CRCLEME
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CSIRO
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AMIRA
Australian Mineral Industries Research Association Limited ACN 004 448 266

OPEN FILE REPORT SERIES

CRC LEME OPEN FILE REPORTS 85 - 111: ABSTRACTS, INDEX AND DATABASE

COVERING CSIRO/AMIRA RESEARCH PROJECTS: 'GEOCHEMICAL EXPLORATION FOR PLATINUM GROUP ELEMENTS (252), 'GEOCHEMICAL EXPLORATION IN AREAS OF TRANSPORTED OVERBURDEN' (P409)

I.D.M. Robertson

CRC LEME OPEN FILE REPORT 112

June 2001

CRC LEME is an unincorporated joint venture between The Australian National University, University of Canberra, Australian Geological Survey Organisation and CSIRO Exploration and Mining, established and supported under the Australian Government's Cooperative Research Centres Program.

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Headquarters: CRC LEME c/o CSIRO Exploration and Mining, Private Bag No 5, Wembley, Western Australia, 6913

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

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

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

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

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

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

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

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

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

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

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

This report (CRC LEME Open File Report 112) is a first impression (first printing) and did not form part of the output of the above research projects. However, it contains abstracts of reports from these research projects.

Copies of this publication can be obtained from:
The Publication Officer, c/- CRC LEME, CSIRO Exploration and Mining, Private Bag 5, Wembley, WA 6913, Australia. Information on other publications in this series may be obtained from the above or from http://leme.anu.edu.au/
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I. Title
CRC LEME Open File Report 112.
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PREFACE

This report presents an index of the 27 reports written for the two CSIRO/LEME-AMIRA research projects 'Geochemical exploration for platinum group elements in weathered terrain (P252)' and 'Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, WA (P409)'. The index and its contained database have been assembled to complement the re-issue of the reports from these projects in the CRC LEME Open File Report series and to provide easy access to the large volume of information contained within them. It is hoped that this index will maximise the usefulness of these reports.

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

Project Leaders

June, 2001

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INTRODUCTION

This index covers 27 CRC LEME Open File Reports originally issued by the following CSIRO-AMIRA research projects :-

P252 *Geochemical exploration for platinum group elements* in weathered terrain.
P409 *Geochemical exploration in areas of transported overburden*, Yilgarn Craton and environs, WA.

Short titles of the research projects are given in italics.

This index volume provides a comprehensive and searchable guide to these reports. In addition, the data supplied on magnetic disc with individual reports has been recompiled on CD because of the limited life of magnetic media.

HISTORY

Issues addressed
Most gold production in Western Australia had come from Archaean terrains and most initial discoveries were made by conventional means and by locating extensions to known mineralisation. As the reserves of known deposits became depleted, attention was directed to the extensive areas occupied by deep lateritic weathering and areas covered by continental sediments, where conventional prospecting methods (use of the geology, geochemistry and geophysics of the time) were much less successful. Rocks were difficult to identify where deeply weathered and lateritised, geochemical anomalies were subtle and confusing and the application of electrical geophysical methods was frustrated by saline or conductive regolith layers. As the deeply weathered areas were progressively explored, interest was refocussed on areas covered by transported continental sediments. An improved understanding of this cover and the strategies necessary to explore beneath it were clearly required. Similar problems were encountered in exploration for platinum group elements, with the added difficulty that there had been no previous discoveries and the only PGE production was as a byproduct of Ni sulphide mining.

The research
In January 1987, four research projects were proposed, through AMIRA (the Australian Minerals Industries Research Association) to member companies in the minerals industry. These included 1) Laterite geochemistry, 2) Weathering processes, 3) Controls of primary gold mineralisation and 4) Remote sensing. Of these, 1 (as Project 240), 2 (as Project 241) and 4 (as Project 243) received industry support and funding and began in July 1987. Reports released by Projects 240, 241 and their extensions are covered by a separate index (CRC LEME Open File Report 75).

In 1988, a project designed to gather information on the geochemical behaviour of the platinum group elements under weathering conditions (P252) commenced between CSIRO and the Universities of Newcastle and Wales (Cardiff). A further research project was commenced in 1993 to study the substantial thicknesses of transported overburden that mantle parts of the Yilgarn Craton (P409). This index covers the activities of these last two projects that were completed in December 1992 and July 1996 respectively.

The objectives
The overall aims of these research projects were to develop improved geological and geochemical methods for mineral exploration to facilitate the location of blind, concealed or deeply weathered gold and platinum deposits. Research concentrated on gold and platinum occurrences and host rocks of the Yilgarn Craton of Western Australia. The Ora Banda Sill is one of the few platinum occurrences on the Yilgarn Craton.

The research projects

The two most recent research projects are detailed below:

P252: Geochemical exploration for platinum group elements in weathered terrain. Leader: Dr C.R.M. Butt.

This project was designed to gather information on the geochemical behaviour of the platinum group elements under weathering conditions using both laboratory and field studies, to determine their dispersion in the regolith and to apply this to concepts that could be used in exploration. The research was commenced in 1988 by CSIRO Exploration Geoscience and the Universities of Newcastle (NSW) and of Wales (Cardiff). The Final Report was completed in December 1992. It was supported by 9 companies.

P409: Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, WA. Leaders: Drs C.R.M. Butt and R.E. Smith.

Over 50% of prospective terrain in the Yilgarn is obscured by substantial thicknesses of transported overburden that varies in age from Permian to Recent. Some of this cover has undergone substantial weathering. Exploration problems in these covered areas were the focus of Project 409. The research was commenced in June 1993 by CSIRO Exploration and Mining but was subsequently incorporated into the activities of CRC LEME in July 1995 and was concluded in July 1996. It was supported by 22 companies.

These projects represented further collaboration between the mineral industry and research providers in a multi-disciplinary program of geoscience research aimed at developing new and improved geological and geochemical methods for exploration in deeply weathered Archaean terrains. This initiative recognised the unique opportunities, created by exploration and open-cut mining, to conduct detailed studies in the weathered zone, with particular emphasis on the near-surface expression of gold and platinum mineralisation.

Confidentiality and release of information

Final reports for P252 and P409 were issued in December 1992 and February 1997 respectively. Although the confidentiality periods of these two research projects expired in December 1994 and 1998 respectively, they have not been made public until recently. Publishing the reports through the CRC LEME Open File Report Series is seen as an appropriate means of doing this. By making available the results of the research and the authors' interpretations, it is hoped that the reports will provide source data for future research and be useful for teaching. It is intended that publication of the reports will be a substantial additional factor in transferring technology to aid the Australian mineral industry. Some of this research has been and is being released as papers in various scientific journals and at conferences (see list of papers).

The reports

Of the 27 reports, the most important for obtaining an overview of the research are the two final reports. Useful reference information may be obtained on regolith materials from the atlas. The remaining reports cover site investigations and some general studies, which provide the scientific foundations of the atlas and final reports. Two field guides, issued to sponsor representatives during well-attended field trips, assisted with technology transfer to industry. What cannot be represented here were the numerous technical presentations and workshops given to the sponsors in general and to individual sponsoring companies.

CSIRO divisional name changes, CRC LEME and report numbering systems

During the life of these projects, the responsible CSIRO division underwent a number of re-organisations. From 1st January 1988 to 1st July 1993, it was the Division of Exploration Geoscience. In 1993, it became the Division of Exploration and Mining and underwent a minor name change to CSIRO Exploration and Mining on 13th March 1998. In 1995, the activities of P409 were incorporated into those of CRC LEME.

The consequences of all this were two CSIRO report numbering systems (either no prefix in the listing and database for Exploration and Mining (majority of reports) or 'EG' prefix for Exploration Geoscience). After the advent of CRC LEME in mid 1995, a CRC LEME Restricted Report number was added to subsequent reports.

All now have CRC LEME Open File Report numbers and it is this numbering system which is used throughout. The CRC LEME Open File Report series has been given a single series ISSN number (1329-4768). Individual ISBN numbers have been allocated to each report volume and another number has been allocated to sets of volumes for multi-volume reports.

Report preparation and replication
As much care as possible has been taken with this re-issue, using the best original material that could be obtained; however, in some instances, original material could not be located so copies were used as the masters. To limit costs, some large, fold-up colour maps (A0) have been reproduced at a reduced size (A1).

INDEX

This index volume consists of maps showing the locations of the study sites. It also contains listings of the reports by LEME Open File Report Number and by the various CSIRO and LEME Restricted Report numbers, by project, by author and by report type.

Maps
Maps have been prepared to show the locations of the investigation sites, and the LEME Open File report numbers to which they refer, projected on Yilgarn bedrock geology (Figure 1) and rainfall information (Figure 2). Some of these locations also refer to sites visited during the field trips (Mt Gibson, Lancefield, Kanowna) and sites from which additional materials were obtained for the Atlas (Greenback, Lancefield).

Listings
Listings have been prepared which are sorted by LEME Open File Report Number, by CSIRO Report Number and by LEME Restricted Report Number, giving the report title, authors, report numbers, original issue date, LEME Open File issue date, and the approximate latitude and longitude of the study site. Brief listings have also been prepared by report type, indicating atlases, final and summary reports, general studies, field guides, site studies, and specialist studies (hydrogeochemistry). The reports are also listed by author and by project.

Index
An index has been prepared from a document of combined titles, authorship and abstracts. This is not an ideal way of indexing - a better way would have been by using the full text of the reports themselves but this was all that could be achieved in the time available and serves as an introduction. This index lists selected subjects by LEME Open File Report numbers.

Compilation of abstracts
A listing of abstracts allows the suitability of the report to be investigated further. The majority of the reports have abstracts but, where reports did not contain abstracts, the executive summary or preface has been used.

Databases and searchable files
During assembly and publication of the Open File reports, a database was produced to control the publication process. Apart from authorship, titles, report numbers, dates of original and subsequent publication, library cataloguing information and geographic coordinates, this included an abstract of each report (if available). The original reference is also supplied. This database has been merged with the database of P240, P240A, P241 and P241A to give a combined database of CSIRO/AMIRA

Yilgarn regolith research. Much more sophisticated searches may be achieved with the database than is possible by using the index.

As software advances, old databases are left stranded and become useless. This database has been supplied as a 'runtime module' that can be used independently of the user's software and may be found on the CD at the back of the volume. It was compiled in *FileMaker Pro* for both the Windows and Macintosh platforms and can be launched as any normal application. All fields in the database have been secured. The reader is advised to read the licensing agreement carefully as breaking of the seal on the CD implies the reader's agreement to its terms. A brief tutorial on the use of *FileMaker Pro* is included at the back of this report.

Geochemical data

Geochemical data has been supplied with some reports on a 3.5" magnetic data disc. Data supplied in this way has a limited life of some 2-6 years. A more permanent storage method is the compact disc (CD). All the data supplied on 3.5" magnetic discs for P252 and P409 have been compiled here and stored on the same CD as the databases and searchable files. The disc is written in ISO format and the data files are in DOS format (some as ASCII files) filed in directories with the appropriate CRC LEME Open File Report Number. Files are generally in tab-delimited format. Many have ReadMe files, stating the content and format.

ACKNOWLEDGEMENTS

CRC LEME acknowledges the AMIRA International and CSIRO Exploration and Mining for authorisation to publish these reports. It is intended that publication of the reports will be a substantial additional factor in transferring technology to aid the Australian Mineral Industry.

Finding the original material of the 27 reports, making the necessary corrections and alterations, document replication and finishing has not been a small task and would have been impossible without the co-operation of a substantial team, apart from the numerous authors. P. Phillips, J. Porter and N. Richardson located and assembled the original material and prepared it for replication. A.D. Vartesi and C.R. Steel assisted with artwork, maps and report covers. A.E. Evans and B. Waugh assisted with keywording and the supply of ISSN and ISBN numbers. Report replication and binding of the reports was by K. Clatworthy (Deluxe Colour & Digital Printing).

For this particular volume, A Cox assisted with GIS skills and R.E. Smith, R.R. Anand and C.R.M. Butt critically reviewed this index volume. The Geological Survey of WA and the Western Australian Waters and Rivers Commission supplied GIS data for the maps at the end of this volume. Uwe Peter compiled the databases into run-time modules. All this assistance is acknowledged with appreciation.

