AGSO

Record 1999/42

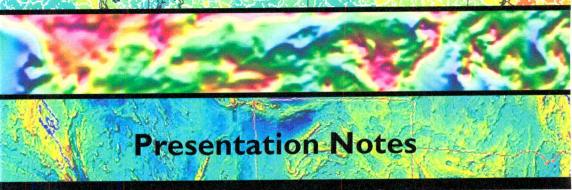
AGSO MINERALS OPEN DAYS

Canberra, 7-8 December 1999









AGSO Minerals Division Open Days

7 – 8 December 1999



John Bain, Richard Blewett, George Gibson, Murray Hazell, Jim Jackson, Lynton Jaques, Russell Korsch, Ian Lambert, Ken Lawrie, Alice Murray, Colin Pain, Chris Pigram, Peter Southgate, Alan Whitaker and Jenni Wines

Record No 1999/42

Australian Geological Survey Organisation

Department of Industry, Science and Resources

Minister for Industry, Science & Resources: Senator the Hon. Nick Minchin Parliamentary Secretary: The Hon. Warren Entsch, MP Secretary: Russell Higgins

Australian Geological Survey Organisation

Chief Executive Officer: Neil Williams

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ISSN: 1039-0073 ISBN: 0642 39805 4

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PROGRAM

	Time	Presentation	Speaker
	9.00-9.10	Welcome	Neil Williams (CEO,
L		aga t	AGSO)
	9.10–9.25	Opening Address, and launch of new Aeromagnetic map	Hon. Warren Entsch,
		of Australia	MP, Parliamentary
			Secretary, DISR
	9.25–9.35	Minerals Division Overview – Introduction	Chris Pigram (Chief)
	9.35–10.10	On elephants and other big ideas for enhancing mineral	George Gibson
	10 10 10 20	exploration in the Curnamona Province	T.1. D.:
	10.10–10.30	Advances in new national geoscience maps	John Bain
	10.30–11.00	tea/coffee (view posters/demonstrations)	
	11.00–11.40	Towards a Palaeoproterozoic Pb–Zn mineralising system	Peter Southgate
		(recent NABRE results)	
	11.40–12.10		Alan Whitaker
		Yilgarn Craton	
	12.10-2.00	Lunch (view posters/demonstrations)	
E L	2.00-2.30	Archaean diversity and mineralising events in the Pilbara	Richard Blewett
3.7 3.	2.30-3.10	Mineral Resources and Advice: AGSO's role extended	Ian Lambert
	3.10–3.35	tea/coffee (view poster/demonstrations)	
	3.35-3.45	Introduction to forming a new Minerals Program	Chris Pigram
	3.45-4.15	Analysis of Australia's major mineral systems	Lynton Jaques
	4.15-5.00	The future directions – constraints, influences and ideas	Chris Pigram
		Discussion	
	5.15-6.30	Tour of AGSO building	
	7.00-10.00	Dinner at The Brassey of Canberra, Barton	

9.00–9.30	Solving regolith problems for exploration (CRC LEME latest results)	Colin Pain
9.30–10.00	Multidisciplinary study, Gilmore (west NSW) — Mineral Systems and Land Use	Ken Lawrie
10.00-10.30	tea/coffee (view posters/demonstrations)	
10.30-11.00	Gravity - higher resolution, lower risk	Alice Murray
11.00-11.20	New developments in AGSO's databases	Murray Hazell
11.20-12.00	Highlights of recent AGCRC results, particularly seismic	Russell Korsch
12.00-12.25	Closing Remarks / discussion	Chris Pigram
12.30-1.30	Lunch (view posters/demonstrations)	
afternoon	Optional – informal discussions with project staff	

Thursday 9th December

Full day workshop (free) convened by AGSO's gravity group: developing future directions in national datasets, processing, and online access; includes hands-on

AGSO CHIEF EXECUTIVE OFFICER: Neil Williams

MINERALS DIVISION

Chief of Division: Chris Pigram

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BROKEN HILL EXPLORATION INITIATIVE (BHEI)

A National Geoscience Mapping Accord Project
Project Manager: George Gibson (AGSO)

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"On elephants and other big ideas for enhancing mineral exploration in the Curnamona Province"

NATIONAL GEOSCIENCE MAPS

Project Leader: John Bain

Ph: 02 6249 9282 Fax: 02 6249 9965

Email: john.bain@agso.gov.au

"Advances in new national geoscience maps"

NORTH AUSTRALIAN BASINS RESOURCE EVALUATION (NABRE)

Project Leader: Peter Southgate

Ph: 02 6249 9206 Fax: 02 6249 9971

Email: peter.southgate@agso.gov.au

"Towards a palaeoproterozoic Pb-Zn mineralising system - recent NABRE results"

YILGARN PROJECT

Project Leader: Alan Whitaker

Ph: 02 6249 9702 Fax: 02 6249 9983

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alan.whitaker@agso.gov.au

"Yilgarn project highlights and new subdivisions of the Yilgarn Craton"

NORTH PILBARA PROJECT

A National Geoscience Mapping Accord Project

Project Manager: Richard Blewett (AGSO)

Ph: 02 6249 9713 Fax: 02 6249 9983

Email: richard.blewett@agso.gov.au

"Tales of a Pilbara-phile - latest results from the Pilbara Project"

MINERAL RESOURCES AND ADVICE

Program Manager: Ian Lambert Project Leader: Bill McKay

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bill.mckay@agso.gov.au

"Mineral Resources and Advice: AGSO's role extended"

PROGRAM PLANNING PROJECT

Project Leader: Lynton Jaques

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"Analysis of Australia's major mineral systems"

CRC FOR LANDSCAPE EVOLUTION & MINERAL EXPLORATION

Project Leader: Colin Pain Ph: 02 6249 9469 Fax: 02 6249 9930

Email: colin.pain@agso.gov.au

Web:

http://leme.anu.edu.au/

GILMORE PROJECT

Project Leader: Ken Lawrie

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Email:

ken.lawrie@agso.gov.au

NATIONAL GRAVIMETRY PROJECT

Project Leader: Alice Murray

Ph: 02 6249 9264 Fax: 02 6249 9913

Email: <u>alice.murray@agso.gov.au</u>

NATIONAL DIGITAL DATABASES AND STANDARDS

Project Leader: Murray Hazell

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Email:

murray.hazell@agso.gov.au

"New developments in AGSO's databases"

AUSTRALIAN GEODYNAMICS CRC

Project Leader: Russell Korsch

Ph: 02 6249 9495 Fax: 02 6249 9972

Email:

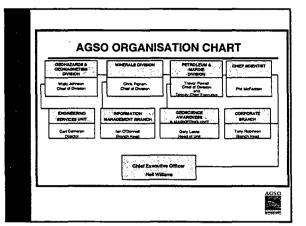
russell.korsch@agso.gov.au

"Highlights of recent AGCRC results, particularly seismic"

[&]quot;Solving regolith problems for exploration (CRC LEME latest results)"

[&]quot;Multidisciplinary study, Gilmore (west NSW) - Mineral Systems and Land Use"

[&]quot;Gravity - higher resolution, lower risk"



AGSO

MAIN ACTIVITIES

- Providing geoscientific framework to attract global minerals and petroleum exploration investment in Australia
- Providing scientific and technical advice and analyses in support of resource policy development and resource management
 - Best practice exploration, mining, petroleum production and $% \left(\mathbf{r}\right) =\mathbf{r}^{\prime }$

regulation

National geoscience databases, standards and information management

AGSO

MAIN ACTIVITIES (Continued)

- Promoting the use of geoscientific research and data for addressing land/marine management and environmental issues
- Providing technical justification for Australia's claim under UN Convention on the Law of the Sea
- Mitigating geohazards risk
- Providing technical responses to international disasters
- Nuclear monitoring



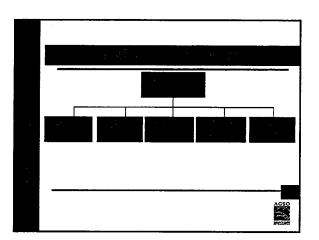
AGSO

- Economic, social and environmental benefits for Australia through first class geoscientific research and information (budget \$59 m)
 - Minerals exploration promotion and technical policy advice (38% of budget)
- Petroleum exploration promotion and technical

policy advice (32%)

- Marine zone management (15%)
- Geohazards and geomagnetism (15%)





Russell Korsch

- Regional Mineral Systems --
 - geological synthesis and identification of geological events, metallogenic studies, etc
 - regional studies of mineral provinces
 - geochronology laboratory



Lesley Wyborn

- National Maps & Information Systems
 - national geoscience infrastructure and standards
 - national maps and datasets
 - geoscience advice to support land-use in, and Australian custodianship of, the Australian Antarctic Territory
 - geochemistry laboratories



Ian Lambert

- Mapping Undercover, Mineral Promotion, Resources and Advice understanding the regolith (includes CRCLEME)
- potential fields research and application in mapping prospective areas undercover
- advice on resources, prospectivity, development
- and land use
- national and international mineral promotion

partnership with the States



Barry Drummond

- Seismic Methods
- ANSIR
- Gravity



Lynton Jaques

- Senior Science Specialist
 - Special research projects
 - Scientific leadership
 - Research quality



INDUSTRY CONSULTATION

- Common themes
 - Regolith: more emphasis on 3D, hydrogeochemistry and processes
 - Gravity: regional grids @ 4km or better
 - Seismic transects
 - Geochronology: (including methods other than zircon)
 - Information Management and National Data sets (get QC sorted out)



INDUSTRY CONSULTATION

- Common themes cont:
- Province scale packages (GIS & gridded data sets)
- Regional to National Geochemistry
- Stratigraphic Drilling in frontier areas
- Trialing new geophysical methods eg AEM, airborne gravity



- Recommendation 1: AGSO reconsider the strategic balance of its mineral promotion program to take into account industry needs for
 - expanded coverage of high resolution geophysical datasets and the gravity dataset in particular.
 - information from areas under a shallow cover of regolith or surficial sediments and the third dimension (through seismic studies)
- Response 1: AGSO will establish a Geophysical Fund
 - in collaboration with NGMA partners, and industry will collect more gravity and seismic data



Minerals Program Evaluation

- Recommendation 1 (cont):
 - regional studies and syntheses to accompany basic data including event recognition through increased application of geochronology.
- Response: AGSO will be involved in a number of major regional studies and synthesis projects
 - they will focus on tackling major problems in key provinces



- Recommendation 2: As part of its program and project planning for Minerals promotion, AGSO explicitly address the issues of project and product design, and timeframes for product delivery, in terms of explorers' needs and especially those of the smaller companies.
- Response 2: AGSO projects will be based on extensive consultation
- · modular and made available in a timely fashion
- delivered in formats and styles preferred by clients
- data accessibility
 - web based delivery
 - GSWA Work Station trial



- Recommendation 3: AGSO with the States/NT to develop and coordinate a strategic plan for the enhancement of the national geoscience knowledge base and mechanisms for drawing in other geoscience institutions to contribute to this affort.
- Response 3: AGSO with the States/NT will re-examine the strategic context of the NGMA taking into account the changes that have occurred in the environment in which precompetitive information is provided and develop a new strategic plan for the NGMA.
- This proposal will be put by the Commonwealth through the Chief Government Geologist conference.

AGSO

NGMA CRITERIA

- · Be of national or strategic importance
- add value to the geoscientific knowledge hase
- have application within the expected useful life of information generated
- or may meet a particular need for Commonwealth-State/Territory cooperation in provinces or basins that cross State boundaries

- Recommendation 4: AGSO be pro-active in advancing the national standards for digital geoscience information relating to minerals promotion by working with the States/NT to develop and implement a specific action plan with defined milastones and outcomes and by assigning resources specifically to this task.
- Response 4: Will seek to develop an action plan with States/NT for the development of a National Geoscience Data Model
- Will seek to develop an action plan with States/NT through GGIPAC for the development of National Standards, including authority tables and data dictionaries.



- Recommendation 5: AGSO develop an AGSO-wide information management system to be used by all projects in which:
 - all data collected by AGSO scientists must be spatially referenced as accurately as possible and stored only once within a designated corporate database.
 - all derivative database systems of syntheses and/or interpretations should be linked to the primary datasets.

Such a system must be consistent with any national standards developed and the holdings be consistent an overall strategic plan.

Minerals Program Evaluation

- Response 5: Agreed. ASGO is currently conducting an IM review of all projects with the aim of establishing an integrated national-scale corporate data model that will incorporate all geoscience data types across AGSO and be consistent with existing national/international standards.
- All primary data will be stored independently of, but still directly linked to those projects that synthesise and value add to these data



- Recommendation 6: In the context of the development of a national geoscience database, AGSO develop and implement a plan for expanding the application of geochronology in its ctudies.
- Response 6: AGSO will broaden its capability into Ar-Ar by employing a specialist geochronologist and negotiating access to the ANU RSES facilities
- AGSO is holding discussions with UWA/Curtin about developing an AGSO geochronology capability in WA.
- AGSO is holding discussions with University of Melbourne to develop a long term collaborative relationship.

- Recommendation 7: AGSO develop a mechanism for formalising the advice it receives from its clients and stakeholders and AGSO's response to that advice.
- Response 7: AGSO's experience of formal structures is that are captured for individual agendas (BMR Advisory Council)
- AGO will seek regular contact with Stakeholders from all levels of the Division
- information gathered will be synthesised each year, posted on the Web and reported at Meetings like the Open Days.
- MD evaluations and Project reviews will held on regular basis and results made public.



Minerals Program Evaluation

- Recommendation 8: The Minerals Division develop an annual marketing plan taking account of the roles of the NGMA partners as appropriate that includes:
 - an awareness raising, particularly amongst smaller companies, of AGSO products and services and forward program.
 - a strategy for targeting companies that may be interested in the work of a particular project.
 - forward advertising and awareness raising of forthcoming releases and timeframes.
- Response 8: AGSO developed a marketing strategy in 1998

 it will be revised in light of the recent changes to both the Act
 Minerals Division and the Industry.

- Recommendation 9: AGSO reconsider its pricing policy for Minerals products in the light of evidence that the price charged for AGSO products may be acting contrary to the desired outcomes of the Program and the impact on the ability of smaller explorers and consultants to access government data and information.
- Response 9: AGSO's pricing policy is part of a broader government policy
- AGSO is working throughout the portfolio with Policy groups to address the issue.



- Recommendation 10: All projects should be formally scoped and managed using appropriate management techniques to ensure a suitable balance between resources, skill requirements, timeliness and quality of products and the outcomes expected by stakeholders.
- Response 10: Agreed timeliness of information and data is a key issue



Minerals Program Evaluation

- Recommendation 11: Collaborative projects with the States/NT should be underpinned by Memoranda of Understanding between AGSO and the respective State/NT surveys laying out deliverables, responsibilities, time frames and mechanisms for adjustment.
- Response 11: AGSO will seek to have an MOU with the appropriate State or NT to cover each of the projects it establishes



- Recommendation 12: Projects should be formally scoped with a shorter time frame (eg 3 years) with well defined objectives and regular deliverables.
- Response 12: Agreed
- AGSO will plan projects with a minimum of annual deliverable's and exit strategies:
- timeliness and relevance of products is seen as a key to stakeholder satisfaction



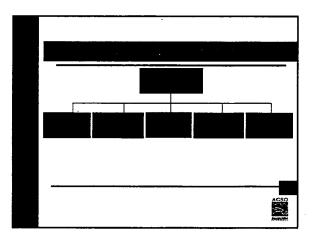
- Recommendation 13: AGSO reconsider its project structure and duration of projects in Minerals with a view to facilitating:
 - integration of geophysical, geological and other disciplines
 - staff movement between project teams and discipline groups
 - improved project and people management.
- Response 13: AGSO projects will be fully integrated multidisciplinary in approach
- specialist input will be scheduled as required
- the appointment of RGL's is designed to facilitate better project and people management



Minerals Program Evaluation

 Recommendation 14: AGSO appoint a senior scientist to lead the geological discipline within the Minerals Division.





- Recommendation 15: The Minerals Division further develop its skills to address the strategic directions outlined in Recommendation 1 and in particular give consideration as to how it will meet the growing demand for regolith expertise.
- Response 15: AGSO has recently placed some of the existing contract staff on permanently (De Caritat and Gibson)
- AGSO has, in cooperation with University of Canberra, move to appoint a Hydrogeochemist to CRCLEME
- Lisa Worrell currently working in the AMETCRC is relocating to Canberra in January 2000.



FUTURE

- Political imperative: need to clearly separate the national role from States/NT role:
 - IM, National Maps, National Promotion (PDAC), Regional Synthesis (across borders), specialist capabilities (ANSIR)



FUTURE

- · Project style:
 - problem solving
 - multidisciplinary
 - timely
 - relevant
 - Data acquisition focussed on problem solving
 - national surveying only from new initiatives (eg airborne gradiometry)



FUTURE

- Terminating projects
 - Pilbara, Yilgam, NABRE, Lachlan, Gilmore
 - AGCRC and AMET CRC
- Continuing projects
 - BHEI, NATMAPS, TASMAP, ANTARCTICA, Gravimetry, Databases, Resources & Advice
 - AMIRA Projects P515, P482 combined with P437, P552.
 - CRCLEME



FUTURE

- NEW PROJECTS ?
- WE SEEK YOUR INPUT



BROKEN HILL EXPLORATION INITIATIVE (BHEI)

A National Geoscience Mapping Accord Project

Project Manager: George Gibson

Ph: 02 6249 9727 Fax: 02 6249 9983

Email: george.gibson@agso.gov.au

Co-operating Agencies: Department of Primary Industries & Natural Resources, SA

New South Wales Department of Mineral Resources

CRC LEME

Australian Geodynamics CRC

Industry Participants

Universities

Objective: To provide a new generation of geoscientific information for the Broken Hill-Olary region (Curnamona Province) as a basis for more effective and efficient exploration by the mineral industry

Overview: The Broken Hill Exploration Initiative (BHEI) commenced in 1994 with a view to securing the long term economic prosperity of Broken Hill and Port Pirie, both of which faced an uncertain future following industry predictions that the Broken Hill ore body would be exhausted within 10-12 years. Pasminco has since announced that the last major mine in the Broken Hill area will close in 2006. The socio-economic imperative to find new mineral deposits in the area has thus become ever more urgent, bringing with it increased pressure on Government agencies to produce new geoscientific datasets and ideas that will promote and encourage mineral exploration in the Broken Hill-Olary region. The BHEI was conceived to deliver these objectives and is a multidisciplinary project, bringing together high-resolution airborne geophysical surveys (aeromagnetics, radiometrics) with regional geology, seismic and gravity data, petrophysics, petrology, geochronology, geochemistry, structural analysis, and metallogenesis studies to provide new insights into the geological evolution of the Broken Hill - Olary region, and thereby establishing a firmer and more effective basis for mineral exploration. The project concludes in June 2000.

The major vehicle for public release of BHEI results, ideas, and datasets has been the BHEI conference held every 12-18 months in Broken Hill. The next BHEI meeting will be held in the year 2000 (May 15-17).

Main Scientific Results and Milestones: The following section is not intended to be a comprehensive account of all BHEI results and outcomes. Rather, this section points to some of the key conceptual advances made by BHEI staff in understanding the regional structure, airborne geophysics (particularly aeromagnetics), and the timing of some base-metal mineralisation in the Broken Hill - Olary region. Geochronological studies currently underway will provide further constraints on the timing of events and mineralisation.

• Detailed structural mapping combined with rock property studies (magnetic susceptibility) clearly demonstrates that many linear magnetic anomalies in the Broken Hill region are structurally controlled and lie within the regional D3 fabric; a few others reside within D2 high-strain zones. This result challenges the long held view that such anomalies reflect stratigraphy and at the same time introduces a

cautionary note about the use of magnetic anomalies as markers for extrapolating lithology and/or stratigraphy below cover. Magnetite distribution in the Broken Hill region is the result of transient and dynamically-induced permeabilities, and as such is potentially a very useful tool in the recognition and mapping of former fluid pathways.

- Contrary to previous expectations, major shear zones in the Broken Hill region dip southeast rather than north-west as evidenced by new structural mapping and BHEI seismic reflection profiling. Although reactivated during younger events (eg. Delamerian Orogeny), most of these structures retain their original geometry and form part of a D3 northwest-vergent fold and thrust belt. This fold and thrust belt was superimposed on an earlier episode of large-scale northeast-vergent recumbent folds (D2) which in turn overprint an earlier layer-parallel fabric of possible extensional origin. The recognition of deformational events (D2 and D3) with near orthogonal orientations has major implications for three-dimensional representations of regional structure and stratigraphy in the Broken Hill-Olary region and the ability to predict accurately what occurs at depth. Reactivation of the D3 shear zones during the Delamerian Orogeny and younger events is supported by Ar-Ar ages ranging from 500 400 Ma.
- The principal copper-gold (-molybdenum) deposits and prospects in the Olary and Broken Hill Domains are epigenetic-syntectonic, early Mesoproterozoic (or Late Palaeoproterozoic) in age, and share several characteristics of iron-oxide associated Cu-Au systems in the Mt Isa Inlier and elsewhere. Stable isotope studies demonstrate a clear difference in sources of fluids in Cu-Au mineralisation and regional syntectonic Na-Ca-Fe alteration that formed at deeper crustal levels. Deposit styles range from Cu-sulfide and Fe-oxide rich to Au-rich with sparse Fe-oxides; such variations have implications for exploration methodologies applied in the region.
- Mineralisation in the Broken Hill-Olary region is in part structurally controlled. Examples of shear-hosted mineralisation occur at Copper Blow south of Broken Hill (Cu-Au) whilst farther north in the Allendale region Pb-Zn-Ag mineralisation is contained within the regional D3 fabric. Less easily determined is whether Pb-Zn-Ag mineralisation, including the main Line of Lode, is also structurally controlled or whether it represent syngenetic-diagenetic mineralisation that was subsequently remobilised during later deformation and metamorphism.

Other activities/results:

- Initial Broken Hill GIS package released (1998) on CD-ROM (includes geological, geophysical, geochemical, topographic, and cultural features). During 2000, a second CD will be released incorporating U-Pb and Ar- Ar geochronology, stable isotope geochemistry, mineral alteration patterns, structural data and cross-sections, rock properties data, petrology and the results of a metallogenesis study currently underway.
- Aeromagnetic data released at 1: 100 000 (Broken Hill) and 1:250 000 (Olary) scales; Seismic data (180 line km) released.
- Collaborative SHRIMP U-Pb dating program with the Australian Geodynamics CRC indicates an episode of bimodal magmatism (granites and mafic intrusives) contemporaneous with sedimentation at ca.1710-1690 Ma. Magmatism most likely occurred in a rift or extensional tectonic environment.

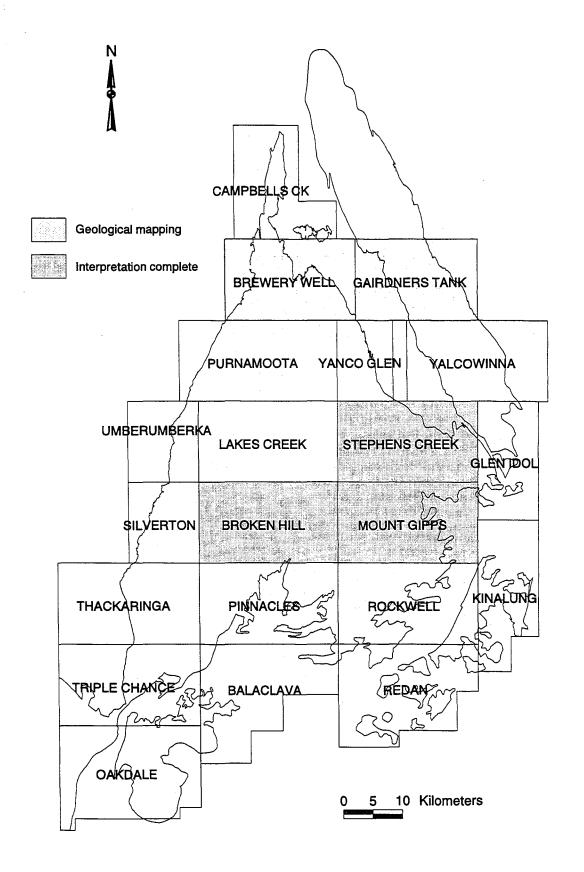


Figure 1. Availability of solid geology (lithological interpretation) maps for the Broken Hill Block. Map coverage from NSWDMR 1:25 000 geology.

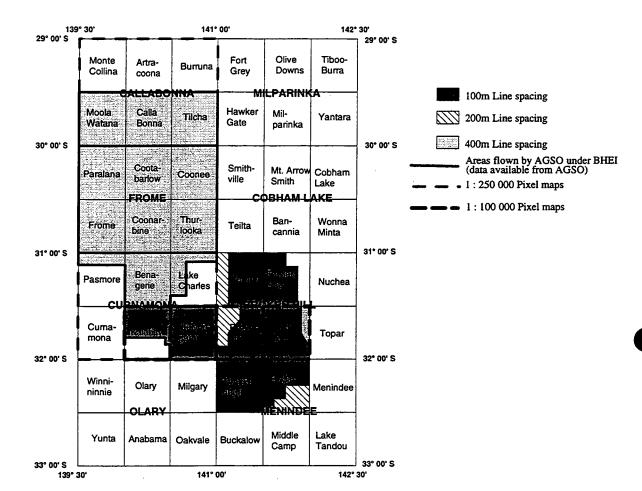


Figure 2: Broken Hill - Olary map sheets for which airborne geophysical data are available

Research Publications:

AGSO Research Newsletter:

- Maidment, D. W., Gibson, G. M. & Giddings, J. W. (1999): Taking geology below cover at Broken Hill. AGSO Research Newsletter 30: 5-7
- Giddings, J. W., Gibson, G. M. & Maidment, D. W. (1999): Rock property structural geology synergy at work in Broken Hill. AGSO Research Newsletter 30: 7-10
- Gibson, G. M., Maidment, D.W. and Haren, R. (1996). Re-evaluating the structure of Broken Hill: implications for mineral exploration and the interpretation of airborne magnetic data. **AGSO Research Newsletter 25**: 1-3

AGSO Records:

- Denham, D. (Compiler) (1997): BHEI Abstracts Volume. AGSO Record 1997/49: 46pp.
- Gibson, G. M., Drummond, B. J., Fomin, T., Owen, A., Maidment, D. W., Gibson, D.L., Peljo, M., & Wake-Dyster, K. (1998): Re-evaluation of crustal structure of the Broken Hill Inlier through structural mapping and seismic profiling. **AGSO Record 1998/11**: 55pp.
- Gibson, G. M. (Compiler) (1998): BHEI Abstracts (extended) Volume. **AGSO Record** 1998/25: 127pp. Some articles also reproduced in MINFO, New South Wales Mining and Exploration Quarterly no. 62 (January, 1999).
- Gibson, G. M., Donaghy, A. G., Peljo, M., Hall, M., and Maidment, D. W. (1998): BHEI Field Excursion Guide. AGSO Record 1998/26: 25pp.
- Maidment, D. W. and Gibson, G. M. (1999): Sources of magnetic anomalies in the Broken Hill region, NSW. AGSO Record 1999/6: 69pp.
- Maidment, D. W., Schmidt, P. W., Giddings, J. W., Peljo, M., and Clark, D. A. (1999): A petrophysical dataset for the Broken Hill region. **AGSO Record** (in press).

