



# Industry interaction



## INDUSTRY INTERACTION, TECHNOLOGY TRANSFER AND COMMERCIALISATION PROGRAM

**G**EMOC RELIES on a vigorous interaction with the mineral exploration industry at both the research and the teaching/training levels. The research results of the Centre's work are transferred to the industry and to the scientific community by:

- collaborative industry-supported Honours, MSc and PhD projects
- short courses relevant to the industry and government sector users, designed to communicate and transfer new technologies, techniques and knowledge in the discipline areas covered by the Key Centre
- one-on-one research collaborations and shorter-term consultancies on industry problems involving national and international partners
- provision of high quality geochemical analyses with value-added interpretations to industry and government organisations, extending our industry interface
- use of Macquarie Research Limited consultancies, which employ and disseminate the technological developments carried out by the Centre
- GLITTER, an on-line data-reduction program for Laser Ablation ICPMS analysis developed by GEMOC and CSIRO GEMOC participants, is available commercially through New Wave Research
- collaborative relationships with technology manufacturers (more detail in the section on *Technology Development*):
  - GEMOC (Macquarie) is the Agilent Technologies ICPMS Australian demonstration site
  - GEMOC (Macquarie) is the international Alpha test site for New Wave Research Lasers



*Agilent Technologies  
representatives  
Tony Crocker and  
Toshiaki Matsuda  
with GEMOC's Norm  
Pearson and Bill  
Griffin.*

## SUPPORT SOURCES

GEMOC industry support includes:

- direct funding of research programs
- "in kind" funding including field support (Australia and overseas), access to proprietary databases, sample collections, digital datasets

- collaborative research programs (eg ARC SPIRT (now Linkage) Projects, APA Industry and PhD program support)
- assistance in the implementation of GIS technology in postgraduate programs
- participation of industry colleagues as guest lecturers in senior courses (eg Bachelor of Technology)
- extended visits to Macquarie by industry personnel for interaction and research
- ongoing informal provision of advice and formal input as members of the Advisory Board

### ACTIVITIES IN 2003

*TerraneChron*<sup>TM</sup> studies (see *Research Highlights*) have been adopted by a large segment of the global mineral exploration industry. This methodology, currently unique to GEMOC, requires the integration of data from three instruments (electron microprobe, LAM-ICPMS and LAM-MC-ICPMS) and delivers fast, cost-effective information on the tectonic history (with ages) of regional terranes.

Collaborative research with Kennecott Canada Inc., continued within the Lithosphere Mapping strand, following the very successful SPIRT project “Lithosphere Mapping and Diamond Exploration”. This involved the synthesis of results from analysis of heavy mineral concentrates from more than 25 localities scattered around North America, and the correlation of the data with seismic tomography and other geophysical data (Publication #348). Results of the SPIRT project were released as planned at the 8<sup>th</sup> International Kimberlite Conference in Vancouver in June 2003.

Nine Industry Reports were completed for collaborative and consulting projects.

An ARC SPIRT project (2001-2003) sponsored by WMC used gravity data to interpret effective elastic thickness and integrate this with tectonic analysis and geochemical data across Australia.

A new ARC Linkage Project with WMC was funded for 2004-2006. This project is titled “Global Lithosphere Architecture Mapping”. Planning and workshop sessions at Macquarie with participants from WMC and GEMOC, and a visit by Macquarie staff to WMC in Perth, were key activities in 2003. Dr Graham Begg spent significant research time at GEMOC through 2003 as part of the close collaborative working pattern for this project.

*Part of the GEMOC/  
WMC GLAM  
(Global Lithosphere  
Architecture Mapping)  
team.*



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Professor J. Harris (on behalf of de Beers) provided samples for the PhD project of Sonal Rege aimed at developing a methodology for the trace-element analysis of diamonds.

The exploration consulting group GeoDiscovery continued to work with GEMOC to develop *TerraneChron*<sup>TM</sup>, a novel approach to terrane analysis (see *Research Highlights*). A GeoDiscovery/Macquarie collaborative project supported the initiation of this project, and another collaborative project, supported by BHP-Billiton, began early in 2003 (see summaries of current industry projects below).



*The TerraneChron<sup>TM</sup>  
Team: Elena  
Belousova, Ayesha  
Saeed, Kirsty  
Tomlinson and  
Eloise Beyer.*

Dr Steve Walters visits Macquarie to participate in this collaboration.

Many companies have provided high levels of in-kind support in the form of samples: these include access to diamonds and xenoliths through Rio Tinto and Kennecott Canada, suites of xenoliths from Ashton Mining of Canada and heavy mineral concentrates from numerous sources including BHP, DeBeers Australia, Monopros and several small companies.