LIST OF REPORTS

Sorted by CRC LEME Open File Report Number

DATABASE OF CRC LEME OPEN FILE REPORTS 85-111 ©CRC LEME

Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Geochemical exploration for platinum group elements in weathered terrain - - P252 Final Report	Butt, C.R.M., Williams, P.A., Gray, D.J., Robertson, I.D.M., Schorin, K.H., Churchward, H.M., McAndrew, J., Barnes, S.J. and Tenhaeff, M.F.J.	85	March 2001		EG 332R	1992/12	Australia
Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, Western Australia: Final Report	Butt, C.R.M., Gray, D.J., Robertson, I.D.M., Lintern, M.J., Anand, R.R., Britt, A.F., Bristow, A.P.J., Munday, T.J., Phang, C., Smith, R.E. and Wildman, J.E.	86	January 2001	036R	333R	1997/02	Yilgarn
Atlas of transported overburden	Robertson, I.D.M., Koning, A.E.M., Anand, R.R. and Butt C.R.M.	87	January 2001	014R	296R	1996/12	Yilgarn
Progress statement for the Kalgoorlie study area - Steinway Prospect, Western Australia	Lintern, M.J. and Gray, D.J.	88	January 2001		095R	1995/01	30°59'00"S, 121°29'02"E

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Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Progress statement for the Kalgoorlie study area - Kurnalpi *Prospect*, *Western* Australia	Lintern, M.J. and Gray, D.J.	89	January 2001		097R	1995/01	30°33'S, 122°12'E
Progress statement for the Kalgoorlie study area - Enigma Prospect (Wollubar), Western Australia	Lintern, M.J. and Gray, D.J.	90	January 2001		098R	1995/01	31°04'06"S, 121°36'59"E
Investigation of the hydrogeochemical dispersion of gold and other elements at Lawlers, Western Australia	Gray, D.J.	91	January 2001		026R	1994/08	27°58'S, 120°23'E
Regolith geology and geochemistry Mt *Magnet District* - Geochemical orientation studies, Stellar and Quasar deposits	Robertson, I.D.M., King, J.D., Anand, R.R. and Butt, C.R.M.	92	March 2001		048C	1994/07	Quasar 28°05'29"S, 117°47'53"E; Stellar 28°02'58"S, 117°46'47"E

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Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Investigation of the hydrogeochemical dispersion of gold and other elements from mineralised zones at the Granny Smith Gold Deposit, Western Australia	Gray, D.J.	93	March 2001		EG 383R	1993/03	28°48'S, 122°25'E
The regolith geology and geochemistry of the area around the Harmony Gold Deposit, (Baxter Mining Centre), Peak Hill, Western Australia	Robertson, I.D.M., Phang, C. and Munday, T.J.	94	March 2001	005R	194R	1996/06	25°39'10"S, 118°37'50"E
Geochemical studies of the soil at the Runway Gold Prospect, Kalgoorlie, Western Australia	Lintern, M.J.	95	March 2001	026R	250R	1996/11	30°39'S 121°28'E
Selective extraction techniques for the recognition of buried mineralization, Curara Well, Western Australia	Gray, D.J.	96	March 2001	009R	210R	1996/02	28°41'48"S, 117°46'44"E

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Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Hydrogeochemical dispersion of gold and other elements at Baxter, Western Australia	Gray, D.J.	97	May 2001	003R	169R	1995/11	25°39'10"S,118°37'50"E
Progress statement for the Kalgoorlie study area - Argo deposit, Western Australia	Lintern, M.J. and Gray, D.J.	98	May 2001		096R	1995/01	31°24'S, 121°47'E
Hydrogeochemistry in the Yilgarn Craton	Gray, D.J.	99	May 2001	021R	312R	1996/09	Yilgarn
Further geochemical studies of the soil at the Steinway Gold Prospect, Kalgoorlie, Western Australia	Lintern, M.J. and Craig, M.A.	100	May 2001	027R	252R	1996/11	30°59'00"S, 121°29'02"E

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Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Further geochemical studies of the soil at the Panglo Gold Deposit, Kalgoorlie, Western Australia	Lintern, M.J.	101	May 2001	010R	251R	1996/11	30°30'S, 121°23'E
The distribution of gold and other elements in surficial materials form the Higginsville palaeochannel gold deposits, Norseman, Western Australia	Lintern, M.J., Craig, M.A., Walsh, D.M. and Sheridan, N.C.	102	June 2001	028R	275R	1996/11	31°46'30"S, 121°45'00"E
Geochemical studies of the soil and vegetation at the Apollo Gold Deposit, Kambalda, Western Australia	Lintern, M.J.,Craig, M.A. and Carver, R.N.	103	June 2001	030R	274R	1997/01	31°23'40"S, 121°46'20"E
Geochemical expression of concealed gold mineralization, Safari Prospect, Mt Celia, Western Australia	Bristow, A.P.J., Lintern, M.J. and Butt, C.R.M.	104	June 2001	013R	281R	1996/07	29°32'S, 122°30'E

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Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Geochemical dispersion in transported and residual regolith, Fender Gold Deposit, Cue, Western Australia	Butt, C.R.M.	105	June 2001	022R	313R	1996/08	27°20'36"S, 117°37'58"E
Geochemical and spatial characteristics of regolith and groundwater around the Golden Delicious Prospect, Western Australia	Bristow, A.P.J., Gray, D.J. and Butt, C.R.M.	106	June 2001	015R	280R	1996/08	29°01'S, 122°28'E
Selective and partial extraction analyses of transported overburden for exploration in the Yilgarn Craton and its margins	Gray, D.J., Wildman, J.E. and Longman, G.D.	107	June 2001	016R	305R	1996/12	Yilgarn
Regolith-landscape evolution and geochemical dispersion about the Bronzewing Gold Deposit, WA	Varga, Z.S., Anand, R.R. and Wildman, J.E.	108	June 2001	018R	308R	1997/03	27°22'S, 121°00'E

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Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Eastern Goldfields Field Excursion Field Guide	Butt, C.R.M., Smith, R.E., Dell, M., Anand, R.R.,Lintern, M.J., Gray, D.J., Vinar, J., Bristow, A.P.J., Churchward, H.M., Varga, Z.S. and Wildman J.E.	109	June 2001	004R	253R	1996/05	Yilgarn
Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs - Murchison Field Trip	Butt, C.R.M., Robertson, I.D.M., Anand, R.R., King, D.J., Munday, T.J., Phang, C and Smith, R.E.	110	June 2001		164R	1995/09	Yilgarn
Supplementary notes and regolith map for the Enigma Prospect (Wollubar), Kalgoorlie, Western Australia	Craig, M.A., Lintern, M.J. and Gray, D.J.	111	June 2001	033R	339R	1997/02	31°02'S, 121°34'E

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Sorted by CSIRO Report Number

Note: In CSIRO Report Number field :-
1) Leading zeros have been added to facilitate sorting - they are not normally referred to.
2) Numbers without a prefix are Division of Exploration and Mining reports.
3) Numbers prefixed with EG were produced during the tenure of the Division of Exploration Geoscience and are sorted at the end.

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Title	Authors	CRC LEME O/F ReptNo	Open File Date	LEME Restricted ReptNo	E&M Restricted ReptNo	Restricted Rept Date	Lats & Longs
Investigation of the hydrogeochemical dispersion of gold and other elements at Lawlers, Western Australia	Gray, D.J.	91	January 2001		026R	1994/08	27°58'S, 120°23'E
Regolith geology and geochemistry Mt Magnet District - Geochemical orientation studies, Stellar and Quasar deposits	Robertson, I.D.M., King, J.D., Anand, R.R. and Butt, C.R.M.	92	March 2001		048C	1994/07	Quasar 28°05'29"S, 117°47'53"E; Stellar 28°02'58"S, 117°46'47"E
Progress statement for the Kalgoorlie study area - Steinway Prospect, Western Australia	Lintern, M.J. and Gray, D.J.	88	January 2001		095R	1995/01	30°59'00"S, 121°29'02"E
Progress statement for the Kalgoorlie study area - Argo deposit, Western Australia	Lintern, M.J. and Gray, D.J.	98	May 2001		096R	1995/01	31°24'S, 121°47'E

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Progress statement for the Kalgoorlie study area - Enigma Prospect (Wollubar), Western Australia	Lintern, M.J. and Gray, D.J.	90	January 2001		098R	1995/01	31°04'06"S, 121°36'59"E
Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs - Murchison Field Trip	Butt, C.R.M., Robertson, I.D.M., Anand, R.R., King, D.J., Munday, T.J., Phang, C and Smith, R.E.	110	June 2001		164R	1995/09	Yilgarn
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Selective extraction techniques for the recognition of buried mineralization, Curara Well, Western Australia	Gray, D.J.	96	March 2001	009R	210R	1996/02	28°41'48"S, 117°46'44"E
Geochemical studies of the soil at the Runway Gold Prospect, *Kalgoorlie*, Western Australia	Lintern, M.J.	95	March 2001	026R	250R	1996/11	30°39'S 121°28'E
Further geochemical studies of the soil at the Panglo Gold Deposit, Kalgoorlie, Western Australia	Lintern, M.J.	101	May 2001	010R	251R	1996/11	30°30'S, 121°23'E

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Eastern Goldfields Field Excursion Field Guide	Butt, C.R.M., Smith, R.E., Dell, M., Anand, R.R.,Lintern, M.J., Gray, D.J., Vinar, J., Bristow, A.P.J., Churchward, H.M., Varga, Z.S. and Wildman J.E.	109	June 2001	004R	253R	1996/05	Yilgarn
Geochemical studies of the soil and vegetation at the Apollo Gold Deposit, Kambalda, Western Australia	Lintern, M.J.,Craig, M.A. and Carver, R.N.	103	June 2001	030R	274R	1997/01	31°23'40"S, 121°46'20"E
The distribution of gold and other elements in surficial materials form the Higginsville palaeochannel gold deposits, Norseman, Western Australia	Lintern, M.J., Craig, M.A., Walsh, D.M. and Sheridan, N.C.	102	June 2001	028R	275R	1996/11	31°46'30"S, 121°45'00"E

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Hydrogeochemistry in the Yilgarn Craton	Gray, D.J.	99	May 2001	021R	312R	1996/09	Yilgarn
Geochemical dispersion in transported and residual regolith, Fender Gold Deposit, Cue, Western Australia	Butt, C.R.M.	105	June 2001	022R	313R	1996/08	27°20'36"S, 117°37'58"E
Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, Western Australia: Final Report	Butt, C.R.M., Gray, D.J., Robertson, I.D.M., Lintern, M.J., Anand, R.R., Britt, A.F., Bristow, A.P.J., Munday, T.J., Phang, C., Smith, R.E. and Wildman, J.E.	86	January 2001	036R	333R	1997/02	Yilgarn

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Supplementary notes and regolith map for the Enigma Prospect (Wollubar), Kalgoorlie, Western Australia	Craig, M.A., Lintern, M.J. and Gray, D.J.	111	June 2001	033R	339R	1997/02	31°02'S, 121°34'E
Geochemical exploration for platinum group elements in weathered terrain - - P252 Final Report	Butt, C.R.M., Williams, P.A., Gray, D.J., Robertson, I.D.M., Schorin, K.H., Churchward, H.M., McAndrew, J., Barnes, S.J. and Tenhaeff, M.F.J.	85	March 2001		EG 332R	1992/12	Australia
Investigation of the hydrogeochemical dispersion of gold and other elements from mineralised zones at the Granny Smith Gold Deposit, Western Australia	Gray, D.J.	93	March 2001		EG 383R	1993/03	28°48'S, 122°25'E

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Progress statement for the Kalgoorlie study area - Kurnalpi Prospect, Western Australia	Lintern, M.J. and Gray, D.J.	89	January 2001		097R	1995/01	30°33'S, 122°12'E
Progress statement for the Kalgoorlie study area - Enigma Prospect (Wollubar), Western Australia	Lintern, M.J. and Gray, D.J.	90	January 2001		098R	1995/01	31°04'06"S, 121°36'59"E
Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs - Murchison Field Trip	Butt, C.R.M., Robertson, I.D.M., Anand, R.R., King, D.J., Munday, T.J., Phang, C and Smith, R.E.	110	June 2001		164R	1995/09	Yilgarn

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The regolith geology and geochemistry of the area around the Harmony Gold Deposit, (Baxter Mining Centre), Peak Hill, Western Australia	Robertson, I.D.M., Phang, C. and Munday, T.J.	94	March 2001	005R	194R	1996/06	25°39'10"S, 118°37'50"E

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P409 Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, WA.
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ABSTRACTS

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OPEN FILE REPORT 85

Geochemical exploration for platinum group elements in weathered terrain - - P252 Final Report

Butt, C.R.M., Williams, P.A., Gray, D.J., Robertson, I.D.M., Schorin, K.H., Churchward, H.M., McAndrew, J., Barnes, S.J. and Tenhaeff, M.F.J.

This report summarizes the results of over three years of research that had the objectives of (i) supplementing existing knowledge of the aqueous geochemistry of platinum group elements (PGE) in the weathering environment, (ii) obtaining information concerning the distribution of these elements in the lateritic regoliths and the potential for supergene enrichment, and (iii) establishing criteria for exploration in lateritic terrain. These objectives were met by conducting detailed laboratory experiments and field-based geochemical investigations.

Laboratory studies demonstrated that, in addition to chloride ion and organic compounds, thiosulphate ion and arsenious acid could mobilize the PGE under weathering conditions. Mobilization as thiosulphate complexes might occur in the vicinity of sulphides oxidizing under neutral to alkaline conditions, whereas arsenious acid could only mobilize Pd. and then only in acid environments. The potential for mobilization by these ligands has not previously been considered, but may have significance in appropriate environments. Studies were also made of the processes that cause immobilisation of the PGE in the regolith. The PGE tend to be sorbed by most regolith materials, thus restricting their potential mobility, although in more organic samples, some redissolution occurred after a few months, possibly due to soluble organic species produced by biological activity. The results demonstrate that despite the theoretical models postulating mobility under specific physico-chemical conditions, the substrate will strongly influence the actual behaviour.

