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PRELIMINARY REGOLITH STUDIES AT ET, MONSOON, JUMBUCK, SOUTH HILGA AND GOLF BORE GOLD PROSPECTS, GAWLER CRATON, SOUTH AUSTRALIA

Volume 1

M.J. Lintern, M.J. Sheard and G. Gouthas

CRC LEME OPEN FILE REPORT 115

April 2002

(CSIRO Exploration and Mining Report 864R/
PIRSA Office of Minerals and Energy Resources,
South Australia, Report Book RB 2002_004)

CRC AUSTRALIA

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CRC LEME is an unincorporated joint venture between CSIRO-Exploration & Mining, and Land & Water, The Australian National University, Curtin University of Technology, University of Adelaide, University of Canberra, Geoscience Australia, Bureau of Rural Sciences, Primary Industries and Resources SA, NSW Department of Mineral Resources-Geological Survey and Minerals Council of Australia.
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PREFACE AND EXECUTIVE SUMMARY

The project is part of the broader "South Australia Regolith Project" of CRC LEME, the principal aim of which is "to develop technically efficient procedures for mineral exploration in the major Cratons of South Australia through a comprehensive understanding of the processes of regolith development and landscape evolution and their effects on the surface expression of concealed mineralisation".

This project is a follow-on to an initial study of regolith geology and geochemistry in the Gawler Craton, sponsored by CRC LEME, PIRSA and Gawler Joint Venture exploration tenement holders commenced in 1997. It was developed after extensive consultation with industry geologists, including an excursion to the various sites. The principal problems identified relate to verification of the thickness of transported overburden and procedures for exploration in terrains where it is present.

The principal objective of this study was to evaluate the use of components of transported overburden for detecting buried Au deposits in the western Gawler Craton. Five prospects (ET, Monsoon, South Hilga, Golf Bore and Jumbuck) were investigated to determine the most suitable single site for detailed study.

A single traverse, several hundred metres in length, was selected across each prospect that had mineralisation, transported overburden and adequate drill spoil. The regolith stratigraphy was described at each site and a selection of samples from the drill spoil was collected for multi-element analysis. An existing company geochemical database for each prospect were also used.

The results showed:

1) the ET Prospect as the most suitable site for further study (see reasons below);
2) complex but repeating patterns in the nature of the regolith stratigraphy;
3) the benefits and limitations of using PIMA;
4) an apparent relationship between Au-in-calcrete anomalies and mineralisation where the transported overburden was thin (<5 m); and
5) limited use for pathfinder elements for finding Au mineralisation.

The ET Prospect was selected for further work as it had the following properties:

1) two hundred drillholes spread over the prospect with cuttings in good condition;
2) a large Au-in-calcrete anomaly that had not been linked to a primary source, leaving potential for additional areas of investigation and possible drill targets;
3) indications that mineralisation might be expressed in the transported overburden;
4) a greater spread and thickness of transported overburden compared with other sites; and
5) sand dunes, typical of the western Gawler Craton, and a hindrance to exploration in this region; there are few previous studies in this type of terrain.

A detailed study at ET Prospect is the subject of a separate report (Lintern et al, 2001).

M.J. Lintern
Project Leader

December 2001

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PRELIMINARY REGOLITH STUDIES AT ET, MONSOON, JUMBUCK, SOUTH HILGA AND GOLF BORE GOLD PROSPECTS, GAWLER CRATON, SOUTH AUSTRALIA.

M.J. Lintern, M.J. Sheard and G. Gouthas

ABSTRACT

The principal objective of this study was to evaluate the use of transported overburden for detecting buried Au deposits in the western Gawler Craton. Five prospects (ET, Monsoon, South Hilga, Golf Bore and Jumbuck) were investigated to determine the most suitable single site for a detailed study.

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M.J. Lintern, M.J. Sheard and G. Gouthas

1 INTRODUCTION

1.1 Background

The project is part of the broader South Australia Regolith Project of CRC LEME, the principal aim of which is "to develop technically efficient procedures for mineral exploration in the major Cratons of South Australia through a comprehensive understanding of the processes of regolith development and landscape evolution and their effects on the surface expression of concealed mineralisation".

The project follows an initial study of regolith geology and geochemistry in the Gawler Craton, sponsored by CRC LEME, PIRSA and the Gawler Joint Venture exploration tenement holders commenced in 1997. It was developed after extensive consultation with industry geologists, including an excursion to various sites. The principal exploration problems identified relate to verification of the thickness of transported overburden and procedures for terrains where it is present.

1.2 Work objectives

The principal objective of these preliminary studies was to choose a single site for detailed study to help mineral exploration in terrain dominated by transported overburden. The objectives at the chsoen site would be to establish relationships between geochemical dispersion, weathering processes and regolith and landform evolution.

Specific objectives at the single site were to:

i) Characterise and map the regolith geology and geochemistry.
ii) Determine the limitations of calcrete as a sampling medium and, if possible, to develop criteria for calcrete as a sampling medium in areas of transported overburden.
iii) Examine the implications of terrain-forming processes on geochemical dispersion in the regolith.
iv) Evaluate airborne hyperspectral (HyMap) data and field hyperspectral data, gamma-ray spectrometry data and precision DEMs for regolith and landform mapping, and to assist in geochemical interpretation.
v) Disseminate the information to the exploration industry.

1.3 Work program

The project was designed to test one 3 x 3 km prospect-scale site within the exploration tenements. The site was expected to be representative of large areas of the Gawler Craton environment. The final selection of ET was made in collaboration with industry sponsors. This report describes the regolith characteristics (including geochemistry) of all five prospects. The more detailed ET study is reported elsewhere (Lintern et al, 2001).

1.4 Location

The study was conducted at five prospects in the north-western Gawler Craton, South Australia (Figure 1); a section was chosen at each prospect and was termed a "regolith line". The prospects and approximate locations using UTM, AGD 66, Zone 53 are: ET (340200E 6636000N); Golf Bore (404500E 6726500N); Jumbuck (376000E 6690450N); Monsoon (350560E 6657300N) and South

1.5 Access and climate

All five prospects are located in the Christie Domain, western Gawler Craton, South Australia (Figure 1). Access is from the Glendambo to Barton unsealed road then either north on turn offs west of Tarcoola, towards Mulgathing Homestead, or further west at Wynbring Rocks. Alternatively, access can be obtained via the Stuart Highway ~100 km north of Glendambo then along the westerly trending unsealed road through Commonwealth Hill Homestead, then via several station and exploration tracks. This region currently has an arid climate with an average annual rainfall of about 150 mm, with hot dry summers and cool wet winters.

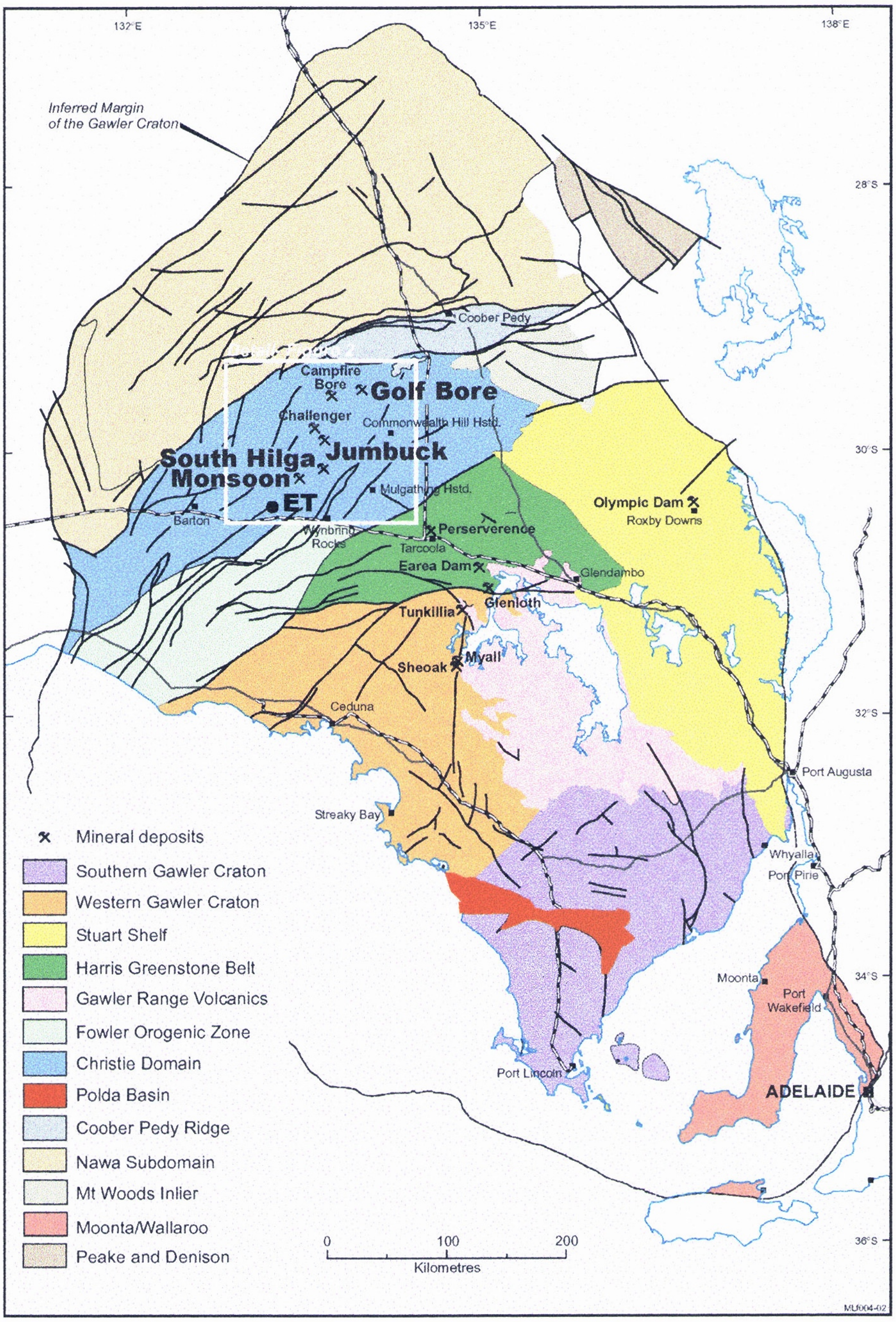


Figure 1: Regional location of the prospects studied. (Modification of written communication from M. Schwarz, PIRSA, 2001).

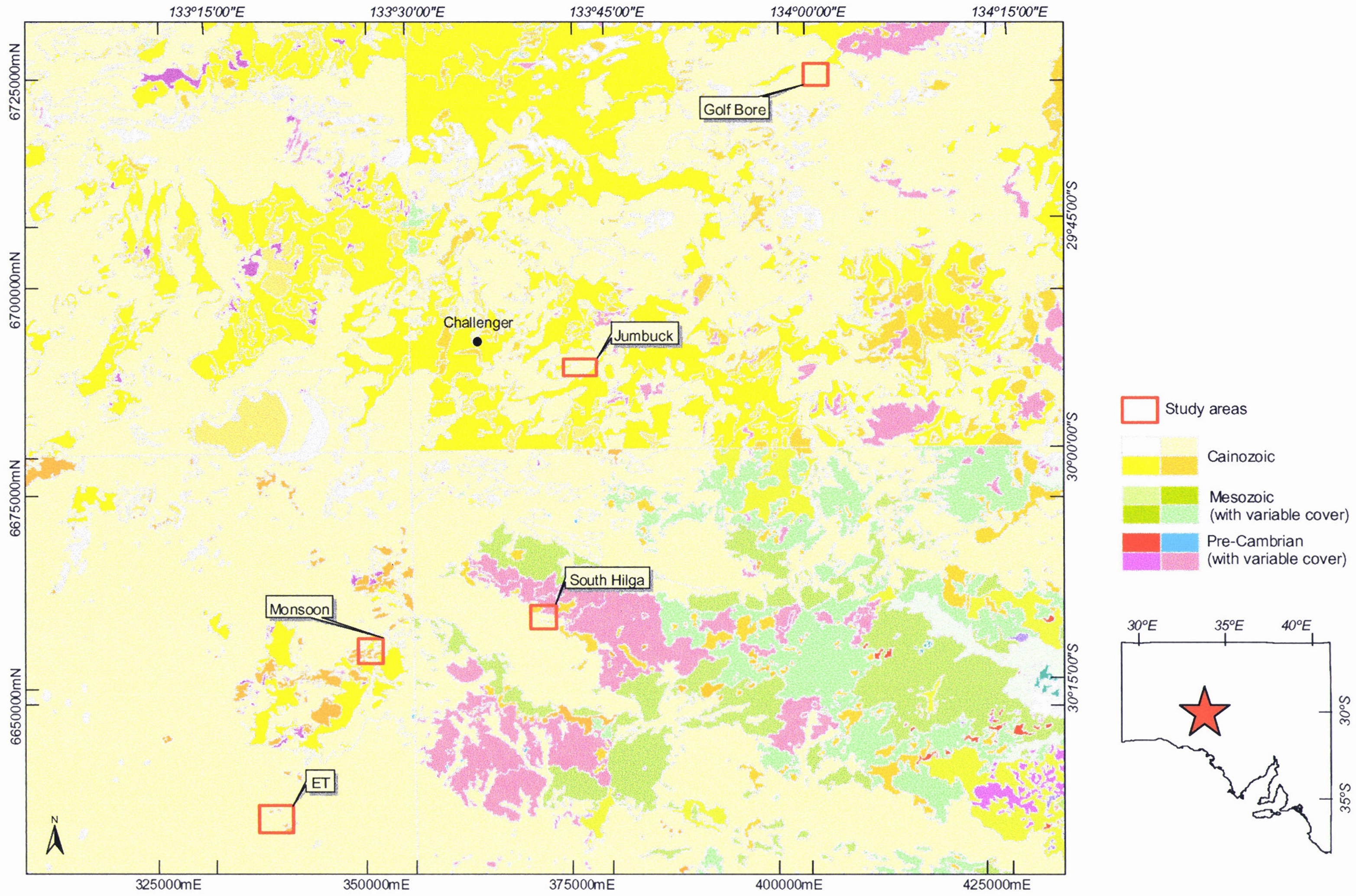


Figure 2: Detail of location of prospects. For explanation of geological units refer to 1:250000 map sheets or Northern and Western Gawler Craton GIS available from PIRSA.

2 METHODS

2.1 Regolith descriptions

All regolith cross-sections presented below were compiled from field-logged RAB and RC drill samples augmented by laboratory logging, microscopic mineral identification and grain characterisation as necessary. For each site, two cross-sections were prepared: an upper one detailing the regolith components to 15 m, and a lower one displaying lithologies to full drill penetration. Descriptive regolith terminology follows that set out in the following sources: *Atlas of Weathered Rocks* (Robertson and Butt, 1997) and *The Regolith Glossary* (Eggleton, 2001).

2.2 Sample collection

Samples were collected at each site of RC and RAB drill cuttings. Some of the drill spoil was up to 5 years old and the original physical condition and composition may have been altered during this time. The drill spoil piles were in variable condition with evidence of mechanical dispersion due to minor stream flow.

Sampling was undertaken at approximately 50-100 m intervals depending on drillhole location. One metre intervals were sampled between 0-10 m depth followed by every other metre to 20 m, then sundry samples from deeper in the profile. This was performed at each site for a total collection of 1,024 samples.

2.3 Down hole sample contamination

Down hole sample contamination was found to occur at all five investigation sites and was most significant in the RAB samples. In many cases, this contamination was visually obvious, *i.e.* near surface-derived calcrete nodules, silcrete fragments and gypsum crystals abundant in sample piles as deep as 30 m below their source (Figure 3).

Figure 3: Photograph showing down hole silcrete contamination (arrowed) of RAB drill spoil piles. The true silcrete location occurs just below the red coloured-sand (about 6 m depth).

There were also less obvious contaminants at similar depths including well-rounded quartz pebbles (5-50 mm diameter) within quartz-rich and pallid clay-rich materials. These pebbles were initially thought to indicate thick transported materials but later laboratory microscopic examination revealed otherwise. Although these rounded clasts appeared to have been derived from the kaolinite-rich saprolite, they had relict ferruginous coatings and cavity and/or fracture infill more consistent with the pebbles derived from either i) the surface colluvium, ii) a gravel layer overlying the red-brown hardpan, iii) the upper part of the silcrete zone, or iv) all of these. At the Jumbuck site, this style of contamination was most problematic, particularly at the eastern end of the regolith line. To resolve this, bulk samples were washed to remove fines (clay, silt) and then examined microscopically for *in situ* material indicators (relict minerals with angular or delicate shapes such as graphite or multi-grained lithic fragments, vein quartz fragments or minerals not likely to have been transported by fluvial or aeolian processes). Once logging was completed, PIMA was used to help determine the *in situ* - transported boundary. A red line marks this KCI boundary (Figure 5 to Figure 25). Allowing for down hole contamination, sampling intervals and ambiguity where the kaolinite content was too low for accurate determination (in silcrete and some pedolith), the visually logged and the KCI boundary are generally in good agreement.

