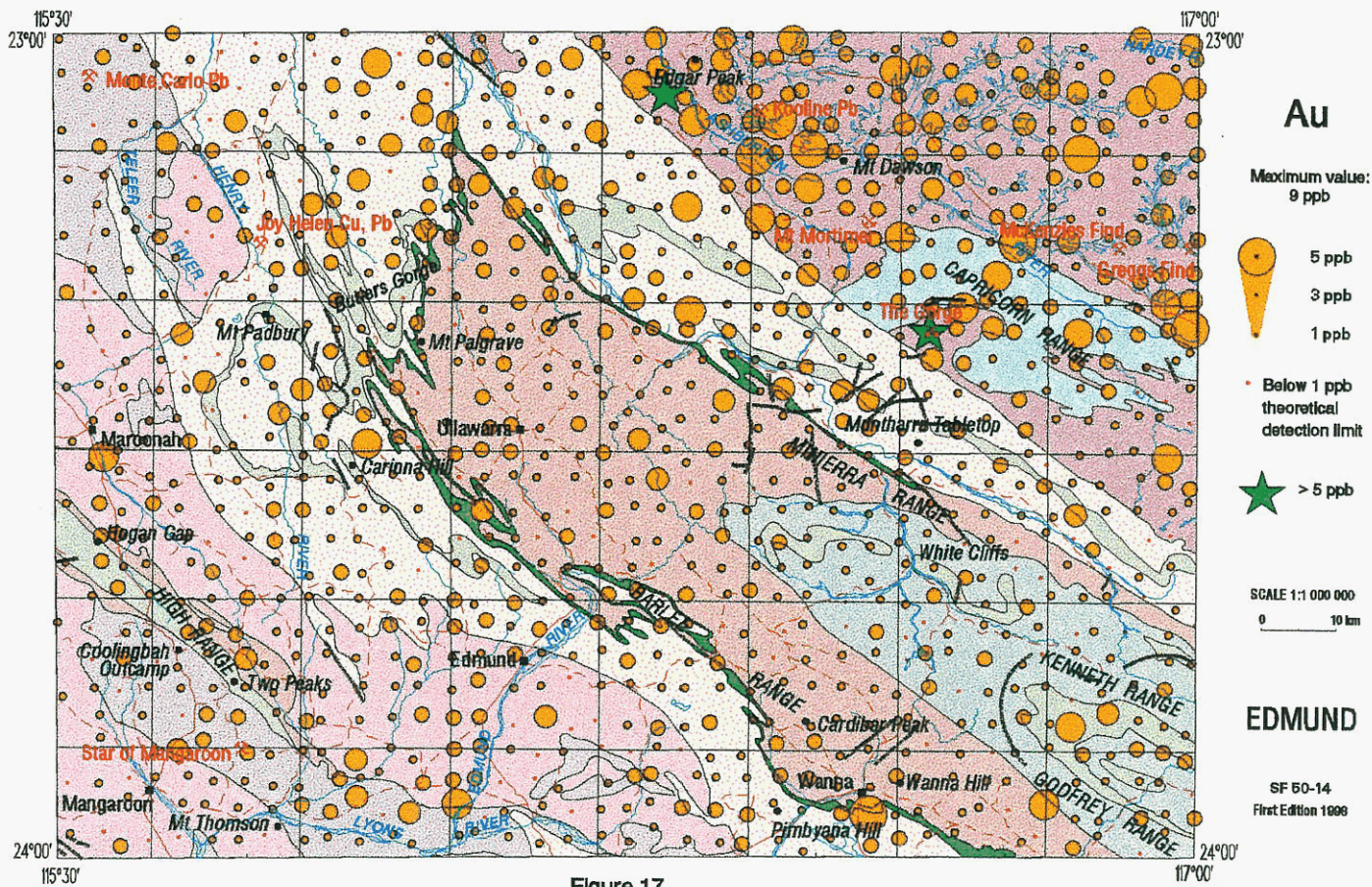


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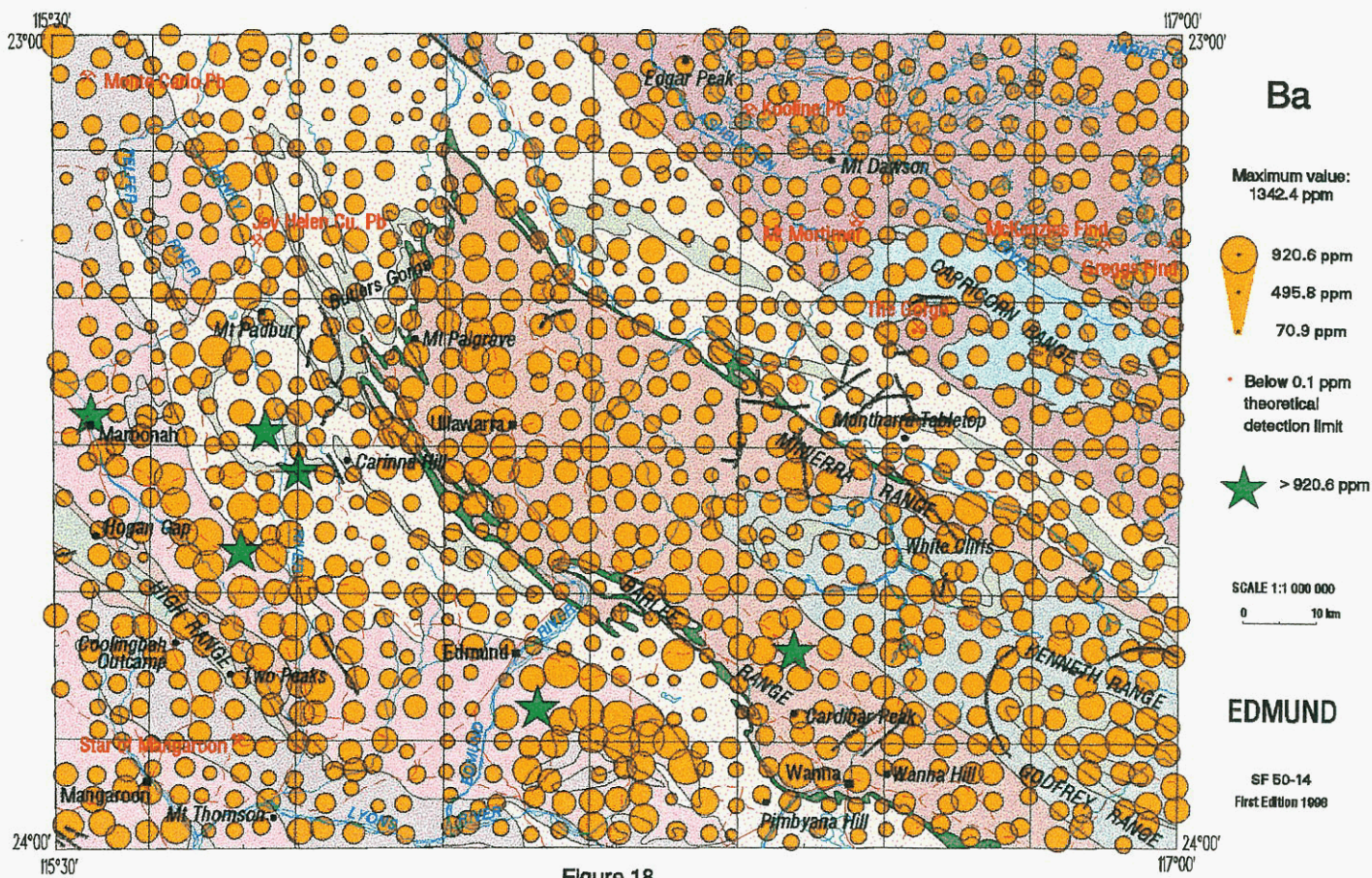


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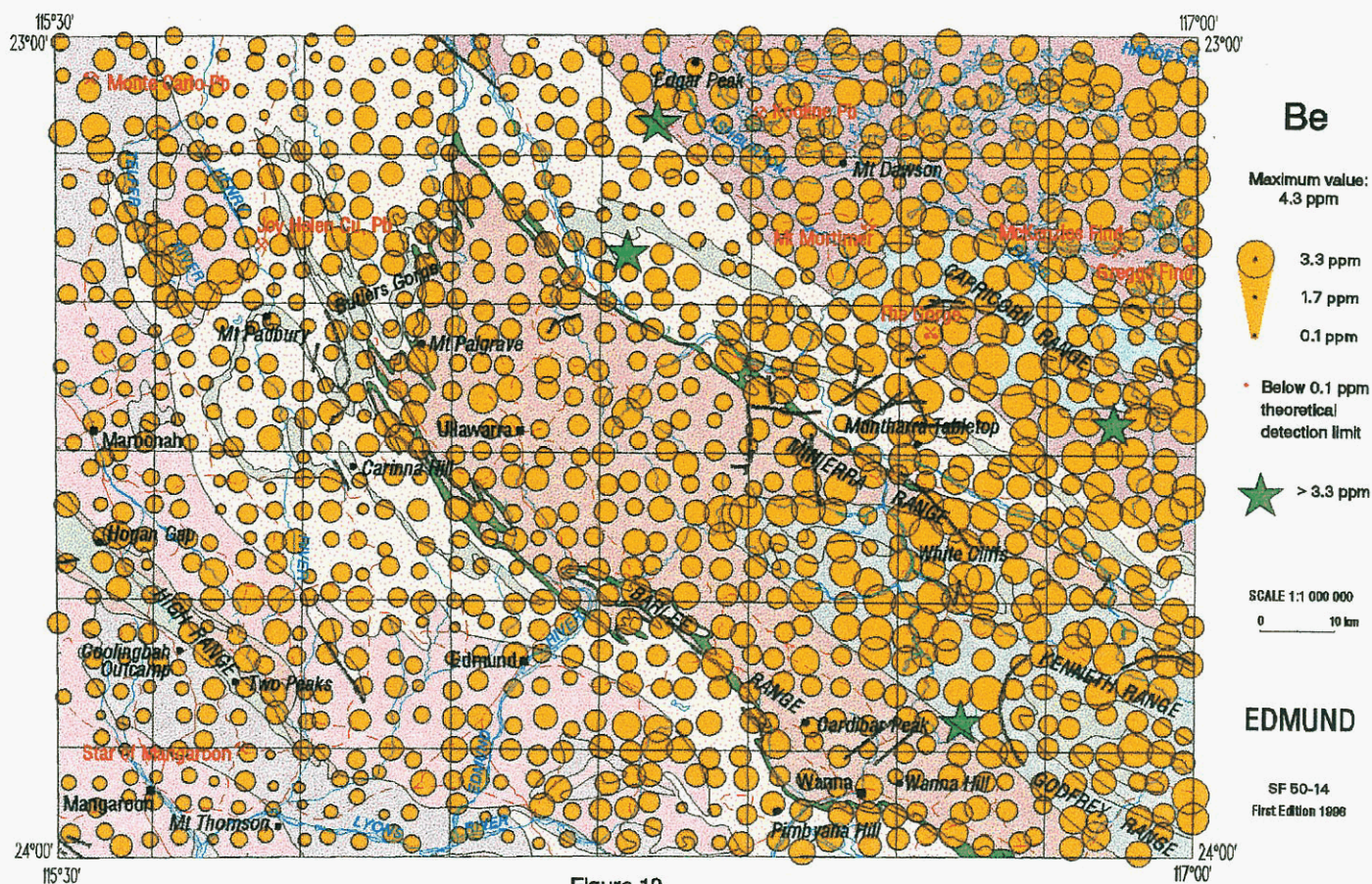


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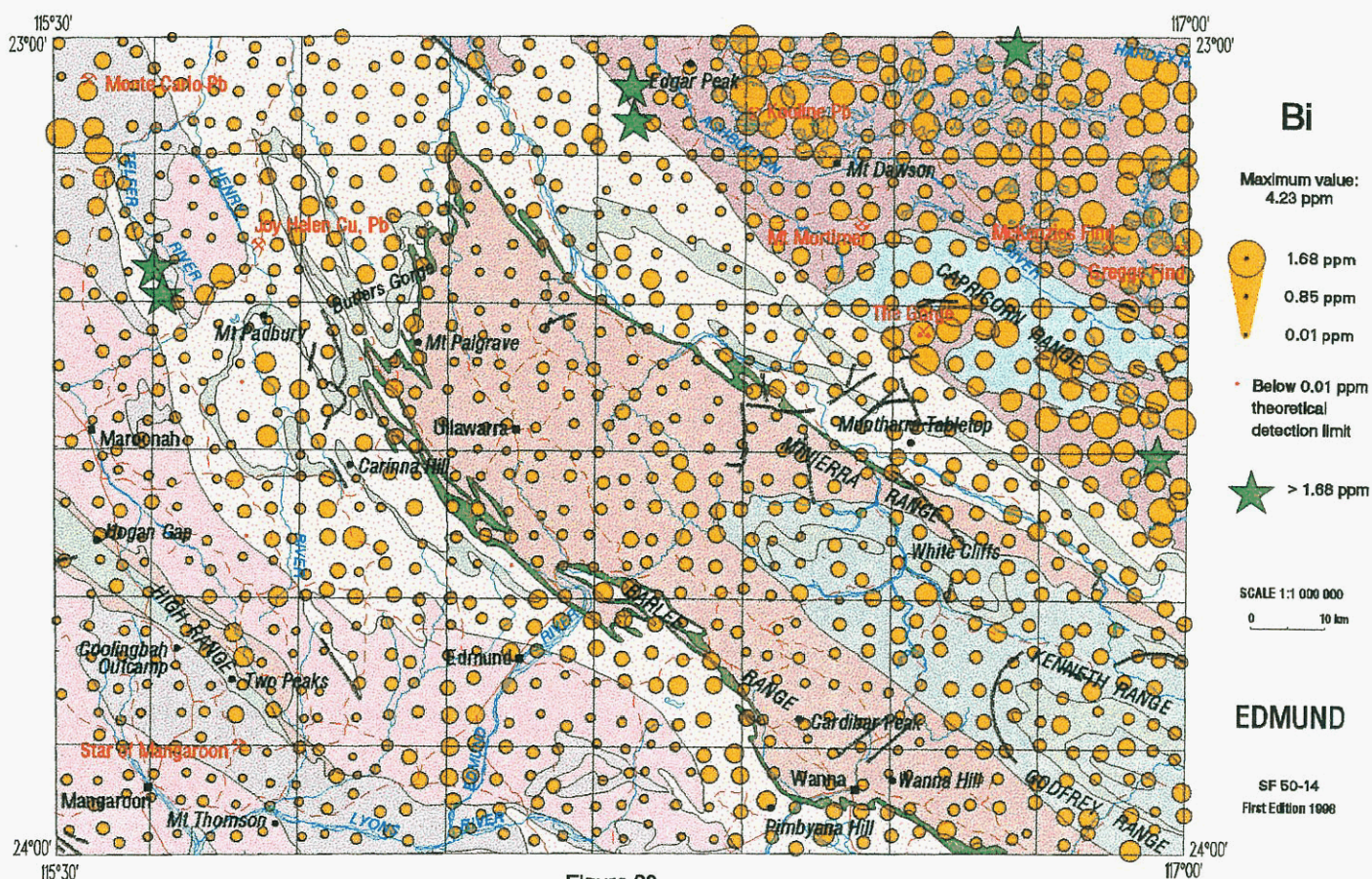


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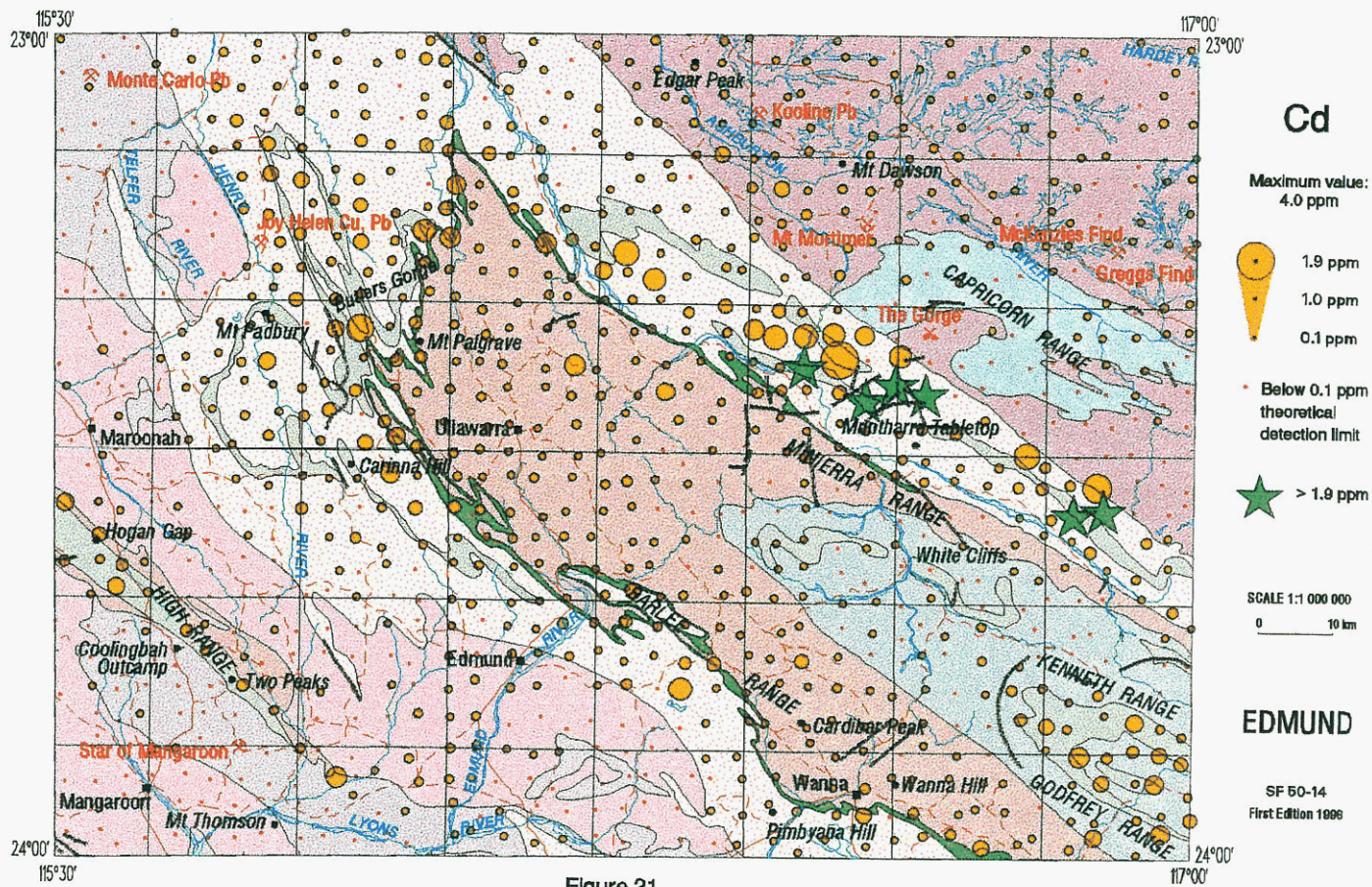