Field investigations on the distribution of PGE were carried out on the Ora Banda Sill, Western Australia, and the Tout Intrusion at Fifield, New South Wales. Lateritic regoliths are well preserved on the pyroxenites of the Ora Banda Sill and the duricrusts locally contain 1-2 ppm Pt + Pd. There has been some relative loss of Pd in the duricrust and, particularly, the ferruginous lag derived from it, but otherwise there seems to have been little mobilization of the PGE. The PGE enrichment appears to be residual and occurs in similar horizons, and by a similar factor, as other relatively immobile elements such as Cr, Cu, V, Ti and Zr. No PGE minerals or alloys were found in the regolith and selective leaching experiments suggest that both Pt and Pd occur predominantly in the minus 2 μm fraction. Platinum is mainly associated with hematite throughout the profile, implying early release from its primary host; in comparison, Pd is present in goethite, but only high in the profile, and is presumed to be released from a primary phase (e.g., chromite) late during weathering. Chromite compositions can discriminate between peridotite and pyroxenite in the regolith and could possibly be useful for indicating sulphide-rich zones within the bedrock. There has been rather greater secondary mobility of PGE, especially Pt. in the regolith over the serpentinized dunites of the Tout Complex, but again no secondary PGE phase was located and the mechanism of remobilisation could not be established, although organic or chloride complexes are most probable. PGE enrichment in alluvium is probably mechanical.

The surface exploration procedures of soil and lag sampling are effective in exploration in lateritic environments. Routine sampling of the laterite itself by shallow drilling may be the best general procedure, especially in areas where much of the laterite is buried. High Pt and Pd concentrations are themselves insufficient indicators, so that it is probably necessary to analyse selected samples for the other PGE. Copper, Cr and Ni are not effective pathfinder elements for none is necessarily associated with primary or secondary mineralisation at either Ora Banda or Fifield. The restricted mobility of the PGE and lack of suitable pathfinder elements may pose problems to effective exploration of areas eroded to the saprolite or

shallow fresh subcrop, since the target will be small and any enlargement is thus dependent on limited physical dispersion at the surface.

OPEN FILE REPORT 86

Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, Western Australia: Final Report

Butt, C.R.M., Gray, D.J., Robertson, I.D.M., Lintern, M.J., Anand, R.R., Britt, A.F., Bristow, A.P.J., Munday, T.J., Phang, C., Smith, R.E. and Wildman, J.E.

Areas with substantial transported overburden present some of the most significant exploration problems in the Yilgarn Craton and its environs, as well as in many other parts of Australia. It is estimated that such overburden conceals as much as 50% of the prospective terrain in the region, and greatly exceeds this in some districts. The previous and current AMIRA projects, Yilgarn Lateritic Environments (projects P240 and P240A) and Weathering Processes (P241, P241A), have shown that research can result in markedly improved methods of exploration in areas of transported cover and this project developed these further by studies of geochemical dispersion in a range of different depositional environments. Geochemical techniques are perceived to have considerable, but largely untested, potential in these environments. This project sought to investigate this potential. The aim has been to develop, if possible, suitable exploration geochemical methods for sediment-covered areas based upon an improved knowledge of the nature of the cover sequences and by reaching a better understanding of the mechanisms of element dispersion that may occur within them. To reach this end, a number of districts and sites were selected with the aid of the sponsoring companies and, following further selection based on some pilot studies, detailed investigations made at those that best typified many of the problems being encountered. The outcomes of these specific studies are given in the various investigation reports issued during the project; the purpose of this report is to summarize these results and to develop some more general conclusions and recommendations.

OPEN FILE REPORT 87

Atlas of transported overburden

Robertson, I.D.M., Koning, A.E.M., Anand, R.R. and Butt C.R.M.

The Atlas has an introductory review of the various types of transported overburden on the Yilgarn Craton, and its margins, including their age, stratigraphy, distributions, depositional environments and provenances. The sediments have been classified by an extension of the scheme developed initially for lateritic and other ferruginous materials. This is followed by a discussion of the general procedures for chemically characterising and discriminating various typs of transported overburden and discriminating between sediments and weathered basement.

The Atlas proper contains detailed descriptions of the principal sediments that comprise the transported overburden types at selected, well-characterised sites. At each site, their field relationships, field appearances, microfabrics and chemical and mineralogical compositions are characterised and illustrated. Where possible, aspects of the distributions, thickness and thickness variations of the sediments have been determined and documented, to assist in mapping regolith stratigraphy from drill cuttings and core. For each type of sediment, the principal criteria are given to distinguish it from the underlying residual regolith. These criteria tend to be site-specific but they indicate what could be applied to make this very important distinction.

It is estimated that as much as 50% of the prospective terrain of the Yilgarn, and substantially more in some districts, is concealed beneath transported overburden which, itself, commonly overlies highly weathered residuum. Thus, it presents one of the most significant challenges to exploration in the region. Effective exploration for mineralisation within and beneath these sediments requires reliable recognition of the transported overburden. The overburden ranges in age from Permian to recent; the older sediments have shared the intense weathering that has affected the basement rocks, so that discrimination between the transported and residual units of the regolith can be very difficult, particularly from drill cuttings. In many places, two or more sedimentary sequences, of quite different ages, may overlie the basement.

This Atlas provides an overview of the types of transported overburden, environments of deposition, relationships to the main period of weathering and a scheme for classification. It documents examples of the main types of transported overburden, provides stratigraphic and distribution information, mineralogy and chemical compositions. Possible means of making the important basement-cover distinction are provided for each site.

Examples of the principal types of transported overburden were collected from many sites used for other investigations in the Project (Figure 1). Their degree of transportation varies from materials such as palaeosols and lateritic residuum, in which only minor movement has occurred by settling and colluvial mass flow during their formation, to polymictic, alluvial sediments of varying ages, with diverse, distal provenances.

Types of transported overburden include Permian fluvioglacial tills (Lancefield - Laverton), collapsed lateritic residuum (Red Lake), collapsed ferruginous saprolite (Bronzewing), lateritic conglomerate (Ora Banda), vallye fill clays and sands of palaeochannels (Greenback and Peak Hill), lateritic colluvium (Mt Magnet and Peak Hill), gravelly sediments (Golden Delicious and Fender), valley calcrete (Lake Way and Yeelerie) and dune sand (Laverton).

OPEN FILE REPORT 88

Progress statement for the Kalgoorlie study area - Steinway Prospect, Western Australia

Lintern, M.J. and Gray, D.J.

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

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

OPEN FILE REPORT 89

Progress statement for the Kalgoorlie study area - Kurnalpi Prospect, Western Australia

Lintern, M.J. and Gray, D.J.

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

i). Gold in surficial horizons;

ii). Sub-surface gold in transported overburden;

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

This progress statement summarizes the recent investigations undertaken at the Kurnalpi Au deposit (Mt Kersey Mining N.L.) located 70 km NE of Kalgoorlie. The Kurnalpi site was chosen for further study for several reasons including the moderate grades of Au mineralization and the remoteness of the deposit from potential contributing upstream sources.

The results indicate:

1). Total, water-soluble and iodide soluble Au exhibit no anomalies over mineralization.

2). Gold is associated with Ca in the top metre of the soil profile.

3). Arsenic may be a useful pathfinder element in lateritic material at the palaeosurface.

More information needs to be gathered from the Kurnalpi area. Specifically, there is a need:

1. to analyse buried lateritic material for As as well as Au. Arsenic appears to be associated with mineralization and has also been found in high concentrations in the lateritic samples analysed thus far.

2. to obtain Mn and other element data for the two remaining auger traverses to examine whether anomalous values occur over the palaeochannel as with Traverse 2. If Mn and other associated element anomalies are located over the palaeochannel for all 3 traverses then there is a further need to test whether the anomalies can be enhanced or decreased using selective extraction techniques that dissolve Mn oxides.

OPEN FILE REPORT 90

Progress statement for the Kalgoorlie study area - Enigma Prospect (Wollubar), Western Australia

Lintern, M.J. and Gray, D.J.

Investigations from previous AMIRA Projects have indicated that Au deposits may have geochemical expression throughout the regolith. In Project 409, knowledge gained from these earlier projects, dominantly in areas of erosional and relict landforms, is being extended to determine whether previously developed methods can be applied or adapted to depositional regimes. In the Kalgoorlie area, the work program has been to investigate potential sample

media in the transported regolith above mineralization at a number of dominantly palaeochannel environments. Specifically, the study has investigated the presence of:

i). Gold in surficial horizons;

ii). Sub-surface gold in transported overburden;

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

This progress statement summarizes the recent investigations undertaken at the Enigma Au deposit located 30 km southeast of Kalgoorlie. The Enigma site was chosen for further study for several reasons including the moderate Au grades in mineralization and the remoteness of the deposit from potential contributing upstream sources.

The results indicate:

1. that total, water-soluble and iodide-soluble gold have no anomalies over mineralization.

2. that gold is associated with calcium in the top metre of the soil profile.

3. that gold in vegetation does not define the location of the mineralization.

4. drilling to the south of the Enigma deposit possibly has not gone deep enough.

5. cobalt, copper, molybdenum, lead, antimony and tungsten may be useful pathfinders for gold mineralization.

More information needs to be gathered from the Enigma area. Specifically, there is a need:

1). to construct regolith sections and plans for the area

2). to detail important type sections for drilling programs which should be also verified by others; this could be easily achieved by archiving chip trays.

3). to collect further samples of ferruginous material from transported overburden, and material from saprolite and bedrock and analyse for tungsten and possibly cobalt, copper, molybdenum, lead and antimony.

OPEN FILE REPORT 91

Investigation of the hydrogeochemical dispersion of gold and other elements at Lawlers, Western Australia

Gray, D.J.

The hydrogeochemistry of the Lawlers district was investigated, with a view to understanding the interaction of groundwaters with mineralized rocks, and the potential for exploration, particularly in areas of extensive overburden. Groundwaters at Lawlers are neutral, with a similar Eh range to other neutral groundwaters. However, they differ from groundwaters investigated at other Yilgarn sites in having low salinities and marked divergence from sea water ratios, suggesting that the major ion concentrations are strongly controlled by local lithological or hydrological factors. Elements that appear to be controlled by mineral equilibration in some or all groundwaters are Ba (barite equilibration), Ca, Mg and HCO_3 (carbonate), Mn (rhodochrosite), Sb [$Sb(OH)_3$], Pb and V ($Pb_2V_2O_7$).

The most marked feature of the Lawlers groundwaters is the extremely high Au concentrations, with the highest observed concentration of 40 µg/L being about ten times greater than any other previously reported values. These high concentrations are correlated with highly anomalous Co concentrations at Hidden Secret and in the Gt. Eastern/Caroline pits area but not at Genesis. Under the groundwater conditions observed at Lawlers, the most likely mechanism for dissolution is expected to be as the thiosulphate complex $Au(S_2O_3)^{23-}$.

The generation of thiosulphate requires oxidation of sulphides to occur under neutral conditions, with the acidity produced being neutralized by the dissolution of minerals such as primary carbonates. This is consistent with limited results at Hidden Secret suggesting that higher Au concentrations are correlated with increased Mg, Ca, HCO_3 (from carbonate dissolution) and SO_4 (from sulphide oxidation).

Most of the specific sites investigated showed specific groundwater element anomalies:

(i) Hidden Secret - Au, TDS, SO_4, P, Mn, Fe, Co, Ni, Y, REE, W, As, Sb, I, U, and possibly Ba, Ga, Sc and Ge;

(ii) Genesis - Au, Sc, As, and possibly Ni and Sb;

(iii) mineralization at Gt. Eastern / Caroline - Au, Co, and possibly SO_4, Sc and As;

(iv) mineralization at Four Corners - SO_4, Al, Ga, Mn, Fe, Co, Ni and Mo (though generally based on only one sample at the centre of the mineralized area);

(v) granitic rocks at Gt. Eastern / Caroline - Al, Ga, Ba, Mn, Mo and U;

(vi) ultramafic rocks - Cr, Cs and Sr;

(vii) southern part of Four Corners - TDS, B, Sr, HCO_3, I and U (possibly indicating a different groundwater system in this area).

The differences in the minor element 'signatures' for the groundwaters in areas of major Au mineralization (Genesis, Gt. Eastern/Caroline, Hidden Secret) may reflect differences in the lithologies of the three sites and/or the geochemistry of the Au mineralization. The Gt. Eastern/Caroline and Hidden Secret groundwaters have groundwater signatures similar to other mineralized sites elsewhere in the Yilgarn, with anomalies in a range of chalcophile and other pathfinder elements. In contrast, groundwaters at Genesis are anomalous in only Au, Sc and As, possibly due to the Genesis ore deposit being hosted in a quartzite unit with free-milling Au and disseminated arsenopyrite.

At the Four Corners area, which is covered with extensive transported overburden, there are anomalous concentrations of varying elements (but not Au), with size of the groundwater anomaly appearing to be less than 250 m diameter. The exception to this is SO_4, which has a more disperse anomaly.

Groundwater at Lawlers appears to have exploration potential, particularly in the residual areas. In areas of extensive transported overburden, there is no observed groundwater Au response, though some elements (SO_4, Ga, transition metals, Mo) may have potential as pathfinders for Au.

OPEN FILE REPORT 92

Regolith geology and geochemistry Mt Magnet District - Geochemical orientation studies, Stellar and Quasar deposits

Robertson, I.D.M., King, J.D., Anand, R.R. and Butt, C.R.M.

Recent exploration under the lag-strewn colluvium-alluvium covered plain, mantling the Boogardie Synform, has located concealed Au mineralisation at Stellar and Quasar. The area is difficult to explore due to structural complexity in the basement, high geochemical backgrounds from numerous mineralised settings, a variably stripped, residual regolith beneath the transported overburden and scattered, high Au contents in the overburden. Pit exposures at Stellar and drilling at Quasar also revealed palaeochannel sediments hidden beneath the colluvium.