The broad-scale use of PIMA with KCIs in the field is recommended in order to determine sample provenance, control sampling and assist interpretation of results.

2.4 Sample preparation and analyses

Soil, calcrete and one metre RAB and RC samples were pre-prepared in the laboratory by weighing, mixing the sample on a plastic sheet, then incrementally extracting approximately 200 g of material (or about 50%, whichever was the smaller) to be sent to the commercial laboratory. Samples were tested for their carbonate content with dilute acid (1M HCl).

Well-characterised standards were entered into the analytical stream at approximately 1 per 30 samples to check for analytical precision and accuracy. All samples and standards were analysed by AMDEL Laboratories Ltd as follows (detection limits in ppm):

(i) approximately 0.25 g of sample was analysed by ICP-OES after mixed acid digest ($HF+HCl+HNO_3$) for Ba (10), Ca (10), Cr (2), Fe (100), K (10), Mg (10), Mn (5), Na (10), Ni (2), P (5), S (500), Ti (10), V (2), and Zn (2);

(ii) approximately 0.25 g of sample was analysed by ICP-MS after mixed acid digest ($HF+HCl+HNO_3$) for Ag (0.1), As (0.5), Bi (0.1), Cd (0.1), Cs (0.1), Ce (0.2), Cu (0.5), Ga (0.1), In (0.05), Mo (0.1), Nb (0.5), Pb (0.5), Rb (0.1), Sb (0.5), Se (0.5), Sr (0.1), Te (0.2), Th (0.02), Tl (0.1), U (0.02), W (0.1), Y (0.05), Zn (0.5) and the REEs Ce (0.05), La (0.05), Dy (0.02), Er (0.05), Eu (0.02), Gd (0.05), Ho (0.02), Lu (0.02), Nd (0.02), Pr (0.05), Sm (0.02), Tb (0.02), Tm (0.05) and Yb (0.05);

(iii) 25 g of sample was analysed by graphite furnace AAS after aqua regia digest for Au (0.001) or by cyanide digest followed by ICP-MS for Au (0.00005), Ag (0.0005) and Cu (0.1).

The geochemical results for the 51 elements analysed are shown graphically in Appendix 1, and tabulated on the CD, except for ET Prospect; ET geochemistry graphics are in the detailed site-specific report (Lintern et al, 2001). Element distributions of Au and selected pathfinders are discussed below for each prospect.

Short Wave Infra Red (SWIR) spectral analyses of selected RAB/RC cuttings were performed using an Integrated Spectronics PIMA II spectrometer. PIMA Acquisition Software (version 1.1B) using Petri Dish Calibration mode was used to acquire the data. The PIMA was calibrated every hour, unless prompted earlier by the software. Each sample was loaded in a petri dish and placed on the PIMA scanning window and scanned with the default integration setting of 1. An integration setting

Ltd.) by comparison with the reference library of spectra within the software package, and by comparisons with a limited number of samples that had XRD data.

3 ET PROSPECT

3.1 Introduction

The ET Prospect is located about 150 km west of Tarcoola and outside the designated pastoral lease areas (Figure 2). The surface geochemical anomaly (Figure 4) is in undulating terrain (<35 m relief) of Archaean basement outcrop and subcrop, partially overlain by westerly trending Pleistocene linear sand dunes. All basement outcrop is deeply weathered and generally has a 1-2 m silcrete duricrust cap. Orange sand dunes form an easterly fringe to the vast Great Victoria Desert. They partly mantle the basement palaeotopography by infilling many depressions with quartz sand (<15 m thick) where vegetative cover is substantially denser and taller. The vegetation at ET is a complex mosaic of different plant communities. Sand spreads and dunes support woodlands, open woodlands and mallee over shrublands, dominated by large trees and woody shrubs (*Acacia*, *Eucalyptus*, *Cratystylis*, *Scleroleana*, *Casuarina* and *Senna*). Areas with thin cover support woodlands and open woodlands over open shrublands of woody shrubs and trees (*Casuarina*, *Senna*, *Eremophila*). This vegetation impedes vehicle access and exploration but has stabilised the dunes.

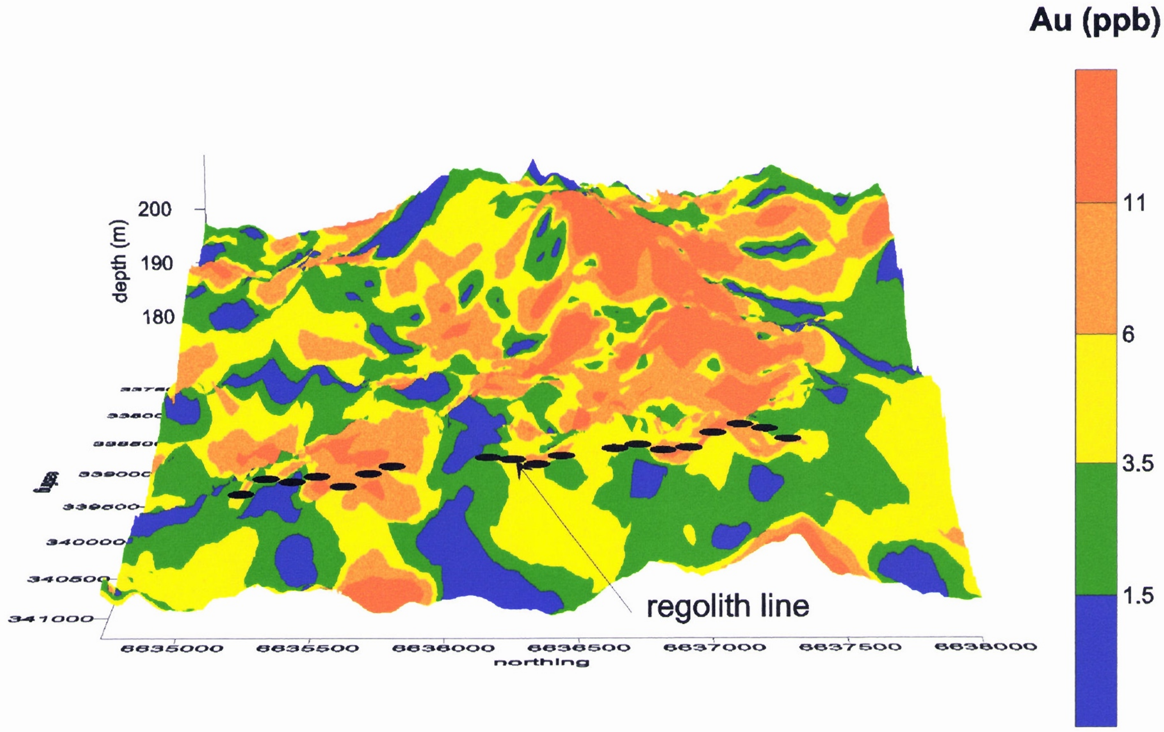


Figure 4: Detail of ET Prospect showing Au-in-calcrete anomaly and regolith line drillholes overlaid on DEM. Viewed from east. Original data supplied by the Gawler Joint Venture.

3.2 Regolith Stratigraphy

3.2.1 Overview

The north-south oriented section (Figure 5 and Figure 6) on 340200E, reveals a broad lens of transported material, up to 11 m thick, overlying deeply weathered Archaean basement. The boundary between these distinct regolith components lies within the silcrete. Localised silcrete outcrops indicate both saprolite and sediment substrates. PIMA kaolinite crystallinity index (KCI) confirms that the *in situ*-transported boundary (red line on section) occurs within the silcrete or just below it, except where the boundary is in the unsilicified *in situ* pedolith zone, due to low residual kaolinite contents.

below it, except where the boundary is in the unsilicified *in situ* pedolith zone, due to low residual kaolinite contents.

The basement is extensively weathered to 30 to 70 m and weathering can extend well below the drilling limit. Fresh basement was not encountered. The grey to brown saprock, in which weathering has altered some feldspars and micas, is thicker where more fine-grained lithotypes occur. A complex saprolite overlies the saprock. It is variably coloured, has some ferruginous mottles (reddish or yellow) and shows distinct weathered mineral phases. RAB cuttings are of insufficient quality to construct a detailed representation of this complex zone. The pedolith varies in thickness from <1 m to about 3 m; it is difficult to recognise from cuttings. Parts have micro-mottles of Fe and Mn staining, and all primary rock fabrics have been obliterated by pedogenesis. The top of the pedolith is intensely silicified to a silcrete horizon. Deeper partial silicification has yielded porcellanite and indurated pedolith. Aeolian sand and colluvium-alluvium make up the overlying transported materials. Neither is cemented, apart from the contained calcrete horizons.

3.2.2 Basement (in situ)

The Christie Gneiss, an Archaean metasediment, forms the crystalline gneissic to granulitic basement at ET Prospect. This complex foliated crystalline rock has undergone multiple deformation, intrusion and hydrothermal mineral deposition (Daly and Fanning, 1993; Benbow *et al.*, 1995; Rankin *et al.*, 1996). Much of the saprock to lower saprolite is variably chloritic, indicating an intermediate to mafic composition. However, more mafic versions were intersected in holes ETAR186-188. Coarse-grained varieties were not encountered in this section, but occur elsewhere. In contrast, the thicker pallid saprolite at the northern and southern ends of the section suggests a more felsic form of the Christie Gneiss occurs there. Quartz veins occur throughout the basement and vary from white, grey blue or dark blue and some are zoned.

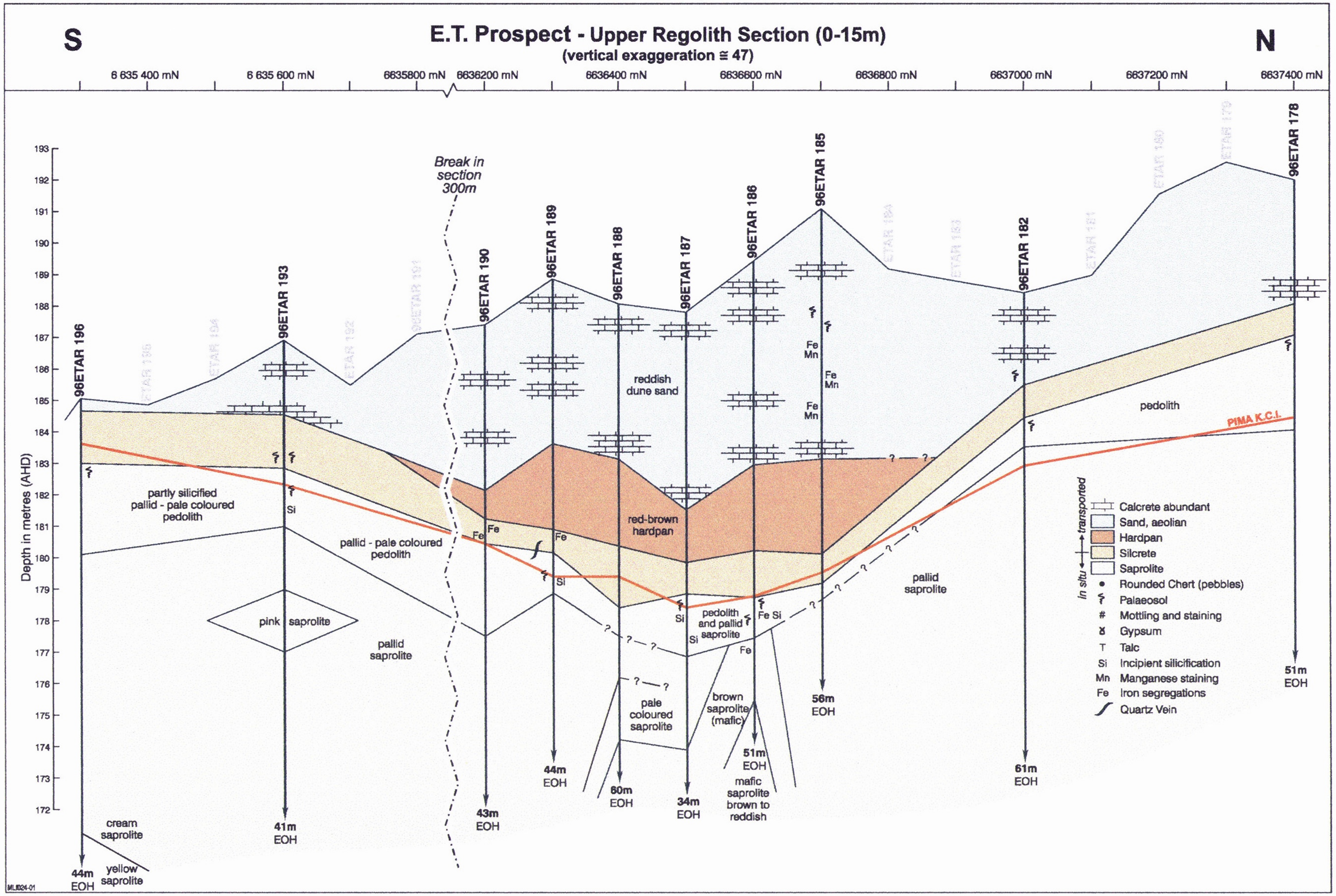


Figure 5: Typical upper regolith section at ET Prospect.

3.2.3 Silcrete (in situ and transported)

Silcrete is thickest at the southern end of the section (approximately 1.5 m) and thinnest (<1 m) below the sediment-infilled channel, where erosion may have stripped some of silcrete away. This probably represents an overprinting by at least two Tertiary silicification cycles (Lintern and Sheard, 1998; 1999a, b). Within it are two separate components, the lower part being silicified pedolith, containing angular quartz and relict quartz veins, and the upper part being silicified colluvium, containing subangular to rounded quartz-rich gravel and an alluvium of well-rounded quartz gravel and pebbles. The silcrete is pale grey to cream or yellow and is stained yellow to red along fractures. It is pedogenic and contains partitioned wisps of anatase and relict minerals such as graphite within the silicified pedolith.

3.2.4 Hardpan (transported)

Hardpan is a convenient field term to describe a distinct red-brown to brown, clay-rich colluvium or alluvium that may display evidence of slight silification. At ET, this unit is 0-2 m thick, underlies dune sand and overlies silcrete. Hardpan contains dark brown to black Fe and Mn sesquioxide and hydroxide cements and/or segregations; the clay may also be partly silicified and is generally noticeably silty. In places, this clay-rich material is partially coated near its top by earthy carbonate. Its strong colour and clay-rich texture make this unit distinct and irregular upper surface indicates it has been partly incised by later fluvial activity (c.f. holes ETAR190 and 187).

3.2.5 Dune sand

Aeolian dune sand blankets a large portion of this prospect and forms a significant dune field. South west of here, these sands have been dated as early last quarter of the Quaternary (Huntley *et al.*, 1999). Colours range from orange to red due to thin ferruginous coatings on the quartz sand grains. These sands are uniformly sorted and textured with some illuviated silt-clay components forming denser dune cores. Along the investigated section these sands range from <1 m to 8 m thick. They host nodules and earthy or low-density forms of calcrete, in more than one horizon. The sand is generally loose, free running, unless cemented by calcrete or clays but is mostly stabilised from erosion by deep-rooted vegetation. Palaeosols occur in holes ETAR185 and 182, seen as colour changes and possible pedogenic mottling.

3.2.6 Calcrete

Calcrete occurs in the upper regolith, within dune sand, exposed silcrete and in soil. In the sands, there is generally more than one calcrete horizon, especially at the centre of the section. Calcretes include nodules within dunes, and earthy powders or coatings in the upper portions of hardpan and laminated coatings and joint infill in silcrete. Most indurated calcretes are pale pink to pale orange.

3.2.7 Soils

Soils range from uniform sandy (Uc) to poorly structured lithosols around silcrete outcrop. They are weakly stratified with little organic component. All are strongly alkaline and the fines-rich types near outcrop or within dune cores are probably sodic (AS2; Northcote and Skene, 1972; Northcote, 1979).

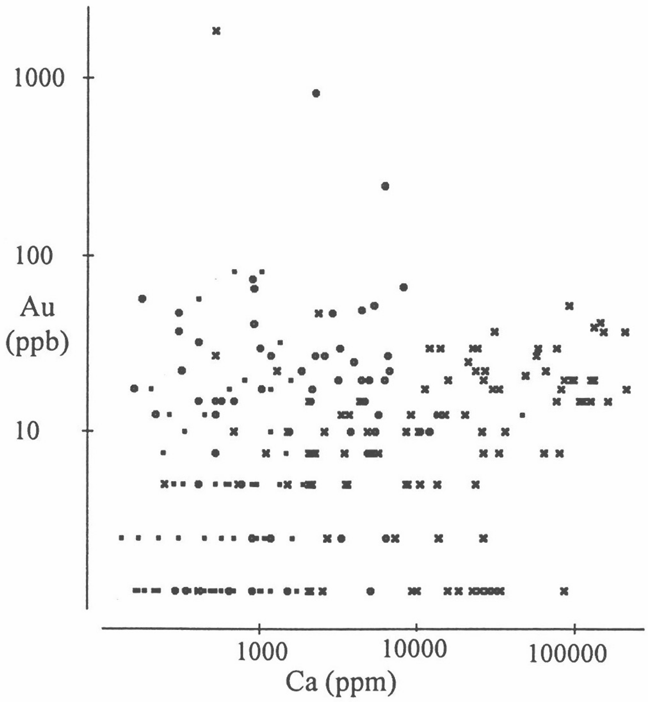
3.3 Geochemistry

Calcrete is common in the dune sand and penetrates the siliceous saprolite where the dune sand is absent or thin. Variable Mg contents suggest that some of the carbonate is dolomitic.