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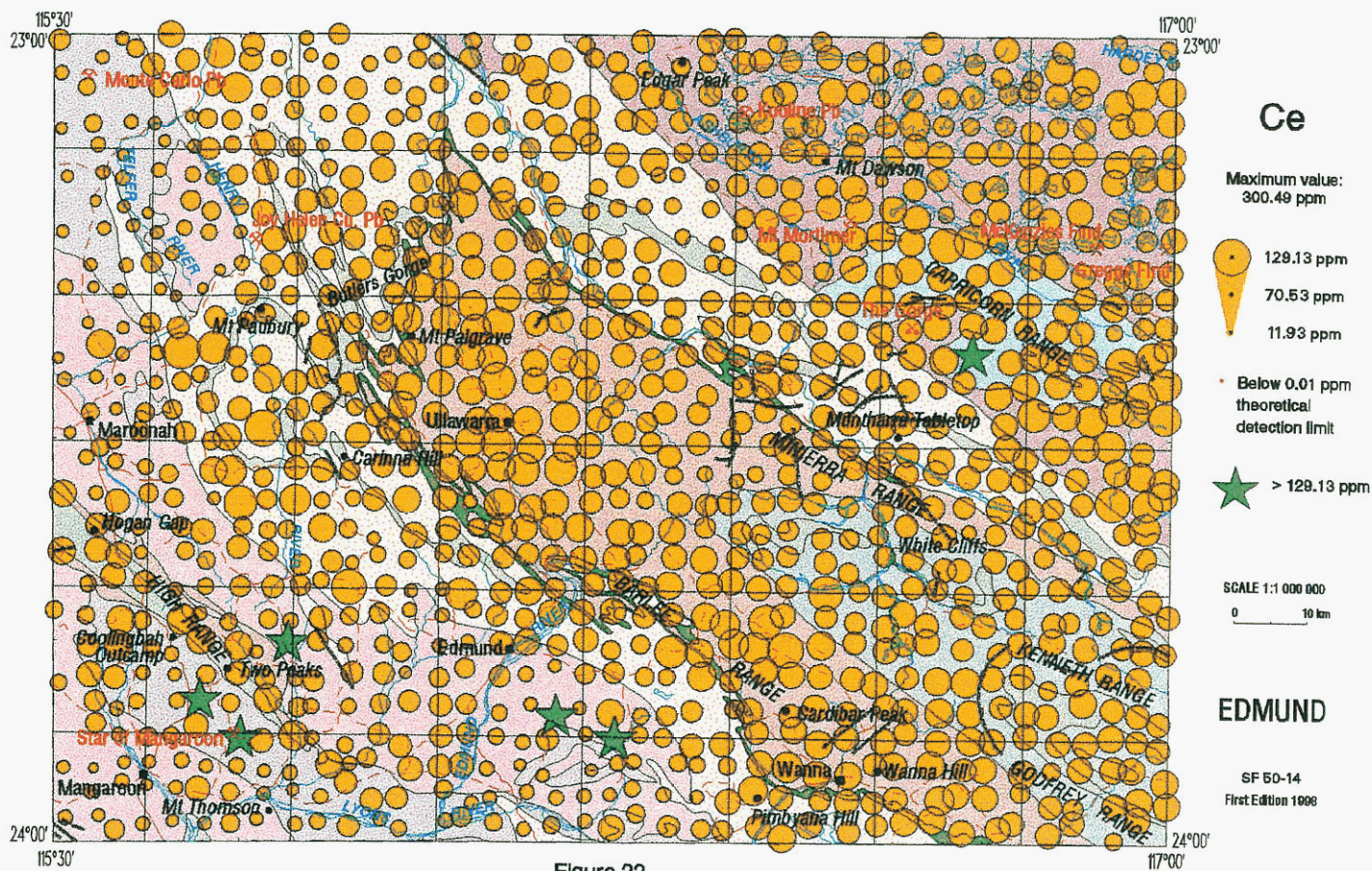
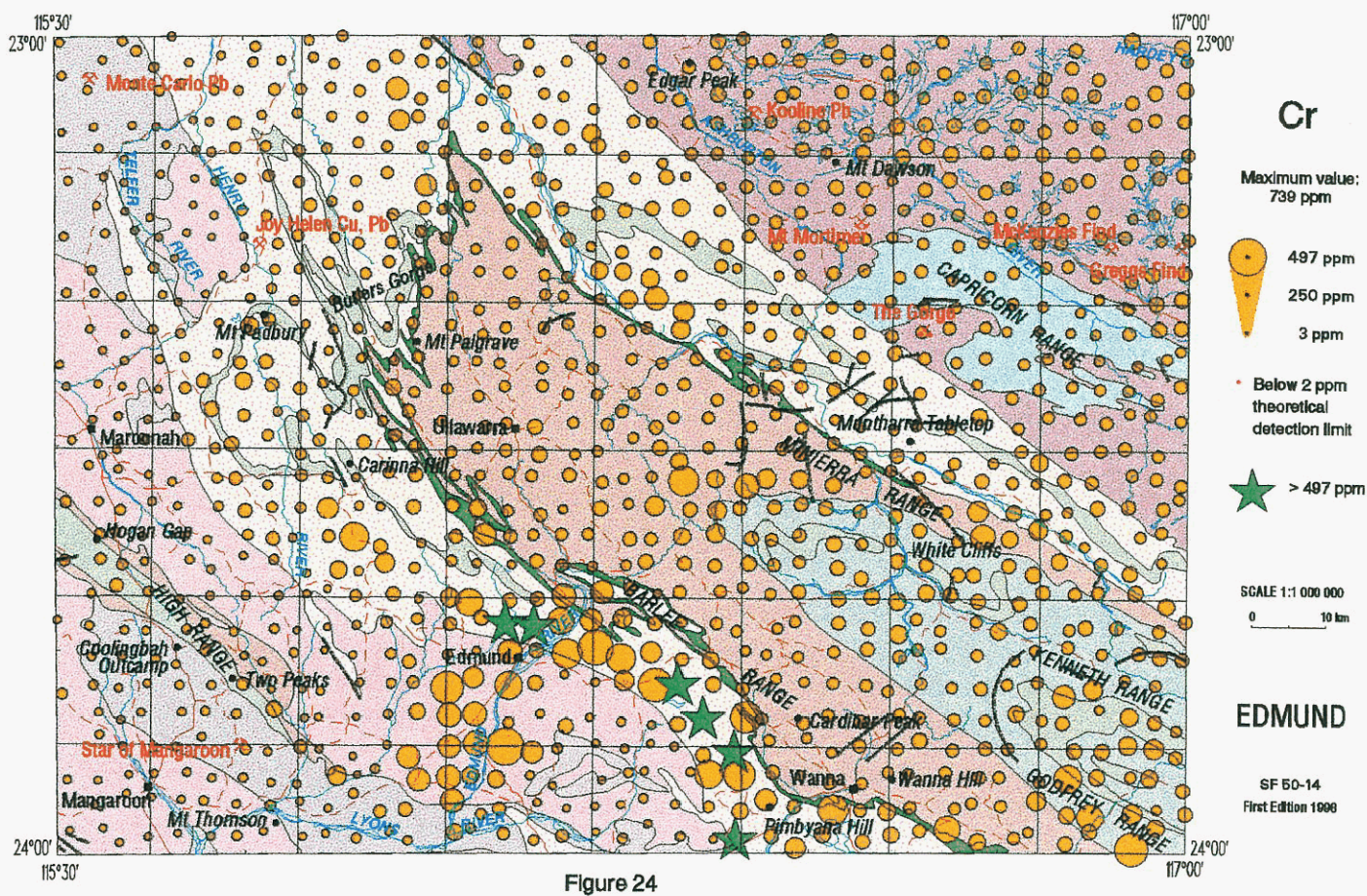
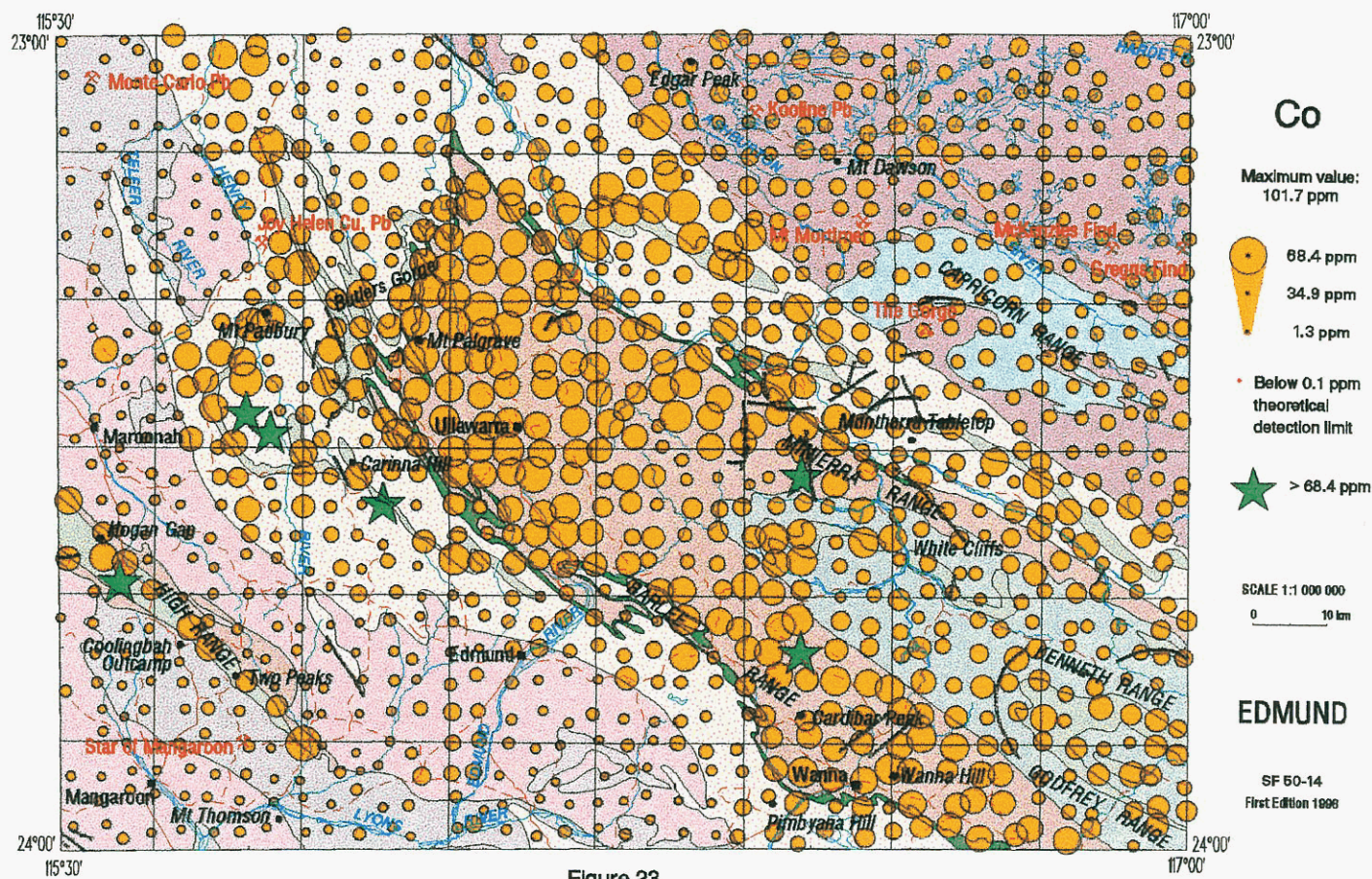


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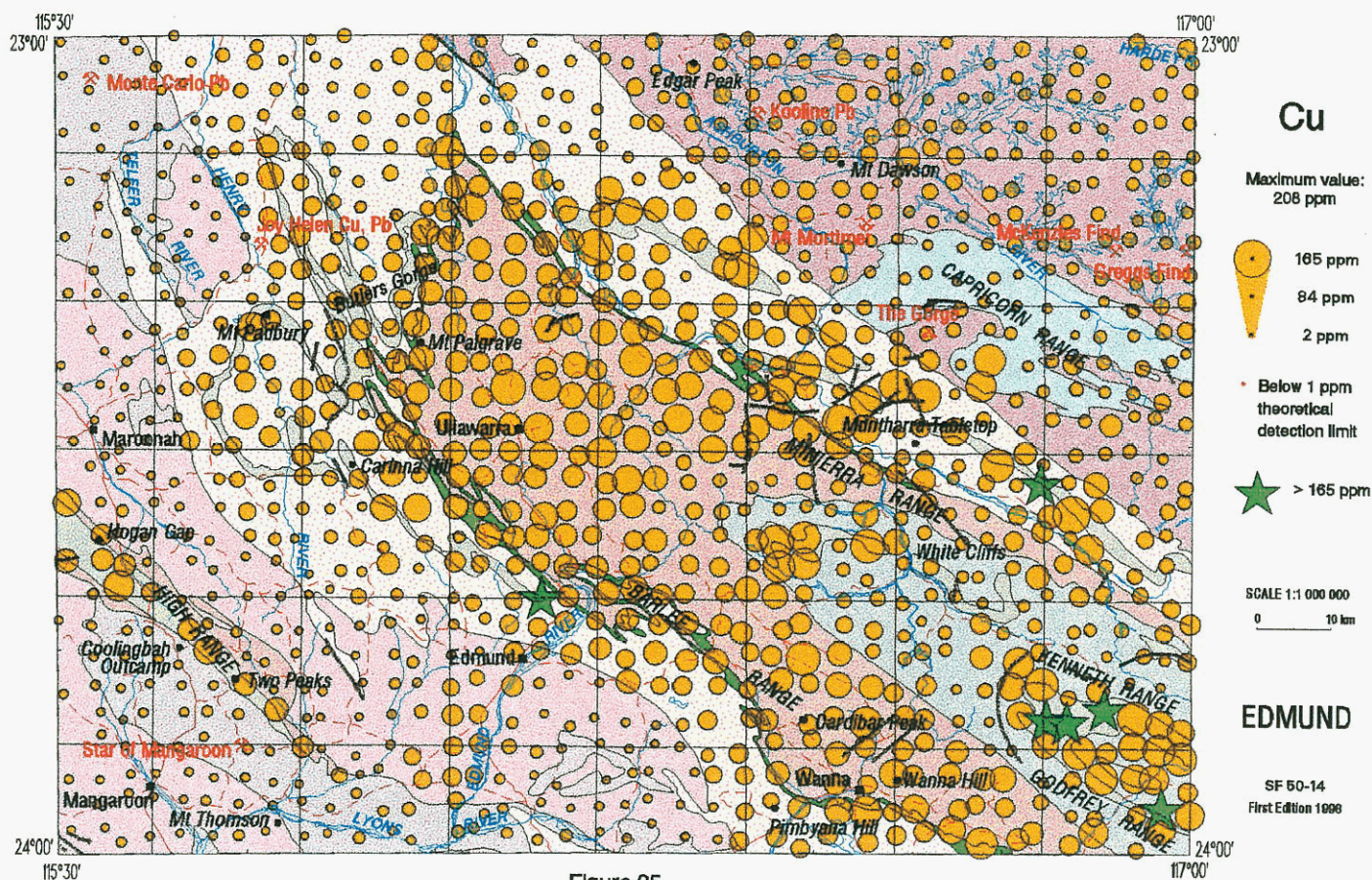


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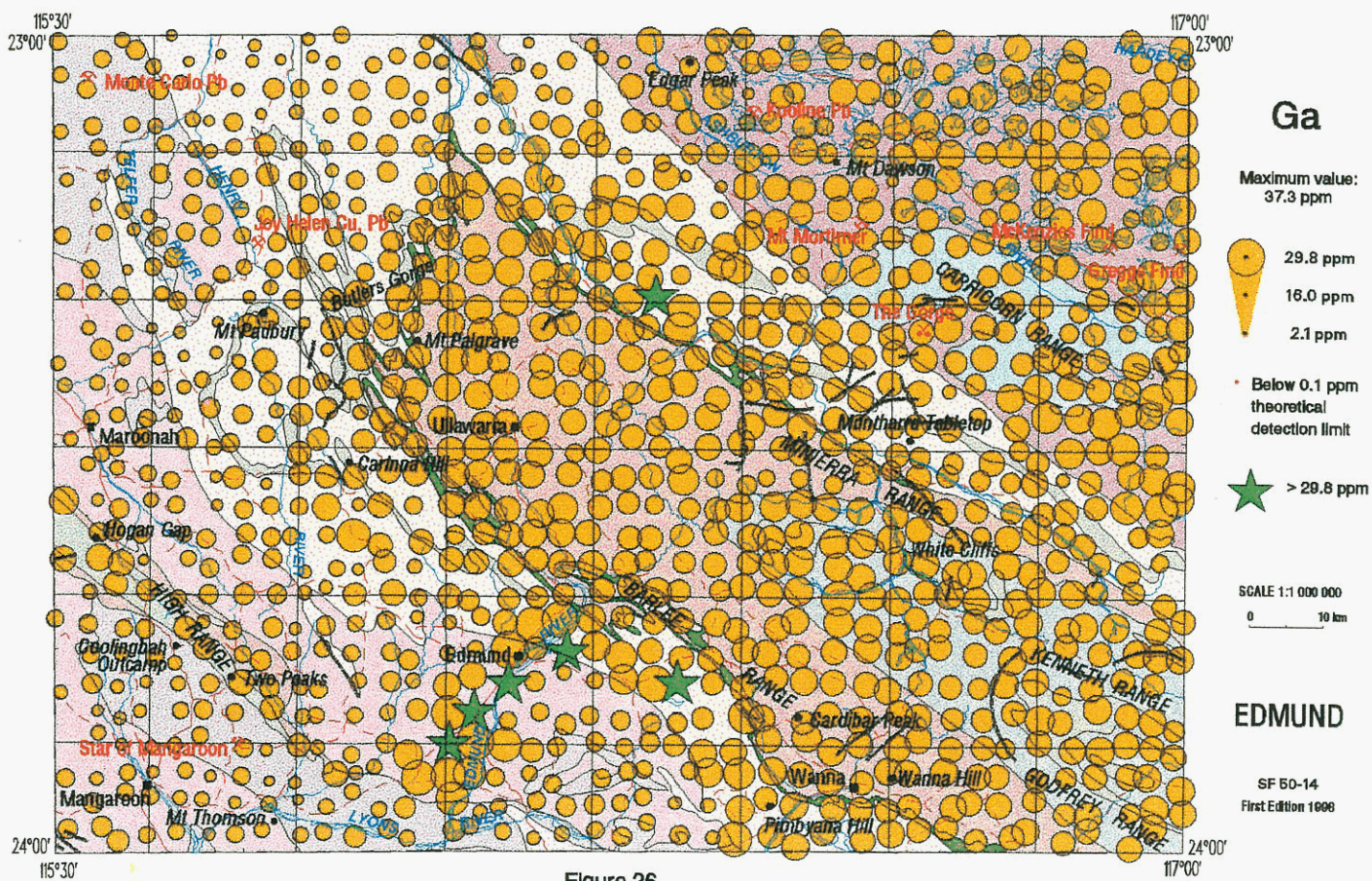
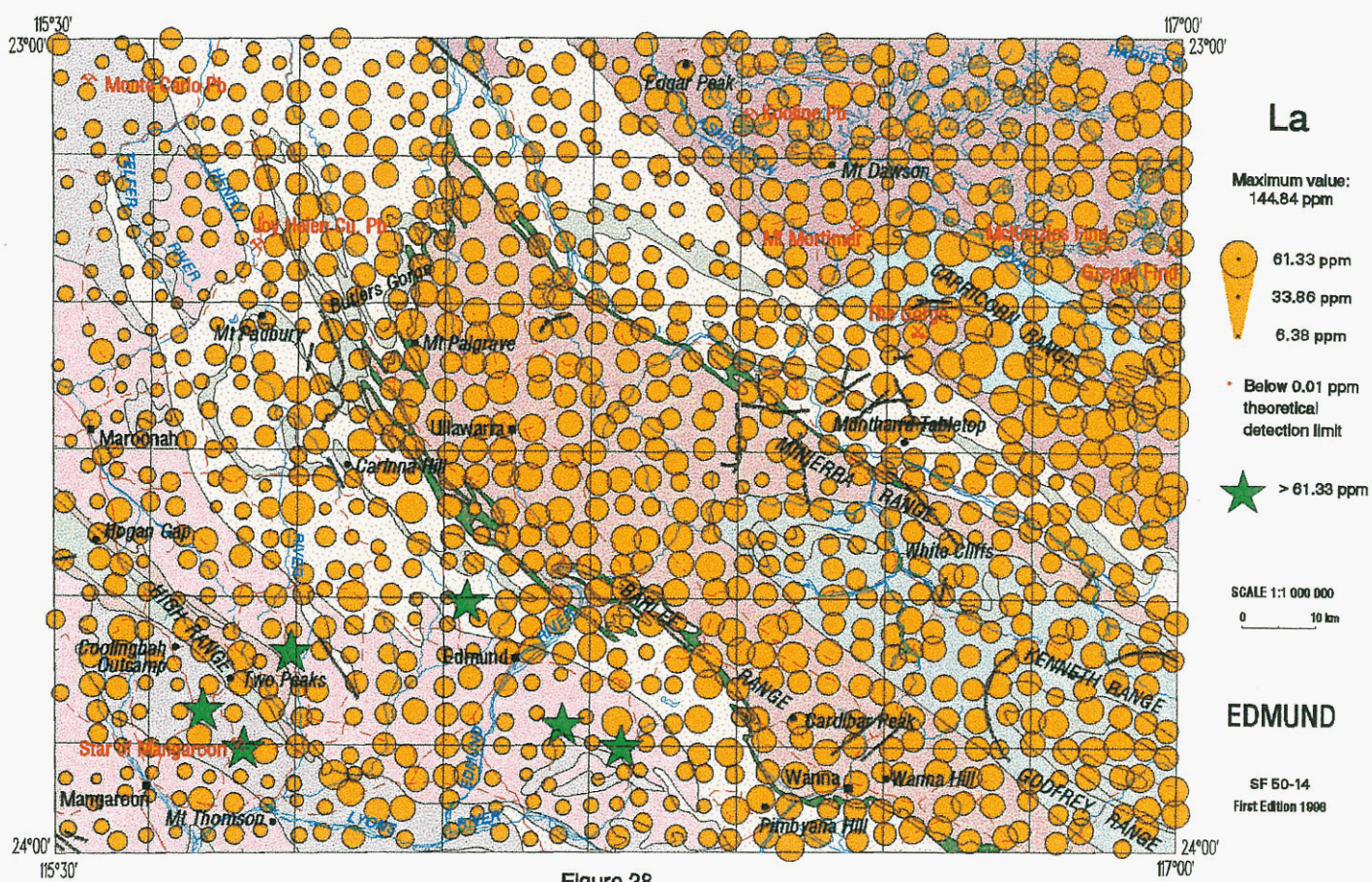
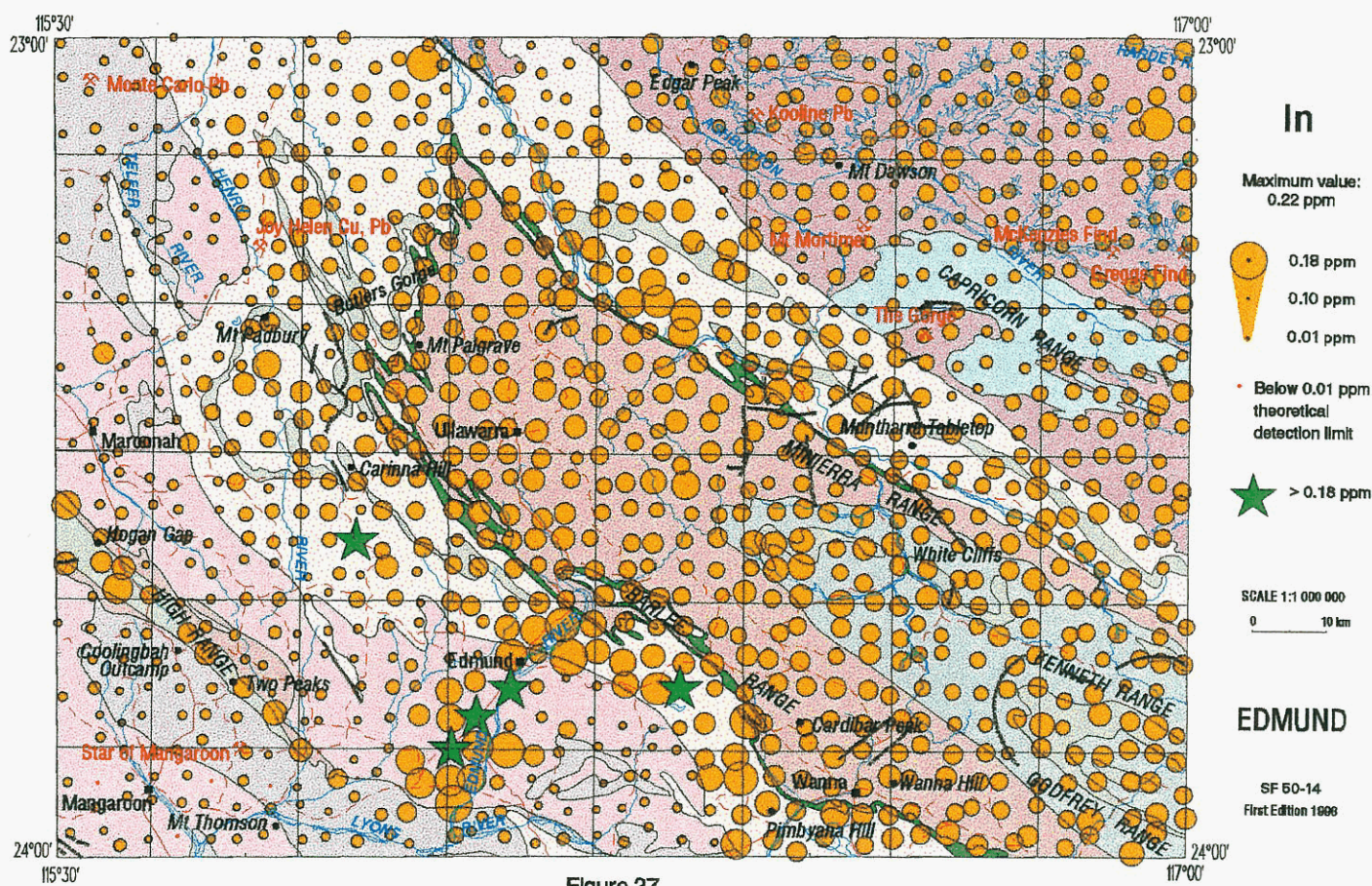