Maps: (see figure 1)

- Gibson, G. M., Maidment, D. W. & Peljo, M. (1999): Lithological interpretation (solid geology) of the Broken Hill 1: 25 000 sheet. AGSO, Canberra.
- Maidment, D. W.; Gibson, G. M.; Stevens, B. P. J (1997): Lithological interpretation (solid geology) of the Mt Gipps 1:25 000 sheet. AGSO, Canberra.
- Maidment, D. M.; Gibson, G. M.; Stevens, B. P. J. (1997): Lithological interpretation (solid geology) of the Stephens Creek 1: 25 000 sheet. AGSO, Canberra.

Other Publications:

- Ashley, P.M., Conor, C.H.H. and Skirrow, R.G. (1998): Geology of the Olary Domain, Curnamona Province, South Australia: Field guidebook to Broken Hill Exploration Initiative excursion, 13-15 October 1998. **Primary Industries and Resources South Australia, Report Book**, 53 p.
- Donaghy, A. G.; Hall, M.; Gibson, G. M. (1997): Structure, high grade metamorphism and stratigraphy at Thackaringa, Broken Hill, NSW. Geol. Soc. Aust. Abstracts 46: p. 21.
- Donaghy, A. G., Ehlers, K., Gibson, G. M., Maidment, D. W., Nutman, A.P. & Venn, C. J. (1997): Dating of multiple Proterozoic thermal events by SHRIMP U/Pb geochronology at Broken Hill, NSW, Australia. Abstract Goldschmidt Symposium.
- Donaghy, A.G.; Hall, M. & Gibson, G. M. (1998): Stratigraphic interpretation in a high metamorphic grade, multiply deformed terrane: a case example from the Palaeoproterozoic Broken Hill block, NSW, Australia. **Abstract, Evolution of structures in deformed rocks:** 26-28. Canmore, Alberta, Canada. Sept. 1998.
- Donaghy, A. G.; Hall, M. & Gibson, G. M. (1998): The age of deposition and first deformation of the Palaeoproterozoic Willyama Supergroup, Broken Hill, Australia. Geol. Soc. Aust. Abstracts 49: p. 118
- Donaghy, A. G., Gibson, G. M., Nutman, A. P., Hall, M. & Maidment, D. W. (1999): Rethinking the Palaeoproterozoic geological history of Broken Hill, NSW,

- Australia: speculation towards a synthesis of structure, geochronology and lithological mapping. Geol. Soc. Aust. Abstracts 53: 48-49.
- Drummond, B. J., Fomin, T., Leven, J. & Gibson, G. M. (1998): Multiple episodes of crustal deformation in a broad zone spanning the boundary between the shield and younger terranes in SE Australia. Abstract, 8th International Symposium on Deep Seismic Profiling of the Continents and their Margins, Barcelona, Spain, September, 1998.
- Fomin, T.; Gibson, G. M.; Owen, A.; Drummond, B.; Wake-Dyster, K.; Maidment, D. W. (1998): The seismic transect through the Broken Hill region. **AGSO Record** 1998/2: p. 74.
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Products:

- **Digital:** Broken Hill Geoscientific GIS on CD-ROM (includes geology, airborne geophysical data, geochemistry, topographic and cultural features, exploration tenements and much more)
- **Broken Hill Seismic Reflection Data**: available in digital form (total data: 180 km). Min. purchase 50 km

Magnetic & Gamma-ray Data:

- Broken Hill, Corona, Fowlers Gap, Mulyungarie, Redan, Taltingan, Thackaringa 1:100 000 sheet areas flown at mainly 100m line spacing (see figure 2)
- Digital data point located (line spacing 100m or 200m): 7½' X 7½'; 1:25 000 sheet, or 1:100 000 sheet. Eastern half of Mawarra, Yalcowinna, Mundi Mundi Creek, Glen Idol
- Gridded: 1:25 000 (15' X 7½'); 1:50 000; 1:100 000 sheets. Glen Idol, Little Aller Creek, Mawarra, Mundi Mundi Creek, Redan II (North & South), Redan III South, Umberumberka, Yalcowinna

Various Line maps as dyelines or transparencies

Magnetic pixel maps: Broken Hill, Kalabity, Mulyungarie, Taltingan 1:100 000 sheets (Pseudocolour or Greyscale)

Gamma-ray pixel maps: Broken Hill, Taltingan 1:100 000 sheets: pseudocolour Semi-detailed Line Spacing Callabonna (S); Frome - 400m line spacing 1:100 000 sheet Digital data - point located; Grids (TMI or 4 -channel gamma-ray 1:250 000 sheet Digital data - point located; Grids (TMI or 4 -channel gamma-ray):

Elevation Data:

- Detailed Line Spacing Broken Hill, Corona, Fowlers Gap, KalabityMulyungarie, Redan, Taltingan, Thackaringa 1:100 000 sheets flown mainly at 100m line spacing. Point located and gridded data (1:100 000 sheet area)
- Semi-detailed Line Spacing Callabonna (S), Frome 400m line spacing Point and gridded data (1:250 000 sheet area)

On elephants and other big ideas for enhancing mineral exploration in the Curnamona Province

George Gibson, David Maidment, Matti Peljo, Roger Skirrow, Barry Drummond, Tanya Fomin, John Giddings, & Lynton Jaques



Picture of elephant big problem in need of a little understanding



BHEI comes of age

Picture of elephants



Some key questions:

- Regional Structure:
 fold or shear dominated (nappes vs thrust model)?
 orientation of major structures?

Interpretation of aeromagnetics:

- structural or stratigraphic control?

Mineralisation:

- uisation:
 original distribution vs line of lode
 syngenetic or epigenetic?
 stratiform or shear-hosted?



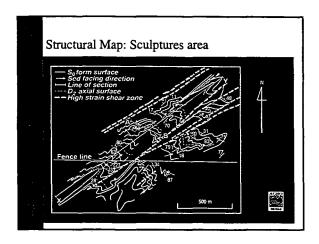
Structural Evolution: post-BHEI

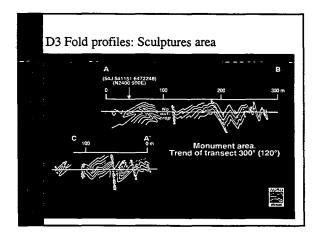
- •D1 ?Early extension (layer-parallel fabric)
- •D2 Recumbent fold & nappe formation
 •D3 West-vergent folding & thrusting; imaged in seismic profiles
 •D4 (Rodinia Breakup; normal & strike-slip
- faulting)
- •D5 & D6 Post-Adelaidean events

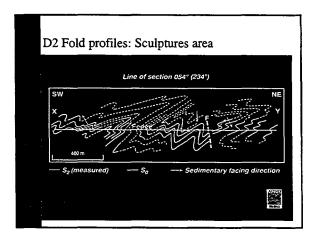
NB: Pb-Zn mineralisation & magnetite in D3 fabric (remobilisation or emplacement age?)

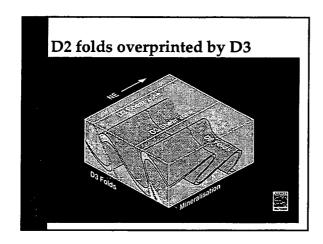


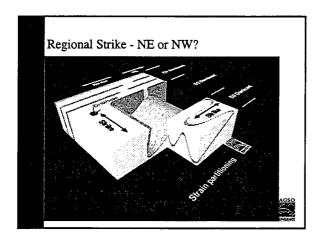
Broken Hill: Early Structural history

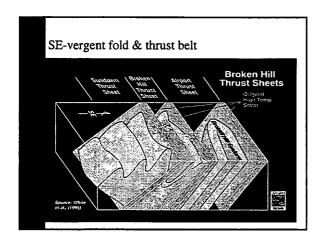


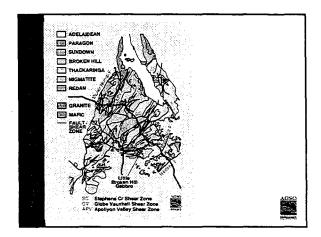


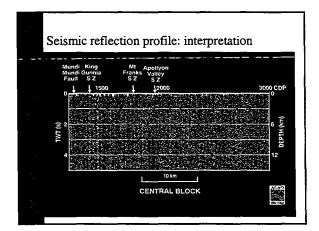


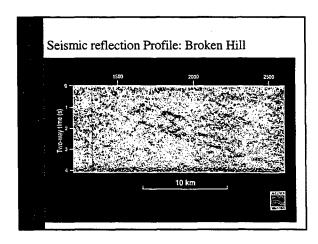












Interpretation of Aeromagnetic data

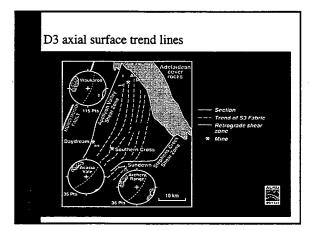
- Anomalies of different ages & origin
 - stratiform
 - melt related (pegmatite)

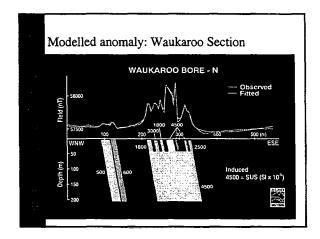
 - structurally controlled:

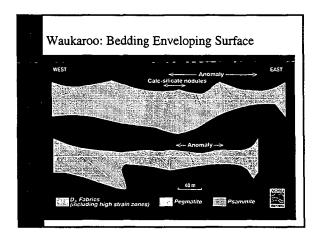
 high temperature shear zones
- lithological boundaries
 regional schistosity
 late shears magnetite destructive

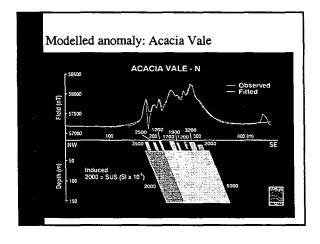


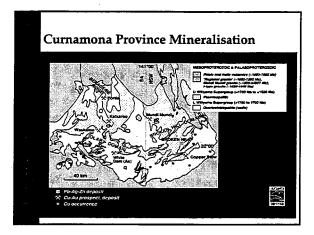
Broken Hill Aeromagnetics: 1st vertical derivative







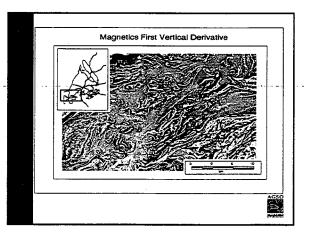


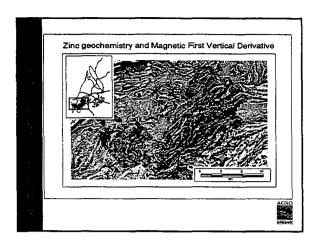


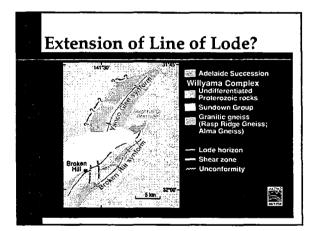
Potential mineralisation styles Curnamona Province

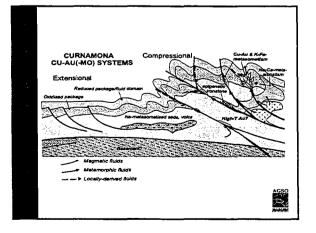
- •D3 shear-controlled Pb-Zn-Ag
 •Stratabound sediment-hosted Pb-Zn-Ag
 •Fe-oxide associated Cu-Au (Cloncurry style)
- •Olympic Dam style Cu-Au
- •Stratabound sediment-hosted Cu •Shear-related high-T? Au











Conclusions

- Regional structure dominated by D2 & D3 deformations (non-coaxial); D1 extensional in origin?
- D3 structures imaged in seismic profile
- Mineralisation partly controlled by D3 structures (?1570-1590Ma)
- Cu-Au (-Mo) mineralisation is epigenetic- syntectonic in origin (L. Proterozoic - E. Mesoproterozoic in age)
- Structurally controlled magnetic anomalies = fluid pathways (D2 & D3 in age)



The next big one?



The Broken Hill Geoscientific Geographic Information System

The Broken Hill Geoscientific GIS is an integrated spatial database of geological, geophysical, geochemical and cultural data for mineral exploration and research. The area covered by the GIS comprises six 1:100 000 mapsheets, encompassing the outcropping portion of the Broken Hill and Euriowie Blocks; namely the Corona, Fowlers Gap, Broken Hill, Taltingan, Redan and Thackaringa mapsheets.

The GIS is available in ArcView or MapInfo format on CD-ROM incorporating a customised project file or workspace file (depending on format). Data access routines are included which display geochemical data, photographs with captions and N.S.W. Geological Survey report abstracts for tenements and drillholes.

The dataset features:

- 1:25 000 geological maps (21) and 1:100 000 stratigraphy.
- Two 1:25 000 lithological interpretations.
- Twenty-three thematic layers of selected lithologies, eg. amphibolite, Potosi gneiss, etc.
- Geophysical images (aeromagnetics, gravity and DEM).
- Geochemical (2 000+ samples) and petrological (8 200+ samples) databases.
- Geochemical images (copper, lead & zinc).
- Topographic and cultural data (eg. drainage, properties and topographic maps).
- Historical and current tenements.
- 3 500+ mineral occurrences.
- 1 400 drillholes and 260 water boreholes.
- 46 hotlinked outcrop photographs.

The cost of the CD-ROM GIS package, which includes a users manual, is \$1 000 plus postage & packaging.

A version of the Broken Hill GIS incorporating high-resolution aeromagnetic data for one 1:25 000 sheet (Mount Gipps) is available for \$1 200.



For further details contact:

AGSO Sales Centre GPO Box 378 Canberra ACT 2601 Phone: (02) 6249 9519 / 9642

Fax: (02) 6249 9982

http://www.agso.gov.au/minerals/

NATIONAL GEOSCIENCE MAPS

Project Leader: John Bain Ph: 02 6249 9282

Fax: 02 6249 9965

email: john.bain@agso.gov.au

Overview: AGSO has responsibility for the production and distribution of National geoscience maps and datasets - a key role acknowledged by most AGSO clients as of great importance to them. Many of the current *National Geoscience Datasets* for sale on the download page and in the *National Digital Geoscience Datasets CD* product are thematic geoscience and geoscience-related data, images and maps of national extent based on generalised regional maps at a nominal 1:5 million scale. We plan to upgrade these datasets with more detailed information and expand the range and variety of the data themes. This upgrade will be based mostly on published 1:1 million scale geological maps and associated information sources. As new datasets are released they will become available on the *National Geoscience Datasets* download page and once yearly a CD product of all datasets will be produced (*National Digital Geoscience Datasets CD*).

In the longer term, we aim to provide efficient, modern digital-era access to all the geoscience information available in current maps and associated digital databases at the best possible resolution. This will be achieved through online (world wide web) access to all primary geoscience information in the form of digital datasets that cover the Australian continent and/or Australian marine jurisdictional areas. This will allow you to view or acquire geoscience information assembled in themes and to build your own maps or datasets from the National Database.

Current Activity: Database modification, data acquisition, spatial data capture/acquisition, compilation, testing, correction, and beta version of basic geological and geophysical datasets to be released June 2001.

- Priority will be assigned to the delineation of:
 - 1. crystalline provinces and sedimentary basins,
 - 2. a first-ever national gamma ray spectrometric map and
 - 3. a new magnetic map and associated datasets.
- A provinces database will record most published versions (including current State and AGSO preferred versions) of basin and province definitions and outlines at various scales.

Gamma Ray Spectrometric and Aeromagnetic Maps

Version 4 of the Magnetic Map of Australia will be more sophisticated and useful than Version 3. Although differences will be seen in the hard copy 1:5 M product, the main improvements will be in the basic gridded data which underlie the map. Some of the improvements envisaged are:

- The data will be gridded to the best cell size for the line spacing in any area. For example in the Broken Hill region where the line spacing is 100 m the grid cell size will be 20 m, while in an area where the line spacing is 3 200 m the grid cell size will be approximately 800 m. Thus users will be able to get a grid which is at the best resolution for the component surveys if they wish.
- New data will be incorporated which are not in Version 3.

- A different edge matching and grid joining procedure will be used which will reduce spurious artifact anomalies with wavelengths of 100 km to 1000 km.
- The data will be stored in such a way that new grids will be more easily incorporated than previously.
- Users will be able to graphically select an area of Australia for which they want data, and receive the seamlessly joined data in a grid cell size they select.

A similar model will apply to the gamma ray data. All the data will be available over the internet.

National Digital Geoscience Datasets on Compact Disc (CD)

A selection of AGSO's continental-scale digital datasets in one digital data package (on two CD's). Raster and vector datasets have been compiled using a standardised coastline, projection and central meridian enabling easy integration of any of the individual coverages. Datasets have been formatted for use with Arcinfo/Arcview and Mapinfo software. This two CD package contains the digital data (Disc 1) and A3 postscript files of the more popular base maps and integrations so that purchasers can print out their own maps (Disc 2). Some datasets are primary (geology, metamorphism, regions), whilst others are subsets of AGSO's major databases and datasets (magnetics, whole-rock geochemistry, mineral deposits etc).

Future Developments

- We plan to update these datasets annually on CD. As new data becomes available datasets will be provided on the National Geoscience Datasets internet page for sale and download.
- We plan to link future National Digital Datasets to digital versions of published 1:250,000 scale geological maps and associated information sources, probably directly to State/Territory Geological Survey/Mines Department web sites.
- Continue development of national digital standards to ensure that new information gathered by geoscience groups in Australia can be readily incorporated into the existing digital datasets.
- Apart from online access we will periodically release some litho-printed paper maps.

LIST OF NATIONAL GEOSCIENCE DATASETS ON CD

Geological datasets

Geology of Australia

Metamorphic rocks of Australia

Crustal elements

Geological regions of Australia based on AGSO Bulletin

181

Regolith-Landforms of Australia

Basins of Australia

Depth to basement image

Spatial representation of AGSO's whole rock

geochemistry database ROCKCHEM

Spatial representation of AGSO's geochronology

database OZCHRON

Spatial representation of AGSO's mineral deposits

database OZMIN

Spatial representation of AGSO's field observation

database OZROX

Geophysical datasets

Magnetics image

Gravity image

Image of estimated crustal temperatures at 5km depth and well data locations used to generate image

Specifications and coordinates of AGSO and contractors airborne surveys

Selected Onshore AGSO Seismic Cross sections, linked to AGSO Onshore Deep Seismic lines

Locations of AGSO Offshore seismic lines navigated by RV Rig Seismic

Earthquake hazard dataset

Australasian Earthquake epicentre locations

Australian Geomagnetic Reference Field

Geoscience related datasets

Digital Terrain Model AUSLIG

1:1m Australian Coastline

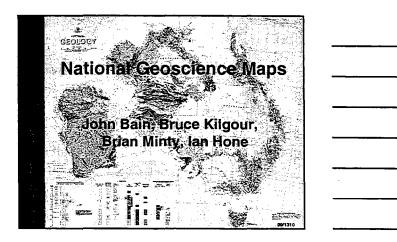
1:100 000 map sheet index of Australia with Index of AGSO publications from GEODX

(AGSO's bibliographic reference database) attached to each mapsheet

1:250 000 map sheet index of Australia with Index of AGSO publications from GEODX

(AGSO's bibliographic reference database) attached to each mapsheet

Coded cultural layers (population centres, road, rail, drainage network



National Geoscience Maps

An important AGSO responsibility

Define the context for mineral exploration

A role in promoting Australia as a first rate exploration destination

Opportunities to bridge the gap between these overviews & detailed info in State and National databases



National Geoscience Maps Where we are now Your needs and priorities How we plan to meet them

National Geoscience Maps	
Now:	
Analog & digital compilations	
Nominally I:5 million scale	
Australian landmass only	
Not generally connected with databases	
No live links with State databases	
Some issued on paper, 30 datasets	
on CD	
National Geoscience Maps	
What we think you want:	
All the latest info	·
Affordable & Digital	
Online & Useable	
Searchable to 1:250k scale or better National standards	
Live connections with State and	
National databases	
99/1232	
	•
National Geoscience Maps	
What you'll get soon (12-18 months):	
Digitally compiled datasets	
Bugitany Complied datasets	
Naminally 4.4 million souls	
Nominally 1:1 million scale	
Australian landmass & marine jurisdiction	
Australian landmass & marine jurisdiction Online viewing & E-commerce	
Australian landmass & marine jurisdiction	

National Geoscience Maps

Our first priorities in the next 12-18 months:

Magnetic map of Australia (upgraded) Gamma ray spectrometric map of Australia

Basins & crystalline provinces of Australia

at 1:1 million scale

Continued development of national digital standards

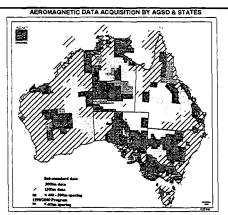


National Magnetic Map

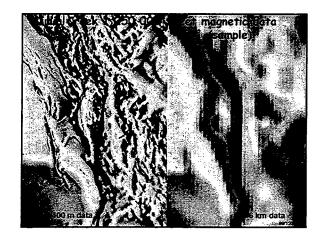
Main improvements will be in the basic gridded data that underlie the map. eg:

- gridded to best cell size for the line spacing in any area
- new edge-matching and grid-joining procedure (to reduce spurious long wavelength artefact anomalies)
- new grids will be more easily incorporated than previously
- graphically selectable, seamlessly joined data with a grid cell size of your choice.
- online viewing (at lower resolution) and down loadable
- new data





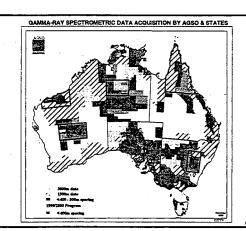
89/1235



National Gamma Ray Spectrometric Map

- A similar model will apply to the gamma ray data.
- 5 Regional datasets being compiled now.
 - printouts will become available as we build these areas -see display
- All the data will be available over the internet subject to bandwidth limitations





99/1229

Basins & crystalline provinces of Australia

- Database with definitions including structural and tectonic units
- State and AGSO preferred versions
- Spatial definition
- Linked to expanded STRATINDEX,



National Geoscience Maps

Down the track (3-5 years):

Digital compilation derived from 1:250k detail or better (need national data standards to achieve)

We could easily have far more national data themes if a National Geoscience Data Model covering all data types is developed and adopted by all geoscience organisations

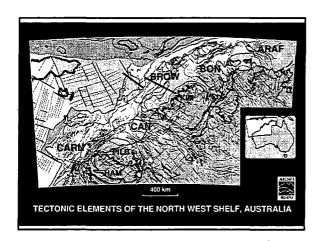
National Geoscience Maps

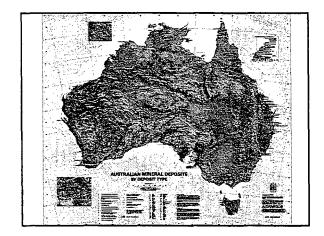
Are we on the right track? What are your priorities for National maps?

.....Tell us now. We're listening!









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National Geos alence Datas ets

AGSO has released a new product which brings together in a single digital GIS package all of AGSO's continental-scale datasets. Some of the datasets are primary (geology, metamorphism, regions)







National Geos dence Datas ets



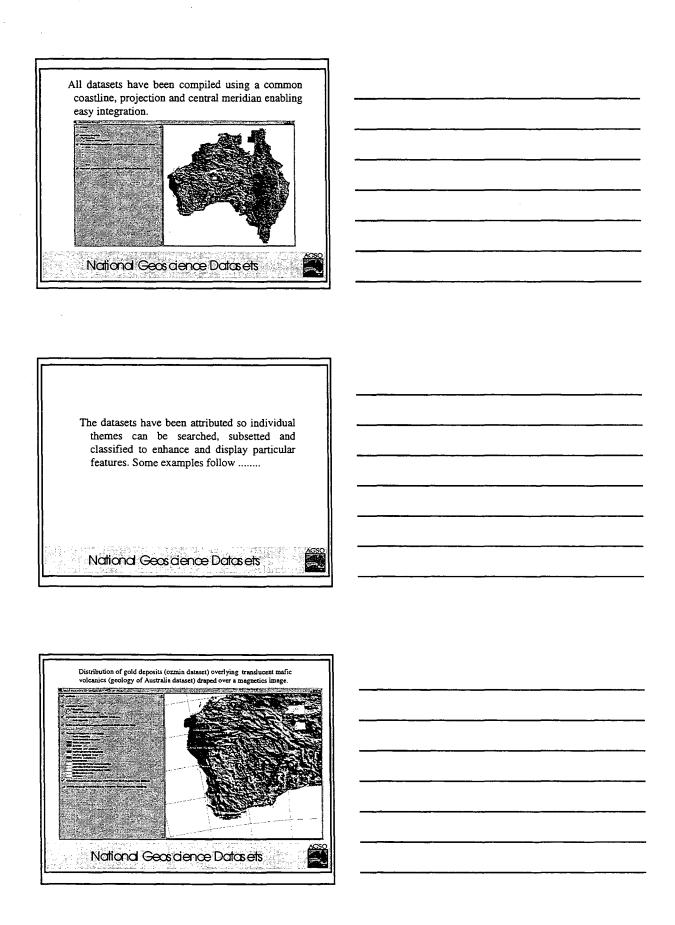


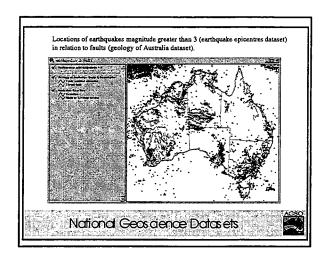


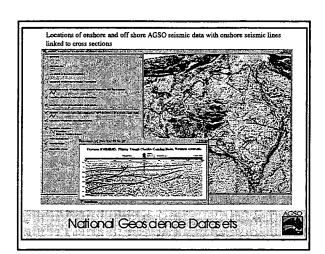
others are subsets of AGSO's major data bases and datasets (magnetics, whole-rock geochemistry, mineral deposits, airborne surveys etc).

National Geos dence Datas ets









The CD Product

Thirty datasets are included in the package. Supported formats for the data are ARCINFO, MAPINFO and ARCVIEW. The data set is sold as a 2-CD product - one CD contains the digital data, whilst the other contains A3 postscript files of the more popular base maps and integrations so that clients can print out their own maps.

CD Product Price

\$950





National Geoscience Datasets



For Further Information Pick up a flyer or ask an AGSO representative for a demonstration. AGSO contacts Bruce Kilgour Phone (02) 62499610 Email bruce kilgour@agso.gov.au John Bain Phone (02) 62499282 Email John Bain@agso.gov.au or see the AGSO internet page at http://www.agso.gov.au/minerais/ams/datasets.html which has on line interactive GIS of selected National Geoscience Datasets To order contact the AGSO Sales Centre Phone (02) 62499519 Fax (02) 62499982 Email sales@agso.gov.au National Geos dence Datas ets

NORTH AUSTRALIAN BASINS RESOURCE EVALUATION (NABRE)

Project Leader: Peter Southgate

Ph: 02 6249 9206 Fax: 02 6249 9971

Email: peter.southgate@agso.gov.au

OVERVIEW

Palaeoproterozoic sedimentary rocks of northern Australia host one of the world's most important zinc repositories. Despite more than fifty years of geological investigation, including the production of 1:250,000 and 1:100,000 geological maps, the drilling of countless mineral exploration holes and the acquisition of thousands of line kilometres of potential field data, the public domain lacks the basic stratigraphic and facies information necessary to undertake a modern basin analysis. Integrated models aimed at constraining the flow of mineralising fluids in these basins require reconstruction of basin shape and sediment architecture at the time of fluid flow. Hence it is necessary to construct a chronostratigraphic basin framework. The NABRE project has spent the past four and a half years developing such a framework

SUMMARY OF PRINCIPAL RESULTS

Basement studies in North Australian Craton indicate temporal correlations to orogenic and magmatic arc events in the Arunta Belt of central Australia. Basin development and widespread magmatism in northern Australia appears to be linked to orogeny and subduction in central Australia. Periods of active subduction cause regional tilting of the North Australian Craton via a dynamic tilting mechanism. Periods of orogenic activity cause flexure of non homogeneous crust and the development of local strike-slip deformation.