Regolith-landform relationships in the district were established by mapping the regolith of an area of 25 km2 around the mines and inspecting drill cuttings and pit exposures. A palaeochannel, filled with mega-mottled, grey clay and sandy clay, with some sepiolite towards the top and detrital, ferruginous, lateritic nodules, pisoliths and authigenic black granules towards the base, is exposed at Stellar. At Quasar, a similar palaeochannel occurs south-west of the pit and was detected by drilling. These fluvial channels appear to have been incised in already weathered basement and the sediments themselves have undergone post-depositional weathering. At Stellar, a clay-rich lateritic duricrust has formed by the weathering and later cementation of a partly transported unit overlying both the felsic and mafic-ultramafic bedrocks. Contemporary weathering of clays in the palaeochannel was probably responsible for the development of mega-mottles and some ferruginous granules. The colluvial-alluvial overburden was derived from dismantling the lateritic regolith. It contains lateritic nodules and pisoliths, probably from a proximal source, but is dominated by polymictic fragments, including BIF, ferruginous saprolite and saprolite, set in a silty-clay matrix. Its upper 2-3 m is silicified to red-brown hardpan.

Analytical data for a suite of 24 elements was provided by Hill 50 NL; the Ti and Zr data were unreliable and not used. Although geochemical backgrounds and thresholds have been established for the major regolith units, these must be regarded as of local application only because no data from distant background areas was available. Elevated concentrations of Cr, Ni, Cu, V and, possibly, Zn indicate mafic-ultramafic rocks. The saprolite and mottled zone have a significantly greater Cr/Fe ratio than the transported materials. Although the laterite has a high Cr/Fe ratio, Cr and Ni were ineffective for discriminating between laterites developed over felsic and mafic-ultramafic rocks. Regolith differentiation can be improved by canonical analysis; the most useful elements appear to be Al, Fe, Ni, Cr, Ga, Y, Zn, Th and Cu.

The Au mineralisation is poor in pathfinder elements such as As and Sb but there are weak anomalies in Bi and Pb. There is no correlation between the composition of the basement and the overlying colluvium, nor between nearly adjacent layers within the colluvium and its overlying lag. Unless partial extraction geochemistry can indicate basement-related anomalies in the colluvium-alluvium, this blanket must be penetrated to reach the weathered Archaean beneath. Comparison of sampling the top of the basement with that of the unconformity, or interface, between basement and colluvium, indicates lower order but broader and more consistent anomalies in the interface; this can be improved using additive indices of Bi, Pb and Zn. The interface sample is, therefore, the preferred sample medium, in this area of buried, stripped regolith, except where there are palaeochannels. Where there has been less regolith stripping and a buried laterite occurs, as at Stellar, this is the preferred sample medium.

OPEN FILE REPORT 93

Investigation of the hydrogeochemical dispersion of gold and other elements from mineralised zones at the Granny Smith Gold Deposit, Western Australia

Gray, D.J.

The hydrogeochemistry, and in particular, the usefulness of groundwater as an exploration medium, has been tested at the Granny Smith gold deposit. Two different sample treatment methods were used and compared:

(i) no field treatment - samples filtered and acidified in the laboratory about 10 days later;

(ii) samples filtered and acidified in the field.

The latter procedure is most commonly followed in groundwater investigations. Comparisons of the results indicated that agreement between the two methods was generally good, except for Fe, Al and, to a lesser extent, Au. However, given the importance of these elements in exploration and for understanding hydrogeochemical processes, it is recommended that the latter method be used.

Groundwaters at Granny Smith are generally neutral, with variable salinity. The waters appear to be depleted in Mg, K and Br, suggesting that halite (NaCl) is dissolving in the groundwater and displacing these ions. Additionally, there is a minor enrichment in Ca and SO4 in the less saline samples, which is possibly due to gypsum (CaSO4.2H2O) dissolution.

Although the hydrogeochemistry of the minor elements at Granny Smith is similar to that of other Yilgarn sites, dissolved Au concentrations at Granny Smith are very low and, indeed, are not much higher than sea water. The reasons for this are not understood, but the potential for dissolved Au alone as an exploration tool in this area is predicted to be poor.

One additional problem at this site is that the groundwater system appears to be highly stratified. Samples obtained via dewatering bores appear to be representative of a deep saline system, whereas those obtained using a bailing system appear to be sampling more shallow, fresher, groundwater. At Windich, mineralization occurs at depth, and the water samples, which were all obtained by bailer, do not appear to be from groundwater contacting mineralization. This may explain why the dissolved Au concentrations in the Windich groundwater samples are very low.

At the Goanna and Granny pits, the water samples are obtained from the dewatering bores, and appear to be in contact with primary Au mineralization. Samples in areas of high Au grade are enriched in Au (relative to Windich), As, Co, Mn, Mo, Ni, Pb, Sb, Tl and Zn, presumably reflecting the geochemistry of the Au mineralization. Arsenic, Mo, Sb and Tl are commonly associated with Au mineralization, whereas Pb and Zn enrichments may reflect associated galena (PbS) and sphalerite (ZnS), and Mn, Co and Ni have been observed to be enriched in mineralized groundwaters at other sites. Thus, this multi-element association may offer scope for exploration.

There is also some potential for elements which may be associated with mineralization, but which are soluble and tend to be readily dispersed, as a regional groundwater exploration tool. These possibly include As, I and Cs. However, further sampling distant from mineralization would be required to test this possibility.

The generally low Au concentrations in all of the groundwater samples, and the major inconsistency between results for Goanna and Granny and those for Windich, suggest that hydrogeochemistry would not be a very useful exploration method in this area. However, the reasons for these effects are only partially understood. Further work in similar, though hopefully less disturbed areas, may be of value in fully understanding the hydrogeochemistry of such deposits.

OPEN FILE REPORT 94

The regolith geology and geochemistry of the area around the Harmony Gold Deposit, (Baxter Mining Centre), Peak Hill, Western Australia

Robertson, I.D.M., Phang, C. and Munday, T.J.

Primary Au mineralisation at Harmony is associated with quartz veins but is low in sulphides. Gold and W (scheelite) are the most significant indicators in mineralised fresh rock at Harmony, supplemented by Ta and Nb. Elements associated with a phyllic alteration halo are K, Rb and Ba. Some REE, namely Eu, Lu and Yb, increase in abundance and range near

mineralisation for reasons that are not clear yet. Although As and Sb are elevated, their abundances are not as great as for other, sulphide-rich mineralisation styles.

The Harmony Au deposit was completely covered by a blanket of soil and colluvium. Drilling beneath this revealed a complex regolith of weathered and partly lateritised Proterozoic basement, clay-rich valley fill sediments and colluvium. Logging the main regolith units produced a 3D regolith model which provided a valuable guide to sampling and later interpretation. The basement has been eroded and weathered and consists of mafic and ultramafic metavolcanics and fine-grained metasediments. The higher parts of this basement are of ferruginous saprolite, the axes of the palaeovalleys are largely of saprolite and mottled zone and are deeply weathered. Lateritic residuum occupies the flanks of the palaeo-relief.

The colluvium varies from 0.5 m over parts of Harmony deposit to 20 m over the palaeovalleys and probably contained some alluvium where the cover was at its deepest. It presents a significant hindrance to exploration. The base of the colluvium is complex in places, being a mixture of saprolite blocks included in what appears to have been a palaeosol.

The palaeovalleys have been infilled with smectite-kaolinite sediments, probably derived from the surrounding saprolites. Hematitic, manganiferous and dolomitic mega-mottles have developed in these sediments and the tops of some valley-fill sediments contain pisolitic structures. All this indicates intense post-depositional weathering both at the surface and at oxidation fronts within the sedimentary pile. Parts of the valley-fill sediments were eroded prior to deposition of the colluvium.

Sampling of the top of the basement (ferruginous saprolite, lateritic residuum and mottles washed from the mottled zone) on a 250 m sample spacing showed significant Au and W anomalies in the vicinity of the Harmony mineralisation. Au dispersion in the ferruginous saprolite is restricted and requires close-spaced sampling (50 m). Some elements (Si, Fe, Cr, Zr, Hf, V, Rb, Ba, As and Sb) are influenced to some extent by the distribution of regolith types. Data normalisation to the modes of background populations removed most of this dependency. Gold and W anomalies were unchanged.

The unconformity between the stripped basement and the colluvium was tested, using a 150 m sample spacing as an alternate to ferruginous saprolite sampling in the vicinity of mineralisation. This capitalised on any mechanical dispersion, soil dispersion or hydromorphic permeation along the unconformity that may have developed during or since deposition of the colluvium. Dispersions of Au, W, Ta and Nb along this interface, indicating mechanical down-slope migration, produced better anomalies than the basement sampling in this stripped environment.

The geochemistry of the valley fill sediments indicated probable leaching of Au, even where a small clay-filled palaeovalley had drained the Harmony Au deposit; however W was mechanically dispersed here. The soil fine fraction (<75 μm) may not be relied upon to locate mineralisation, even though some very weak Au anomalies appeared where the colluvial cover over the Harmony mineralisation was extremely thin (~0.5 m).

OPEN FILE REPORT 95

Geochemical studies of the soil at the Runway Gold Prospect, Kalgoorlie, Western Australia

Lintern, M.J.

The CSIRO-AMIRA Project "Exploration in Areas of Transported Overburden, Yilgarn Craton and Environs" (Project 409) has, as its principal objective, development of geochemical methods for mineral exploration in areas with substantial transported overburden, through investigations of the processes of geochemical dispersion from

concealed mineralization. The Project has two main themes. One of these, *'Surface and subsurface expression of concealed mineral deposits is* addressed by this report, which focuses on the soil geochemistry of the Runway Au prospect (Kalgoorlie Area).

This study is located in the northern part of the Runway Au prospect where the thickness of transported material is less than 2 m, and the depth to mineralization (beneath barren saprolite) is of the order of 50 m. While the thickness of transported material is not substantial, the great thickness of barren saprolite provides an important contrast with depositional terrain environments from the Kalgoorlie area which have similar thicknesses of barren overburden. It is considered that a detailed study of the nature of Au in surficial material from such an environment will enhance our understanding of the processes whereby Au may (or may not) be enriched in the surficial environment in areas of substantially transported material.

The results for this study are summarized below:

1. Surficial samples (0 - 2 m) are anomalous in Au, As, Sb and W. Multi-element geochemistry may be a useful adjunct exploration tool in this area since data from KCGM indicate that As, Sb and W are associated with mineralization.

2. Gold appears to be associated with carbonate in surficial material, but it is also present in saprolite, which occurs close to the surface.

3. Partial extraction techniques indicate that the proportions of water-soluble Au are lower and iodide-soluble Au higher than for areas of deeply transported cover.

4. Biogeochemical data indicate that some Au is present in bluebush samples overlying mineralization but that the data are close to detection.

5. Selection and analysis of components within samples may be used to enhance concentrations in excess of the bulk sample concentration for selected elements; Au concentrations may be higher in the calcareous and/or ferruginous granule component of the sample.

OPEN FILE REPORT 96

Selective extraction techniques for the recognition of buried mineralization, Curara Well, Western Australia

Gray, D.J.

The Curara site was selected for initial investigations of the utility of partial/selective extraction for mineral exploration in the Yilgarn. There are up to 20 m of barren transported overburden over laterite, which is enriched in Au above primary mineralization. It was considered that MMI (mobile metal ion) extractions were successful in locating the buried mineralization. This was tested, using one soil profile in the middle of the mineralized zone, two traverses across the region of Au-rich laterite and one traverse in a background area, which were treated using standard selective extraction techniques. The first extraction, acetate, which measures pH 5 soluble metals, shows no direct correlations with underlying Au-rich laterite, except for Mn, which appears to be moderately enriched directly above mineralization. The second extraction, hydroxylamine, which extracts Mn oxides and amorphous Fe oxides, gives higher levels of Fe, Mn, Cu, Zn and Pb overlying mineralization. The best signal to noise contrast was obtained for Mn, and is clearly caused by significant concentrations of separate phase Mn oxides above the Au-rich laterite. Analysis of the data suggests that the higher concentrations of extractable base metals are primarily due to association of these metals with Mn oxides. Furthermore, examination of the MMI results

suggested that those MMI extractable metals showing high contents over mineralization (*e.g.*, Cu and Cd) were also associated with Mn oxides.

The enrichment in Mn over mineralization is greater than 800 ppm, which cannot be characterized as a subtle extraction anomaly. Despite some evidence for moderate Mn enrichment in groundwaters contacting mineralized areas, it is considered that there is unlikely to be a direct link between the surface Mn anomaly and the Au-rich laterite ten or more metres below. Instead, it is likely that surface phenomena, such as an observed drainage system through the anomalous area, is the cause of this effect. This suggests that the MMI and CSIRO extraction results showing a correlation of greater extractable metals with buried Au-rich laterite at Curara is coincidental.

It is considered that partial extractions (such as MMI or enzyme leach) can only be understood and interpreted correctly if conducted in conjunction with determinations of the levels of critical soil phases such as Mn oxides, amorphous Fe oxides and/or any other materials expected to adsorb or otherwise accumulate dissolved ions at the site under investigation.

OPEN FILE REPORT 97

Hydrogeochemical dispersion of gold and other elements at Baxter, Western Australia

Gray, D.J.