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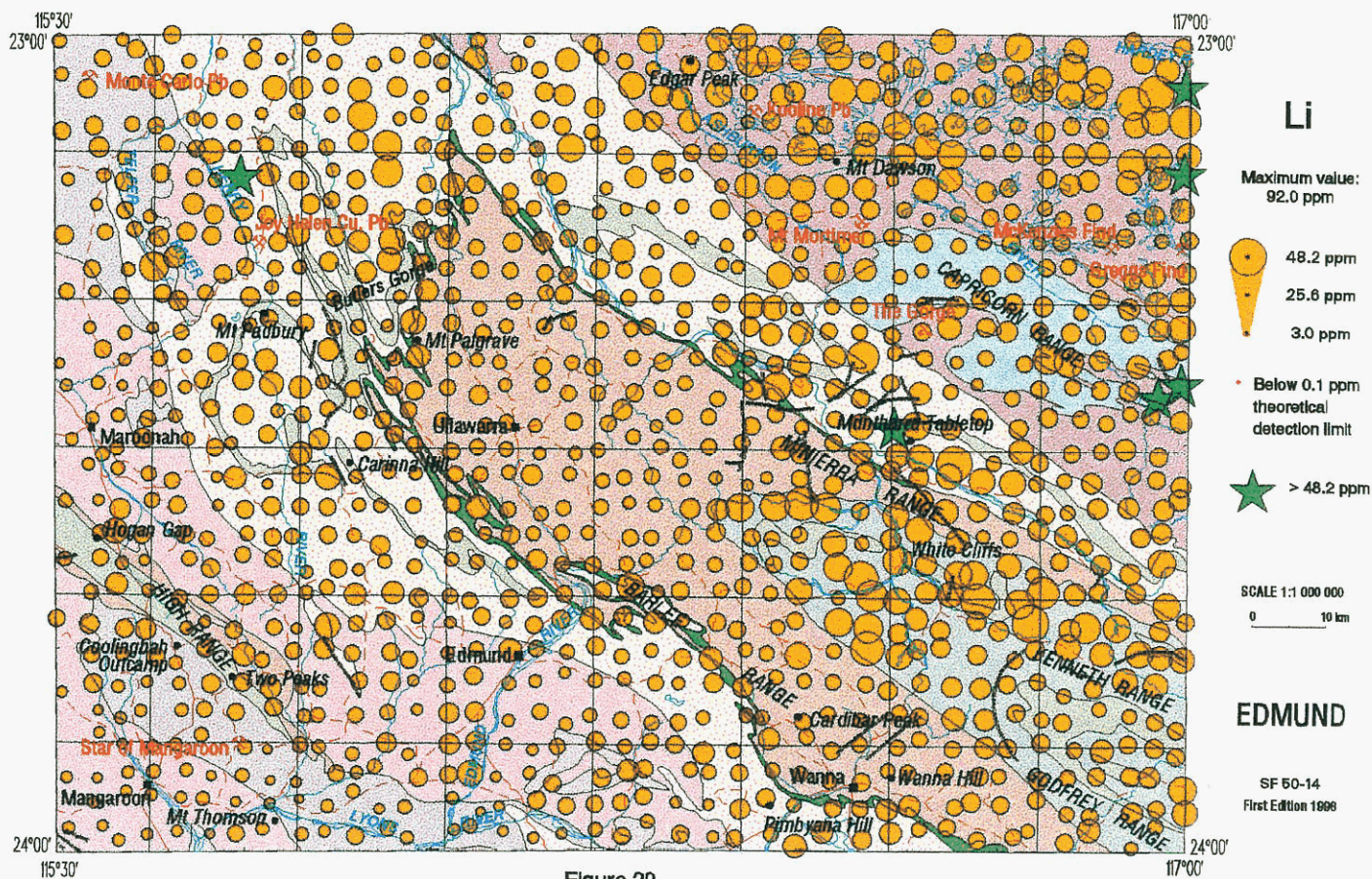


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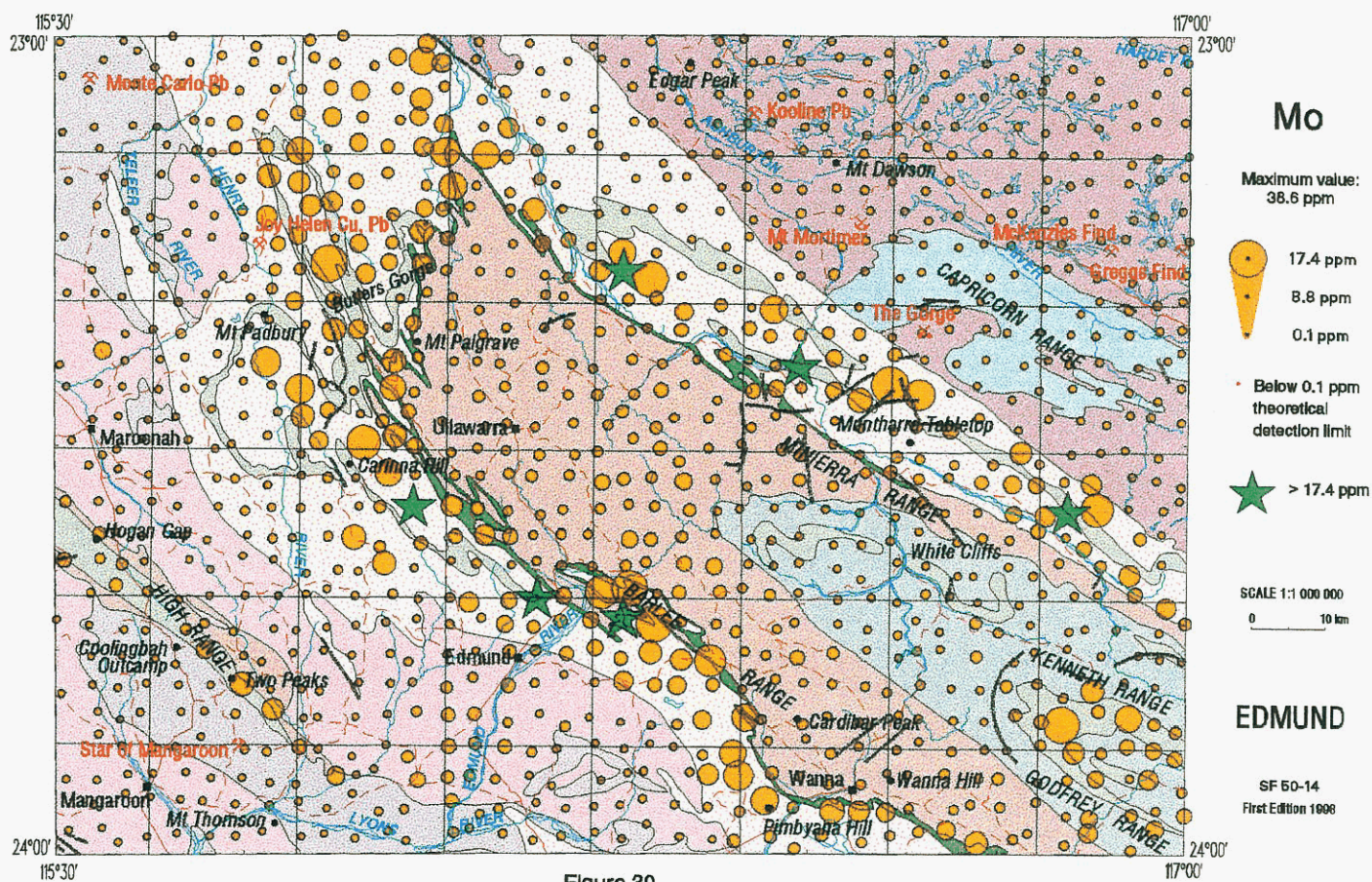


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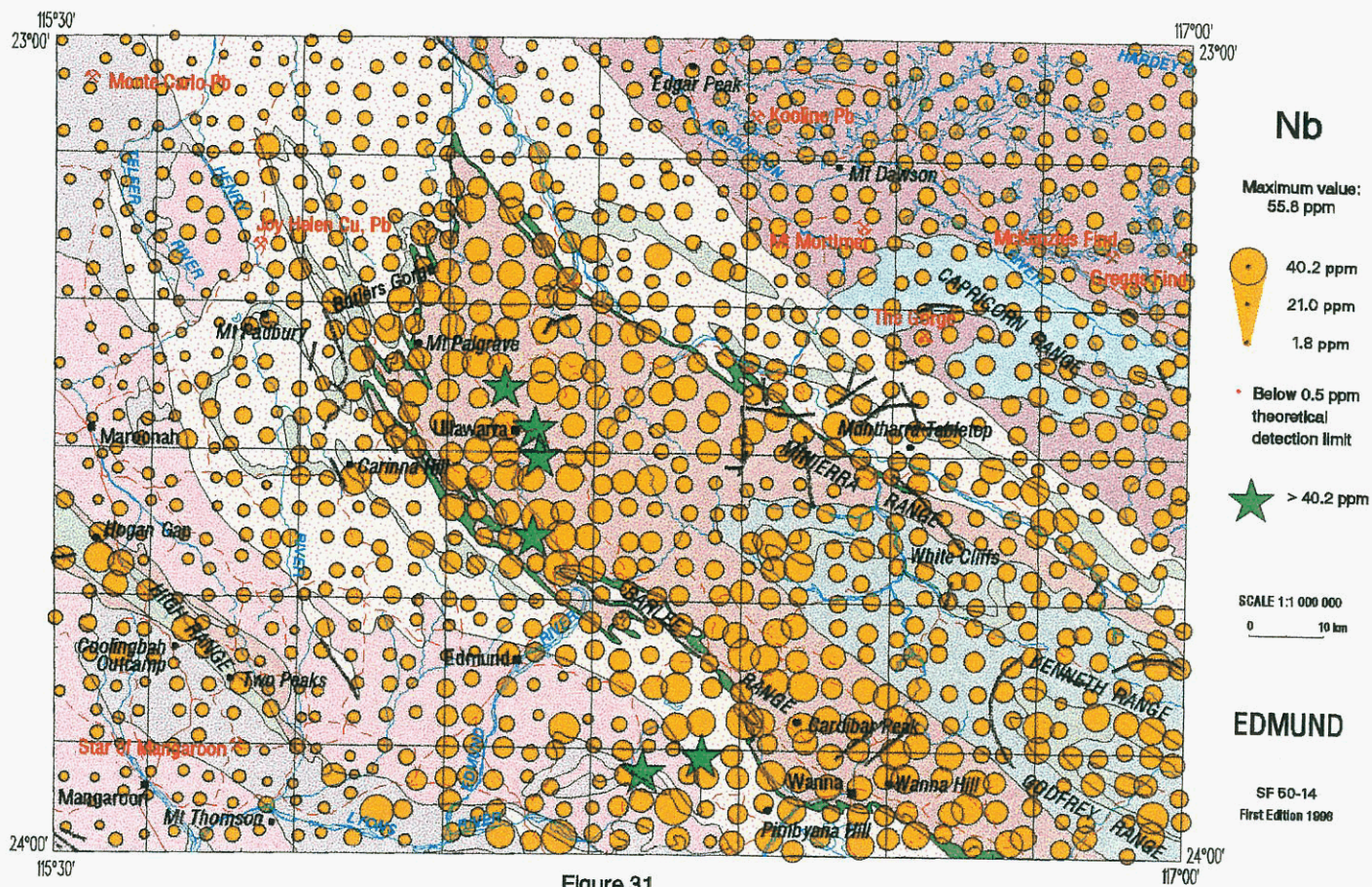


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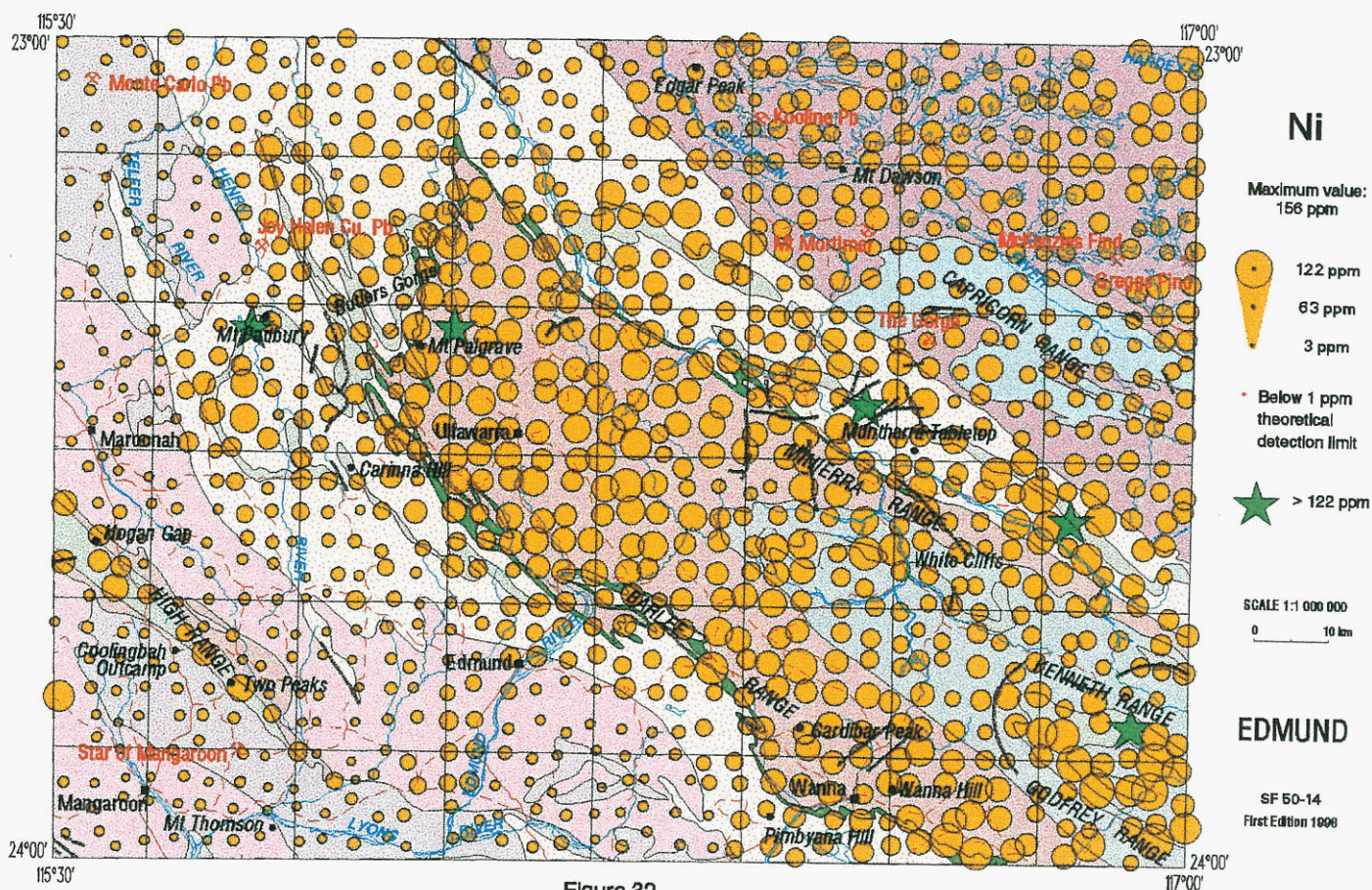


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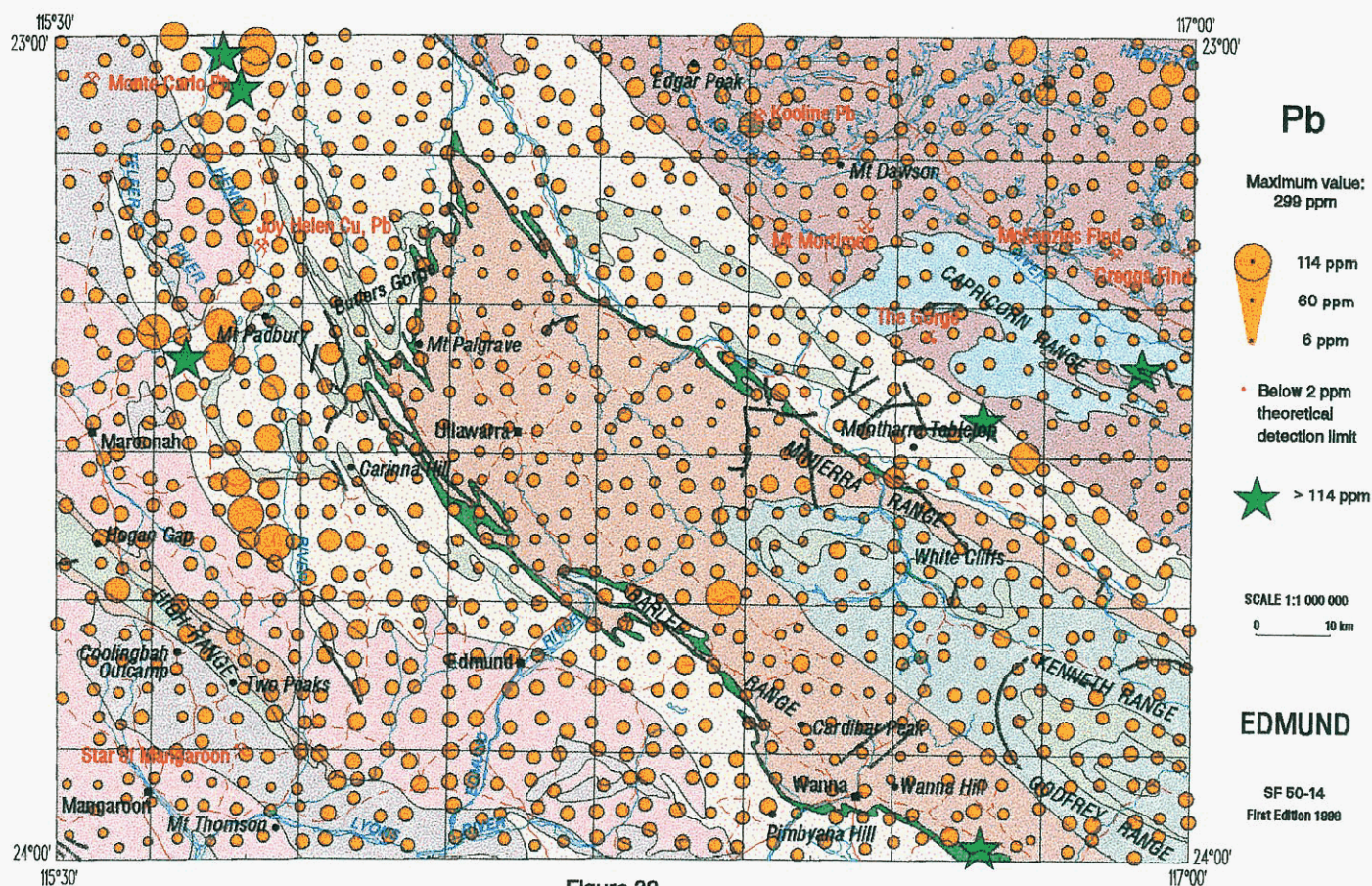


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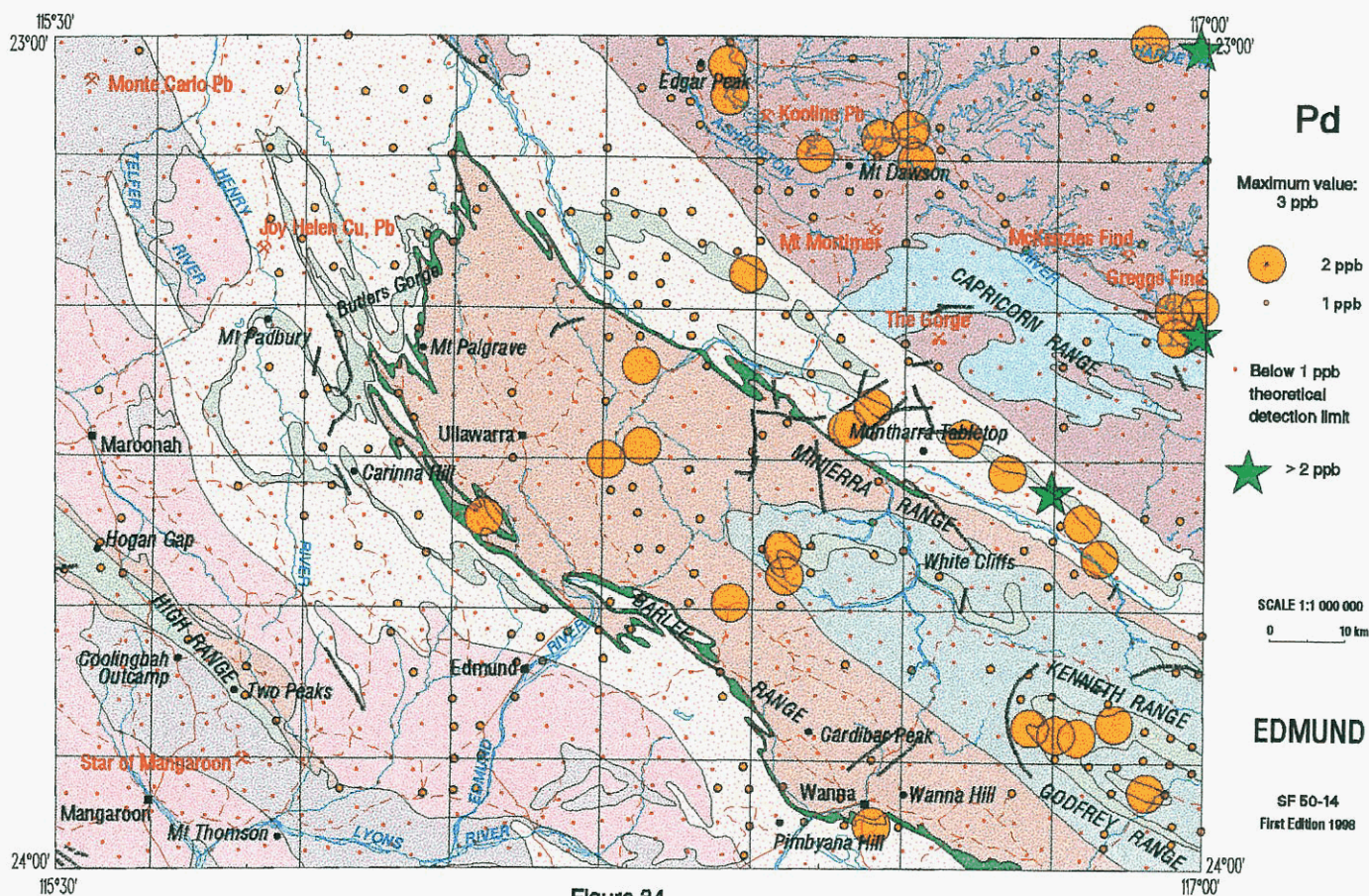