Stratigraphic studies identify three Superbasins in the 1800-1575 million year period: the Leichhardt (1800-1750Ma), Calvert (1730-1690Ma) and Isa Superbasins (1670-1575Ma). Unconformities with ~ 20 m.y. of missing rock record separate the superbasins. Seven supersequences are recognised in the Isa Superbasin, which hosts the Pb-Zn-Ag deposits of northern Australia. Each supersequence has a duration of 10-15 m.y. and is internally divisible into a series of nested fourth and fifth order sequences. Regional correlations have been made to the fourth order scale of precision. Each of the fouth order sequences has a duration of approximately 1 m.y. Sequence stratigraphic correlations, SHRIMP zircon ages and Apparent Polar Wander Path (APWP) data for the Calvert and Isa Superbasins are summarised in an Event Chart. The integrated analysis demonstrates that the Calvert and Isa Superbasin boundaries and Loretta, River and Wide Supersequence boundaries plot at or near bends on the APWP curve. Furthermore Pb/Pb model ages for the Broken Hill (1675 Ma), Mt Isa (1653 Ma), McArthur River (1640 Ma.) and Century (1575 Ma) Zn-Pb-Ag deposits coincide with bends on the APWP. Thus, supersequence boundaries, changes in rates of accommodation and fluid flow events responsible for metal transport may be correlated with periods of intraplate stress manifested as bends on the APWP.

IMPLICATIONS FOR MINERALISATION

The integrated structural and chronostratigraphic analysis has led to the development of a strike/slip model for basin evolution and fluid flow leading to Pb-Zn mineralisation in the Mt Isa Valley. The Mt Isa Valley is now interpreted as a major basin depocentre with high accommodation rates and deposition of reductant facies controlled by strike/slip tectonics which created an area of dilatent longevity. Regional, north-south

compression related to the Argilke Orogeny in central Australia caused paired uplift and subsidence belts to develop in the Leichhardt River Fault Trough and adjacent Lawn Hill Platform. Areas of dilation created space for sediment accumulation. Restraining fault segments led to uplift, provenance rejuvenation and a topography driven fluid circulation system. Dilating faults that bound the depocentre focus and tap the deeper topography driven and thermobaric/compactive fluid systems. The Pb-Zn bearing basinal brines move up the dilating faults with sulphide precipitation taking place where reactive, reductant facies are encountered. Strike/slip basins also host mineralisation in the River Supersequence (McArthur River, Walford Creek and Grevillea prospects and deposits) and the Wide Supersequence (Century deposit). A Century equivalent mineral play, termed Elizabeth Creek, has been identified on the northern Lawn Hill Platform at the southern extremity of the Comalco seismic grid. The chronostratigraphic basin framework permits the visualisation of four stratigraphic/structural mineral plays. These are discussed in the accompanying talk.

OUTCOME

An integrated structural and chronostratigraphic framework for basin evolution is the major project outcome. The project results have also led to the successful implementation of an AMIRA project. AMIRA Project P552 commenced in February 1999. This project is utilising the basin framework to address questions concerning the timing of generation of a fertile (Pb-Zn-Ag) brine, the locations of brine reservoirs in the basin, the pathways of brine migration and times of brine expulsion. The results of mineral paragenesis and geochemical studies will be combined with the chronostratigraphic framework to constrain models aimed at understanding fluid flow in these basins. The project is a combined initiative of AGSO, Queens University, Canada, CODES (University of Tasmania), University of Queensland, CSIRO and the Queensland Department of Mines & Energy. It has eight sponsors, each contributing an average of \$25,000/year for three years. The sponsors are: Cameco, Cominco, MIMEX, Minorca, North Ltd., Pasminco, Rio Tinto and Western Metals. Sponsorship for this project is still available.

OUTPUTS

AGSO RECORDS

95/77 Zeilinger I. NABRE Project 1995 Field Survey, Measured field sections and gamma ray logs (Superseded by Records 99/10 & 99/15)

98/4 Bradshaw B.E., et al., Elizabeth Creek Prospect: Buried mineral play in Century equivalent strata, northern Lawn Hill Platform, Queensland.

98/38 - Lindsay J.F. The Broadmere Structure: a window into Palaeoproterozic mineralisation, McArthur Basin, northern Australia. - CD ROM

99/10 - Southgate P.N. et al., (Prelim Ed.) Measured sections and sequence stratigraphic interpretations:lower McNamara, Mt Isa & Fickling Groups - CD ROM

99/15 - Krassay A.A. et al., (Prelim Ed.) Measured sections and sequence stratigraphic interpretations:upper McNamara, & Fickling Groups – CD ROM

99/19 - Bradshaw B.E. & Scott D.L., (Prelim Ed.) Integrated basin analysis of the Isa Superbasin using well log & geopotential data: An evaluation of the economic potential of the northern Lawn Hill Platform. – CD ROM

99/27 - Tarlowski C.Z. & Scott D.L. Geophysical investigation of north central Australia, Images, Algorithms and Crustal models. – CD ROM

Thematic Issue of the Australian Journal of Earth Sciences (June 2000) Basement Studies

SCOTT, D.L., et al., Basement Framework for the Isa Superbasin: an integrated review of geophysical, geochronological, and geochemical data towards a crustal evolution model.

JACKSON, M.J., et al Stratigraphic Framework for the Leichhardt and Calvert Superbasins: review and correlations of the pre-1700 Ma successions between Mt Isa and McArthur River

Constraining the Stratigraphic Results

IDNURM M. Towards a high resolution late Palaeoproterozoic - early Mesoproterozoic apparent polar wander path for northern Australia

PAGE R.W. et al., Constraining sequence stratigraphy in north Australian basins - New SHRIMP zircon U-Pb ages, Mt Isa-Roper River.

Documenting the stratigraphic results

SOUTHGATE, P.N. et al., A chronostratigraphic basin framework for Palaeo- and Mesoproterozoic rocks (1730-1575 Ma) in northern Australia and implications for base metal mineralisation.

DOMAGALA J., et al., Sequence stratigraphic evolution of Palaeoproterozoic successions in the Mt Isa Group and Surprise Creek Formation

SOUTHGATE P.N, et al., Basin shape and sediment architecture in the Gun Supersequence: A deep burial strike-slip model for Pb-Zn ore genesis at Mt Isa

KRASSAY A.A., et al., From regional shoreline to growth-faulted, turbiditic sub-basins - the Proterozoic River Supersequence of the upper McNamara Group on the Lawn Hill Platform.

KRASSAY A.A., et al., Lowstand fans and deep water Mesoproterozoic facies of the Lawn Hill Platform: the Term, Lawn, Wide and Doom Supersequences of the Isa Superbasin.

BRADSHAW B.E., et al., Attenuated Basin Margin Sequence Stratigraphy of the Isa Superbasin, Fickling Group, southern Murphy Inlier.

JACKSON, M.J. & SOUTHGATE, P.N. Three stacked carbonate ramps - the Lawn, Wide and Doom Supersequences (Nathan Group) in the McArthur River area.

ABBOTT S & SWEET I. Tectonic origin of third order sequences from the Roper Group (Mesoproterozoic), McArthur Basin, Northern Territory

International Publications

SCOTT, D.L. et al 1998. The tectonostratigraphic history of the Proterozoic Lawn Hill Platform, Australia: An Australian integrated intracontinental basin analysis. *Tectonophysics* 300, 329-358.

JACKSON, M.J., et al. 2000 Gamma ray logs and U-Pb zircon geochronology—essential tools to constrain lithofacies interpretation of Palaeoproterozoic depositional systems. In In J. P. Grotzinger and N. P. James Eds, Carbonate Sedimentation And Diagenesis In The Evolving Precambrian World. SEPM Special Publication 65.

SAMI, T. T. et al 2000 Evolution of Late Palaeoproterozoic Ramp Systems, Lower McNamara Group, Northeastern Australia, In J. P. Grotzinger and N. P. James Eds, Carbonate Sedimentation And Diagenesis In The Evolving Precambrian World. SEPM Special Publication 65.

Towards a Palaeoproterozoic Pb-Zn Mineralising System

• Recent NABRE Results

AGSO

Barry Bradshaw, Mart Idnurm, Jim Jackson, Andrew Krassay, Jim Leven, John Lindsay, Graham Logan, Bruce McConachie, Rod Page, Deborah Scott, Peter Southgate, Chris Tarlowski & Alan Wells. GSQ

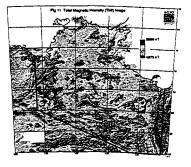
Jan Domagala

NTGS

Steve Abbott & Barry Pietsch Queens University Canada Terry Sami



Nabre Region



Objectives

- Build a time-series predictive framework for Paleoproterozoic basin evolution
- Reconstruct basin shape and sediment architecture at time of fluid flow
- Provide predictive fluid flow models for these basins

Strategy INTEGRATED multidisciplinary basin analysis combining petroleum & mineral industry techniques - Stratigraphic Architecture - Structural Architecture ▶ Framework - Basement Studies - Specialist Studies to constrain Sequences: SHRIMP Zircon, Palaeomagnetism, Chemostratigraphy. AMIRA P552 Utilises framework to constrain Paragenesis, Geochemical and Burial History Studies All of Above Constrain Fluid Flow Modelling **Integrated Stratigraphic Data** 80 kms Outcrop, Drill Core & Wireline Logs - Mt Isa, Iower McNamara & Fickling Groups • Twenty four composite sections -27,000m · Twelve drill holes -6,500m - Upper McNamara & Fickling Groups • Thirty four composite sections - 28,000m Twenty five drill holes 5,000m - McArthur Group · Eight composite sections -3,500m · Twenty drill holes -10,000 m **Other Integrated Datasets** Geophysics - Comalco seismic grid QLD (1000 kms) - Broadmere seismic grid NT (300 kms)

- Airborne magnetics

- 1:100,000 and 1:250,000 geological coverages for northern Australia

GravityGeological Maps

AGSO Records

- Seismic Data
 - Southern Flank Murphy Inlier, western Qld (CD ROM)
 - Elizabeth Creek Prospect
 - Broadmere Structure, NT (CD ROM)
- **Outcrop Sections & Drill Core**
 - Mt Isa, lower McNamara, & Fickling Groups (CD ROM)
 - Upper McNamara & Upper Fickling Groups (CD ROM)
- Potential Field Geophysics (CD ROM)



Journal Publications

- Thematic Issue of AJES
 - Twelve papers detailing NABRE results
 - · Two basement related
 - · Two provide independent data for constraining the stratigraphic results
 - Eight detail the sequence stratigraphic results, including implications for mineralization
- · International Journals
 - Three papers
 - Two sequence stratigraphic SEPM Special Publicationsse
 One structural and geophysics based Tectonophysics



Constraining Stratigraphy

- Geochronology
 - 55 new SHRIMP ages in 1800-1580 Ma interval
- Palaeomagnetism
 - Seven new primary poles for period 1730-1590 Ma. Sixteen primary poles now exist
 - Nine poles have associated SHRIMP ages
 - Pole path extended to interval 1770 -1500 Ма.

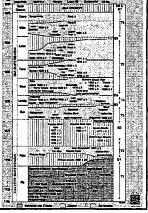


Stratigraphic Results

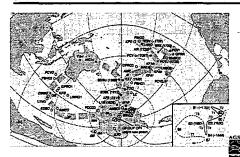
- 3 Superbasins in 1800-1575 million year period
 - 1) Leichhardt 1800-1750 my, 2) Calvert 1730-1690 my and 3) Isa 1670-1575my.
- Unconformities with 20-40 my of missing rock record separate Superbasins
- Seven Supersequences recognised in Isa Superbasin, which hosts the Pb-Zn-Ag deposits
- Supersequences have a duration of 10-15



EVENT CHART FOR ISA AND CALVERT SUPERBASINS



Apparent Polar Wander Path



Integrated Stratigraphic Results

- Calvert & Isa Superbasin boundaries & Prize, Gun, Loretta, River & Wide Supersequence boundaries plot at or near bends on the APWP
- Pb/Pb model ages for mineralisation at:
 - Broken Hill (1675), Mt Isa (1653), McArthur River (1640) and Century (1575) coincide with bends 2,3, 4 & 6 respectively on the APWP.
- Century age mineralisation coincides with closure of the Isa Superbasin during onset of D2 at Isa



Questions Raised

- Why do Pb/Pb model ages, Superbasin & some Supersequence boundaries coincide with APWP bends?
- · Why are Supersequences of similar duration?
- What can be inferred about the timing of assembly of the North Australian Craton from the presence of synchronous, regional unconformities?
- What tectonic regime drove accommodation in northern Australia during the period 1800-1500Ma?
- What was the orientation of the principal stress field?



Basement Analysis

- Questions
 - Determine basement architecture
 - Determine its influence on basin evolution
 - Determine basin-forming mechanisms
- · Conventional Wisdom
 - 1665-1575Ma Isa Superbasin
 - ~8km "mega-sag"
 - 1730-1690Ma Calvert Superbasin
 - ~3-5km rift/sag cycles
 - 1780-1750Ma Leichhardt Superbasin

rift/sag cycles

• -10km

In Search Of A Rift

- Local extensional features at multiple stratigraphic levels,
- Generally 10-100m of relief on synsedimentary faults
- Kinematics of local fault movement not regionally consistent
- Seismic datasets identify two transtensional-transpressional events:
 - River Event and Wide Event



Time & Space

- Temporal correlation to orogenic and magmatic arc events in the Arunta Belt:
- WHAT IS THE LINK BETWEEN
 - Concurrent basin development and widespread magmatism in the north Australian craton
 - -2) Orogeny/subduction in central Australia?



Unifying Mechanisms

- · Periods of active subduction
 - REGIONAL tilting of the NAC via a dynamic tilting mechanism
 - produces deposition of widespread siliciclastics which generally thicken to the south/southeast
- Periods of orogenic activity
 - Flexure of non-homogeneous crust and development of local strike-slip deformation
 - Strain propagates through basement and partitioned by earlier structures



During Isa Superbasin

- · Strike slip deformation creates
 - local areas of dilation for extraction of magmas
 - Paired subsidence and uplift belts
 - · local areas of dilation create accommodation
 - · local areas of compression cause uplift



Lower McNamara Group Mount Isa Group Lady Laretta Fm Integration Spear & Kermedy Sillstones Uredward State Bee Sillstone Pand use Creek Famalian Mount Orde Chert Marker Gunpewder Oreck Fm Broakway Chert Morter Gunpewder Oreck Fm Warring Park Quartatle Surprise Creek Fm (Alter Denick & Sweet 1550) • Urnamed chart member (mid stromatolite marker bed)

sa-McNamara Group Stratigraphy

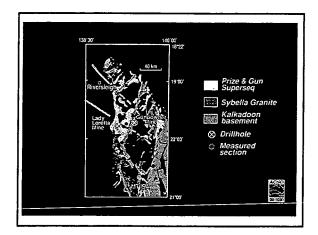
• Pre NABRE

- Facies changes inhibit Mt Isa-McNamara Group correins
- Lacustrine V's Marine environments
- Ubiquitous shallow to emergent environments

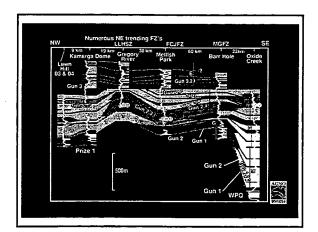
Outcome

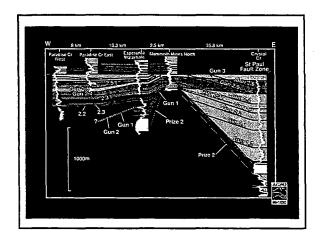
- Relationships between Mt Isa & McNamara Group depositional systems problematic
- Uncertainties concerning basin shape and fluid migration pathways for Isa deposits

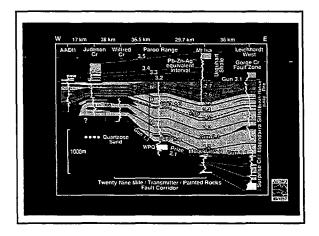


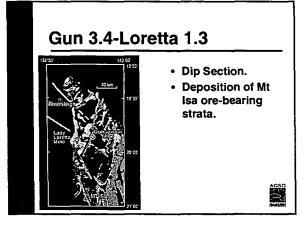


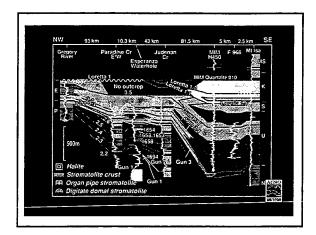
LHP-LRFT Transects Broadly NW - SE Cross NNE and NNW oriented structures Correlations based on 4th Order SB's & MFS Resolution to 1my per sequence







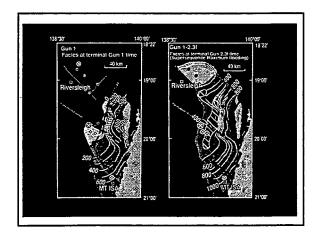


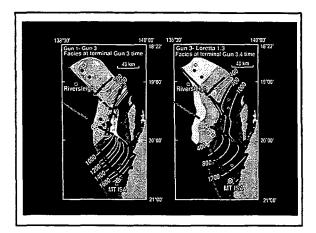


Cross Section Summary

- LHP-LRFT SE progradation of facies
- Shoreline siliciclastics to far north, peritidal to deep water carbonates in middle, deep water siliciclastics to south
- Onlap of Gun 1.1 to 2.3 sequences onto MGFZ
- Truncation of Gun 2.4-2.7 sequences along MGFZ at Gun 3 Sequence Boundary
- Paired uplift and subsidence at Gun 2.5 & Gun 3.4







Tectonic Model

Needs to Explain

- Location of major depocentre at SE corner and eastern side of a regional SE facing carbonate depositional ramp.
- Western Siliciclastic Provenance Area
- Paleogeographic high along Mt Gordon Fault Zone
- Paired subsidence & uplift at several 3rd and 4th order sequence boundaries.
- Gradual change in facies belts from shallow Gradual change in facies pers more siliciclastic in northwest to carbonate in mid-ramp and then deep water & basinal mixed carbonate and siliciclastic in southeast.



TMI Image



- Sinistral strike slip on NW trending faults
- Kalkadoon/Leichhardt & Ewen Blocks stable
- Mt Isa Valley in site of dilatent longevity.
- NE trending magnetic anomaly delineates principal restraining structure & western clastic provenance



Redie Creck Fault Zone Termite Range Fault Zone Fiery Creck Fault Zone Mount Gordon Fault Zone © Curpsweder © Lit Oxide © Digitate dome © Organ pipe stremutolite Big Gun

Stratigraphic/Structural Plays

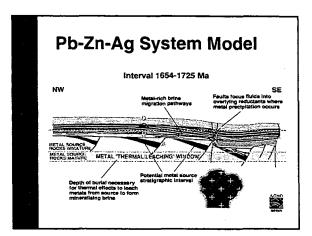
- Major basin depocentre, accommodation and reductant facies related to strike/slip fault system with dilatent longevity eg Mt Isa Valley
- Regional "north-south" compression.
 - Paired uplift and subsidence infers strike/slip tectonism.
 - Dilating fault segments create depositional space.
 - Restraining fault segments lead to uplift, provenance rejuvenation and a topography-driven fluid circulation system.
 - Dilating faults that bound the rapidly subsiding depocentre, focus and tap, deeper, topography-driven and thermobaric/compactive basinal fluid circulation systems.
 - Rapid subsidence rates creates overpressuring & elevates temperature of basinal fluids (130-200°C) giving enhanced rates of metal leaching to produce fertile brine

AGSO

Base Metal Mineral System

- · Where are the metal source rocks?
- What is the burial depth / temperature necessary to produce a fertile brine?
- Where were the fertile brine reservoirs and migration pathways located?
- What is the timing of brine expulsion?
- What are the relationships between Brine & OM at sites of metal precipitation?





Amira Project P552

- Eight project sponsors
 - Cameco, Cominco, MIMEX, Minorco Pasminco, Rio Tinto, Western Metals,
- \$25,000 / year for three years
- Sponsorship is still open
- The November 1999 half yearly sponsors meeting was very successful
- Join now to avoid missing out!



YILGARN PROJECT

Project Manager: Alan Whitaker

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Objective: To increase exploration activity and reduce exploration risk in the Yilgarn Craton of Western Australia, particularly in areas of thin cover, by providing an improved understanding of the Archaean geology, superimposed regolith and mineral systems.

Project Components:

Eastern Goldfields National Mapping Accord Project 1:1M Sheet Geophysical Interpretation

Linked project: AMIRA P482 'Yilgarn Granites and Metallogeny'

Cooperating Agencies:

Major

Geological Survey of Western Australia
CRC for Landscape Evolution and Mineral Exploration
Mineral exploration companies

Minor

Australian Mineral Exploration Technologies CRC Australian Geodynamics CRC?

Key Results:

Geological mapping

- Identification of early, pre- or syn-D1 extension, eg., in Leonora area, possibly caused by granite doming. Doming produced low-angle shear zones on top of domes, tight folds in troughs beside domes.
- Identification of D1 shear zones and folds in Minerie and Leonora 1:100 000 Sheet areas; around Lawlers Anticline; and in Dingo Range greenstone belt. D1 shear zones are mineralised, eg., at Sons of Gwalia—early gold event implied.
- Identification of major late (D3 or D4) shears and previously unidentified areas of greenstones in De La Poer-Urarey 1:100 000 Sheet areas.
- Recognition that the sequence of deformation events in the northern Goldfields is essentially the same as in the southern Goldfields, although the times of deformation in the north are not yet known weakens the 'terrane' notion.

Seismic reflection lines - Kalgoorlie & Kambalda regions

- The greenstone belts are only 4 7 km thick.
- Angular relationships between the folded, truncated greenstones and the reflector below, suggest that the base of the greenstones is a detachment surface.
- Deep crust penetrating faults/shears are interpreted from the data.
- The crustal thickness under western granitoids was confirmed at about 33 km but thickens eastward under the greenstones to about 38 km.
- Several imbricate wedges of layered material above the basal detachment are interpreted to be felsic (to meet regional gravity data constraints).
- A number of granitoids crossed by the traverse are interpreted as thin, tabular bodies with steep sides and clearly intrusive relationships with the surrounding greenstones.

Fluid inclusion studies

- The alteration associated with gold mineralisation is potassic and is likely to have been in equilibrium with felsic rocks.
- The fluid characteristics of gold deposits in high (metamorphic) grade rocks differ (CH₄>CO₂) from those in low grade rocks (CH₄<CO₂) possible different sources or events.

Granite geochemistry

- Five major granite types of which 2 groups (High Ca ~50%, Low Ca ~25%) dominate.
- Relative age determinations based on deformation overprints are not supported by geochronology.
- Granite ages span >2.72 Ga to < 2.63Ga, with the majority generated at 2.675 to 2.64 Ga. Most (>98%) dated granites are of similar age or younger than the greenstones, suggesting widescale and thorough crustal reworking.
- Granites not derived from greenstones but from pre-existing felsic crust consistent with isotopic data and presence of inherited zircons.
- Sm-Nd isotope systematics show that the source rocks for the Low-Ca granites
 become progressively younger eastwards, consistent with a model for eastward
 crustal growth of the northern part of the province (pre-greenstone formation). The
 High-Ca granites, which do not show this trend, must have been derived from an
 isotopically distinct source.
- Granite-hosted gold deposits are preferentially associated with granites from the Mafic group, even though gold mineralisation appears to post-date intrusion.

Geophysical interpretation

- Five main crustal components are defined: undivided gneiss-migmatite-granite; sinuous gneiss, parallel banded gneiss; greenstone; and discrete granite plutons.
- Gneiss-migmatite-granite and parallel banded gneiss are inferred to have risen in the crust (some as domes) relative to greenstone bringing up high grade greenstone, which is commonly in concordant contact.
- Greenstones of the Eastern Goldfields are severely dislocated (relative to those of the Southern Cross Prov). Shear/ fault systems are the most continuous geological entities in the greenstone belts.
- Granite plutons are most common in/adjacent to the greenstone belts and are inferred to have a wide range of thicknesses (including some thin sheets). Many are spatially associated forming intrusive corridors.

Activities:

Geological mapping - 26 x 1:100 000 Sheets – northern Eastern Goldfields
Regolith mapping – 5 x 1:250 000 Sheets – northern Eastern Goldfields
Seismic Reflection – 1 regional line Kalgoorlie & 2 short regional lines Kambalda
Geochronology – ~25 zircon granite ages

Fluid inclusion studies – several deposits including Mount Charlotte & Sand King Database population - field observations, geochemistry, petrology Geophysical data acquisition with GSWA

13 x 1:250 000 Sheets of 2 - 4 Km gravity data - Eastern Goldfields 17 x 1:250 000 Sheets of 400m aeromagnetics/gamma ray data

Presentation of results - at the Kalgoorlie 93 & 97 Conferences and 'Open Days' at Kalgoorlie in 1995, 1996, 1998 and 1999.