The hydrogeochemistry of the Baxter study area was investigated, with a view to understanding the interaction of groundwaters with mineralized rocks, and the potential for exploration, particularly in areas of overburden. Groundwaters at Baxter are neutral, with a similar Eh range to other neutral groundwaters from the Yilgarn Craton. However, they differ from groundwaters investigated at sites in the southern Yilgarn in having very low salinities and marked divergence from sea water ratios, suggesting that the major ion concentrations are strongly controlled by local lithological or hydrological factors. The groundwaters at Baxter strongly resemble those at Lawlers, about 300 km to the SE in the north Yilgarn. Elements that appear to be controlled by mineral equilibration in some or all Baxter groundwaters are Ba (barite equilibration), Ca, Mg and HCO3 (carbonate), Pb and V (chervitite; Pb2V2O7).

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

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

OPEN FILE REPORT 98

Progress statement for the Kalgoorlie study area - Argo deposit, Western Australia

Lintern, M.J. and Gray, D.J.

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

(i) Gold in surficial horizons;

(ii) Sub-surface gold in transported overburden;

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

This progress statement summarizes the recent investigations undertaken at the Argo gold deposit (Western Mining Company Ltd) located 25 km south of Kambalda. The Argo site was chosen for further study for many reasons including the high grade Au mineralization, the variation in the depth of cover from about 10 m to several tens of metres, the remoteness of the deposit from potential contributing upstream sources and the future exposure of the mining pit, allowing sampling from, and examination of, the pit wall.

The results indicate:

1. Soil gold values are generally low (mean <10 ppb) with anomalous gold contents (>15 ppb) located 200m from mineralization.

2. Total, water- and iodide-soluble gold values are not anomalous over mineralization.

3. Gold is associated with the distribution of soil moisture in the top metre of the profile.

4. Gold is associated with calcium in the top metre of the soil profile.

5. Gold in vegetation does not locate mineralization.

6. Gold is present in groundwaters over mineralization.

7. Tungsten, in a variety of sample media (samples from the transported overburden, saprolite, bedrock) appears to be a pathfinder for gold mineralization.

8. Lignitic material appears to scavenge gold and is a useful sample medium in the transported overburden.

More information needs to be gathered from the Argo area. Specifically, there is a need:

1. to extend the auger line(s) to the west and east to establish true background concentrations. Soil pits may be required to examine the gold distribution in detail. Furthermore, by extending to the east, the high proportion of water extractable gold (relative to total gold) can be investigated.

2. to construct a regolith map to put the study site in the context of the surrounding landforms. The results suggest that there may be anomalous gold concentrations in a clay pan adjacent to the Argo deposit.

1. to determine the significance of the anomalous total gold results from the auger traverse on 525800N by examining and sampling a soil profile(s).

4. to analyse lignite from the transported overburden for gold to determine its significance as a sample medium for gold exploration in this district.

5. to examine the potential of tungsten as a pathfinder for gold mineralization.

OPEN FILE REPORT 99

Hydrogeochemistry in the Yilgarn Craton

Gray, D.J.

This Report is a compilation of work done to date within CRC LEME on the hydrogeochemistry of the Yilgarn Craton and its margins. The various sites can be grouped into three distinct regions: the Kalgoorlie region, which has acid and saline to hypersaline groundwaters; the Central region, at and immediately N of the Menzies line, which has variably saline and neutral groundwater; and the Northern region, which has neutral and mostly fresh groundwaters. These differences are reflected in trace element geochemistries, with Kalgoorlie groundwaters having high dissolved Au, base metals, REE and U but low oxy-anions (e.g., As, Sb, Mo, W, Tl, Bi), Central groundwaters having moderate dissolved Au and high oxy-anion concentrations, and Northern groundwaters having low Au, moderate oxy-anions and high V and P. Exploration strategies resulting from these observations are discussed, as are effects of transported overburden.

Gold dissolution is hypothesized to be mainly as a result of halide (chloride and/or iodide) complexation of Au. This only occurs in saline/acid/oxidizing conditions, which do occur regularly in the Kalgoorlie region and to a lesser extent in the Central region. This is reflected in the Au concentrations observed for the three regions. The presence of dissolved Mn is hypothesized to be important for the generation of sufficiently high oxidation potentials for Au dissolution, whereas dissolved Fe appears to precipitate Au. As the primary source for dissolved Fe is from depth, this is consistent with leaching of Au in the upper part of the water table and Au precipitation at depth where the oxidized Au contacts dissolved Fe.

As well as exploration for Au, a number of pathfinder elements may be useful for lithological discrimination. This includes base metals for distinguishing various lithologies, particularly in acid groundwaters, and Cr, which appears to reliably distinguish ultramafic rocks, in all groundwater types, regardless of the degree of weathering.

Although the hydrogeochemistry of further sites should be investigated, particularly in the south-west Yilgarn, data accumulated to this point does indicate consistent hydrogeochemical behaviours within each of the three regions given here, thus allowing a consistent use of groundwater data in each region, for Au exploration, lithological discrimination or enhancing our understanding of weathering and dispersion processes.

OPEN FILE REPORT 100

Further geochemical studies of the soil at the Steinway Gold Prospect, Kalgoorlie, Western Australia

Lintern, M.J. and Craig, M.A.

This study is located in the central and northern part of the prospect where the thickness of transported overburden is variable but greater than 20 m, and the depth to mineralization is about 30 to 40 m. The great thickness of sediments is similar to other sites within the Kalgoorlie area studied in this project, but the presence of the Au at the surface makes it highly unusual. It was considered that a more detailed study of the nature of Au in the surficial material from such an environment will enhance our understanding of the processes whereby Au may (or may not) be enriched in the surficial environment as a result of its proximity to the buried mineralization.

The principal results are summarized as follows:

1. Microscopically visible Au was present in some ferruginous granules;

2. Gold concentrations of individual ferruginous granules are extremely variable, ranging from <40 to 1500 ppb;

3. Total Au content of coarse material are weakly related to the total Au content of the soil.

Specific targeting of the calcareous horizon has been demonstrated to maximize the probability of sampling the most consistently auriferous sample in all landscape regimes in the Kalgoorlie region. In relict and erosional regimes, such sampling may accurately define drilling targets. However, in depositional regimes, the results for Steinway indicate that there is no direct link with mineralization. Here,-although the Au anomaly in the calcareous soil directly overlies buried mineralization, the data suggest that it is derived from detrital Fe granules in the soil, rather than the mineralization itself.

It is concluded that, in depositional areas, sampling of calcareous material at best may indicate the potential of the (sub-)catchment. It is suggested, therefore, that for such landscape regimes, wider sampling intervals should be used, with a follow-up requirement that deep samples be collected including basal sands or ferruginous material in saprolite.

OPEN FILE REPORT 101

Further geochemical studies of the soil at the Panglo Gold Deposit, Kalgoorlie, Western Australia

Lintern, M.J.

The CSIRO-AMIRA Project "Exploration in Areas of Transported Overburden, Yilgarn Craton and Environs" (Project 409) has, as its principal objective, development of geochemical methods for mineral exploration in areas with substantial transported overburden, through investigations of the processes of geochemical dispersion from concealed mineralization. The Project has two main themes. One of these, *'Surface and subsurface expression of* concealed *mineral deposits' is* addressed by this report, which focuses on the soil geochemistry of the Panglo Au deposit (Kalgoorlie Area).

This study is located in the northern part of the deposit where the thickness of transported material is less than 5 metres, and the depth to mineralization (beneath barren saprolite) is of the order of 30 to 40 metres. While the thickness of transported material is not substantial, the great thickness of barren saprolite provides an interesting contrast with other sites from the Kalgoorlie area which have similar thicknesses of barren transported overburden. It is considered that a detailed study of the nature of Au in surficial material from such an environment will enhance our understanding of the processes whereby Au may be enriched in the surficial environment in areas of substantially transported material.

OPEN FILE REPORT 102

The distribution of gold and other elements in surficial materials form the Higginsville palaeochannel gold deposits, Norseman, Western Australia

Lintern, M.J., Craig, M.A., Walsh, D.M. and Sheridan, N.C.

The CRCLEME-AMIRA Project "Exploration in Areas of Transported Overburden, Yilgarn Craton and Environs" (Project 409) has, as its principal objective, development of geochemical methods for mineral exploration in areas with substantial transported overburden, through investigations of the processes of geochemical dispersion from

concealed mineralization. The Project has two main themes. One of these, *'Surface and sub-surface expression of* concealed *mineral deposits' is* addressed by this report, which focuses on the soil geochemistry of palaeochannel Au deposits located 60 km south of Kambalda and 40 km north of Norseman.

The study area is located near Higginsville and encompasses the Mitchell and the Challenger-Swordsman palaeochannel Au deposits where the thicknesses of transported overburden and depth to mineralization vary from about 15 m to over 50 m. The study site is important since it provides several examples of a variably thick overburden, and extends the boundaries of Project 409 to an area well south of the Kalgoorlie study sites with which it can be contrasted. The great thicknesses of transported overburden are comparable to sites previously studied near Kalgoorlie but unlike many of them, the palaeochannels at Higginsville contain considerable economic deposits of Au, which are being extensively mined. It is considered that a detailed study of the nature of Au in surficial material from such an environment will enhance our understanding of the processes whereby Au may be enriched in the surficial environment in areas of substantially transported material.

The Higginsville palaeochannels are of considerable interest since it has been reported that at a number of locations there is a detectable surface expression of Au. One of the purposes of this research is to assess the validity of such reports by careful sampling and analysis and discuss the implications of the investigation for exploration in this area. The results indicate that:

(i) Specific targeting of the calcareous horizon maximizes the probability of sampling the most consistently auriferous sample. In relict and erosional regimes, such sampling may accurately define drilling targets. However, in depositional regimes, the results indicate that there is no direct link with mineralization. Here, although a soil carbonate anomaly discretely overlies buried mineralization, the data suggest that it is derived from detrital Fe granules in the soil.

(ii) Separate sampling of ferruginous granules may provide a local source of the Au found in the carbonate horizon. Gold in ferruginous granules usually indicates that Au is being shed from relict or erosional areas within the catchment, hence these areas are most prospective. Like carbonate, ferruginous granules do not in themselves provide an indication of underlying palaeochannel mineralisation.

It is concluded that, in depositional areas examined in this study, sampling of calcareous material at best may indicate the potential of the area. It is suggested, therefore, that for such landscape regimes, wider sampling intervals should be used *i.e.* soil sampling is a regional tool, with a follow-up requirement that deep samples be collected including basal sands or ferruginous material in saprolite. Sampling of Fe granules or lag is a possible alternative, but the distribution of Au within them is more erratic. The most cost-effective sampling procedure is by power auger drilling and compositing the cuttings through the carbonate-rich horizon. Surficial soil sampling or drilling and routinely sampling at a specified depth without regard to the sample type may be inappropriate because Au anomalies may be overlooked.

OPEN FILE REPORT 103

Geochemical studies of the soil and vegetation at the Apollo Gold Deposit, Kambalda, Western Australia

Lintern, M.J.,Craig, M.A. and Carver, R.N.

The CSIRO-AMIRA Project "Exploration in Areas of Transported Overburden, Yilgarn Craton and Environs" (Project 409) has, as its principal objective, development of

geochemical methods for mineral exploration in areas with substantial transported overburden, through investigations of the processes of geochemical dispersion from concealed mineralization. The Project has two main themes. One of these, *'Surface and subsurface expression of* concealed *mineral deposits' is* addressed by this report, which focuses on the soil geochemistry of the Apollo Au deposit, Kambalda, WA.

This study is located in the central and northern part of the deposit where the thickness of transported overburden is about 5 to 10 m, and the depth to mineralization is of the order of 15 to 80 m. Apollo is about 500 m to the north-east of the Argo deposit (Lintern and Gray, 1995) where the depth of transported overburden and mineralization are greater.

Summarising the main points of the research:

(i) extraction techniques using iodide or water do not assist in the location of buried mineralization;

(ii) limited data from this study suggests mat anomalous Au concentrations in soil are usually >15 ppb whereas background is <10 ppb; this needs further testing.

(iii) Zn is anomalous in soils over mineralization; however, absolute Zn concentrations are lower in saprolite and bedrock than in the soil;

(iv) Au is generally associated with Ca and Mg carbonates in soils;

(v) bluebush should be investigated further as a sample medium for Au exploration in areas of transported overburden.

OPEN FILE REPORT 104

Geochemical expression of concealed gold mineralization, Safari Prospect, Mt Celia, Western Australia

Bristow, A.P.J., Lintern, M.J. and Butt, C.R.M.

The distribution and solubility of Au and the distribution of other elements in the upper regolith and the nature and distribution of regolith materials has been studied at and around the Safari deposit, 200 km NE of Kalgoorlie, Western Australia. The deposit has a resource of 1.08 Mt @ 3.3 g/t Au associated with quartz veins within sheared metavolcanic rocks (mainly quartz-chlorite-sericite schists) in the southern extension of the Laverton Tectonic Zone. The mineralised and country rocks are deeply weathered, and subsequently eroded to the lower saprolite and, in places, fresh rock. They are now covered by up to 9 m of colluvium/alluvium derived from eroding greenstone and granite regolith several km to the ENE. Groundwater at the deposit is approximately 40 m below surface. Much of the regolith, and particularly the upper few metres, shows evidence of widespread and intensive modification associated with arid conditions (namely calcification from approximately 0.5-4.0 m below surface). Samples of regolith (transported overburden and the upper two metres of saprolite) from a drill traverse across the deposit, and selected samples of primary mineralisation and vegetation have been examined to determine element distributions, their relationship to regolith evolution and their significance in exploration. Elements associated with Au mineralisation are W, As, Zn, S, Pb, Si, heavy REE and possibly Sb, though only Pb displays a direct correlation with Au. Of these, (excluding Pb, S and Si, not analysed in the regolith), only Au shows evidence of remobilisation in the regolith, the others being closely confined to the mineralised zones in the weathered Archaean. Plant materials were found to be ineffective in detecting mineralisation.