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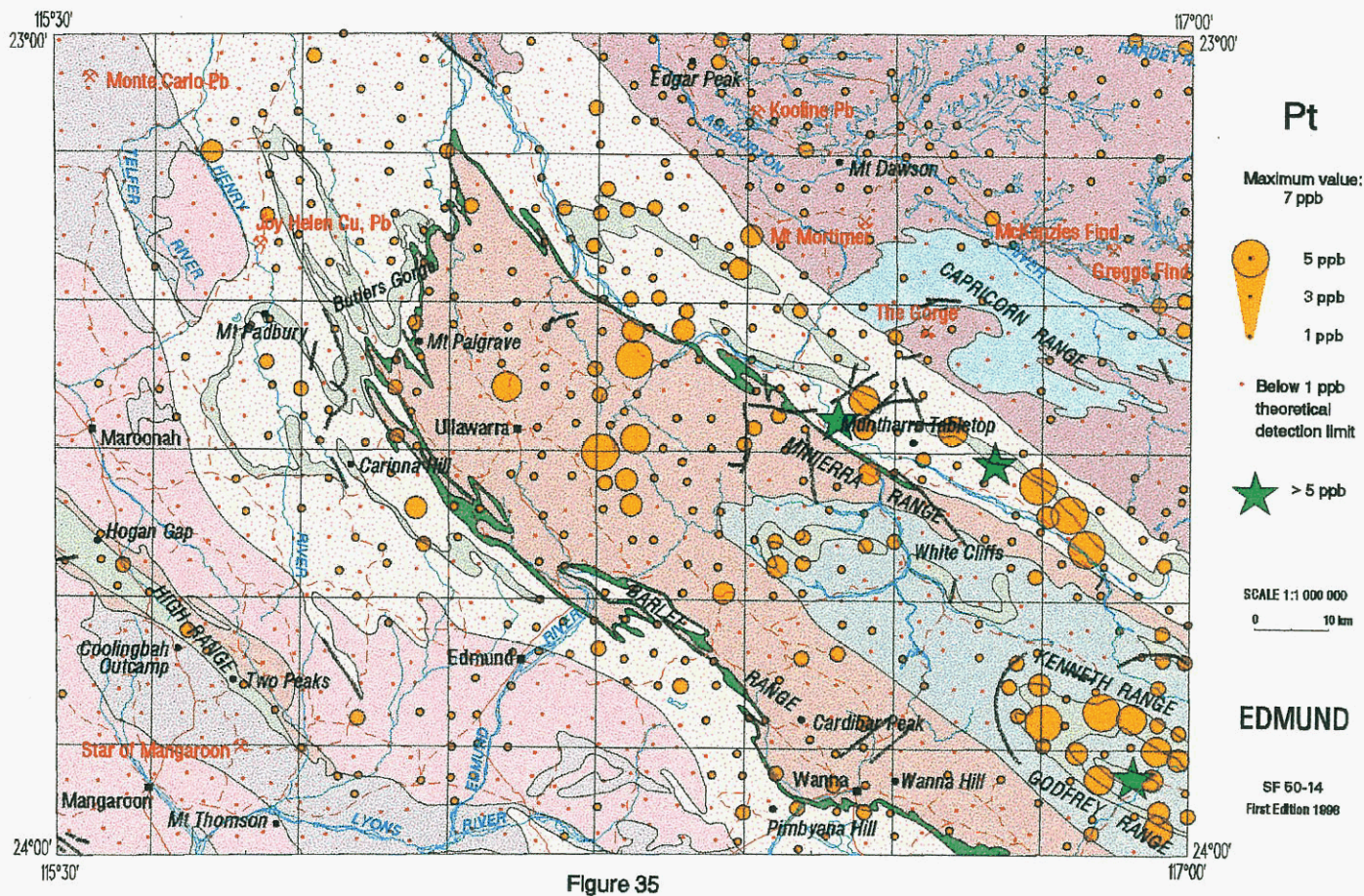


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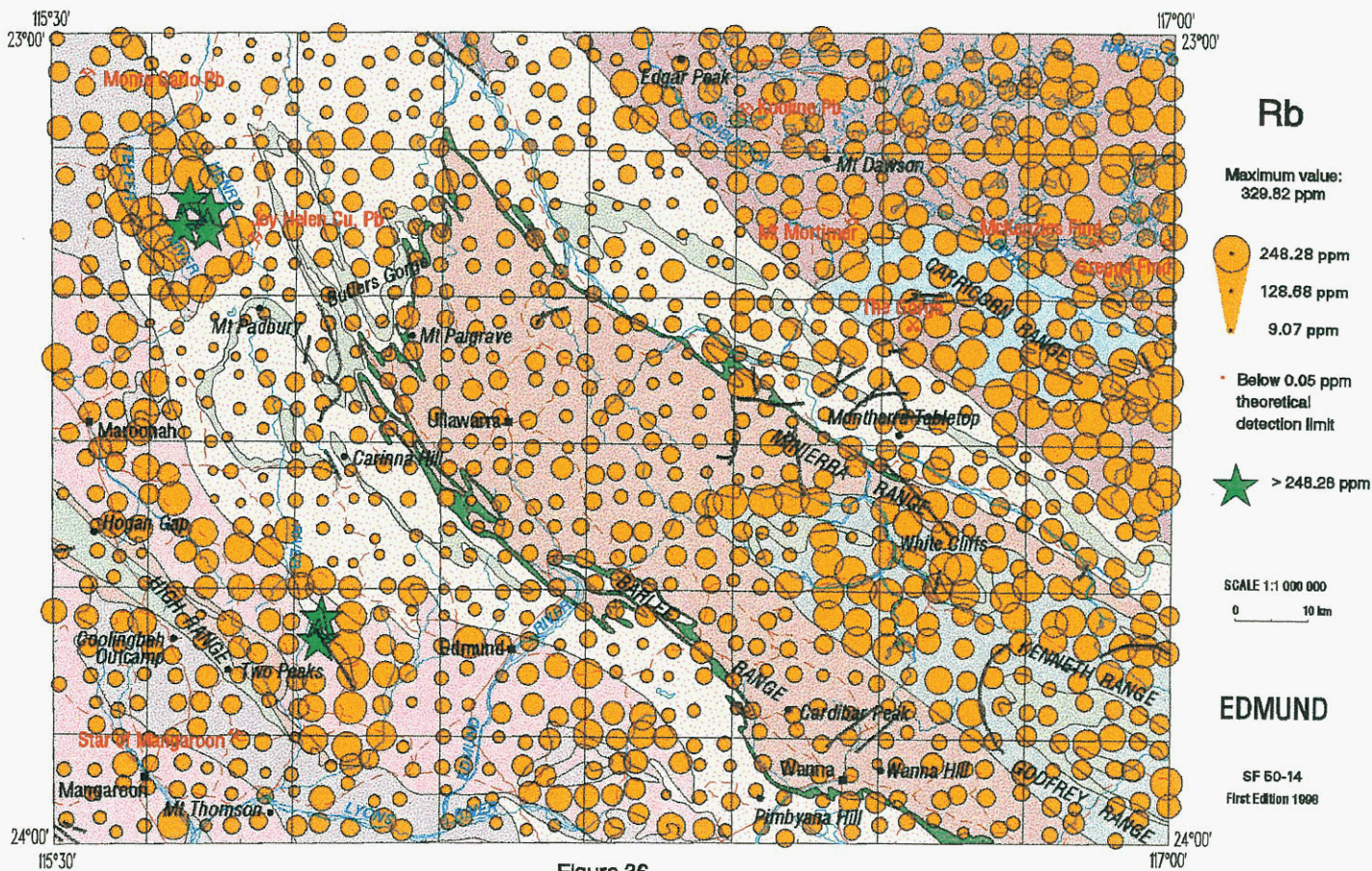


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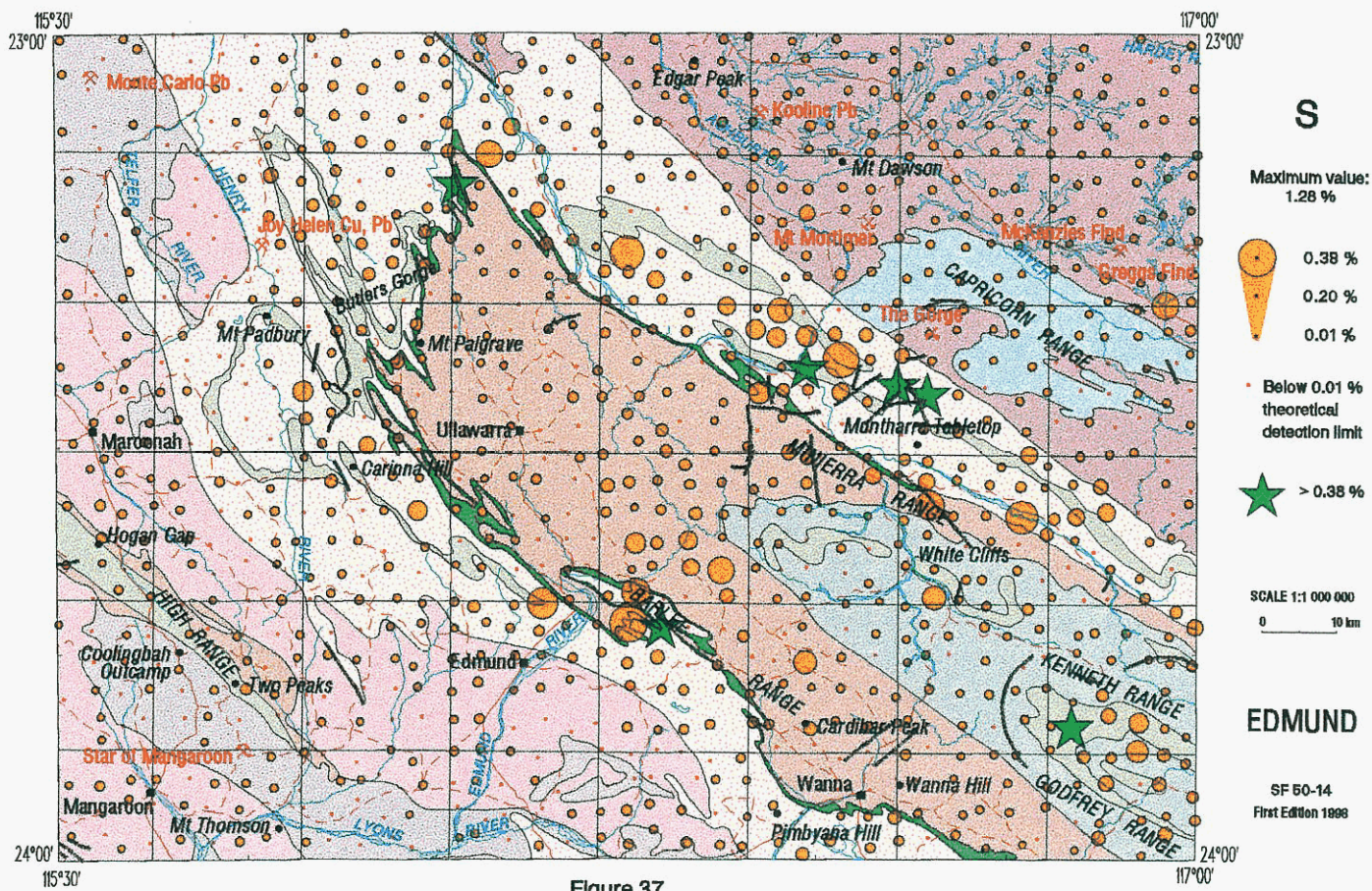


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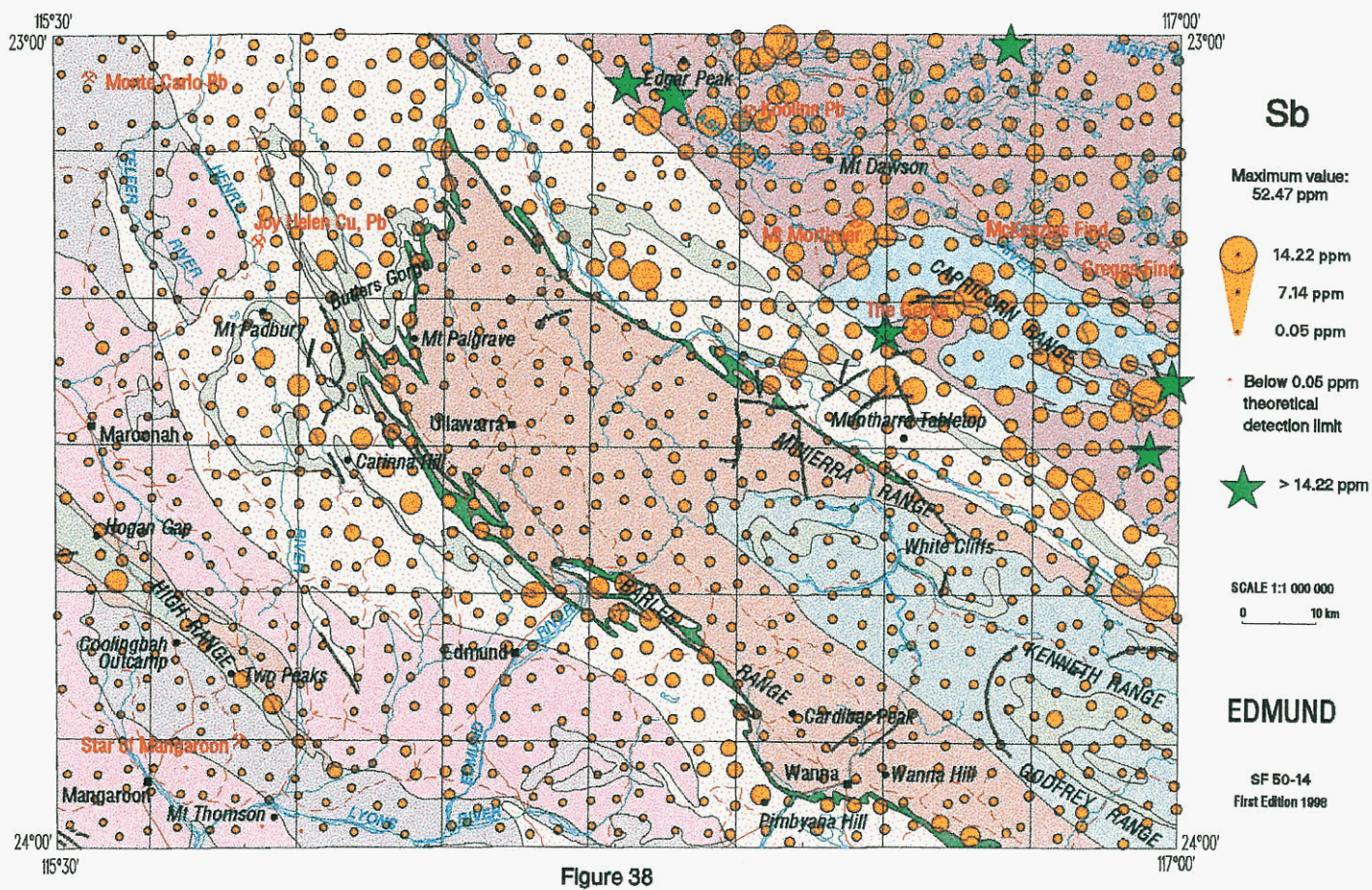
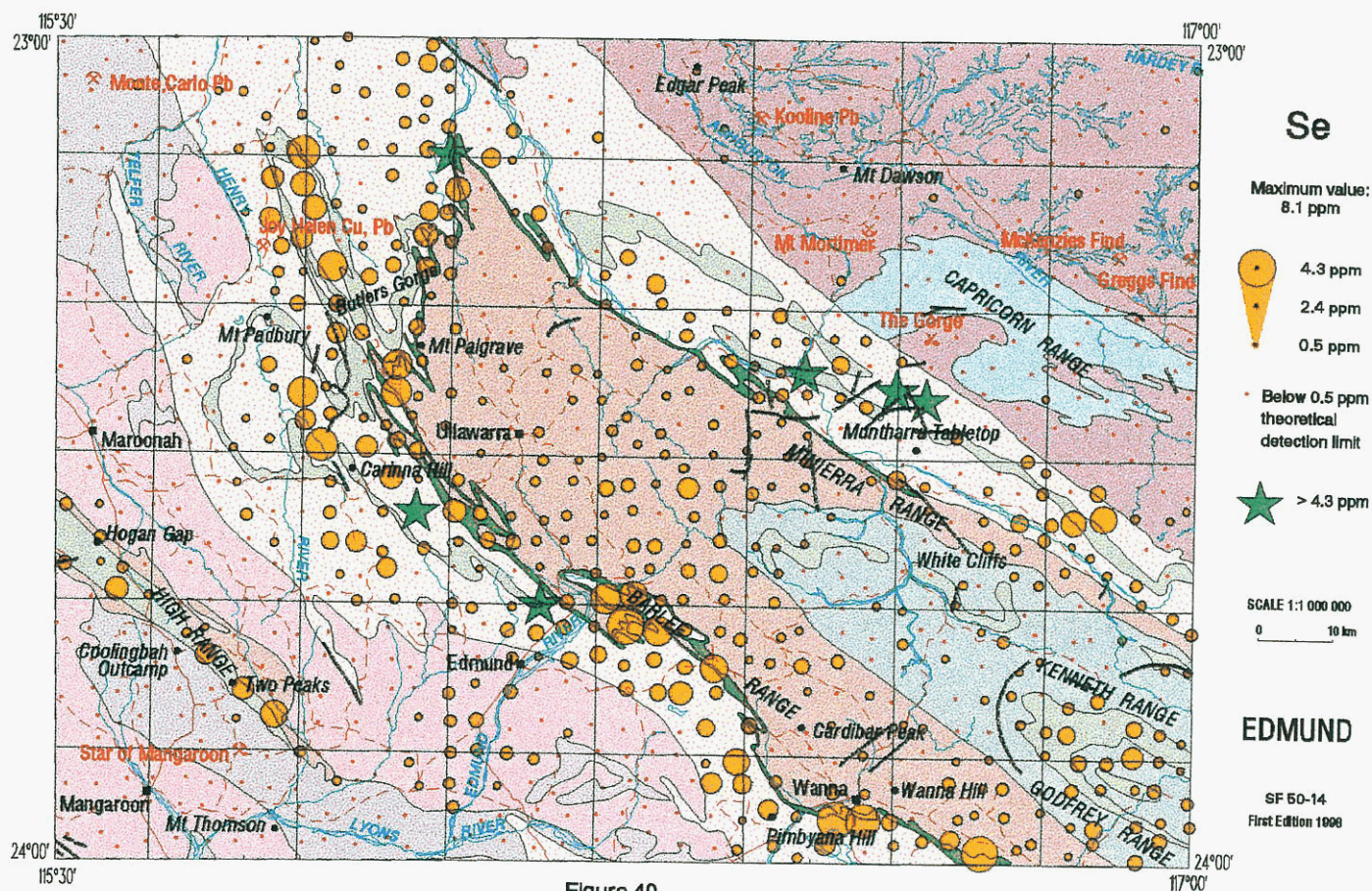
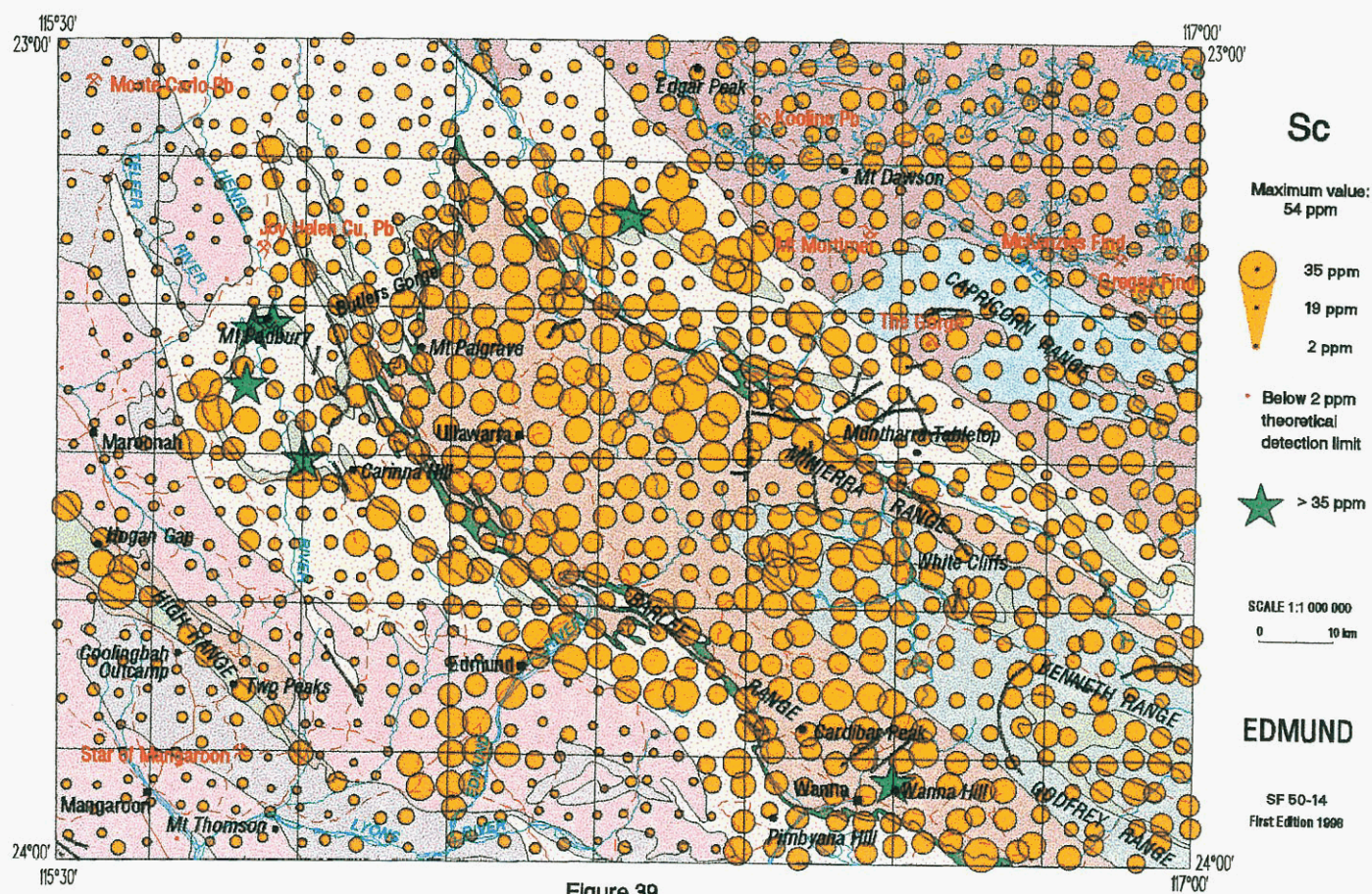