Yilgarn Project Publications

AGSO Records:

- Jagodzinski, E.A., Stewart, A.J., & Champoin, D.C., 1999. Geology, structure, and mineral resources of the Mount Keith 1:100 000 Sheet (3043), Western Australia. AGSO Record 1999/37.
- Stewart, A.J. (1999): Geology of the De La Poer (3443) and Urarey (3343) 1:100 000 Sheet areas, Yilgarn Block, Western Australia, AGSO Record 1999/33.
- Williams, P.R. (1998) Geology, structure and gold resources of the Leonora 1:100 000 Sheet, W. A. AGSO Record 1998/9.
- Cassidy, K.F., Whitaker, A.J., & Liu, S.F. (Compilers) (1997): Kalgoorlie 97, An international conference on crustal evolution, metallogeny and exploration of the Yilgarn Craton An update, Extended Abstracts. **AGSO Record 1997/41**.
- Champion, D.C. 1997. Granitoids in the Eastern Goldfields. In: Cassidy, K.F., Whitaker, A.J. & Liu, S.F. (Compilers) An International Conference on Crustal Evolution, Metallogeny and Exploration of the Yilgarn Craton An Update. AGSO Record 1997/41, 71-76.
- Drummond, B.J., Goleby, B.R. & Swager, C.P., 1997. Crustal signature of the major tectonic episodes in the Yilgarn Block, WA: evidence from deep seismic sounding. In K.F. Cassidy, A.J. Whittaker & S.F. Liu (Compilers), An International Conference on Crustal Evolution, Metallogeny and Exploration of the Yilgarn Craton an Update. AGSO Record, 1997/41, 15-20.
- Whitaker, A.J., 1997. Granite-greenstone structures from regional geophysics in the northern Eastern Goldfields. In:Cassidy, K.F., Whitaker, A.J., & Liu, S.F. (compilers), Kalgoorlie 97, An International Conference on Crustal Evolution, Metallogeny and Exploration of the Yilgarn Craton- An update, Extended Abstracts. AGSO Record 1997/41, 21-26.
- Williams, P.R., & Haldane, J.A. (Compilers) (1993): Kalgoorlie 93, An international conference on crustal evolution, metallogeny and exploration of the Eastern Goldfields, Extended Abstracts. **AGSO Record 1993/54**.
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- Mernagh T.P. and Witt W.K., (1993) Evidence for fluid mixing and immiscibility and implications for gold mineralization in the Missouri and Sand King deposits, Eastern Goldfields Province, WA. AGSO Record 1993/54, p. 245-246.
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- Goleby, B. R; Rattenbury, M. S., Swager, C. P., Drummond, B. J., Williams, P. R., Sheraton, J. W., & Heinrich, C. A. (1993): Archaean crustal structure from seismic reflection profiling, Eastern Goldfields, Western Australia. Results from the Kalgoorlie seismic transect. AGSO Record 1993/15.
- Vanderhor, F. (1992): (Mineral Provinces 16) Strain partitioning near the Keith-Kilkenny Fault Zone in the central Norseman-Wiluna Belt, WA. AGSO Record 1992/68.
- Passchier, C.W., (1992): (Mineral Provinces 28) The nature of high-strain zones in the Laverton-Leonora area, WA. AGSO Record 1992/53.
- Chan, R. A., Craig, M. A., Hazell, M. S., & Ollier, C. D. (1992): Kalgoorlie regolith terrain map commentary sheet SH51 Western Australia 1:1 000 000 regolith

- Hill, R. I., Chappell, B. W., & Campbell, I. H. (1991): Late Archaean granitoids of the southeastern Yilgarn Block, Western Australia: age, geochemistry, and origin. Abstracts Second Hutton Symposium on Granites and Related Rocks. Chappell, B.W., (Editor). BMR Record 1991/25.
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Other Publications:

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- Williams, P.R., and Whitaker, A.J., 1993. Gneiss domes and extensional deformation in the Archean Eastern Goldfields Province, Western Australia. Ore Geology Reviews 8, 141-162.
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Products:

Eastern Goldfields Gravity Anomaly Pixel Image map 1:1million

Northern Eastern Goldfields Gravity (Colour) with 1st v.d. of TMI (intensity) Pixel image map 1:500 000

Perth & Meekatharra 1:1million TMI Pixel image maps

Colour gradient enhanced TMI

& greyscale TMI(RTP)

Aeromagnetic and gamma-ray spectrometric data/images 1:250 000 Sheets

Nabberu, Wiluna, Kingston, Sir Samuel, Duketon, Throssell-Rason Leonora, Laverton, Edjudina

Geology - northern Eastern Goldfields 1:100 000 Sheets

Wiluna 1:250K Sheet

Ballimore

Lake Violet.

Sandalwood

Sir Samuel 1:250K Sheet

Yeelirrie

Mount Keith

Wanggannoo

Duketon 1:250K Sheet

Tate

Urarey

De La Poer

Leonora 1:250K Sheet

Munjeroo

Wildara

Weebo

Mount Alexander

Wilbah

Leonora

Laverton 1:250K Sheet

Nambi

Mount Varden

McMillan

Minerie

Laverton

Burtville

Menzies 1:250K Sheet

Mount Mason

Ballard

Edjudina 1:250K Sheet

Yerilla

Lake Carey Mount Celia

Solid Geology 1:100 000

Lake Violet

Mount Keith

Geology 1:250 000

Laverton

Solid Geology 1:250 000

Nabberu

Regolith Landform Maps 1:250 000

Wiluna

Sir Samuel

Leonora

Menzies

Kurnalpi

Regolith Thematic Maps 1:250 000

Wiluna

Sir Samuel

Leonora

Menzies

Regional Regolith map 1:1 000 000

Kalgoorlie

Regional Geophysical Interpretation maps 1:1 000 000

Kalgoorlie

Albany

Esperance

Yilgarn Project

Background

Production & resources (Au, Ni others) Prospectivity Cover & geology

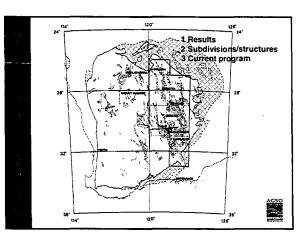
• Project components

Eastern Goldfields NGMA 1:1M geophysical interpretation

• Other Yilgarn Activities

AMIRA P482 Granites AGCRC seismic, LEME regolith, AMET EM





Yilgarn Project

Results:

Geology (26 x 1:100 000 sheets mapped)

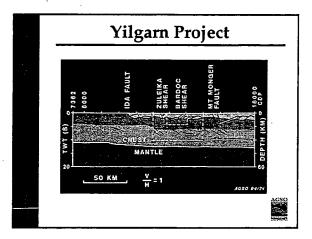
- -Early extension / grantte doming -D1 early gold event

- -New greenstones
 -Deformation sequence

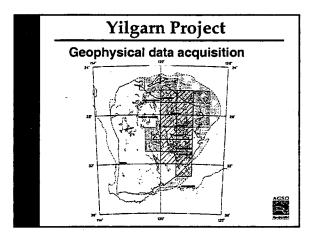
Seismic

- -Greenstone thickness
- -Deep crust penetrating faults (path for ore fluids?)
- -Crustal thickness





Yilgarn Project Results: Granites - High Ca, Low Ca, HFSE, mafic, syenites - >2.72 - <2.63Ga - Pre-existing felsic crust - Gold - mafic granite association Fluid inclusions - Potassic alteration - Au ore fluid vs metamorphic grade amphibolite CH,>CO₂ greenschist CH,<CO₂



Yilgarn Project

Craton domains - Aeromagnetics

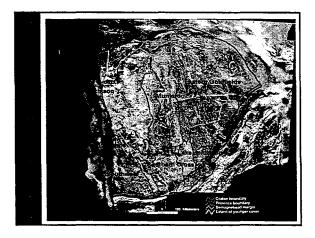
5 crustal components

granite plutons

gneiss-migmatite-granite sinuous gneiss

parallel banded gneiss greenstone





Yilgarn Project

Craton - structures

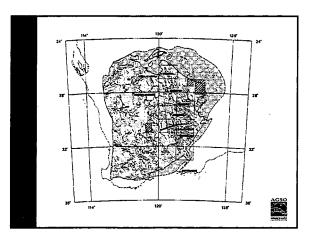
80% granitoid

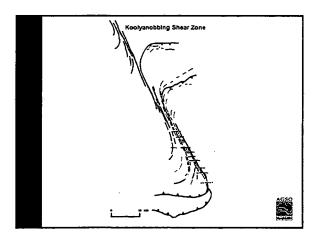
Crust and structure under greenstone

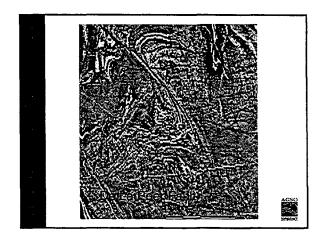
Ductile deformation - shear zones

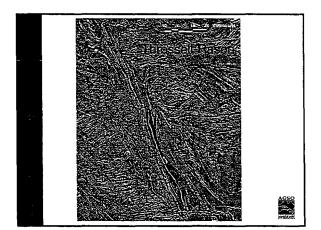
Brittle deformation - faults

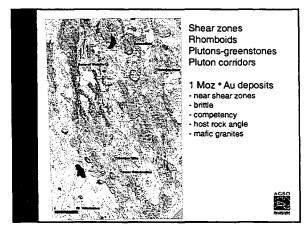












Yilgarn Project Gold opportunities • granite-hosted • gneiss-hosted • thin cover

Yilgarn Project

Current program:

Eastern Goldfields NGMA

- Leonora & Ballard Sir Samuel
- Records

1:1M geophysical interpretation - Perth - Meekatharra



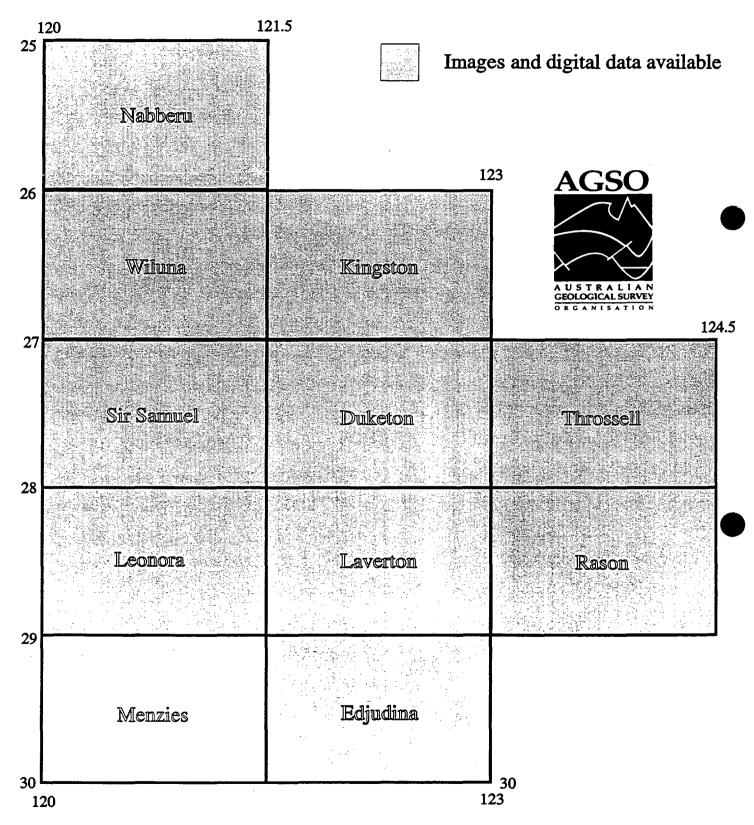
Eastern Goldfields Gravity Data Availability from AGSO

11 Km Regional Grid Infill track/helicopter surveys 120 121.5 123 4 Km stations 26 Wiluna Kingston 2 to 4 Km stations 27 Sir Samuel Duketon 1:1 M image \$300.00 28 Leonora Laverton 29 Edjudina 30 Kurnalpi 31 Boorabbin 32 Lake Johnston October 1999 33

123

121.5

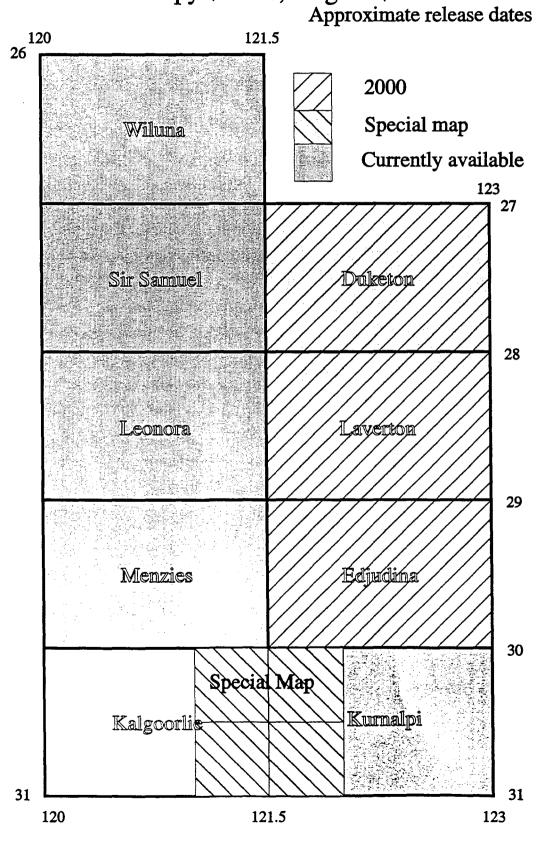
Eastern Goldfields Aeromagnetic data and images (400 m, 1:250 K sheets) Availability from AGSO



1:1 M images, Wiluna to Edjudina, \$300.00

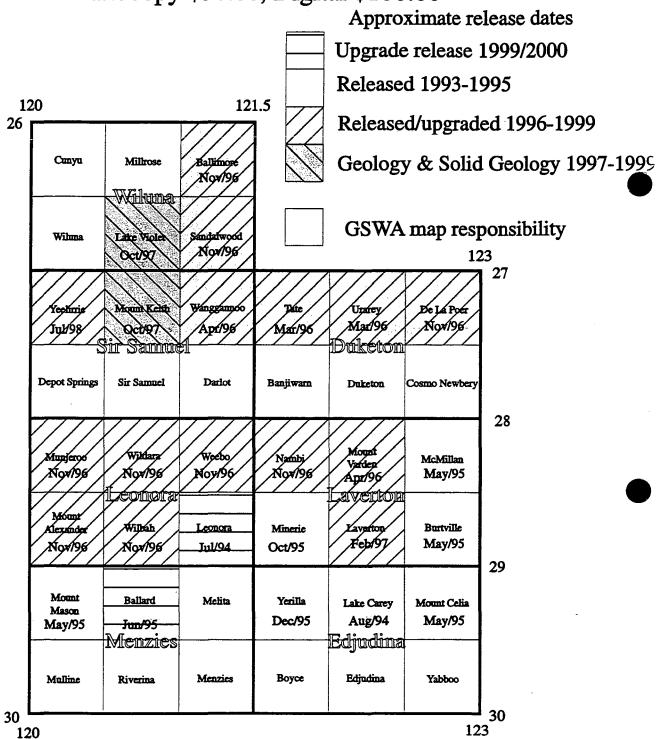
Eastern Goldfields 1:250 000 Regolith Maps Availability from AGSO

Hardcopy \$50.00, Digital \$500





Eastern Goldfields 1:100 000 Geological Maps Availability from AGSO Hardcopy \$50.00, Digital \$100.00



NORTH PILBARA PROJECT

A National Geoscience Mapping Accord Project

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Email: richard.blewett@agso.gov.au

Cooperating Agencies: Geological Survey of Western Australia

Industry Resolute Ltd, Sipa Resources, Lynas Gold NL, Sons of Gwalia, Hamersley Iron, Haoma Resources, Straits Resources

University ANU, Curtin, UWA, Muenster, Monash, Newcastle, Utrecht

Objective: To provide the resources sector with timely and relevant new-generation geoscientific information to assist exploration in the Pilbara.

Background: Results from the NGMA project highlight fundamental tectonic and metallogenic differences between the mid Archaean Pilbara craton (3.65-2.8 Ga) and the late Archaean cratons (2.75-2.5 Ga), *viz:*

- 1. Presence of common mineral deposit types such as Sn-Ta pegmatites, porphyry Mo-Cu deposits and adularia-sericite epithermal Au deposits that are better known in Proterozoic or younger rocks, and are absent in the late Archaean cratons.
- 2. Multiple mineralising events over a period of 800 Ma (eg. 4 VHMS events and 5 orogenic gold events) as opposed to the single, global events in the Neoarchaean (eg 2710±20 Ma for VHMS and 2630±10 Ma for orogenic gold in the Eastern Goldfields, the Superior & Slave Provinces).
- 3. Phanerozoic-like characteristics for some deposit types in the Pilbara (eg significant Pb and baryte with calc-alkaline volcanic rocks in VHMS deposits).
- 4. Different regional controls on mineralisation (eg general lack of craton-scale shear zones which are first-order controls on orogenic gold deposits in the Eastern Goldfields and Superior Provinces).
- 5. Different crustal architecture of the Pilbara relative to late Archaean Provinces (eg the greenstone belts and the domal granitoids that they envelop both extend to greater depths (~14 km) in the Pilbara).

Exploration models and genetic interpretations of Archaean mineral deposits are largely based on late Archaean examples and therefore somewhat limited in application in the Pilbara. The aim of the Pilbara project has been to document these differences by providing regional thematic synthesis datasets so that more robust models can be developed to encompass the entire Archaean era. These datasets, together with our research into new exploration tools, will assist exploration in the Pilbara, and have applications to other terranes.

Major AGSO achievements

New Potential-Old Province

Extensive areas of the Pilbara are presently exposed close to the ca. 2765 Ma Hamersley Basin unconformity surface. This exceptional preservation significantly improves younger mineralising events of gold and possibly diamonds in the mostly older mid Archaean Pilbara granite-greenstone terrane. Newly documented areas of high-level (epithermal) systems preserved in west and far east Pilbara are related to NNW dextral faults and associated relay movements during early Fortescue extension (NW-SE). Epithermal veins cut 2765 Ma Opaline Well Granite, and similarly aged Gregory Range Granite. Epithermal veins are incorporated in NNW-trending Gidley Granophyre breccia dykes (2765 Ma).

New Exploration Tools

The Pilbara project has had significant success with alteration mapping using the HYMAP multispectral scanner, gamma-ray spectrometrics, oxygen isotopes, and whole rock geochemistry. These tools have been successful over the poorly exposed and calcretised Mallina-Indee gold prospects and over the well exposed Panorama VHMS district. The HYMAP data have successfully mapped alteration minerals such as pyrophyllite, sericite, successfully separated Fe-chlorite from Mg-chlorite, and separated dolomite from calcite in calcrete. Several of the targets generated from the HYMAP image maps produced anomalous gold on subsequent analysis. Oxygen isotope mapping and conversion to palaeotemperatures in VHMS terrains can be used as an exploration tool. The temperatures define fluid pathways as vectors to ore and are predictors of metal deposition ($Zn \nu Cu$). District-scale depletion of Zn and Cu has been mapped with whole-rock geochemistry, and these depletion zones map the fluid pathways related to VHMS deposits. Regional AGSO gamma-ray spectrometric data have been used to map K-depletion anomalies associated with the Panorama alteration system.

Regional synthesis and GIS

The project has brought together a comprehensive set of digital themes for the entire Pilbara craton. These are stored in a project GIS, from which a set of derivative products have been produced. These include a 1:1 500 000 scale colour atlas with forty three A3 pages, as well as a thematic series of 1:500 000 scale maps and images (print-on-demand or postscript files). A subset "teaching" GIS has been produced. These datasets provide explorers with a suitable baseline and regional context for their exploration and target generation. The project has documented the variety of mineral deposits—especially gold, VHMS, Sn-Ta, and high-level deposits, and produced databases (GIS) and AGSO Records. The diversity of the Pilbara gold is being documented. A successful industry (June-July 1999) field trip was run to examine key deposits and relationships.

A regional structural synthesis has been conducted and a new deformation chronology and kinematics of some of the major shear zones has been documented. The advances include a better understanding of shear zone timing and movement senses, an improved understanding of the complexity of the polyphase deformation, recognition of the importance of horizontal compression as a tectonic driving force, and a clearer link between regional tectonics and mineral deposits (especially gold).

3D geometry of the Pilbara

3D mapping the entire Pilbara craton using gravity, magnetics and seismic refraction data has resulted in the following new observations of the Pilbara Craton. Applications of the 3D knowledge include constraints on tectonic models, ideas on which are the important shear zones that transect the crust, estimates of depth and volumes of metal reservoirs and fluid pathways.

- the craton is ovoid with dimensions of 600 x 550 km diameter, only 25% is exposed
- the average crust depth is 30-32 km (thickening to the south), the mid crust is at 14 km
- the greenstones are highly magnetic and extend to the base of the mid crust (14 km) and most granitoids have steep (vertical) contacts to the base of the mid crust (14 km)
- more dense and faster lower crust, more dense and less magnetic crust in the northeast ν the northwest
- major shear zones present in the northwest and the east, circular patterns of granitoids are everywhere except far the northwest

Publications:

- Bierwirth P. Blewett R.S. & Huston D.L. 1999. Finding new mineral prospects with HYMAP: early results from a Hyperspectral remote sensing case study in the West Pilbara. AGSO Research Newsletter 31 1-3.
- Blewett R.S. & Huston D. L. 1999. Deformation and gold mineralisation of the Archaean Pilbara Craton Western Australia. AGSO Research Newsletter 30 12-15.
- Blewett R.S. & Huston D. L. 1999. Structural controls of Archaean gold in the North Pilbara Craton Western Australia. Geological Society of Australia Abstract Series 53 15-16.
- Champion D.C. Smithies H. 1998. Archaean granites of the Yilgarn and Pilbara Cratons. In: The Bruce Chappell Symposium Granites Island Arcs the Mantle and ore Deposits. AGSO Record 1998/33 24-25.
- Champion D.C. & Smithies R. H. 1999. Archaean granites of the Yilgarn and Pilbara Cratons Western Australia: Secular changes. The Origin of Granites and Related Rocks 4th Hutton Symposium BRGM Documents 290 137.
- Glikson A.Y. 1997. Mineral mapping in the North Pilbara craton: A directed principal components of band ratios method for correlating Landsat-5 Thematic Mapper spectral data with geology. Australian Geological Survey Organisation Research Newsletter 26 1-4.
- Glikson A.Y. 1997. Explanatory Notes for a Landsat-5-TM image series according to an RGB directed principal components/band ratio formula North Pilbara craton Western Australia. Australian Geological Survey Organisation Record 1997/20 11p.
- Glikson A.Y. 1998. Landsat-5-Thematic Mapper spectral-lithological correlations northern Pilbara craton Western Australia Australian Geological Survey Organisation Record 1998/22.
- Huston D.L. 1997. Reconnaissance Economic Geology Studies for 1996 North Pilbara NGMA project. AGSO Record 1997/13 48 p.
- Huston D.L. Kamprad J. & Brauhart C.W. 1997. Preliminary results of PIMA analyses of the alteration zone underlying the Sulphur Springs deposit Panorama district Pilbara Block Western Australia. AGSO Record 1997/14.
- Huston D.L. Brauhart C.W. Wellman P. Andrew A. 1998. Mapping regional alteration haloes in massive sulphide districts using gamma-ray spectrometry and oxygen isotopes: an example from Panorama Central Pilbara AGSO Research Newsletter 29 14-16.
- Huston D.L. Kamprad J. & Brauhart C. 1999. Definition of high-temperature alteration zones with PIMA: an example from the Panorama VHMS district central Pilbara Craton. AGSO Research Newsletter 30 10-12.
- Ratajkoski M. Blewett R.S. Wellman P. 1998. A proposed GIS package for teaching integration of Geology with image interpretation of remote sensed data based on an area in the Archaean Pilbara craton. Geological Society of Australia. Abstracts 49 371.
- Smithies R.H. & Champion D.C. 1998. Secular compositional changes in Archaean granitoid rocks of the west Pilbara. West Australian Geological Survey Annual Review 1997-98 71-76.
- Smithies R. H. & Champion D.C. 1999. Archaean high-Mg diorite (sanukitoid) suite Pilbara Craton Western Australia. The Origin of Granites and Related Rocks 4th Hutton Symposium BRGM Documents 290 190.
- Smithies R. H. & Champion D.C. 1999. High-Mg diorite from the Archaean Pilbara Craton characteristics petrogenesis and possible links to gold mineralisation. Annual Review 1998-99 in press.

- Sun S-s. & Hickman A.H. 1999. Geochemical characteristics of ca 3.0 Ga Cleaverville greenstones and later mafic dykes West Pilbara: implication for Archaean crustal accretion. AGSO Research Newsletter 31 25-29.
- Van Kranendonk M.J. 1998. Timing and tectonic significance of Late Archaean sinistral strike-slip deformation in the Central Pilbara Structural Corridor Pilbara Craton Western Australia. Precambrian Research 88 207-232.
- Wellman P. 1998. Gamma-ray spectrometric data: modelling to map primary lithology and later chemical mobilisation. AGSO Research Newsletter 28 1-4.
- Wellman P. 1998. Mapping of a granite batholith using geological and remotely sensed data: the Mount Edgar Batholith Pilbara Craton Exploration Geophysics 29 643-648. (Abstract)
- Wellman P. and Blewett R.S. 1998. Mapping of Granites using remotely sensed data. Geological Society of Australia. Abstracts No.49 p.463.
- Wellman P. 1999. Granitoid complexes and greenstone belts in the Pilbara Craton interpreted to extend down to the mid-crustal boundary at 14 km. AGSO Research Newsletter 30 15-17.

Products:

Landsat-TM-5

- Glikson, A.Y. 1997. 1:100 000 scale enhanced Landsat-5-TM images (51 in total) with explanatory notes.
- Macias, L. 1998. 1:500 000 scale enhanced Landsat-5-TM image map North Pilbara Craton, Western Australia. Australian Geological Survey Organisation. (digital data as ERMapper BIL file)

Layered Mafic-Ultramafic Complexes

Hoatson, D.M., Wallace, D.A., Sun, S-s., Simpson, C.J. and Keays, R.R. 1993. Layered intrusions of the Pilbara Block. AGSO Bulletin 242.

Magnetic Maps

- Mackey, T.E. and Richardson, L.M., 1997. Total magnetic intensity (reduced to the pole) with northeast illumination colour pixel-image map of the Pilbara Region, WA, scale 1:500 000, Australian Geological Survey Organisation.
- Mackey, T.E., 1997. Total magnetic intensity (reduced to the pole) with northeast illumination colour pixel-image map of Nullagine/Yarrie, WA, scale 1:250 000, Australian Geological Survey Organisation.
- Mackey, T.E., 1997. First vertical derivative of total magnetic intensity (reduced to the pole) greyscale pixel-image map of Nullagine/Yarrie, WA, scale 1:250 000, Australian Geological Survey Organisation.
- Mackey, T.E. and Richardson, L.M., 1997. Total magnetic intensity (reduced to the pole) with westerly illumination colour pixel-image map of Marble Bar, WA, scale 1:250 000, Australian Geological Survey Organisation.
- Mackey, T.E. and Richardson L.M., 1997. East-west gradient of first vertical derivative of total magnetic intensity (reduced to the pole) greyscale pixel-image map of Marble Bar, WA, scale 1:250 000, Australian Geological Survey Organisation.

- Mackey, T.E. and Richardson, L.M., 1997. Total magnetic intensity (reduced to the pole) with northwest illumination colour pixel-image map of Port Hedland, WA, scale 1:250 000, Australian Geological Survey Organisation.
- Mackey, T.E. and Richardson L.M., 1997. Fractional vertical derivative of total magnetic intensity (reduced to the pole) greyscale pixel-image map of Port Hedland, WA, scale 1:250 000, Australian Geological Survey Organisation.
- Mackey, T.E. and Richardson, L.M., 1997. Total magnetic intensity (reduced to the pole) with northwest illumination colour pixel-image map of Roebourne/Pyramid, WA, scale 1:250 000, Australian Geological Survey Organisation.
- Mackey, T.E. and Richardson L.M., 1997. Fractional vertical derivative of total magnetic intensity (reduced to the pole) greyscale pixel-image of Roebourne/Pyramid, WA, scale 1:250 000, Australian Geological Survey Organisation.

Gamma-ray Maps

- Mackey, T.E., 1997. Airborne gamma-ray spectrometry colour composite pixel-image map of Nullagine/Yarrie, WA, scale 1:250 000, Australian Geological Survey Organisation.
- Mackey, T.E. and Richardson L.M., 1997. Airborne gamma-ray spectrometry colour composite pixel-image map of Marble Bar, WA, scale 1:250 000, Australian Geological Survey Organisation.

Structural Geology

Van Kranendonk, M.J. 1997. Results of field mapping, 1994-1996, in the North Shaw and Tambourah 1:100 000 Sheet areas, eastern Pilbara craton, northwestern Australia. Australian Geological Survey Organisation, Record 1997/23, 44 p.