The distribution and solubility of Au in the regolith suggest that Au has been dissolved from mineralisation in the top of the saprolite and re-precipitated in the transported overburden close to the surface, in association with carbonate minerals. Gold is strongly enriched at the

top of the saprolite (10-1000 ppb for 500 m peaking over mineralisation), and solubility is generally high, although appears lower close to mineralisation (<30% iodide soluble), increasing with lateral distance from mineralisation (up to 80% iodide soluble), suggesting secondary lateral dispersion around the unconformity. In contrast, Au is anomalous (7-40 ppb), and highly soluble (>70% iodide soluble) throughout the calcareous horizon, and close to surface, for up to 800 m across strike, peaking directly over mineralisation, suggesting dominantly vertical chemical dispersion. This may be the result of two phases of Au dispersion: the first, prior to sedimentation, resulted in lateral dispersion of Au down the relatively steep palaeo-surface; the second, after sedimentation, resulted from solution of Au from the carbonates in the upper saprolite and vertical dispersion by capillary action and/or evapo-transpiration, resulting in evaporative precipitation with carbonate 0.5-4 m from the surface.

It is suggested that a combination of a shallow overburden and a source at the top of the saprolite have contributed to the formation of Au anomalies in the transported overburden. These factors need to be considered if carbonate sampling is to be applied to other depositional landform regimes.

OPEN FILE REPORT 105

Geochemical dispersion in transported and residual regolith, Fender Gold Deposit, Cue, Western Australia

Butt, C.R.M.

Fender is a small Au deposit (248 000t @ 2.4 g/t Au) approximately 2 km south of Big Bell, WNW of Cue, on the margin of a colluvial-alluvial plain. The deposit itself is entirely overlain by a thin (2-5 m) cover of transported overburden and does not outcrop. The overburden consists of two units, fine- to coarse-grained sandy clay, sand and gravel, overlying silty clays. Both the sands and the silty clays locally contain detrital lateritic gravels. The sands are weakly cemented in the top metre to form hardpan and some deeper sediments are mottled; there is no pedogenic carbonate. The sediments contain feldspar grains (0.5-1.0 cm) and are probably derived from the granites to the west. There are two principal regolith situations beneath the overburden. In the south, the lateritic profile appears largely complete and a small Au resource is hosted by lateritic residuum and ferruginous saprolite. In the north, the lateritic profile is truncated and the sediments are deposited on saprolite which, in some places, is depleted in Au but, in others, has Au at ore-grade concentrations immediately beneath the unconformity. Similar situations are present 200 m to the west, where lateritic residuum and saprolite outcrop. There is no surface geochemical expression of the deposit in soils (15-30 cm depth), determined by conventional total analysis or by bulk cyanide leach (BLEG) analysis, nor in composite samples (4 m) of the sediments, except where drilling has penetrated into the concealed lateritic residuum. Possible geochemical dispersion into the sediments has been investigated by careful sampling of the sediments and uppermost residuum by RAB drilling, with care taken to avoid cross-hole contamination. The primary mineralization (Au >1000 ppb) is characterized by enrichment in Ag (mean 1.4 ppm), As (145 ppm), Sb (450 ppm), W (130 ppm), Cd (1.2 ppm) Mo (37 ppm), Tl (7 ppm), Zn (475 ppm) and Hg (100 ppm). However, of these, only As, Sb and W are detectable in the near-surface samples. In the residuum, the W distribution indicates the weathered primary mineralization, even where Au has been depleted in saprolite or enriched and dispersed in lateritic residuum. In comparison, As and Sb are both enriched and widely dispersed in the nodular ferruginous clays and ferruginous saprolite to give broad anomalies. Concentrations are homogeneous and remain anomalous (>50 ppm As, 70 ppm Sb) in shallow ferruginous saprolite and outcropping lateritic gravels for at least 200 W of the subcropping mineralization. Gold abundances are generally <5 ppb in the sediments over saprolite, except

for some spot concentrations (80-245 ppb) immediately above subcropping mineralization, and an associated weak enrichment (5-16 ppb) extending 50 m down slope. However, they are significantly anomalous (60 ppb Au) for over 100 m east of the subcropping lateritic residuum. In comparison, As (40-120 ppm), Sb (12-50 ppm) and, over saprolite, W (5-17 ppm) are anomalous in the clays for at least 200 m down slope to the east. Essentially all of the As and Sb in the silty clay unit is hosted by mechanically transported ferruginous nodules (80 to over 100 ppm Sb, 300-450 ppm As). Neither Au nor W are concentrated in the nodules. The sands and soils contain background concentrations of Au, As, Sb and W except where directly overlying lateritic residuum. It is concluded that a sampling strategy that targets lateritic residuum, whether outcropping or buried, would locate this deposit. Where the regolith is truncated, restricted dispersion in residual and transported units implies that analysis for Au alone is unsatisfactory in the top 20 m. Multi-element analysis would reveal broad, low-order As+Sb+/-W anomalies in the silty clays, which can be markedly enhanced by selective sampling of ferruginous nodules. Such selective sampling is preferable to the common practice of compositing samples over intervals of 2-6 m. However, composites of ferruginous nodules from the lowermost 2-4 m of the sediments may be suitable, especially if they are scarce. The preferential concentration of As and Sb in detrital ferruginous nodules, rather than in the matrix, of the silty clays, implies that there has been little or no post-depositional chemical dispersion.

OPEN FILE REPORT 106

Geochemical and spatial characteristics of regolith and groundwater around the Golden Delicious Prospect, Western Australia

Bristow, A.P.J., Gray, D.J. and Butt, C.R.M.

The dispersion and solubility of Au and other elements in the regolith, and the nature and distribution of regolith materials has been studied at and around the Golden Delicious deposit near Laverton, Western Australia. The deposit has a resource of 6.1 Mt ~ 1.3 g/t Au hosted by a suite of Archaean granitoids that intrude mafic volcanic and volcaniclastic greenschist host rocks in the southern part of the Laverton tectonic zone. The mineralised and country rocks are deeply weathered, and subsequently partly eroded to the clay zone and upper saprolite. They are now covered by up to 20 m of colluvium - alluvium derived from eroding mafic regolith several km to the ESE. Late-stage hematite mega-mottling has overprinted the upper residual horizons. The entire regolith is saturated with saline, weakly alkaline groundwater below approximately 10 m. Much of the regolith, including the transported overburden, has been extensive modified during arid conditions. Samples of regolith and groundwater from a drill traverse across the deposit have been examined in detail to determine element distributions, their relationship to regolith evolution and their significance in exploration. Elements associated with Au mineralisation were W, Sb, K and REE, though none displayed a very direct correlation with Au. Only Au showed evidence of significant remobilization, the other elements approximating their distribution in the Archaean prior to weathering.

The distribution, solubility and accessibility of Au in the regolith, its concentration in groundwater, and the chemistry and depth of groundwater, suggest that Au has been dissolved from mineralisation, and re-precipitated in the base of the transported overburden to give a Au anomaly (12-100 ppb), 500 m across strike, offset slightly down-slope of underlying mineralisation. No evidence, other than the Au contents of the groundwater and the slightly soluble nature of Au in the weathered Archaean, was found to suggest significant Au depletion or mobilization and it is suggested, based on the distribution and solubility of other elements associated with Au mineralisation, that the present Au distribution in the residual regolith is similar to that prior to weathering. Despite the lack of evidence for significant Au mobility, there is some enrichment (12-80 ppb) in the top few metres of the residuum for 300

m across strike, directly overlying mineralisation, that may be associated with late stage mottling or residual concentration. Gold in groundwater is anomalous, (0.046-0.18 1µg/L), though slightly offset to the west, for 200 m across strike of mineralisation. Tungsten is anomalous (8->50 ppm) below the top few metres of the residuum for 400 m across strike, and indicates a broader primary halo than Au in the primary mineralisation. The distribution of Sb concentrations when normalised to Fe is similar to that of W. Neither Sb nor W are anomalous in the transported overburden overlying mineralisation and are relatively insoluble in the weathered Archaean.

OPEN FILE REPORT 107

Selective and partial extraction analyses of transported overburden for exploration in the Yilgarn Craton and its margins

Gray, D.J., Wildman, J.E. and Longman, G.D.

Seven sites from across the Yilgarn Craton and the northern Proterozoic margin were selected to test the utility of partial extractions for exploration for buried mineralization. The techniques used were selective extractions for carbonates, Mn oxides and amorphous Fe, varying HCl treatments, the CSIRO iodide extraction for Au, mobile metal ions (MMI) and enzyme leach. The selective extractions work consistently and give good correlations with the HCl digests. The MMI method involves two separate extractions: the first, for Cd, Cu. Pb and Zn, gave results that are similar, in terms of comparison between samples at each site, to HCl and selective extractions; whereas the second extraction, for Ag, Au, Co, Ni and Pd. commonly dissolves all of the extractable Au and Ag (commonly 70-80% of the total Au, and closely correlated with total, iodide and HCl soluble extractions). Therefore, the MMI extraction does not appear to be giving any additional information for Au or Ag than can not be obtained using standard analyses. The enzyme leach reagent is targeted at an 'amorphous' Mn phase, though the proportion of the Mn dissolved (< 0.5 to 20%) varies dramatically between sites. The enzyme leach method also appears to give unique results, not correlated with other methods, and gives a much larger range of elements than MMI. However, Cs, Fe, Ga, Hf. La, Li, Nb, rare earth elements, Pb, Sc, Sn, Th, Ti and Zr show very close linear correlations, suggesting either a highly specific interaction between these elements and Fe or an analytical interference from Fe.

The extraction results for the soil traverses indicate that soil is a successful exploration medium only where the transported overburden in thin (<10 m), as at Safari and in restricted areas at Baxter and Fender, and that Au, for a number of methods, is by far the best target element. Use of partial extractions gave a number of strong false positives and/or very poor ability for the extraction methods to shows buried mineralization, except where total extractions would work anyway. Even at those sites where Au successfully delineates mineralization, partial extraction methods for the other elements are unsuccessful.

OPEN FILE REPORT 108

Regolith-landscape evolution and geochemical dispersion about the Bronzewing Gold Deposit, WA

Varga, Z.S., Anand, R.R. and Wildman, J.E.

Mineralisation

The Bronzewing deposit is in the Archaean Yandal Greenstone Belt. Gold mineralisation occurs within a sequence of mafic volcanics (basalts, dolerites) and minor sediments, which are intruded by felsic porphyries. The mineralisation is associated with a dense stockwork of

quartz veining, and alteration of the host sequence, and is accompanied by pyrite, pyrrhotite and minor chalcopyrite and scheelite. Gold, W and Cu are the most significant indicators in mineralised bedrock.

Regolith

Regolith-landform relationships over the 1000 km2, centred on the Bronzewing deposit, were mapped at 1:50 000. This was based on interpretation of aerial photography, image enhanced Landsat TM images and field traverses. The Bronzewing Au deposit was covered by a blanket of soil and colluvium. Mapping regolith relationships and distributions using drilling and pit faces, has revealed the details of the sub-surface regolith and palaeolandscape, from which the weathering history and likely origins of anomalies in the residuum and transported cover can be deduced. A wide range of sediments overlie older, residual regolith. Colluvial and alluvial sediments are 20-30 m thick in the Discovery pit and directly overlie saprolite. In the southwest of the Central pit, the sediments are 15-20 m thick and overlie lateritic residuum in places. The sediments thin towards the northeast to less than 5 m thick in the Laterite pit. Alluvium is most likely derived from the south, and the colluvium from the east where there is a subdued breakaway.

The palaeochannels have been infilled with kaolinite-smectite sediments derived from the erosion of pre-existing red soils and saprolites. On a regional scale, palaeochannel sediments reach 120 m in thickness. Dolocretes, calcretes, pisoliths and megamottles have developed in these sediments. Mobilisation and segregation of Fe by a combination of roots and reduced groundwaters in porous, vegetated red clays was probably responsible for the formation of the megamottles. Dolocretes are likely to be relict forms equivalent to those in deep sediments in the Roe palaeodrainage. They are confined to the base of the channel above the lateritic residuum and may have formed by evaporation of Mg-rich lakewaters so their formation appears to be related to a period of high evaporation rates. The dolocretes differ from valley calcretes of the region, which are surficial deposits in major, active drainages.

Considerable palaeotopography (60 m) around Bronzewing suggests that lateritic residuum did not form a simple, extensive, peneplained surface but a discontinuous cover on an undulating plateau. The pre-Eocene landscape at Bronzewing was not only mantled with lateritic residuum but also with thick blankets of kaolinite-hematite red soils. Ferruginous duricrusts and red soils developed in different sites in response to contrasting geological and topographic conditions. Duricrusts were developed on mafic and ultramafic rocks and red soils were probably restricted to felsic lithologies on well-drained upper slopes. Where fully preserved, the residual profile beneath the colluvium and alluvium has a 2-5 m thick lateritic residuum consisting of lateritic nodules and some pisoliths, set in a silty clay matrix. The nodules were formed by the fragmentation and collapse of the underlying ferruginous saprolite. The ferruginous saprolite, a few metres thick, grades downwards into saprolite. Fresh rock is encountered at 80 to 120 m depth.