The major minerals identified in drill cutting samples by PIMA are kaolinite and smectite. Small amounts of poorly crystalline kaolinite and smectites occur in the dune sand with a sharp boundary to well crystalline kaolinite of the *in situ* regolith. Kaolinite in the siliceous material beneath the dune sand and hardpan is mainly poorly crystalline, suggesting a large transported component.

Element distributions at ET are primarily governed by regolith type. In particular, element abundances in the dune sand are generally lower than for other regolith materials, except for Ca, Sr and, to a lesser extent, Au (Figure 7a), Mn, Ni, Co and the alkalis. Element abundances in dune sand are correlated with one another and narrow in their concentration ranges due to mixing e.g. Fe and Ga (Figure 7b). Concentrations of pathfinder elements, commonly associated with Au, are generally low (Table 1).

a)



b)

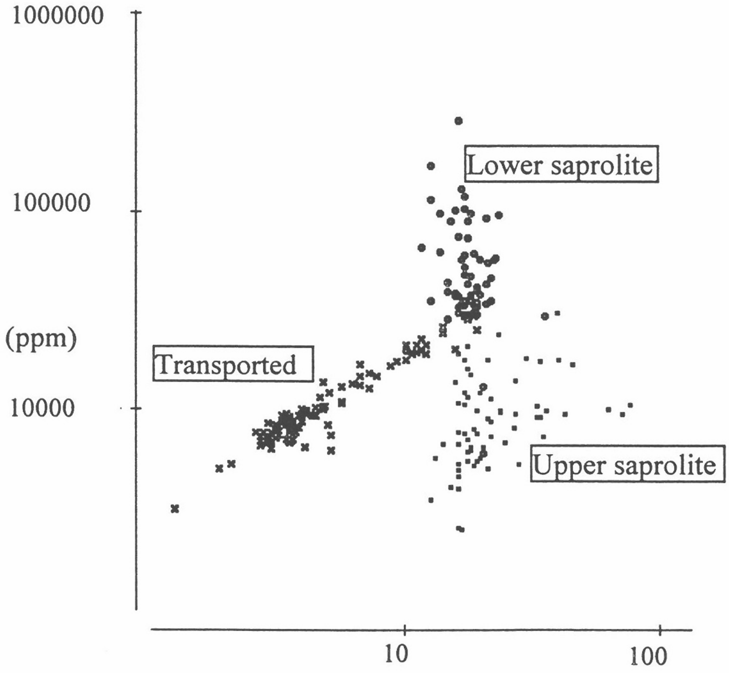


Figure 7: Scatter plots (logarithmic axes) for selected elements. Large cross, small cross and circle symbols represent predominantly transported, upper saprolite and lower saprolite, respectively: a) Ca v. Au; b) Fe v. Ga.

Gold concentrations in the dune sand are surprisingly high (maximum 21 ppb) considering that the dunes are only a few hundreds of thousands of years old at most (Figure 8). One Au concentration (ETAR189, 33 ppb) occurs close to the interface between the *in situ* and transported regolith units and may be attributable to detrital Au in silicified alluvium at the base of the palaeochannel. Another very high Au concentration of 755 ppb Au was subsequently re-analysed at 0.1 ppb and was also located at the interface and is also suggestive of detrital Au. Higher Au concentrations in the dune sand appear to be not necessarily restricted to the calcrete but can also be relatively high in the carbonate-poor surrounding material; however, this interpretation may be incorrect due to down-hole contamination. Gold concentrations in the dune sand do not necessarily reflect higher Au concentrations in the upper saprolite or mineralisation in the lower saprolite.

Table 1: Highest Au concentrations and other anomalous intervals in drillholes.

Drillhole	Interval (m)	Analyses (ppm unless stated)	Regolith type
96ETAR185	47-48	Au 390 ppb	saprolite
96ETAR187	33-34	Au 101 ppb	saprolite
96ETAR196	17-18	Au <1 ppb Cu 320	saprolite
96ETAR188	42-43	Au 30 ppb Ni 1400	saprolite

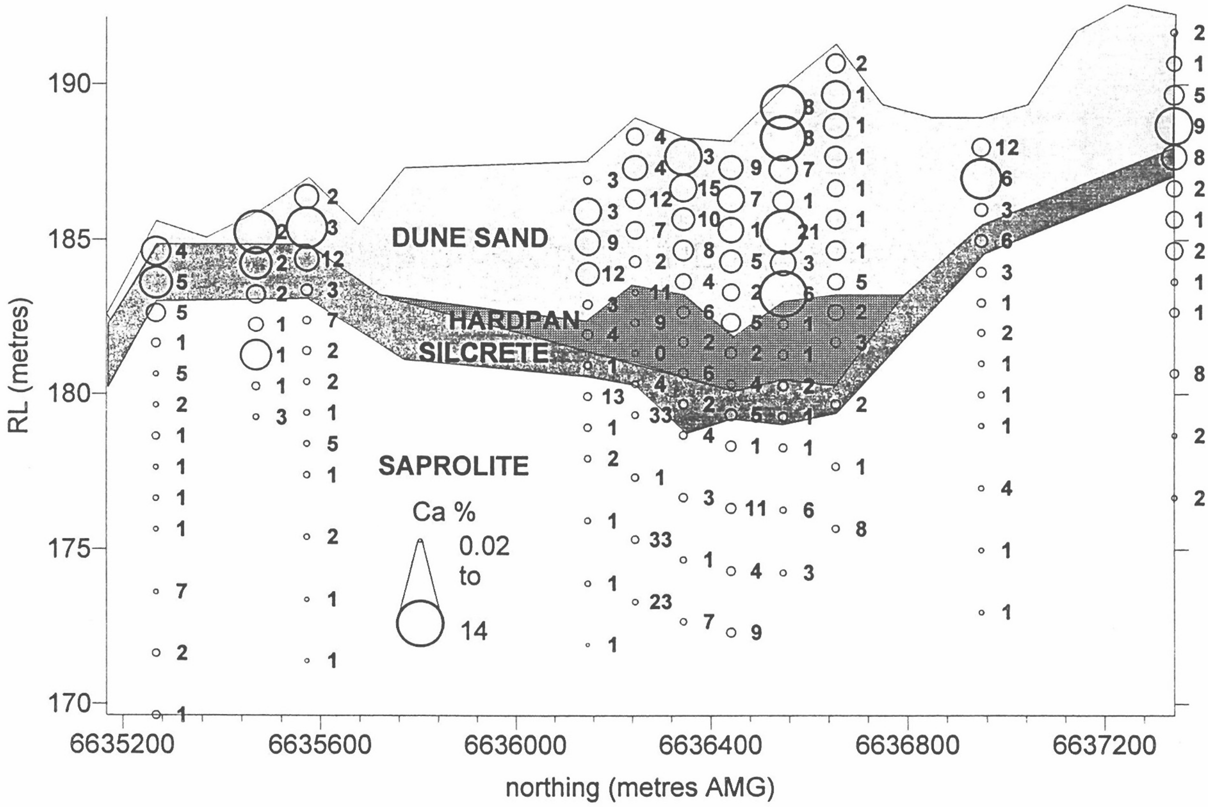


Figure 8: Distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith section at ET. Calcium is present principally as calcrete.

4 MONSOON PROSPECT

4.1 Introduction

The Monsoon Prospect and its associated geochemical anomaly lie on flat to undulating terrain about 150km WNW of Tarcoola (Figure 2, Figure 9). Here, Archaean basement outcrops and subcrops and is partly overlapped by Cainozoic alluvial sediments with silcrete and calcrete. All basement outcrop is deeply weathered and generally has a 1-2 m thick silcrete capping. Low points of the palaeotopography have been filled with Quaternary alluvial deposits and the modern drainage lines follow this palaeodrainage. The geochemical anomaly supports sparse *Acacia* woodland and numerous woody shrubs (*Eremophila*, *Senna* and bluebush *Maireana*) but the vegetation is more substantial just north of the geochemical anomaly.

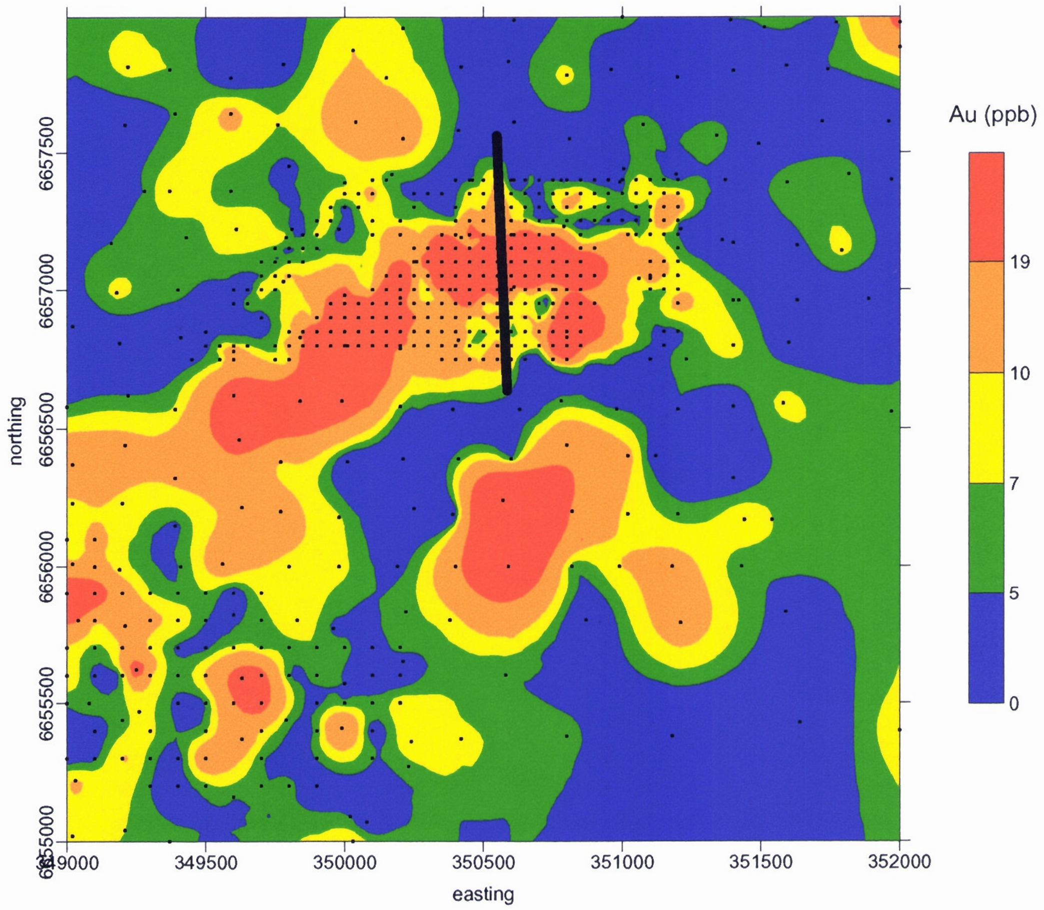


Figure 9: Detail of Monsoon Prospect showing Au-in-calcrete anomaly. Black dots are sample points; black line is regolith line. No detailed DEM available for the area. Original data supplied by the Gawler Joint Venture.

4.2 Regolith stratigraphy

4.2.1 Overview

The north end of (Figure 10 and Figure 11) 350500E reveals a broad wedge of transported material up to 8 m thick, overlying deeply weathered Archaean basement. The boundary between these major regolith components lies within the silcrete. At the southern end, localised silcrete outcrops indicate saprolite and sediment substrates. PIMA kaolinite crystallinity index (KCI) confirms that the *in situ*-transported boundary (red line on section) occurs mostly within the silcrete horizon except at hole MNAR049 where low residual kaolinite contents puts this KCI change into the unsilicified *in situ* pedolith zone.

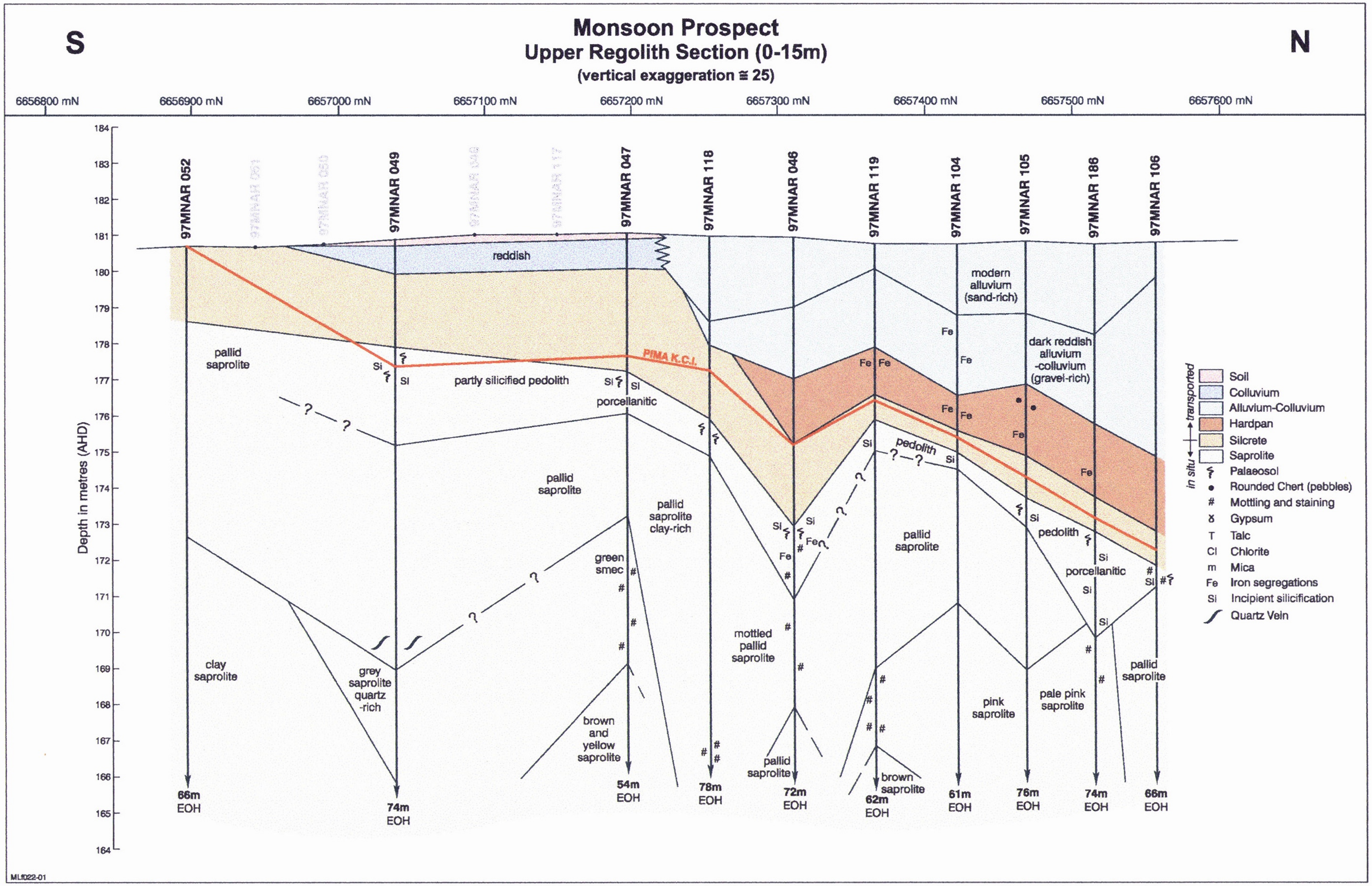


Figure 10: Typical upper regolith section at Monsoon Prospect.

The basement is extensively weathered to 50 to >70 m. Unweathered basement was rarely encountered. The grey saprock has some altered feldspars and micas, and is thicker on fine-grained rocks (holes MNAR047-119). A complex saprolite overlies the saprock. It is variably coloured, has some ferruginous mottles (red or yellow) and distinct weathered mineral phases. RAB cuttings are of insufficient quality to construct a detailed log of this complex zone. The pedolith varies in thickness from <1 m to >2 m and is not difficult to recognise from cuttings and include micro-mottles and Fe-Mn staining; all rock fabrics have been obliterated by pedogenesis. Further along section 350500E, the upper pedolith is intensely silicified, forming silcrete; deeper, partial silicification has yielded porcellanite and indurated pedolith. Colluvium and alluvium overlie the pedolith and are essentially un-cemented apart from their contained calcrete horizons.