Geochemistry

Wyborn, L.A.I. 1995. ROCKCHEM - Pilbara Block digital dataset and Record. AGSO Record 1995/026

GIS

- East Pilbara 1:250 000 scale Digital Geological maps (Port Hedland, Yarrie, Marble Bar, Nullagine) in ArcView, ArcInfo, MapInfo and ArcExplorer (CD contains all formats) Ratajkoski, M., Blewett, R.S. & Wellman, 1999. The North Pilbara GIS Teaching Package, v.1.0, Australian Geological Survey Organisation.
- A craton-scale GIS package of existing geological maps, mineral deposits, magnetic, gravity, gamma-ray, Landsat-5-TM, solid geology time-based, solid geology lithology-based, geochemistry, geochronology, structural elements will be available (early 2000) as ARC-INFO export, ARCVIEW or MapInfo datasets.

All map products are available as postscript plot files. Landsat TM data are available as ERMapper BIL files and grids are available of all geophysical products.

GSWA products and publications are not included in this list. Please contact Dr Arthur Hickman (GSWA) regarding availability and price [(08) 9222 3220 (ph) (08) 92223633 (fax) E-mail: a.hickman@dme.wa.gov.au].

Tales of a Pilbara-phile

North Pilbara Outline

- Introduction
- Regional synthesis and GIS
- 3D Geometry of the Pilbara
- New Exploration Tools
- New Potential-Old Province
- Conclusions



North Pilbara

- 1995-2000
- NGMA project with GSWA
- North Pilbara granite-greenstone only small 1/4 exposed
- AGSO Activities: geophysics, mineral deposits & alteration mapping, structural analysis, geochronology, remote sensing, GIS synthesis, geological mapping.



North Pilbara outcome

Enhanced global attractiveness of Australia's exploration investment in the Pilbara Region through the provision of craton-scale geological syntheses with their associated data, interpretation and exploration tools.



North Pilbara team (AGSO)

Richard Blewett Leader & structural geology

• David Huston - Economic geology

Mitch Ratajkoski GIS and product development

• David Champion Geochemistry

• Peter Wellman*

Geophysics

Shen-su Sun*

Sm-Nd Pb-Pb geochronology

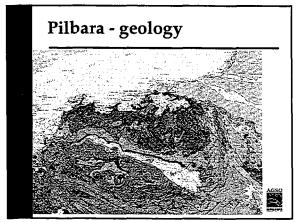
* left AGSO



Pilbara - geology

- 3.65-2.85 Ga granitoid-greenstone terrane
- mostly domal composite granitoids (11 events) & synformal stacked greenstone (7 packages)
- · regional unconformities separate greenstone packages
- · polyphase structural evolution
- not 100% exposed 25% exposed
- polymetal events (4-5 gold events)





Pilbara - geology

Q. Is the Pilbara unique??

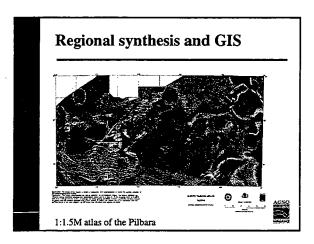
- "Phanerozoic-types" viz. Sn-Ta pegmatites, porphyry Cu-Mo, adularia-sericite epithermal Au
- Phanerozoic-like characteristics (e.g. Pb & baryte in calc-alkaline VHMS deposits
- multiple mineralising events over 800 Ma (e.g. 4 VHMS events and 5 orogenic gold events)
- general lack of craton-wide shear zones
- domal crustal architecture, depths >10 km

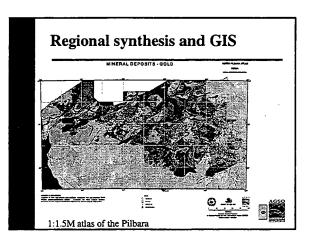


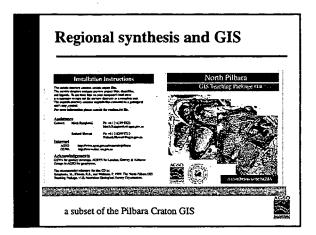
Regional synthesis and GIS

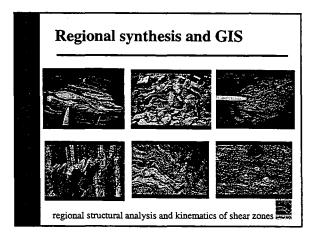
- Extensive data holdings
- · GIS of thematic layers
- 1:1.5M synthesis atlas (37 plates)
- 1:500K thematic maps
- · new events chronology defined
 - structural controls of selected lode gold deposits
 - very complex polyphase penetrative deformation, kinematics of major shear zones

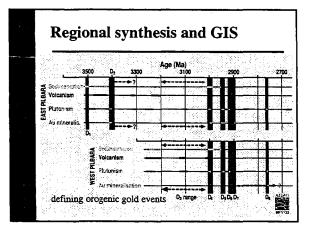








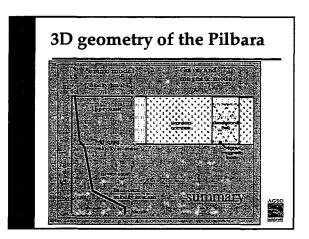


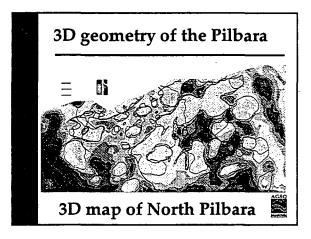


3D geometry of the Pilbara

- ovoid craton 600 x 550 km diameter
- mid crust 14 km, average crust ~30 km
- steep (vertical) contacts tap deep g.stones
- most granitoids to 14 km
- more dense lower crust
- more dense and less magnetic NE vs NW
- · major shear zones in NW
- · circular patterns except far NW







3D geometry of the Pilbara

Implications?

- steep & deep faulted granite-greenstone
- · greater ratio of greenstone volume to surface area
- unique tectonic regime? diapirism? need different exploration models?
- · only a few craton-scale shear zones



New Exploration Tools

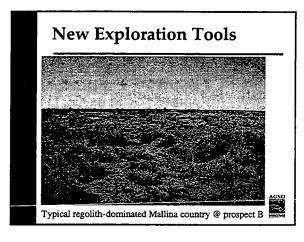
- HYMAP studies test flights over the Mallina Au district-new targets confirmed by assay
- Oxygen isotope mapping alteration at Panorama VHMS district
- Mapping alteration using regional gamma-ray data-Panorama VHMS district

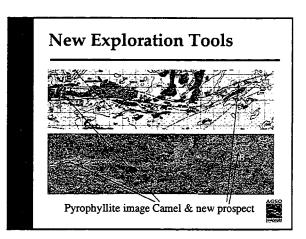


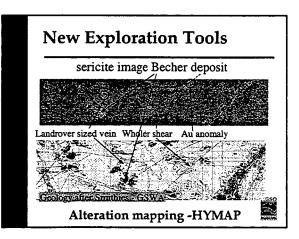
New Exploration Tools

- Hymap multispectral scanner
- 128 channel airborne system
- 10 m pixel, 4.6 km swath
- AGSO acquired two test 20 km lines
- Mallina-Indee gold district
- · mineral maps confirmed by PIMA
- · collaborative work with Phil Bierwirth (ANU) - philb@geology.anu.edu.au







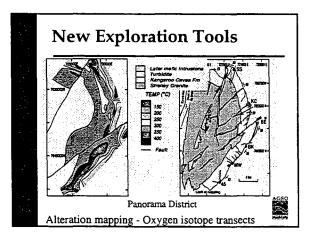


New Exploration Tools

- Oxygen isotopes
- · Calculate to palaeotemperatures
- Map discharge zones of VHMS system
- · Locate vectors to ore & Zn-Cu ratio
- Understand volcanic architecture
- Sample strategy is strike parallel



New Exploration Tools THE PROPERTY OF THE PRO



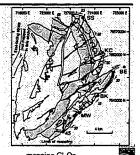
New Exploration Tools

- 400 m gamma-ray spectrometric data
- · Value add regional data
- Easy K/Th ratio, map K depletion
- Closely maps Cl-Qz alteration system



New Exploration Tools





400 m spectrometric data

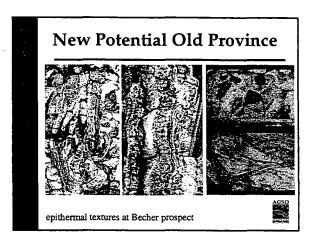
Alteration mapping - gamma-ray depletion of K

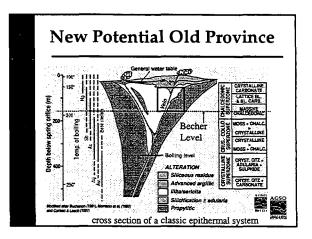
New Potential Old Province

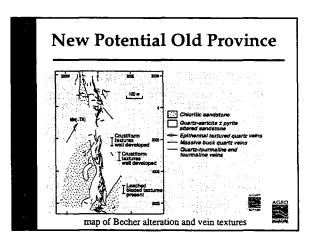
- Recognised new potential for epithermal (high-level) Au systems
- extensive areas of high-level systems
- ca. 2760 Ma proto-Hamersley age
- · Hamersley base exposed widely
- N-trending dextral faults, conjugate sinistral set to NE??
- locally may be above Au zone



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New Potential Old Province | Damplet Guerren |

Major AGSO achievements

- New potential old province
 - proto-Hamersley epithermal gold at ca 2760 Ma
- New exploration tools
 - HYMAP
 - Oxygen isotopes, gamma-ray
- · Regional synthesis and GIS
 - 1:1.5M Atlas, thematic 1:500K maps, GIS
 - Regional structural synthesis
- 3D shape of granite-greenstone
 - ~14 km, steep dips on contacts



Conclusions

- Not all 100% exposed
- · Unrealised new potential
- New exploration techniques could be used elsewhere
- Very long & diverse tectonometallogenic history
- Steep & deep in 3D



The 'Northeast Pilbara GIS teaching package'

For integrating and interpreting remotely sensed and geological datasets.

The 'Northeast Pilbara GIS teaching package' is made up of geophysical and geological data from an outcrop area 100 x 80 km in the northeast Pilbara (WA). This area constitutes a classic Archaean geological terrain, in which greenstones (mafic and felsic volcanics and intrusives) envelope the Corunna Downs and Mount Edgar Batholiths. These data represent a subset of a craton-scale GIS developed by the joint AGSO-GSWA (Geological Survey of Western Australia) 'North Pilbara' project for the National Geoscience Mapping Accord.

The well-exposed rocks have facilitated mapping in the northeast Pilbara by classical geological methods. The datasets reveal intriguing aspects of the geology not usually apparent in most Archaean terrains around the world where regolith or cover masks the 'solid' or basement geology. These datasets — derived from outcrop geological mapping, the typically shallow-recording Landsat 5 Thematic Mapper and gamma-ray spectrometry, and the more deeply penetrative magnetometry and gravimetry — are invaluable comparative, correlative, and analytical tools.

The 'Northeast Pilbara GIS teaching package' provides a medium for students to learn about and develop their skills in GIS experimentation and analysis and customised image processing and interpretation. In addition, it is designed to help the student rationalise not only conflicts between the various datasets but also the prospect of multiple interpretations of the geology. The range of datasets in the teaching package encourages the student to face up to the reality of geological mapping problems, and to speculate on the integrity of maps compiled from a single remotely sensed dataset (e.g., magnetic data under covered areas). The package will be especially useful to those training for work in more poorly exposed Archaean granite—greenstone terrains (e.g., Yilgarn) where the geological complexities are less obvious than those on display in the Pilbara.

The datasets in the 'Northeast Pilbara GIS teaching package' include raster images (band-interleaved BIL files), contours, and ArcView3 and MapInfo5 point and polygon themes. The images can be output for interpretation purposes at varying scales depending on the dataset resolution, A0 plotters are needed when scales up to of 1:100 000 or 1:25 000 are chosen. An executable copy of ArcExplorer (shareware) is included for those users without Arcview3. The real grids are available for high-end users for further image manipulation in addition to byte data for the grids of the magnetic, gamma-ray, and DEM (digital elevation model) datasets. The package includes:

- geology (1:250 000 published 2nd edition)
- solid-geology interpretation based mainly on magnetic and gravity data
- culture and drainage (subset of Geodata)
- Landsat-5-TM image (applying the PC2(4/3;5/7):5/4:1+7 formula)
- High counts and low counts RGB gamma-ray colour ternary image maps (line spacing 400 m):
 - ♦ chemical map of principal rock type granite, sediment, mafic rocks
 - ♦ principal-components maps (9 variations)
 - ♦ grid of real data
- magnetic images (line spacing 400 m) with:
 - ♦ first vertical derivative reduced to the pole
 - ♦ total magnetic intensity
 - ♦ grid of real data
- gravity images and contour maps
- DEM
 - ♦ airborne-acquired 80 m cell size
 - ♦ first vertical derivative image
 - grid of real data
 - ♦ 9-s dataset 250 m cell size (subset of Geodata)
- mineral deposits
- whole-rock geochemistry
- geochronology



The 'Northeast Pilbara GIS teaching package' is available on CD from the AGSO Sales Centre. It costs \$500 (byte-data grids) or \$950° (byte-data and real-data grids) + postage and handling charges. View low-resolution gifs at http://www.agso.gov.au/minerals/pilbara/
For more information, contact Richard Blewett (tel. +61 2 6249 9713, email Richard.Blewett@agso.gov.au).

MINERAL RESOURCES AND ADVICE

Program Manager: Ian Lambert

Project Leader: Bill McKay

Ph: 02 6249 9003 Fax: 02 6249 9917

Email: bill.mckay@agso.gov.au

Overview: With the transfer of the Minerals Resources and Energy Program from the former Bureau of Resource Sciences in late 1998, AGSO's role was extended to encompass mineral resource assessment and technical advice into policy areas.

Outputs of the Mineral Resources and Advice Project are designed to underpin Government resource policy and program development by contributing to:

- enhanced global attractiveness of Australia's exploration investment opportunities through increased knowledge of identified and potential mineral resources; and
- sustainable development through improved resource management based on effective use of geoscientific information in decisions concerning resource access and land use.

Current Activities

- Provision of independent scientific and technical advice on mineral resources, exploration, discoveries, mining, processing, land access and use, and metals and the environment. Includes advice on offshore exploration programs in Commonwealth waters under the Offshore Minerals Act 1994, and uranium under the Atomic Energy Act 1953. For policy areas in ISR, and other areas of government and the private sector as appropriate.
- National assessment of identified mineral resources for government, industry and the private sector.
- Assessment of identified and potential mineral resources and integration of mineral values with other values in land use considerations under the Commonwealth-State Regional Forest Agreement (RFA) process.
- Developing GIS-based systems that facilitate land use decisions by integrating and analysing geoscience and other layers, for government decision makers and stakeholders.
- Preparation of GIS for Cocos (Keeling) Islands for Department of Transport and Regional Services, and Nauru for the Nauru Phosphate and Rehabilitation Corporations.
- Participation in the activities of the OECD/NEA and IAEA Uranium Group, including preparation of Australia's contribution to annual publication on 'Uranium Resources, Production and Demand' (the "Red Book").
- Provision of secretariat for, and representation of the Commonwealth at, ANZMEC's Conference of Chief Inspectors of Mines.
- Participation in meetings and activities of the APEC Group of Experts in Minerals and Energy Exploration and Development (GEMEED), including convening the 3rd Environmental Cooperation Workshop on Sustainable Development of Mining Activities (ECOW'99).

 Production of maps for the www of renewable energy and fossil fuel power stations, for the Australian Greenhouse Office.

Future plans/activities

The independent scientific/technical advice and analysis activities for policy areas, and national identified mineral resource assessments will continue. The emphasis of these activities will evolve with the changing needs of clients.

Emphasis is to be given to further development of geographic information system (GIS)—based decision support systems (DSS) to facilitate analyses, weighting, and modelling diverse types of data. The objectives are to ensure that:

- resource access is not denied or decreased through decisions based on insufficient information on mineral resources, and
- geoscience data are more widely used in defining the causes and extents of land degradation.

The work will involve software developments, increasing the datasets available for these systems — including the compilation of a geoprovince—scale GIS layer on resource potential of Australia — and ongoing collaboration with land and water agencies in further developing and broadening the utility of DSS.

Products (hardcopy and/or electronic)

- Australia's identified mineral resources 1999 (AIMR '99). AGSO publication.
- Australia's Gold Resources 1988 to 1998 a review. M B Huleatt and R G Sait Record 1999/44.
- Mineral assessment reports for Comprehensive Regional Assessment areas: Gippsland (December 1999), West Victoria (December 1999), North-East Victoria (August 1998), Eden (February 1998), SW Western Australia (1998); Central Highlands (1997), Tasmania (1996) and East Gippsland (1996). Available on-line http://www.rfa.gov.au
- Australian industrial minerals resources for future opportunities. R R Towner.
 Keynote presentation, Industrial Minerals Conference Perth, November 1999.
- Application of GIS-based systems for land use decisions and resource management in relation to small- and medium-scale mining. W J McKay and K Porritt. For ECOW'99, Cairns, October 1999.
- Energy/Greenhouse Benchmarking Study of Coal Mining Industry. J Deslandes (AGSO Fellow). Study undertaken for Energy Efficiency Best Practice Program, ISR, September 1999.
- Mineral fact sheets. AGSO and Minerals Council of Australia pamphlets. 1999/00.
- Sustaining Economic Benefits from Mineral Resources: Government Investment in Geoscience. Article by I.B. Lambert, AusIMM Bulletin, No. 3, p.82-87, 1999.

MINERAL RESOURCES AND ADVICE:

AGSO'S ROLE EXTENDED

lan Lambert

Group Manager
Mapping Undercover, Minerals Promotion,
Resources and Advice



Outline of Presentation

- Introduction
- Outline of Resources and Advice activities
- Case studies:
 - ⇒ Regional Forest Agreement (RFA)
 - ⇒ Christmas Island
 - \Rightarrow ASSESS system (BRS)
- Future



Historical Background: Resources & Advice

1992: BMR → AGSO + BRS

AGSO: Geoscience survey, research

BRS: Mineral resources and advice

1998: AGSO + BRS → 'New' AGSO

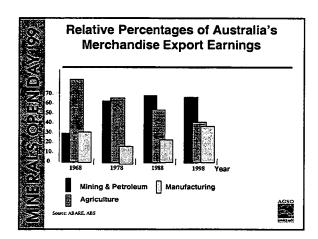


Traditional Role of Geological Survey Organisations

Reducing "Geological" risk

- precompetitive geoscience





	Resource ture
Mining & petroleum production	
Agriculture (

Government Perspective: The Triple Bottom Line

Meet community (voter) expectations

- seeking informed, transparent land use decisions that balance
 - economic + environmental + social values
- integrated consideration of each type of value --> sustainable development



Industry Perspective: Triple Bottom Line vs "Sovereign Risk"

Industry generally accepts triple bottom line in principle but concerned about

- negative decisions on specific mine proposals:
 - Coronation Hill
 - Shoalwater Bay
- designation of new reserves that prevent/limit resource access

Can now mine with no lasting impact

- but community scepticism

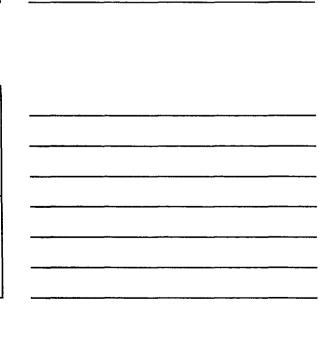


Land Use/Management Issues

Resource access:

- Conservation reserves, etc:
 - multiple and sequential land use
 - "Precautionary Principle": no exploration or production
- Land and water management:
 - water access already a major issue for resource development (eg Olympic Dam, NSW)
 - salinity proposed major multi-agency initiative







Extending AGSO's role Geoscience data and skills have potential for wider applications - technical support for decisions on land/marine use and management Opportunity for AGSO to increase relevance/clients and external funding **AGSO's New Corporate Outcome Enhanced potential for the Australian** community to obtain economic, social and environmental benefits through the application of first class geoscientific research and information Extending AGSO's role Reducing "Geological" risk Reducing "Sovereign" risk Informing/facilitating decisions on land management

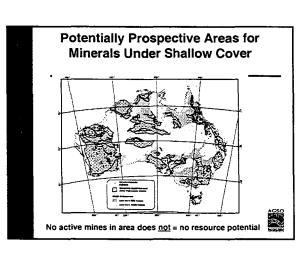
Mineral Resources & Advice Project

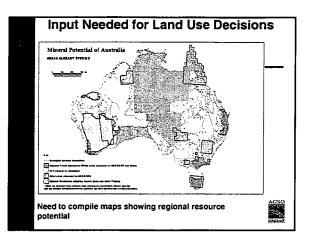
Supports policy development and informed decision-making through:

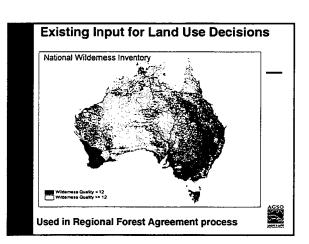
- assessments of mineral resources
- advice on exploration, mining, processing, metals and the environment
- advice under legislation on offshore exploration, uranium
- decision support on land access/use
- Conference of Chief Inspectors of Mines

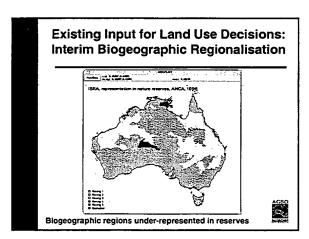


Mineral Resources & Advice Outputs









Facilitating Transparent and Informed Decisions Decision Support Systems (DSS): · powerful, user-friendly • good range and quality of input data capacity to weight data and model "what if" portable for demonstration purposes Community expects Commonwealth to be involved in major decisions First Case Study of Decision Support **System** Regional Forest Agreement (RFA) process - Mineral potential studies + laptop-based DSS to guide reserve design RFA Process: Stakeholder Agreement on Ground Rules · Decisions will be made anyway Approach based on elements of qualitative **USGS** methodology · Each State provides data and decides on

level of involvement in assessment

· Consultation/peer review

RFA Process

Prepare mineral potential maps for individual deposit styles

Collate to produce summary maps:

Weighted Composite Mineral Potential Mineral deposit models described



BD.	TBIC	1 808	U/A
HICH	нисн	HICH	J**
POTENTIAL	POTENTIAL	POTENTIAL	
MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/B MODERATE POTENTIAL	UNKNOWN
LOW POTENTIAL	L/C LOW POTENTIAL	LOW POTENTIAL	POTENTIAL
N/D NO POTENTIAL			
D (Hilgh)	c	В	A (Lew)

Composite Mineral Potential Map

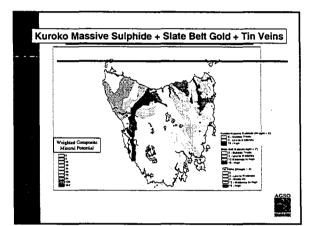
- Mineral potential tracts (areas) for individual deposit styles are superimposed
- Where the tracts overlap, the area is assigned the highest potential of all the overlapping tracts

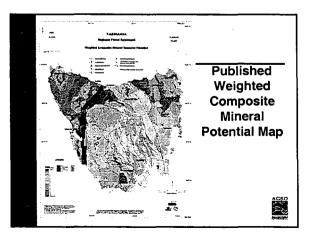


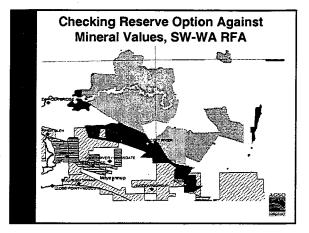
Weighted Composite Mineral Potential Maps

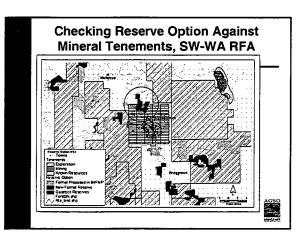
- Relative economic significance between different deposit types
- Mineral deposit type are ranked (on a scale of 0 to 10) to reflect their relative economic significance
- Ranking by a panel of experts











Summary: RFA Case Study

- Created Mineral Resource Assessment-GIS
- Methodology allows for rapid and consistent regional assessments
- Mineral resource values integrated with other values in considerations of reserve design



Second Case Study of Decision Support System

Christmas Island GIS

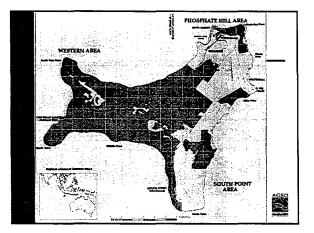
- resource management and development
- multiple clients in government and private sector



Christmas Island

- Australian Indian Ocean Territory, administered by Commonwealth
- Population about 2000
- 135 Km² in area





- Mining Mined for phos prior mining of
- Islander buy-out in 1990
- 300 'discarded' stockpiles now valuable
- 700,000 tonnes per year of phosphate shipped

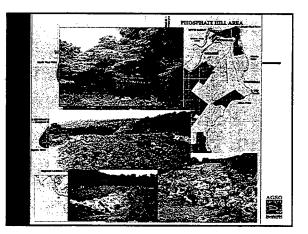
Rehabilitation



Abbotts Booby chick has one chance at flight

- · cleared forest abatement of wind turbulence
 - flatten pinnacles
 - cover with 1m of C-grade
 - planting strategy

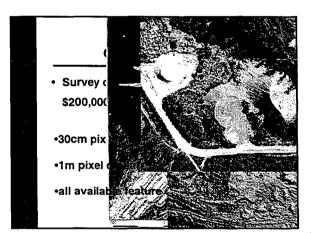


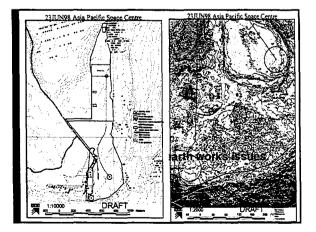


AGSO (BRS) Input

- Assessed remaining phosphate and viability of future mining
- · Mining schedule
- · Royalty options
- Data recovery (eg. drillhole database)
- Captured all available data in Geographic Information System (CIGIS)
- Training to ensure wide use of CIGIS







Third Case Study of Decision Support System

ASSESS

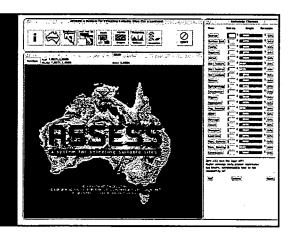
 Selection of suitable sites for National low-level radioactive waste repository (RADWASTE site, BRS)

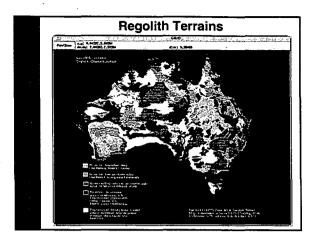


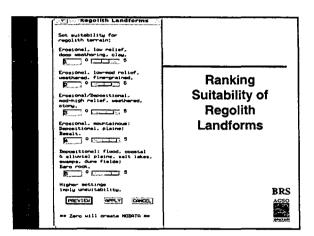
Examples of Site Selection Criteria for Radioactive Waste Repository (NHMRC)