Geochemical dispersion in the regolith

Sampling of the residual materials (ferruginous saprolite and lateritic residuum) showed significant Au, W and Cu anomalies in the vicinity of the Bronzewing deposit. The lateritic duricrust and nodules and pisoliths of the Laterite and Central pits, where developed over primary mineralisation, contain significant amounts of Au. Elements associated with the Au mineralisation in the lateritic residuum of the Laterite pit are Ag, Ba, Ce, W, Mo, As, Sb and Cu. The Au anomalies are not as consistent in the Discovery pit, and the lateritic residuum of both the Central and Discovery pits are enriched in Cu and W close to the primary mineralisation. Wide spaced sampling would be adequate to sample areas of buried lateritic residuum and ferruginous saprolite. The buried lateritic residuum contains Au to ore grade, which sometimes extends into the colluvium. This relationship is particularly apparent in the Central pit area where extensive Au anomalies occur across the unconformity. Size

fractionation of the gravelly colluvium that occurs within a metre of the residuum/colluvium interface, indicates that Au is concentrated in the plus 2000 μm fraction and depleted in the minus 75 μm fraction, relative to the bulk sample. The enrichment in the coarse fractions represents clastic dispersion of lateritic detritus. There is no evidence to show that hydromorphic dispersion has accumulated Au in the fine fraction. Gravelly colluvium is a useful sampling medium in situations where lateritic residuum or ferruginous saprolite are missing.

Mottles extracted from the palaeochannel sediments contain no significant enrichment of pathfinder elements, and Au contents are below detection. No significant concentrations of Au or pathfinder elements are present in bulk soils collected from 0.3-0.5 m depth; the Au content barely exceeded the detection limit of 5 ppb. No dispersion of Au into the soil was detected by partial extraction of the soil fine fraction (<250 μm).

OPEN FILE REPORT 109

Eastern Goldfields Field Excursion Field Guide

Butt, C.R.M., Smith, R.E., Dell, M., Anand, R.R.,Lintern, M.J., Gray, D.J., Vinar, J., Bristow, A.P.J., Churchward, H.M., Varga, Z.S. and Wildman J.E.

AMIRA Project *409, Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs,* has, as its principal objective, the development of geochemical exploration methods for areas having a substantial cover of surficial sediments, through investigations of the processes of geochemical dispersion from concealed mineralization. An important aspect of the project is to translate research findings into practical outcomes. Field excursions have a significant role in this process, for they permit geologists and geochemists from the research group and the supporting companies to examine key sites together. This interaction promotes a much freer exchange of ideas than is possible during, for example, the formal atmosphere of seminars. The project has several important research sites and districts across the Yilgarn Craton. It is impractical to visit all of these in one excursion. The excursion in August 1995 examined sites in the Murchison and adjacent areas, including Mt Gibson, Mt Magnet, Baxter and Fender, having a variety of different types of transported overburden. Each is characterized by the development of red-brown hardpan in the surface horizons but, except at Mt Gibson, Pedogenic carbonates are rare or absent. This second excursion is to the Eastern Goldfields region and again provides an opportunity to examine a range of different overburden types and offers a comparison between areas having a strong development of pedogenic carbonates, south of the Menzies line, and those having red-brown hardpans, to the north.

The first visit is to the Kanowna Belle gold mine. This has not, in fact, been studied during this project, but it was an important site for AMIRA Project 240A, *Yilgarn Lateritic Environments.* It serves as an excellent introduction to many of the important features of the regolith of the Kalgoorlie region and to the usefulness of surface soil sampling in areas of shallow transported cover, including the use of pedogenic carbonates as sample media. The excursion then visits two areas within which the effectiveness of surface sampling has been investigated where mineralization concealed by deeper sediments, in both cases associated with palaeochannels. Steinway and Greenback have supergene mineralization within and beneath 15-25 m of oxidizing sediments. There is a surface anomaly at Steinway, whereas there is none at Greenback, although mineralization is shallower and has been mined. The anomaly at Steinway is now considered possibly coincidental, a result of natural contamination - a common and potentially misleading feature of the region. Argo and Apollo are concealed beneath reducing lake and channel sediments. Although Au is again concentrated in the calcareous horizons of the soils, there is no surface anomaly. Partial

extraction analyses appear to be ineffective in defining anomalies in either the Steinway or Argo-Apollo areas.

On the second day, the excursion visits the Safari prospect at Mt Celia, and Golden Delicious, on or north of the Menzies line. Carbonates are present at both sites, though commonly deeper in the regolith (below 2-5 m) than the pedogenic carbonates further south. Selective sampling of carbonates appears to give a good response at Mt Celia, where the cover is shallow (mostly <10 m) and, for the most part, overlies truncated profiles. At Golden Delicious, about 17 m of sediments overlie residual profiles truncated to approximately the mottled zone. There is no geochemical expression of the mineralization in the sediments, but dispersion along the unconformity gives a widespread anomaly, particularly associated with ferruginous nodules and mottles.

Near Laverton, the South Lancefield, Telegraph and Beasley Creek pits have Permian boulder clays exposed in the walls. These have not been examined for their geochemical response, although some results from the dispersion study at Beasley Creek, carried out during AMIRA Projects 240 *(Laterite Geochemistry)* and 241 *(Weathering Processes)* are given in this guide. The excursion then travels to Bronzewing, to examine sites where essentially complete profiles

are preserved, with lateritic residuum close to the surface (Laterite pit) or buried beneath alluvium and colluvium that includes lateritic debris (Central pit). A similar situation is present at North Pit, Lawlers, the last stop, where lateritic duricrust is buried by 20 m of sediments.

The authors of the articles in the guide wish to thank Colin Steel and Angelo Vartesi for drafting the diagrams, and Gill Ashton for preparing and compiling the final manuscript. Gill Ashton also assisted with much of the organization of the excursion. We are also grateful to Kanowna Belle Gold Mines, Newcrest, St Ives Gold Mines, RGC Exploration, Acacia Resources Ltd., Metex Resources Ltd., Great Central Mines and Plutonic Resources for permitting access to their mines and exploration properties.

OPEN FILE REPORT 110

Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs - Murchison Field Trip

Butt, C.R.M., Robertson, I.D.M., Anand, R.R., King, J.D., Munday, T.J., Phang, C and Smith, R.E.

AMIRA Project 409, *Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs*, has, as its principal objective, the development of geochemical exploration methods for areas having a substantial cover of surficial sediments, through investigations of the processes of geochemical dispersion from concealed mineralization. An important aspect of the project is to translate research findings into practical outcomes. Field excursions have a significant role in this process, for they permit geologists and geochemists from the research group and the supporting companies to examine key sites together. This interaction promotes a much freer exchange of ideas than is possible in the formal atmosphere of seminars. The project has several important research sites and districts across the Yilgarn Craton. It is impractical to visit all of these at once, hence there will be at least two excursions during the course of the final year of the project. This, the first excursion, examines sites in the Murchison and adjacent areas: their wide separation necessitates extensive travel. The locations are shown on Figure 1. All are characterized by the development of red-brown hardpan in the surface horizons. Pedogenic carbonates are also present at Mt. Gibson and, in places, Mt. Magnet, but are generally absent from the other

sites. The first visit is to the Mt. Gibson gold mine. This has not, in fact, been studied during this project, but it was an important site for Project 240, *Yilgarn Lateritic Environments*, and serves as an excellent introduction to many of the important features of the regolith and to the value of regolith-landform mapping. Transported overburden is a feature of the district, so that many of the findings at Mt. Gibson are of direct relevance to the objectives of the present project. The second series of visits is to locations in the Boogardie Synform in the Mt. Magnet district, including the Quasar and Stellar gold deposits, the subjects of detailed regolith mapping and geochemical orientation. Several different regolith-landform settings will be examined, including near-complete and truncated residual profiles overlain by colluvial and palaeochannel sediments. On the third day, the excursion will visit the Harmony deposit at Baxter, near Peak Hill. This is a new development, mining having commenced in July, and provides a first opportunity for close inspection of the regolith at this location. The excursion will demonstrate the regional landform setting of the deposit and examine the regolith as exposed in the new pit and as seen in drill core and drill cuttings. Finally, there will be a brief visit to the Fender deposit, about 2 km south of the Big Bell mine, near Cue. Mining was due to commence in July but, unfortunately, this has been delayed and it is now improbable that the anticipated exposure of the upper regolith will have occurred. The site is important, because it appears to be completely blind, even though the cover is thin and, in places, directly overlies ore-grade mineralization. The visit will examine the setting of the deposit and inspect samples of the regolith in core and cuttings.

OPEN FILE REPORT 111

Supplementary notes and regolith map for the Enigma Prospect (Wollubar), Kalgoorlie, Western Australia

Craig, M.A., Lintern, M.J. and Gray, D.J.

The CRCLEME/AMIRA Project 409 "Exploration in areas of transported overburden, Yilgarn Craton and environs" has, as its principal objective, development of geochemical methods for mineral exploration in areas with substantial transported overburden, through investigations of the processes of geochemical dispersion from concealed mineralization. An earlier report (EM Report 98R), entitled "Progress statement for the Kalgoorlie study area, Enigma prospect (Wollubar), Western Australia", focussed on soil geochemistry. Subsequently, district/scale regolith/landform mapping (1:50 000 scale) has been undertaken to determine the geomorphological setting of the Enigma prospect. This should more readily enable comparisons between this site and equivalents in the region.

The procedures by which the map has been compiled are briefly described and a copy of the map itself is included. This report and Report EM 98R are complementary and should be read in conjunction with one another.

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LIST OF PAPERS

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FileMaker Pro Tutorial

This brief tutorial will allow you to use the basics of the run-time 'FileMaker Pro' Database, which is stored on the CD in the back of this volume. For more elaborate operation of a FileMaker Pro database, see Hester (1998)[1].

There are two database versions; *S240_241.FP3* for those using the MS Windows platform and *S240_241.MAC* for the Macintosh platform. These databases are runtime modules and contain all the software you require. Ownership of FileMakerPro software is unnecessary. First, read the license agreement on the last page of this volume. Provided you accept this agreement, you may copy the appropriate file to your hard disc and launch it as you would any normal application. A splash screen with the license agreement appears. On accepting the terms of the license, the data may be accessed. All the data in these databases has been secured. However, in the extremely unlikely event of file corruption, reload the file from the CD.

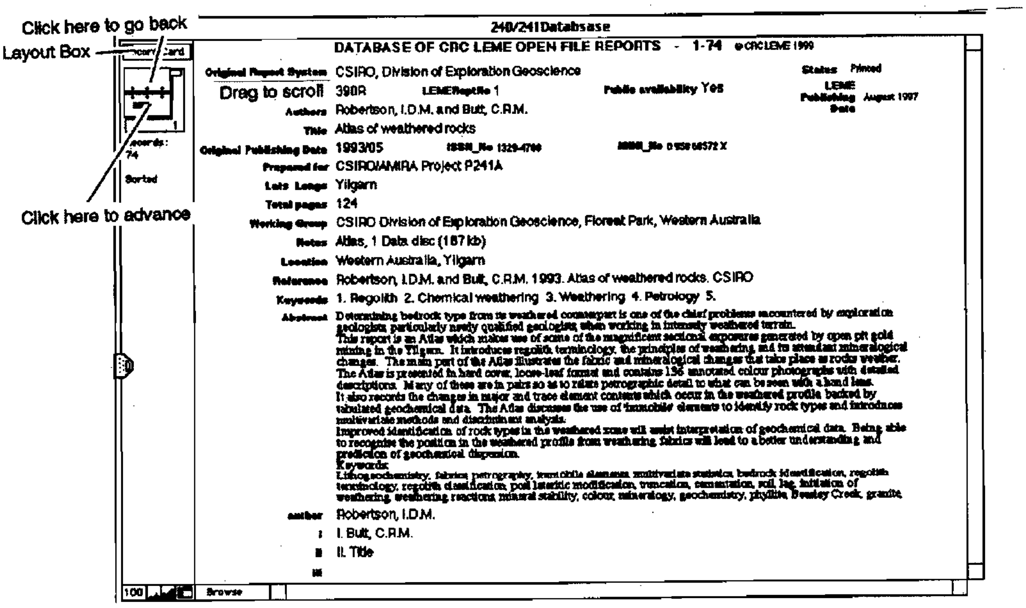

Figure 1. The appearance of the Record Card layout. Stepping through the database is achieved with the booklet icon and scroll bar in the top left.

Layouts and getting around

The first layout is the Record Card layout as in Figure 1. In the top left is a booklet icon on edge with a mini-scroll bar. The number of records is stated (74 in this database) and the database is sorted according to LEME Open File Report Numbers. You may scroll up and down the database, report by report, by clicking on the upper or lower pages of the booklet icon or by dragging the scroll bar for gross changes.

Three other layouts may be accessed by selecting from a menu activated by clicking on the Layout box. These other layouts are Bibliographic, Index Listing and Reference. The Index Listing is a similar layout to the listings given elsewhere in this volume. The Reference layout is used for a list of the *original* references; this will require editing to suit the required format. The Bibliographic layout contains information that might be required by librarians.

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[1] Hester, N. 1998. FileMaker Pro for Windows and Macintosh. Peachpit Press. Website http://www.peachpit.com. This quickstart guide gives details of the full implimentation of FileMaker Pro.