4.2.2 Basement (in situ)
Christie Gneiss forms the crystalline gneissic to granulitic basement at Monsoon Prospect. Much of the saprock to lower saprolite is chloritic, indicating the basement is more Fe-, Mg- and Mn-rich. Medium- to coarse-grained lithologies were not encountered but the thicker pallid saprolite at the southern end of the section suggests more felsic forms of the Christie Gneiss occurs there. Quartz veins occur randomly throughout the basement and range from white, grey to blue and some are zoned.

4.2.3 Silcrete (in situ and transported)
Silcrete is thickest (2 m) at the southern end of the section and thinnest (<1 m) below the sediment-filled channel where it may have been partly eroded. There are two separate components, a lower part being silicified pedolith, containing angular quartz grit and relict quartz veins, and an upper part being silicified colluvium, containing subangular to subrounded quartz-rich gravel and an alluvium of well-rounded quartz gravel and pebbles. The silcrete is pale grey, cream or yellowish. It is pedogenic and contains partitioned wisps of titania minerals, some ferruginous staining, and relict minerals such as graphite in the silicified pedolith.

4.2.4 Hardpan (transported)
At Monsoon, the hardpan is 0-2 m thick, underlies the sand-rich modern creek alluvium and overlies the silcrete zone. It contains dark brown to black Mn-Fe sesquioxide and hydroxide cement and/or segregations; the clay may also be partly silicified. In places, this clay-rich material is carbonate coated or fracture-impregnated. A strong colour and clay-rich texture makes this unit easily identifiable from all the others. An irregular upper surface to the hardpan may indicate it has been partly incised by later fluvial activity.

4.2.5 Dark reddish alluvium-colluvium
Restricted to the main sediment wedge, this material fills the lower portion of a distinct channel and consists of loose rounded to subrounded quartz and lithic clasts; it ranges from fine sand to cobble range but is dominantly a gravel-rich unit with a distinct brown colour, ferruginous staining and calcrete coatings on clasts and/or cementation within discrete bands. The variable degree of clast rounding suggests transport ranging from local to perhaps several kilometres. There is some evidence from the drill cuttings that this unit may contain thin layers of reddish silty clay as lenses or localised low-flow regime stringers. An irregular upper boundary to this sediment indicates later incision by the coincidental modern creek.

4.2.6 Modern alluvium
Also restricted to the main sediment wedge, this material fills the upper portion of a distinct channel and consists of loose rounded to subrounded quartz and lithic clasts, in the fine sand to cobble size range; it is though predominantly sand-rich. This sediment is much paler in colour than the underlying alluvial unit and contains calcrete as clast cementation within part of its overall thickness. The degree of clast rounding suggests a combination of locally derived, short transport history while others are more distally sourced. Much of this material can be assigned to modern creek activity.

4.2.7 *Colluvium*

Between drillholes MNAR118 and 052 is a subsoil colluvium (<1 m thick) overlying the silcrete zone. This is basically a weathering-erosional lag unit where materials derived from the underlying silcrete, locally exposed saprolith and any aeolian and slope wash alluvium have accumulated. Most clasts are angular to subrounded, range from blocks to fine gravel and ratio to the fines component at >2:1. Calcrete has impregnated and stabilised this unit, thus minimising erosion.

4.2.8 *Calcrete*

Calcrete occurs across the upper regolith within the soil profile and colluvium. It coats the silcrete and penetrates several metres into the alluvium wedge. Forms include nodules, earthy powders, coatings, irregular sheets and thick horizons within very porous media. Most indurated calcretes are mildly coloured pale pink to pale orange, but are usually near white where earthy or as infill to silcrete joints.

4.2.9 *Soils*

Soils range from uniform sandy (Uc) to gradational calcareous (Gc) to poorly structured stony lithosols. They have weakly developed horizons and little organic component. All are strongly alkaline and are probably sodic (AS2) where clayey to silty (Northcote and Skene, 1972; Northcote, 1979).

4.3 Geochemistry

Calcrete occurs across the regolith and penetrates several metres into the colluvium-alluvium; low Mg concentrations suggests that calcite is the dominate carbonate mineral present.

The major minerals identified by PIMA spectrometry are kaolinite and smectite, with intermediate (Fe-Mg) chlorite and muscovite recorded in a few samples from the lower regolith. Poorly crystalline kaolinite and smectite characterise the alluvium, colluvium and hardpan. There is a sharp boundary to well crystalline kaolinite in the *in situ* regolith. The silcrete contains well crystalline kaolinite which suggests that it has developed in saprolite.

Iron correlates with Cu, As, Co and Ni but, unlike Golf Bore, not Mg, and not as strongly as at Jumbuck and Golf Bore. Some samples relatively rich in S (up to 2.1%) and Fe are also relatively rich in Cd, Zn and Au suggesting some association with sulphide mineralisation (Figure 13). The co-presence of S and Fe potentially provides a larger drilling target. Gold mineralisation is also associated with elevated Cu, As, Tl and Ni (Table 2).

For the upper regolith, the highest Au concentrations (10-30 ppb) occur in the western part of the section and are associated with Ca in the siliceous upper saprolite and thin colluvial units. Anomalous but lower Au concentrations (10-20 ppb) continue into calcareous facies of the adjacent alluvium. Gold is only weakly anomalous above mineralisation in the siliceous units below the alluvium in the eastern part of the section. The dominant factor in the distribution of Au appears to be lateral dispersion related to known sub-cropping mineralisation occurring to the west, and the presence of calcrete (Ca) with which it is strongly associated (Figure 13). There is no evidence of vertical migration of Au to the surface from mineralisation located beneath 5 m of transported overburden (and ~30 m of leached saprolite) in the north of the section.

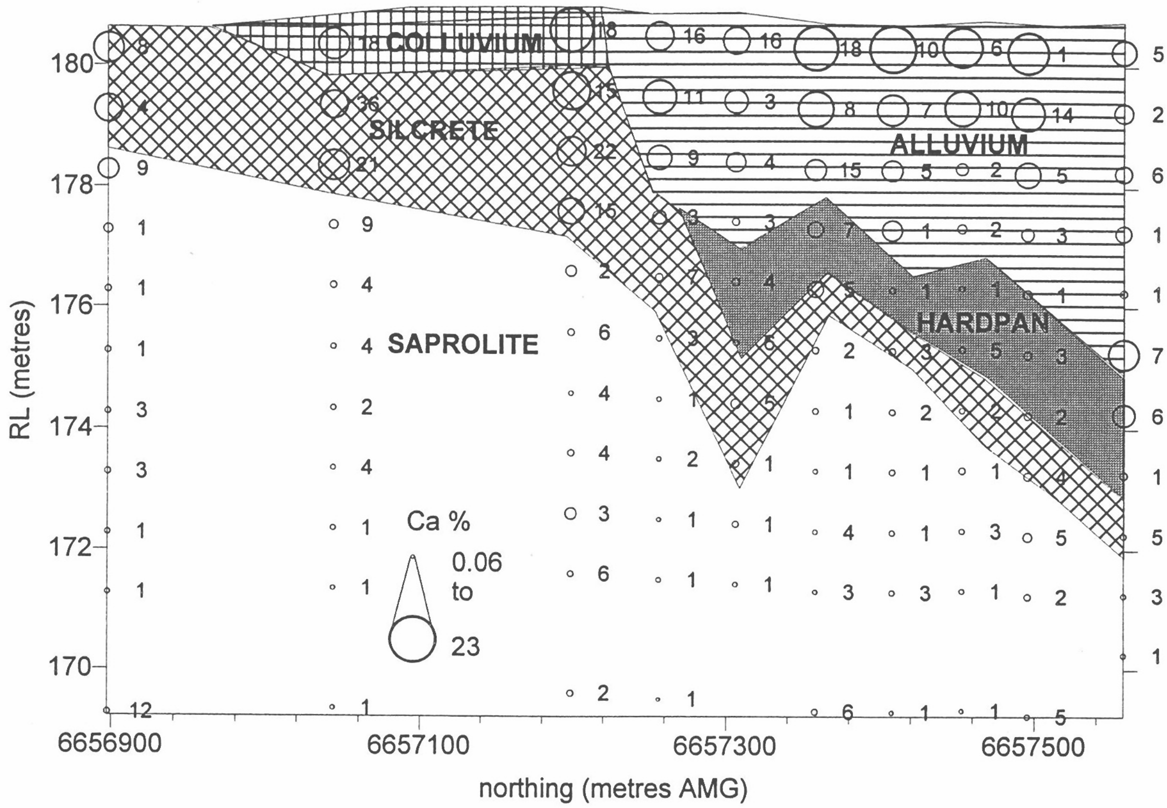
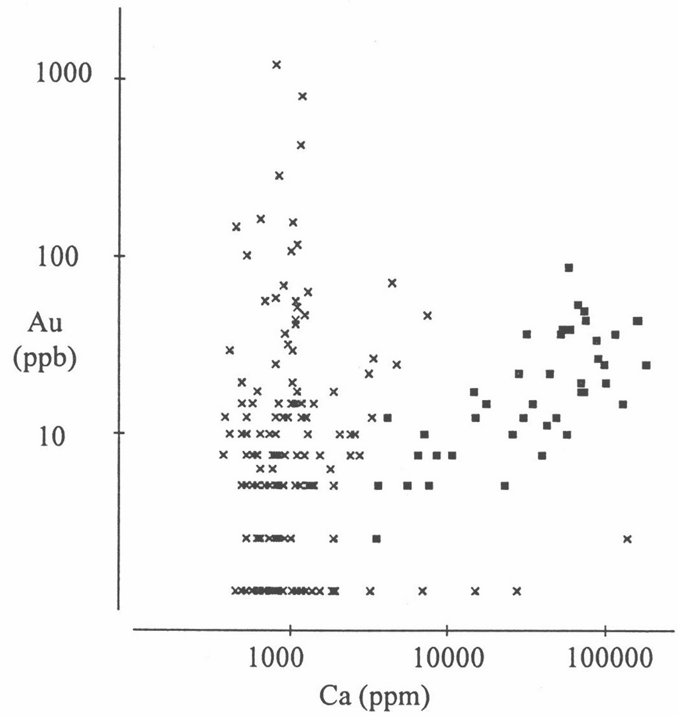


Figure 12: Distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith section at Monsoon. Calcium is present principally as calcrete.

Table 2: Highest Au concentrations and other anomalous intervals in drillholes.

Drillhole	Interval (m)	Analyses (ppm unless stated)	Regolith type
97MNAR105	43-44	Au 495 ppb	saprolite
97MNAR104	44-45	Au 170 ppb	saprolite
97MNAR105	45-46	Au 320 ppb, Cu 550, Ag 2	saprolite
97MNAR105	55-56	Au 115 ppb, As 450, Zn 950, Ni 1050, Tl 15	saprock
97MNAR105	19-20	Au 2 ppb Se 20	saprolite
97MNAR119	31-32	Au 23 ppb Se 13, Cu 500	saprolite
97MNAR49	24-25	Au 4 ppb As 550	saprolite
97MNAR47	29-30	Au 65 ppb Ni 1350	saprolite

a)



b)

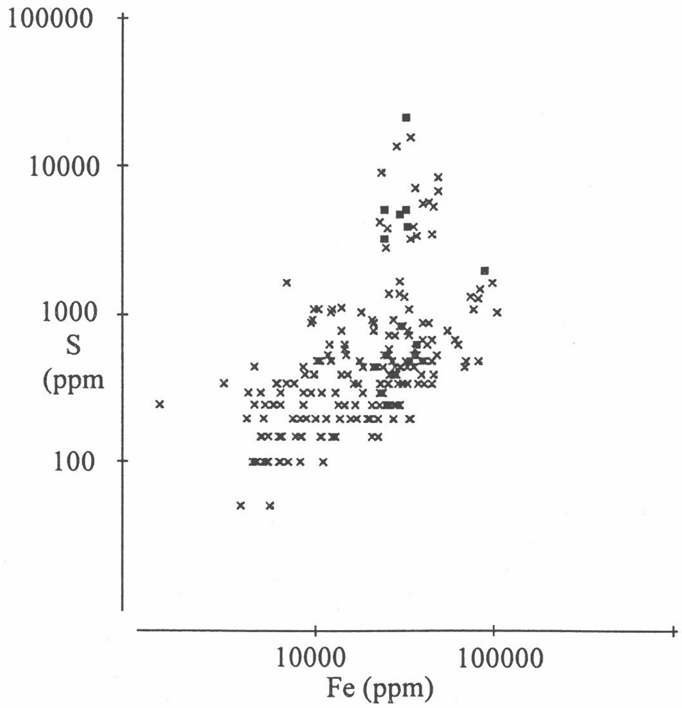


Figure 13: Scatter plots for selected elements at Monsoon:

- **a) Ca v. Au; large box symbols indicate highly calcareous surficial samples showing strong association between Ca and Au;**
- **b) Fe v. S; large box symbols in top right of plot indicate samples with high Au contents.**

5 SOUTH HILGA PROSPECT

5.1 Introduction

Located on almost flat terrain (<2 m of relief) to the southeast of rising ground, the South Hilga Prospect is located about 130 km WNW of Tarcoola (Figure 2). The geochemically anomalous area (Figure 14) consists of Archaean basement, beneath Cainozoic alluvial deposits and exposed calcrete. The basement is deeply weathered and generally has a 1-1.5 m thick silcrete duricrust capping. Most of the palaeotopography has been completely infilled with Cainozoic alluvial deposits, yielding the near flat surface that supports *Acacia* woodland with numerous shrubs (*Eremophila*, *Senna*, *Sclerolaena* and bluebush *Maireana*).

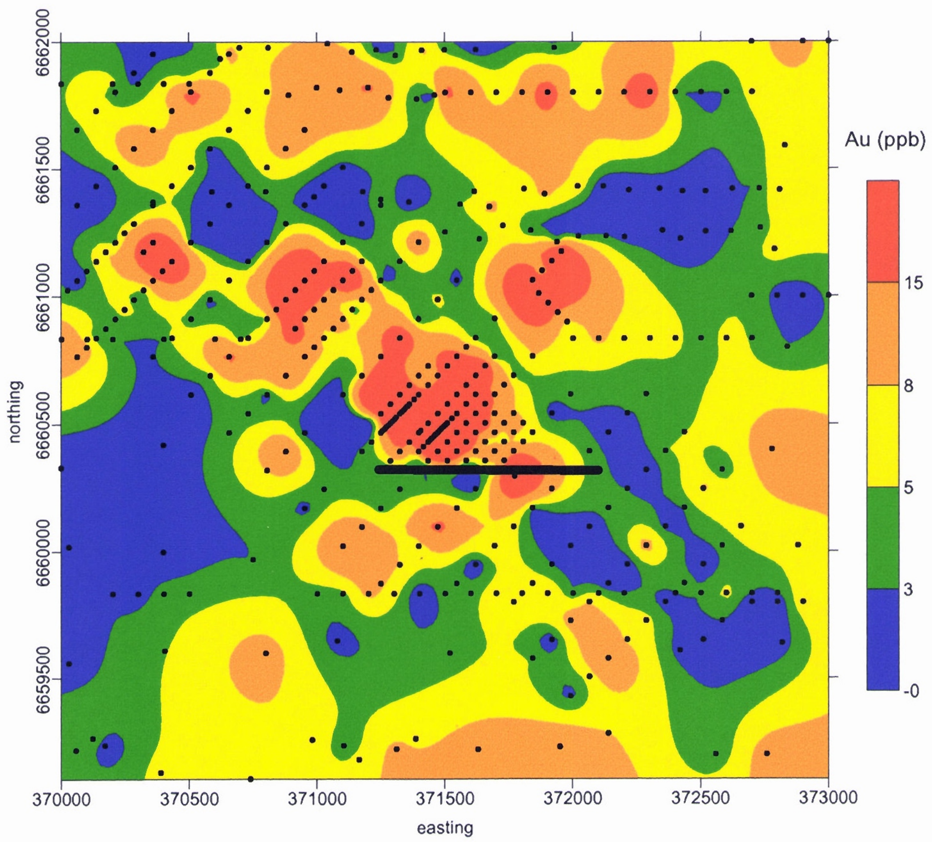


Figure 14: Detail of South Hilga Prospect showing Au-in-calcrete anomaly. Black dots are sample points; black line is regolith line. No detailed DEM available for the area. Original data supplied by the Gawler Joint Venture.