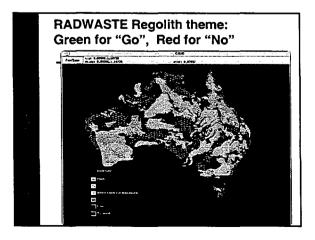
- a) low rainfall, free from flooding, good surface drainage, stable geomorphology
- b) a generally stable hydrogeological setting and water table at least five meters below the buried waste
- c) away from known or anticipated geohazards
- e) low population density
- f) groundwater that is not suitable for human consumption or agriculture
- g) properties that inhibit radionuclide migration
- h) reasonably close to roads/tracks

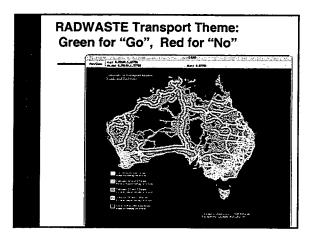










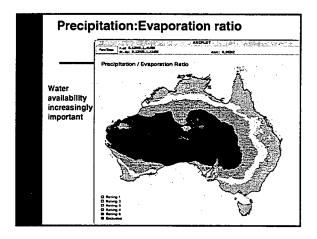


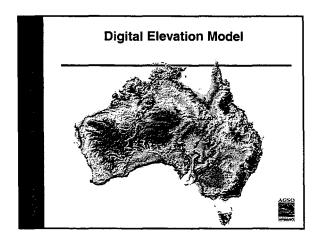
Examples of "Other Values" for Land Use Decisions in ASSESS

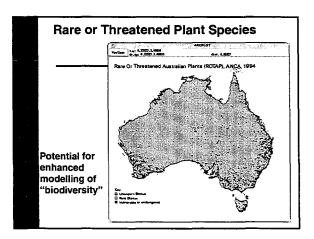
- National Wilderness Index
- Interim Biogeographic Regionalisation of Australia

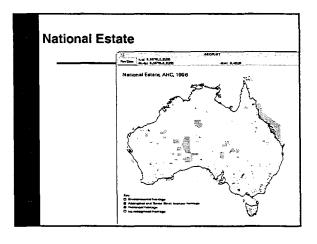
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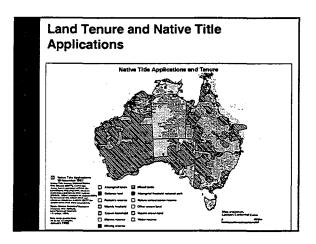


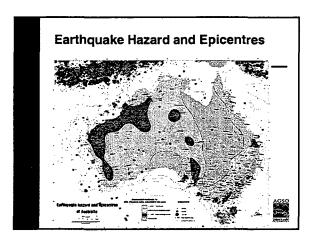


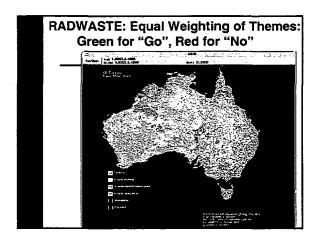


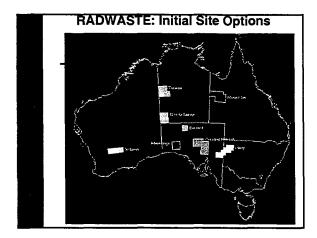


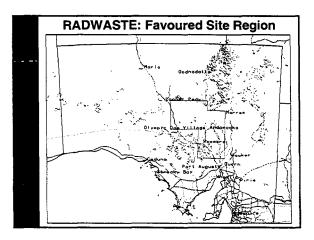












Current activities: Mineral Resources an	ıC
Advice Project 1999-2000	

- Combining ASSESS system with RFA minerals assessment system
 - ⇒ advanced, user-friendly DSS
- Preparing geoprovince-based mineral potential layers
- Other GIS development / applications
 - Nauru, Cocos Island

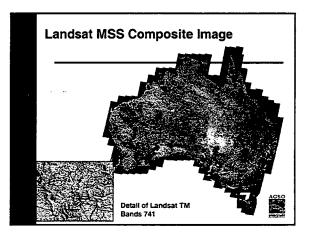


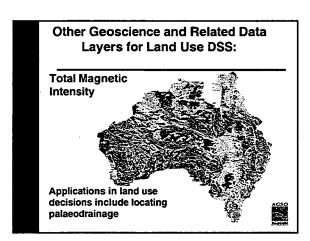
Future Developments

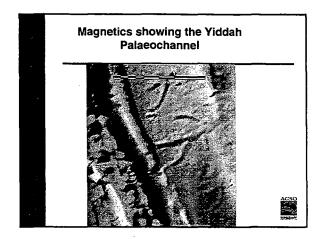
Continuing to develop and apply GISbased DSS that can access, integrate, weight and model diverse data, including:

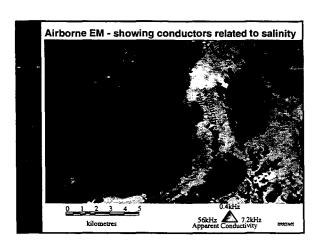
- resources + other geoscience values
- environmental and social values (including those related to land and water degradation)

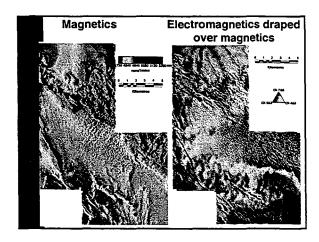


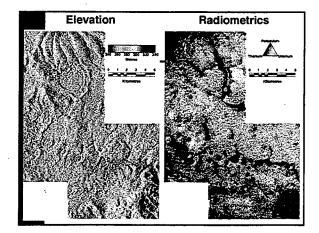












The Future

Mineral Resources and Advice

- Continuing resource assessment
- Continuing scientific/technical advice
- Enhancing AGSO's capacity in facilitating informed, transparent decisions:
 - resource access
 - land use/management in areas of land degradation (salinity, acid sulfate potential)

Collaborating, data sharing, demonstrating DSS

Conclusions

Mineral Resources and Advice Project

Meeting AGSO's challenges:

- Quality science and technology
- Increasing options
- Increasing efficiency



	
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THE END		
	AGSO	
	22(34)472	

Analysis of Australia's Major Mineral Systems



OBJECTIVE

 To undertake a rapid continentwide risk-based analysis of Australia's major mineral systems as a basis for future Minerals program development

OUTPUT

- 1) Prioritised potential projects to discuss with stakeholders and clients
- 2) Basis of work plan for 2000+



MINERAL	S PLANNING	PROCESS
		Priority Commodities
Mineral Systems 5		
Geoprovince Analysis		
Risk Analysis	MACHINE.	Research Priorities
Consultation		Project Plan

GLOBAL ISSUES

- · Low metal prices
- Exploration down 32%
- Globalisation
 - Exploration world-wide
 - Projects ranked world-wide
- · Rationalisation/mergers
- · Acquisition as alternative to exploration
- Strategic exploration alliances
- · Out-sourcing exploration, R&D
- Focus on world-class deposits, low costs
- · Lack of equity funds for juniors
- · Risk assessment/return on capital



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WHICH MINERAL DEPOSIT TYPES?

- What is Australia's potential for world-class deposits?
- What are the major deposit styles for each commodity
 - Australia
 - world-wide?
- What new styles could exist in Australia?
- What would make a difference to Australia's international competitiveness?



WHICH MINERAL SYSTEMS? 22 Ore deposit types

- Magmatic:
 Mafic Extrusive
 Felsic Extrusive
- **Epithermal**
- Mafic intrusive
- Felsic intrusive

Sedimentary basins:

- Chemical sediments
- Clastic-hosted Carbonate-hosted

Metamorphic: • Lode gold

- Metamorphic copper Others



MINERAL SYSTEMS APPROACH







- How well do we understand the mineral system?
- What do we know about the evolution of the province?
- What don't we know but need to?



PROVINCE ANALYSIS

- What are the known and potential mineral systems?
- What are the geological risks?
 - Poorly defined events, mineral systems?
- What are the exploration risks or impediments in this province?
 - Regolith type or cover
- · What are the development risks?
 - Remoteness, lack of infrastructure



PROVINCE HISTORY

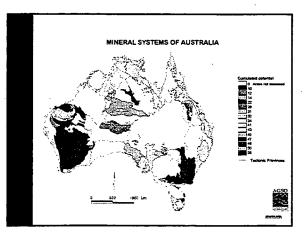
- 1) Time-event plots at province scale
 - Basement geology
 - Magmatic history
 - Basin evolution
 - Tectonic, metamorphic, metallogenic
- 2) Analyse mineral systems
 source, transport/pathway, trap
 3) Analyse risks
- 4) Define project to change risk profile

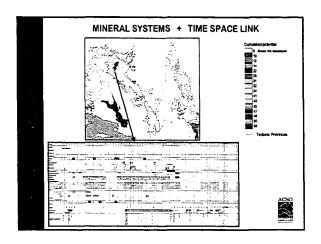


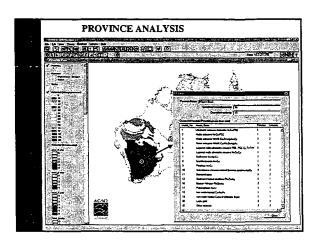
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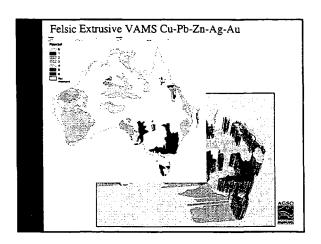
- Tectonic framework]
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- · Palaeogeography

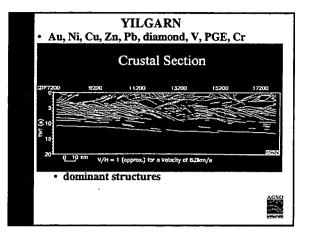












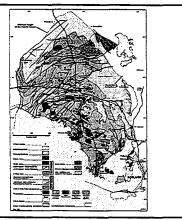
YILGARN

- YILMET seismic, gravity transects across main terrane boundaries to define framework of Yilgarn, geochronology to define events
- 1) NE goldfields
- 2) Eastern Goldfields Southern Cross
- 3) Southern Cross Murchison
- 4?) northern Yilgarn (Marymia Dome Bangemall Basin?

benefits

integrate GSWA, UWA, AMIRA research to provide better framework for gold exploration







GAWLER CRATON

- Cu, Au, (U, REE), Ni, Cu, PGE, diamonds
- Models 19, 20, 1, 12, 13, 4, 11
- Stuart Shelf-Olympic Subdomain
 - structure of Stuart Shelf and extensions, Torrens Hinge Zone, NW tectonic corridors
 - Hiltaba Suite, Gawler Range Volcanics (volcanic architecture, facies)
 - chronostratigraphy of Meso Palaeoproterozoic
 - event timing
 - fertile vs barren mineral systems
 - basement to Stuart Shelf



GAWLER CRATON cont

- Western Gawler Craton Issues
 - extent of greenstones, granites and gneiss domains
 - structural domains/sub-domains
 - event timing
 - testing of buried geophysical features
 - seismic, gravity definition of major faults
 - western tectonic margin
 - northern margin relationship with Mt Woods Inlier



DELAMERIAN • Zn, Cu, Pb, Au, Ag, Ni, (Sn-W) • Models 4, 9, 20, 10, 12 · Cambro-Ordovician orogen - Tas, Vic, SA, NSW, Qld Extension of Mt Read Volcanics into Vic/SA NE Goldfields seismic transect - magnetic, gravity mapping seismic transect(s) - Padthaway Ridge, Koonenberry Belt - palaeogeography - solid geology - geological environments - metallogenic map(s) - time-event definition TANAMI-TENNANT CREEK · Au, Cu, Zn, Pb, diamonds • Models 20, 18, 4, 11, 8 (Tanami, TA) Issues - nature of basement - extent of Archaean - relationship between TC and TA - tectono-stratigraphic framework - age and controls on Au in TA - hematite-hosted Au potential potential of younger sequences in TC (Ashburton Basin) for base metals (12) - lode gold potential - define structures, traps - regolith evolution - metallogenic synthesis

NORTH AUSTRALIAN TERRANES

- Au, Cu, Pb, Zn, Ag, diamond, (Ni, Cr, PGE, V)
- Subdivision of North Australian elements (craton)
- · Define Archaean domains
- · Define terrane boundaries
- Tectonostratigraphic elements
- Palaeogeography
 - magmatism, sedimentation, deformation
- Time-element definition
- · Crustal structure and thickness
- Regolith



RISK ANALYSIS High •Bangemail base metals Geological risk •Tanami Au Exploration risk High

PROJE	ECT PRIORITY	Y SETTING			····
High Attractiveness Relative potential benefit to industry	• Project A	В	·		
	• Project Feasibility Relative feasibility risk profile	High	ACSO FEDERAL		

AGSO MINERALS PROGRAM

- Thematic studies
 - commodity
 - tectonostratigraphic regime
 - national
 - province
- Geographic

 craton

 - terrane
 - mineral province extensions under cover
- Information systems
 - decision support systems



AGSO MINERALS PROGRAM

- · National role and strategic objectives
- State/NT priorities
- Promotion
- Proven and greenfields provinces
- · New data
- New concepts/plays
- Potential to develop synergies with unis, industry, CSIRO, CRCs

Potential for AGSO to have impact



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CRC FOR LANDSCAPE EVOLUTION & MINERAL EXPLORATION

Project Leader: Colin Pain Ph: 02 6249 9469 Fax: 02 6249 9930

Email: Colin.Pain@agso.gov.au Web: http://leme.anu.edu.au/

Overview: The CRC for Landscape Evolution and Mineral Exploration (CRC LEME) is an unincorporated joint venture between the University of Canberra, the Australian National University, the Australian Geological Survey Organisation and CSIRO Division of Exploration and Mining. The broad objectives of CRC LEME are to:

- Establish a framework for the greater understanding of the three-dimensional evolution of the Australian landscape.
- Translate knowledge of the evolution of Australia's landscape into a greatly improved ability to recognise major mineral deposits.
- Integrate industry-supported research with education to ensure a suitable skills base for industry, general earth science communities and for further research.
- Inform and guide decision-makers about the relevance and contribution of regolith geology and geochemical research to Australia's future.

Strategic Themes

The focus of CRC LEME has been sharpened into six strategic research themes. Together these themes provide the mineral industry in Australia with world-leading capabilities in understanding and dealing with the regolith. They are all interrelated, and thereby gain from each other. The themes are:

- Mapping the regolith in three dimensions (3D); describing and predicting the distribution of regolith in 3D, now recognised as a first necessary step in exploring deeply weathered terrain and areas of transported cover.
- Exploration in areas of basin cover, a difficult theme that looks at developing procedures to explore for mineral deposits beneath the margins of sedimentary basins.
- Regolith evolution, a theme that gains knowledge from the first two themes and
 from studying the weathering processes. If geologists understand the regolith setting
 and the landscape processes, they will be better placed to explore because the same
 weathering and landscape processes are those that produce geochemical dispersion
 from concealed mineral deposits.
- Regolith expression in ore systems, a theme that draws on each of the previous themes to recognise major mineral deposits. Conversely, studies specifically on the expression of ore systems yield fundamental knowledge on regolith distribution and evolution.
- Terminology and classification, a theme that places emphasis on establishing a common language so those people dealing with the regolith understand one another.

Until now regolith terms have been confusing. The terminology and classification theme focuses on exploration but is also fundamental to research.

Synthesis GIS/Expert System, a theme that draws the wealth of CRC LEME's
reference works in research, such as our case studies, mapping, mineralogical
studies and geochemical data, together for ready and permanent access. In addition,
the experience of CRC LEME researchers in being incorporated into an expert
system designed to be used in a predictive sense in exploration and research.

Current Activity

Some examples of recent CRC LEME achievements are:

- Tanami Project: The project area includes the regions centred on and around the Tanami and Granites mines in the Northern Territory. Regolith-landform mapping and 3D regolith and geochemical modelling have improved geochemical sampling methods for gold exploration in areas under cover or obscured by deep weathering.
- Yandal Project: This is a collaborative research project between CRC LEME and Great Central Mines. A 3D regolith model over the project area allows visualisation of geochemical data in the study area. This in turn assists interpretation and ranking of geochemical anomalies.
- Gilmore Project: As part of a multi-agency project, CRC LEME is providing the 3D regolith background to studies of mineralisation on the one hand and salinisation on the other.
- Cannington Project: Buried under 40m of sedimentary cover, the Cannington deposit provides an excellent opportunity to undertake a baseline study over a known ore deposit. A regolith map has been prepared, and geochemical and mineralogical studies undertaken.
- Broken Hill Project: CRC LEME is studying a number of areas in the Broken Hill-Curnamona region. Regolith-landform maps have been released on CD, and a number of mineralogical and geochemical studies are also in progress.
- A manual describing the regolith of the Yilgarn, together with exploration strategies, is nearing completion.
- A draft Glossary of Regolith and Related Terms has been released.
- CRC LEME is assisting a commercial group who are testing Resonance Acoustic Profiling as a technique for mapping sub-surface regolith materials. Test sites are in the Yilgarn, and in the Gilmore project area.

There is also a very strong education and training component in CRC LEME, based at the two universities, but utilising most of the staff across the CRC.

Future Developments

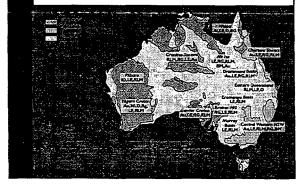
In 2000, CRC LEME is applying for a renewal of funding for a further 7-year period. This will see a continuation of work on the regolith of Australia, with renewed activities relating to mineral exploration combined with a broader approach to the use of regolith information.

CRC for Landscape Evolution and Mineral Exploration

Colin Pain **CRC LEME/AGSO**



Research in Australia

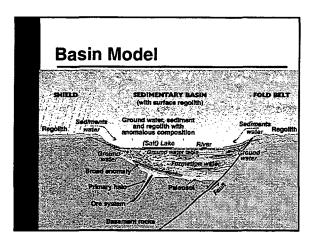


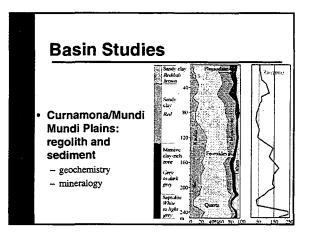
Strategic Themes

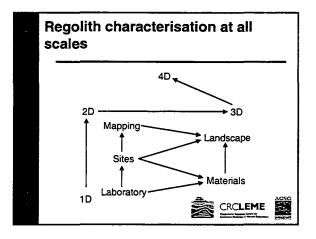
- Exploration under Basins
- Regolith Mapping, 1D 4D
- Regolith Evolution
- Expression of Ore systems in the Regolith
- Terminology and Classification
- · GIS and Expert Systems











Regional Surface Mapping 1:500,000 regolithlandform maps for Broken Hill & Curnamona: new hardcopy & GIS on CDROM

Detailed Surface Mapping

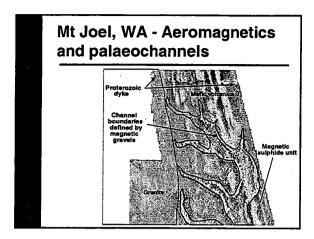
 1:25,000 Balaclava & Redan regolithlandform maps & GIS

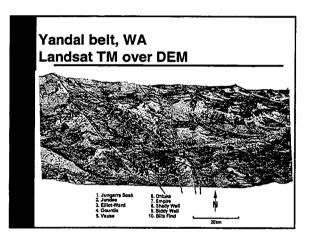


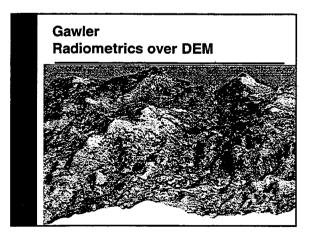
Hymap survey near Broken Hill

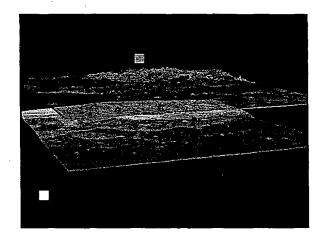
- 128 channels
- Approx 2.5 by 2.5 km
- Red: clays.
- Green: iron-oxides
- Blue: green vegetation (appears white where dense)

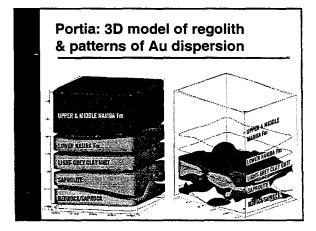




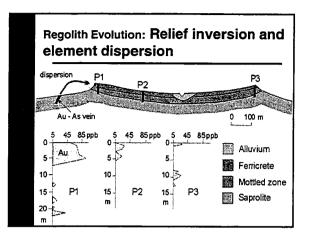


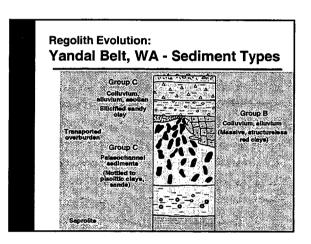


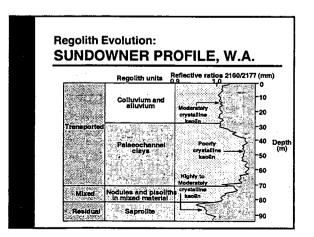


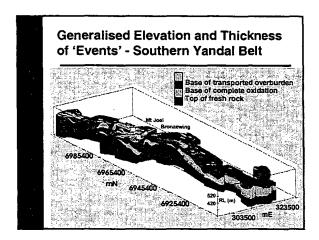


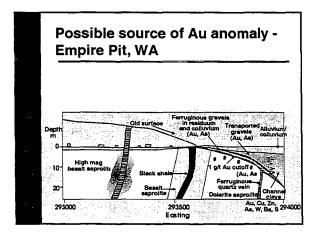
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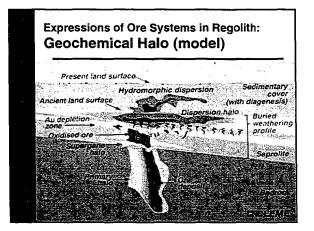




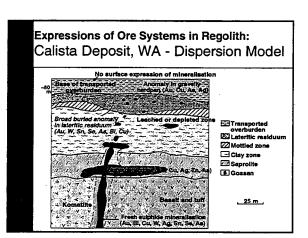


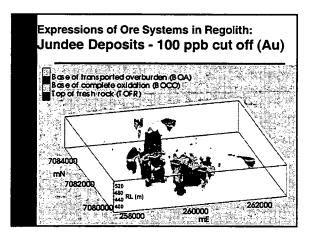




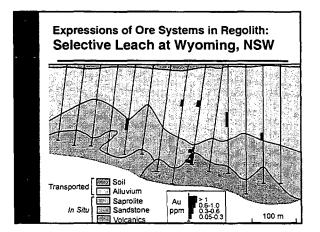


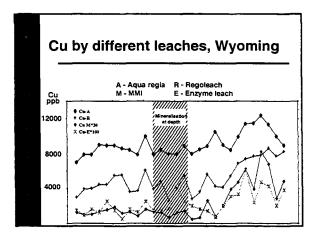
Expressions of Ore Systems in Regolith: Bronzewing Deposit, WA - Dispersion Up to Gravelly colluvium Transported overburden Itemsported regolith Au anomaly Leached or depieted zone Seproits Seproits Seproits





Surface responses to mineralisation Regolith Surface anomaly Supergene Comment halo 0-5 m cover Lag/Soil 5-15 m cover Absent/Present >15 m cover Absent >15 m cover Absent Can be anomalous





Au by different leaches, Wyoming A - Aqua regia R - Regoleach M - MMI E - Enzyme leach

Conclusions (1)

- · We understand regolith geochemistry and mineralogy, and how they can be used in exploration
- · We only partially understand regolith hydrology
- · We don't understand the influence of micro-organisms in regolith formation



CRCLEME



Conclusions (2)

- Maturity of our science, that is "good enough" for the needs of industry and the public, is decades away over most of Australia
- Over our 7.7 million square kilometres, regolith science is mature in perhaps 5 to 10 percent

Ross Fardon, Chairman, CRC LEME





GILMORE PROJECT

(Geoscience In Land Management and Ore system Research for Exploration)

Project Leader: Ken Lawrie

Ph: 02 6249 9847 Fax: 02 6249 9983

Email: ken.lawrie@agso.gov.au

Project summary

AGSO's Mineral Division is co-ordinating a multi-disciplinary project 'Gilmore', involving 50+ scientists from 14 research organisations. The project, in central-west NSW, brings together scientists examining ways to map Au and Au-Cu mineral systems concealed beneath complex regolith cover, and scientists trying to understand and manage dryland salinity. Benefits include the sharing of costs in acquisition of new geophysical datasets, integration of datasets not commonly utilised outside their respective disciplines, and new scientific insights that arise from this inter-disciplinary approach.

A significant component of the study involves ground truthing of new high resolution geophysical datasets. The approach adopted considers the regolith mass to be an integral component of the mineral system, and utilises the geophysical signatures of both unweathered bedrock (primary lithologies and hydrothermal alteration zones), and their weathered equivalents in the regolith mass, to assist with delineating mineral systems. Integration of geological, geochemical, geophysical and hydrological datasets is helping to explain and model the movement of salt (and metals) in the subsurface. Data from the project are largely confidential until July 2000.

Main Research Objectives

The main objectives of the project from the minerals-potential perspective are:

- to assess the capabilities of airborne geophysical techniques including magnetic, gamma-ray spectrometric, and electromagnetic (EM) methods to map bedrock geology, including primary hydrothermal mineral systems, beneath a variably thick regolith cover sequence;
- to construct a three-dimensional model of the regolith cover sequence;
- to examine the distribution of metals in surface and subsurface regolith, and to combine the resulting data with hydrological modelling and palaeohydrological data to determine metal dispersion patterns and vectors through the regolith cover.
- construction of conceptual models for the salt cycle involved in dryland salinity: inputs include the flow (and palaeo-flow) and storage of groundwater, and resolving the source(s), storage and flow of salt, and rates of groundwater recharge.

Research Partners

Research partners include CRC AMET, Land & Water Sciences Division of Bureau of Rural Sciences (BRS), CRC LEME, NSW Department of Land & Water Conservation, NSW Department of Mineral Resources, Australian National University, University of Canberra, Macquarie University, CRC for Sensor Signal and Information Processing, Curtin University of Technology, ANSIR, AGCRC, Monash University and University of Melbourne. The project has research agreements with the minerals exploration industry, and is collaborating with rural land-management groups, and the Grains Research and Development Corporation.

Project location and rationale

The 'Gilmore' project is located adjacent to the Gilmore Fault Zone, a major NNW-trending structure that may have played a role in localising mineralising fluids in the study area. This area, between West Wyalong and Junee (in the southwest Forbes and Cootamundra 1:250 000 Sheet areas, western NSW), lies in an area known for its Au and Cu mineralisation, as well as its grain-cropping industry. It was selected for study because of its mineral potential, its location straddling two hydrology catchments (Lachlan and Murrumbidgee), and its extensive, variably thick regolith (up to 150 m of Cainozoic sediments), which sustains substantial industry and government datasets.

Several Au-Cu and Au deposits occur in the study area, variably concealed beneath complex regolith cover. The minerals system approach has involved mapping the larger alteration footprints associated with these deposits, in addition to lithology and structure, using high resolution airborne magnetics, airborne EM, γ -ray radiometric and gravity datasets. Constraints are provided by limited surface data and a dataset and materials from numerous drillholes.