Note that, in the Record Card layout, some fields contain more information than their field initially shows. Click on the field to read all its contained information. Click and drag in the Abstract field to read large abstracts.

Searching

Select **Find** from the **Mode** menu. Click in the Abstract box, type the word 'calcrete' and click the **Find** button. This will search all abstracts for the word 'calcrete'. There are 16 reports with this specification. Step through them with the book icon.

A more complex search can be achieved by typing different criteria into different boxes before initiating the **Find**. In this case, the search will find only those records that match all these criteria. To include an extra search criterion (where *either* one *or* the other (or both) will be met) select **New Request** from the **Mode** menu for the second or subsequent criterion before starting the **Find**. A * may be used as a wild-card for zero or more unknown characters. In numeric fields (only the number of pages and the Open File Report Number are numeric fields) <, or > etc may be used to set criteria. See Hester (1998) for details of more sophisticated searches.

To return to *all* the records, select **Find All** from the **Select** menu.

Sorting

The **Sort** command is found in the **Mode** menu. Select the required sort fields and >>**Move**>> them from the LH menu to the RH menu and click **Sort**.

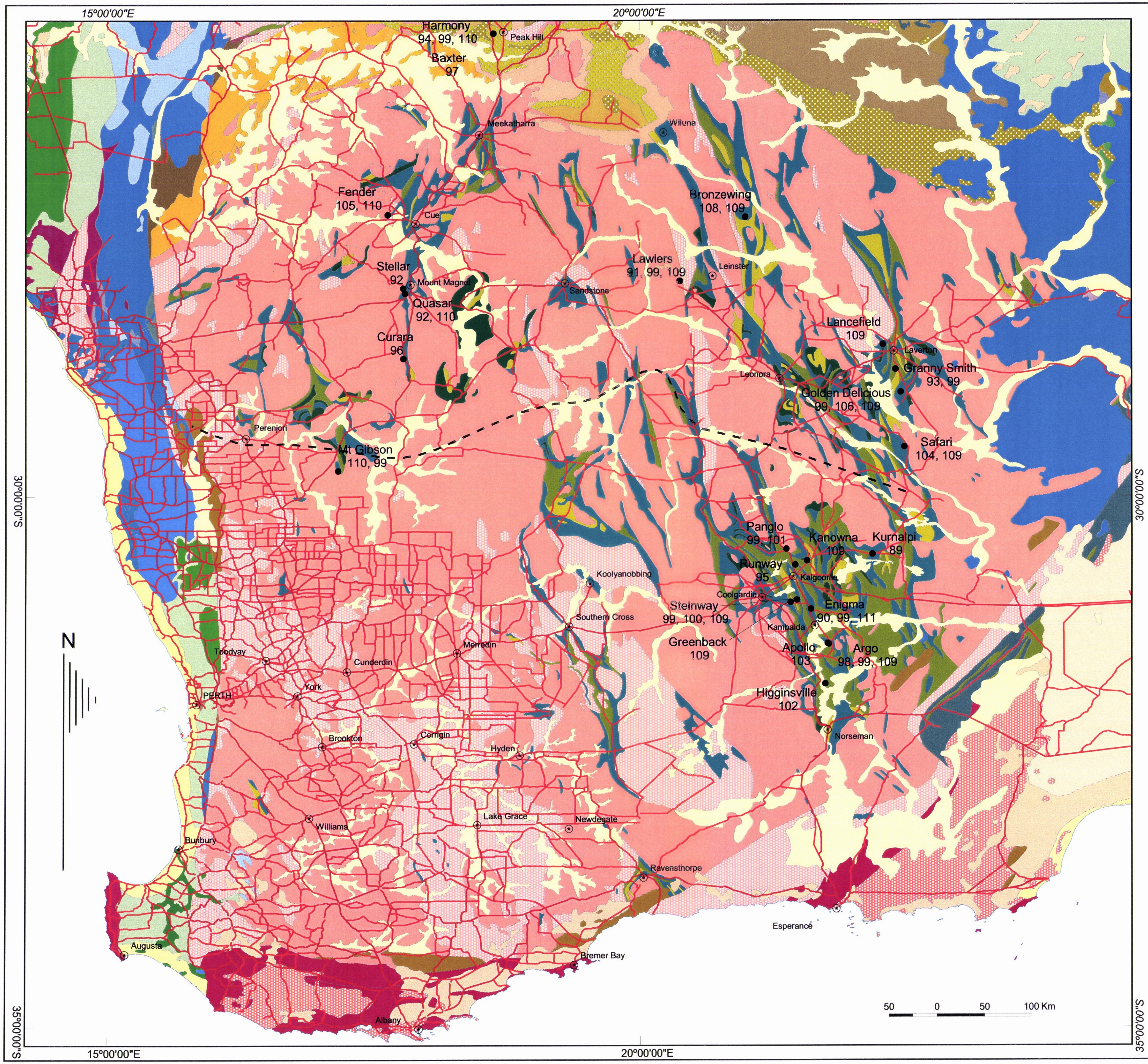
Printing

Print from your chosen layout using the **Print** command in the **File** menu. It may be necessary to scale the size of the printed output, using the **Page Setup or Printer Setup**, to suit your printer and paper size.

Exporting

Exporting of selected records is achieved by selecting **Import/Export** from the **File** menu and selecting **Export Records** *but read and ensure compliance with the license agreement before doing this*. Give the export file a name and, under **Type**, select the export file format required. Be aware of the severe limitations in field sizes imposed by Excel and MS Access if the abstracts are to be exported. ASCII text is selected as comma-delimited text or tab-delimited text. Output to Excel may be achieved with SYLK. Select the fields to be exported from the LH Menu and >>**Move**>> these to the RH menu. Click **Export** to write the file in the chosen format.

In general, basic operation of this secure database is easy and intuitive but more complex use will require a little reading.



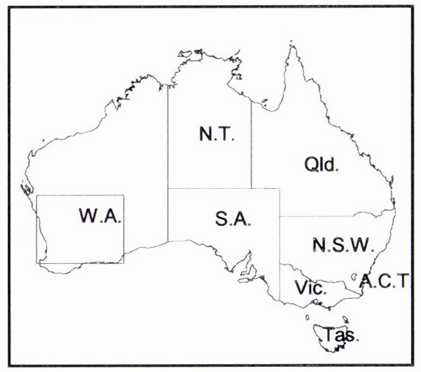


Figure 1
Site Investigations

Miocene - Recent

- Marine; shoreline and aeolian deposits; generally calcareous.
- Alluvial and lacustrine valley-fill deposits; variably calcreted.
- Marine and continental shale; siltstone and sandstone; minor conglomerate.

Eocene

- Marine limestone; marine and continental sandstone; minor lignite and pisolitic ironstone.
- Marine limestone; chalk; marl and greensand.
- Marine and continental sandstone and siltstone.
- Shale; sandstone; glacigene rocks.

Palaeozoic

- Gneiss
- Granite intrusions (syenite gy)
- Dolerite; gabbro and ultrabasic intrusions
- Sandstone; shale.

Proterozoic

- Shale; sandstone; carbonate.
- Sandstone; shale; conglomerate.
- Sandstone; BIF; shale.

Archaean

- Granite intrusions (syenite gy)
- Sedimentary rocks
- Acid volcanic rocks
- Dolerite; gabbro and ultrabasic intrusions
- Basic and ultrabasic volcanic rocks
- Gneiss

- Major Roads
- Menzies Line
- Coastline
- Study Sites
- Towns

Reference: Myers, J.S. and Hocking, R.M (compilers), 1988, Geological map of Western Australia, 1:2 500 000, Geological Survey of Western Australia. (Explanation modified by I. Robertson CRC-LEME)

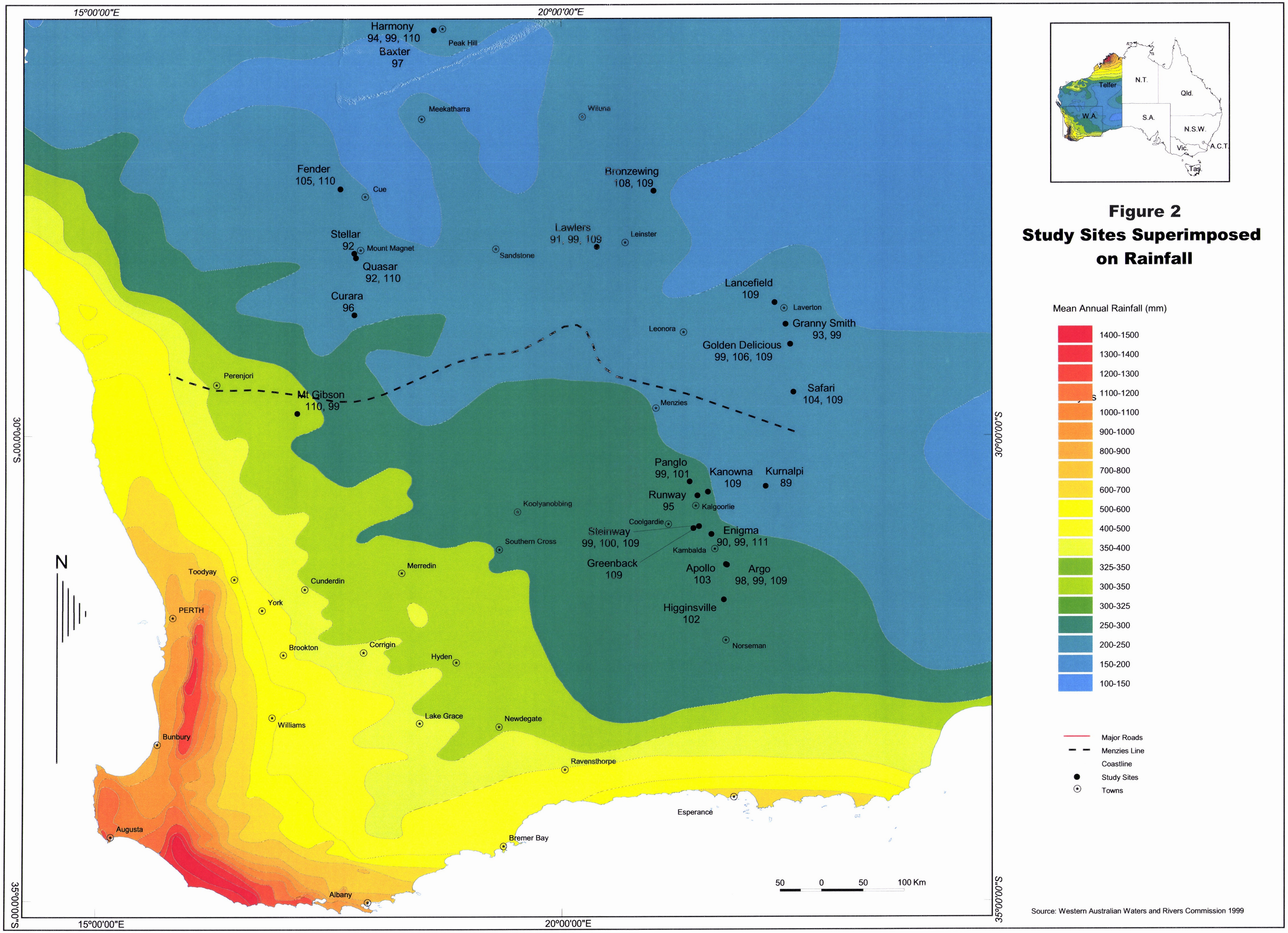


Figure 2
Study Sites Superimposed on Rainfall

Source: Western Australian Waters and Rivers Commission 1999

CONTENTS OF COMPACT DISC

This is a multi-session disc with a Macintosh part (MAC.VOL) and a Windows part (WIN_VOL). Macintosh computers will be able to see both parts; Windows machines will only be able to see the WIN_VOL part. Each contains an identical license agreement (see next page). The contents of the disc are as follows: -

WIN_VOL - for Windows computers

Copy the contents of this volume to a directory of your choice. Its contents are given below.

DATABASE This contains the Filemaker Pro runtime module with supporting files (ten in all). Launch the executable file in the usual way and the database will run.

FMPTUTOR This contains a brief HTML FileMaker Pro tutorial, which will be readable with your web browser. There is also a JPG file with an image to support the tutorial.

GEOCHEM This contains a number of directories (by CRC LEME Report Number) each of which contain a compilation of all the geochemistry in the relevant Open File report. In some cases, individual Readme files are provided to give content and format.

LICAGREE.PDF The License Agreement in PDF[2] format.

ABSTRACT This contains the Abstracts in Word, PDF and text format.

MAC.VOL - for Apple Macintosh Computers

Copy the contents of this volume to a folder of your choice. Its contents are given below.

LICAGREE.pdf The License Agreement in PDF[2] format.

Database.fldr This contains the Filemaker Pro runtime module with supporting files and directories. Read the installation instructions and complete the installation.

Abstracts This contains the Abstracts in Word, PDF and text format.

Geochem Data This contains a number of directories (by CRC LEME Report Number) each of which contain a compilation of all the geochemistry in the relevant Open File report. Individual Readme files are provided for some to give content and format. These files are in DOS format and may need a minor translation into the Mac format.

FileMaker Tutorial This contains a brief HTML FileMaker Pro tutorial, which will be readable with your web browser. There is also a JPG file with an image to support the tutorial.

[2] Readable by Adobe Acrobat Reader downloadable free through http://www.adobe.com/

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