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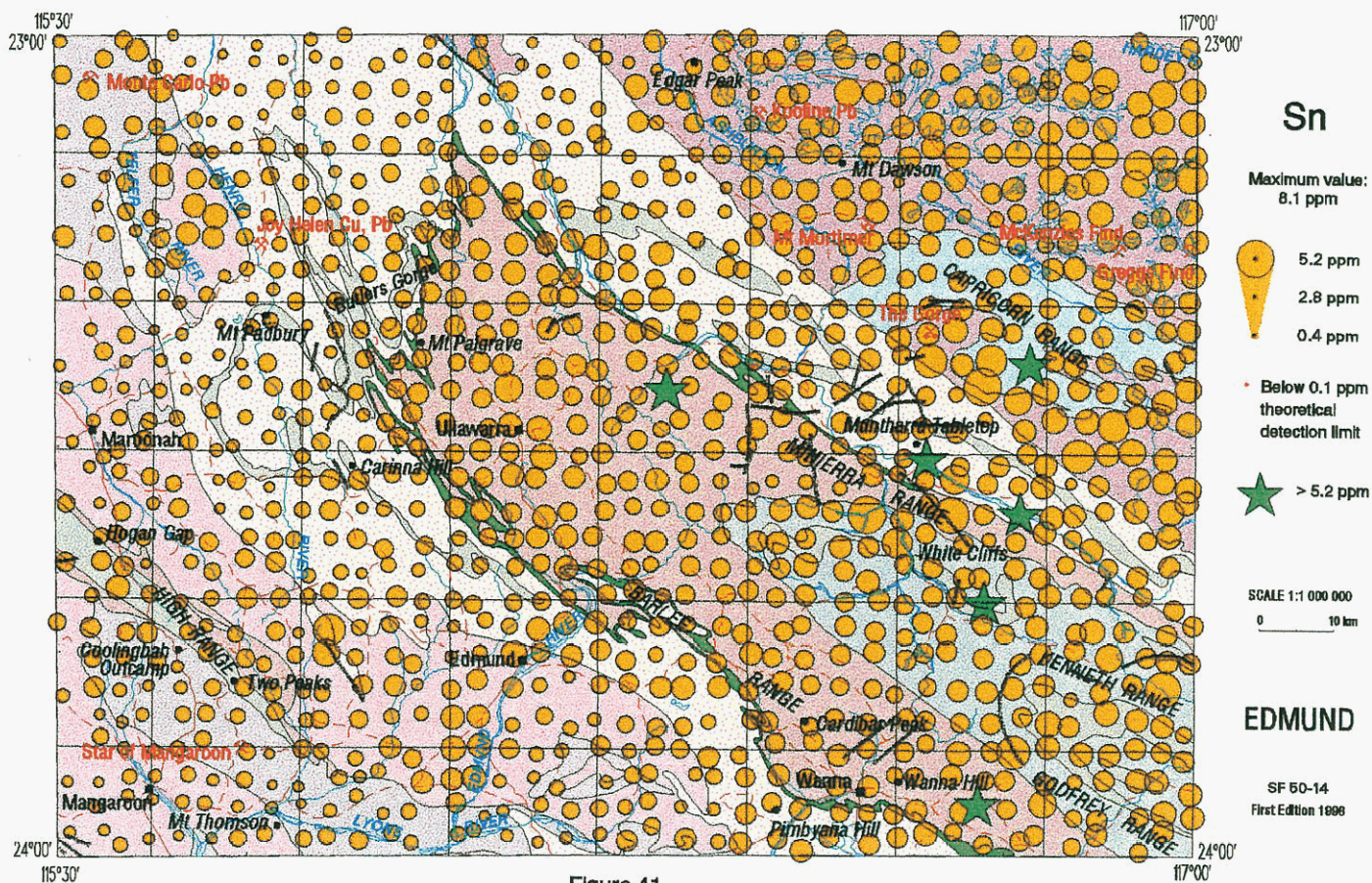


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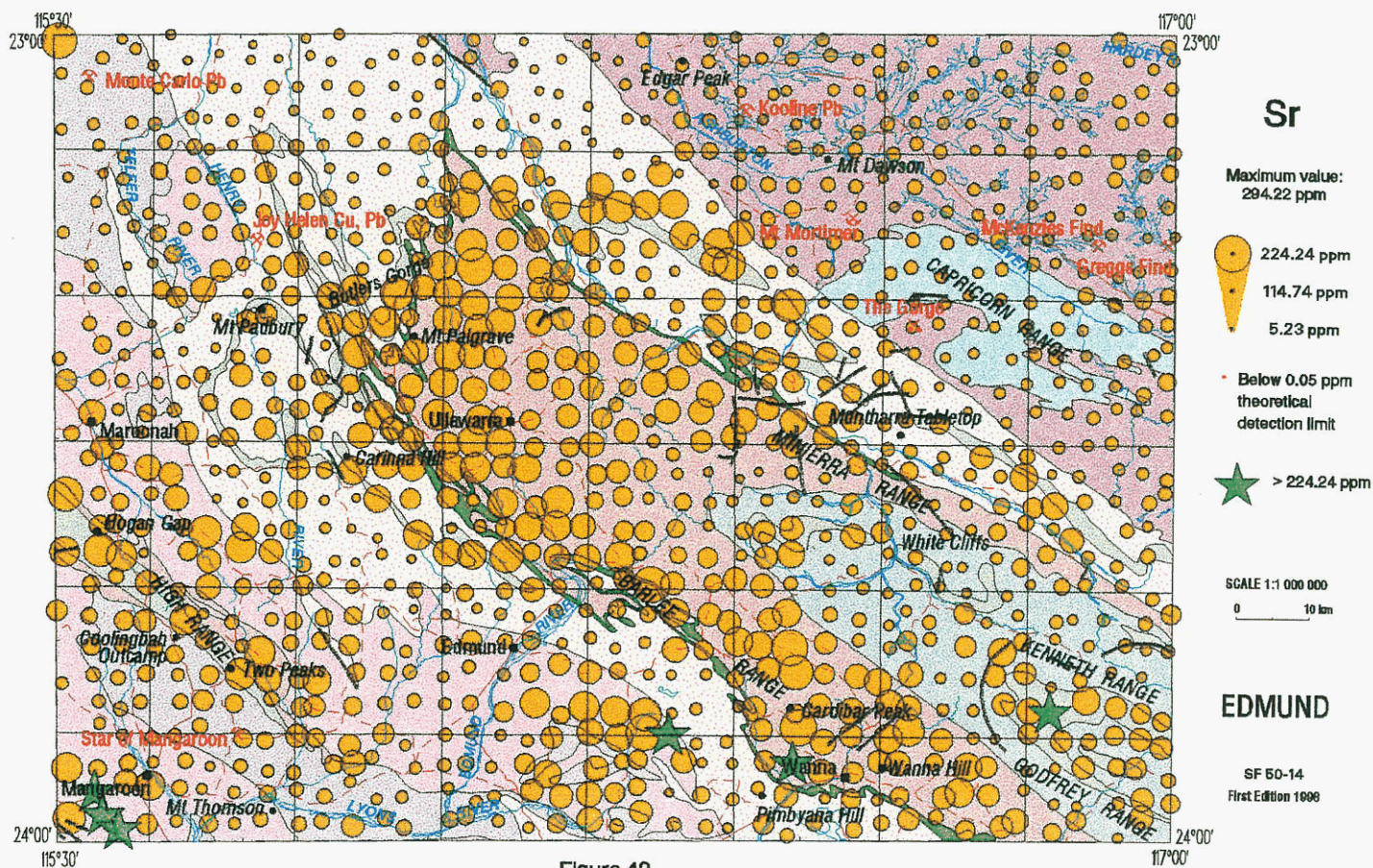


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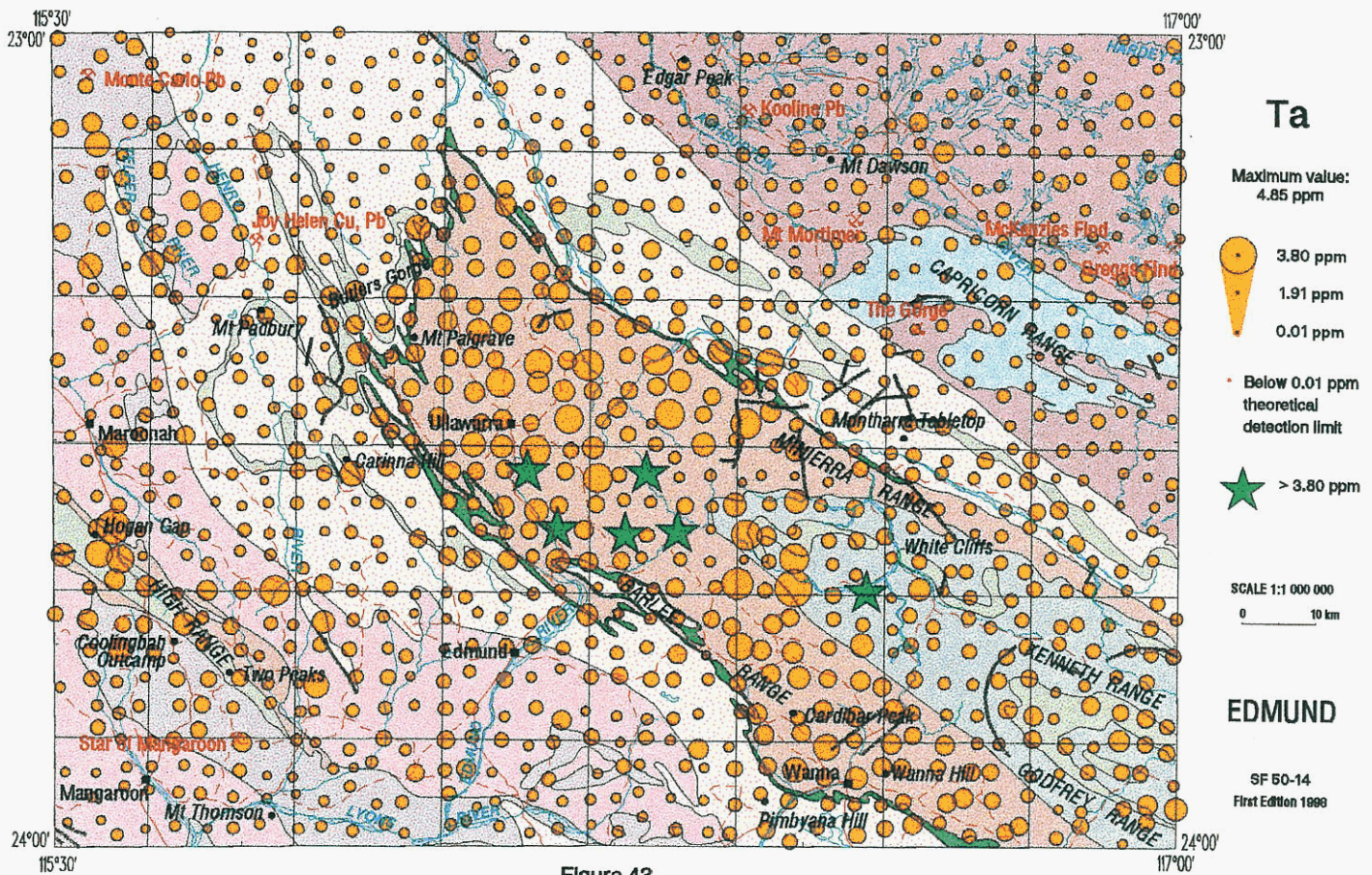


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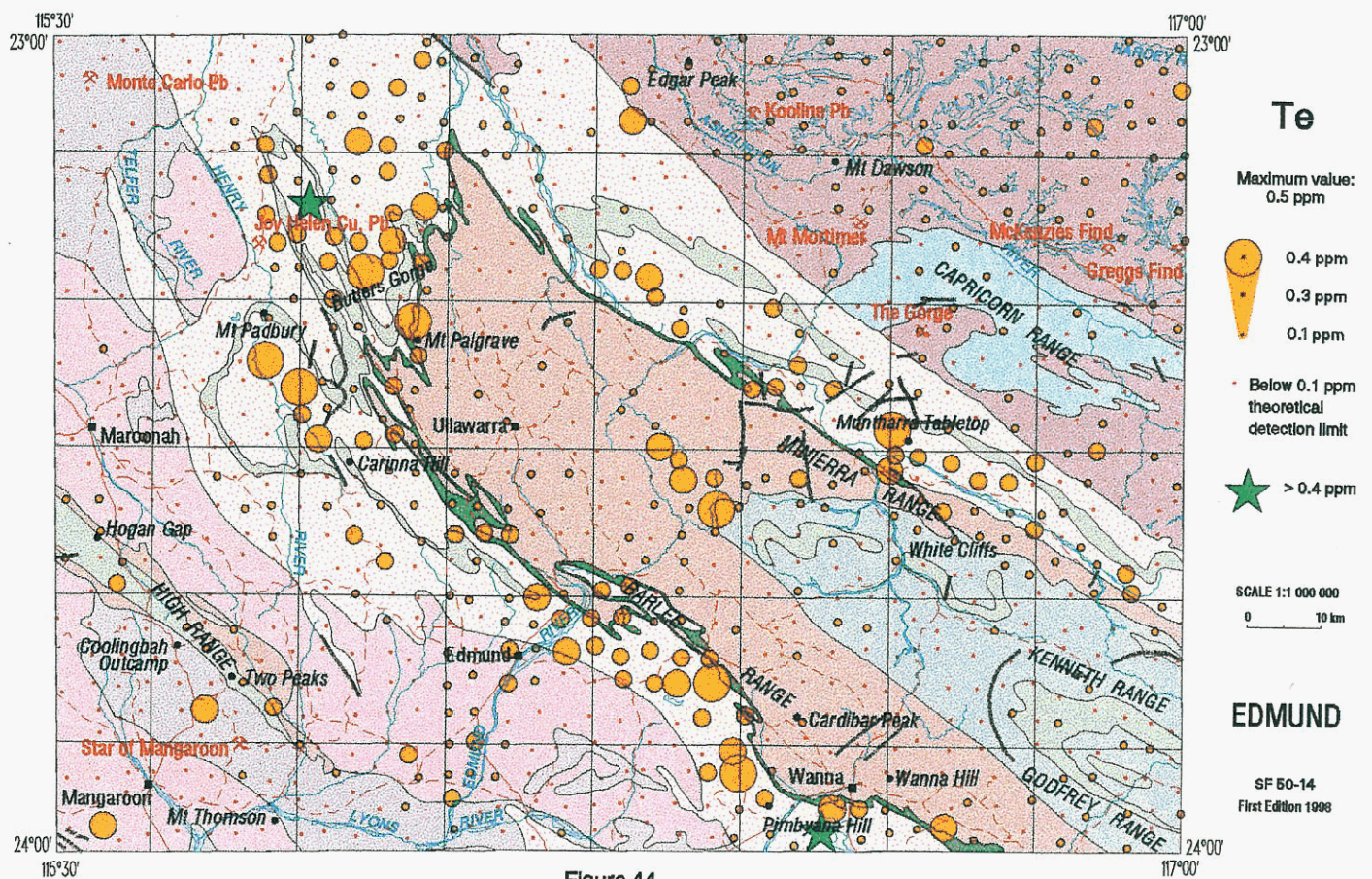
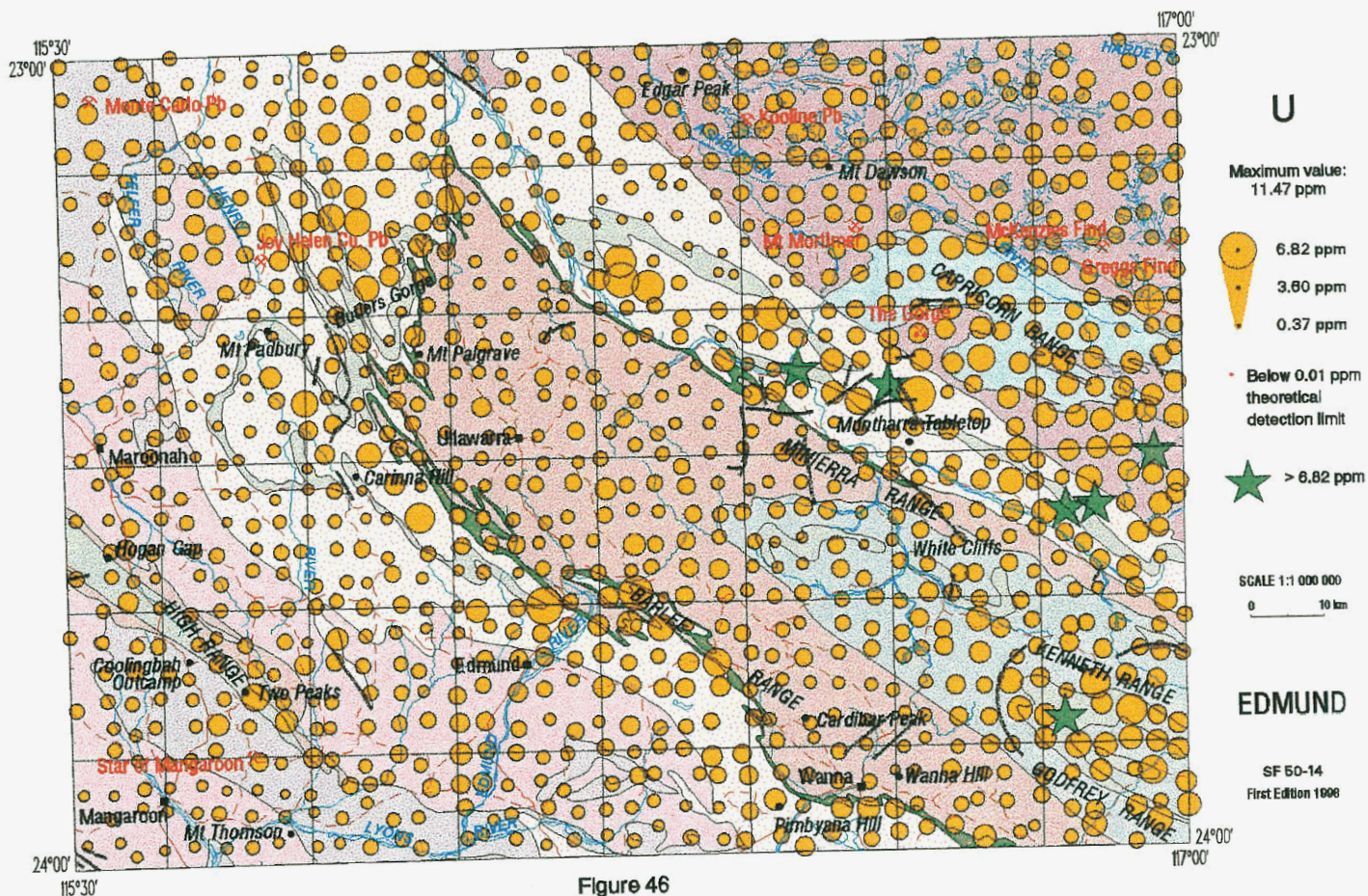
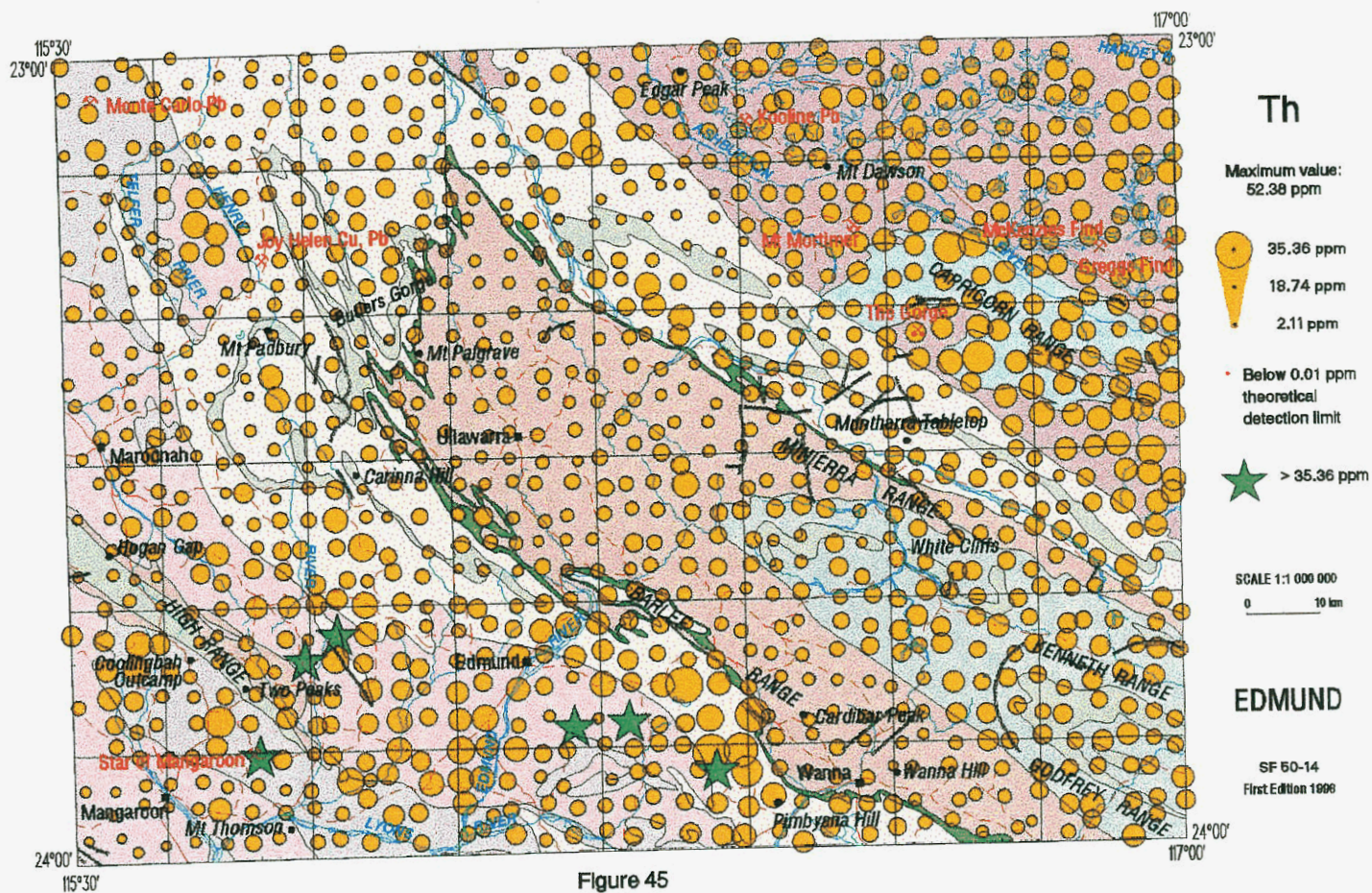
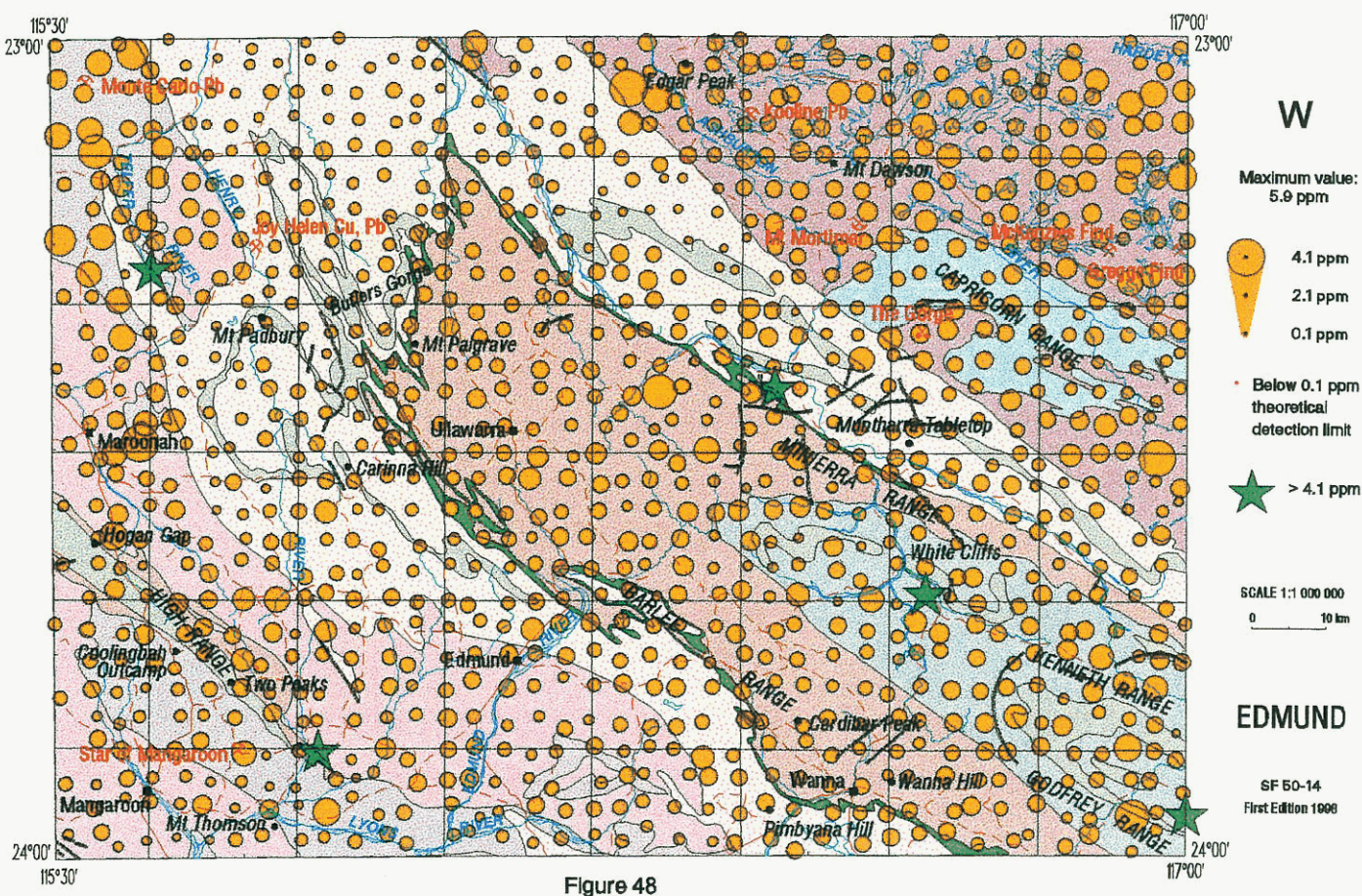
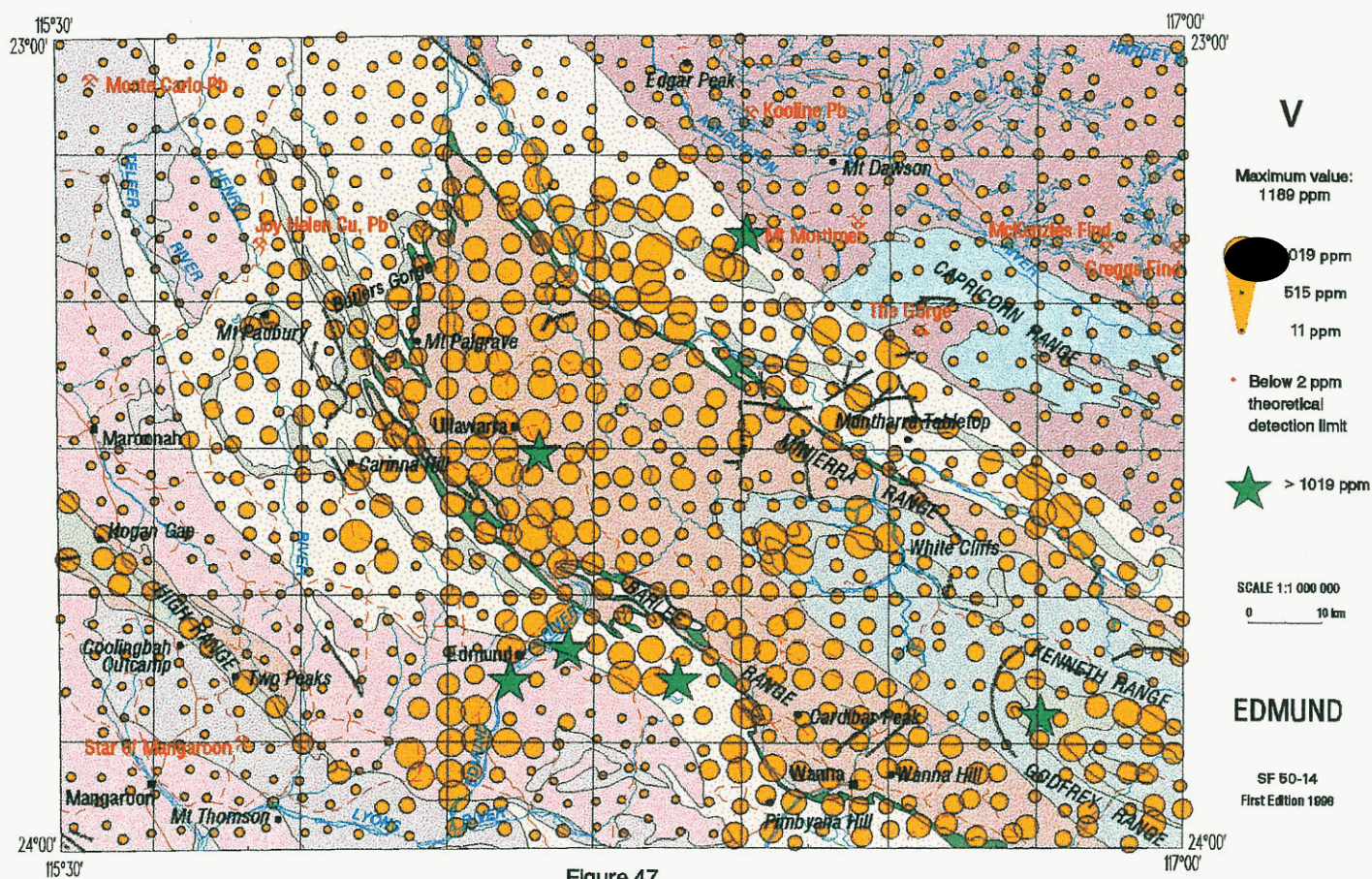