New Datasets

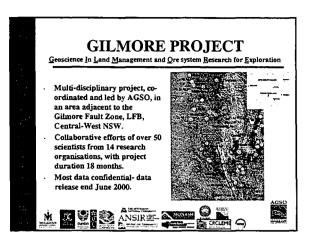
New geophysical datasets include an airborne EM survey, and some high-resolution, airborne magnetic and gamma-ray spectrometric datasets. A regional digital orthophotography dataset acquired for the Cootamundra Sheet area will provide an accurate reference framework for field studies and GIS referencing. New geochronology is being acquired to determine the age and nature of primary bedrock and intrusive magmatism (U-Pb), and sulphides in Au and Au-Cu ore deposits (Re-Os). Shallow-penetrating and deep crustal seismic reflection datasets were acquired to ascertain likely fluid and magmatic pathways and offsets.

Surface datasets being acquired over the same profiles as the seismic reflection data include ground penetrating radar, ground EM, ground magnetics, and close-spaced gravity. Downhole data acquisition includes conductivity and magnetic data. The project also includes mapping of regolith materials in 3D, and PIMA, XRD and thin section studies of regolith and bedrock materials. Regolith studies are included as an integral component of identifying mineral systems. Relationships between regolith materials and hydrothermal alteration are being examined in this context. Secondary physical deposits and chemical (hydromorphic dispersion) halos are also being delineated.

A hydrological and palaeo-hydrological understanding of the area is important in salinity studies for resolving water-rock interactions, and will also help clarify the process of metals dispersion in the regolith cover sequences. Buried palaeochannels in the regolith also have the potential to form Au-bearing deep leads and stores for saline groundwaters. This study also integrates hydrological datasets, high resolution airborne geophysical mapping techniques, and regolith and bedrock geological mapping methods (from magnetics, and information obtained from drilling) to provide information on the distribution of salt sources and potential salt stores.

Gilmore Outputs-30th June 2000

- Report documenting the geological characteristics of epithermal Au and porphyry Au-Cu mineralisation systems in the Gilmore project area;
- Report documenting the alluvial gold potential, Gilmore project area.
- Report documenting a methodology for a 3D minerals system approach to exploration for porphyry Au-Cu and epithermal Au deposits under shallow regolith cover, in Gilmore project area.
- Release of Tempest AEM datasets.
- A report and maps documenting the landscape evolution and 3D regolith distribution in the study area.
- A CD ROM GIS and associated digital datasets on the metallogenic potential of the Gilmore project area, Lachlan Fold Belt, N.S.W.



Gilmore Project What are the links between mineral exploration and dryland salinity? Gidginbung Mine site - Area of complex regolith cover repository for metals and salts - Sharing of resources, datasets and ideas to solve problems in area of

2 catchments, >4,000 drillholes

Gilmore Project Rationale/ strategy

- Need to develop the mineral potential of areas under shallow regolith and sedimentary basin cover (~200m)
- Requires the application of new approaches and technologies
- . Inter-disciplinary strategic research alliances
- Minerals system has larger footprint than discrete orebodies- need to understand these systems



AEM- Confidential slide 1

Geological framework: new insights



Structure/geophysics: gravity and magnetic data suggest GF is part of GFZ - thin skinned tectonics: west-dipping imbricate thrust fault system?

Geochronology:

Ordovician MORBs

E. Silurian calcalkaline intrusive complexes

E. Devonian Au-Cu

post-E. Dev. Au

Post-E. Dev. Au



Gilmore Project: Au-Cu, Au deposits

Six deposit styles recognised in Gilmore project area:

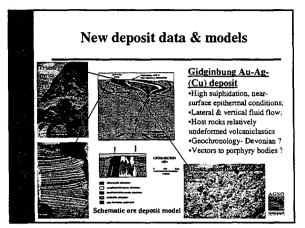
- Low temperature Audominated high sulphidation epithermal
- High temperature Au-Ag-(Cu) high sulphidation epithermal
- Porphyry Au and Au-Cu
 Intrusive-related Au-Cu
- Intrusive-related Au-Cu breccias
- Fault-controlled plutonic/subvolcanic Au vein
- Brittle-ductile shear- and faulthosted quartz-illite/sericitepyrite Au vein

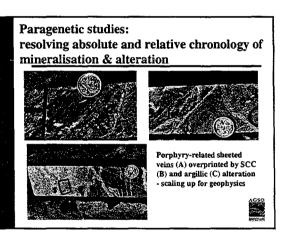


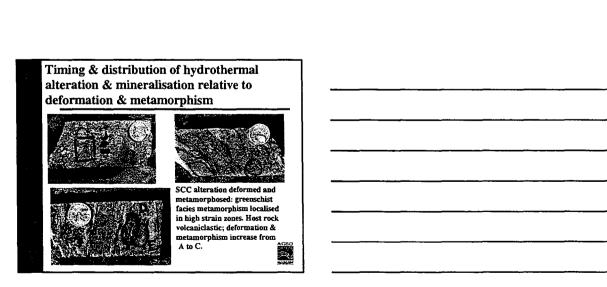
- 400 Ma E. Devonian event
- E. Silurian calc-alkali magmatism
- Other models ?



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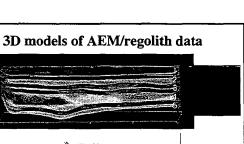
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	High resolution magnetics-	
	too many targets??	
	Regional 250K 200m line- High resolution 50m	
	spaced data line-spaced data	
	Cu-Au porphyry prospect / Cu-Au mineral system	
	Cu-Au mineral system	
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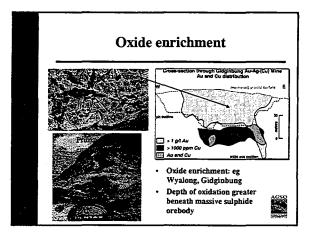


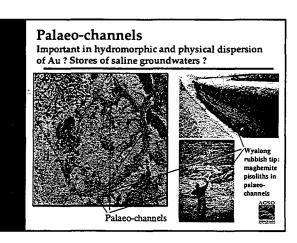


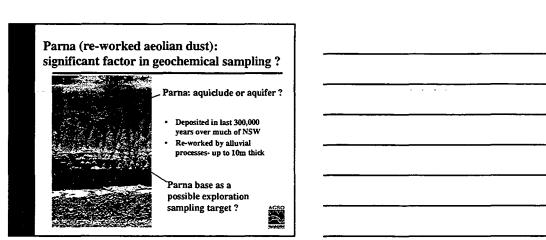
Au and Cu exploration sampling Maghemite pisoliths in surface lags and palace channels November land surface. Maghemite pisoliths in surface lags and palace channels Soil, palacosols Calcarcous material Dispersion in pulaco-channels and basins Suppose profession policy Dispersion in pulaco-channels and basins Suppose profession in topographic in topographic highs and buried ridges

-Lateral versus vertical fluid flow? -Significance of historical changes in water tables levels ? -Are there any barriers to vertical fluid flow?









Gilmore Project - Outcomes New techniques for mapping primary lithologies, alteration and mineralisation under regolith cover; Mineral system models that may influence exploration strategies in LFB; Better understanding of metals dispersion in the regolith cover; Model for dryland salinity management in upland catchments; Products will be available to clients in GIS format in accordance with AGSO corporate standards - end June 2000.

NATIONAL GRAVIMETRY

Project Leader: Alice Murray

Ph: 02 6249 9264 Fax: 02 6249 9971

email: <u>alice.murray@agso.gov.au</u>

Overview

AGSO's *National Gravity Database* contains data from more than 900 000 point gravity observations derived from over 1000 surveys dating back to 1937. This repository is a valuable national asset with importance to the mineral and petroleum exploration industries, geodesy and the international scientific community. We are continually seeking additional data from State and Territory governments and private exploration companies to augment the Database. We also conduct or coordinate gravity in-fill surveys in strategic areas.

The Australian Fundamental Gravity Network provides a consistent and accurate set of gravity control points throughout Australia and its territories. These gravity control points, which are now largely digitally documented, are spaced at intervals of about 150 km over the continent. Ideally, all gravity surveys carried out in Australia should be tied to one or more of these stations. We currently have a program to augment, refurbish and complete digital documentation of the Fundamental Gravity Network.

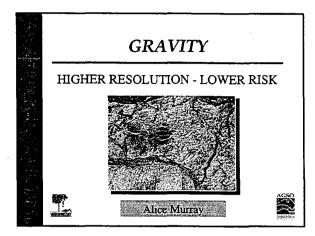
The National Gravimetry project has responsibility for providing national guidelines for gravimetry in Australia; in the past this has been provided to State and Territory governments and industry on request, but a need for a more complete and formalised code of best practice is obvious. To satisfy this need we are developing a *National Gravimetric Code* which will define the current best practice in gravimetry.

Current Activity

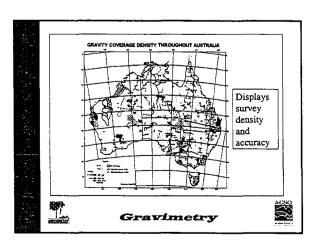
- Database translation from an in-house system to Oracle and Intrepid
- Gravity information, particularly for survey coverage and base stations put on-line
- Release of Data from the Tanami-Granites in-fill survey
- Release of base station documentation for Sydney, Tasmania and Western Australia
- Release of new edition of the digital National Gravity Database
- Development of a new series of high quality print-on-demand gravity maps.

Future Developments

- To achieve cooperation and coordination between AGSO, State and Territory governments and industry in matters relating to gravity
- Integration of the onshore and offshore gravity data into a seamless dataset
- Cooperation with AUSLIG in setting up gravity bases on national geodetic points and encouraging international visitors to make absolute gravity measurements.
- Organising high quality scientifically targeted in-fill gravity surveys in cooperation with our clients
- Continue development of the National Gravimetric Code to define standards in surveying, processing, storage, delivery and interpretation of gravity data
- Keep abreast of new developments in airborne gravity gradiometry and research its use in practical geological interpretation



• Maintain and enhance the NATIONAL GRAVITY DATABASE • Maintain, strengthen, augment and document the FUNDAMENTAL GRAVITY NETWORK • Develop, document and promote NATIONAL GRAVITY STANDARDS • Provide information, expert advice, data and images



National Gravity Database

- New Oracle / Intrepid database structure
- · Internet access to survey metadata
- Intrepid field processing system
- 1 000 000 observations on 1000 surveys
- · Survey coverage and reliability diagram
- Integration of land and marine data



Gravimetry



Micro-grid compilations

Broken Hill region

region Mined area is visible



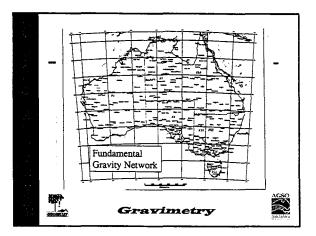
Fundamental Gravity Network

- Provides a consistent level for surveys
- 300 localities throughout Australia
- Documentation of 1000 base stations
- · Diagrams made available on the web
- International absolute measurements
- · Augmentation and refurbishment





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National Gravity Standards

- Scientific survey design and practice
- Frame of reference for gravity surveys
- Comprehensive contract specifications
- · Field processing and interpretation
- Archiving and exchange of gravity data
- Recommended reporting requirements





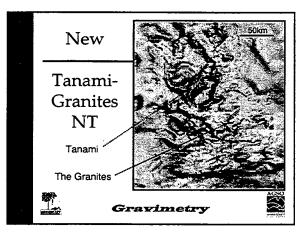
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Sci	entific Survey Planning	_
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*********	Gravimetry	

Criteria for in-fill surveying

- Economic or scientific priority
- Scientific 3D-risk based assessment
- Integration with geological study
- Completion of province coverage
- Size of area total cost of survey
- Unsatisfactory existing coverage







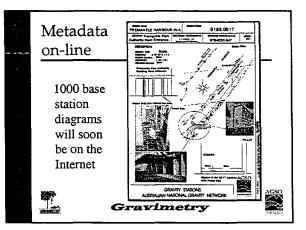
Our future direction

- Cooperation and coordination with states and industry joint venture surveys
- Targeting areas of economic potential
- Multi-disciplinary surveys and research
- Integrated geological solutions
- Data and information on-line for clients



Gravimetry





On the horizon:

- Airborne gradiometry high frequency data controlled by surface coverage
- Systematic absolute surveys
- Optimum gridding of the continent with a mesh size down to 100m or less
- · Isostatically corrected data
- · Automated inversion methods





NATIONAL DIGITAL DATABASES AND STANDARDS

Project Leader: Murray Hazell

Ph: 02 6249 9375 Fax: 02 6249 9971

Email: murray.hazell@agso.gov.au

Overview: This project is responsible for the development and maintenance of national scale digital databases, and data standards, of relevance to resource analysis and informed decision making about environmental protection. AGSO has developed an integrated system of corporate geological, laboratory and mineral resource databases running on an ORACLE relational database management system. We are constantly extending the coverage of our databases to include new data types and link with AGSO's petroleum databases. The ultimate aim is to achieve rationalisation across AGSO to ensure that each data type is entered only once and its currency is maintained by those designated as the primary custodian.

AGSO follows the concept of the 'active archive' in that all AGSO projects, as they capture primary field and laboratory data, will store it within the corporate data system and then export the required data to their own project-based systems. Any updates to data will be made in the corporate, rather than the project-based systems and data releases will be made from the corporate data system, in recognised standard formats, via corporate quality control/quality assurance systems. The *National Geoscience Maps Project*, a major new initiative of AGSO, will develop continental scale compilations directly from key data sets within the corporate databases.

To facilitate the efficient use and exchange of digital data AGSO has been active in establishing digital data standards for its databases and GIS. All projects in Minerals Division follow strict standards laid down in AGSO's GIS data dictionary for depicting and attributing features within GIS. At the request of industry we have made both our database lookup tables and our GIS data dictionary available on the WWW.

Critical to AGSO's use of GIS is the Geological units database based on the Stratigraphic Index database (STRATINDEX). For many digital data sets and digital maps the Geological names database can act as an authority table with the potential to automatically provide information on the related parentage, age and province. In order to ensure that all geological units on Australian maps and publications can be uniquely coded, the STRATINDEX is being modified to better store information on granite suites and unnamed units. We are also developing a standard for naming sequence stratigraphic units.

Our long term aim is to make as much information as possible accessible via WWW. To this end we have developed a corporate metadata catalogue, AGSOCAT. All data sets and products produced by AGSO will be recorded in AGSOCAT and clients will be able to search spatially or using keywords, view thumbnails and ultimately purchase and receive data via the web.

Recent Highlights:

- Internet queries on the stratigraphic index have increased to an average of 30 per day. We have also added the ability to search bibliographic references. Usage averaging 7 queries per day.
- Development of ORACLE web forms for deployment in an Intranet environment in AGSO.

- The OZCHRON database has been redesigned to facilitate automated access to age information and the derivation of province-wide and continent-wide ages from the original data on individual ages in an 'audit-trail style' of database.
- The OZCHEM database created to replace ROCKCHEM. This new database structure is capable of storing all types of geochemical data including whole-rock, stream chemistry and isotope data.
- Changes to OZROX include: a table redesign to better incorporate structural and alteration mapping information; the ability to store and display photos and field scanned field sketches.
- The MINLOC and MINRES databases have been combined within a web enabled application called MINERALIS.
- An expert system has been developed for regolith mapping and prediction, thematic
 modeling and data visualisation within the framework of a desktop GIS. The expert
 system will be used to develop and test models of landscape evolution in different
 environmental settings in Australia.

Future Plans:

- Modify STRATINDEX for recording unnamed units, so that a unique geological identifier is available for all geological polygons (not just the named units) in digital data sets.
- Upgrade the STRATINDEX web page to include the ability to reserve names on the Internet and provide more information on stratigraphic nomenclature.
- Establish standard naming, definition and database requirements for adequately recording sequence stratigraphic units
- Upgrade the OZCHRON database to become a fully integrated information system for the derivation of province and continent wide dated "events" with links to the Stratigraphic Index.
- Merge the MINLOC and MINRES databases into OZMIN to form a single mineral deposits database.
- Release of ROCKCHEM 4 to be called OZCHEM 1 with ~9 000 new analyses in early 2000.
- Release of version 3 of OZMIN National Mineral Deposits database by June 2000.
- AGSO's geophysical line and marker sets have been revisited with the eventual aim
 producing a standard set of symbols for geophysical interpretation maps that are
 acceptable to all the geological surveys across Australia.

Products:

Databases

- OZMIN A compilation of commodity, resource and geological information for ~950 of Australia's largest mineral deposits. (POA)
- OZCHRON A compilation of geochronological information generated over more than 30 years from AGSO's field work and from literature. Includes over 630 SHRIMP, over 500 Sm-Nd, 395 Rb-Sr and 135 U-Pb conventional ages. (POA)
- ROCKCHEM A data base of over 48 000 whole rock chemistry analyses, of which approximately 25 000 are available for purchase. (POA)
- MINLOC Locations for more than 73 000 mineral occurrences. (POA)
- OZMIN deposits on grey-scale magnetic image of Australia maps. (\$150 each; \$250 for both)
- OZMIN Mining Council of Australia mining operations map. (postage and handling)
- Record 1999/16 The AGSO field geological note books a users' guide. (\$10; inc database codes on floppy and field notebooks \$50)

NEW DEVELOPMENTS IN AGSO'S DATABASES

AGSO's Databases

- External trends influencing database development in AGSO
 - Knowledge based economy and information management
 - Federal Government's aim is to promote the knowledge economy by having all information available on line by 2001
 - Internet



Data Management

- Geology
 - OZROX in Oracle, GIS on corporate disk
- Airborne geophysics
 - Survey data on Unix, metadata in Oracle and Access
- Gravity
 - Survey data on Unix, metadata on Unix
- Seismic
 - Survey data on magnetic tape



Knowledge Management

- Capturing knowledge within the Organisation
 - knowledge on how interpretation created
 - ensuring original data preserved



KNOWLEDGE

INFORMATION {

DATA



SOME DEFINITIONS......

DATA

Known facts or things used as

a basis for inference or

reckoning

INFORMATION

Knowledge communicated or

received concerning some

fact

INTERPRETATION

To explain the meaning of, to

make out or bring out the

meaning of

KNOWLEDGE

The sum of what one knows awareness or familiarity

gained by experience

Knowledge Management

- Capturing knowledge within the Organisation
 - knowledge on how interpretation created
 - ensuring original data preserved

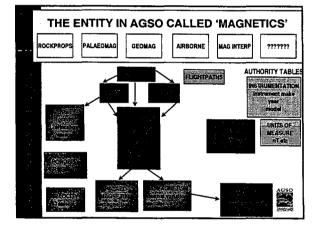


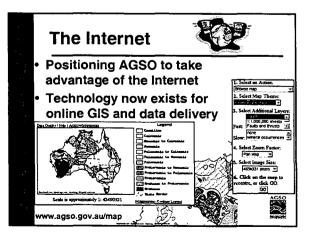


Information Management

- Project IM reviews
- · Rationalising databases
 - Surveys table
 - Mineral deposits databases
- · Including new data types
 - gravity, fluid chemistry, image data, rock properties
- Entity mapping







Internet commerce

- Use of Internet now routine
- E-commerce, online data delivery

amazon.com



Making the Internet work

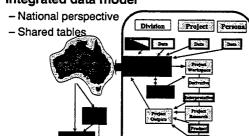
- Well structured integrated databases
- Metadata
- Standards
- Good IM practices





Well structured integrated databases

Integrated data model



Metadata

- · Data set specifications
 - projection, lineage, data quality
- · Catalogue information
 - finding at data set, where is it stored?
- AGSOCAT
 - All AGSO products and data sets
 - Spatial and key word searches
 - Physical location of data



Standards

- Database look up tables
 - lithology, rock textures, alteration
- · GIS data dictionary on web
- · Database standards on web

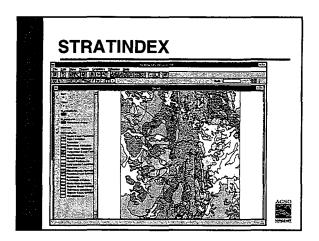
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alagen	Lithelegical terms chariffed into qualifier (QUALIFIER = Q), ignores (QUALIFIER and contemp) (QUALIFIER = S), matemorphic (QUALIFIER = N), etc.
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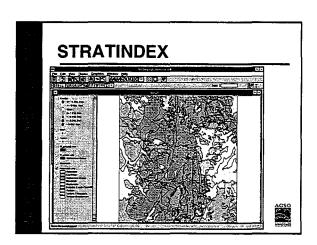


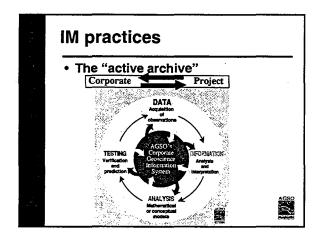
STRATIGRAPHIC INDEX

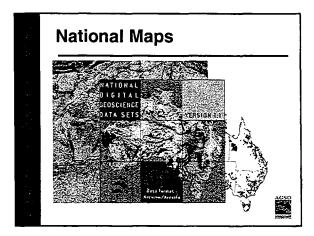
- A joint collaboration with the State Surveys
- Contains a wealth of information on most geological units in Australia
- Each geological unit is uniquely identified
 - a valuable resource for GIS
 - provides link to other data sets

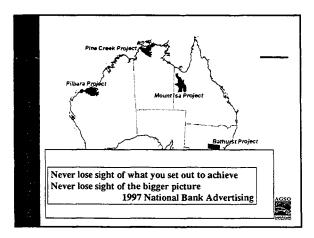












Competitive advantage is in how data are used Geological Surveys as the data managers

External data access

- Packaged data set products
- · Discreet data layers
- Online integration

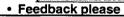




External data access

- AGSO's web site being upgraded
- Online purchase and delivery







Feedback

Web Master Jonathon Root jonathon.root@agso.gov.au

http://www.agso.gov.au



National Digital Geoscience Data Sets

AGSO Releases new compilation of continent-wide geoscience data sets

AGSO has released a new product which brings together in a single digital GIS package all of AGSO's continental-scale data sets. Some of the data sets are primary (geology, metamorphism, regions), whilst others are subsets of AGSO's major data bases and data sets (magnetics, whole-rock geochemistry, mineral deposits, hydrology etc). All data sets have been compiled using a common coastline, projection and central meridian enabling easy integration of any of the individual coverages. Several coverages (e.g., geology, regolith, regions and ROCKCHEM) have more than one attribute and hence from the one coverage, several different themes can be plotted.

The Product

Thirty data sets are included in the package. Supported formats for the data are ARCINFO, MAPINFO and ARCVIEW. The data set is sold as a 2-CD product - one CD contains the digital data, whilst the other contains A3 postscipt files of the more popular base maps and integrations so that clients can print out their own maps.

Image data sets

- ♦ Magnetic's image (pixel size 1600m)
- ♦ Gravity image (pixel size 2500m)
- ◆ Digital Terrain Model AUSLIG (pixel size 1600m)
- ♦ Depth to basement image (pixel size 2000m)
- ♦ Image of estimated crustal temperatures at 5km depth (pixel size 5000m)

Vector data sets

- Well data locations used to generate image of estimated crustal temperatures at 5km
- Specifications and coordinates of AGSO Airborne Surveys
- ♦ Geological regions of Australia based on AGSO Bulletin 181
- Crustal elements map
- Metamorphic Map of Australia
- ♦ Regolith Landform Map of Australia
- Australian Geological Map
- ◆ Spatial representation of AGSO's whole rock geochemistry database ROCKCHEM
- Spatial representation of AGSO's geochronology database OZCHRON
- Spatial representation of AGSO's mineral deposits database OZMIN
- Spatial representation of AGSO's field observation database OZROX
- Selected Onshore AGSO Seismic Cross sections, linked to AGSO Onshore Deep Seismic lines
- Locations of AGSO Offshore seismic lines surveyed by RV Rig Seismic
- Basins of Australia
- Australasian earthquake epicentres
- Earthquake hazards map
- Australian Geomagnetic Reference Field
- Hydrogeological map of Australia
- ♦ 1:1m Australian Coastline
- 1:100 000 map sheet index of Australia with index of AGSO publications from GEODEX (AGSO's bibliographic reference database) attached to each mapsheet
- 1:250 000 map sheet index of Australia with index of AGSO publications from GEODEX (AGSO's bibliographic reference database) attached to each mapsheet
- Coded cultural layers (population centres, road, rail, drainage networks).





Product Price

CD of National Digital Geoscience Data Sets

\$950

For further information

Bruce Kilgour

Phone 02 62499610 Fax 02 62499971

Email bruce.kilgour@agso.gov.au

or

Lesley Wyborn

Phone 02 62499489

Fax 02 62499971

Email lesley.wyborn@agso.gov.au

AGSO internet site http://www.agso.gov.au/minerals/ams/datasets.html

(Which includes images and metadata for all National Geoscience Data Sets and on line interactive GIS of selected data sets)

To order

contact the AGSO Sales Centre Phone 02 62499519 Fax 02 62499982 Email sales@agso.gov.au

Australian Thematic Mineral Deposit Maps

AGSO has released two thematic 1:5 million scale national maps (930 x 820 mm) which overlay mineral deposit information from OZMIN (AGSO's mineral deposit database) on a grevscale magnetic image of the continent. They are:

- 'Australian mineral deposits by deposit type'; and
- 'Australian mineral deposits by age of formation'.

Areas of mainly Phanerozoic basin cover that are essentially unmineralised have been superimposed as a green or orange stipple on the image used in each map. Providing information on the distribution, age, and types of mineral deposits developed in Australia, both maps will be of considerable value to those with an interest in the mineral resources sector. They promote the global attractiveness of Australia for investment in mineral exploration, and reveal extensions to prospective areas concealed beneath sedimentary basin cover.

Both maps are a spatial representation of selected attribute information retrieved and simplified from the national dataset in AGSOs mineral deposit database known as OZMIN (see AUS.GEO News 42). This dataset has been compiled from published reference material. It contains comprehensive mineral deposit information covering location, deposit, host rock, and deposit environment characteristics, and includes references. OZMIN has been designed so that attribute information can be retrieved and analysed in relation to spatial data contained in geographic information systems (GIS). The dataset covers almost 60 commodities (including coal).

> The maps take in almost 900 of Australia's major current and historic mines and undeveloped mineral deposits. In both maps, currently operating mines and those yet to be developed are labelled with deposit name and commodities whereas historic

mines are labelled by commodity only. Enlargements detailing heavily mineralised areas in the Kalgoorlie and Pine Creek regions appear as insets on each of the map sheets, and a further inset illustrates the distribution of major Australian deposit types through geological time.

The map depicting deposit type has cast Australia's major deposits into 20 categories based on their geological setting and general deposit characteristics. The map illustrating deposit age has been simplified from the detailed age information stored in OZMIN, and depicts 21 age categories at the era and period level (e.g. Cainozoic, Palaeozoic, Jurassic, Ordovician, etc.). For fuller information on each deposit and their relationship to infrastructure, both maps should be read in conjunction with the 'Australian Mining Operations and Significant Mineral Deposits' map produced by AGSO at the same scale in mid-1998 for the Minerals Council of Australia (see AUSGEO News 46).

Australia's mineral endowment is a direct result of its geological evolution. Mineral deposits have been discovered and mined mainly where the major crustal elements that make up Australia are exposed and not obscured by younger sedimentary basins and regolith materials. The magnetic image shows the extent of these elements and major structures beneath the basin cover, and reveals the full extent of concealed prospective areas. It is a greyscale total magnetic intensity image of Australia that has been enhanced by a sunangle illumination from the northeast.