5.2 Regolith stratigraphy

5.2.1 Overview

A west-east oriented section (Figure 15 and Figure 16) along 6660300N was selected for study. Generally, the area is covered by 2-4 m of transported material overlying deeply weathered Archaean basement. The boundary between these major regolith components lies within the silcrete. Field inspections of localised silcrete outcrop indicated saprolite and sediment substrates. PIMA kaolinite crystallinity index (KCI) analysis has confirmed the *in situ*-transported boundary (red line on section) to occur mostly within or just below the silcrete.

Basement lithotypes are extensively weathered to depths of >76 m and extend well below the drilling limit. Fresh basement was not encountered. The lower saprolite, where weathering is less apparent, occurs along the western half of the section between holes SHAR102-154. A complex saprolite zone overlies this and is variably coloured near the more mafic zones or is otherwise pallid, and ferruginous mottling is of limited extent (reddish or yellow). RAB cuttings are insufficient to construct a detailed representation of this complex zone, which has many secondary, coloured segregations (mottles and stains). The pedolith varies in thickness from <0.5 m to >1.5 m and is difficult to recognise. Micro-mottles, Fe and Mn staining are partly preserved but all primary rock textures are obliterated. Along this section, the top of the pedolith is intensely silicified, forming silcrete; deeper partial silicification has yielded a variably indurated pedolith. Colluvium and alluvium make up the overlying transported materials. Those above the silcrete are essentially un-cemented, apart from the calcrete horizons within the soil-subsoil. Mid-section are two more deeply incised channels (>5 m deep) containing alluvium. Both incisions coincide with two mafic basement zones that may have been preferentially eroded.

5.2.2 Basement (in situ)
Christie Gneiss forms the crystalline gneissic to granulitic basement at South Hilga Prospect. Relict lithic fragments from hole SHAR152 indicate the basement to be a garnet-bearing quartz-feldspar-mica gneiss. Quartz veins are rare along this section and only observed in cuttings from hole SHAR145, where colours range from pale to medium greys. Much of the more regional saprolite is pallid and appears to be derived from a felsic protolith but between holes SHAR079 and 145, a strongly mafic variant occurs as two distinct zones or bands, steeply dipping to the east. Here the saprolite is strongly coloured in yellow to brown and at depth is intensely chloritic.

5.2.3 Silcrete (in situ and transported)
Silcrete is thickest (0.5-1.5 m) outside the two channel incisions, and is thinnest (<1 m) or almost absent below the sediment-infilled channels. Within it are two separately sourced components, the lower part is a silicified pedolith containing angular quartz grit and relic graphite grains, the upper part is silicified colluvium, containing subangular to subrounded quartz-rich gravel and an alluvium of well-rounded quartz gravel and pebbles. The silcrete is pale grey to cream and yellowish. It is pedogenic and contains partitioned wisps of titania minerals and some ferruginous staining.

5.2.4 Red-brown alluvium-colluvium
These materials cover the site to an average depth of 2-3 m and also infill the two distinct channels at the centre of the section to depths of 6 m. Much of the upper part is probably related to Quaternary alluvial fans flanking nearby higher ground, but the lower parts are significantly older, darker coloured and partly indurated. Generally, the materials consist of rounded to subrounded quartz and lithic clasts (fine sand to cobble size) but is dominantly a gravel-rich, clast to matrix supported unit. It has a distinctly reddish to brown colour with strongly developed ferruginous staining. Poor clast rounding suggests dominantly short transport (colluvial). Calcrete cementation within discrete bands only affects the upper parts of this material.

5.2.5 Calcrete
Calcrete occurs throughout the upper regolith within the soil profile and upper colluvium-alluvium as distinct near-white horizons. Forms include nodules, earthy powders, coatings and irregular, 0.5 m thick, low density bands.

5.2.6 Soils
Soils range from uniform silty to sandy (Um, Uc) to gradational calcareous (Gc) to poorly structured lithosols in gravelly lag areas. These soils are generally poorly structured and with little organic matter present in the A horizon. All are strongly alkaline and are probably sodic (AS2) where clay-rich (Northcote and Skene, 1972; Northcote, 1979).

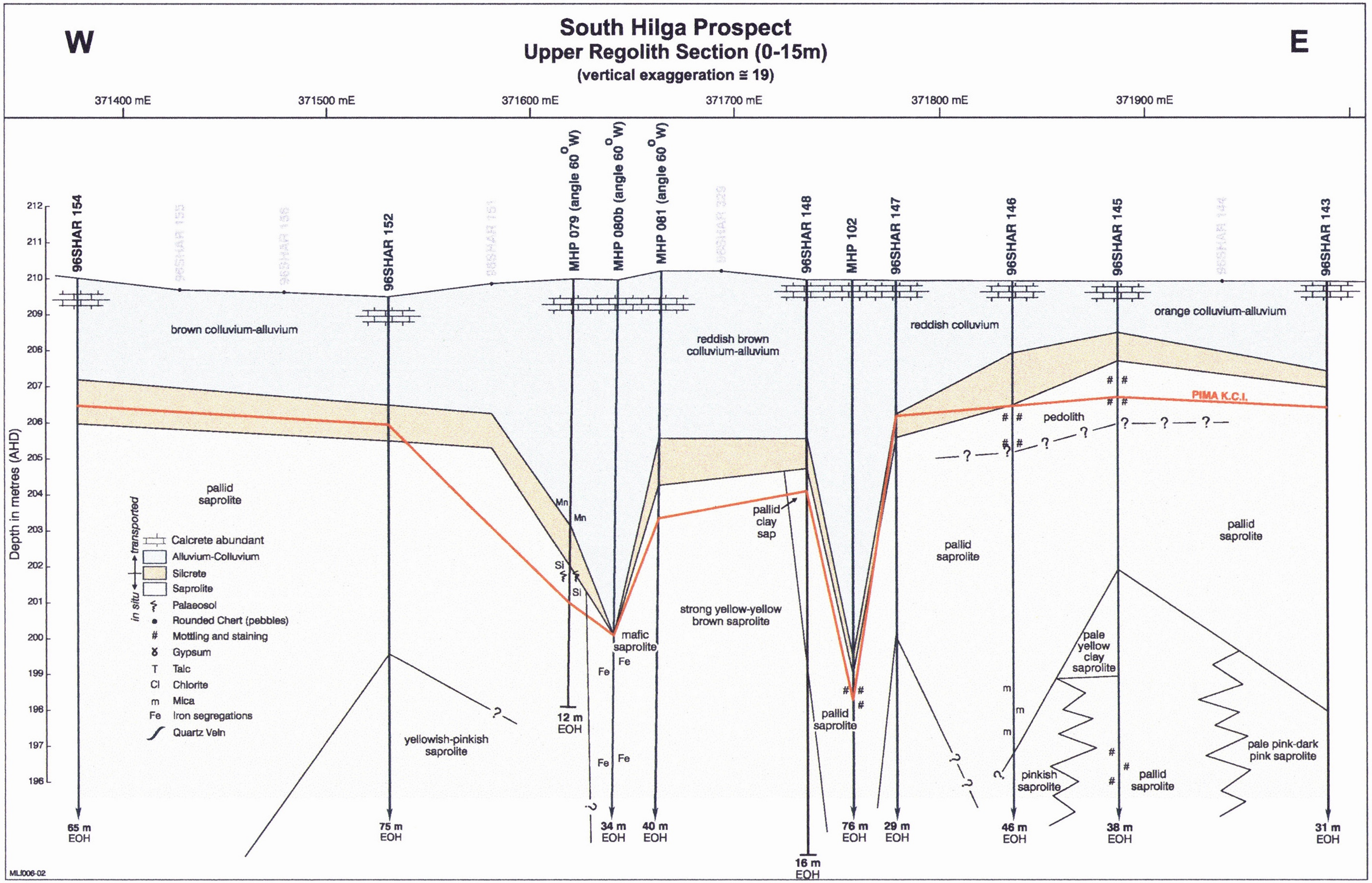


Figure 15: Typical upper regolith section at South Hilga Prospect.

5.3 Geochemistry

PIMA spectrometry of the upper regolith indicates poorly crystalline kaolinite and smectite in the colluvium and a sharp boundary with more crystalline kaolinite in the saprolite. The spectrometry confirms the location of the boundary between the *in situ* and transported regolith as determined by microscopic and field studies. PIMA spectrometry also indicates the presence of Mg-chlorite (371530 m E at 43-63 m), K-alunite (371880 m E at 24-25 m) and, possibly, diopside (371650 m E) in the Fe-rich (probably goethitic) saprolite centre of the section. Iron is moderately associated with Zn, Ni, Mn, As and Co (e.g., Figure 18b), probably due to adsorbtion on Fe oxyhydroxide.

The greatest Au concentration (2.2 ppm maximum) is in the centre of the section about 30 m below surface in strongly ferruginous, yellow-brown, mafic saprolite and forms part of a mineralised interval averaging 8 m at 1.3 g/t. It is associated with moderate concentrations of Cu (mean 120 ppm) (Table 3). As adjacent holes are relatively poor in Au, mineralisation is probably confined to narrow veinlets. Above mineralisation, however, anomalous Au is continuous through the 10 m deep transported material to the surface. Maximum concentrations in the transported regolith (960 ppb at 6-8 m) are associated with slightly calcareous samples in a buried channel close to the interface between transported and *in situ* units adjacent to mineralisation. In calcrete, samples reach up to 100 ppb Au above mineralisation. However, all these samples are downslope of mineralisation to the north and so the origin of the anomalous concentrations is equivocal.

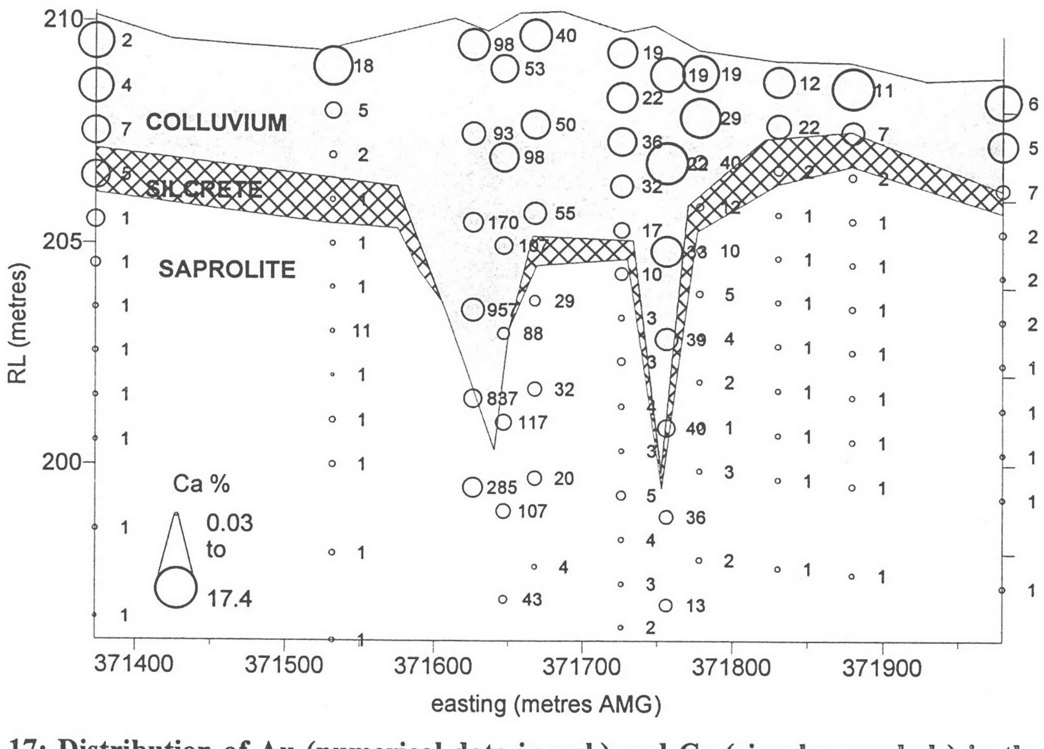
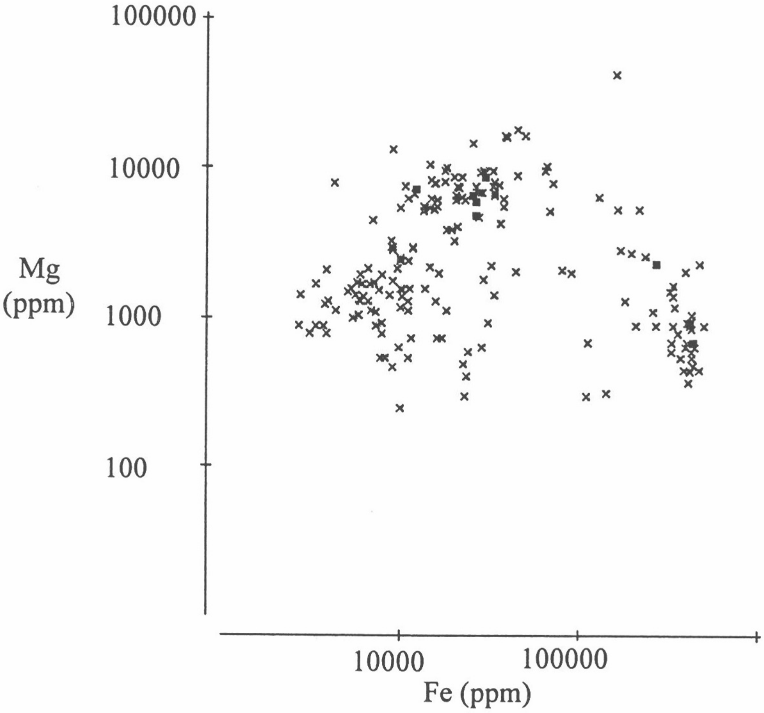


Figure 17: Distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith section at South Hilga. Calcium is present principally as calcrete.

Table 3: Highest Au concentrations and other anomalous intervals in drillholes.

Drillhole	Interval (m)	Analyses (ppm, Au in ppb)	Regolith type
MHP080B	26-34	Au 1340 ppb, Cu 120	saprolite
MHP079	4-12	Au 560 ppb	colluvium/alluvium and saprolite
MHP081	34-36	Au 530 ppb	saprolite
96SHAR147	13-14	Au<1 ppb As 250, Sb 14	saprolite
96SHAR152	63-64	Au 3 ppb Zn 370, Ni 1150	saprolite
96SHAR145	24-25	Au <1 ppb Pb 340	saprolite

a)



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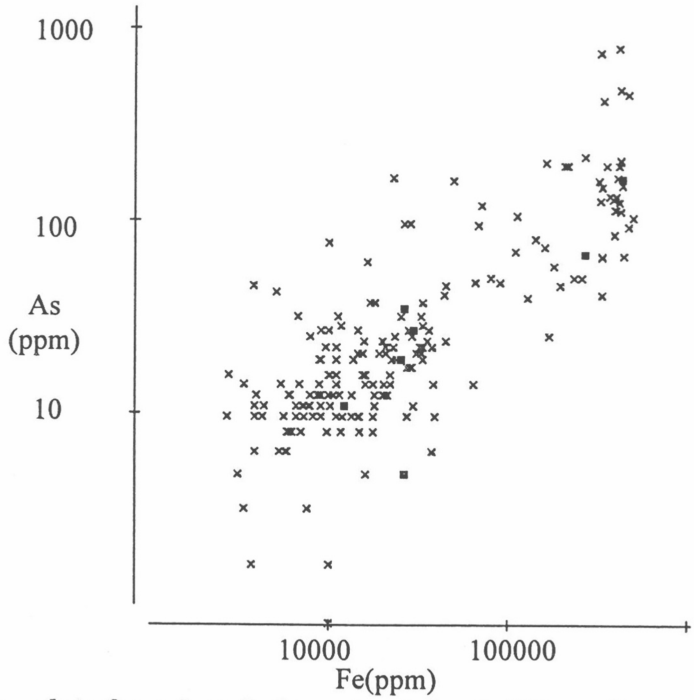

Figure 18: Scatter plots for selected elements at South Hilga. Box symbols indicate samples with the highest Au concentrations:
a) Fe v Mg. Note the cluster of high Fe and relatively low Mg (lower right) that indicates highly ferruginous saprolite (derived from a mafic source);
b) Fe v As. Some pathfinders, e.g. As, are adsorbed by Fe oxyhydroxides (goethite).

6 JUMBUCK PROSPECT

6.1 Introduction

Jumbuck Prospect is about 40 km east of Commonwealth Hill Homestead (Figure 2). The geochemical anomaly (Figure 19) lies on undulating terrain in an area occupied by west-trending, linear, Pleistocene sand dunes. These cover deeply weathered and silcrete-capped Archaean basement and overlying clay sediments. The orange dunes form an easterly outlier of the Great Victoria Desert. In part, they infill depressions in the basement with up to 6 m of sand. Vegetative cover includes woodland (*Eucalyptus* and *Acacia*), numerous woody shrubs (e.g., *Acacia*, *Eremophila* and *Maireana*) and various ground cover plants (e.g., *Ptilotus*, *Eragrostis*, *Sclerolaena Thyridolepis*). This vegetation has stabilised the dunes.