Figure 44











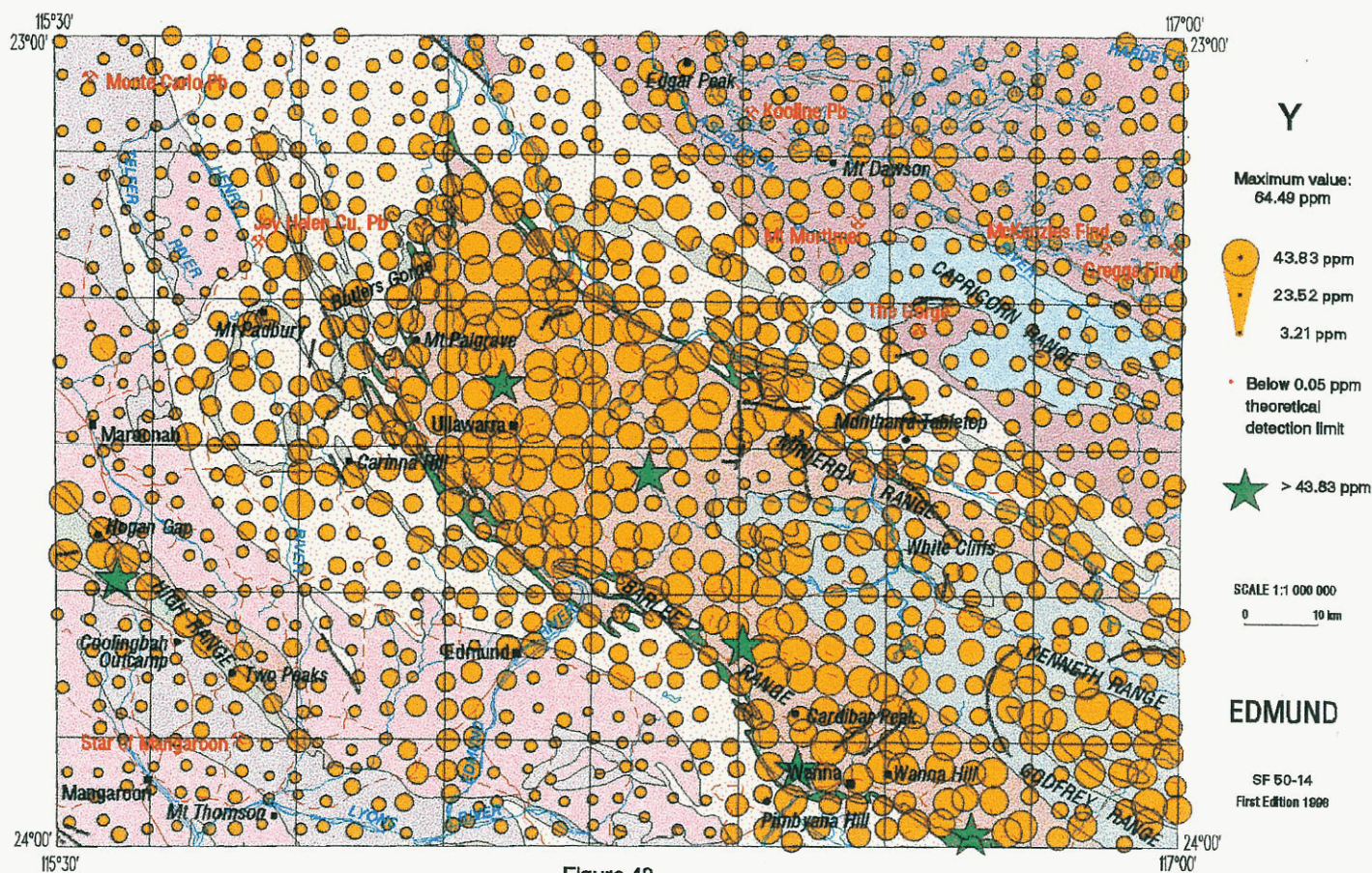


Figure 49

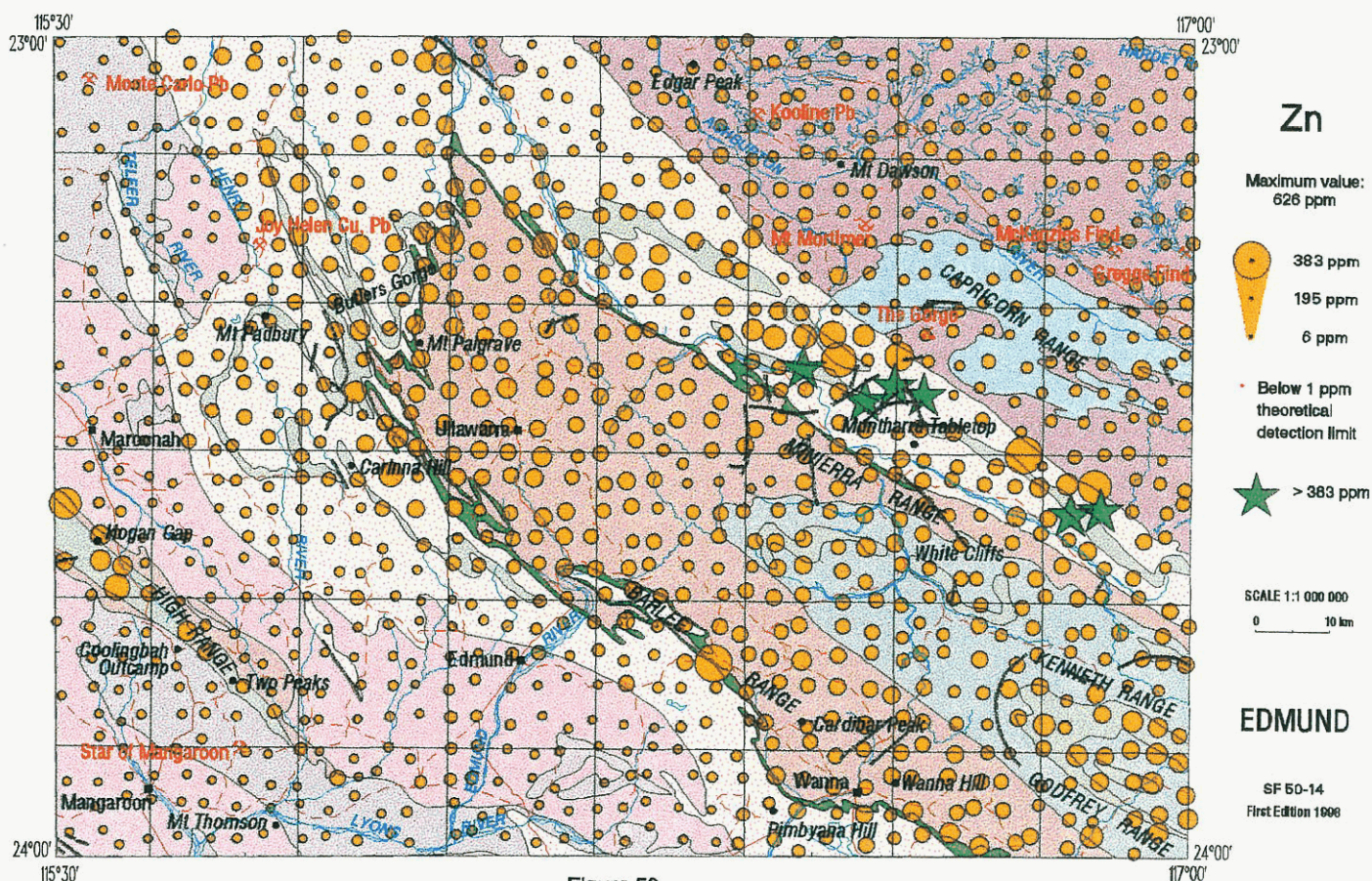


Figure 50



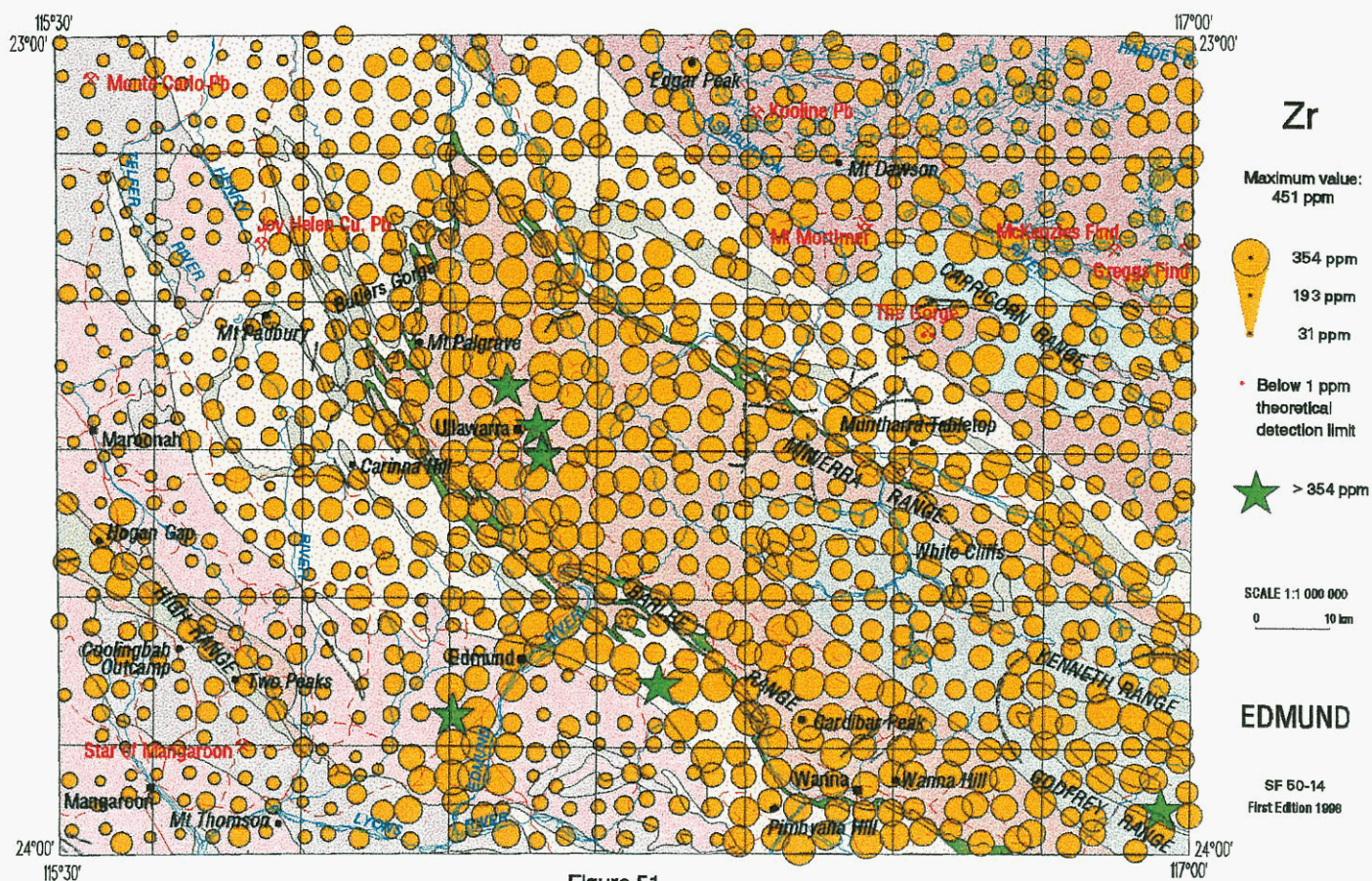


Figure 51



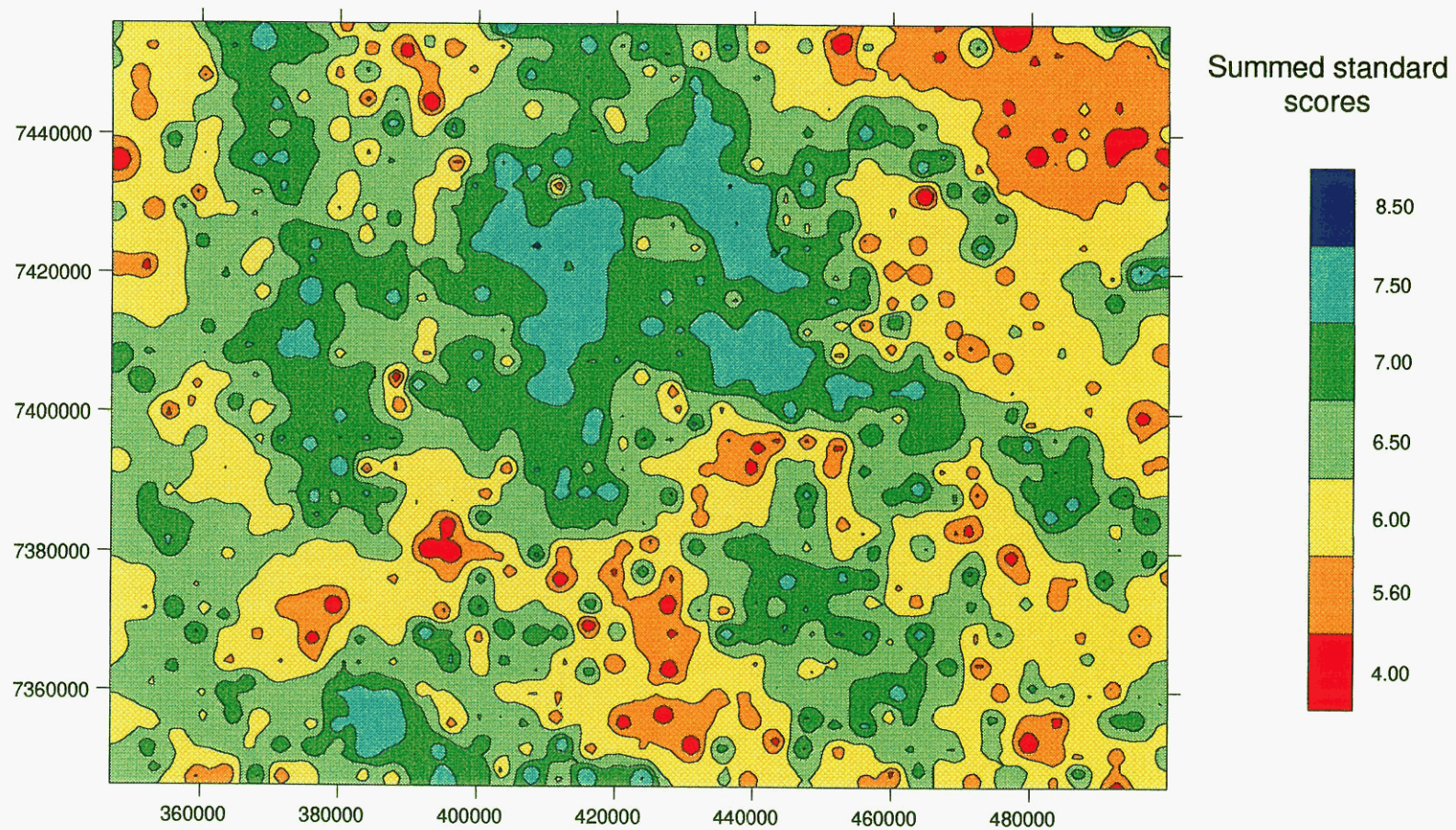


Figure 52. Contoured regolith pH



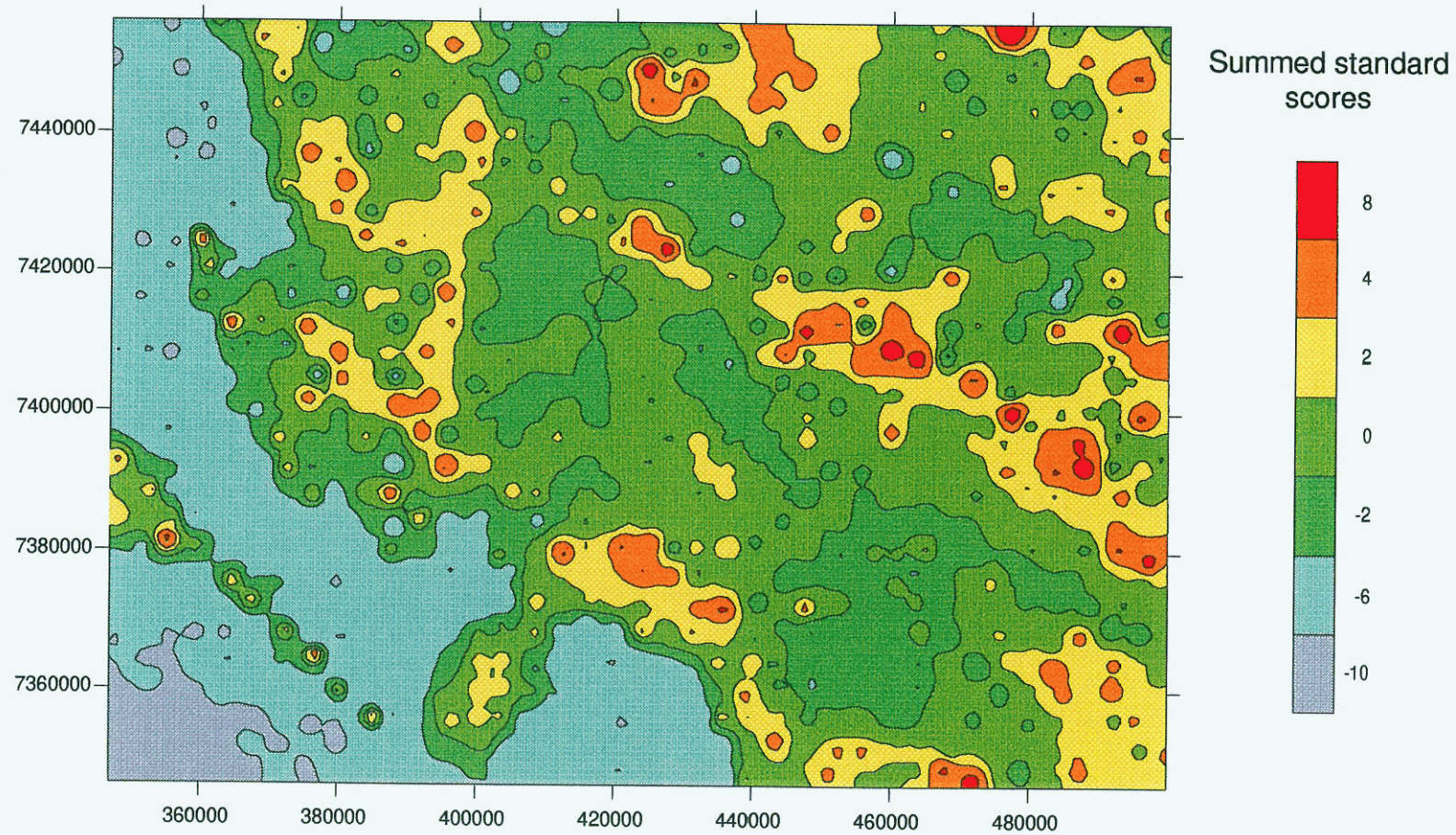


Figure 53. Base-metals index (Cu + Pb + Zn + As + Sb)



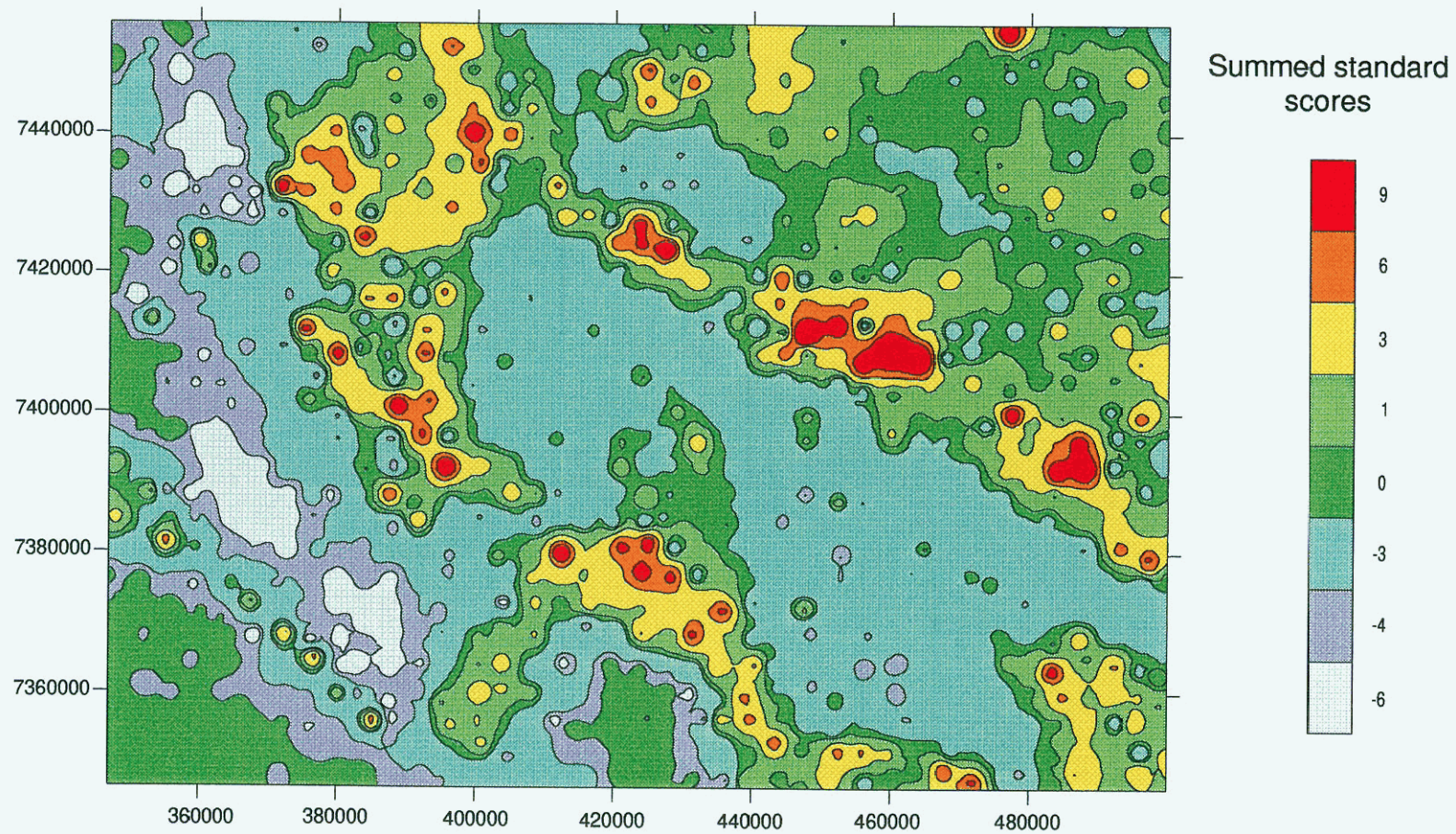


Figure 54. Chalcophile index (As + Ag + Bi + Cd + Sb + Mo)



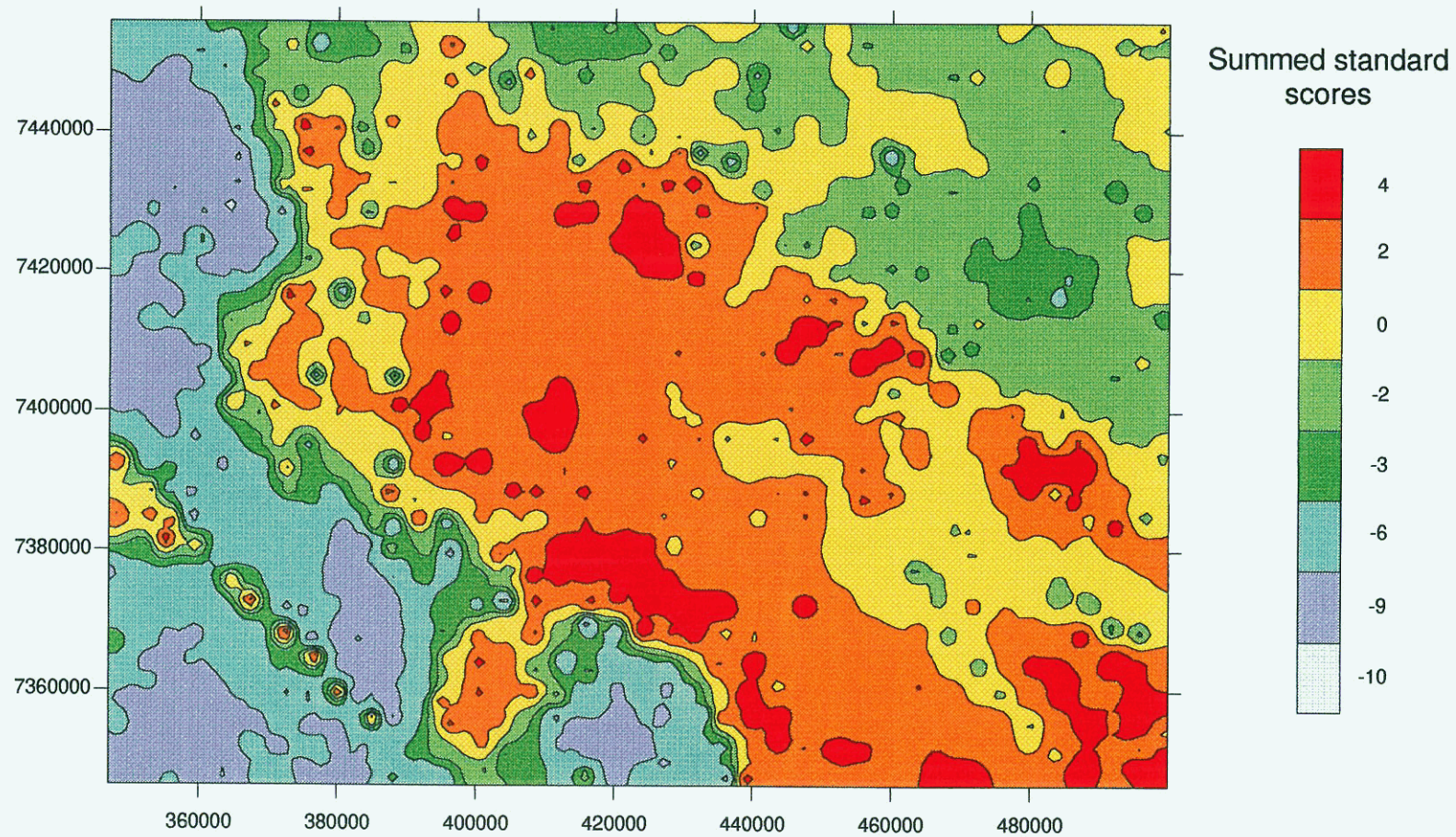
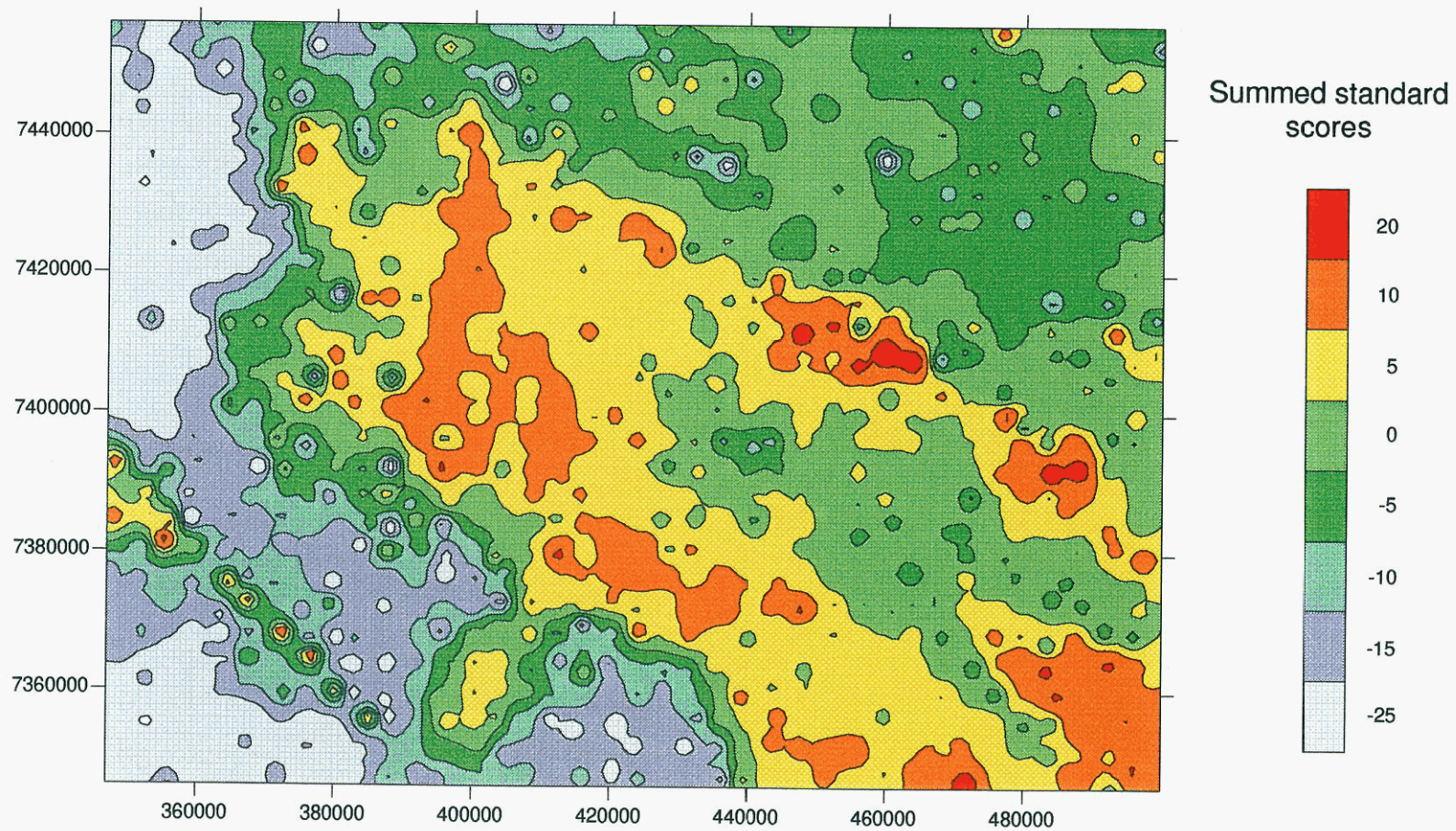


Figure 55. Ferro-alloy index (Ni + Cr + Mo + Co + V)





**Figure 56. Metalliferous black-shale index (V + Cr + Co + Ni + Cu + Zn + Ag + Cd + Pb + U + As + Se + Sb + Ti + Ba + Na<sub>2</sub>O + La + Ce + Zr)**

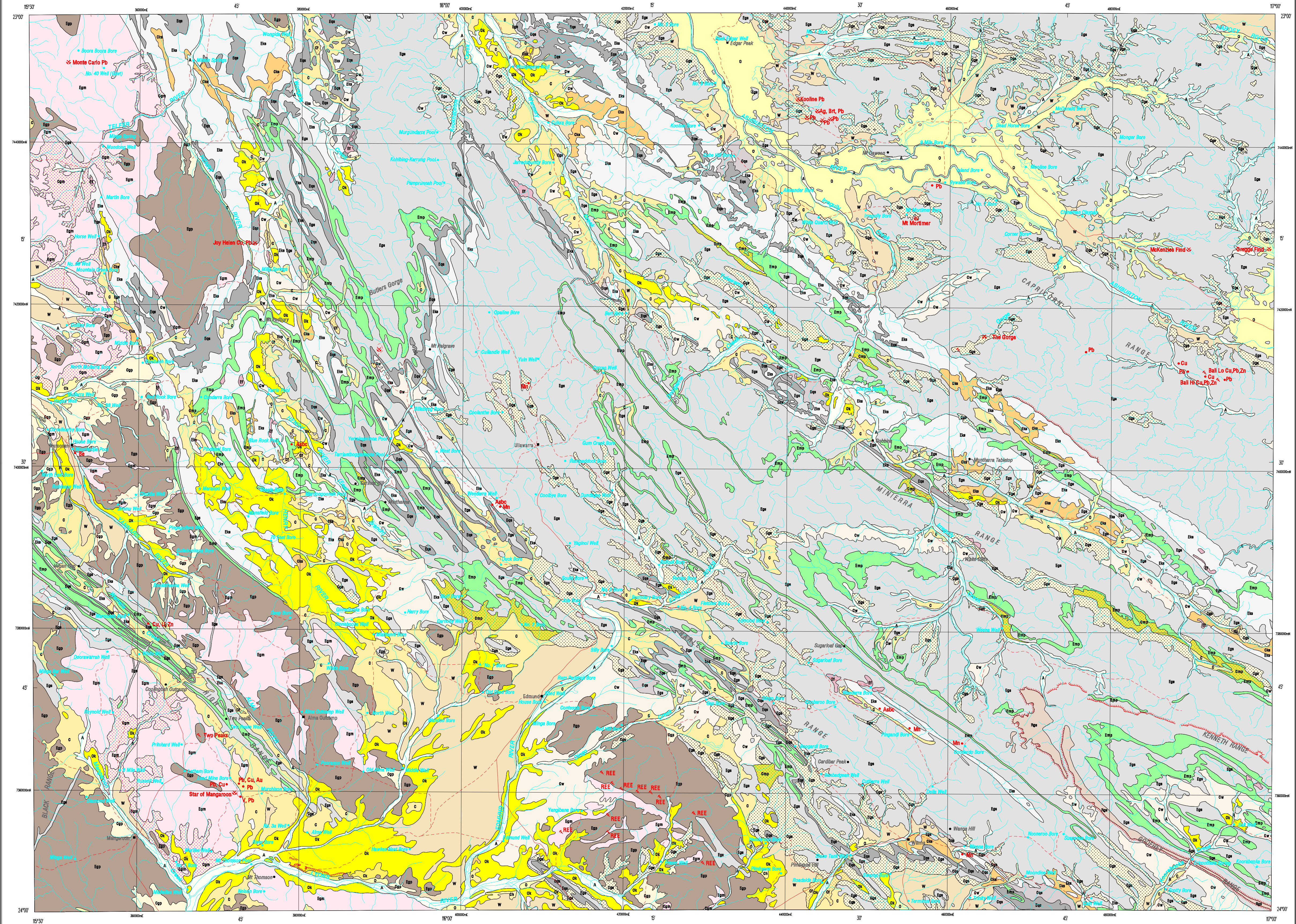


EDMUND  
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

AUSTRALIA 1:250 000 REGOLITH GEOCHEMISTRY SERIES

SHEET SF 50-14

REFERENCE



**RELICT REGIME**

- Rz: Silts, sometimes weakly ferruginized, forming remnant land surfaces (may include chert-rich capping on calcrete)
- Rgs: Silicified capping on sandstone, usually horizontally bedded, forming mesas

**EROSIONAL REGIME**

- Ef: Outcrop of saprock, bedrock, and subcrop with locally derived sand and sandy clays; coarse boundary (ag may be present adjacent to prominent ridges, derived from ferruginized rock)
- Egm: As for 'Ef'; derived from quartzfeldspathic metamorphic rock
- Egs: As for 'Ef'; derived from quartzfeldspathic plutonic rock
- Ege: As for 'Ef'; derived from quartzfeldspathic sedimentary rock
- Eka: As for 'Ef'; derived from carbonate-rich sedimentary rock
- Emp: As for 'Ef'; derived from coarse-grained ferromagnesian rock
- Eps: As for 'Ef'; derived from quartz-rich sedimentary rock