For further information contact:

Dr Greg Ewers

Tel: 61 2 6249 9580 Fax: 61 2 6249 9983

email: Greg.Ewers@agso.gov.au

http://www.agso.gov.au/minerals/



Australian Thematic Mineral Deposit Maps Order Form

Γo: AGSO Sales Cer

GPO Box 378

CANBERRA ACT 2601

Australia

Tel:

61 2 6249 9519 or 61 2 6249 9642

Fax:

61 2 6249 9982

sales@agso.gov.au

email: web:

http://www.agso.gov.au

Thematic Mineral Deposit Maps	Price (A\$)
'Australian Mineral Deposits by Deposit Type' (laminated print-on-demand colour map)	\$150
'Australian Mineral Deposits by Age of Formation' (laminated print-on-demand colour map)	\$150
Map package (discount of \$50 applies if one copy of each of the above maps is purchased together	\$250
wish to order the following: I would like further information o	
Qty Publication	Cost (A\$)
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We understand that AGSO owns the copyright of this product, and we agree not to reproduce communicate to any other company or persons, any part of this product without prior written Director, Australian Geological Survey Organisation, Australia.	permission of the Executive
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AUSTRALIAN GEODYNAMICS COOPERATIVE RESEARCH CENTRE

Research Coordinator: Russell Korsch

Ph: 02 6249 9495 Fax: 02 6249 9972

Email: Russell.Korsch@agso.gov.au

Overview

The aim of the AGCRC is to develop, in partnership with the Australian minerals and energy exploration industry, a geodynamic framework of the continent that enhances industry's capacity to discover world-class deposits. The AGCRC is an unincorporated joint venture between AGSO, CSIRO Exploration and Mining, Melbourne University, Monash University, La Trobe University, and Compaq Computers. It was funded for 7 years and is due to cease operating on 30 June 2000.

The AGCRC has seven objectives:

- to define links between geodynamic processes and the formation of world-class deposits;
- to build syntheses of the geodynamic evolution of key prospective terranes;
- to understand the plate tectonic and geodynamic setting of the Australian continent and its provinces;
- to develop geologically relevant mechanical models, including both conceptual frameworks and computer codes, which simulate and predict geodynamic evolution at all scales;
- to develop integrated sciences and technologies for visualising and modelling geophysical and geological data and geodynamic processes through time.
- to build a partnership with the Australian minerals and energy industry (including Government and other research groups) to promote the transfer of knowledge, technologies and skills developed within the AGCRC; and
- to develop an advanced education and training environment around the AGCRC's research activities.

The AGCRC maintains a comprehensive world wide web site and the interim results of the AGCRC's endeavours are made available as soon as possible via the www (at URL http://www.agcrc.csiro.au) and in standard scientific publications.

Highlights of Key Projects

PREDICT Geological Information System

The PREDICT geological information system provides key information about the nature, timing and distribution of tectonic events, at varying scales, which have had a bearing on the formation and evolution of terranes/tectonic assemblages and sedimentary basins which host petroleum and mineral resource systems. PREDICT is based on two key concepts: the current understanding of the hierarchy of geological processes and the tectono-stratigraphic units that are produced, and, the petroleum system concept, which is now starting to be applied to minerals systems. PREDICT attempts to quantify and synthesise information in a series of relational database tables that can be interrogated in a structured and meaningful fashion. The outputs from these queries can be represented in a series of pre-defined graphical templates that allow the digital construction of time-space plots to compare tectonostratigraphic histories for several terranes. All aspects of PREDICT, including input and output forms and output graphic templates are accessed via a single world wide web interface.

Eastern Goldfields, Yilgarn Craton

The AGCRC has reinterpreted the 1991 deep seismic reflection profile and has undertaken geodynamic modelling of the interpreted geometry as part of developing an exploration model for the Kalgoorlie region. In 1997, in conjunction with Kalgoorlie Consolidated Gold Mines Pty Ltd, the AGCRC acquired new regional and high resolution seismic data near Kalgoorlie. In September 1999, the AGCRC acquired about 195 line km of deep seismic regional reflection data along a grid of 5 lines to provide three dimensional information on the relationship between the greenstones and the granites in the vicinity of the highly mineralised Bardoc/Boorara Shear. The internal structure of the greenstones within the Kalgoorlie region shows an overall thrust-stack geometry. The basal greenstone detachment is irregular in nature and exhibits a significant variation in depth from 5 - 9 km. The Moho is interpreted to occur at approximately 35 km depth.

Mt Isa Inlier

A crustal-scaled depth section of the Mount Isa Inlier has been produced using the deep seismic reflection data and refraction data acquired by the AGCRC, coupled with geological mapping along the seismic transect. The seismic refraction results indicate the crust to be thick (~55 km) throughout the region. The crust-mantle boundary is not sharp but is a thick (up to 15 km) transitional zone. The refraction survey detected the presence of two high velocity (7 km/s), lens-shaped bodies in the lower and middle crust, that are most likely mafic to ultramafic in composition. The Eastern Fold Belt shows a series of easterly-dipping faults that, in places sole onto or cut a highly reflective, shallowly east-dipping reflective zone that lies beneath almost the entire Belt. This presumably older, shallowly-dipping reflective zone is interpreted as a major, regional detachment surface. The Mount Isa Fault appears to be part of a family of west-dipping faults that dip at about 70°. One of these, the Adelheid Fault, is a highly reflective zone that projects downwards from the surface and extends westwards beneath the Sybella Granite.

Broken Hill and the Tasman Line

A major 350 km northwest-southeast refraction line was shot in 1997 across the Broken Hill block by the AGCRC. This showed that the Moho ranges in depth from 35 km on either side to 43 km beneath the Broken Hill Block. The region consists of a two layer crust: an upper layer with velocities of 5.9 km/s to 6.4 km/s with variable thickness ranging between 20 and 30 km, and a lower layer of 6.8 km/s to 7.2 km/s with a relatively constant thickness of around 14 km. Thus there is thickening of the upper crustal layer beneath the Broken Hill Block by 50%, but with the lower crustal layer maintaining a constant thickness. There is no evidence for a mid-crustal body with a high P-velocity beneath the Broken Hill Block which might have sourced the mafic dykes. The crustal P-velocities are relatively low compared with those in eastern Australia, and there is no evidence of an underplated lower crustal layer with P velocities around 7.7 km/s.

Western Victoria: VicGOLD

A deep seismic reflection transect in western Victoria, undertaken by the AGCRC as part of a multidisciplinary study into the geodynamic factors controlling gold mineralisation in the region, was designed to provide insights into the structural relationship between the Lachlan and the Delamerian Orogens. The Lachlan Orogen is dominated by a west-dipping fabric, and the Delamerian Orogen is weakly reflective, and cut by east-dipping faults. Between the two orogens the Moyston Fault and Pleasant Creek Fault are planar, and east dipping. The lower to middle crust is highly reflective,

with possible crustal-scale duplexes. The Moho is poorly defined, at about 33-36 km depth

Eastern Lachlan Orogen, New South Wales

As part of its contribution to the geological understanding of the mineral-rich eastern part of the Lachlan Orogen, the AGCRC acquired approximately 103 km of deep seismic reflection data in the Orange district of New South Wales in 1997 and 187 km in 1999. We also acquired a major 350 km north-south refraction line in 1997 along the Molong volcanic belt. Two of the 1997 reflection lines provide a staggered transect across, from west to east, the Silurian-Early Devonian Cowra Trough, the Ordovician Molong volcanic belt (a rifted piece of Ordovician volcanic arc), the overlying Mumbil Shelf (mid Silurian to mid-Devonian) and the deepwater (mid Silurian to mid-Devonian) Hill End Trough. The seismic data suggests that Ordovician volcanics underlie the Hill End and Cowra troughs flanking the Molong volcanic belt. Eastdipping faults cut the Ordovician volcanics of the Molong volcanic belt, but there is little evidence for west-dipping faults. East of the Molong volcanic belt, rocks of the Mumbil Shelf are cut by east-dipping faults that have undergone initial east-blockdown, followed by reactivation as east-over-west thrusts during regional inversion. The Godolphin Fault displays net major extension, with Ordovican volcanics in the hangingwall below rocks of the Hill End Trough.

AGCRC Projects

The below list of AGCRC projects includes only those projects managed within AGSO and those projects in which AGSO had a substantial contribution. Full details on each project can be found on the AGCRC website: http://www.agcrc.csiro.au/projects/

1053M	VicGOLD
1070A	Deep Seismic Acquisition in the Yilgarn
1062A	Australia's Geodynamic Framework
1061A	Australia's Palaeogeography
2042A	Boundary between the Proterozoic and Palaeozoic of Eastern Australia
3047A	Broken Hill Structural Analysis
1060A	Seismic Surveys in the Eastern Lachlan Orogen
3044A	Australian Continental Synthesis
3029A	Tectonic Framework of Eastern Australia
2052M	Tasmania Tectonic Synthesis
1031M	Tectonic Synthesis along the Mt Isa Seismic Traverse
1016A	Mt Isa Seismic Reflection Survey
1019A	Mt Isa Transect - Geophysical Add-Ons
1039A	Establishing a Tomography Capability in the AGCRC
1007A	AGCRC - Program I Development and Support
1035A	Analysis of Depth to Basement Techniques in Regions of Complex
Structure	

Products

1:2.5M map "Stratotectonic and structural elements, southern Tasman Fold Belt System" – available from AGSO as either a print-on-demand colour hard copy map or as a series of Arc/Info and MapInfo coverages on a single CD-ROM.

Seismic data (available from AGSO)

Mt Isa (AGCRC/MIMEX) 1994. 2 deep crustal reflection lines, 287.08 km 4 high resolution reflection lines, 16.64 km Crustal refraction profile, 500 km

Broken Hill (AGSO/NSWDMR/AGCRC) 1996 & 1997. 3 deep crustal reflection lines, 294.6 km Crustal refraction profile, 350 km

Western Victoria – Grampians (AGCRC) 1997. 3 deep crustal reflection lines, 68.96 km

Kalgoorlie (AGCRC/KCGM) 1997. 2 deep crustal reflection lines, 25.54 km 2 high resolution reflection lines, 8.02 km

Eastern Lachlan Orogen (AGCRC) 1997. 3 deep crustal reflection lines, 105.35 km Crustal refraction profile, 350 km

Yilgarn Craton - Kalgoorlie area (AGCRC) 1999. 5 deep crustal reflection lines, 194.6 km

Eastern Lachlan Orogen (AGCRC/NSWDMR/AGSO/Newcrest), 1999.

3 deep crustal reflection lines, 187.4 km

2 high resolution reflection lines, 19.84 km

Tasmania (AGSO/MRT/AGCRC), 1995

3 Dimensional seismic tomography data

Publications

A comprehensive list of publications can be found on the AGCRC website, which has a full search capability: http://www.agcrc.csiro.au/publications/

Highlights of Recent AGCRC Results, Particularly Seismic

Russell Korsch AGCRC @ AGSO



Unincorporated Joint Venture

between:

AGSO
CSIRO
La Trobe University
Melbourne University
Monash University
Compaq Computers
[Acknowledgements]



Focus of AGCRC Research within AGSO

- Joint projects with research partners
- Province to continent scale syntheses
- PREDICT Geological Information System
- Deep seismic reflection and refraction traverses in mineral provinces
- High resolution seismic reflection with industry partners

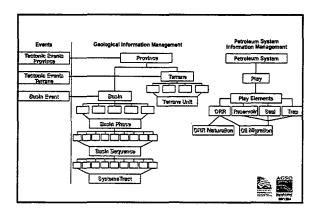


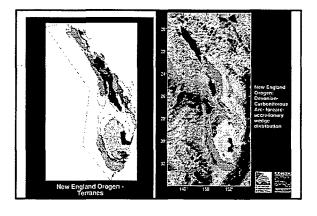
PREDICT Geological Information System

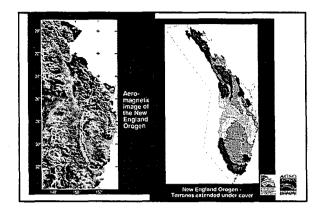
- WWW based for both Input & Output
- Time-based synthesis of tectonostratigraphic terranes and basins
- Nature & timing of main tectonic events
- Computer generation of time-space plots and graphic templates

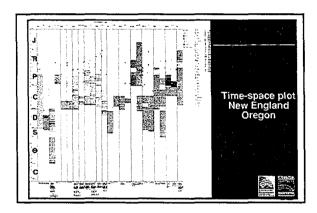


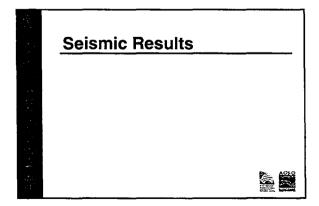


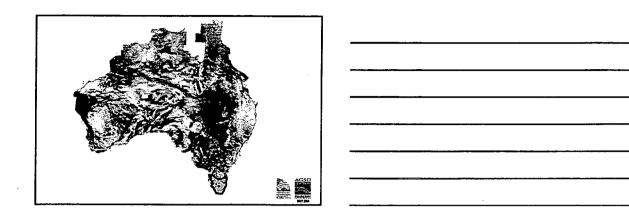










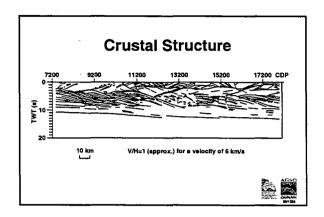


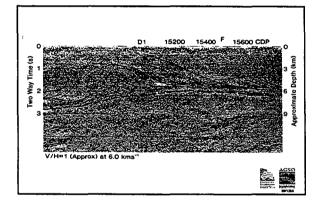
Yilgarn Craton					

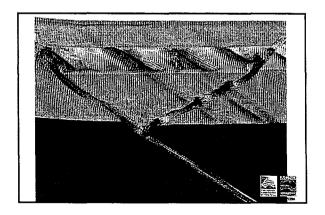


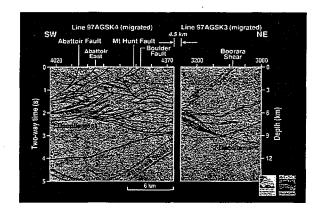
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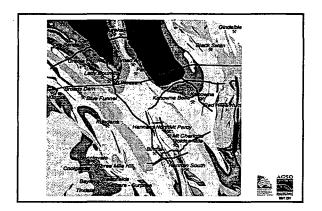








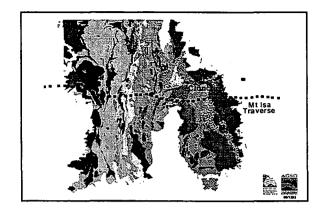


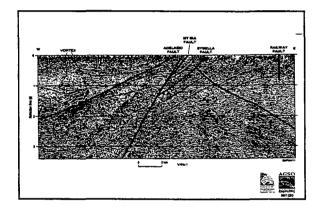


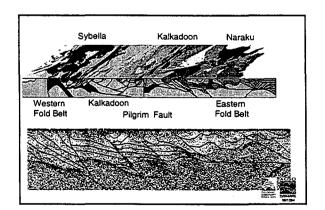
Mt Isa Inlier

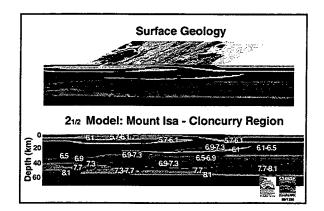
- Regional deep seismic reflection data
- Regional seismic refraction survey
- High resolution reflection survey in Mt Isa Valley (jointly with MIM)

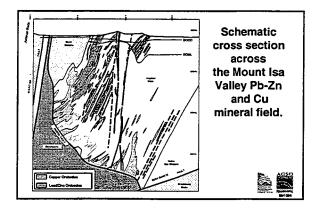


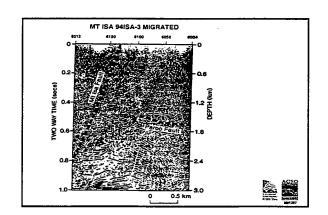








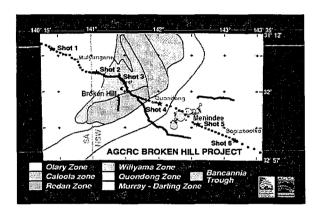


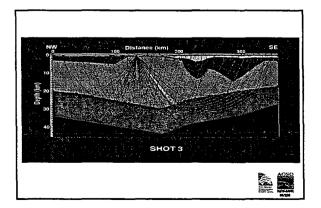


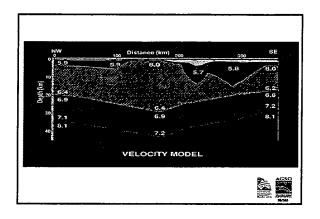
The Tasman Line in Western New South Wales

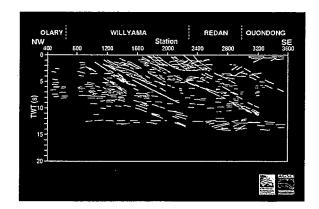
Boundary between Proterozoic and Palaeozoic Australia

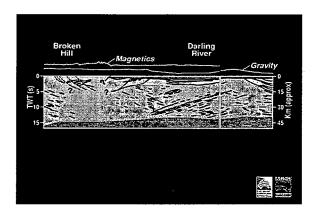












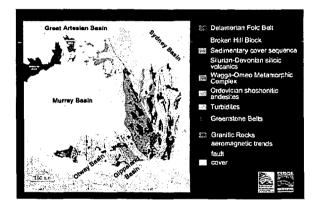
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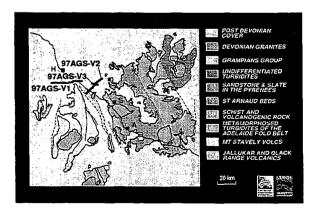
Western Victoria

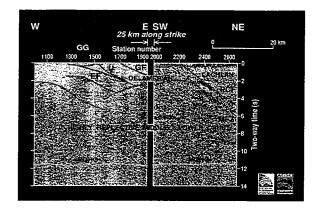
Boundary between the Delamerian and Lachlan orogens

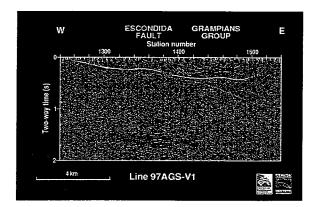


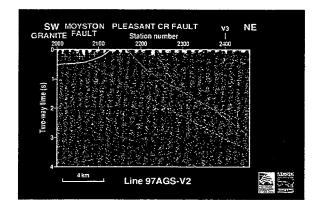




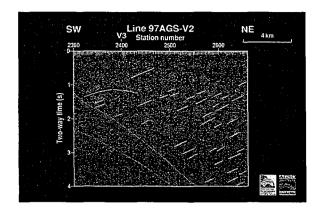








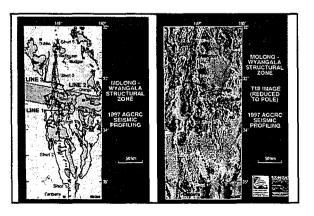
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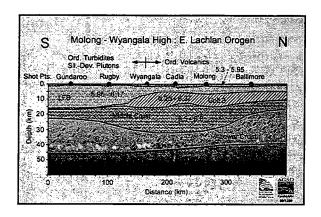


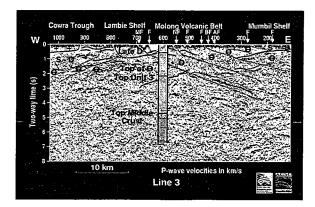
Eastern Lachlan Orogen New South Wales

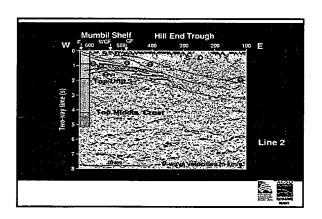
- Two regional deep seismic reflection surveys
- Regional seismic refraction survey
- Two high resolution reflection surveys

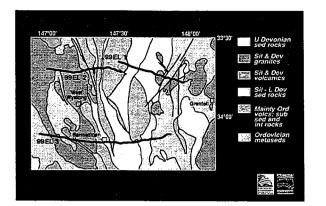










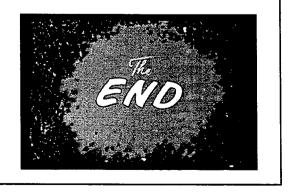


CONCLUSIONS

- PREDICT WWW based geological synthesis of terranes and basins
- Regional seismic reflection and refraction surveys in several key Australian mineral provinces
- Images of the 3rd dimension, including potential regional plumbing systems







LACHLAN FOLD BELT

A National Geoscience Mapping Accord Project

Maps and Digital Data

Geological Data

- Bathurst 1:250 000 sheet area
- Cootamundra 1:250 000 sheet area
- Dubbo 1:250 000 sheet area
- Forbes 1:250 000 sheet area

Airborne Geophysical Data

- Magnetic and Gamma-ray Data
 - > Semi-detailed line spacing (400m, 200m)
 - > Reconnaissance line spacing (1500m)
- Elevation Data
 - > Semi-detailed line spacing (400m, 200m)
- Gravity Data
 - > Detailed Gravity data
 - > Regional Gravity data

Geological Data

Bathurst 1:250 000 sheet area

•	1:250 000 scale geological map (2nd edition)	\$30
•	Explanatory Notes - Bathurst 1:250 000 scale	
	geological sheet (430 pages)	\$60
•	GIS (Digital data package on CD)	\$1,995

Available in ARCINFO Export and Mapinfo formats. Point datasets also available as ASCII and EXCEL files. Includes the following digital datasets covering the 1:250 000 sheet area, which may be purchased separately:

•	Geological polygons and linework - digitised from 1:50 000 and 1:25 ()00
	scale compilations. A 1 km AMG grid and annotated graticule are	
	included. \$600	
_	Derived cools are themes, including an extended cools sized attribute to	L 1a

•	Derived geology themes - including an extended geolog	gical attribute table,
	pre-Tertiary interpretive geology, buffered structures ar	nd intrusive bodies,
	and cross sections.	\$400

	and cross sections.	\$400
•	Whole rock geochemistry summary theme –	
	including over 20 elements	\$300
•	Site observation data - over 9000 sites	\$100
•	Structural measurements - over 8000 readings	\$100
•	Mineral occurrence database * -	
	over 1300 fully attributed occurrences	\$200
•	NSW DMR petrological descriptions *	\$180
•	AGSO petrological descriptions	\$50
•	Fossil database * - over 700 descriptions	\$130
•	Geochronology database - 24 SHRIMP zircon dates	\$240

t • I	Photographic database - point theme linked o over 130 images. Regolith landform polygons and geomorphic data Also available from NSW DMR as maintained databases.)	\$80 \$100
• 1	:100 000 scale geological maps (1st edition)	\$50 each
•	240,4151 (0031)	
<i>Digi</i> i 6 she	tal data for each of the above 1:100 000 sheets \$120 each (or seets)	\$600 for all
	0 000 scale regolith landforms maps (preliminary edition) for e sheets \$50 each	each of the
Α	Whole rock geochemical analyses AGSO data - 396 analyses ASW DMR data - 185 analyses	\$792 \$85
Cootamundi	ra 1:250 000 sheet area	
	:250 000 scale basement geology map (interpreted from geopl utcrop geology)	hysics and \$300
• 1: • E: (5	0 000 sheet area :250 000 scale geological map (2nd edition) Explanatory Notes - Dubbo 1:250 000 scale geological sheet 504 pages) :100 000 scale geological maps (preliminary edition)	\$30 \$75 \$50
	Wellington (8632) Dubbo (8633) Euchareena (8732) Cobbora (8733) Mudgee (8832) Gulgong (8833)	
• 1: • 1: • 1:	2250 000 scale simplified basement geology map 2250 000 scale regolith landforms map orbes Field Conference Guide (108 pages)	\$50 \$50 \$50 \$50 \$50 \$50 each

- Bogan Gate (8431)
- Condobolin (8331)
- Grenfell (8530)
- Marsden (8430)
- Parkes (8531)
- Wyalong (8330)

Airborne Geophysical Data

Magnetic and Gamma-ray Data

Semi-detailed line spacing (400 m, 200 m)

Available for Ballarat, Bendigo, Cootamundra, Dubbo, Forbes, Goulburn, Liverpool Plains, St Arnaud (S), Wangaratta (N)

Digital data

• Point located data

Unit	400 m	250 m	200 m
4 - 15 of 7.5'x7.5' areas	\$150 ea	\$240 ea	\$300 ea
16 + of 7.5'x7.5' areas	\$130 ea	\$210 ea	\$260 ea
1:100 000 sheet area	\$2,080	\$3,360	\$4,160
1:250 000 sheet area	\$10,750	\$17,200	N/A

Grids - TMI or 4-channel gamma-ray data

Unit	400 m	250 m	200 m
1:100 000 sheet area	\$500	\$800	\$1,000
1:250 000 sheet area	\$2,500	\$4,000	N/A

Line maps

Map type	Dyelines	Transparencies
Profiles, flight path (1:100 000)	\$15	\$45
Contours (1:100 000)	\$40	\$120
Contours (1:250 000)	\$120	\$250

• Pixel image maps

Available for Bendigo, Dubbo, Forbes, Goulburn, Liverpool Plains, Wangaratta

Map type	Pseudocolour	Greyscale	Both
Magnetic	\$300	\$250	\$500
Gamma-ray	\$300	N/A	N/A

Reconnaissance line spacing (1 500 m)

Digital data

- Point located data \$750 per 1:250 000 sheet area
- Grid data (magnetic only) available on 1:1 000 000 sheet basis, 15" grid

Adelaide	\$2,000
Armidale	\$1,000
Bourke	\$2,000
Canberra	\$2,000
Hamilton	\$1,000

Melbourne \$1,500 Sydney \$500

Line maps

Map type	Dyelines	Transparencies
Profiles, flight path (1:250 000)	\$10	\$20
Contours (1:250 000)	\$25	\$75

Elevation Data

Semi-detailed line spacing (400 m, 200 m)

Point located and gridded data

 Ballarat, Bendigo, Dubbo, Forbes, Liverpool Plains, Wangaratta (N) \$1,000 per sheet
 Goulburn \$1,600

Line maps (1:250 000)

•	Dyeline	\$40
•	Transparency	\$120

Pixel image maps (1:250 000)

Available for Bendigo, Goulburn, Wangaratta

• Pseudocolour \$300

Digital Images on CD-ROM

• Goulburn \$4,000

Gravity Data

Detailed Gravity data

(ca. 4 km station spacing with some more detailed areas) Available for Dubbo, Narromine, Bathurst, Forbes

•	Gravity - contours and station locations, per sheet (film)	\$75
•	Gravity - contour and station locations, per sheet (dyeline)	\$25
•	Digital data (single map sheet)	\$200
•	Digital data (two map sheets)	\$300
•	Digital data (all four sheets)	\$500

Regional Gravity data

•	Available for all 1:250 000 and 1:1 000 000 sheet areas	
•	1:250 000 gravity contours, per sheet (transparent film)	\$75
•	1:250 000 gravity contours, per sheet (dyeline)	\$25
•	1:1 000 000 gravity contours, per sheet (transparent film)	\$75
•	1:1 000 000 gravity contours, per sheet (dyeline)	\$25