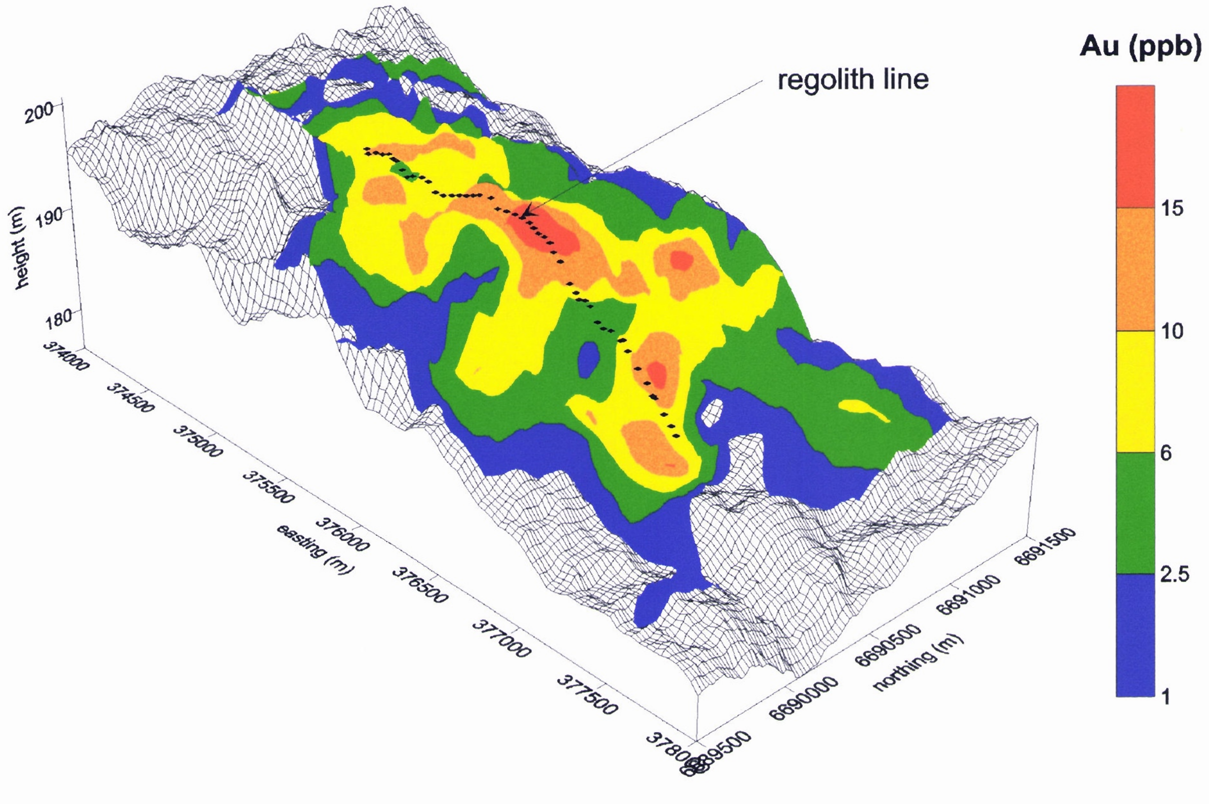

Figure 19: Detail of Jumbuck Prospect showing Au in calcrete anomaly and regolith line overlaid on a DEM. Exposed grid indicates data below 1 ppb. View from south east. Original data supplied by the Gawler Joint Venture.

6.2 Regolith stratigraphy

6.2.1 Overview

The west-east oriented section (Figure 20 and Figure 21) at 6690400N was selected. Generally the area is covered by aeolian, quartz-rich sand 2-4 m thick, overlying other transported materials on deeply weathered Archaean basement. The boundary between these distinct regolith components lies within the silcrete duricrust horizon. Localised silcrete outcrops indicate saprolite and sediment substrates. PIMA kaolinite crystallinity index (KCI) analysis has confirmed the *in situ*-transported boundary (red line on section) to occur mostly within or just below the silcrete, except (i) within channel sediment below the silcrete horizon or (ii) where low residual kaolinite concentrations are present.

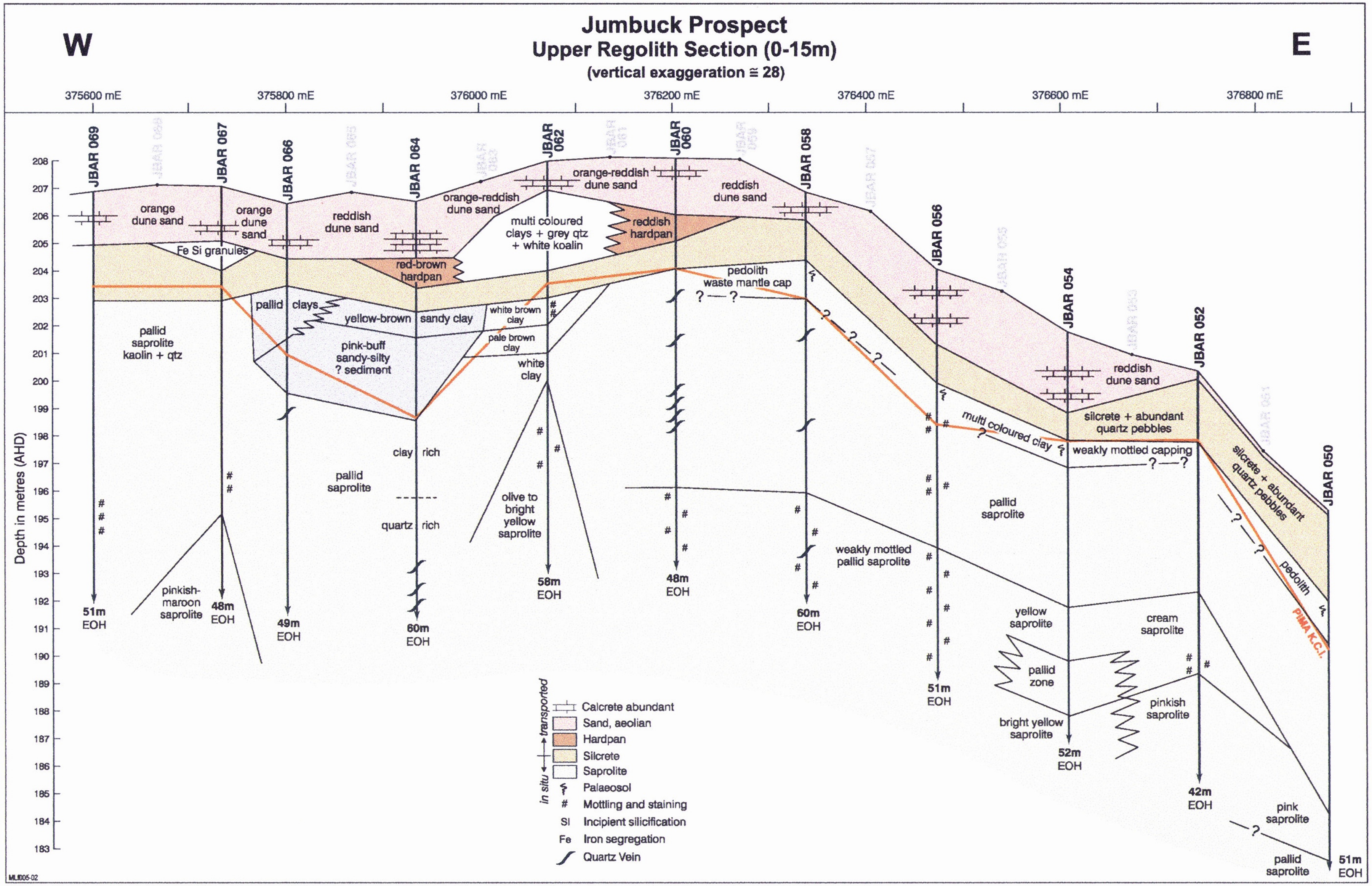

Figure 20: Typical upper regolith section at Jumbuck Prospect.

Basement lithotypes are extensively weathered to depths of >30 to >56 m. Fresh basement was not encountered, although some of the saprock from holes JBAR066 to 052 provide relicts exhibiting a strongly foliated mafic-rich gneiss. A more complex saprolite zone overlies this and is variably coloured or strongly mottled. Higher in this sequence, the saprolite becomes weakly coloured to pallid. The pedolith varies in thickness from <0.5 m to 1.0 m and is not always recognisable from cuttings alone. However, where obvious, it can exhibit micro-mottles, Fe and Mn staining but all primary rock textures have been obliterated. Between holes JBAR066 and 064, a fluvial sediment infilled channel was intersected. The clays within this sediment have been confirmed by PIMA analysis to be transported. Along the whole section, all pedolith is intensely silicified and the top, forming silcrete; deeper partial silicification has yielded a variably indurated pedolith. Silica has also cemented the upper portion of the channel infill, forming a silcrete horizon of a similar depth to that in the surrounding pedolith. Aeolian sand and colluvium make up the overlying transported materials.

6.2.2 Basement (in situ)

Christie Gneiss forms the crystalline gneissic to granulitic basement at Jumbuck Prospect. Much of the saprock to lower saprolite is chlorite- and biotite-rich indicating a mafic or basic general bulk composition. Coarse-grained varieties were not encountered but the freshest fine- to medium-grained saprock displays strongly foliated quartz-feldspar-biotite gneiss. A more mafic character is expressed in hole JBAR058, where olive clays occur to within 26 m of the surface. Quartz veins are quite common and occur randomly throughout the section; they have colours from translucent-white to grey to bluish to dark bluish and zoned varieties.

6.2.3 Alluvium (transported)

Between holes JBAR066 and 064, a fluvial sediment-infilled channel was intersected. This may be pre- or Early Tertiary in age as its upper portion has been silicified in an identical manner to the surrounding saprolith. Distinct clay and sandy silt form the dominant textural facies of this channel infill to a thickness of 5 m. PIMA analysis of the clays have confirmed a transported origin. This channel may be related to a more substantial regional palaeo-drainage system encountered also at the nearby Challenger Gold Deposit (Lintern and Sheard 1999a, b; van der Wielen, 1999).

6.2.4 Silcrete (in situ and transported)

Silcrete is continuous along the section's entire length; it is thickest (>2 m) at either end of the regolith line and thinnest (<1 m) over the sediment filled channel. Generally, within it are two separately sourced components, the lower part being silicified pedolith containing angular quartz grit plus basement-sourced relict grains of graphite, and the upper part being silicified colluvium containing subangular to subrounded quartz-rich gravel plus alluvial well-rounded quartz-rich gravel to pebbles. The exception to this partitioning occurs over the infilled channel where the silcrete is totally encapsulating transported material. Silcrete from this area is pale grey to cream and sometimes yellowish coloured. It is pedogenic and contains partitioned wisps of titania minerals and some ferruginous staining.

6.2.5 Siliceous ferruginous granules

Unusual pea to marble-sized silica impregnated ferruginous granules or nodules were observed at two drill intersections (holes JBAR068 and 067 at ~2 m). These nodules had khaki coloured cutans on siliceous, brown, goethitic cores. Materials resembling these have been observed and described from 2 of 8 soil pits at the nearby Challenger Gold Deposit (Lintern and Sheard, 1999a: Mason and Mason, 1998). They were described as being concretionary sandy ferricrete to ferruginous claycrete conglomerate but the nodules at Jumbuck do not appear to easily fit within either of those descriptions. Their origin remains conjectural and requires further study.

6.2.6 Hardpan (transported)

At Jumbuck hardpan is 0-2 m thick; it underlies the aeolian dune sand, overlies the silcrete zone and intertongues with a related multicoloured clay facies (see section 2.5.7). In hole JBAR064, the hardpan contains dark brown to black Fe and Mn sesquioxide and hydroxide cements and/or segregations, the clay may also be partly silicified or otherwise indurated. But in hole JBAR060, the same material is sand- to gravel-rich with a strong fluvial character but is coloured similarly to the more clay-rich hardpan. The clay-rich material is carbonate-coated but not impregnated. A strong reddish brown colour makes this unit easily identified from all the others.

6.2.7 Multi-coloured clay

This unit appears to be a lateral facies variant or time equivalent to the red-brown hardpan, but is otherwise very different. They consist of pink, yellow and white clays; white components dominate towards the base of the unit. Grey quartz-rich sand also occurs within. PIMA analysis indicates the presence of smectite (transported) and moderately crystalline kaolinite (?*in situ*) but low crystallinity kaolinite of probable transported origin occurs below this unit. These materials may have derived from a once exposed saprolith area nearby and were rapidly eroded then redeposited as sheet-style or mudslide slurry to form a localised colluvial-alluvial body.

6.2.8 Dune sand

Aeolian dune sand blankets most of this prospect and forms a small but significant dune field outlier to the Great Victoria Desert. Dating elsewhere places these sands early into the last quarter of the Quaternary (Huntley *et al.*, 1999). Colours range from orange to reddish and are caused by thin ferruginous coatings on the quartz-rich sand grains. These sands are uniformly sorted and textured with little or no illuviated silt-clay components. Along the investigated section, these sands range from <1 m to >2.5 m in thickness, and host calcrete as nodules to earthy or low density forms, sometimes at more than one level. The sand is generally loose and free running, except where cemented by calcrete, but is mostly stabilised through the presence of deep-rooted vegetation.

6.2.9 Calcrete

Calcrete occurs across the upper regolith within the dune sand and soil profile. There is commonly more than one calcrete horizon in the dune sands, especially at holes JBAR056-054. Nodules are dominant within the dunes, but earthy powders or laminated coatings were observed on, or as joint infill to, silcrete outcrop and subcrop. Colouring is usually pale pink or pale orange, but near white on silcrete or where low density earthy bands have formed.

6.2.10 Soils

Soils range from uniform sandy (Uc) to poorly structured lithosols around outcrop. All are strongly alkaline and where fine-grained near outcrop are probably sodic (AS2; Northcote and Skene, 1972; Northcote, 1979). Little organic matter is present and true A horizons are difficult to define.

6.3 Geochemistry

PIMA spectra are dominated by kaolinite. The PIMA spectrometry indicates both highly crystalline and poorly crystalline kaolinite in the interpreted transported-*in situ* boundary as identified by microscopic examination. Thus there is a discrepancy in the position of the boundary by the two methods. In one hole (JBAR050), apparently poorly-crystalline kaolinite at 8-9 m has highly crystalline kaolinite on either side of it; however, this particular sample has a high proportion of smectite that may mask the crystallinity of the kaolinite. Smectite suggests a conduit for groundwater (possibly related to the slope) and approximately coincides with the transported-*in situ* boundary as determined by microscopic examination.

As at Golf Bore, Fe is highly correlated with As, Cu, Cr, Co, Ni, V and Zn, and moderately correlated with Mg, although the low K concentrations suggest a lack of sericitic alteration.

Significant Au concentrations in the regolith are listed in Table 4. Above background (>1 ppb) concentrations of Au are found in the transported cover and upper, *in situ* regolith at Jumbuck. The eastern part of the regolith section has higher concentrations of Au (13 ppb) in the upper regolith and this corresponds with higher Au concentrations (110 ppb) found in the deeper regolith in hole 54

(376500E). For the upper regolith, the highest Au concentration (13 ppb) is found in a calcrete-silcrete sample towards the centre of the section and on the edge of the slope. Lower but still elevated concentrations of Au are found sporadically in surficial calcrete developed in colluvium and sand (1-6 ppb).

Table 4: Highest Au concentrations and other anomalous intervals in drillholes.