**DEPOSITIONAL REGIME**

**DOMINANTLY COLLUVIAL**

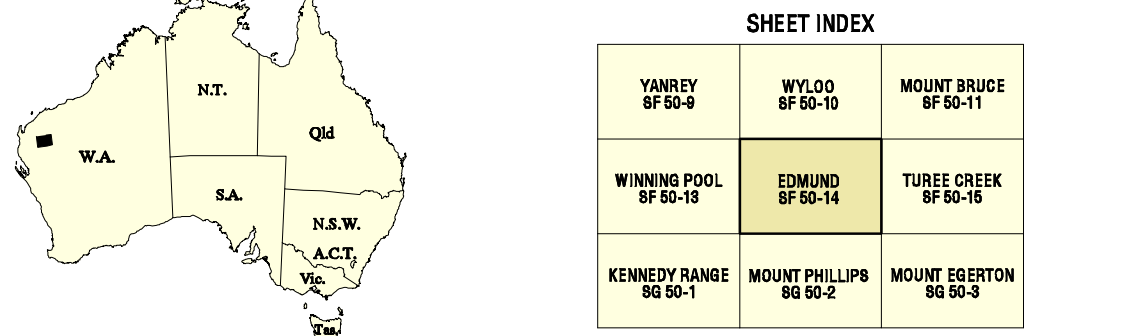
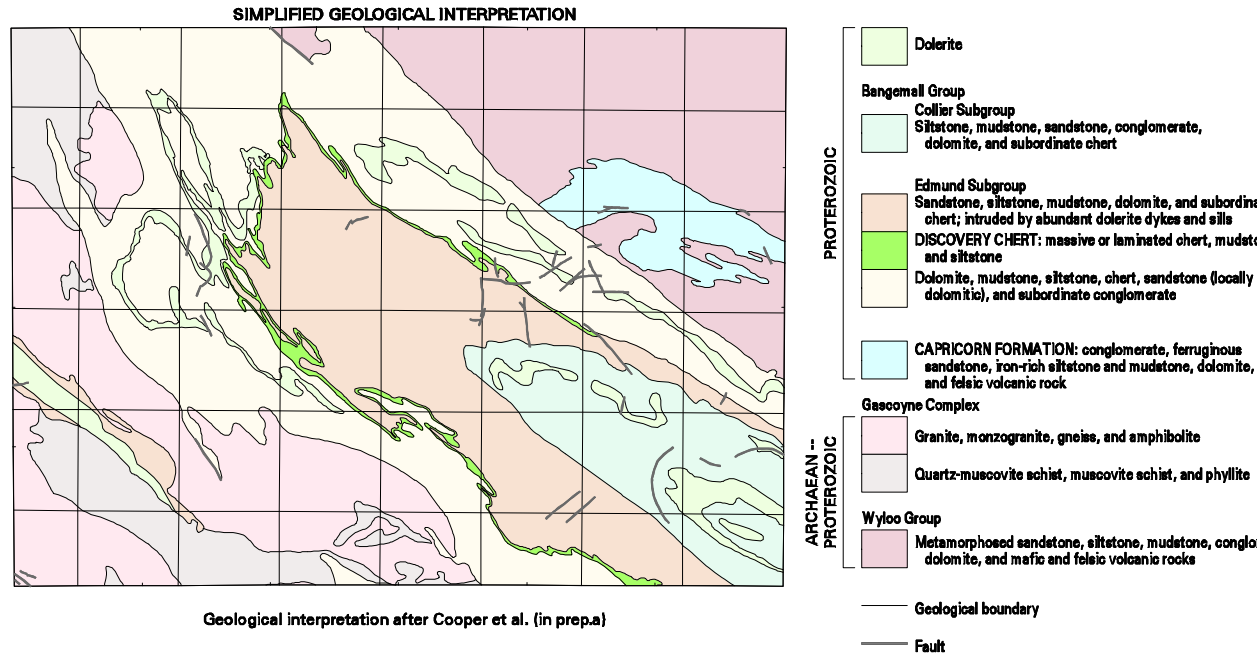
- C: Unconsolidated and semi-consolidated sand, silt, gravel, and rubble (derived from various sources)
- Cf: As for 'C'; derived from strongly ferruginized rock
- Cg: As for 'C'; derived mainly from quartzfeldspathic rock
- Cgm: As for 'C'; derived mainly from quartzfeldspathic metamorphic rock
- Cgp: As for 'C'; derived mainly from quartzfeldspathic plutonic rock
- Cgs: As for 'C'; derived mainly from quartzfeldspathic sedimentary rock
- Ck: As for 'C'; derived mainly from calcrete
- Cks: As for 'C'; derived mainly from carbonate-rich sedimentary rock
- Cqe: As for 'C'; derived mainly from quartz-rich sedimentary rock
- Cmp: As for 'C'; derived mainly from coarse-grained ferromagnesian rock
- Cw: Consolidated to semi-consolidated sand, silt, gravel, and rubble; commonly deeply bedded; may include areas of hardpan
- Ch: Consolidated to semi-consolidated sand, silt, gravel, and rubble; commonly deeply bedded; may include areas of hardpan

**DOMINANTLY ALLUVIAL**

- A: Cobbles, gravel, sand, silt, and clay in active alluvial channels; commonly flattened by steep-sided alluvial slopes
- O: Overbank deposits, sand-, or clay-rich alluvium and colluvium on floodplains; includes calcrete fragments and non-saline claypans
- Ok: Valley calcrete, silicified in places
- W: Sand- and clay-dominated colluvium or sheetwash with indistinct alluvial channels; may be scattered with small lakes

**SYMBOLS**

- Regolith boundary
- Minor road
- Track
- Breakaway
- Watercourse
- Lake
- Homestead
- Locality
- Wanna
- Two Peaks
- Kooline
- Mt Mortimer
- The Gorge
- Bail Hi
- Mineral occurrence
- Asbestos, chrysotile
- Barite
- Beryllium
- Copper
- Gold
- Lead
- Manganese
- Rare-earth elements
- Silver
- Uranium
- Vanadium
- Zinc



REGOLITH MATERIALS

REGOLITH GEOCHEMISTRY SERIES  
**EDMUND**  
SHEET SF 50-14  
FIRST EDITION 1988  
© Western Australia 1988

Edited by D. Ferdinando and G. Loan  
Cartography by L. Kulak and D. Ladbroke  
Topography from Australian Surveying and Land Information Group Sheet SF 50-14 and modified from geological field survey (1987)  
This map was compiled digitally and produced using a Geographic Information System (ARC/INFO), and the data are available in digital form  
Published by the Geological Survey of Western Australia. Copies of this map, or extracts of the data, are available from the Information Centre, Department of Minerals and Energy, 100 Plain Street, East Perth, W. A., 6004. Phone (08) 9222 5456, Fax (08) 9222 3444

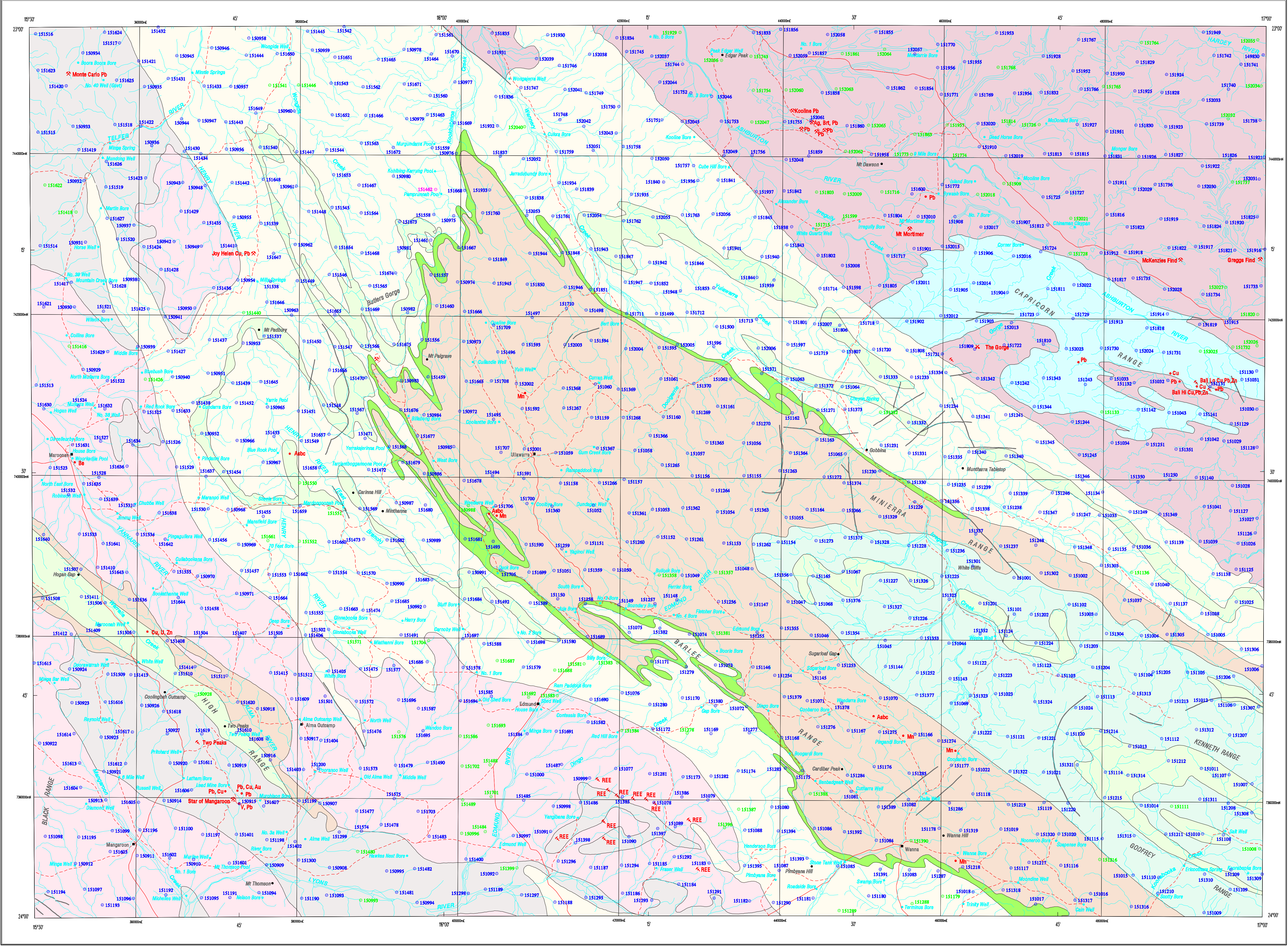


SCALE 1:250 000  
TRANSVERSE MERCATOR PROJECTION  
HORIZONTAL DATUM: AUSTRALIAN GEODETIC DATUM 1984  
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM  
Grid lines indicate 20 000 metre interval of the Australian Map Grid Zone 50

Compiled by K. J. Pye and J. Colar, 1988  
Field observations by A. Franchitto, M. Tiller, D. Hardwick, (Geoschem Australia), S. Shevchenko, S. Chen, and R. Cooper (GSWA), 1987  
Compiled using Landsat TM Images 1988 and 1989, black-and-white aerial photography 1978, GSWA geology 1989, and field observations 1987  
The recommended reference for this map is PYE, K. J., COKER, J., FAULKNER, J. A., and SANDERS, A. J., 1988, Edmund, WA Sheet SF 50-14 - Regolith materials, Plate 1: Western Australia Geological Survey, 1:250 000 Regolith Geochemistry Series.

WARNING: Inks are water soluble and will fade with prolonged exposure to light





# SAMPLE LOCATIONS

SYMBOLS

Formed road

Track

Watercourse

Lake

Homestead

Locality

Mine

Opencut

Alluvial workings

Prospect

Mineral occurrence

Absc

Barite

Beryllium

Copper

Gold

Lead

Manganese

Rare-earth elements

Silver

Uranium

Vanadium

Zinc

Sample point references

Stream sample

Sheetwash sample

Soil sample

GEOLOGICAL INTERPRETATION

Dolerite

Bangemall Group

Edmund Subgroup

DISCOVERY CHERT

Dolomite, mudstone, siltstone, chert, sandstone (locally dolomitic), and subordinate conglomerate

CAPRICORN FORMATION

Gascoyne Complex

Wyloo Group

Geological boundary

Fault

SHEET INDEX

YANREY SF 50-4

WYLOO SF 50-10

MOUNT BRUCE SF 50-11

WINNING POOL SF 50-13

EDMUND SF 50-14

TUREE CREEK SF 50-15

KENNEDY RANGE SF 50-16

MOUNT PHILLIPS SF 50-17

MOUNT ELLERTON SF 50-18

SAMPLE LOCATIONS

REGOLITH GEOCHEMISTRY SERIES

EDMUND

SHEET SF 50-14

FIRST EDITION 1998

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Edited by N. Tatlow and C. Brin

Cartography by L. Kule

Topography from Australian Surveying and Land Information Group Sheet SF 50-14 and modified from geological field survey (1997)

This map was compiled and produced using a Geographic Information System (ARC/INFO), and the data are available in digital form.

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DEPARTMENT OF MINERALS AND ENERGY  
L.C. RANFORD, DIRECTOR GENERAL

GOVERNMENT OF WESTERN AUSTRALIA  
HON. NORMAN MOORE, M.L.C.  
MINISTER FOR MINES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA  
DAVID BLIGHT, DIRECTOR

SCALE 1:250 000

TRANSVERSE MERCATOR PROJECTION  
HORIZONTAL DATUM: AUSTRALIAN GEODETIC DATUM 1984  
VERTICAL DATUM: AUSTRALIAN HEIGHT DATUM  
Grid lines indicate 20 000 metre interval of the Australian Map Grid Zone 50

Sampling by D. Hardwick, M. Tiller, and A. Franchitto (Geochemex Australia), A. Abernethy, R. Isley, and E. Peiris (GSWA), 1997

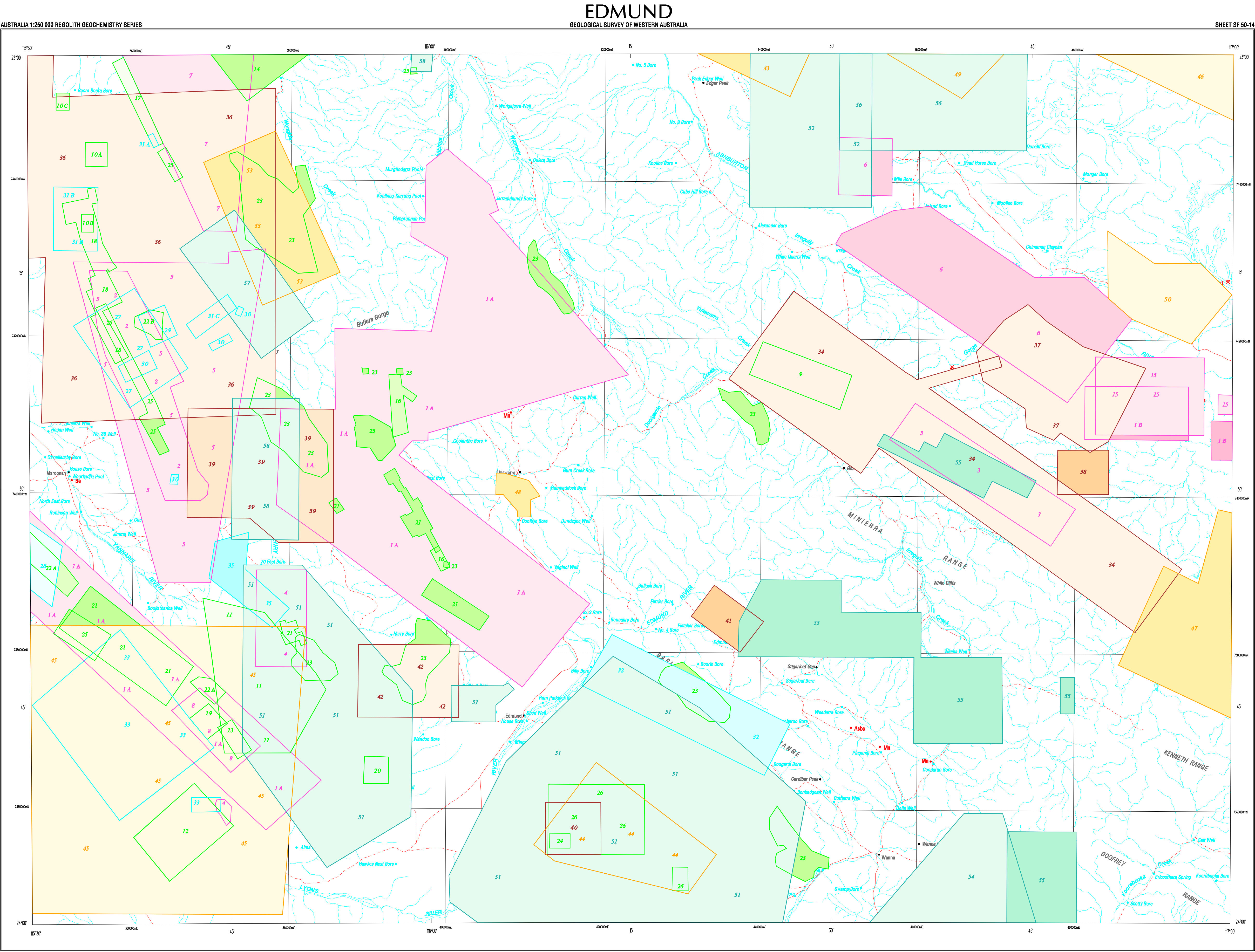
Total sample area: 1054; 988 stream sediment, 80 sheetwash, 1 soil

Analysis: Geochemex Laboratory Services. Minimum sample size: 1.5 kg. Fraction of sample analysed: >0.6mm <2mm

Geological interpretation after Cooper et al. (in press)

The recommended reference for this map is: PYE, K. J., GOKER, J., FAULKNER, J. A., and SANDERS, A. J., 1998, Edmund, W.A. Sheet SF 50-14 - Sample locations, Plate 2: Western Australia Geological Survey, 1:250 000 Regolith Geochemistry Series.





COMPANY PROJECTS WITH SURFACE  
GEOCHEMISTRY DATA IN OPEN-FILE  
REPORTS (at February 1998)  
AREAS OF EXPLORATION REPORTED BETWEEN  
1965 AND 1997

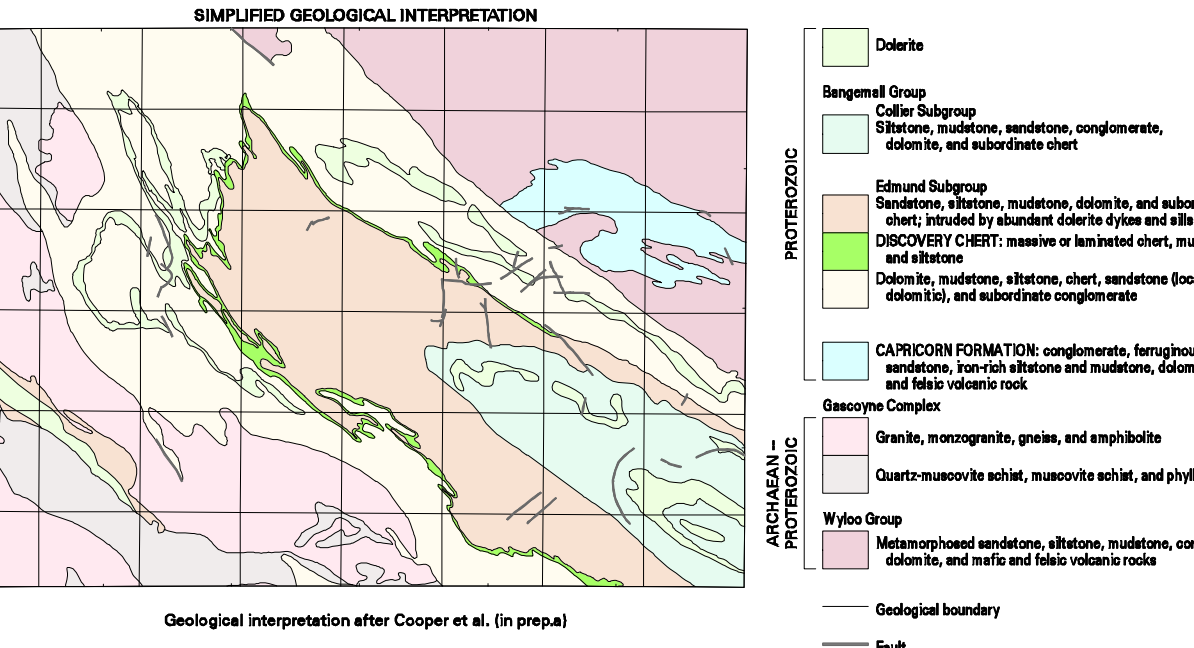
**SYMBOLS**

- Formed road
- Track
- Watercourse
- Lake
- Homestead
- Locality
- Mine
- Open-cut
- Alluvial workings
- Prospect
- Mineral occurrence
- Asbestos, chrysotile
- Barite
- Beryllium
- Copper
- Gold
- Lead
- Manganese
- Rare-earth elements
- Silver
- Uranium
- Vanadium
- Zinc

**Period project reported within**  
(Various colour shades used for ease of project identification)

- 1965 - 1970
- 1971 - 1975
- 1976 - 1980
- 1981 - 1985
- 1986 - 1990
- 1991 - 1997

Number within project area is a database ID number (see Appendix 2)



**SHEET INDEX**

YANREY 8F 50-9	WYLOG 8F 50-10	MOUNT BRUCE 8F 50-11
WINNING POOL 8F 50-13	EDMUND 8F 50-14	TUREE CREEK 8F 50-15
KENNEDY RANGE 8G 50-1	MOUNT PHILLIPS 8G 50-2	MOUNT EBERTON 8G 50-3

**INDEX TO 1:100 000 MAP SHEETS  
WITHIN EDMUND 1:250 000**

MARDONAH 2061	ILLAWARRA 2161	CAPRICORN 2261
MARGANDORA 2062	EDMUND 2162	ELLIOT CREEK 2262



COMPANY PROJECTS WITH SURFACE  
GEOCHEMISTRY DATA IN OPEN-FILE  
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