Rio Tinto supplied samples for pilot studies of garnets, chromites and pyroxenes from kimberlites on the Dharwar Craton of India; the results were used to support a successful proposal for a Macquarie University Collaborative Grant (2004).

A pilot study on detrital zircons from Paleozoic sediments was carried out with the New South Wales Geological Survey; the results were used to support a successful proposal for a Macquarie University Collaborative Grant (2004).

Numerous industry visitors spent varying periods at GEMOC in 2003 to discuss our research and technology development (see visitor list, *Appendix 3*).

DIATREEM continued to provide LAM-ICPMS analyses of garnets and chromites to the diamond-exploration industry on a routine basis, in cooperation with CSIRO, North Ryde.

GEMOC publications, preprints and non-proprietary reports are available on request for industry libraries.



## CURRENT INDUSTRY-FUNDED COLLABORATIVE RESEARCH PROJECTS

**T**HESE ARE brief descriptions of current GEMOC projects that have direct cash support from industry and timeframes of at least one year. Projects are both national and global.

GEMOC's industry collaborative projects are designed to develop the strategic and applied aspects of the basic research programs based on understanding the architecture of the lithosphere and the nature of Earth's geodynamic processes that have controlled the evolution of the lithosphere and its important discontinuities. Most of the industry collaborative projects rely on geochemical information from the Geochemical Analysis Unit in GEMOC and especially on novel methodologies developed by (and some unique to) GEMOC.

Geochemical data on crustal and mantle rocks are being integrated with tectonic analyses and large-scale datasets (including geophysical data) to understand the relationship between lithosphere domains and large-scale mineralisation.

The new methodologies of using mantle sulfides to date mantle events, and of characterising crustal terrane development using U-Pb dating and Hf isotopic compositions of zircons provides more information for integration with the geophysical modelling. *TerraneChron*<sup>TM</sup> (see *Research Highlights*) is proving an important new approach to characterising the tectonic history and crustal evolution of terranes on the scale of 10 – 100 km as well as delivering a cost-effective exploration tool to the mineral (and potentially petroleum) exploration industry.

### Proterozoic crustal evolution: Development of a global comparative library of Event Signatures linked to mineral endowment

*Supported by a matching Macquarie University Collaborative grant (2002-2003)*

*Industry Collaborator: BHB-Billiton*

**Summary:** This project is aimed at understanding processes of Proterozoic crustal formation. We will measure the U-Pb ages, Hf isotope ratios and trace-element patterns of detrital zircons from selected Proterozoic terranes to study the timing, nature and sources of magmatic rocks. The Event Signature for each region will be compared with our data from geologically similar districts, eg Mt Isa block (Australia) and Arivalli Craton (India), and event styles will be correlated with differences and similarities in known mineralisation styles. The project will contribute to a unique global 'library' of Event Signatures with application to area selection for mineral exploration.



*Elena Belousova  
collecting zircons with  
Steve Walters near  
Broken Hill.*

### **Lithosphere mapping beneath the Dharwar Craton, India**

*Supported by a matching Macquarie University Collaborative grant (2004)*

*Industry Collaborator: Rio Tinto*

*Summary:* The project uses major- and trace-element analysis of mantle-derived minerals in kimberlites to map vertical and lateral variations in the composition and thermal state of the lithospheric mantle across the Archean Dharwar Craton in central India. The kimberlites are 900-1200 million years old, and may provide information on a relatively unmodified lithospheric root. Comparison with geophysical data (today's situation) will help to define the fate of this root during India's northward movement after its separation from Gondwanaland. The results will be directly relevant to diamond exploration models for the Dharwar Craton, and for other areas in India.

### **Global Lithosphere Architecture Mapping**

*Supported by ARC Linkage (2004-2006)*

*Industry Collaborator: WMC*

*Summary:* Compositional domains in the subcontinental lithospheric mantle reflect the processes of continental assembly and breakup through Earth's history. Their boundaries may focus the fluid movements that produce giant ore deposits. Mapping these boundaries will provide fundamental insights into Earth processes and a basis for the targeting of mineral exploration. We will integrate mantle petrology, tectonic synthesis and geophysical analysis to produce the first maps of the architecture of the continental lithosphere, to depths of ca 250 km. These maps will provide a unique perspective on global dynamics and continental evolution, and on the relationships between lithosphere domains and large-scale mineralisation.

### **Continental Flood Basalts: geochemical discrimination with relevance to exploration for nickel and platinum-group elements**

*Supported by a matching Macquarie University Collaborative grant (2004)*

*Industry Collaborator: WMC*

*Summary:* A major proportion of magmatic Ni- platinum group element (PGE) deposits are hosted in mantle-plume-derived continental flood basalts (CFB). Therefore, geochemical discrimination of CFB from other mantle-derived rocks and identification of Ni-PGE-prospective CFB are significant for Ni-PGE exploration. This project is exploring existing geochemical databases for mantle-derived rocks to provide user-friendly practical discrimination parameters to identify CFB-related mafic rocks and to evaluate their Ni and PGE economic potential. The research will also further constrain the role of mantle plumes in formation and evolution of subcontinental lithosphere and the behaviour of sulfides during the process of mantle evolution.