Drillhole	Interval (m)	Analyses (ppm unless stated)	Regolith type
97JBAR054	50-51	Au 110 ppb	saprock
97JBAR054	29-30	Au 32 ppb	saprolite
97JBAR052	20-21	Au 44 ppb	saprolite
97JBAR066	44-45	Au 21 ppb	saprolite
97JBAR062	15-16	Au <1 ppb Cu 250, Zn 270	saprolite
97JBAR062	11-12	Au <1 ppb Cu 220, As 33, Zn 290	saprolite

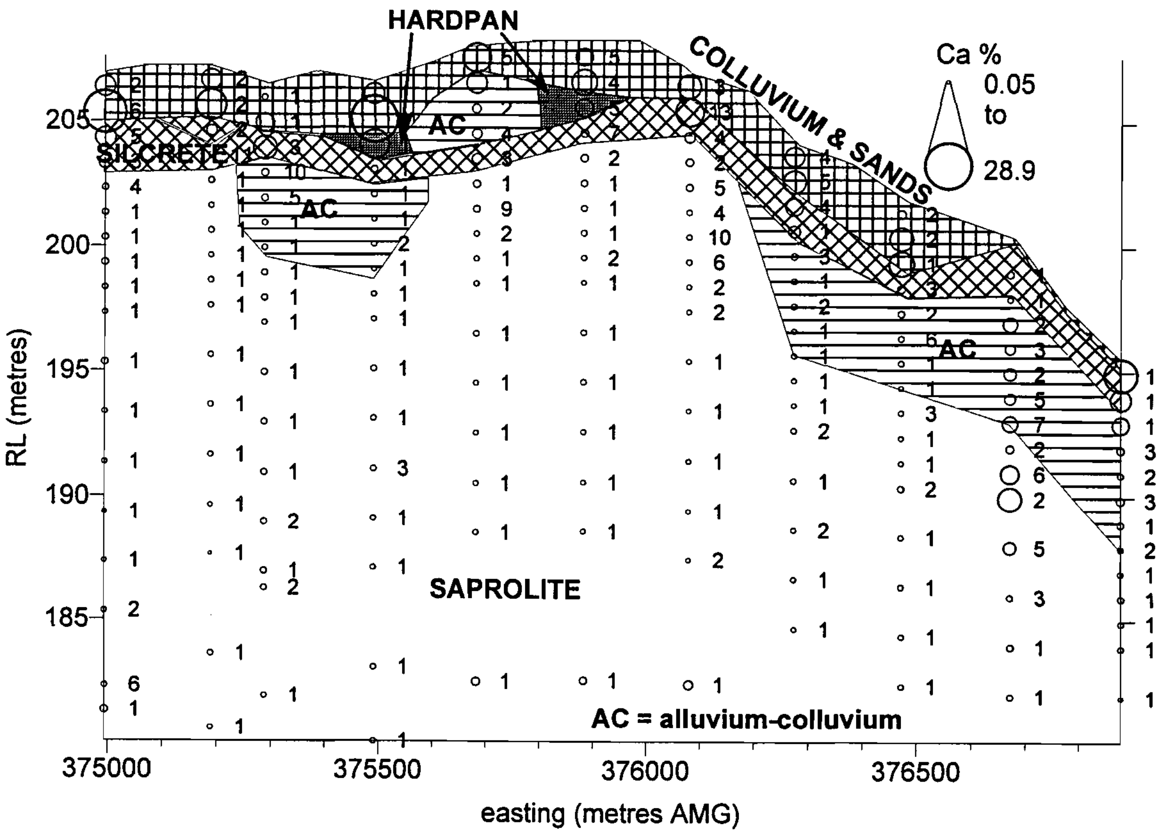

Figure 22: Distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith section at Jumbuck. Calcium is present principally as calcrete.

7 GOLF BORE PROSPECT

7.1 Introduction

Golf Bore Prospect lies 36 km northeast of the Challenger Gold Deposit (Figure 2). This area is occupied by isolated west-trending, low, Pleistocene linear sand dunes and the surface geochemical anomaly (Figure 23) lies within moderately undulating terrain. Aeolian sand partly covers deeply weathered Archaean basement with a silcrete capping. The orange dunes are an easterly outlier of the Great Victoria Desert and infill depressions in the basement with up to 6 m of quartz sand. Several outcrops show low-angle sections through the duricrust capping, where silica has cemented alluvial, colluvial and *in situ* materials into a single silcrete horizon. This supports open woodland

(*Eucalyptus* and *Acacia*), numerous woody shrubs (*Acacia*, *Eremophila* and *Maireana*) and other plants (*Ptolitus, Eragrostis* and *Atriplex*). As at Jumbuck and ET, plants have stabilised the dunes.

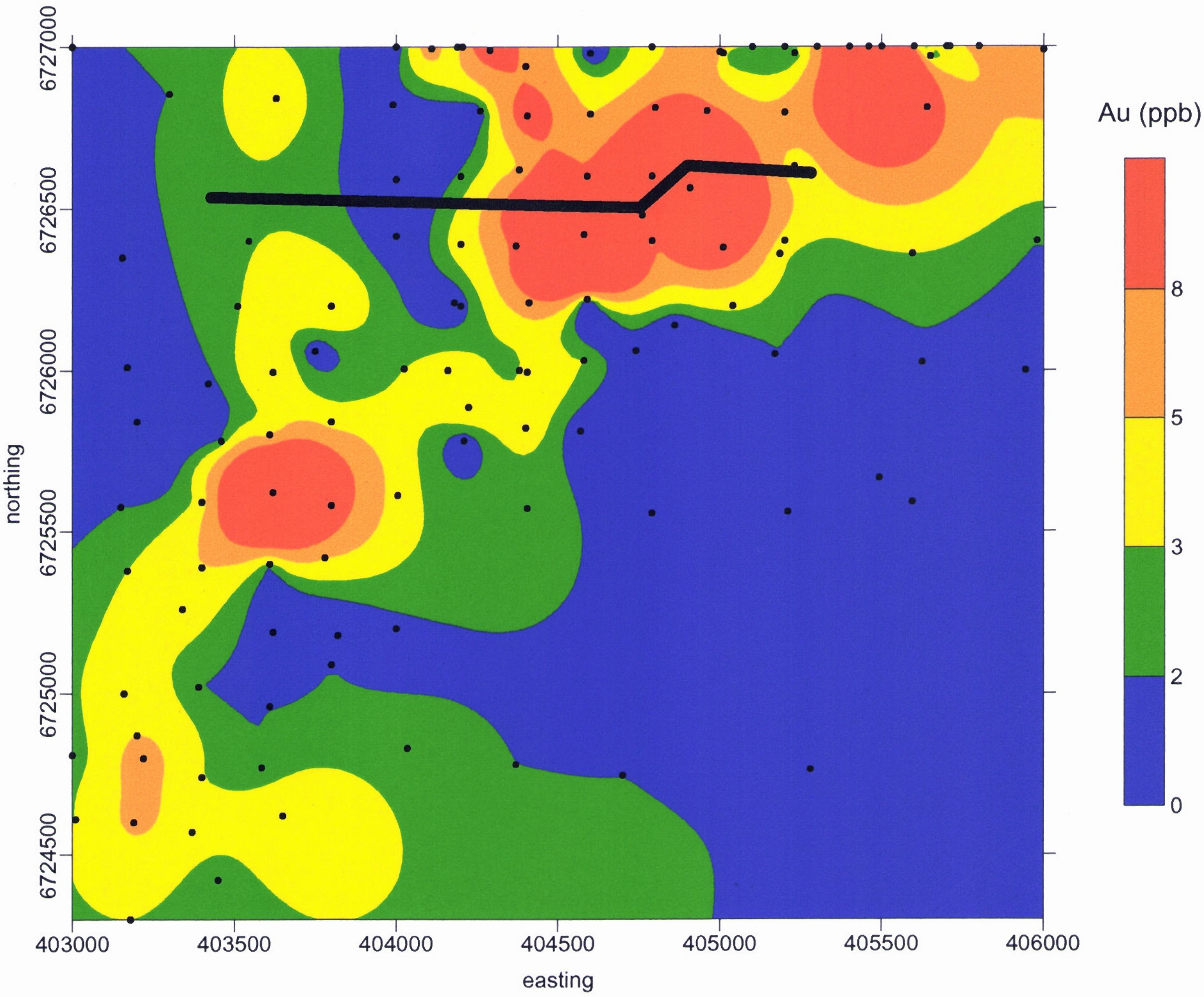

Figure 23: Detail of Golf Bore Prospect showing Au-in-calcrete anomaly. Black dots are sample points; black line is regolith line. No detailed DEM available for the area. Original data supplied by the Gawler Joint Venture.

7.2 Regolith stratigraphy

7.2.1 Overview

A combined west-east oriented section (Figure 24 and Figure 25) on 6726500N and 6726600N was studied in detail. The section was selected ("connected" between holes GBAR088 and 102) in order to include the surface geochemical anomaly and drilling-intersected mineralisation (Figure 23). Generally, the Golf Bore area is covered by aeolian quartz-rich sand 1-5 m thick, overlying other transported materials on deeply weathered Archaean crystalline basement. Large portions of this landscape have silcrete outcrop as low rises with gibber-clad aprons. The true boundary between these two distinct regolith components lies within the silcrete duricrust horizon. Localised silcrete outcrops indicate saprolite and sediment substrates. PIMA kaolinite crystallinity index (KCI) analysis has confirmed the *in situ*-transported boundary (red line on section) to occur mostly within or just below the silcrete duricrust. Exceptions occur below this or where low residual kaolinite puts the KCI change into the unsilicified *in situ* pedolith zone.

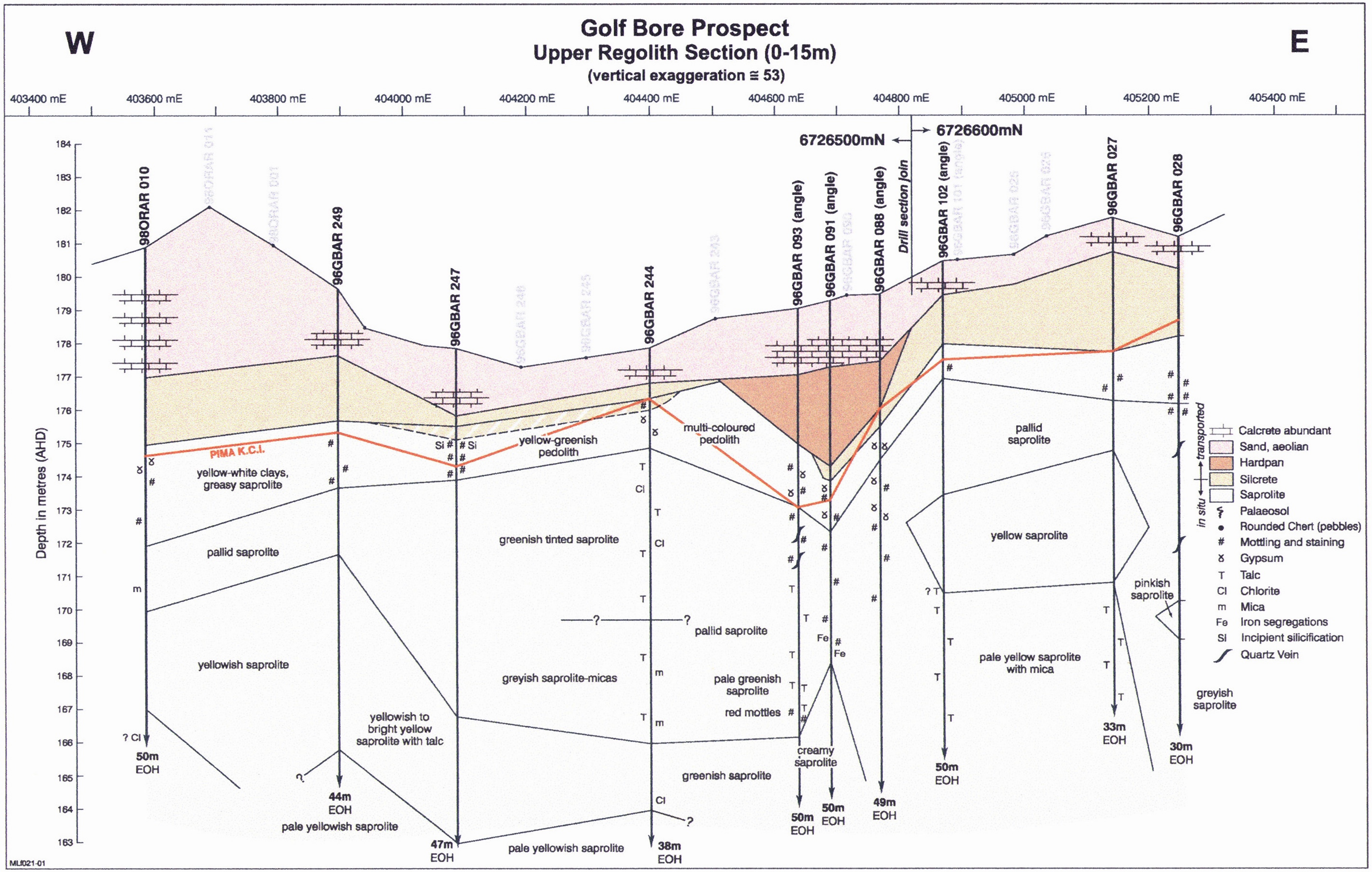

Figure 24: Typical upper regolith section at Golf Bore Prospect.

Basement lithotypes are extensively weathered to depths of >30 m. Fresh bedrock was not encountered, although saprock from several holes provides relicts of a strongly foliated intermediate to mafic-rich gneiss. A more complex saprolite zone overlies this and is variably coloured or strongly mottled. Many drill cuttings from 10-30 m were sericite-rich. More mafic saprolite occurs between holes GBAR093-028 as indicated by chlorite. Higher in this sequence, the saprolite becomes weakly coloured to pallid. The pedolithvaries in thickness from ~0.5 -1.0 m. It can exhibit micro-mottles, Fe and Mn staining, but all primary rock textures are obliterated by pedogenesis. This zone and others below have been impregnated with ubiquitous coarsely crystalline gypsum at the centre and western end of the section. Along most of the section, the top of the pedolith is intensely silicified, forming silcrete; deeper partial silicification has yielded a variably indurated pedolith. Part of the silcrete may have been stripped by erosion within the central channel feature and appears to be missing totally at hole GBAR093. Between holes GBAR243 and 088, an infilled channel-like depression feature was intersected, containing red-brown hardpan. Aeolian sand and colluvium make up the overlying transported materials.

7.2.2 Basement (in situ)

Christie Gneiss forms the crystalline gneissic to granulitic basement at Golf Bore Prospect. Much of the saprock to lower saprolite is chlorite-rich, indicating a mafic bulk composition. Coarse-grained varieties were not encountered but the freshest fine- to medium-grained saprock displays strongly foliated quartz-feldspar-biotite-muscovite gneiss. A more mafic character is expressed in holes GBAR093-028 where chlorite is a common weathering product. Quartz veins occur randomly or in clusters throughout the section; they have colours from translucent grey to bluish to dark bluish to black and zoned variants thereof.

7.2.3 Silcrete (in situ **and** *transported)*

Silcrete is most thickly developed (2 m) at either end of the regolith line and is thinnest (<1 m) to absent below the channel. It generally contains two separately sourced components, the lower part being silicified pedolith containing angular quartz grit and relict graphite grains and the upper part being silicified colluvium containing subangular to subrounded quartz-rich gravel and alluvial well-rounded quartz-rich gravel to pebbles. Outcrop sections through this cementation horizon are easily accessed and examined in the Golf Bore area. Silcrete here is pale grey to cream and occasionally yellowish or greenish coloured. It is pedogenic and contains partitioned wisps of titania minerals and some ferruginous fracture staining.

7.2.4 Hardpan (transported)

Hardpan is a convenient field term to describe a distinct red-brown to strong brown clay-rich colluvium to alluvium. At Golf Bore this unit is 0-3 m thick, and underlies the aeolian dune sand and overlies the silcrete. The hardpan contains dark brown to black Fe and Mn sesquioxide and hydroxide cements and/or segregations; any clay may also be partly silicified or otherwise indurated. Quartz-dominated sand- to gravel-rich materials with a strong fluvial character also occur, but the unit appears to be dominantly clay matrix supported. The clay-rich material is carbonate-coated towards the surface but is not carbonate impregnated.

7.2.5 Dune sand

Aeolian dune sand blankets about half of this prospect and forms a significant outlier to the Great Victoria Desert. Colours range from orange to reddish and are caused by thin ferruginous coatings on the quartz-rich sand grains. These sands are uniformly sorted and textured with little or no illuviated silt-clay components. Along the investigated section, these sands range from 1 to 5 m thick, and host calcrete as nodules to earthy or low-density forms, sometimes at more than one level. The sand is generally loose free running, unless cemented by calcrete but is mostly stabilised from erosion through the presence of deep-rooted vegetation.

7.2.6 Gypsum

Crystalline gypsum occurs between holes GBAR088-093 and at ORAR010, usually below the silcrete horizon, within the pedolith and upper saprolite. It ranges from colourless to honey yellow and forms matts of pencil-sized or smaller interlocking crystals. The origin of the gypsum is uncertain but it appears spatially associated with the weathered sulphide mineralisation. A similar association was observed at the Challenger Gold Deposit (Lintern and Sheard, 1999a, b). Localised sources of windblown lacustrine gypsum are not present in the immediate area.

7.2.7 Calcrete

Calcrete occurs across the upper regolith within the dune sand, exposed silcrete and in the soil profile. In the dune sands there were sometimes more than one calcrete horizon observed, especially at the western end of the section. but earthy powders or laminated coatings were observed on, or as joint infill to, silcrete outcrop and subcrop.

Nodules are dominant within the dunes, but earthy powders or coatings in the upper hardpan and laminated coatings to joint infill on silcrete occur. Colouring is usually pale pink or pale orange but near white on silcrete or where low density earthy bands have formed.

7.2.8 Soils

Soils ranged from uniform sandy (Uc) to poorly structured lithosols around silcrete outcrop. All are strongly alkaline and where fine-grained near outcrop are probably sodic (AS2; Northcote and Skene, 1972; Northcote, 1979). They contain very little organic matter and A horizons are difficult to define.

7.3 Geochemistry

PIMA analysis indicates gypsum in the sub-surface and this extends across the Golf Bore section. Gypsum is developed principally beneath sand, colluvium and silcrete and is most clearly seen in the S data and, to a lesser extent, in the Ca data. Weathering products indicated by PIMA spectrometry are kaolinite, smectite and muscovite (sericite). The boundary between highly and poorly crystalline kaolinite is distinct and correlates well with the transported-*in situ* boundary delineated by microscopic and field observations.

In the lower profile, samples associated with partly weathered rock or saprock are relatively rich in Fe, Mg, As, Co, Cr, Cs, Cu, Mn, Ni and Zn. The most likely original source for these elements is the Christie Gneiss (Mulgathing Complex), which include cordierite, garnet, feldspar, biotite and quartz. Higher in the profile, the minerals have largely weathered to kaolinite and muscovite (sericite), with a subsequent depletion of the chalcophile and siderophile elements. However, the upper regolith still retains the elemental signatures noted at depth, though at a lower concentration.

Gold concentrations in calcrete (n=6) above mineralisation have a mean concentration of 20 ppb against a background of about 3 ppb (n=8). The calcrete has developed in about 2 m of colluvium over a siliceous (non-calcareous) hardpan also containing elevated Au concentrations similar to those found in the calcrete. The highest Au concentrations (85 ppb) in the upper regolith were found in the saprolite immediately beneath a Au- and Ca-rich silcreted horizon indicating a possible geochemical origin for the Au anomaly. Unfortunately, the corresponding colluvium and sand above these materials was not sampled due to poor drill spoil condition, so it was not possible to establish whether the Au anomaly continued to the surface.

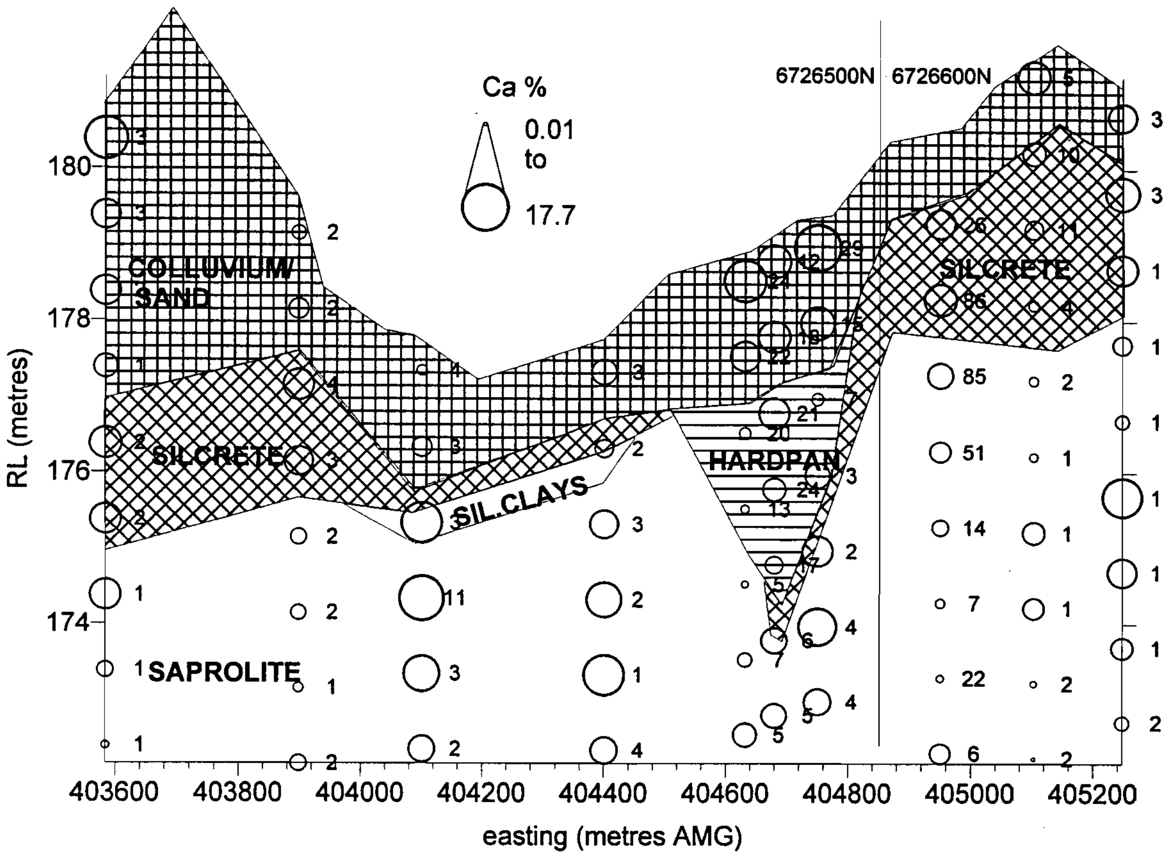

Figure 26: Distribution of Au (numerical data in ppb) and Ca (circular symbols) in the upper regolith section at Golf Bore. Calcium is present principally as gypsum and calcrete.

Gold is weakly correlated with As, Mn and W. Some of the more significant correlations between major and trace elements are found in Table 5. Selected drillhole intervals with elevated Au and base metal concentrations are summarised in Table 6.

Table 5: Associations between major and trace elements.

Major Element	Trace element association	Interpretation
Ca	S and Sr	related to gypsum
K	Ba, Cs, Rb, Tl and (mainly) light REE	related to white micas
Mg	Co, Cu, Cs, Fe, Mn and Zn	partly related to adsorption by Fe oxyhydroxides
Ti	Th, Nb and U	

Table 6: Selected drillhole intervals with elevated Au and base metal concentrations.

Drillhole	Interval (m)	Analyses (ppm except Au)	Regolith type
96GBAR102	22-23	Au 85 ppb, As 145	saprolite
96GBAR93	46-47	Au 284 ppb, As, 120	saprolite
96GBAR93	35-36	Au 483 ppb	saprolite
96GBAR249	19-20	Au 5 ppb Cu 420, As 100	saprolite
98ORAR10	25-26	Au 2 ppb Cu 600	saprolite

8 COMPARATIVE GEOCHEMISTRY

Comparisons were made between selected major and trace element concentrations for the five prospects using box plots[1] (Figure 27 and Figure 28). The findings are:

1) Gold: Au concentrations are strongest at South Hilga, although median values are similar for all areas except Jumbuck. Jumbuck has the least median Au concentration.
2) Silver: Ag concentrations were similar with Jumbuck and Monsoon having slightly greater means.
3) Arsenic: As concentrations are variable for the prospects with Monsoon having the greatest concentrations and Jumbuck the least.
4) Copper: Cu concentrations are similar for all prospects with Monsoon having a slightly higher median concentration.
5) Calcium: Ca concentrations reflect the calcareous and gypseous materials sampled. Golf Bore has the greatest median concentration of Ca.
6) Iron: Monsoon has the greatest median concentration of Fe and reflects the presence of sulphides in some of the samples.
7) Sodium: Na concentrations are broadly similar for all prospects.
8) Sulphur: S concentrations are highest for Golf Bore where gypsum dominates the upper regolith. Sulphides may explain some anomalous high S concentrations in saprolite at Monsoon.
9) Potassium: K concentrations are variable and reflect the presence of mica alteration and feldspars.
10) Magnesium: high Mg concentrations at ET reflect the presence of mafic lithotypes and dolomite in the calcrete.

[1] The boxplots are made up of several parts. The box depicts the central half of the data approximately between the 25% and 75% percentages. The line across the box displays the median value. The whiskers extend from the top and the bottom of the box to depict the extent of the main body of the data. Outliers are plotted with a star. An outlier is any point that falls above Q_U-1.5*IQR where Q_U is the value of the upper quartile and IQR is the interquartile range.

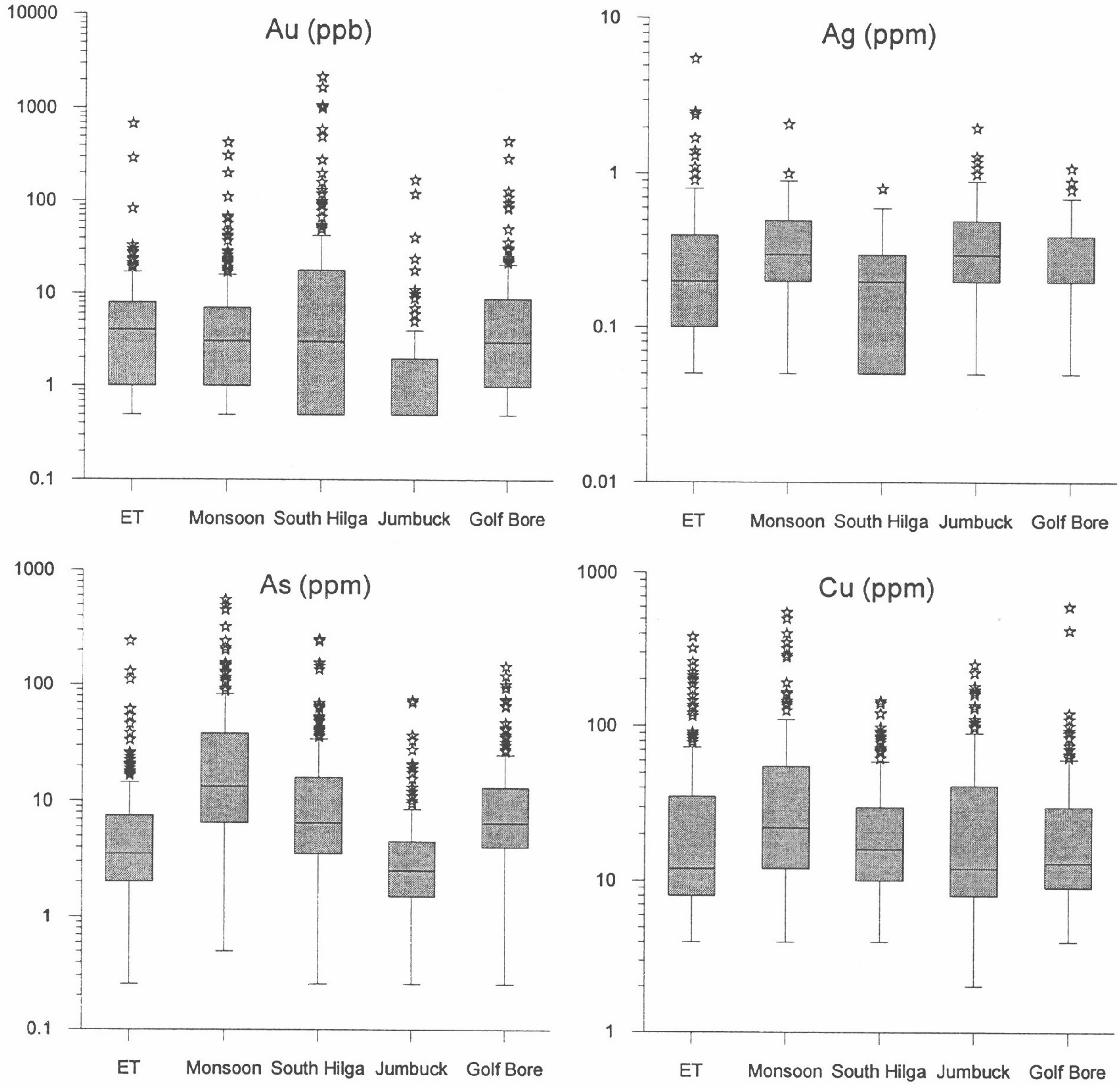

Figure 27: Comparison of selected trace element concentrations for ET, Golf Bore, Jumbuck, Monsoon and South Hilga Prospects.

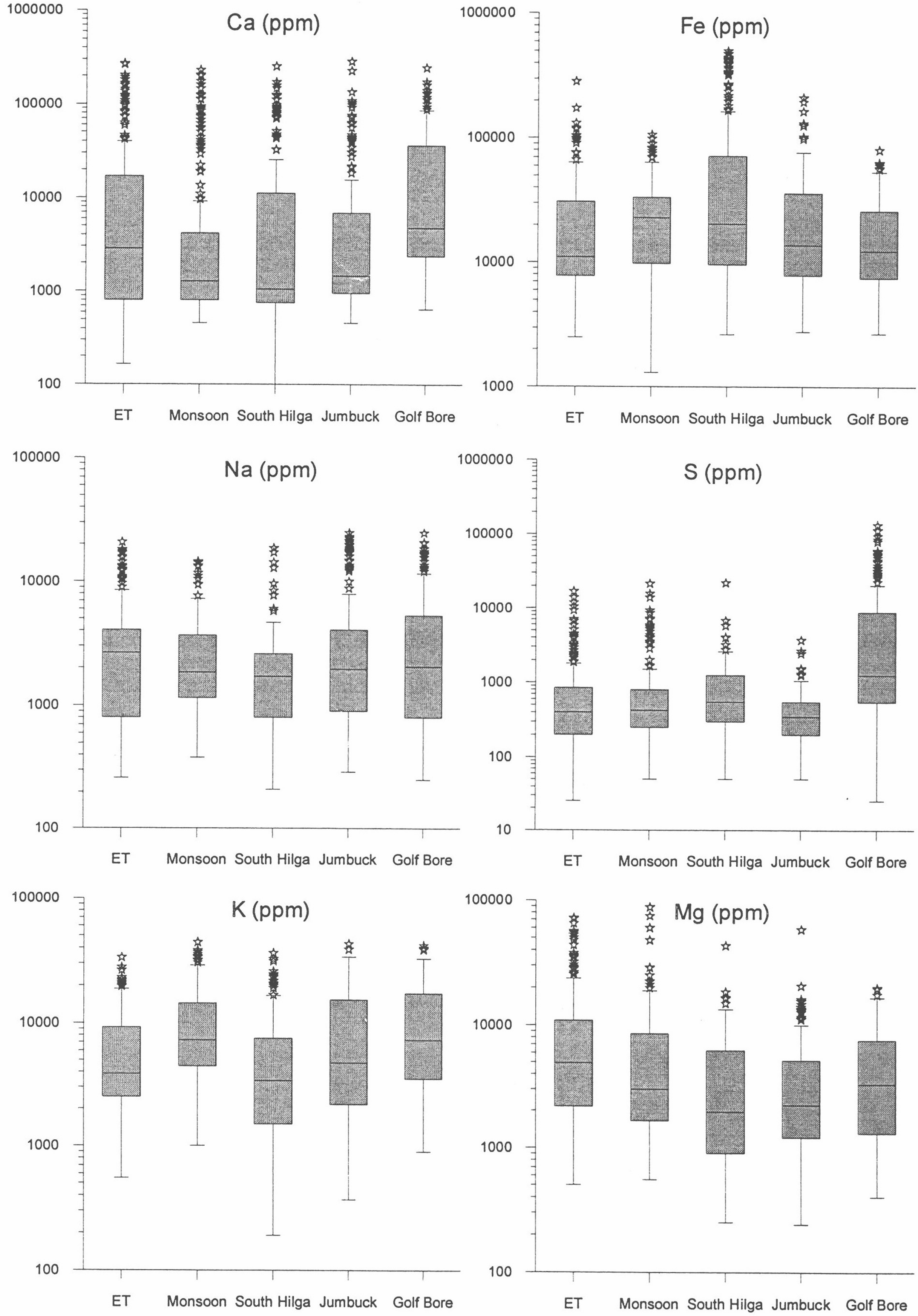

Figure 28: Comparison of selected major element concentrations for ET, Golf Bore, Jumbuck, Monsoon and South Hilga Prospects.

9 CONCLUSIONS

The five prospects: Jumbuck, South Hilga, Golf Bore, Monsoon and ET were evaluated as sites for the investigation of dispersion into transported overburden. Each site has one or more limitations including only thin transported overburden, weak mineralisation and close proximity to outcrop. Most of the transported overburden is relatively young at all five sites. No Mesozoic or Palaeozoic sediments overlie mineralised basement. Therefore the influence of time on geochemical signature in transported cover has not been addressed. The ET Prospect was selected for further study because:

1) two hundred drillholes spread over the prospect with cuttings in good condition;
2) a large Au-in-calcrete anomaly that had not been linked to a primary source, leaving potential for additional areas of investigation and possible drill targets;
3) indications that mineralisation might be expressed in the transported overburden;
4) a greater spread and thickness of transported overburden compared with other sites; and
5) sand dunes, typical of the western Gawler Craton, and a hindrance to exploration in this region.

The drawback of attempting to investigate geochemical dispersion on single regolith transects is a lack of information on potential geochemical contributions from a lateral source. Thus, if anomalous concentrations of an element occur in transported overburden, there is no means of determining whether the anomaly source was below or upslope. Hence, any such study must be comprehensive and include factors such as topography, adjacent multiple sections and the strength and location of mineralisation. Three-dimensional visualisation of geochemical anomalies is a major priority for the detailed study (Lintern et al, 2001).

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