## **Where was Baltica? Testing continental reconstructions with TerraneChron™**

*Supported by a matching Macquarie University Collaborative grant (2003-2004)*

*Industry Collaborator: University of Oslo and Norwegian Geological Survey*

**Summary:** Norway represents the western margin of the ancient landmass of Baltica, which was partly destroyed in the Caledonian Orogeny ~550-400 million years (Ma) ago. Its position before 600 Ma is debated. This project is using U-Pb dating and Hf-isotope analysis of zircons in basement rocks in SW Norway and in far-transported thrust sheets (nappes) derived from the vanished western margin of Baltica, to reconstruct the geological history of this margin. The results will allow evaluation of models for continental assembly, and will be relevant to studies of the provenance of sediments in the oil/gas basins of the North Sea.

## **Testing Ordovician-Devonian tectonic models for the Lachlan Orogen**

*Supported by a matching Macquarie University Collaborative grant (2004)*

*Industry Collaborator: NSW Geological Survey*

**Summary:** This project combines the TerraneChron™ technology developed at GEMOC with tectonic and structural concepts developed at the Geological Survey of NSW, to understand the plate-tectonic evolution of SE Australia. U/Pb dating and Hf-isotope analysis of detrital and primary zircon grains will shed light on potential terrane accretion and on the timing of crustal growth and will be used to test published models of the Ordovician–Devonian tectonic development of Eastern Australia. This in turn will help to understand the nature of the interaction between the Australian plate and the proto-Pacific margin of the Gondwana supercontinent.

## **Crustal evolution in southern Norway: U-Pb and Hf-isotope analysis of zircons from bedrock, sediments and modern drainages**

*Supported by a matching Macquarie University Collaborative grant (2002-2003)*

*Partners: Geological Survey of Norway and the University of Oslo*

**Summary:** The broad-scale evolution of the Proterozoic crust of southern Norway is being investigated, using U-Pb, Hf-isotope and trace-element analysis of zircons from selected bedrock units and the overlying Neoproterozoic Sparagmite sedimentary sequence. The results will provide an “Event Signature” for comparison with similar data from more strongly mineralised Proterozoic crust elsewhere. Signatures from small modern drainages in the study area will be compared with those from the rock samples to test the usefulness of this approach for the study of crustal evolution in glaciated areas. The results will enhance the technique’s applications to mineral and energy exploration.

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*Bruce Chappell, Neil Williams, Shunso Ishihara, Alan White and Phil Blevin at the Ishihara Symposium.*



### Lithospheric architecture of Australia: relevance to location of giant ore bodies

*Supported by an ARC SPIRT grant (2001-2003)*

*Industry Collaborator: WMC*

*Summary:* This research project is designed to test the concept that giant magmatic and hydrothermal ore bodies are localised by major structural discontinuities that extend through the Earth's lithosphere. Modelling of geophysical data across the Australian continent is defining regional trans-lithospheric domains and their boundaries. Tectonic analysis and geochemical data on crustal and mantle rocks are defining the age and composition of the upper mantle beneath each domain, and the history of crust-mantle interaction (magmatism, extension, compression). This history will be integrated with information on the timing and style of large ore deposits to understand the relationship between lithosphere domains and large-scale mineralisation. The focus of this project was expanded in 2002 to include the detailed analysis of lithosphere structure and evolution worldwide, using seismic tomography and other geophysical datasets.

### Igneous metallogenic systems of eastern Australia

*Supported by AMIRA (Project P515)*

*Industry Collaborators: Newcrest, Rio Tinto, Delta, GA, NSWGS, QDME, Triako Normandy*

*Summary:* The research part of this project was completed in 2002. The final outcome in 2003 was a three-day symposium on granites, "The Ishihara Symposium: Magmas to Mineralisation", held at Macquarie from 22-24 July 2003. The initial suggestion for this

meeting came from representatives of the companies and surveys that sponsored AMIRA projects of Phil Blevin and Bruce Chappell. The symposium was named in honour of Dr Shunso Ishihara who has been at the forefront of developing ideas on the relationships between granites and mineralisation. More than 100 participants included academics, students, survey geologists and mineral exploration geologists. Abstracts for the symposium were published as Geoscience Australia Record 2003/14 and GA is also making available adaptations of PowerPoint

presentations of many of the talks. The Ishihara Volume from the Conference will be published as an issue of the Japanese journal Resource Geology in September 2004.